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MAN AND THE MICROBE

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A CASE of measles or typhoid fever is not only a most unpleasant kind of practical problem, but a natural history phenomenon of a mysterious and interesting sort. Here is a person who wakes up apparently well and goes about his daily tasks as usual. Gradually he is conscious of some strange clog in the machine, a dragging of the wheels, such as we experience when a carriage passes from a good road into a sandy by-way. Pains and aches begin to be felt in head and back. The general weakness increases, and, with or without a sharp chill, the patient gives up and takes to bed. Fever has set in. The vigorous and active human animal of the morning has been changed in a few hours to a mere wreck of his former self. What has happened? What subtle force has produced so sudden and mysterious a catastrophe?

The later history of such an attack is almost as remarkable as its inception. Most diseases go on and grow worse unless something definite is done to remove their exciting cause. If, however, your measles or typhoid patient be let alone, or only protected by hygienic precautions against certain secondary results, 99 times out of 100 in the case of measles, and 9 times out of 10 in the case of typhoid fever, he will get well. These are "self-limited" diseases, to use the old expressive term. They run a course of so many days or weeks, and then, unless death or some complication supervenes, there is a steady progressive recovery. The temperature falls, the mind clears, the strength returns, the patient is as he was before, with one important exception, that he is now, to a greater or less extent, and for a longer or shorter time, resistant or immune against the particular malady from which he has suffered. Think what a curious phenomenon this really is, divested of the cloak of familiarity with which it is commonly invested. What sort of strange process goes on in the body, which has a definite cycle like the life of an animal, fulfils its appointed round, and then draws to a close, leaving only the impress of immunity to mark its passage.

Nor is this all. There is another characteristic of this particular group of diseases, which is quite as remarkable as those associated with their inception and their cyclical course. They are catching, contagious, infectious, communicable. They do not occur singly, but spread from person to person, as flame leaps from tree to tree in a forest. The degree to which this quality is manifest varies widely. When measles was first carried to the unprotected inhabitants of the Faroe Islands, it spread indeed, like wildfire, to almost every person. When smallpox is brought into an unvaccinated community the same thing happens to-day. In other communicable diseases, like tuberculosis and typhoid fever, the transfer of infection is less inevitable and less direct. In all the maladies of this type, however, the same principle obtains. The disease neither originates within the patient nor comes, in the last analysis, from any influence of earth or water or air. It arises ultimately in every instance from a previous case of the same disease, from a specific spark of the same conflagation.

To the primitive mind, deeply tinged with anthropomorphism, the natural explanation of all disease was sought in the evil influence of a demon or other supernatural power. The plagues and pestilences in particular were punishments inflicted upon a people for their sins. There was no possibility of escaping such visitations except by the dubious expedient of flight; no hope except in the relaxation of the celestial anger of which they were the sign. As Defoe says of the cessation of the plague in London:

> Nothing but the immediate finger of God, nothing but Omnipotent Power could have done it. The contagion despised all medicine; death raged in every corner; and had it gone on as it did then, a few weeks more would have cleared the town of all and everything that had a soul. Men everywhere began to despair; every heart failed them for fear; people were made desperate through the anguish of their souls, and the terrors of death sat in the very faces and countenance of the people.

The modern view that disease is not a divine infliction, but a natural phenomenon, with natural causes, which may be progressively grasped and controlled by the steady and disciplined activity of the human mind, we owe first to the wonderful nation whose genius came to its flower on the sea-girt promontories and islands of the Ægean twenty centuries ago. Of all our debts to Greece there is none greater than this, that the Greeks, first of all western nations, sought to find a natural rather than a supernatural explanation of the phenomena in the world about them. They often failed to find it, as was inevitable in the absence of the mass of observations needed for good induction. They fell back on poetic abstraction, almost as fanciful as the demons of their savage forefathers; in the case of the causation of disease, for example, upon the theory of the four humors developed to a position of commanding influence by Galen. Yet the great fact remained that whether the explanations of the

Greeks were scientific or not, they aimed to be scientific, and they firmly implanted along with all their error, a zeal for the scientific truth about nature and a confident belief in the possibility of its ultimate attainment.

From Hippocrates down to our own times, then, we find that the explanation of diseases of all kinds has been sought by scientific men, not in the activities of spiritual beings, but in the workings of natural law. Results were almost nil, however, so far as the communicable diseases are concerned, until the nineteenth century when a sudden and rich fruition took place here, as in all fields of the biological sciences, as a result of a simple mechanical discovery, the lens-maker's trick of the achromatic objective, which made possible the modern high power microscope and revealed all at once a new and stupendous world— "The world of the infinitely little."

It is true that Leeuwenhoek and other early naturalists had seen the microbes with their primitive simple lenses. It is true that still earlier, in the sixteenth century, the Veronese physician, Fracastorius conceived the communicable diseases as due to "seminaria contagionum," minute particles capable of reproduction in appropriate media and having many of the attributes we know to be characteristic of the bacteria to-day. The Roman author Varro, in writing on the choice of sites for a farm house cautions the builder against the neighborhood of swampy ground "because certain minute animals, invisible to the eye, breed there, and borne by the air, reach the inside of the body by way of the mouth and nose, and cause diseases which are difficult to get rid of." Nevertheless, so far as any scientific demonstration of their nature was concerned, the communicable diseases remained as much a mystery in 1800 as in 400 B.C.

It was the achromatic objective, perfected about 1840, which first revealed the ubiquity of microbic life and its special richness in connection with the processes of fermentation and decay; and it was of profound moment in the history of medicine and sanitation when Pasteur proved, against the opposition and the ridicule of the great Liebig and a host of lesser critics, that fermentation was the result of the action of microbes, little living things which entered into the fermentable fluids and grew and multiplied there, the fermentation being the result of their powerful chemical secretions. The "little leaven that leaveneth the whole lump" was shown to be a self-propagating plant, and the many desirable and obnoxious decompositions to which sugary fluids are subject, each the result of a special microbe.

The analogy between fermentation and disease must have sprung into many minds, with the hope that the solution of the latter problem too might be found by the study of microscopic life. It was again Pasteur who by his rigid experimental method extracted the truth from the mass of good and bad guesses of those who had preceded him. In his study of the disease which threatened to wipe out the great silkworm industry of France, he again applied his microscope to the task, demonstrated the presence of living corpuscles in the bodies of the moths, whose offspring later succumbed to the disease, and saved the silk cultivators by a quarantine based on the destruction of eggs from such infected parents. In his later studies of anthrax and chicken cholera, he demonstrated that diseases of the higher animals too were due to specific microbes; and with his work and its extension by Robert Koch the mystery which for centuries had shrouded the communicable diseases was at last solved. Each case of sickness of this kind is a definite infection with a specific microscopic germ, which grows in the body as a mold grows in a jar of jelly and in its growth produces chemical poisons, which cause the weakness, pain, fever, delirium and the other manifestations of disease. The self-limited nature of such maladies is due, as Pasteur too showed, to the fact that the body cells react against the invaders in a specific and purposeful manner, which, if they finally triumph, leads to a more or less lasting state of immunity. The spread of communicable disease in the community is no longer a "pestilence that walketh in darkness," but the transfer in tangible ways of a small but definite animal or plant; and its control can be confidently looked for from the study of the life histories of these microscopic organisms and the working out of practical methods which shall prevent them from gaining access to our bodies.

The communicable diseases are merely striking examples of the more general biological phenomenon of parasitism described by Swift in the famous and often misquoted lines:

So naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em
And so proceed ad infinitum.

It should be remembered that the word parasite was first coined for members of the human species. The parasite in Grecian times was the one who "sat beside" the great man, the hanger-on in the palace of the prince, who gained a precarious living at the expense of his complaisant host. We may hope that the type is less common in modern times and it is fair to remember that in the microbic world, as in our own, the parasite is an exception rather than the rule. The great majority of the bacteria are honest, industrious, useful citizens, who ripen our cream and butter and cheese, make our vinegar and lactic acid, dispose of our waste materials and play a most important part in maintaining the fertility of the soil. The tubercle bacillus and the malaria germ, like the thief and the murderer are perverted individual representatives of a generally sound stock.

There is another very important point of resemblance between the disease germ and the human parasite. Just as the man who has learned to live at the expense of society soon loses the capacity to do an honest day's work and would starve if left to his own resources, so the microbic parasites in adapting themselves to live at the expense of their human host have lost the capacity to gain a living in the world outside. They have been so modified in the course of evolution as to thrive in the rich warm fluids of the body and perish outside of it. If a hundred typhoid germs are discharged into a lake their fate is much the same as that of a hundred men under the same conditions. A few of the men may be good swimmers and a few may be lucky enough to cling to floating planks. Most die very quickly, however, and in the course of time all will surely perish. So with most disease germs in water or soil or anywhere outside the body. Certain pathogenic microbes may actually multiply in suitable media, in milk for example. As a rule, however, there is a steady decrease, rapid at first and slower afterward, but inevitably leading to extinction in a comparatively short period. We read of disease germs persisting in dust or ice for several months, and a very few may sometimes do so. Quantitative studies show, however, that the survivors are few indeed and that the danger from such remote infection is practically negligible. In the case of water, which has been more carefully studied than any other medium, we know, for example, that in a period of two or three weeks even gross infection will be removed by the natural mortality of the microbes. Dr. Houston, of London, who has done some of the most important work upon this subject, has repeatedly demonstrated his confidence in his results by drinking halfpint portions of water, merely kept in bottles for a few weeks in the laboratory after infection with millions of typhoid bacilli. Both bacteriological and epidemiological evidence indicates very clearly that it is only fresh, recent infectious material which plays an important part in the transmission of communicable disease.

This conclusion is one of the most important fruits of recent sanitary research; for it focuses attention sharply upon the human being, the original source of virulent disease germs, rather than upon vague and obscure miasms of the earth and air. It is people, primarily, and not things that we must guard against. Certain media, like milk and water, are important agents in the transfer of infection from person to person. Others, like air and dust and fomites (books, toys and the like which have been exposed to infection) are known to be far less dangerous than was supposed. Back of all such material agents of transmission, however, lies the human being, and the nearer to this source we get,—the more direct and rapid the transfer,—the greater is the danger.

Unfortunately, however, it is not only the obviously sick person who may be a center for the distribution of active disease. Another of the great contributions to sanitary science in the last ten years has been the recognition of the part played by incipient cases and "carriers," apparently well persons, who are nevertheless discharging from nose and throat or bowels the virulent germs of disease. Measles, for example, is spread chiefly in its incipient stage, when the child has no other symptom than a slight running at the nose and goes to school or to a party, thinking it has only a cold in the head. The carrier, properly so-called, may be a convalescent, entirely cured so far as his own symptoms are concerned, but still distributing virulent germs. From three to five per cent. of all typhoid cases continue to discharge typhoid bacilli for three months or more after convalescence. A recent milk borne epidemic in New York was due to infection from a carrier who had had typhoid in the West forty-six years before. Malarial infection is very frequently introduced into a community by Italian laborers who have themselves become immune to the parasites they carry, in their own country years before. Finally we have the most striking type of carrier, in which there is no present or past history of active disease at all. The famous cook, Typhoid Mary, for example, caused epidemics in eight different families where she worked, but so far as is known had never suffered herself. Two or three persons in a hundred in any normal population have been found on bacteriological examination to be carriers of the diphtheria bacillus, two or three in a thousand, of the typhoid bacillus. The problem of the carrier is one of the most serious of those which confront us since he is moving about in the world, mixing with others, perhaps taking part in the preparation and handling of food, and so may be proportionately much more dangerous than the sick person who is confined to his bed and under medical care.

It is a great step forward, however, to have learned that the human body, of the sick person or the carrier, is the primary source of infection; that every case of communicable disease is caused by the transfer of infectious material from such a person to a susceptible victim; and that the extent of the danger varies directly with the immediacy of the transfer. As this conception has been worked out in detail it has become clear that many of the supposed dangers of the pre-scientific period were of altogether minor import. To the older sanitarian the atmosphere was full of vague dangers, but its part in the spread of disease is now known to be exceedingly limited. In the immediate vicinity of a sick person or a carrier the air is infected by fine spray thrown out of the mouth in coughing, sneezing or loud speaking; but this is really a form of contact, not a general infection of the atmosphere. The mouth spray is a sort of rain which falls quickly to the ground, where it dries and the disease germs perish. It is true that dust collected from the surface in streets and rooms contains vast numbers of harmless germs and occasionally some disease-producing types. I am myself of the opinion that there may be real danger in breathing in such gross quantities of dust as one sometimes encounters in a dirty street on a windy day. This again, however, like the mouth spray, is an occasional and local pollution. Bacteriological studies, such as those carried on last winter in the New York schools, show that quiet indoor air contains comparatively few microbes of any kind and is singularly free from germs of human origin. So strong is the evidence of the insignificance of aerial infection that in some of the most modern hospitals, cases of various contagious diseases have been treated with perfect success in open wards, provided, of course, that the most rigid precaution be taken to prevent the direct transfer of infectious material by the hands and clothing of attendants.

One of the most striking examples of the exorcism of a bogey of the older sanitation by modern exact methods is the case of sewer gas. Dreaded as a prime spreader of disease ever since sewerage began, we now know that sewer and drain air is freer from microbes than the air of a city street, and that the microbes which are present are of the same harmless type in the two cases. From a careful series of experiments in Boston, it was calculated that if one placed the mouth over a house drain and breathed the drain air continuously for twenty-four hours the number of intestinal microbes ingested would be less than those taken in in drinking a quart of New York water, as it was before routine disinfection of the supply was introduced.

Disease germs do not enter the household through the sewer pipes or by flying in at the windows (unless borne on the wings of insects). They are not to any important extent brought in on books or toys or clothing, where, if any infection existed, it has mostly dried up and died. They are brought in directly by infected persons (carriers). They are brought in by insects. They are brought in by certain articles of food and drink. These three types of transmission, which have been alliteratively described as infection by fingers, flies and food, account for ninety nine cases of communicable diseases out of a hundred, and each of them deserves a somewhat more detailed consideration.

In order that a given food may be important as an agent in the transmission of disease there are three different conditions which must be met, and it is only in a few instances that all three are met at once. The substance must be exposed to infection, it must be delivered and used promptly and it must be eaten raw. For the great majority of our foods cookery furnishes an effective safeguard and, as has been often pointed out, the sanitary results of this practise must have played an important part in the evolution of the human race. Most processes of cookery destroy the disease germs and their toxins and make it possible to use such foods as the meat from slightly tuberculous animals with entire safety. It is fortunate that this is the case because the ideally healthy animal is as rare as the perfect human being, and the increasing burden of the cost of living makes it essential that we should utilize all food materials which can be consumed with safety. The common practise, in certain European countries, of eating meat only partially cooked often leads there to serious epidemics of meat poisoning, but in America such outbreaks are usually due to subsequent infection of cooked foods which have been improperly handled in the kitchen, rather than to original infection of the meat before it enters the household.

Of the food materials which are eaten raw and might therefore be expected to play an important part in the wholesale transmission of disease, some, like certain fruits, are rendered safe by the fact that they are peeled before being eaten so that the edible portion has never been exposed to infection. Others are protected by the fact that long storage usually intervenes between exposure to pollution and ultimate consumption. Thus ice, though often cut on polluted streams, is one of the safest foods, as shown by careful bacteriological and epidemiological studies. Ninety per cent. of the bacteria in the water are thrown out in the physical process of freezing; and in a few weeks ninety-nine per cent. of any disease germs remaining will have perished.

Water and milk and raw shellfish are the three foods which in the highest degree fulfill all the requirements of a dangerous disease medium. If water is taken from streams or ponds or wells into which sewage enters, and is used for drinking without adequate storage or purification, the best possible opportunity is offered for a transfer of infection on a gigantic scale. The great epidemics of typhoid fever and cholera which used to sweep through European cities and more recently have continued to ravage American communities, bear eloquent testimony to this fact. With the cheap and effective methods of purifying water, by storage, filtration or disinfection, now at our disposal, there is no excuse for the delivery of a public water supply which is not absolutely safe. In uncivilized communities, which persist in using polluted supplies, and in the country where a local well is under suspicion, the householder may always, however, protect himself by using a Berkefeld or Pasteur filter, either of which types is efficient if properly cared for, or by boiling the water to be used for drinking.

Milk is second only to water as an agent in the transmission of disease. It is frequently infected with tubercle germs and sometimes with other pathogenic organisms from the cow. It is contaminated by dirt in the stable, and it is polluted at a dozen different points by the numerous individuals who handle it on its way through the dairy to the consumer. Furthermore, of all foods milk is the one which in some cases apparently permits an actual multiplication of disease germs and an increase instead of a diminution of virulence in transit. Epidemics of typhoid fever, diphtheria, scarlet fever and tonsilitis without number have been traced to milk, and to young children even the ordinary germs of decay in milk, aside from infection with specific diseases, are often fatal, as evidenced by the terrible toll of summer diarrhœa among infants, which is almost exclusively confined to those fed on cow's milk. Carefully protected milk, such as is certified by our medical societies, is of course much freer from danger than the ordinary product, but the history of epidemics which have affected the patrons of dairies where every possible precaution was taken shows that no raw milk can be considered a safe food. For infants, breast milk is the only proper nutriment, but for babies who can not possibly receive a mother's care, and for older children and adults, we have fortunately a simple and efficient protection in pasteurization. This process, which involves simply the heating of the milk to a temperature of 145° or thereabouts for a period of twenty minutes, represents the application of the saving grace of cookery to the food product which of all food products needs it most. Unlike scalding or boiling pasteurization does not alter the taste of milk, and one of the most effective ways of guarding the household against disease is to see that all milk which enters it is properly pasteurized. There is no more excuse for drinking raw cow's milk than for eating raw beef.

A third danger, but far less important than those inherent in water or milk, lies in the consumption of raw shellfish which have been grown, or more commonly fattened (swelled up and made to seem more plump by immersion for a time in brackish water), in tidal estuaries exposed to sewage pollution. Fortunately it appears that during the winter months oysters, at least, enter into a state of practical hibernation, closing their shells and taking in little water from outside. Under such conditions sewage bacteria, already present within the shell, soon die out and the oyster even when taken from polluted waters becomes a comparatively safe source of food. Most of the famous epidemics of typhoid fever caused by shellfish have occurred in the months from September to November, after the eating of raw shellfish begins and before hibernation has set in. The eating of raw or partially cooked shellfish (steamed clams, fried oysters, oyster stew) from unknown sources, particularly in the autumn months, is, however, a dangerous practise until the oyster industry is more thoroughly supervised than at present.

Finally, in connection with the transmission of disease by food, the danger of infection of any and all foods in the process of preparation should always be kept in view. If for example, sandwiches are prepared by a typhoid carrier, an epidemic is likely to result, as was the case recently in a town of Illinois. I have referred to Mary Mallon, our most famous American case of the carrier in the kitchen. After a brief incarceration by the New York City Health department, this woman was set free and she may now under another name be cooking for some one of the readers of this article. Not only water and milk and shellfish, but meats and vegetables and bread and forks and spoons and tumblers may be infected by a cook or a waitress who is a carrier, and many obscure cases of disease are traceable to this cause. The tragedy of such an occurrence was once personally brought home to me with keenness by the death of one of the most promising young sanitary engineers I have known—a student of mine at the Massachusetts Institute of Technology, who with many others was infected in a boarding house by a waitress who was nursing another servant ill with typhoid, in the intervals of her regular domestic duties. It is often impossible to prevent such catastrophes, but the danger should be kept in mind and all possible effort made to ascertain the health antecedents of those whom we take into our households.

The second of the common modes of disease transmission to which I have referred, spread by the agency of insects, is on the whole easier to control and in highly civilized communities is much less important than spread by articles of food. We must bring foods into our homes, and it is often hard to discriminate between the infected and the non-infected. Insects however can be entirely excluded from the household in cities, and may be kept under reasonable control even in the country. The most spectacular triumphs of modern sanitation have been achieved in the war against insect-borne disease and even before their sanitary importance was at all comprehended, rising standards of personal cleanliness, by the elimination of vermin, incidentally caused a marked reduction in diseases of this class. Our medieval ancestors with their rush strewn dining halls and their uncleansed bedding and clothing paid a heavy toll to the insect carriers of disease. Bubonic plague, the terrible Black Death of the Middle Ages, we know to be primarily a disease of the rat, commonly transmitted from rat to man and from man to man by the flea. Two great pandemics of this disease are recorded in history, one beginning in the sixth and the other in the eleventh century. In each case the pandemic started in Asia, spread to Constantinople and then through Europe, to almost all parts of the known world. At the height of the second great pandemic, in the fourteenth century, twenty-five million people—about one fourth of the population of Europe—were swept away and in the London plague year, immortalized by Defoe, 100,000 persons perished. A third great epidemic began in Hongkong in 1894 and again spread in India, killing 6,000,000 people between 1896 and 1907. Since that time infection has spread as far as Australia and Brazil. The rats in certain districts of England and the ground squirrels in California are known to be still infected with the plague bacillus. Yet no epidemics have occurred outside of Asia, simply because the rats and fleas which spread the disease are under control. If we lived in filth, as our forefathers did, there can be no doubt that we should be in the midst of a great world scourge of plague like that of the fourteenth century. So with typhus, or ship, or jail fever, which was one of the serious diseases of Europe and America a hundred years ago. It has now almost disappeared in western Europe and the United States, and its decrease was a mystery until it was shown that the germ is carried by the body louse. Personal cleanliness has automatically wiped out this disease, while typhoid fever, named from its supposed resemblance to typhus, and in olden times a malady of comparatively less importance, remains one of our grave sanitary problems.

The only household pest which still generally persists in city and country alike is the house-fly; and the public agitation against this insect has grown to such proportions in recent years that we may now look for substantial progress toward its elimination. The fly breeds in horse manure and other deposits of decomposing matter and it is always a carrier of filth, though only incidentally of disease. In paved and sewered cities there is little evidence that the fly is an important factor in disease transmission, but where human excreta are exposed, as in rural districts or cities with badly constructed privy vaults, the opportunity for flies to pick up the germs of typhoid fever and other diseases and carry them to food is so great that the danger becomes serious, particularly of course in the warm climates of our Southern States. During the Spanish War 142 out of every 1,000 of the men in our army camps contracted typhoid fever, and 15 out of every 1,000 died of it; and it was shown that the incidence of the disease was due mainly to careless disposal of excreta and consequent facilities for fly transmission. In Jacksonville, Fla., Richmond, Va., and other southern cities remarkable results in the reduction of typhoid and intestinal diseases have been attained by proper disposal of excreta and anti-fly campaigns. It is by no means a simple matter to control the multiplication of house-flies, but everything possible should be done, by trapping and by the cleaning up of possible breeding places, to reduce their numbers.

The transmission of typhoid fever by insects is, of course, only occasional and incidental, and even plague may at times assume a form in which it is spread directly from man to man by the discharges from the mouth. There is another class of diseases which are carried always and necessarily by insects, the germ passing through certain stages of its life history in man and others in the body of a particular insect host. The most important example in temperate climates is malaria. "Malaria," the bad air disease, was known to be somehow connected with night exhalations from swampy land and a large amount of curiously puzzling information about its prevalence was explained, only when it was shown fifteen years ago that it is transmitted by the bite of a particular mosquito which breeds in swampy pools and along the weed-grown margin of streams. It then became clear that marshlands did indeed cause malaria because their stagnant waters propagated the mosquitoes which carried the malaria germ from man to man. Malaria followed the turning up of the soil, not because emanations were set free in the process, but because digging produces pools of water which breed the insect hosts of the malarial microbe. The practical control of mosquitoes and the consequent elimination of malaria has been shown to be quite practicable, in temperate climates at least, by the drainage of marsh lands and the filling or oiling or stocking with fish of the smaller mosquito breeding pools.

The third mode of infection, by contact, the more or less direct transfer from person to person, is by far the most important factor in the spread of communicable disease in temperate climates. Malaria is our only important insect-borne disease. Typhoid may sometimes be spread by flies and often by water or milk—diphtheria and scarlet fever and tuberculosis and tonsilitis, sometimes by milk. On the other hand, diphtheria and scarlet fever and tuberculosis and, in cities with good water supplies, even typhoid fever, are all more commonly transmitted by contact than in any other way; and contact is practically the sole cause of smallpox, measles, epidemic cerebro-spinal meningitis, influenza, common colds and the venereal diseases. It is in the nose and throat, or on the hands of a human being, that disease germs generally enter our homes, and this sort of infection is obviously most difficult to detect and control. The child infected with measles yet showing no symptoms but those of a simple cold in the head, the person with a "little sore throat" which is the beginning of an attack of diphtheria, the friend who comes in with uncleansed hands to visit the cook after nursing a sister just put to bed with typhoid fever, the visitor who is "practically all over" whooping cough; these are the dangers against which it is so difficult to guard.

The term contact is a broad one and covers a wide variety of ways in which infective material may be spread from person to person. There are all degrees between such direct contact, as occurs when one person coughs over another person's hand, and the more remote infection carried by some object which has been recently handled; no absolute line can be drawn between what may be infective and what may not. If I handle an apple with infected hands and hand it to you and you eat it, we are dealing with clear and obvious contact. If I put it on the table and you find it and eat it an hour later, the connection is almost as direct, although some of the germs will probably be dead. If twenty-four elapses, most of the infection will be gone; if two weeks, practically all of it. Objects which are supposed to remain infective after a considerable period of time, are called fomites, and fomites' infection was once held to be an important factor in the spread of disease. The recent discoveries in regard to the rapid mortality of disease germs outside the body have made it clear, however, that objects are only dangerous when they have recently been exposed to fresh infection. The old stories of toys put away in a closet and causing scarlet fever after a lapse of several years are quite apocryphal. Such mysterious cases as were once explained in this fashion are now more reasonably attributed, and very often definitely traced, to direct contact with an unrecognized carrier case.

The danger of contact infection from such gross discharges as the sputum are sufficiently obvious. Material of quite as dangerous a nature is thrown out from the mouth as a fine spray in coughing, sneezing or loud speaking. Furthermore, it is a sad fact that cleanliness in a bacteriological sense is a very rare thing and the hands are usually more or less soiled with discharges from the nose and throat and too often from the intestines as well. Dr. C. V. Chapin, in his classic book, on "The Sources and Modes of Infection," has some striking paragraphs which, though not pleasant reading, must be pondered by all who would really understand how communicable disease is spread.

Probably the chief vehicle for the conveyance of nasal and oral secretions from one to another is the fingers. If one takes the trouble to watch for a short time his neighbors, or even himself, unless he has been particularly trained in such matters, he will be surprised to note the number of times that the fingers go to the mouth and the nose. Not only is the saliva made use of for a great variety of purposes, and numberless articles are for one reason or another placed in the mouth, but for no reason whatever, and all unconsciously, the fingers are with great frequency raised to the lips or the nose. Who can doubt that if the salivary glands secreted indigo the fingers would continually be stained a deep blue, and who can doubt that if the nasal and oral secretions contain the germs of disease these germs will be almost as constantly found upon the fingers? All successful commerce is reciprocal, and in this universal trade in human saliva the fingers not only bring foreign secretions to the mouth of their owner, but there exchanging them for his own, distribute the latter to everything that the hand touches. This happens not once but scores and hundreds of times during the day's round of the individual. The cook spreads his saliva on the muffins and rolls, the waitress infects the glasses and spoons, the moistened fingers of the peddler arrange his fruit, the thumb of the milkman is in his measure, the reader moistens the pages of his book, the conductor his transfer tickets, the "lady" the fingers of her glove. Every one is busily engaged in this distribution of saliva, so that the end of each day finds this secretion freely distributed on the doors, window sills, furniture and playthings in the home, the straps of trolley cars, the rails and counter and desks of shops and public buildings, and indeed upon everything that the hands of man touch. What avails it if the pathogens do die quickly? A fresh supply is furnished each day.

The control of contact transmission, the breaking of the chain of communication between the infected and the non-infected person, involves one or both of two measures. On the one hand, the spread of infective material from sick persons and carriers must be checked, so far as possible, and, on the other hand, the mouths of well persons must be guarded against infective material which, despite all our efforts, will to some extent be distributed in the world about us. The first half of this task involves the recognition of the sources of danger, and is of course greatly complicated by the presence of the unrecognized carriers. Much may be hoped, however, from the development of what may be called the sanitary conscience, the recognition on the part of each man, woman and child of the grave responsibility which he may incur by careless mingling with friends and neighbors when at the beginning or end of an attack of communicable disease. The isolation of even frank cases of the so-called mild diseases is still too often regarded as an unreasonable imposition by the uneducated (and the uneducated are by no means always those of the most limited incomes). We still hear "Every one must have measles and the children might as well have it as soon as possible." There has seldom been a more cruel superstition. The children's diseases, measles, scarlet fever and whooping cough are no light matter. Each one of them kills more victims than smallpox, and in many cities often more than typhoid fever. In New York City in 1912, there were two deaths from smallpox, 500 from typhoid, 671 from measles, 614 from scarlet fever and 187 from whooping cough. Furthermore, the seriousness of these maladies decreases directly with the age of a child, so that each year for which an attack may be postponed is so much gained. With the progress of health education in the public schools we may look for the day when the social crime of spreading communicable disease will be realized at its full value, so that it will be recognized as wanton recklessness, not courage, to continue business or social intercourse when "coming down," half-sick with some as yet undefined but impending disease, and no thoughtful person will hasten to mix with his fellows when possibly still a carrier after an attack. In all these diseases there are two factors, the invading germ and the more or less susceptible host, and even a common cold is often due less to poor vitality than to fresh and virulent infection. Some day, perhaps, responsibility may be felt for the reckless dissemination of even this supposedly mild disease, of which Dr. Rosenau well says in his recent work on "Preventive Medicine and Hygiene": "Could the sum total of suffering, inconvenience, sequelæ and economic loss resulting from common colds be obtained, it would at once promote these infections from the trivial into the rank of the serious diseases."

It is of course, not essential that "isolation" of an infected person should mean solitary incarceration within four walls. In the Middle Ages the only protection against disease was quarantine, which in its derivative meaning was forty days' detention of all persons, well or sick. coming from an infected port. With the progress of sanitary science preventive measures have become at the same time more efficient and less irksome. When ships from cholera countries came to our eastern seaports two years ago, only a detention of a day or so was necessary, pending a bacteriological examination of the passengers and detection of the few carriers among them. Isolation of individuals takes the place of quarantine against nations, and a practical isolation may often be effected by simple precautions against the transfer of discharges, without interference with human intercourse. Disease germs do not fly across a room to seize on their prey. They are carried by direct material contact of some sort, by the discharge of mouth spray, by hand shaking, by the use of common drinking cups and the like. The careful consumptive, who guards others from his sputum and mouth spray and infected utensils, is no menace to his family and friends.

The essential point is that the discharges of the patient and all objects soiled thereby should be freed from living germs before they infected others. This is no easy task, as you will realize if you seriously try to carry it out. The common cold offers an excellent opportunity for a practical study of the problem. The next time some member of your family has a cold in the head, try to prevent its spreading further, and you will be surprised to note in how many ways discharges may be interchanged. If we seriously wish to prevent the further spread of infection from a case of communicable disease, an elaborate series of precautions must be taken. The dishes and spoons and forks used by the patient should be kept separate until they have been boiled. Handkerchiefs, towels and bed linen must be treated in the same way. A special wash basin should be set aside for the patient and faucets should be handled by him, not with the hand just to be cleaned, but with the interposition of a bit of paper. The hands of those who touch the patient or touch objects he has recently handled should be at once washed with some simple disinfectant like eighty per cent. alcohol. The mouths of the patient and of those in attendance on him should be kept as free as possible from infection by frequent gargling with a mild antiseptic, such as a mixture of one part of hydrogen peroxide, two of listerine and six of water.

The recognition that objects which have been in immediate contact with sick persons or carriers are the important, and the only important, sources of danger, has quite revolutionized our older ideas of disinfection. As Dr. Chapin, the pioneer in this field has pointed out, the disinfection of the general air and the surfaces of a room by formaldehyde is a burning of incense to the false gods of pre-scientific sanitation. He describes the doctor who comes into the sick room, sits chatting on the bed, puts a spoon in the patient's mouth, then handles it by the infected end, leaves it on the table, deposits some of the material he has smeared on his hand on the door handle and the rest on the faucet as he turns it to wash his hands; and attempts to atone for his sanitary sins by placing a bowl of so-called chlorides (which have about the disinfectant action of tap water) under the bed, and at the end of the attack by performing the sacrificial rite of the formaldehyde candle. As a matter of fact, the prevention of contact infection during the illness with immediate disinfection of excreta, soiled linen and the like, is a thousand times more important than any terminal disinfection after death or recovery. At the end of the illness there will be left on woodwork or furniture only an insignificant number of living virulent germs. If any do persist, they may be removed by a cleaning-up with hot water, soap and elbow-grease far more effectively than by formaldehyde or any other disinfectant.

The attempt to prevent the discharges of the sick from being spread abroad can, of course, only be partially successful at best. Furthermore, besides the frank cases of disease there will always be the unrecognized and in some cases unrecognizable, carriers. We must invoke here our second line of defence, the protection of the portal of the mouth against the infective germs, always likely to be present about us. This means the cultivation of an instinct of discrimination which I call the aseptic sense, an instinct which automatically keeps out of the mouth everything not bacteriologically clean. I have a baby of five who a year ago when told to open a door said, "Why mother just touched that handle and her cold germs are on it." At the kindergarten the children hold each other's hands, pass objects from one to another, work with common modeling clay, and then eat their lunch. My little girl is the only one who washes her hands first and I believe nothing could make her omit that ceremony. There is no phobia in this, no dread of "germs," merely a habitual instinct, no more irksome than the habit of taking off one's hat when meeting a lady in the street.

Is it worth while to trouble ourselves with these things? Our fathers lived happily enough without bothering their heads about them. True enough, but our fathers' brothers and sisters died in great numbers because of their ignorance. To-day there are, each twenty-four hours, 200 death beds in the city of New York. If the death rate of twenty years ago had been maintained, there would be 130 more. A forty per cent. decrease in the death rate has already resulted from the advances of sanitary science. Yet there is still upon us a great burden of preventable disease and death. The large, easy things, the purification of public water supplies, the pasteurization of milk supplies, are being accomplished. The insididous spread of contact infection can only be checked by the conduct of life of the individual citizen, by the diffusion of knowledge in the home and the factory, and by the building upon that knowledge of daily habits of personal cleanliness, which shall banish contact infection, as the insect-borne plagues have been banished by our emergence from the grosser filth conditions of the Middle Ages. These fruits of the sanitary conscience, these applications of the aseptic sense, are little things, and therefore hard things; but they are fraught with the possibility of large results in human health and human happiness.

FACTS AND FACTORS OF DEVELOPMENT

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II. Development of the Mind

THE development of the mind parallels that of the body: whatever the ultimate relations of the mind and body may be, there can be no reasonable doubt that the two develop together from the germ. It is a curious fact that many people who are seriously disturbed by scientific teachings as to the evolution, or gradual development of the human race, accept with equanimity the universal observation as to the development of the human individual,—mind as well as body. The animal ancestry of the race is surely no more disturbing to philosophical and religious beliefs than the germinal origin of the individual, and yet the latter is a fact of universal observation which can not be relegated to the domain of hypothesis or theory, and which can not be successfully denied. If we admit the fact of the development of the entire individual, surely it matters little to our philosophical or religious beliefs to admit the development or evolution of the race.

The origin of the mind, or rather of the soul, is a topic upon which there has been much speculation by philosophers and theologians. One of the earliest hypotheses was that which is known as transmigration or metempsychosis. This doctrine probably reached its greatest development in ancient India, where it formed an important part of Buddhistic belief; it was also a part of the religion of ancient Egypt; it was embodied in the philosophies of Pythagoras and Plato. According to these teachings, the number of souls is a constant one; souls are neither made nor destroyed, but at birth a soul which had once tenanted another body enters into the new body. This doctrine was generally repudiated by the Fathers of the Christian Church. Jerome and others adopted the view that God creates a new soul for each body that is generated, and that every soul is thus a special divine creation. This has become the prevailing view of the Christian Church and is known as creationism, On the other hand Tertullian taught that souls of children are generated from the souls of parents as bodies are from bodies. This doctrine, which is known as traducianism, has been defended by certain modern theologians, but has been formally condemned by the Roman Catholic Church.

Traducianism undoubtedly comes nearer the scientific teachings as to the development of the mind than does either of the other doctrines named, but it is based upon the prevalent but erroneous belief that the bodies of the parents generate the body of the child, and that correspondingly the souls of the parents generate the soul of the child. Now we know that the child comes from germ cells which are not made by the bodies of the parents, but which have arisen by the division of antecedent germ cells. Every cell comes from a preexisting cell by a process of division, and every germ cell comes from a preexisting germ cell. Consequently it is not possible to hold that the body generates germ cells, nor that the soul generates souls. The only possible scientific position is that the mind (or soul) as well as the body develops from the germ.

No fact in human experience is more certain than that the mind develops by gradual and natural processes from a simple condition which can scarcely be called mind at all; no fact in human experience is fraught with greater practical and philosophical significance than this; and yet no fact is more generally disregarded. We know that the greatest men of the race were once babies, embryos, germ cells, and that the greatest minds in human history were once the minds of babies, embryos and germ cells, and yet this stupendous fact has had but little influence on our beliefs as to the nature of man and of mind. We rarely think of Plato and Aristotle, of Shakespeare and Newton, of Pasteur and Darwin, except in their full epiphany, and yet we know that when each of these was a child he "thought as a child and spake as a child," and when he was a germ cell he behaved as a germ cell.

The development of the mind from the activities of the germ cells is certainly most wonderful and mysterious, but probably no more so than the development of the complicated body of the adult animal from the structures of the germ. Both belong to the same order of phenomena and there is no more reason for supposing that the mind is supernaturally created than that the body is. Indeed, we know that the mind is formed by a process of development, and the stages of this development are fairly well known. There is nowhere in the entire course of mental development a sudden appearance of psychical process, but rather a gradual development of these from simpler and simpler beginnings. No detailed study has been made of the reactions of human germ cells and embryos, but there is every reason to believe that these reactions are simpler in the embryo and germ cell than in the infant, and they are generally similar to the reactions of the germ cells and embryos of other animals and to the behavior of many lower organisms.

A few years ago such a statement would have been branded as "materialism" and promptly rejected without examination by those who are frightened by names. But the general spread of the scientific spirit is shown not only by the growing regard for evidence, but also by the decreasing power of epithets. "Materialism," like many another ghost, fades away into thin air or at least loses many of its terrors, when closely scrutinized. But the statement that mind develops from the germ cells is not an affirmation of materialism, for while it identifies the origin of the entire individual, mind and body, with the development of the germ, it does not assert that "matter" is the cause of "mind" either in the germ or in the adult. It must not be forgotten that germ cells are living things and that we go no further in associating the beginnings of mind with the beginnings of body in the germ than we do in associating mind and body in the adult. It is just as materialistic to hold that the mind of the mature man is associated with his body as it is to hold that the beginnings of mind in the germ are associated with the beginnings of the body, and both of these tenets are incontrovertable.

It seems to me that the mind is related to the body as function is to structure; there are those who maintain that structure is the cause of function, that the real problem in evolution or development is the transformation of one structure into another, and that the functions which go with certain structures are merely incidental results; on the other hand are those who maintain that function is the cause of structure and that the problem of evolution or development is the change which takes place in functions and habits, these changes causing corresponding transformations of structure. Among adherents of the former view may be classed many morphologists and Neo-Darwinians, among proponents of the latter, many physiologists and Neo-Lamarckians. It seems to me that the defenders of each of these views fail to recognize the essential unity of the entire organism, structure as well as function; that neither of these is the cause of the other, though each may modify or condition the other, but that they are two aspects of one common thing, viz., organization. In the same way I think that the body or brain is not the cause of mind, nor mind the cause of body or brain, but that both are inherent in one common organization or individuality.

In asserting that the mind develops from the germ as the body does, no attempt is made to explain the fundamental properties of body or mind. As the structures of the body may be traced back to certain fundamental structures of the germ cell, so the characteristics of the mind may be traced back to certain fundamental properties and activities of the germ. Many of the psychical processes may be traced back in their development to properties of sensitivity, reflex motions, and persistence of the effects of stimuli. All organisms manifest these properties and for aught we know to the contrary they may be original and necessary characteristics of living things. In the simplest protoplasm we find organization, that is, structure and function, and in germinal protoplasm we find the elements of the mind as well as of the body, and the problem of the ultimate relation of the two is the same whether we consider the organism in its germinal or in its adult stage.

In some way the mind as well as the body develops out of the germ. What are the germinal bases of mind? What are the psychical *anlagen* in embryos and how do they develop? In this case, even more than in the development of the body, we are compelled to rely upon the comparison of human development with that of other animals, but the great principle of the oneness of life, as respects its fundamental processes, has never yet failed to hold true and will not fail us here. In the study of the psychical processes of organisms other than ourselves we are compelled to rely upon a study of their activities, their reactions to stimuli, since we can not approach the subject in any other way. The reactions and behavior of organisms under normal and experimental conditions give the only insight which we can get into their psychical processes—and this applies to men no less than to protozoa.

1. *Sensitivity.*—The most fundamental phenomenon in the behavior of organisms is irritability or sensitivity, which is the capacity of receiving and responding to stimuli: this is one of the fundamental properties of all protoplasm. But living matter is not equally sensitive to all stimuli, nor to all strengths of the same stimulus. Many of the simplest unicellular plants and animals show that they are differentially sensitive; they often move toward weak light and away from strong light, away from extremes of heat and cold, into certain chemical substances and away from others—in short, all organisms, even the simplest, may respond differently to different kinds of stimuli or to different degrees of the same stimulus. This is what is known as *differential sen-*

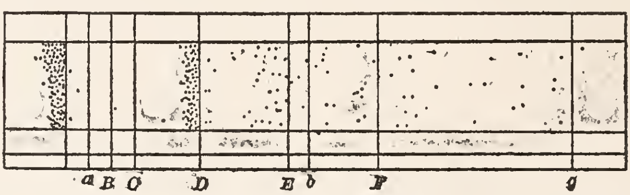

FIG. 17. DISTRIBUTION OF BACTERIA IN THE SPECTRUM. The largest group is in the ultra-red at the left; the next largest group is in the yellow-orange close to the line *D*. (From Jennings, after Engelmann.)

sitivity (Figs. 17, 18, 19.) On the other hand, many organisms respond in the same way to different stimuli and this may be taken to indicate generally that they are not differentially sensitive to such stimuli; it is not to be concluded that because organisms respond differently to certain stimuli they are therefore capable of distinguishing between all kinds of stimuli, for this is certainly not true. Even in adult men the capacity of distinguishing between different kinds of stimuli is far from perfect.

Egg cells and spermatozoa show this property of sensitivity. The egg is generally incapable of locomotion, and since the results of stimulation must usually be detected by movements it is not easy to determine to what extent the egg is sensitive; but though the egg lacks the power of locomotion, it possesses in a marked degree the power of intra-cellular movement of the cell contents. When a spermatozoon comes into contact with the surface of the egg the cortical protoplasm of the egg flows toward that point and may form a cone or protoplasmic prominence into which the sperm is received (Figs. 4, 5, *E C*). It is an interesting fact that the same sort of response follows when a frog's egg is pricked by a needle, thus showing that in this case the egg does not distinguish between the prick of the needle and that of the spermatozoon. The spermatozoon is usually a locomotor cell and it responds differently to certain stimuli, just as many bacteria and protozoa do; spermatozoa are strongly stimulated by weak alkalies and alcohol, they gather in certain chemical substances and not in others, they collect in great numbers around fertilizable egg cells, etc.

The movements of fertilized egg cells, cleavage cells, and early embryonic cells are usually limited to flowing movements within the

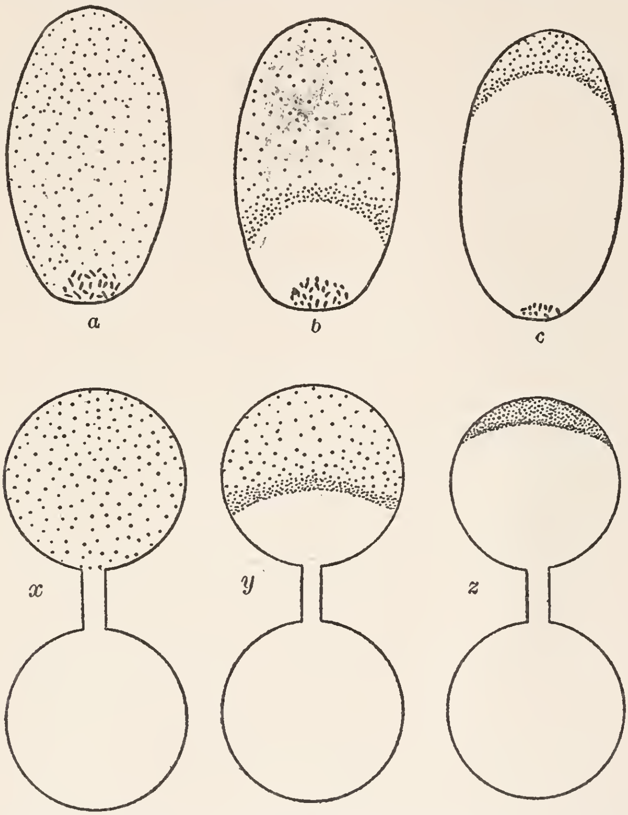

FIG. 18, *a, b, c.* REPULSION OF *Spirilla* BY COMMON SALT. *a*, condition immediately after adding crystals; *b* and *c*, later stages in the reaction.
x, y, z, repulsion of *Spirilla* by distilled water. The upper drop consists of sea-water containing *Spirilla*, the lower drop of distilled water. At *x* these have just been united by a narrow neck; at *y* and *z*, the bacteria have retreated before the distilled water. (From Jennings, after Massart.)

individual cells. These movements, which are of a complicated nature, are of the greatest significance in the differentiation of the egg into the embryo; they are caused chiefly by internal stimuli and by non-localized external ones. Modifications of the external stimuli often lead to modifications of these intra-cellular movements and to abnormal types of cleavage and development—in short, these movements show that the fertilized egg is differentially sensitive.

In the further course of development particular portions of the embryo become especially sensitive to some kinds of stimuli, while other portions become sensitive to others. In this way the different sense organs, each especially sensitive to one particular kind of stimulus, arise from the generalized sensitivity of the oosperm, and thus general sensitivity, which is a property of all protoplasm, becomes differential sensitivity and special senses in the process of embryonic differentiation. Such sensitivity is the basis of all psychic processes: sensations are the elements of the mind.

3. *Tropisms, Reflexes, Instincts.*—All the responses of germ cells, and of the simplest organisms, to stimuli are in the nature of tropisms or reflexes, that is, relatively simple, automatic responses. Such tropisms or reflexes are seen in the movements of bacteria, protozoa and

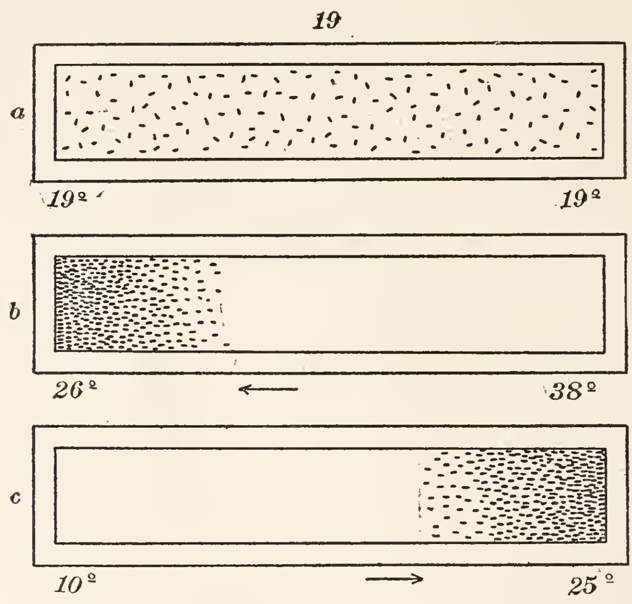

Fig. 19. Reactions of *Paramecium* to Heat and Cold. At *a* the infusoria are uniformly distributed in a trough, both ends of which have a temperature of 19°; at *b* the infusoria are shown collected at the cooler end of the trough; at *c* they have collected at the warmer end of the trough. (From Jennings, after Mendelssohn.)

many higher animals and plants as well as in movements of spermatozoa, the movements of the protoplasm in egg cells and embryonic cells, the movements of cells and cell masses in the formation of the gastrula, alimentary canal, nervous system and other organs. Indeed the entire process of development, whether accompanied by visible movements or not, may be regarded as a series of automatic responses to stimuli.

When the embryo becomes differentiated to such an extent as to have specialized organs for producing movement its capacity for making responsive movements to stimuli becomes much increased. If the responses of animals and plants to stimuli are of such a sort that the organism turns or moves toward or away from a source of stimulus they are termed tropisms; if the responses are very complicated, one response calling forth another and involving many reflexes, as is frequently the case in animals, they are known as instincts. In the embryo the rhythmic contractions of heart, amnion and intestine are early manifestations of reflex motions. These appear chiefly in the involuntary muscles before nervous connections are formed, the protoplasm of the muscle cells probably responding directly to the chemical stimulus of certain salts in the body fluids, as Loeb has shown. Reflexes which appear later are the random movements of the voluntary muscles of limbs and body, which are called forth by nerve impulses. Tropisms are manifested only by organisms capable of considerable free movement and hence are absent in the foetus though present in many free living larvæ. Some instincts are present immediately after birth, such as the instinct of sucking or crying, though these are so simple when compared with some instincts which develop later that they might be classed as reflexes; it is doubtful whether any of the activities before birth could properly be designated as instincts. Reflexes, tropisms and instincts have had a phylogenetic as well as an ontogenetic origin, and consequently we might expect that they would in general make for the preservation of the species, and as a matter of fact we usually find that they are remarkably adapted to this end. For instance the instincts of the human infant to grasp objects, to suck things which it can get into its mouth, to cry when in pain, are complicated reflexes which have survived in the course of evolution probably because they serve a useful purpose.

Very much has been written on the nature and origin of instincts, but the best available evidence strongly favors the view that instincts are complex reflexes, which, like the structures of an organism, have been built up, both ontogenetically and phylogenetically, under the stress of the elimination of the unfit, so that they are usually adaptive.

3. *Memory.*—Another general characteristic of protoplasm is the capacity of storing up or registering the effects of previous stimuli. A single stimulus may produce changes in an organism which persist for a longer or shorter time, and if a second stimulus occurs while the effect of a previous one still persists, the response to the second stimulus may be very different from that to the first. Macfarlane found that if the sensitive hairs on the leaf of *Dionea,* the Venus fly-trap (Fig. 20, *SH*), be stroked once, no visible response is called forth, but if they be stroked a second time within three minutes the leaf instantly closes. If a longer period than three minutes elapses after the first stimulus and before the second no visible response follows, *i. e.,* two successive stimuli are neces-

sary to cause the leaves to close, and the two must not be more than three minutes apart; the effects of the first stimulus are in some way stored or registered in the leaf for this brief time. This kind of phenomenon is widespread among living things and is known as "summation of stimuli." In all such cases the effects of a former stimulus are in some way stored up for a longer or shorter time in the protoplasm. It is possible that this is the result of the formation of some chemical substance which remains in the protoplasm for a certain time, during which time the ef-

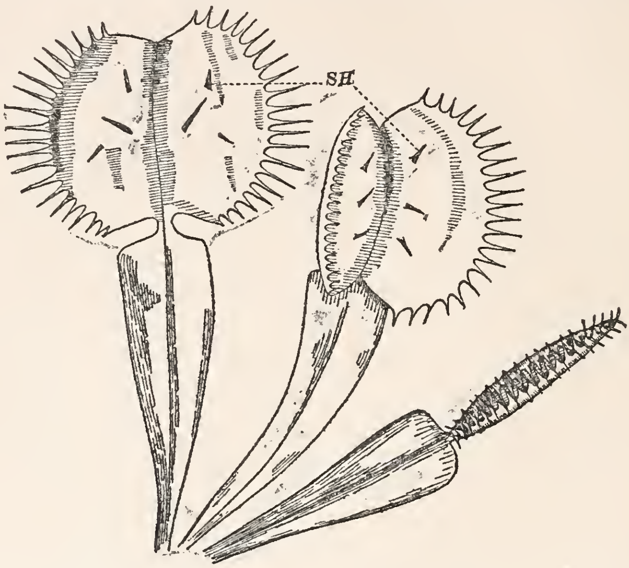

Fig. 20. *Dionæa muscipula* (Venus' Flytrap). Three leaves showing marginal teeth and sensitive hairs (*SH*). The leaf at the left is fully expanded, the one at the right is closed.

fects of the stimulus are said to persist, or it may be due to some physical change in the protoplasm analogous to the "set" in metals which have been subjected to mechanical strain.

Probably of a similar character is the persistence of the effects of repeated stimuli and responses on any organ of a higher animal. A muscle which has contracted many times in a definite way ultimately becomes "trained" so that it responds more rapidly and more accurately than an untrained muscle; and the nervous mechanism through which the stimulus is transmitted also becomes trained in the same way. Indeed such training is probably chiefly a training of the nervous mechanism. The skill of the pianist, of the tennis player, of the person who has learned the difficult art of standing or walking, or the still more difficult art of talking, is probably due to the persistence in muscles and nerves of the effects of many previous activities. All such phenomena were called by Hering, "organic memory," to indicate that this persistence of the effects of previous activities in muscles and other organs is akin to that persistence of the effects of previous experiences in the nervous mechanism which we commonly call memory. It seems probable that this ability of protoplasm in general to preserve for a time the effects of former stimuli is fundamentally of the same nature as the much greater power of nerve cells to preserve such effects for much longer periods and in complex associations, a faculty which is known as associative memory. The embryos, and indeed even the germ cells of higher animals, may safely be assumed to be endowed with protoplasmic and organic memory, out of which, in all probability, develop associative and conscious memory in the mature organism.

4. *Intellect, Reason.*—Even the intellect and reason which so strongly characterize man have had a development from relatively simple beginnings. All children come gradually to an age of intelligence and reason. In its simpler forms at least reason may be defined as the power of predicting future events and of reaching conclusions regarding unexperienced phenomena under the influence of past experience. In the absence of individual experience young children have none of this power, but it comes gradually as a result of remembering past experiences and of fitting such experiences into new conditions. Young infants and many lower animals lack the power of reason, though their behavior is frequently of such a sort as to suggest that they are reasoning. Even the lowest animals avoid injurious substances and conditions and find beneficial ones; more complex animals learn to move objects, solve problems, and find their way through labyrinths in the shortest and most economical way; but this apparently intelligent and purposive behavior has been shown to be due to the general elimination of all sorts of useless activities, and to the persistence of the useful ones.

The ciliated infusorian, *Paramecium,* moves by the beating of cilia which are arranged in such a way that they drive the animal forward in a spiral course. However, when it is strongly irritated, the normal forward movement is reversed; the cilia beat forward instead of backward and the animal is driven backward for some distance (Figs. 21, 1, 2, 3); it then stands nearly still merely rolling over and swerving toward the aboral side and finally it goes ahead again, usually on a new course (Fig. 21, 3, 4, 5, 6). These movements seem to be conditioned rather rigidly by the organization of the animal: they are more or less fixed and mechanical in character though to a certain extent they may be modified by experience or physiological states. *Paramecium* behaves as it does in virtue of its constitution, just as an egg develops in a particular way because of its particular organization.

But although limited in its behavior to these relatively simple motor reactions, *Paramecium* does many things which seem to show intelligence and purpose. It avoids many injurious substances, such as strong salts or acids and it collects in non-injurious or beneficial substances, such as weak acids, masses of bacteria upon which it feeds, etc. It avoids extremes of heat and cold and if one end of a dish containing paramecia is heated and the other end is cooled by ice, the paramecia collect in the region somewhere between these two extremes (Fig. 19). Jennings, by studying carefully the behavior of single individuals, established the fact that this apparently intelligent action is due to differential sensitivity and to the single motor reaction of the animal. If in the course of its swimming a *Paramecium* comes into contact with an irritating substance or condition, it backs a short distance, swerves toward its aboral side, and goes ahead in a new path; if it again comes in contact with the irri-

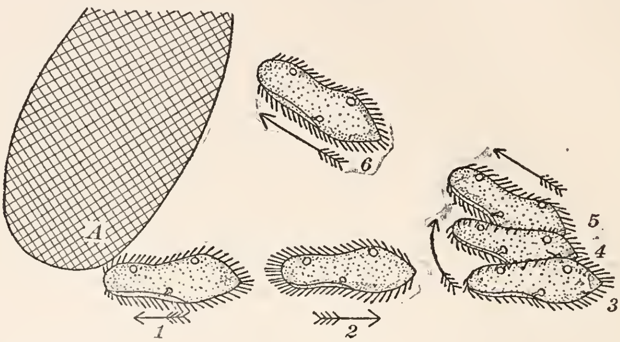

FIG. 21. DIAGRAM OF THE AVOIDING REACTION OF *Paramecium*. *A* is a solid object or other source of stimulation. *1–6*, successive positions occupied by the animal. The rotation on the long axis is not shown. (After Jennings.)

tating conditions this reaction is repeated, and so on indefinitely until finally a path is found in which the source of irritation is avoided altogether. In short, *Paramecium* continually tries its environment, and backs away from irritating substances or conditions. Its apparently intelligent reactions are thus explained as due to a process of "trial and error."[2]

The behavior of worms, star-fishes, crustaceans, mollusks, as well as of fishes, frogs, reptiles, birds and mammals, have been studied and in all cases it is found that their method of responding to stimuli is not at first really purposive and intelligent but by the gradual elimination of useless responses and the preservation (or remembering) of useful ones the behavior may come to be purposive and intelligent.

Thorndike found that when dogs, cats and monkeys were confined

[3] In *Paramœcium*, there is certainly no consciousness of trial and error, and probably no unconscious attempt on the part of the animal to attain certain ends. Its responses are reflexes or tropisms, which are determined by the nature of the animal, and the character of the stimulus. The fact that these responses are in the main self-preservative is due to the teleological organization of Paramœcium which has been evolved, according to current opinion, as the result of long ages of the elimination of the unfit. If, in the opinion of any one, the expression "trial and error" necessarily involves a striving after ends, it would be advisable to replace it in this case by some such term as "useful or adaptive reactions."

in cages which could be opened from the inside by turning a button, or pressing upon a lever, or pulling a cord, they at first clawed around all sides of the cage until by chance they happened to operate the mechanism which opened the door. Thereafter they gradually learned by experience, that is, by trial and error, and finally by trial and success, just where and how to claw in order to get out at once. When a dog has learned to turn a button at once and open a door we say he is intelligent, and if he can learn to apply his knowledge of any particular cage to other and different cages, a thing which Thorndike denies, we should be justified in saying that he reasons, though in this case intelligence and reason are founded upon memory of many past experiences, of many trials and errors and of a few trials and successes.

There is every evidence that human beings arrive at intelligence and reason by the same process, a process of many trials and errors and a few trials and successes, a remembering of these past experiences and an application of them to new conditions. A baby grasps for things which are out of its reach, until it has learned by experience to appreciate distances; it tests all sorts of pleasant and unpleasant things until it has learned to avoid the latter and seek the former; it experiments with its own body until it has learned what it can do and what it can not do. Is not this learning by experience akin to the same process in the dog and more remotely to the trial and error of the earthworm or the adaptive reflexes of *Paramecium?* Is not intelligence and reason in all of us, and upon all subjects, based upon the same processes of trial and error, memory of past experiences and application of this to new conditions? Surely this is true in all experimental and scientific work. Indeed the scientific method is the method of trial and error, and finally trial and success—the method recommended by St. Paul to "try all things and hold fast that which is good."

In *Paramecium* the reflex type of behavior is relatively complete; there is no associative memory and no ability to learn by experience. In the earthworm associative memory is but slightly developed and the animal learns but little by experience and can make no application of past experiences to new conditions. In the dog associative memory is well developed; the animal learns by experience and can, to a limited extent, apply such memory of past experiences to new conditions. In adult man all of these processes are fully developed and particularly the last, viz., the ability to reason. But in his development the human individual passes through the more primitive stages of intelligence, represented by the lower animals named; the germ cells and embryo represent only the stages of reflex behavior, to these trial and error and associative memory are added in the infant and young child, and to these the application of past experience to new conditions, or reason, is added in later years.

5. *Will.*—Another characteristic, which many persons regard as the supreme psychical faculty, is the will. This faculty also undergoes de-

velopment and from relatively simple beginnings. The will of the child has developed out of something which is far less perfect in the infant and embryo than in the child. Observations and experiments on lower animals and on human beings, as well as introspective study of our own activities, appear to justify the following conclusions:

(1.) Every activity of an organism is a response to one or more stimuli, external or internal in origin. These stimuli are in the main, if not entirely, energy changes outside or inside the organism. In lower organisms as well as in the germ cells and embryos of higher animals the possible number of responses are few and prescribed owing to their relative simplicity, and the response follows the stimulus directly. In more complex organisms the number of possible responses to a stimulus is greatly increased, and the visible response may be the end of a long series of internal changes which are started by the original stimulus.

(2.) The response to a stimulus may be modified or inhibited in the following ways:

(*a*) Through conflicting stimuli and changed physiological states (due to fatigue, hunger, etc.). Many stimuli may reach the organism at the same time and if they conflict they may nullify one another or the organism may respond to the strongest stimulus and disregard the weaker ones. When an organism has begun to respond to one stimulus it is not easily diverted to another. Jennings found that the attached infusorian, *Stentor,* which usually responds to strong stimuli by closing up, may, when repeatedly stimulated, loosen its attachment and swim away, thus responding in a wholly new manner when its physiological state has been changed by repeated stimuli and responses. Whitman found that leeches of the genus *Clepsine* prefer shade to bright light, and other things being equal they always seek the under sides of stones and shaded places; but if a turtle from which they normally suck blood is put into an aquarium with the leeches, they at once leave the shade and attach themselves to the turtle. They prefer shade to bright light but they prefer their food to the shade. The tendency to remain concealed is inhibited by the stronger stimulus of hunger. On the other hand he found that the salamander, *Necturus,* is so timid that it will not take food, even though starving, until by gradual stages and gentle treatment its timidity can be overcome to a certain extent. Here fear is at first a stronger stimulus than hunger and unless the stimulus of fear can be reduced the animal will starve to death in the presence of the most tempting food.

(*b*) Responses may also be modified through compulsory limitation of many possible responses to a particular one, and the consequent formation of a habit. This is the method of education employed in training all sorts of animals. Thus Jennings found that a starfish could be trained to turn itself over, when placed on its back, by means of one particular arm simply by persistently preventing the use of the other arms. Many responses of organisms are modified in a similar way, not only by artificial limitations, but also by natural ones.

(*c*) Responses which have become fixed and constant through natural selection or other means of limitation may become more varied and general when the compulsory limitation is relaxed. Behavior in the former case is fixed and instinctive, in the latter more varied and plastic. Thus Whitman found that the behavior of domesticated pigeons is more variable and their instincts less rigidly fixed than in wild species. If the eggs are removed to a little distance from the nest the wild passenger pigeon returns to the nest and sits down as if nothing had happened. She soon finds out, not by sight but by feeling, that something is missing, and she leaves the nest after a few minutes without heeding the eggs. The ring-neck pigeon also misses the eggs and sometimes rolls one of them back into the nest, but never attempts to recover more than one. The dove-cote pigeon generally tries to recover both eggs.

In these three grades the advance is from extreme blind uniformity of action, with little or no choice, to a stage of less rigid uniformity. . . . Under conditions of domestication the action of natural selection has been relaxed, with the result that the rigor of instinctive coordination, which bars alternative action, is more or less reduced. Not only is the door to choice thus unlocked, but more varied opportunities and provocations arise, and thus the internal mechanism and the external conditions and stimuli work both in the same direction to favor greater freedom of action. When choice thus enters no new factor is introduced. There is greater plasticity within and more provocation without, and hence the same bird, without the addition or loss of a single nerve cell, becomes capable of higher action and is encouraged and even constrained by circumstances to learn to use its privileges of choice. Choice, as I conceive it, is not introduced as a little deity encapsuled in the brain. . . . But increased plasticity invites greater interaction of stimuli and gives more even chances for conflicting impulses.

(*d*) Finally in all animals behavior is modified though previous experience, just as structure is also. Where several responses to a stimulus are possible and where experience has taught that one response is more satisfactory than another, action may be limited to this particular response, not by external compulsion, but by the internal impulse of experience and intelligence. This is what we know as conscious choice or will. Whitman says:

Choice runs on blindly at first and ceases to be blind only in proportion as the animal learns through nature's system of compulsory education. The teleological alterations are organically provided; one is taken and fails to give satisfaction; another is tried and gives contentment. This little freedom is the dawning grace of a new dispensation, in which education by experience comes in as an amelioration of the law of elimination. . . . Intelligence implies varying degrees of freedom of choice, but never complete emancipation from automatism.

Freedom of action does not mean action without stimuli, but rather the introduction of the results of experience and intelligence as additional stimuli. The activities, which in lower animals are "cabined, cribbed, confined," reach in man their fullest and freest expression; but the enormous difference between the relatively fixed behavior of a protozoan or a germ cell and the relatively free activities of a mature man is bridged not only in the process of evolution, but also in the course of individual development.

6. *Consciousness.*—The most complex of all psychic phenomena, indeed the one which includes many if not all of the others, is consciousness. Like every other psychic process this has undergone development in each of us; we not only came out of a state of unconsciousness, but through several years we were gradually acquiring consciousness by a process of development. Whether consciousness is the sum of all the psychic faculties, or is a new product dependent upon the interaction of the other faculties, it must pass through many stages in the course of its development, stages which would commonly be counted as unconscious or subconscious states, and complete consciousness must depend upon the complete development and activity of the other faculties, particularly associative memory and intelligence. The question is sometimes asked whether germ cells, and indeed all living things, may not be conscious in some vague manner. One might as well ask whether water is present in hydrogen and oxygen. Doubtless the elements out of which consciousness develops are present in the germ cells, in the same sense that the elements of the other psychic processes or of the organs of the body are there present—not as a miniature of the adult condition, but rather in the form of elements or factors, which by a long series of combinations and transformations, due to interactions with one another and with the environment, give rise to the fully developed condition.

Finally there seems good reason for believing that the continuity of consciousness, the continuing sense of identity, is associated with the continuity of material substance, for in spite of frequent changes of the materials of which we are composed our sense of identity remains undisturbed. However, the continuity of protoplasmic and cellular organization generally remains undisturbed throughout life, and the continuity of consciousness is associated with this continuity of organization, especially in certain parts of the brain. It is an interesting fact that in man and in several other animals which may be assumed to have a sense of identity, the nerve cells, especially those of the brain, cease dividing at an early age, and these identical cells persist throughout the remainder of life. If nerve cells continued to divide throughout life, as epithelial cells do, there would be no such persistence of identical cells, and one is free to speculate that in such cases there would be no persistence of the sense of identity.

Organization includes both structure and function, and continuity of organization implies not only persistence of protoplasmic and cellular structures, but also persistence of functions, of sensitivity, reflexes, memory, instincts, intelligence and will; the continuity of consciousness is associated with the continuity of these activities, as well as with the structures of the body in general and of the brain in particular. It is well known that things which interrupt or destroy these functions or structures interrupt or destroy consciousness. Lack of oxygen, anesthetics, normal sleep cause in some way a temporary interruption of these functions and consequently temporary loss of consciousness; while certain injuries or diseases of the brain which bring about the destruction of certain centers or association tracts may cause permanent loss of consciousness.

The development of all of these psychical faculties runs parallel with the development of bodily structures and apparently the method of development in the two cases is similar, viz., progressive differentiation of complex and specialized structures and functions from relatively simple and generalized beginnings. Indeed the entire organism—structure and function body and mind—is a unity, and the only justification for dealing with these constituents of the organism as if they were separate entities, whether they be regarded in their adult condition or in the course of their development, is to be found in the increased convenience and effectiveness of such separate treatment.

Development, like many other vital phenomena, may be considered from several different points of view, such as (1) physico-chemical events involved, (2) physiological processes, (3) morphological characters, (4) ecological correlations and adaptations, (5) psychological phenomena, (6) social and moral developments. All of these phases of development are correlated, indeed they are parts of one general process, and a complete account of this process must include them all. General considerations may lead us to the belief that each of the succeeding aspects of development named above may be causally explained in terms of the preceding ones, and hence all be reducible to physics and chemistry. But this is not now demonstrable and may not be true. Function and structure may be related causally, or they may be two aspects of one substance. The same is true of body and mind or of matter and energy. But even if each of these different phases in the development of personality may not be causally explained by the preceding ones, at least the principle of explanation employed for any aspect of development ought to be consistent and harmonious with that employed for any other aspect.

The phenomena of mental development in man and other animals may be summarized in the following table:

Development of Psychical Processes in Ontogeny and Phylogeny

All Living Things, including Germ Cells and Embryos, show:	Mature Forms of Higher Animals show:
1. *Differential Sensitivity* = Different Responses to Stimuli differing in Kind or Quantity.	1. *Special Senses and Sensations* = Sensations are the Elements of Mind.

2. *Reflex Motions* =
   Relatively Simple, Automatic Responses.
3. *Organic Memory* =
   Results of Previous Experience registered in General Protoplasm.
4. *Adaptive Responses* =
   Results of Elimination of Useless Responses through Trial and Error.
5. *Varied Responses*
   Dependent upon Conflicting Stimuli and Physiological States.
6. *Identity* =
   Continuity of Individual Organization.

2. *Instincts (Inherited), Habits (Acquired)* =
   Complex Reflexes, involving Nerve Centers.
3. *Associative Memory* =
   Results of Experience registered in Nerve Centers and Association Tracts.
4. *Intelligence, Reason* =
   Results of Trial and Error plus Associative Memory, *i. e.* Experience.
5. *Inhibition, Choice, Will*
   Dependent upon Associative Memory, Intelligence, Reason.
6. *Consciousness* =
   Continuity of Memory, Intelligence, Reason, Will.

Factors of Development

These are some of the facts of development—a very incomplete résumé of some of the stages through which a human being passes in the course of his development from the germ. What are the factors of development? By what processes is it possible to derive from a relatively simple germ cell the complexities of an adult animal? How can mind and consciousness develop out of the relatively simple psychical elements of the germ? These are some of the great problems of development—the greatest and most far-reaching theme which has ever occupied the minds of men.

Preformation.—When the mind is once lost in the mystery of this ever recurring miracle it is not surprising to find that there have been those who have refused to believe it possible and who have practically denied development altogether. The old doctrine of "evolution" as it was called by the scientists of the eighteenth century, or of preformation as we know it to-day held that all the organs or parts of the adult were present in the germ in a minute and transparent condition as the leaves and stem are present in a bud, or as the shoot and root of the little plant are present in the seed.[3] In the case of animals it was generally impossible to see the parts of the future animal in the germ, but this was supposed to be due to the smaller size of the parts and to their greater transparency, and with poor microscopes and good imagination some observers thought they could see the little animals in the egg or sperm, and even the little man, or "homunculus," was described and figured as folded up in one or the other of the sex cells.

[4] The little plant in the seed is itself the product of the development of a single cell, the ovule, in which no trace of a plant is present, but of course this fact was not known until after careful microscopical studies had been made of the earliest stages of development.

This doctrine of preformation was not only an attempt to solve the mystery of development, but it was also an attempt to avoid the theological difficulties supposed to be involved in the view that individuals are produced by a process of gradual development rather than by supernatural creation. If every individual of the race existed within the germ cells of the first parents, then in the creation of the first parents the entire race with its millions of individuals was created at once. Thus arose the theory of "emboitement," or "box in box," the absurdities of which contributed to the downfall of the entire doctrine of preformation, which, in the form in which it was held by many naturalists of the eighteenth century, is now only a curiosity of biological literature.

Epigenesis.—As opposed to this doctrine of preformation, which was founded largely on speculation, arose the theory of epigenesis, which was in its main features founded upon the direct observation of development, and which maintained that the germ contains none of the adult parts, but that it is absolutely simple and undifferentiated, and that from these simple beginnings the individual gradually becomes complex by a process of differentiation. We owe the theory of epigenesis, at least so far as its main features are concerned, to William Harvey, the discoverer of the circulation of the blood, and to Caspar Friederich Wolff, whose doctor's thesis published in 1759, and entitled "Theoria Generationis," marked the beginning of a great epoch in the study of development. Wolff demonstrated that adult parts are not present in the germ, either in animals or in plants, but that these parts gradually appear in the process of development. He held, erroneously, that the germ is absolutely simple, homogeneous and undifferentiated, and that differentiation and organization gradually appear in this undifferentiated substance. How to get differentiations out of non-differentiated material, heterogeneity out of homogeneity, was the great problem which confronted Wolff and his followers, and they were compelled to assume some extrinsic or environmental force, some *vis formativia* or *spiritus rector,* which could set in motion and direct the process of development.

The doctrine of preformation, by locating in the germ all the parts which would ever arise from it, practically denied development altogether; epigenesis recognized the fact of development, but attributed it to mysterious and purely hypothetical external forces; the one placed all emphasis upon the germ and its structures, the other upon outside forces and conditions.

Preformation and Epigenesis.—Modern students of development recognize that neither of these extreme views are true—adult parts are not present in the germ, nor is the latter homogeneous—but there are in germ cells many different structures and functions which are, however, very unlike those of the adult, and by the transformation and differentiation of this germinal organization the complicated organization of the adult arises. Development is not the unfolding of an infolded organism, nor the mere sorting of materials already present in the germ cells, though this does take place, but rather it consists in the formation of new materials and qualities—of new structures and functions—by the combination and interaction of the germinal elements present in the oosperm. In similar manner the combination and interaction of chemical elements yield new substances and qualities which are not to be observed in the elements themselves. Such new substances and qualities, whether in the organic or in the inorganic world, do not arise by the gradual unfolding of what was present from the beginning, but they are produced by a process of "creative synthesis."

Modern studies of germ cells have shown that they are much more complex than was formerly believed to be the case; they may even contain different "organ-forming substances" which in the course of development give rise to particular organs; these substances may be so placed in the egg as to foreshadow the polarity, symmetry and pattern of the embryo, but even the most highly organized egg is relatively simple as compared with the animal into which it ultimately develops. Increasing complexity, which is the essence of development, is caused by the combination and interaction of germinal substances under the influence of the environment. The organization of the oosperm may be compared to the arrangement of tubes and flasks in a complicated chemical operation; they stand in a definite relation to one another and each contains specific substances. The final result of the operation depends not merely upon the substances used, nor merely upon the way in which the apparatus is set up, but upon both of these things, as well as upon the environmental conditions represented by temperature, pressure, moisture or other extrinsic factors.

Heredity and Environment.—Unquestionably the factors, or causes, of development are to be found not merely in the germ but, also in the environment, not only in intrinsic but also in extrinsic forces; but it is equally certain that the directing and guiding factors of development are in the main intrinsic, and are present in the organization of the germ cells, while the environmental factors exercise chiefly a stimulating, inhibiting or modifying influence on development. In the same dish and under similar environmental conditions, one egg will develop into a worm, another into a sea urchin, another into a fish, and it is certain that the different fate of each egg is determined by conditions intrinsic in the egg itself, rather than by environmental conditions. We should look upon the germ as a living thing, and upon development as one of its functions. Just as the character of any function is determined by the organism, though it may be modified by environment, so the character of development is determined by heredity, *i. e.*, by the organization of the germ cells, though the course and results of development may be modified by environmental conditions.

Summary

In conclusion, we have briefly reviewed in this lecture the well known fact that every living thing in the world has come into existence by a process of development; that the entire human personality, mind as well as body, has thus arisen; and that the factors of development may be classified as intrinsic in the organization of the germ cell, and extrinsic as represented in environmental forces and conditions. The intrinsic factors are those which are commonly called heredity, and they direct and guide development in the main; the extrinsic or environmental factors furnish the conditions in which development takes place and modify, more or less, its course.

WASTE IN ELEMENTARY AND SECONDARY EDUCATION

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THE test of efficiency is being applied to every form of organized activity. Methods of procedure in commerce, manufacture and government are being studied to discover the causes of waste and on the basis of these studies new methods are being devised to eliminate waste in time and effort. The same tests are being applied to our religious, philanthropic and educational organizations. A typical illustration is seen in the investigation made by the Bureau of Municipal Expenditures for the public schools of the city of New York. Another illustration in the field of higher education is afforded by the state of Kansas in which a commission has recently been appointed to study the efficiency of the various institutions of the state with a view to such a reorganization as will avoid the waste involved in the present duplication of equipment and instruction. Similar tests are being made in other school systems and in single institutions. But all of these, though most significant, represent somewhat isolated and local conditions.

At the same time, however, the efficiency of our entire system of elementary and secondary schools is being called in question. A committee of the department of superintendents of the National Education Association on Economy of Time in Elementary and Secondary Education appointed in 1911 is investigating the problem. Their preliminary reports indicate that a thorough study of the situation is being made which may be expected to form the basis for important changes.

The history of education in this country shows that our system of organization, assigning eight years to elementary, four years to secondary, and four years to collegiate education, was not based on any rational theory, but was rather the result of accident. Each type sprang up in a large measure independently of the others, in response to distinct social demands, and a satisfactory adjustment of these independent parts to the needs of a coherent and efficient system of education has not yet been made.

In no other country is a similar organization found. Germany may be cited as typical with three years devoted to elementary, nine years to secondary, and four years to university education. The American college with two years of secondary work and two years of university work is unique. It is a significant fact that the Japanese, who have shown wonderful skill in selecting and adapting to their needs the best in western civilization, have modeled their new school system, not upon ours, but upon that of European countries. While there is a presumption in favor of the majority, the ultimate test to be applied to these differing types of organization is that of efficiency.

It is difficult to apply exact scientific comparisons to educational systems in countries with different social conditions. The age test is the most obvious to be applied. In a bulletin of the U. S. Bureau of Education on the "Age and Grade Census of Schools and Colleges," Strayer has shown that in ninety-three colleges having more than one hundred students each, the average age of graduation is about twenty-three years. Statistics of ages of graduation from medical schools confirms this figure. The average age[1] of medical candidates in 1912 at the following institutions was: Western Reserve, 27.9; Harvard, 27.2; Rush, 27; California, 27; Johns Hopkins, 26.4; Cornell, 26.4. The average age of students graduating in medicine at these institutions in 1912 was thus about 27 years. As a collegiate degree is required for admission to the medical schools at Western Reserve, Harvard and Johns Hopkins, it appears that medical students in these institutions completed their college courses at about the age of twenty-three. In a recent bulletin of the Bureau of Education, the age at which students complete the course in medicine is given as follows: France, 23; Germany, 23; Great Britain, 23; Netherlands, 24; Switzerland, 23; United States, 26. There is then a difference of at least two years in the ages at which physicians are ready to enter upon active practise in this and European countries. Counting twenty-three years as the average age for completing the college course, the average age of students entering college in this country is seen to be about nineteen years, which, in the absence of more exact knowledge, may be assumed as about the average of graduation from high school. The average age of graduation from the German gymnasium is about nineteen. The gymnasium course is generally regarded as equal in content to our high-school course plus two years of our college course. With this assumption, it will be seen that at the close of the period of secondary education our youth are about two years behind those of Germany. While it is not possible to test for purposes of exact comparison the training received by the graduates of our high schools with that of the German student with two years of his gymnasium course still before him, it is probably not far from the truth to say that not merely in relative time, but also in actual intellectual training, our high school graduates are two years behind those at the corresponding period in the German schools.

Now from the point of view of efficiency this apparent waste of two years is a matter of prime importance. What are the causes of waste? Where does it occur? How may it be checked? These are questions of great educational significance.

[1] Harry Pratt Judson, "Waste in Education Curricula," *School Review*, Vol. 20, page 435.

Of first importance among the causes of waste is the lack of coordination between the separate parts of our organization. Until recently the requirements which the college has made upon the high school have not been based upon any comprehensive view of the increasing scope and of the methods of secondary education. College courses have not been built upon the work of the high school. College instructors have failed to utilize some of the training which the student has received, and have complained loudly over the lack of what they have assumed a high school ought to give. An attitude of superior wisdom has furnished a cloak by which college instructors have concealed their ignorance of educational theory and practise. But with the changed attitude on the part of the high-school teachers from that of complaisant acquiescence to college domination to one of bumptious officiousness, we have suddenly come upon a situation that is full of promise for increased efficiency through better understanding. A new and strange spectacle in educational history was presented last year when the University of Chicago invited secondary-school teachers to visit its class-rooms for a period of several weeks, and based a two days' series of departmental and general conferences upon a critical discussion by these teachers of the methods of the university class-rooms. Another important step is being taken this year in the visitation by junior college instructors of high-school classes in Chicago and near-by towns, not in a perfunctory manner for an hour or two, but for successive days. It is safe to say that we shall soon be able to avoid no small waste at this point, due to a lack of knowledge and appreciation on the part of both school and college instructors of the work done on the opposite sides of the arbitrary line which has separated them.

But lack of coordination and the waste incident thereto is not found alone at the point of transition from high school to college; it is equally marked between the elementary school and the high school. The ignorance of the methods and content of high-school courses displayed by college instructors is, if possible, exceeded by the lack of definite knowledge displayed by high-school instructors of what goes on in the grades below. The abrupt change from the class-room organization of the elementary school with the careful supervision of the pupil's study to the departmental organization of the high school where so much emphasis has been placed upon home study and so little attention has been given to the method of the pupil's study, together with the sudden introduction of the pupil to so many new subjects, has been responsible in no small degree for the enormous percentage of failure and elimination in the early part of the high-school course. Again a prolific source of waste is found in the lack of correlation between different departments, particularly in the high school, of which a more detailed discussion will be given later.

Another source of waste is found in the character and training of our teachers. This will be seen most clearly by a comparison with the situation in the German schools. Candidates for positions in German secondary schools must hold certificates for a full course in one of the secondary schools and must have done three years' work in a German university. The doctor's degree is not required, but is held by a large number. Searching examinations are required of all to determine both the preparation for teaching special subjects and also the professional fitness of the candidates. The latter examination includes psychology, philosophy, the history of education and the principles of pedagogy. Three grades of positions are recognized, each with its corresponding examination. These examinations presuppose a more extensive training in the specific subjects than is required of teachers in our high schools. It is obvious that only those with professional as well as specialized training may find a place among the teachers of the German secondary school. But the passing of the examination is not all that is required of a candidate for a gymnasial position. In most parts of Germany he is required to spend two years in further preparation, the seminary year (*seminar Jahr*), usually in connection with some gymnasium or university, and a trial year (*probe Jahr*), during which he gives from eight to ten hours of instruction weekly without pay, under the guidance of the director and the department teacher. If he has met the exacting standard required during these two preliminary years of special professional training and experience, and has finally presented a satisfactory thesis of a professional character, he is given a certificate authorizing his appointment to teach in a secondary school.

I have presented these detailed facts regarding the requirements for teaching in the German secondary schools in order to indicate clearly one cause of waste in our own school system. Some cities require of candidates for high-school positions graduation from college and some professional training; the state of California requires for a high-school certificate a college training and one year of professional training. But even the highest requirements do not equal those which are practically universal in Germany, and in most parts of our country the scholastic requirements are low and there is no professional requirement whatever. A large number of our high-school teachers of both sexes enter upon teaching not with the expectation of making it a life work, but because it offers the most convenient means of earning a living until some more attractive opening is offered into the fields of matrimony or business. So long as the requirements for high-school positions are so low we must expect our ranks to be filled by teachers of meager training, and often without serious purpose. While there are a large number of teachers in our schools well trained and professionally expert, it is apparent that the results secured must be far short of what might be expected if our schools were taught by uniformly well trained teachers.

A third source of waste is found in the short tenure of position prevalent among the teachers in our schools. This again may be seen most clearly by contrasting the situation in Germany. Once appointed to a position in Germany, with few exceptions, the teacher remains in the same school until he dies or is retired on pension. The following statistics of the Prussian secondary schools for 1894 are cited by Bolton ("The Secondary School System of Germany," p. 119):

Total number of positions	7.302
Number of new teachers	233
New teachers first position held	225
New teachers from other positions	8
Total number leaving	209
Called to other positions	2
Choosing other occupations	42
Number retiring	8
Retired on pension	98
Number of deaths	59

This remarkable permanency of tenure is made possible by the exacting methods of testing candidates which prevents the unfit from securing positions in the schools. Conditions in our schools are in marked contrast. Dr. Jessup in a paper recently read at the secondary-school conference of the University of Chicago reported recent investigations bearing on this point. In Indiana for 1912 the median tenure of 186 superintendents was 2.16 years, and for the past fifty years in that state about half the positions were open every other year. In Iowa for 1912 the superintendents of 250 accredited schools had a median tenure of two years, and 40 per cent. were new to their position that year. Including schools not on the accredited list, the condition was still more striking, showing that of 768 schools considered, 46 per cent. of the positions were open last year, and 70 per cent. of the superintendents of these schools had been in their positions two years or less. High-school principals show the same tendency to short tenure. Bolton declares that in Wisconsin about one third of the high-school principals change position every year. Jessup states that of 183 principals in Indiana high schools in 1912, 45 per cent. were new to their positions. In towns of 25,000 population or over, one third of the principals were new to their positions. The same condition holds among high-school teachers. That it is not confined to small schools or particular states is seen from the following statistics of schools on the list of the North Central Association for 1912: In Wisconsin 46 per cent. were new to their positions; in Colorado, 44 per cent.; in Missouri, 37 per cent.; in Iowa, 37 per cent.; in Indiana, 40 per cent.

In a recent study of "The Social Composition of the Teaching Population" (Teachers College Contributions to Education, No. 41) based upon reports of 5,215 teachers from twenty-two states, including rural, town and city schools, Dr. Coffman finds the median number of years men teachers have taught, irrespective of location and of position, is seven; for women, it is four. These figures represent the total years of teaching and take no account of the number of positions occupied by each teacher. Tenure of position in city schools is much longer than in the country. Of 1,248 teachers in city schools, Dr. Coffman finds that the median city school man has taught twelve years in the city; the median city school woman has taught seven years in the city. Commissioner Harris in his report for 1904 published the results of reports from a much larger number of teachers from 398 cities of 8,000 inhabitants and over, including twenty-nine cities of over 100,000 inhabitants. He found that, in cities of 8,000 inhabitants and over, the median man had taught eleven years and the median woman nine years, and that both the median man and the median woman had taught seven years in their present positions. In cities of 100,000 inhabitants and over, the median teacher had taught ten years and had occupied the same positions eight years. It is obvious that even under the most favorable conditions the average tenure of position is short. Dr. Coffman also has statistics bearing on the youthfulness of teachers, showing that 52.9 per cent. of men teachers and 73.8 per cent. of women teachers are under thirty years of age. Sex has a potent bearing upon the question of tenure in position. German secondary teachers are all men, while in this country a very large majority are women. No exact material is available to show the effect of this constant changing of teachers. It is apparent that it greatly lowers the efficiency of our schools. The short tenure of superintendents and high-school principals hardly allows them to become adjusted to the new conditions in each position filled, not to speak of the possibility of working out any constructive educational policy, which must require years to be of real value.

Having discussed the causes of waste, there remains for us to consider the means by which it may be eliminated. I shall consider such remedies as are involved (1) in a readjustment of our school organization, (2) in a change in the methods and (3) in a reorganization of the materials of instruction.

Many experiments have been tried in the reorganization of the elementary and high schools and are in more or less successful operation in various parts of the country. These involve such combinations as a six-year elementary school followed by a six-year high school; a seven-year elementary and a five-year high school; and a six- or seven-year elementary school, a junior high school of one to three years, and a senior high school. All of these combinations, however, still include a total of twelve years in the period of elementary and high-school training and are based upon the assumption that these new types of organization are better adapted to the physical and psychological development of the child. Whatever benefits are claimed as a result have not been in the saving of time in elementary and secondary education.

As of practical bearing upon the solution of this important problem, I shall describe in detail an experiment in the elementary and high schools of the school of education of the University of Chicago which has already resulted in the complete elimination of one year from the elementary school and which we expect will ultimately eliminate a second year from the period of secondary education in the high school and junior colleges of the university. These schools occupy a peculiarly advantageous position for the conduct of such an experiment, being private schools unhampered by connection with a large school system and having faculties composed of teachers of rather more than ordinary professional training and interest, so organized that it is possible to treat the various stages of elementary and secondary education as a continuous process. The schools are large enough, having over 800 pupils from the homes of the immediate vicinity, to make the experiment typical and of value to other schools and communities.

It should perhaps be stated, at this point, that the program of the university elementary school contains considerable material that is not found in most schools of similar grade. This includes either French or German, which all the pupils take continuously from the beginning of the fourth grade. Much attention is also given to nature study, including, in addition to work in the school gardens, considerable physics, hygiene, zoology and botany. A good deal of emphasis is also laid on instruction in the manual arts and in various industries, such as sewing, weaving, cooking, woodworking and printing. It should be understood that the effort to save time has not involved the elimination or curtailment of any of this work which is regarded as equally important with the other subjects of instruction.

That considerable time has been wasted in elementary schools by teaching material of no practical and little educational value is certain. Arithmetic offers a good illustration in which one may find, from examination of text-books or by consulting the memory of his own school days, a good deal of material of a highly specialized sort which is of no practical value to the pupils, and much more material whose only purpose is to serve as a basis for intellectual gymnastics, the value of which is highly questionable. By far greater waste is involved in the common practise of extended reviews in the upper grades by which each teacher has felt it necessary toward the end of the year to round out her pupils for the work of the year to come. This is not infrequently supplemented by another period of review at the beginning of the following year. The practise of devoting most of the last half of the eighth grade to a comprehensive review of the entire work of the elementary school is very common. It is a matter of common observation that these reviews are not interesting to the pupils and it may be concluded that they are ineffective from the fact that high-school teachers generally complain of the deficient preparation shown by the classes that come up from the lower schools. To such an extent is this recognized that a widely used text-book in first-year Latin frankly devotes a large number of pages to English grammar to be taken up at the opening of the year before attacking the intricacies of the Latin tongue.

For the purpose of a better understanding of the material and methods employed in the university schools, about three years ago a series of conferences was begun between the teachers of the high school and of the later years of the elementary school. The material of the seventh and eighth grades and of the first year of the high school was gone over in detail. It was found at once that time was wasted in the repetition of work already done and in the failure to utilize fully some of the training already given in an earlier grade. These departmental conferences, including English, history, mathematics and modern languages, were continued at frequent intervals for a period of one or two years, and at less frequent intervals have become a part of the regular school procedure. They resulted in a thorough understanding, on the part of the teachers of both schools, of the content and method of the work of both the elementary and high schools, and made it possible for the eighth grade to enter the high school last autumn with more than half of the first year's work already accomplished and for the present seventh grade to enter the high school next autumn, thus fully eliminating the eighth grade.

In this connection it may be interesting to discuss somewhat in detail the steps taken to effect this readjustment in the different departments.

In modern languages, children have for many years begun either French or German in the fourth grade and have continued this during the remainder of the elementary school. There is no doubt that pupils at this age take up the study of a spoken foreign language with great interest and advantage. They do not take it up in the same way as it is usually taught to pupils of older years but by the end of the elementary-school course they have made very substantial progress in the use of the language in speaking, writing and understanding. We had been accustomed in the high school to carry these pupils forward in their chosen language in special classes, but they were given little substantial credit for their previous work and not infrequently found themselves before they had completed the high-school modern language courses, in the same classes as those who had begun their modern language work in the high school. The time spent in the elementary school in the study of French and German was, to some degree for all and to a very large degree for some, absolutely wasted. The modern language conferences resulted in modifications in the work and more particularly in the attitude of the teachers in both schools. Elementary teachers have been giving instruction this year in first-year high-school classes, and high-school teachers have come in frequent contact with the modern language work of the elementary school, and next year will conduct classes in the lower grades. The result has been that pupils from the elementary school will next year go on with the regular work of the second-year high-school classes in modern languages, equally well trained with the pupils who began their language work in the high school, and superior to them in their feeling for the language and in their ability to pronounce it accurately.

The adjustment in English was comparatively easy. It was found that here there was considerable unnecessary repetition of material. By eliminating this and securing definite progress at each point in the course it was found possible to promote the eighth grade directly into the second-year work in high-school English. The class thus promoted this year is proving one of the best of our divisions in second-year work.

In mathematics, as I have already indicated, there is likely to be much waste. By eliminating this much may be saved, but the most effective results in mathematics teaching can not be secured without recasting our material for the upper grades of the elementary and the earlier years of the high school. Much material from constructive geometry and the use of the equation in securing the value of the unknown quantity could be introduced into the grades naturally and with advantage to the pupil at the time, which would result in a considerable saving at the point at which formal algebra and geometry are taken up, with tremendous toll of failure, in the high school. In our own high school the material of the first two years has been thoroughly reorganized, interweaving elementary elgebra, plane geometry and some trigonometry, in a way to secure a more unified and sequential development of mathematical knowledge and power without the waste involved in the usual method of breaking this material up into the usual arbitrary divisions. While the introduction into the grades of the geometric and algebraic material referred to above has not been fully secured, we succeeded last year in giving our eighth grade fully one half of the first-year high-school mathematics. This year the eighth grade is taking the entire first-year high-school work in mathematics and in the monthly uniform tests which have been given to all our first-year mathematics classes, have every time stood well above the average of the regular high-school classes.

The elementary school, as already indicated, gives much attention to elementary science. In the high school a course in general science has been organized which is required of first-year pupils. It was found, on investigation, that this first-year science course was uninteresting and of little value to pupils of our own elementary school by reason of its repetitious nature. These pupils are now allowed to omit this course and take either in their first year or later some of the specialized science courses designed to follow the general introductory course.

A similar lack of coordination in manual training, in which our own elementary-school pupils took the same work as those who had had no previous manual training, has also been remedied.

By using whatever the pupils bring from the elementary school and building upon this their first work in the high school, we have secured a high degree of correlation between the work of the two schools, which has resulted in reducing to a minimum the shock of change from one school to the other. By reducing the amount of unnecessary reviewing and the repetition of material in successive years we have saved one year from the elementary school without undue forcing of pupils, without loss of anything of value, and with positive gain in the mental attitude and habits of the pupils.

It is probably neither possible nor desirable to save still further time from the elementary school. There remains for us to consider the period of secondary education. It should be observed at the outset that the four-year high-school course does not represent the actual range of secondary education either as regards the natural development of the pupil or as regards the material and method of instruction. Most of the work of the first and much of that of the second year in college is secondary, both in content and method. In earlier times when the range of subjects taught in high schools and academies was small and the college requirements were few in number and specific in content, the student on entering college continued in the same subjects and from the same point at which his work had ended in the lower school. But with the greatly expanded scope of high-school courses and the corresponding increase in the range of subjects accepted for admission to college, it has become necessary for the college to offer elementary courses in almost every subject of the curriculum. We find in college beginning courses in Greek, French, and German, and in Latin the courses corresponding to the second and third year of the high school; elementary courses in all sciences; in mathematics one half the courses offered in any first-class high school; and in history a repetition of most or all the work of the high school.

The practise of colleges to admit students with conditions sometimes equivalent to a year or even more of high-school work indicates the acceptance on the part of the college faculties of the fact that the first year or more of the college course is concerned with secondary work. The latest statistics of the colleges and universities of the North Central Association illustrates this.

This table shows that of the seventy-three institutions on the list of

Units Required	No Conditions Allowed	One Condition Allowed	One and One Half Conditions	Two Conditions Allowed	Three Conditions Allowed	No Rule	Total
14	1	0	1	1	0	0	3
15	4	19	8	27	5	2	65
16	0	0	0	2	2	1	5

the association, although all but three require fifteen or more units for admission, in only four are fifteen units actually required, while twenty-two admit students with fourteen units; eight with thirteen and one half units; twenty-nine with thirteen units; one with twelve and one half units; and six with twelve units. If this represents the practise of the stronger colleges of the Middle West, it must be true that many institutions are admitting students with even less units of preparation.

The importance of economy of time in education has long been recognized by representatives of the higher institutions. A notable discussion of this subject from the point of view of the university is found in the proceedings of the National Educational Association for 1903, participated in by Ex-Commissioner Brown, Presidents Eliot, Butler, Harper, Dean West, and others. President Eliot urged that the boy be prepared to enter college at eighteen and that the college course be reduced to three years. A saving of two years was to be secured not by reducing the content, but "by better organization of the whole course of education from the beginning to the end, by better methods of teaching, and by large and early freedom of choice among different studies." At Harvard it has become possible for the abler and more diligent students to secure the baccalaureate degree in three years by accomplishing in that time the work formerly done in four years by all students receiving the degree. President Butler, insisting upon the importance of preserving the integrity of the college, urged that the student should be prepared to enter college at the age of seventeen, or in some cases at sixteen. To preserve the college he proposed "to fix and enforce a standard of admission which can be met normally by a combined elementary and secondary-school course of not more than ten years well spent and to keep out of the baccalaureate course purely professional subjects pursued for professional ends by professional methods." For students intending to pursue professional courses later, however, he regards the four-year college course too long. "Pedagogs," he says, "suppose that the more time a boy spends in school and college the better; educators know the contrary." "There should be," he continued, "a college course two years in length, carefully considered as a thing by itself and not merely the first part of a three-year or a four-year course, which will enable intending professional students to spend this time as advantageously as possible in purely liberal studies." This principle has been successfully carried out in many of our universities. President Harper also regarded it as important to preserve the four-year college course, but thought sixteen or seventeen the desirable age for entering college.

From an investigation on the "Changes in the Age of College Graduation" published in the Report of the Commissioner of Education for 1902, the author, W. Scott Thomas, proposes three possible means of reducing the period of education:

First, cut off one year from the college course, without lowering the entrance requirements; secondly, in view of the far greater efficiency of the secondary school, reduce the entrance requirements to college, and retaining the four year's course, permit the boy to enter college a year younger; thirdly, drop one year from the college course, increase the length of the actual weeks of residence and instruction to thirty-eight or forty, and endeavor to disabuse the mind of the average collegian of the belief that college is a place to dawdle and loaf four years for the sake of a degree that he does not earn, but which he generally gets just the same.

The discussion has recently been resumed by President Judson of the University of Chicago. It is fair to interpret his laconic statement that "The best thing to do with the freshman year is to abolish it" as meaning that the period of secondary instruction should be reduced by one year. Whether this be done by shortening the periods now administered by the high school or the college is of less importance.

The problem is clearly stated: assuming that two years must be eliminated from the period of elementary and secondary education, find the years. It is plain that this can be done only by a careful study of the material and methods employed and a reorganization of the work of the period involved. It is a study involving not only the twelve years which have preceded the college course, but also the earlier part of the college course itself. Having found it possible to eliminate one year from the elementary school, the problem is reduced one half. I am confident that conferences of high-school and college teachers in foreign languages, English, mathematics, history and science, going over the materials and methods of secondary work in the same careful manner employed by the departments in the university schools above described, could easily eliminate a year by the avoidance of duplication and closer coordination of courses.

In the matter of foreign languages all will agree that it is much better for the elementary work to be done in the high school. In fact, there is abundant evidence in the practise of European countries and in some schools in this country that the study of foreign language may be begun advantageously before the high-school age. With improved methods in the high school and better correlation between high school and college, it should be possible for students to complete the elementary work in foreign language and either drop the study on entering college or go on with more advanced work without the repetition of any work already done. Against the elimination of elementary work in foreign language in college it may be urged that with the great variety of subjects included in the high-school curriculum many students will complete their high-school courses without foreign languages, and as colleges require a certain amount of foreign language of all candidates for a degree, they must either offer elementary courses or throw the student back upon the high school for a still longer period of preparation. But as the student who goes to college must either present foreign language for entrance or take it up on entering college, it would be altogether to his advantage to induce him to take it up in the high school. And this could in most cases be accomplished, particularly if he could know that it would result in the saving of time.

As for English, it is a recognized fact that the first college courses in composition and literature are of an elementary character, quite within the reach of the high school to accomplish in the time now devoted to the study. This is recognized by the practise of some colleges which allow the better trained pupils credit for these courses on proving by examination, and in some cases by the recommendation of their high-school instructors, that they are competent to go on with more advanced work. First-class high schools are able to give the preparation required for the present college courses in three years. A great gain would be made in training high-school pupils in the effective use of the vernacular both in speaking and writing, if not only the teachers of English, but those of all subjects, would come to share in this training. At present the pupil feels that high standards of form are required only in the English class rooms. If in history, science and other subjects, the same standards of form in the notes and papers and in spoken language were required as in the English classes, our students would be better prepared for college in less time than is now devoted to the work. Many papers required in other departments might also be used to meet the requirement for written work in English, thus saving time which the pupil devotes to the preparation of themes used by the English teacher alone.

In science, the preparation at present required by colleges is doubtless of a more specialized form than our high schools can profitably give to the large number of pupils who will never enter college. It should be possible, however, to organize courses in high school of the highest value to the students as a training in the materials and method of science, which could also form the basis for further work in college without going over again the same ground covered in the high school. High-school science would be more profitable in itself as well as for college preparation if the various courses in the high school were organized in a more unified and progressive sequence. Their value as preparation for further courses in college would be greatly enhanced if college teachers could become well acquainted with the aim and method of high-school science.

The situation in history may be described as similar to that of the sciences. Of both history and science, it may rightly be said that some and often all the work of a student has been taken in the earlier years of the high school when he was too immature to pursue the subject in any other than a most elementary manner. In this case repetition is not only necessary, but desirable, if the student is to take up these subjects in college. Repetition is not necessarily wasteful if it be from a different point of view and for the sake of developing more advanced work. But elementary college courses in which pupils who have already covered the same ground in high school are taught together with those who have had no previous training in the subject force the conclusion that the time spent in either the high school or the college is wasted.

If our colleges are to continue to offer in their various departments elementary work which may be as well done in the high school, economy of time might be secured by allowing high-grade students credit for a certain amount of this work, even though they had already been allowed admission credit for the same work. Given a certain minimum of required work involving continuity, say ten units in four subjects with not less than two in any one, the likelihood of success in college depends more upon a student's ability and habits of work than upon his presentation of any fixed number of additional units. A study of the records made in the Harvard Medical and Law Schools by graduates of Harvard College, published by President Lowell in the *Educational Review* (1912), showed that the quality of work in these professional schools corresponded very closely with the work done by the same student in college and was influenced very little by the type of courses pursued during his college course.

There is no doubt that a student entering college with thirteen units secured with a high grade is better fitted for a successful college course than one entering with fifteen units secured with a low grade. A very serious obstacle to efficiency in high-school work is found in the lack of incentive offered to able pupils to do their best. Most of the administrative machinery of our schools and much of the teaching energy are spent in an effort to lift the indifferent and incompetent over the barrier of a passing grade, while the able or exceptional pupil is allowed to acquire the habit of being satisfied with attainment far below his capacities. In most schools it is not regarded as good form to secure high grades. The "gentleman's grade" has come to be recognized as well below the median. Distinctions resulting from good scholastic records are usually petty and unsubstantial and make small appeal to students in general. The position of valedictorian is not held in sufficient esteem to induce many boys and girls to pay the price of four years of hard study. A few schools have adopted the plan of giving extra credit for high grades. In the university high school we give 1.2 units for a year's work with a grade of A, 1.1 units for a grade of B, 1 unit for a grade of C, and .9 unit for a grade of D. A substantial reward is thus secured for excellent work and a corresponding loss for work of low grade. We have observed a steady improvement in the quality of our work since the adoption of this system of awarding credit. Several students will be graduated in June who would not otherwise be able to do so, exceptional students having secured in two years since the adoption of the plan two full units of excess credit. What attitude the college will take toward such cases I do not know, but I am convinced that this student with only thirteen units on the usual basis for reckoning admission credits is by all means the best prepared student in the entire class. With the rapidly growing tendency for college authorities to place the responsibility for the decision as to the fitness of pupils to enter college upon the high school, I see no reason why students should not be accepted from properly accredited schools a limited part of whose credits have been given because of exceptionally good work.

Another means for increasing the efficiency of school work is in the improvement of class-room methods. One of the most frequently reiterated complaints made by high-school and college teachers is that our pupils do not know how to study. They certainly do not in most cases, and those who do have not consciously been taught the art by their teachers. Each teacher who makes the complaint lays the fault upon the teachers in the grades below and recognizes no responsibility on his own part for teaching this neglected lesson. The teacher of Cæsar thinks it so important to get his pupils through the four books which long tradition has assigned to his year's work, that he has no time to lose in teaching his pupils how to study. Let those who can not keep the pace fall by the wayside! And the dead scattered along the road each year are as numerous as those who fell in the most sanguinary of Cæsar's campaigns in Gaul. The usual practise of daily assignments of home work to be done under varying and often most unfavorable conditions, followed by a period spent in an ineffectual attempt to secure anything approaching an adequate and coherent recitation of the day's assignment, affords little incentive to the bright pupil and little training to the dull one. The method is most ineffectual so far as the mastery of the immediate material is concerned[2] and breeds slipshod, if not dishonest, habits of work and of thinking. Some valuable experiments have been made recently, showing that without any home study at all, by devoting the class period to careful teaching followed by work under the direction and supervision of the teacher, more actual ground can be covered and better results secured at the end of a given time, than under the usual recitation method. This method has been employed in Latin in several New Hampshire schools, in which the classes have covered in three years the amount of work usually done in four, and the fourth year has been given to the reading of college authors in an amount and with a facility which is surprising. And all this has been done with much less than the usual elimination of pupils by failure. When teachers of the upper years of the elementary school and the first year of the high school come to realize that it is more important that pupils learn right habits of work than that they get through a certain

1 See the article "Teaching High School Pupils How to Study," by Ernst R. Breslict in the *School Review* XX: 505–15.

number of pages in a text-book we shall find that the actual accomplishments measured in material mastered will be greater, that school work will be done with far greater zest, and, what is more valuable, that the pupils will have acquired methods of study which will greatly increase their efficiency in the more advanced work of later years. It is this method of teaching instead of hearing recitations which, more than any other single cause, characterizes the work of the German schools and makes possible the greater accomplishment during the period of secondary education.

Our present school day and year could be considerably lengthened with great gain in efficiency and without danger of overtaxing the pupil's strength. Much recreational and occupational activity has been added to the work of the school without any corresponding addition to the time spent in school. With the greater variety and interest secured by improved methods of teaching, and with much less work assigned for home study, a longer day would add greatly to the pupil's attainment in a given number of weeks. If, in addition, the long period of vacation with its accompanying dissipation of the results already secured, could be reduced, it is not unreasonable to expect that three years would be sufficient for the accomplishment of what is now done in four. The large number of pupils who now voluntarily attend vacation schools in our large cities suggests the conclusion that many students would welcome such an extension of the school year.

To summarize this discussion briefly. Waste in our elementary and secondary education is due chiefly to: (1) a lack of coordination between the separate parts of our school organization; (2) to the lack of training of teachers; and (3) to the short tenure of position of teachers. A remedy may be sought in: (1) a readjustment of our school organization; (2) in the elimination of unnecessary reviews and repetitions; (3) in improved methods of instruction; (4) by furnishing substantial incentive to better work on the part of the pupils; (5) and by lengthening the amount of time given to instruction during the school year.

Any effective treatment of the problem will depend upon the recognition of the fact that we are dealing with a unified process extending through the entire period of elementary and secondary education. The problem can be solved only when teachers employed at every point in the process, including the instructors in the early years of the college course, devote serious attention, not merely to the small sphere of their immediate activity, but to the materials and method of the entire period involved.

THE STRUGGLE FOR EQUALITY IN THE UNITED STATES VIII

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The Current Trend of Affairs. III

No feature of the present era is more full of promise than the growing strength of the working classes. The gain in self-respect, political influence, ability to cooperate and capacity for self-help during the nineteenth century is almost beyond belief. This is notably true where the working classes occupy a strategic position in bargaining with their employers, as in the building trades and in connection with railways. Quite the reverse of the progressive deterioration of the masses predicted by some prophets of disaster is taking place. The rank and file of society is the recruiting ground of so much that is best among our political and industrial leaders that it is obviously the mainstay of our civilization. If any one thing has been clearly demonstrated it is the capacity of the man of humble origin to make good in a surprising number of instances if he is only given a chance. It is a mistake to associate the working-class movement with turbulence and disorder to the exclusion of the fortitude and self-sacrifice displayed in attaining its ends. The acts of lawlessness are, after all, sporadic, and are so generally recognized as anti-social that society can usually be depended upon to suppress them with a firm hand. Unfortunately, there is less certainty that the community possesses the foresight, patience and resolution necessary to deal intelligently with the straitened circumstances and conditions out of which lawlessness springs. Among the factors that are welding together the diverse linguistic, racial and religious elements that come to us from other lands, few are as influential as the labor movement. The independence and self-reliance of working people, and the quickness with which they resent an insult, are common subjects of remark among employers of domestic and of other help. The point of view of the employer is easy enough to understand, but it calls attention to a situation that is socially hopeful. Even from the standpoint of employers, a working class that knows its rights and dares maintain them is to be preferred to one that is servilely submissive. It puts employers on their mettle and under bonds of good behavior. Much as socialism, when it goes to certain extremes, is to be feared, it renders wealth less arrogant in its demands, makes powerfully for the correction of many of the manifest evils of the times, and is, on the whole, a good rather than a bad omen for society.

I am, of course, aware that the working classes have no monopoly of virtue. Their ranks have their full share of those whom Horace Greeley described as "the conceited, the crotchety, the selfish, the headstrong, the pugnacious, the unappreciated, the played-out, the idle and the good-for-nothing generally." The position of the employer, consequently, is not in a bed of roses. His best efforts are ofttimes misconstrued and rewarded with ingratitude. Harassed by walking delegates, it is not strange that he sometimes concludes that his employees ought to starve till they come to their senses. "Lay a silver dollar on the shelf," an employer of railway labor once remarked, "and it will be there when you come back. Lay a working man on the shelf and he will starve. This is the solution of the labor problem." These words well express the inability of labor to hold out in any contest with capital. None the less, the majority of employers in their calmer moments do not court a contest with their employees. In the first place, the contest may be a protracted one and employers are not unmindful of their own losses. In this age of organized sympathy, those on a strike are often supported for weeks by contributions from those at work. In the second place, there is a better solution of the labor problem. The more enlightened employers find it good business to manifest a disposition to do the square thing, and to talk over the facts with their men fully and frankly. Because a man is getting a living wage, or one well above what he once got, is no reason for smothering his ambition for one still higher. The suppression of ambition would be fatal to progress. There can be no enduring peace between capital and labor save on the basis of fair dealing by both parties.

Attention is sometimes called to the fact that the working class, by playing upon the fears of rival politicians, can extort legislation unduly favorable to itself. Instances of such legislation undoubtedly occur and they are a source of danger to the state. It is doubtful, however, whether they are as common as the control of the state in the interests of other classes, especially in the United States where social legislation lays so far behind many European countries. It is true that social legislation is piling heavy burdens upon the state. But it is a worthy object and it is far less expensive than modern military establishments which it helps to keep within bounds. Viewed simply as an investment, the cost of social legislation may more than justify itself. It is said that social insurance in Germany has made the working classes more contented and efficient and has contributed to the rapid industrial advance of the empire. The world has never been unfamiliar with class rule. But the spectacle of the working class using the state for the advancement of its own interests is so modern that it strikes many minds as especially dangerous.

There is a feeling that the working class will use its power with less moderation than the capitalist class. It is doubtful whether this feeling is well founded. There is no force in mere numbers unless they act together, and there is little reason to suppose that the working class is any more nearly united than the capitalists in our politics. The demands of working people sometimes appear more brazen than those of capitalists, but this is an element of weakness rather than strength. So long as the political activities of any faction are not insidious, society has little to fear.

There is a good deal of dissension in the ranks of labor. Dissimilarity rather than similarity of interest between trades is the basis of trade-unionism. The downfall of the Knights of Labor is commonly attributed to disregarding this basis. By admitting workmen of different trades into its local organizations, the seed of dissolution was sown. Many workingmen, such as those in the building trades and the railway trainmen, have more in common with their employers than they have with the great mass of unskilled labor. The railway trainmen are not affiliated with the American Federation of Labor, and the latter is on unfriendly terms with the Industrial Workers of the World. The political or parliamentary socialists in turn differ with the I. W. W. on the important matter of tactics. Moreover, socialism as a political movement is divided into the orthodox followers of Marx and the reformists or possibilists, a line of cleavage destined to become much more marked the moment socialism captures the reins of power.

> Men's economic interests are rarely single; in the complexity of modern industrial society their relations are not confined to a single group; they can not be classified solely from one viewpoint. The strata are many, the cross-sections innumerable. Geographical division, occupational interest, color and racial differences cut athwart the symmetrical lines of the class-struggle theorist. Not merely do the interests of workmen and employer diverge, so far as the sharing of the product goes, but the German agrarian struggles against the manufacturer, the small shopkeeper against the great department store, the independent manufacturer against the trust, the white bricklayer or fireman against the negro, the American trade unionist against the immigrant, carpenters' against woodworkers' union in jurisdictional disputes. Employers and employed unite in a closed shop, closed-masters' agreement to prey on the consuming public; trade unions back trusts' demands for more room at the tariff trough.[18]

It is only fair to say, however, that certain aspects of the labor movement can not but excite the apprehension of the disinterested observer. For one thing, there is serious ground for regret that the different classes of labor are advancing at such unequal rates. On the one hand, there is an aristocracy of organized labor that revels in prosperity. On the other hand, there is much unskilled labor that gets less than a living wage. There are labor monopolies which by threatening to strike

[18] O. D. Skelton, "Socialism, a Critical Analysis," pp. 112–113.

can bring such pressure to bear as to secure demands far beyond their just deserts, and part of what they are able to extort is at the expense of their less fortunate brethren. · To those who have more is given, while from those who have not is taken away part of even the little that they have. The rules governing apprenticeship sometimes aim at monopoly. The stay-at-home vote is as fatal to competent leadership in the labor world as in politics. The sympathy of the public with labor is sometimes so strong that it condones acts of violence. On occasion the demands of labor are so immoderate as to threaten the goose that lays the golden egg. It is possible that this condition has about been reached in the case of railway labor. The professed object of the militant branch of the Industrial Workers of the World is to take over the capital of the country by destroying the business of the employer. To this end, costly strikes are precipitated, materials and machinery wantonly damaged, the good will of the business wilfully injured, and inefficiency on the part of the workers openly encouraged and practised. The fact that organized labor, in general, is seemingly so indifferent to increasing the efficiency of the workers and so largely contents itself with strengthening their bargaining power is to be regretted. It unwarrantedly interferes at times with proper discipline by the employer. The shallow view that the way to make work and raise the general level of wages is for every man to confine himself to a minimum stint is unfortunately too frequently a fundamental article of faith in labor circles. Organized labor less frequently aims at increasing the efficiency of production than organized capital.

IV

There are some indications that private property, far from being on its last legs, is taking on new life. At any rate, it is showing symptoms of great vitality. Man has an incurable desire for property. This is nowhere more conspicuous than among a large portion of the foreign born. The industry and thrift of the German immigrants are proverbial, and much the same thing is true of the Norwegian, Swedish, Italian and Jewish immigrants. The Poles in the Connecticut Valley work from early dawn till dusk at weeding onions and practise the strictest economy. They are buying farm after farm and are noted for meeting their obligations on the dot. The yearning for one's own is so deep and strong that in many Polish boarding houses each man's meat, potatoes, etc., is purchased for his individual account and cooked in separate vessels for his personal use. If some portions of the population are given to extravagance, other portions carry the practise of thrift to an excess, in many instances going without things necessary to health which they are abundantly able to buy.

The drift of current opinion is not hostile to property *per se*. Its animus is rather against special privilege of all kinds. It is also bent on subjecting property that has outgrown the restraints of competition to political control. Where political control proves inadequate, however, there is a disposition to resort to collective ownership and operation. It is undeniable, also, that the right of private property in such gifts of nature as forest and mineral wealth, and in the future "unearned increment" of land in large cities, is being more and more called in question. But, on the other hand, practically every one recognizes the indefeasible right of a man to property in any value that his labor creates, and the great majority of minds approve the right to property in the product which capital creates under competitive conditions that are normal and fair. The preponderance of opinion still strongly favors private ownership and initiative, and relies upon self-interest as the fountain source of the additional capital required for the further development of our resources. It is noteworthy that socialism limits its attack on property to things instrumental in exploiting the working classes. A member of the Socialist party in such good and regular standing as Spargo contemplates the retention of private property in a portion of producer's as well as of consumer's goods. In appealing to farmers and small dealers, socialism is under the necessity of moderating its attacks on property, thereby losing something of its purely proletarian character. It is significant, also, that the national constitution of the Socialist party, approved by referendum in 1912, declares that any member of the party

> who advocates crime, sabotage, or other methods of violence as a weapon of the working class, to aid in its emancipation, shall be expelled from membership in the party.[19]

There is little prospect of a contest in which all the property owners will be found in one camp and all those without property in another. The normal craving in every man of ambition to accumulate something of his own works strongly against such an alignment. In most contests, those who ride are not pitted singly against those who walk, but various combinations of these two classes constitute the contending parties. Moreover, the combinations are rarely the same in two successive contests.

Many of the great reforms that have been adopted have not destroyed property, but have changed conditions in such a way as to increase the incentives in life, and to enlarge the sum total of things capable of ownership. The abolition of slavery simply transferred slave property from the master to him who had been the slave to the mutual good of both parties. Railway control and effective regulation of trusts

[19] National Constitution of the Socialist Party, Section 6, Article II.

do not make the community poorer, but give increased zest to life by interfering with the few plundering the many. If it were practicable to restore the unlawful pickings of industrial combinations to those whose pockets have been filched, there would be no destruction of property, but merely a return of value to those to whom it rightfully belongs. The control which the community is asserting over children, in so far as it makes the child stronger mentally and physically, increases the value of the property right which the child at maturity has in himself. The greater freedom accorded women, married or single, including the recognition of their individuality in the ownership of property, has merely lodged a control in them which was formerly exercised by their husbands or fathers.

Furthermore, an increase of collective property may enlarge rather than contract the sphere of private property by giving the individual more playroom in life. This is the normal consequence of public expenditures for education. The municipalization of public works, such as water, lighting and surface transportation, has contributed to the prosperity of private industry in many European cities. If the state were completely freed from the control of special interests, if all forms of exploitation were abolished, including the various kinds of corporate rascality, it may well be that private property in numberless directions would be given a new lease of life. The lack of sympathy between capital and labor is an ominous fact. But every successful attempt to bridge the chasm, every reform that makes the working class feel that it has something more than a stipulated wage at stake in industry or that makes the relation between wages and efficiency more obvious, will make for the continuance of the existing order. It is no longer prudent for the state to take a negative attitude toward the social problem. Positive action is imperative or it will fall into the hands of the more venturesome portion of society. The Liberal party in Great Britain has pointed the way. By keeping abreast of the times it has helped to prevent a radical brand of socialism from sweeping the country. As Lowell puts it:

> It is only when the reasonable and practicable are denied that men demand the unreasonable and the impracticable; only when the possible is made difficult that they fancy the impossible easy.[20]

V

It is possible that our institutions may be wrecked by innovation, but our danger lies rather in not responding rapidly enough to the reasonable demands of the times. Our different states are so many political experiment stations for the trying out of new ideas, and a dan-

[20] *Op. cit.*, pp. 16–17.

gerous fad is apt to be found out and discarded before it makes its way over many states. If any features of the Oregon plan of government prove unwise, it is only a matter of time when they will be abandoned by the people of the state themselves.

The best way to conserve what is good is sedulously to remove what is bad. The nation that is genuinely progressive is in the best sense conservative. The man who gains recognition and promotion is inclined to take due credit to himself and to think that, after all, the world is not fundamentally wrong. Hence, there is no better way to maintain the social order than to remove every species of favoritism that prevents men of ability from advancing in life. The effect is at once to strengthen the powers that be and to deprive the forces of discontent of able leadership. The stability of the social order in England lies in the fact that the nation has not stood still, but has from time to time adapted its institutions to changing conditions. This is probably the most distinctive fact in English history. Every one is aware that revolutionary outbursts frequently miscarry by creating a reaction. But the reverse is also true. Where the dominant class places freedom of discussion under the ban and will permit no change, as has been true much of the time in Russia, the forces that make for progress have no alternative but revolution. The French Revolution itself was largely due to the obstructionists who held out blindly against reform. The reactionaries of our time are assuming a heavy responsibility.

American democracy is commonly associated with an open mind. We have avoided the extreme conservatism to which Sir Henry Maine thought a broad suffrage inclined.[21] Our material civilization has been one of progressive improvement. Our inventive ingenuity has a world-wide reputation. We have become *par excellence* the land of large-scale production. The prevalence of the reading habit has familiarized the public with the more important achievements of science. The doctrine of the ascent of man has displaced that of the fall of man in secular affairs and to some extent in theology. We have been in a measure free from many of the old-world traditions. "The American people, as a rule, approach a new object, a new theory, or a new practise; with a degree of hope and confidence which no other people exhibit."[22] Such facts as these indicate a state of mind favorable to progress, but they do not warrant the belief that we are prone to revolutionary suggestion.

Contrary to the common supposition, there is a large streak of conservatism in the American people. Bagehot claimed for the people of Great Britain the proud distinction of excelling every other people in "the virtue of stupidity," "nature's favorite resource for preserving steadiness of conduct and consistency of opinion."[23] In this respect,

21 ''Popular Government,'' pp. 35, 36, 41 and 98.

22 Charles W. Eliot, *op. cit.*, p. 63.

23 Thomas Nixon Carver, ''Sociology and Social Progress,'' pp. 501–502.

the American people are not so far behind those of Great Britain as many suppose. Not until 1912 was a federal bureau established to gather information about children. We were one of the last among the leading nations of the world to take steps to abolish the wholly unnecessary disease known as "phossy jaw." The visionary and impracticable enthusiast is probably accorded as scant a hearing in the United States as in any other country. Our toleration of all sorts of fads and isms should not be mistaken for approval. In many industries, such as steel, agricultural implements, the textile trades and dressed meats, the individual has become a cog in a huge industrial machine. Nevertheless, a return to the scheme of production formerly in vogue is not seriously considered. Probably the Socialists are as much opposed to sacrificing the efficiency of large-scale production as any one else. We pride ourselves on our freedom from tradition, all the time oblivious to the fact that we have been rapidly gathering a set of traditions all our own. We have clung tenaciously to competition as a regulator of the railway industry long after it has broken down, and we are seeking to restore competitive conditions by dissolving the trusts. We have a strong aversion to a third term for the presidency. We still retain the form of the electoral college, and the custom of Congress not meeting in regular session till thirteen months after its members have been chosen. A population that is instinctively radical would hardly have tolerated our judicial system for more than one hundred years. Our system of checks and balances is of the very essence of conservatism. We content ourselves with a written constitution so rigid that, like a religious creed, the only well-recognized mode of amendment is by interpretation and the slow process of accretion. Interstate commerce has increased by leaps and bounds, and many of our industries have become nation-wide in character, and yet we retain a distribution of powers between the states and the nation intended for a time when comparatively little commerce crossed state lines, when industry was largely a neighborhood affair, and when the sense of nationality was weak. Our constitution antedates "the railroad, the steamboat, and the French Revolution, and was contemporary with George the Third, Marie Antoinette, and flintlock muskets."[24]

An appreciative foreign observer remarks:

So far as their Constitution is concerned the American people have shown themselves the most stable of all people. Their Constitution is to-day the same as when it was created; in the century and a quarter that has elapsed since then, the constitution of England—England, the very type of conservatism—has silently changed; Englishmen have seen disestablishment, the enlargement of the franchise, real parliamentary representation and government, the removal of political disabilities, the last relics of feudal privileges destroyed. To speak of

[24] Walter E. Weyl, *op. cit.*, p. 15.

Germany and France, of Italy and Russia, of all Europe and all South America, is to recall constitutions made and unmade, and codes that bear little relation to their originals.[25]

Our most distinctive and persistent tradition is our self-reliant individualism. This is at once our strength and our weakness. It has hastened the industrial conquest of a continent, but it has wasted our natural resources, needlessly sacrificed human life, and it has been indifferent to the general welfare. So long as private profit is consistent with public ends, it is a source of strength, but the moment it becomes inconsistent it is a source of weakness. The flagrant evils of American life are largely due to applying to present-day conditions a philosophy suited to the frontier. We can not regulate the railways and the trusts, reform the tariff, or abolish the slums without encountering an overweening individualism. The disregard of speed ordinances by automobilists, the prostitution of public office to private ends, the corrupting influence of business on our political life, and the all too prevalent spirit of lawnessness are traceable to this characteristic. We have been optimistic to a fault. We have cherished the delusion that our manifest evils if left alone will eradicate themselves. We have assumed that we are in a special sense the chosen people of God. No matter which way we turn, the "psychological twist" which originated in pioneer days interferes with our becoming a socialized democracy.

VI

The opponents of the demand for a larger measure of popular government forget the growing intelligence of the people. Schools and colleges, books, newspapers and magazines, modern transportation and communication, business intercourse, the trade union, political discussion, the numerous clubs and Chautauqua circles, and the growing density of population which brings mind more frequently in contact with mind, are so many agencies for promoting the general enlightenment. Rural free delivery, the telephone, the interurban trolley, and the influence of the city are widening the mental horizon of the farmer.

More fundamental is the influence of the scientific spirit to which Darwin's works gave such a decided impetus. Laboratory methods of research are pushing forward the frontier of knowledge. Many of our universities and technical schools are devoting themselves to pure science as well as to vocational training. Electrical machinery, the aeroplane, the automobile and wireless telegraphy arouse the scientific curiosity of the young. They also engender respect for the profession of the engineer who delves into the mysteries of nature. Besides, the ideals of democracy are permeating all classes of society.

[25] A. Maurice Low, "The American People, A Study in National Psychology, The Harvesting of a Nation," Vol. 2, p. 300.

John Stuart Mill aptly said more than sixty years ago:

> Of the working men, at least in the more advanced countries of Europe, it may be pronounced certain, that the patriarchial or paternal system of government is one to which they will not again be subject. That question was decided, when they were taught to read, and allowed access to newspapers and political tracts; when dissenting preachers were suffered to go among them, and appeal to their faculties and feelings in opposition to the creeds professed and countenanced by their superiors; when they were brought together in numbers, to work socially under the same roof; when railways enabled them to shift from place to place, and change their patrons and employers as easily as their coats; when they were encouraged to seek a share in government, by means of the electoral franchise. The working classes have taken their interests into their own hands, and are perpetually showing that they think the interests of their employers not identical with their own, but opposite to them. Some among the higher classes flatter themselves that these tendencies may be counteracted by moral and religious education: but they have let the time go by for giving an education which can serve their purpose. The principles of the reformation have reached as low down in society as reading and writing, and the poor will not much longer accept morals and religion of other people's prescribing.[26]

The common man is not only more intelligent, but he has a keener sense of self-respect. This is partly because he is better off materially. Penury and want have a brutalizing effect because they prevent man from leading a wholesome, normal life. The material comforts of life not only affect our physical welfare, but they influence our mental and moral outlook. Give a man something more than the bare necessities of life and you make it possible for his better nature, his desire for books, travel and education, to compete with his lower or sensual self. Doubtless something more than an increase of this world's goods is necessary to the reformation and upbuilding of character. The springs that issue from the hidden recesses of the heart are no less important. An increase of wealth unaccompanied by a wholesome expansion of desires is a curse rather than a blessing. Great wealth is often enervating. Habits of luxurious ease are degrading. There can be no doubt, however, that the comforts and decencies which the nineteenth century brought within the reach of the masses have done much to civilize mankind. Besides, the process of acquiring wealth has been helpful. It has forced men to contrive and has saved them from idle and aimless lives. Commercial intercourse has done much to widen the mental horizon, to undermine prejudice and to banish provincialism.

The problems of the day which give character to the present age are not due to the growing ignorance and degradation of the electorate. We are not witnessing "the revolt of the unfit," but the demands of the "fit" for simple justice. The spread of intelligence and a stronger spirit of fair play are liberating new wants, pointing the way to new ambitions, and are rendering men more self-assertive, more insistent

26 *Op. cit.*, p. 756.

upon justice. "Wider knowledge," says Lloyd George, "is a creating in the mind of the workman growing dissatisfaction with the conditions under which he is forced to live."[27] Besides, the improvement in economic conditions that has occurred within a life time whets the appetite for something more, and the shortening of the working day gives men time to realize how inferior their state is in comparison with their fondest hopes. The hope of better things in our present social system has to some extent taken the place of religious belief. The failure of incomes among a large portion of the population to keep step with rising prices always makes men chafe. But when the expectations of men for something better are once aroused, such a rise of prices as the last fifteen years have witnessed is doubly trying. When a nation like China, in which ancestor worship and reverence for the past have been time-honored points of view, is shaken to its very foundation by a political and social revolution, we in America who profess democracy as our ideal can hardly hope to escape the sweep of a movement that aims at uplifting the common lot and according the masses a larger voice in the management of affairs. The movement for the betterment of mankind seems destined to go on whatever befalls the fortunes of particular individuals. The forces of democracy are so strong that it matters little whether a Roosevelt, a Taft or a Wilson is president.

Six facts justify a hopeful view of the future. The first is "toleration in religion, the best fruit of the last four centuries." This is fundamental to liberty and promises to save us from frittering away our energies in needless bickerings. The second is our system of public schools, which provides us with a certain minimum of enlightenment. The third is the keen ethical sense of the people. The questions of the day that arouse most interest involve matters of right and wrong. Our most successful politicians are great preachers. The fourth is the spirit of unity that pervades the land. Sectional feeling is at a low ebb. The east and the west, the north and the south, are more nearly one than ever before. The entire country acquiesces in the influence which the states that tried to secede in 1861 now exercise at Washington. Exhibitions of class feeling are, after all, exceptional. Commercial intercourse between different portions of the country makes strongly for community of interest. When one considers how frequently the bonds of affection within the family are strained to the point of breaking, the spirit of concord in the business world is little less than marvelous. The fifth is the success with which large corporations sift out competent leaders. Big business occasionally acquires an element of monopoly and menaces the state itself, but the management of its own affairs is commonly marked by a high degree of efficiency. Rivalry for promotion among capable men is especially keen in the large concern.

[27] Robert Donald, "The Square Deal in England," an authorized interview with David Lloyd George, *The Outlook*, Vol. 101, June 22, 1912, p. 398.

Nepotism and other forms of favoritism now and then determine preferment, but large enterprises have usually been free from these influences. The sixth is the wholesome effect which comes from doing things in the open. The tendency to insist upon publicity in corporate and public management is strong.

Publicity exposes not only wickedness but also folly and bad judgment. It makes crime and political corruption more difficult and less attractive. The forger, burglar and corruptionist need secrecy, for two reasons: first, that they may succeed in their crimes; and secondly, that they may enjoy the fruits of their wickedness. The most callous sinner finds it hard to enjoy the product of his sin if he knows that everybody is aware how he came by it. No good cause ever suffered from publicity; no bad cause but instinctively avoids it.[28]

I am not unmindful of the perils which attend the period upon which we have entered. Some of them have been alluded to in the course of these pages. In addition I will mention the following. First, is the prevalence of a superficial habit of reading and thinking. Few college graduates, even, are capable of sustained thought. Many voters read nothing but a party newspaper. Second, is the difficulty which many voters experience in foreseeing the distant consequences of some kinds of political action. Third, is the vice of indifference and irresponsibility to which some voters are subject. In a large population, the amount of sovereignty that resides in the individual is so small that he is tempted to wonder if it makes any difference whether he votes or not. Fourth, is the temptation to assume that the majority is invariably right, or, at any rate, that it is irresistible and that it is not worth while to try to reverse it. Fifth, the press is interested in selling news and has a certain bias in favor of war. It is therefore tempted to pander to prejudice against foreigners and to foment international ill-feeling. The manufacturers of armor plate and other military supplies are subject to the same temptation. These and other perils, however, seem to me for the most part as inevitable as the dangers which attend the young man who leaves home to go to college, or is set adrift in the world to shift for himself. Moreover, they are largely offset by the critical spirit which has taken the place of a blind obedience to authority and precedent among a large number of the population. As responsibility is the making of the man that is in the boy, so political institutions that depend upon the self-control, public spirit and wisdom of the masses tend to bring out the better side of human nature. One can not learn to swim without the perils which attend going into the water. Neither can humanity acquire a larger measure of self-discipline with the aid of democratic institutions without the risk of not making the best use of its opportunities. When the suffrage was enlarged in Great Britain in 1867, Robert Lowe is said to have remarked: "We must now at least educate our new masters." No words are more appropriate at the present juncture in human affairs.

[28] Charles W. Eliot, *op. cit.*, p. 55.

Looking Up Yosemite Valley from Artist's Point. El Capitan on the left is a monument to the resistance of massive granite to erosion. Cathedral Rocks, above Bridal Veil Falls, on the right, show the weathering of fissured zones.

GENESIS AND REVELATIONS OF THE YOSEMITE VALLEY

By HAROLD FRENCH
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THE marvelous structure and sculpture of the Yosemite Valley kindles the imagination of every visitor to this great natural wonder and causes scientist and layman alike to evince the most intense interest in the origin of this mile-deep trough amid the granite waves of the High Sierra. Each pilgrim to this Mountain-Mecca endeavors to satisfy his mind as to the causes of its carving. Every one who wanders there wonders and guesses at its genesis; but the revelations of its geomorphogeny are far from being satisfactory or complete. Scientists have come and savants have gone, but few have agreed in their conclusions. The scenic grandeur of the Yosemite has sunk deep in the souls of poets and painters, artists and literateurs; and to the most practical of men, engineers and miners, do its unique features equally appeal. Awe-inspiring evidences of colossal dynamic agencies, such as the undermining and subsidence of vast areas, or the tremendous upheaval of sky-piercing peaks and ridges, the quarrying and ground-sluicing of Brobdignagian blocks of granite, are all of deep significance and extreme interest to the mind of the miner. Over all this weird wonderland broods the spell of an enigmatic Sphinx. To this day, the Yosemite is, of a verity, the Valley of Mystery.

General Geological Features

Before discussing the conflicting theories conjectured about the origin of the Yosemite Valley, it will be proper to present the salient features of its surroundings. Trite, but essential to clearer understanding, is the statement that the valley is approximately eight miles long and nearly a mile in extreme width and depth. Its floor averages 3,960 feet above sea level. At first glance, it will impress the miner as being a great open cut quarried through blocks of more or less resistant granite. And to many it will appear to be a great basin, the bottom of which had sunk to unfathomed depths. Whatever forces may have quarried this great open cut—if open cut it may be truly called—the accumulation of the tailings down stream from this titanic denudation is conspicuous by its absence. Therefore, the secret of the transportation of these billions of tons of tailings is one of the mysteries of the geological history of the Yosemite yet to be unfolded.

Looking up the valley from its lower portal, two striking differences in the structure of its walls are seen in bold contrast to each other.

El Capitan, 3,100 Ft. Sheer. Most striking illustration of massive, resistant granite.

As massive monoliths of smooth, sand-papered granite, appear El Capitan, Sentinel Rock and Dome, Glacier Point and the Half and North Domes. These burnished, jutting promontories attract far more attention than do the hollowed-out recesses of the tributary canyons. And yet, it is more among the shadows of these deep-furrowed clefts that the geologist must look for the most convincing evidences of the actual sculpturing of the Yosemite Valley. The domes stand out more as mighty monuments signalizing their resistance to erosion, rather than as facetted and modeled masses of rock. But between these promontories are zones of fissured strata showing the shearing and sawing of corrasive forces. The pinnacled Cathedral Spires and Rocks, the wrinkles of the Three Graces and the creases of Three Brothers most distinctly illustrate the differentiation of zones of more friable, granitic materials. Beneath one's feet is the remarkable floor of the valley, whose gradient is but little more than a foot of fall to the mile. Far above the rim of the main gorge of the Merced are dozens of "hanging valleys" cut off abruptly by the transverse trend of the precipitous walls of the Yosemite Basin. Above and beyond rise an ascending series of polished domes and U-shaped troughs culminating in the serrated crest of the High Sierra. Its eastern slope affords a most striking contrast to the gentler gradient towards the Pacific. The sunrise-fronting spurs of the Sierra plunge abruptly at a high angle down to the Mono plain seven thousand feet below. Alternating with steep escarpments, are deep-carved canons descending giant staircases, whose hollowed treads are frequently filled with azure lakelets. Beyond, over the drab desert, arise an array of dead "fire-mountains," recording an important chapter in the history of the High Sierra.

According to Professor Joseph Le Conte, this mighty range was born out of the ocean during the Jurassic period, the strata bulging, mashing and crumpling as it yielded to horizontal pressure. Its first physical appearance in the poetic diction of John Muir was as "one vast wave of stone in which a thousand mountains, domes, canons and ridges lay concealed." Geologists agree that the original crest of the Snowy Range was in the vicinity of the Yosemite Valley, but, at the end of the Tertiary and the beginning of the Quaternary periods, the Sierra block was tilted upward by volcanic upheavals which burst forth all along its eastern border. The Sierras were pitched *en masse* in a steep slope toward the west, while a great fault system produced the precipitous escarpment towering above the desert. Consequently, the crest of the range was transferred to its eastern rim. Throughout the Quaternary period, a newer system of rivers, accelerated by the increased inclination of their watersheds, cut their beds deeper and deeper along the lines of least resistance. Then followed an "over-deepening" of these stream courses by corrasive forces of far greater potentiality than the agency of running water.

Early Hypotheses

The fact that no concordance in the conjectures of geologists exists is probably due to their different earlier environment and experience. Some were more familiar with the phases of stream erosion, others had studied the folding of sedimentary rocks, while certain savants were so carried away with their theory of glaciation that, in their imagination, they could only see the Sierras buried beneath a sea of ice a thousand fathoms deep. More who came to guess at its genesis, remained firm in their faith that "the bottom of the Yosemite dropped

Looking Up Tenaya Canon, between the North and Half Domes of Yosemite and from near Glacier Point. Floor of Valley 3,000 Feet Below. The Half Dome is 4,900 feet above its base. Cloud's Rest in the distance is 9,925 feet in altitude and 5,965 feet above the valley floor.

out." The commonplace processes of work-a-day life psychologically bore their imprint in their deductions. Miners could only see gigantic excavations. The metallurgist would detect an apparent analogy in the swelling of these domes to the bubbling and solidification of molten metal. Engineers were most impressed by the evidences of stresses, strains and the rupture of weaker materials.

One of the most ingenious interpretations of the subsidence theory was advanced most ingenuously by one of the gentler sex. To new-comers in the Yosemite I was explaining the "cataclysmic hypothesis," still popular with those who prefer the more spectacular speculations. Suddenly, she exclaimed: "Did you ever bake a cake?" I answered proudly in the affirmative. "Well, did you ever spoil a cake?" Again, but with less pride, I admitted that such had been my experience. "Then you will know," she continued, "how it is that heat and the gas formed by baking-powder make the batter rise. Up it swells. Then a crust forms. If all goes well, the cake becomes crisp and compact. But, if some one jars it, while it is rising, down it drops in the middle. And so I guess the Yosemite Valley must have dropped in just such a way." This homely homology from an expert in culinary science was unanswerable. Her mind was made up. Even the most uncompromising glacialist could only have caused her to concede that the ice sheet was but a frosting spread over the surface of her hypothetical cake.

During the summers of 1863–4, Professor Josiah Dwight Whitney, chief of the California Geological Survey, conducted a most thorough reconnoissance of the Yosemite and High Sierra region. In his first report, published in 1865, he advanced his theory that the Yosemite Valley had been formed by the subsidence of a limited area during the processes of upheaval of the Sierra. This supposed sinking of its floor he attributed to the fracturing of its strata in a series of cross fractures and faults traversing each other, generally at right angles. The pioneer geologist declared that "this great cataclysm may have taken place at a time when the granitic mass was in a semiplastic condition below, although quite consolidated at the surface and for some distance down." But Professor Whitney must not be misunderstood as maintaining that the gorge of the Yosemite is one gigantic fissure. Later, in 1870, in his celebrated "Yosemite Guide-book," he demonstrates that "the valley is too wide to have been formed by a fissure." Had such been the case its opposite walls would have corresponded in most details, instead of differing as notably as they do. Rather did he regard its fracturing as having been the resultant of a chaotic complication of dislocations. Believing that its supports had been withdrawn during the convulsive movements of the plastic strata, he assumed in his homely phrase that "the bottom of the Yosemite dropped out." When pressed for further evidence to support his theory, he could show no conclusive, concrete indications of such complex fissuring and faulting, but reasoned in rebuttal, that pressure from the mile high rock-masses above had so united yielding materials, subsequently transported by erosion, that all the traces of fracture had been lost.

Professor Whitney was most positive in his idea that denudation had but little affected the formation of the walls of the valley or its domes. Had there been a considerable amount of erosion, its evidence would have been piled up in masses of débris along the course of the Merced River. "No ordinary denudation moulded the domes," he declared. Instead, he insisted that the Sierran domes of granite were fashioned in a series of concentric layers while the igneous rocks were cooling.

Associated with Professor Whitney was young Clarence King, who later won fame as the chief of the United States Geological Survey. King was the first to trace the courses of glaciers down into the Yosemite Valley. He called attention to the beautifully-polished surfaces gleaming above the floor of the valley and pointed out four distinct moraines, one between Half Dome and Washington Column, a medial moraine between Tenaya Creek and the Merced River, a third, lingering in the gorge of the latter stream above the Happy Isles, while a fourth forms an imposing barrier below the narrows where the Cathedral Rocks approach El Capitan. Clarence King did not claim that ice filled the Yosemite Valley, but he declared its maximum depth to have been about 1,000 feet.

When John Muir first explored the Sierras, some forty-five years ago, he became imbued with the belief that the carving of the Yosemite had been effected almost entirely by ice. His earliest contributions to the literature of science and of the Sierras was a series of papers in which he endeavored to show how a vast sheet of ice, forty or fifty miles in width, cut across the crest of the range, quarrying for thousands of feet down through more friable formations; or enveloping and sweeping over the harder masses of granite, leaving striated and polished domes in the wake of the congealed flood. Muir attached great significance to the "hanging valleys," cut off abruptly by precipices, two and three thousand feet sheer. To this glacialist, their only logical explanation was that a great plow of ice, shod with sharp abrasives, had furrowed the main valley below to untold depth. All the wealth of scenic wonders for which the Yosemite region is so famous, he contended had been chiseled by grinding glaciers. Tracing the tributaries of the San Joaquin, Merced and Tuolumne Rivers to their fountains of perpetual snow, he discovered, during the seventies, no less than sixty-five surviving glaciers still busy at their lapidary labors.

Professor Whitney at first credited the discoveries of Clarence King, referring in his report of 1865 to the fact that "King and Gardner obtained ample evidence of the former existence of a glacier in the Yosemite Valley." But, five years later he reversed his decision, de-

North Dome of Concentric Granite Formation 3,600 Feet Above Merced River.

claring, that "there is no reason to suppose, or at least no proof, that glaciers have ever occupied the valley or any portion of it. . . . A more absurd theory was never advanced than that by which it was sought to ascribe to glaciers the sawing out of these vertical walls and the rounding of the domes." At the same time, Professor Whitney was thoroughly convinced that the Tuolumne watershed to the north had been entirely filled by a gigantic glacier which he agreed had hewn out the Hetch Hetchy Valley, a miniature Yosemite situated twenty miles northwesterly and three hundred feet lower in altitude.

An able ally who came to the aid of Professor Whitney was the noted glacialist, Israel C. Russell. Detailed by the United States Geological

Survey to study the eastern slope of the High Sierra and particularly the basin of Mono Lake, he devoted several summers during the early eighties to extended observations of the adjacent region. Although he mapped the ramifications of a vast system of Quaternary glaciers, flowing down from the cirques of the Snowy Range, he adopted *in toto* the theory first advanced by Professor Whitney that dislocations of the cross-fractured granite, comprising the former bulk of the Yosemite Basin, had caused the orographic block to subside to an unknown depth, forming an appalling abyss.

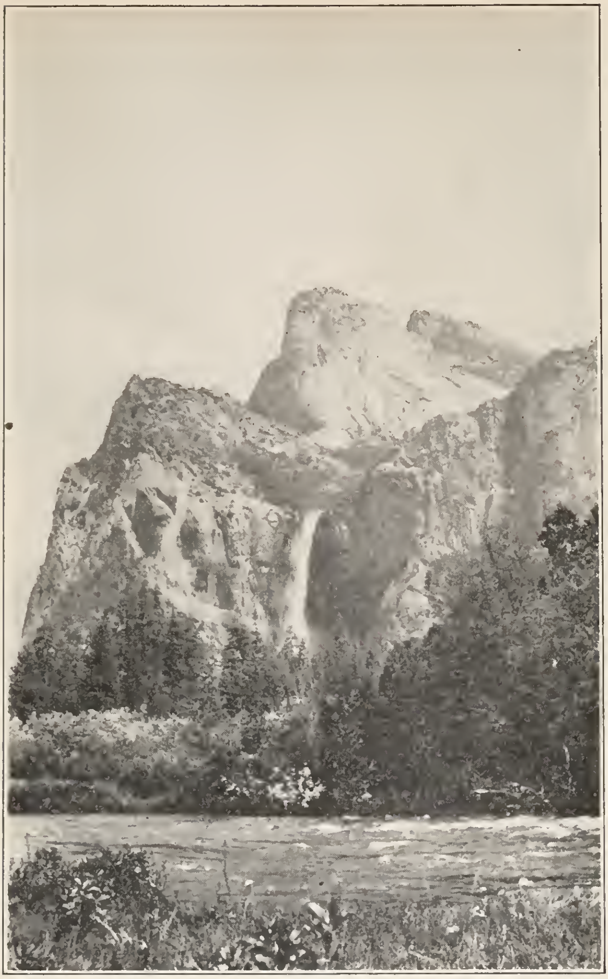
"Those who seek to account for the formation of the Yosemite," Professor Russell wrote, "by glacial erosion should be required to point out the moraines deposited by the ice streams that are supposed to have done the work." It is evident that he did not seriously consider the four reputed moraines on the floor of the valley which King first discovered. "The glaciers of this region," he continued, "were so recent that all the coarse débris resulting from their action yet remains in the position where it was left when the ice melted." In reply to this reasoning, John Muir insisted that sufficient time had elapsed since the recession of the glacier from the Yosemite to permit the disintegration of most of the detritus and its transportation to the lower levels by the Merced River. And Mr. Muir has strengthened his argument by demonstrating the rapidity with which aqueous and aerial agencies transform loose granite into sand. The extreme depth of the alluvium in the San Joaquin Valley far below is undeniable evidence of the decomposition of thousands of cubic miles of igneous rock, crushed by the mills of the glaciers and conveyed by the ground-sluices of the streams. A general conclusion reached by Professor Russell was, in his words, that

> The main work of sculpturing the Sierra Nevada and the production of the variety of scenery for which these mountains are remarkable is to be attributed to water erosion; while only minor features, such as the rounding and broadening of the bottom contours of valleys, the smoothing of the higher mountain slopes, the polishing and striation of rock surfaces are to be referred to glacial action.

Still, the relative importance to be attached to each of the several agencies at work in this wonderland remains to be estimated accurately by the geological engineer.

Le Conte and Later Investigators

Joseph Le Conte, the eminent geologist, author of the "Elements of Geology," a standard manual for two generations, was one of the first to survey the valley with the vision of an engineer. In his "Ramblings in the High Sierra," an account of his first visit to this region in 1870, appear his preliminary observations. His practical eye discerned the peculiar petrography of the walls of the Yosemite. "Already, I ob-



Bridal Veil Falls and Typical Hanging Valley. The Three Graces in the Background.

serve," he notes, "two very distinct kinds of structure in the granite of this region . . . which determine all the forms about this wonderful valley, . . . the concentric structure and a rude, columnar structure, or perpendicular cleavage." By these differentiations he traced the sculpture of every ragged spire or rounded dome. Later, he confirmed his observations by demonstrating the effect of dynamic forces upon the separate formations, showing the processes of sculpturing, whether by quarrying along the least resistant lines of perpendicular fissuring, or the exfoliation of concentric layers of onion-like granite. Coming in close association with John Muir, he accepted his theories of glacial erosion. Following the ancient trough of the grand Tuolumne glacier, he traced its tangential branch which overflowed southward and poured its powerful volume down the deep-gashed gorge of Tenaya Creek into the Yosemite Valley. Professor Le Conte estimated that the main Tuolumne glacier ranged in thickness from a thousand feet in the upper meadows of the modern stream to half a mile in the brimming basin of the Hetch Hetchy. Its length he measured as having been fully forty miles. In the upper canon of the main Merced, Le Conte and Muir studied the striations of grinding ice recorded on every outcropping surface, particularly in the "hanging valley" of "Little Yosemite." Together with the Tenaya glacier, the Merced River of ice mingled at the upper end of the Yosemite Valley, proper, to form a grand glacier which Le Conte believed was the most potent factor in the carving of the U-shaped trough of the Yosemite. And, despite the doubts of Whitney and Russell, Le Conte pointed as *prima facie* proof the remaining medial moraine at the base of Half Dome near the junction of the two reputed rivers of ice.

Several Geological Survey parties have been sent to solve the riddle of this Sphinx of the Sierras, but still no explanation of the origin of the Yosemite has won the general recognition of geologists or reconciled their differences of opinion. Mr. Francois E. Matthes, of the Survey, in his recent monograph, "The Origin of the Yosemite and Hetch Hetchy Valleys," approaches the problem along the following unbiased lines of logical observation and deduction. Like Le Conte, he lays great stress upon the phases of erosion in the more fissured zones. He accepts the general theory of the uptilting of the Sierra block during the late Tertiary period by volcanic levers, but gives little credence to the subsidence dictum of Whitney. As an ardent advocate of the glacial theory, he traces the apparent agency of ice in the evidence of over-deepened rock-basins and quarried canons like the steep gorge of Tenaya Creek. This striking instance is a graphic illustration of the excavation of a yielding mass of perpendicular cleavage set between walls of massive and adamantine granite. In brief, he argues that the Yosemite and Hetch Hetchy Valleys have been developed by an early system of rapidly-eroding streams; then "greatly deepened and enlarged by repeated ice invasions which modelled in the rough. The finer fashioned details of diversified sculpturing he attributes to more recent aqueous agencies and fracturing by frost and aerial forces. Far the most convincing evidence of the former glaciation of the Yosemite Valley he finds in the apparent scooping out of the rock-basin of the Yosemite to the depth of approximately 500 feet. This is confirmed, he contends, by the absence of sills of bed-rock, such as are usually seen outcropping among ordinary watercourses. Another important factor in the leveling of the floor of the valley he sees in the signs of several advances and recessions of terminal moraines across the bottom of this basin, in which process they were arranged in local ridges at frequent intervals. The most conspicuous terminal moraine is that which still

WEATHERING OF CONCENTRIC LAYERS OF GRANITE DOMES.

remains below the base of El Capitan, and which he believes dammed the downflowing waters and formed a lake six miles in length. Subsequently, sediments filled Lake Yosemite until they made the entrancingly beautiful meadows of to-day. A continuation of this process is now beheld in the outgrowing delta of Tenaya Creek which gradually is encroaching upon Mirror Lake.

Messrs. Matthes and Calkins of the Geological Survey have intimated to the writer that the forthcoming report of their latest reconnoissance will endeavor to prove that the Yosemite Valley was produced almost entirely by various forces of erosion as revealed by their investigation of the influence of corrasive forces upon the fissured zones of granite. They are now looking for such concrete evidence.

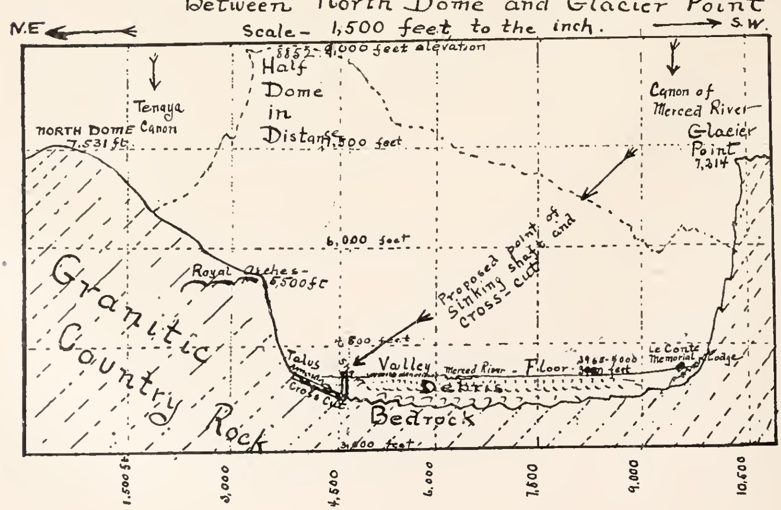
CONCLUSIONS BASED ON CONCRETE FACTS

In this summary of the several theories of the genesis of the Yosemite, the general drift of their method of presentation has been to lead to a few conclusions based on concrete facts. But, perhaps, the first and most logical conclusion is that the evidence is still far from being complete. Local geologists, however, have much faith that some new discoveries are about to be made public by the government investigators. The absence of rock sills outcropping along the rim of the valley has been explained as being due to their overburden of detritus. And yet there are reasons for believing that the solid bottom of the Yosemite did actually subside during the period of upheavals and dislocations. The enigmatic formation of the domes suggests the expansion of plastic masses of igneous rocks. If these waves of stone once swelled to such stupendous heights, there must have been intervening troughs. And so, the original sinking away of the valley floor along the lines of cross-fracture still is obvious to many competent observers.

The present-day frequency with which great joint-blocks of granite give way in weathering, or from earthquake shocks, and fall to talus still suggest the subsidence hypothesis of Whitney.

A compromise, composite theory may now be advanced. Consideration of all the evidences of the structure and sculpture of the Yosemite region will justify the premise that during the upheaval of the molten granitic magma, domes swelled in rounded masses to much their present form, cooling in concentric layers, which were later exfoliated by aqueous and glacial denudation and aerial forces. Between these domes, the trough of the stone wave, faulted and cross-fractured along cleavage planes, formed the original floor of the Yosemite Valley. Subsequently, the tilting of the Sierra range caused the carving of the usual form of V-shaped valleys. Then, during the Quaternary period, down plowed the glaciers scooping out the bed-rock, sapping and scoring the walls of the valley, and leaving their moraines as mementoes to remind mankind of their ancient estate and power. But these moraines are either so wasted or considerable that much doubt is still entertained as to their extent. If erosive forces carved out the mile-deep Yosemite, the question of the transportation of the detritus is still to be raised. The comparatively lightly-covered bed of the Merced River below the valley does not indicate the accumulation of any immense amount of detritus. Only by extremely fine comminution of boulders to silt could this immense mass be almost completely carried away. There is every evidence that a glacier reached the floor of the Yosemite Valley, but the extent of its quarrying is still unknown. Whether by direct grooving, or by undermining the overhanging escarpments, it unmistakably transformed the canyon's V into a broad,

Cross Section of Yosemite Valley
Between North Dome and Glacier Point



U-shaped valley. As the glacier receded, torrential streams cut into the glacial moraines, changing the vicinity of the upper reaches of the Merced into more angular surfaces, with the ultimate purpose of eliminating U and substituting V.

After all the theories have been advanced, their truth or fallacy will remain a matter of conjecture until the underlying facts are brought to light. Buried far below the flowery meadows and boulder overburden lies the unseen, pristine bed rock. Graven on tablets of stone in indelible characters is the key to the cryptic cipher of this Sierran Sphinx. The mining geologist is more practical than academic. He would prospect the floor of the valley to unearth that hidden key. Therefore, he would advise the sinking of shafts down through the sediments, ascertaining their character and striking the sunken sill. Following the rim of the latter for a short distance, the miner-geologist would soon determine in finality the genesis of the Yosemite Valley. If this deep basin was once shattered by a cataclysm, causing the falling away of an almost bottomless abyss, the zones of its marginal fracturing could be definitely discovered. Or, if overdeepening of the bed rock by the abrasive-shod plow of a glacier be the true cause of its carving, the striated strata and the morainal drift will tell the tale. Stream-erosion will also be revealed to its exact extent. Therefore, it would seem that no appropriation for the researches of the Geological Survey in this region can be expended to better advantage than by prospecting in miner-like fashion for the hidden truth of the making of this great natural wonder. That this practical idea meets with the approval of the Geological Survey party is shown by a recent expression by Mr. Francois E. Matthes in the Sierra Club Bulletin. "It is to be hoped that some day such borings may be undertaken; they would not merely serve to solve a problem of great local interest, but would contribute much-desired data regarding the still-challenged eroding efficiency of glaciers."

The Yosemite at the Exposition

One of the most interesting features of the federal government's participation at the Panama-Pacific International Exposition will be the presentation of a large relief model of the Yosemite National Park. Cartographers of the United States Geological Survey are putting the finishing touches on this miniature of the Yosemite Valley and its surroundings. They will show its stupendous steeps and glaciated basins as vividly as though viewed from an aeroplane. Every visitor to the Exposition who may be interested in geological science will find this replica replete with fascinating details carefully set forth.

Buffalonians laid special stress upon the nearness of Niagara Falls to the Pan-American Exposition. Likewise, Californians take great pride in their unique wonderland, the Yosemite National Park. It can now be reached by train and auto stage in a dozen hours from the Exposition City. The Department of the Interior is spending large sums in putting this great public playground in order for the enjoyment of probably 100,000 visitors who will view its glories in 1915. Few there are who have not dreamed of making a pilgrimage to Nature's most awe-inspiring shrine at least once in their lives. Tourists to the Exposition at San Francisco will have the double opportunity of seeing all of its varied attractions and at the same time include the Yosemite in their itineraries. With notably reduced rates to the Pacific Coast throughout 1915, they will have the chance of a life time to see the Yosemite and other scenic wonders of the west under the best possible traveling and tarrying conditions. The riddle of this Sphinx of the Sierras is still far from being solved; therefore, geologists will find an unlimited field for special investigations and study following in the footsteps of John Muir and Joseph Le Conte.

GRAPHICS OF THE AMERICAN WHALING INDUSTRY

BY DR. J. ARTHUR HARRIS

CARNEGIE INSTITUTION OF WASHINGTON

RECENTLY in connection with another piece of work, I found it desirable to express graphically various phases and factors of the rise and decline of American whaling.

In these graphs nothing is added to the facts recorded by Scammon, Starbuck, Goode, Tower and others who have investigated and written on the economic phases of the problem, and from whose tables the various diagrams have been compiled. But the graphical treatment seems to bring out so forcefully some of the points of greatest biological and economic interest concerning the remarkable development and decline of the once great and now insignificant industry that I have ventured to offer them for publication, with a few explanatory remarks.

In Fig. 1 the abscissæ are years from 1805 to 1905, while the ordinates are marked off by the total tonnage[1] of the whaling fleet.

Here are clearly shown (*a*) the vascillations in size of fleet during the first few years of trial and establishment of the industry, (*b*) the depression associated with the war of 1812, (*c*) the phenomenal growth of a quarter of a century made possible by the unrestrained exploitation of ocean-wide resources up to the maximum point where there were over seven hundred vessels aggregating over two hundred and thirty thousand tons and valued at over twenty-one millions, (*d*) the temporary fluctuations when the industry had reached its crest, (*e*) the precipitous fall due to the depletion of the resources of the seas, to the risks and losses of the great war, and to other causes, and finally the decline which followed more slowly with the restoration of safety, but inevitably as almost every product of the whale except the bone was replaced by those derived from petroleum.

The curve is remarkable for its regularity and for its similarity to a biological variation polygon—to the normal or "Quetelet's" curve. Indeed, the factors to which the form of the curve is due are in large part biological, although economic and social forces are also patent.

Some of the minor irregularities are doubtless due to the unavoidable inaccuracies in the data. Apparently, the depression in 1850 and '51 is a real one; the revival of the industry resulting in the second mode

[1] Number of sail which in 1846 reached 736 would be interesting for comparison, but the data are not available for so wide a range of years.

on 1854 is probably due to the opening up of the bowhead whaling of the Okhotsk Sea, possibly by Captain Freeman Smith, of the ship *Huntsville* of the Cold Spring Harbor fleet, and of true arctic whaling by Roy's voyage through Behring strait in the bark *Superior* (275 tons), of Sag Harbor, L. I., in 1848.

In diagrams 2–4 the products of this fleet are represented for the various years. Here barrels of whale oil and of sperm oil and pounds of

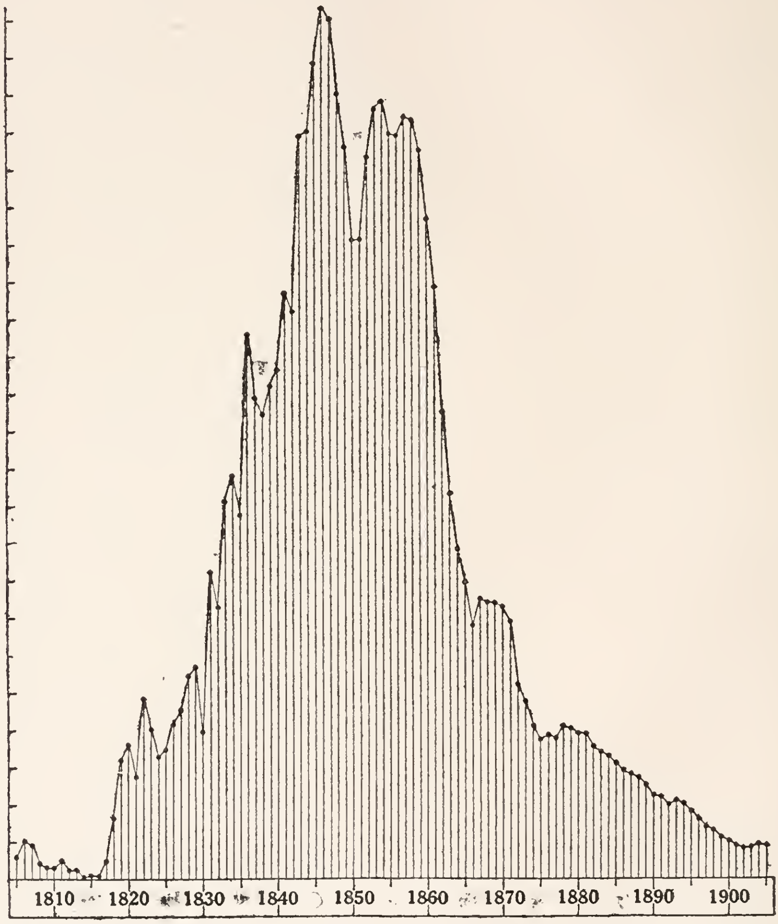


DIAGRAM 1. TOTAL TONNAGE OF AMERICAN WHALING FLEET, 1805–1905. One unit on the vertical scale denotes 10,000 tons.

bone are marked off on the vertical scale for each year. In general form the curves for all three products resemble that for tonnage. There are, however, certain distinct and conspicuous differences.

First among these, one notes the great variations from year to year in the quantity of products brought in—fluctuations which show the great uncertainty which surrounded the industry. This is most conspicuous for whale oil: it is almost equally marked in the case of whale bone after the latter came to be of considerable commercial importance; for sperm oil too it is unmistakable.

The most remarkable drop is that for whale oil and whale bone in 1852. Doubtless, this is in part due to unfavorable years, but it is probably also an after-effect of the reduction of the fleet seen in 1850 and 1851—a reduction the effects of which would not be seen until at least a year or two later, when the vessels would be returning with their cargoes.

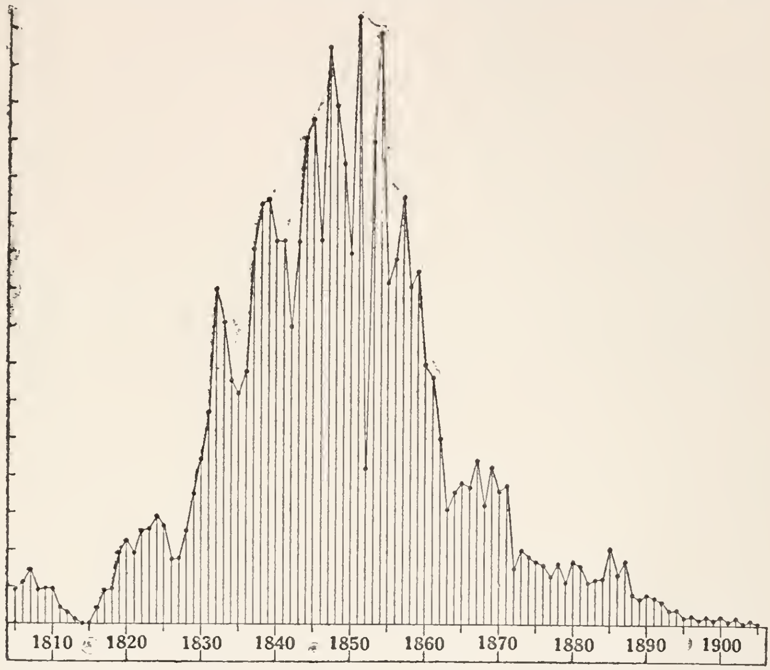


DIAGRAM 2. WHALE OIL, BROUGHT IN BY AMERICAN FLEET. Unit for ordinates = 20,000 barrels.

That the depression does not affect the sperm-oil curve is perhaps due to the fact that the sperm whales might be taken at any part of the voyage —not merely on closely circumscribed "grounds" during a limited "season."

The curves for whale oil and sperm oil differ in certain important points. Except on the "tails" of the curves the imports of the more valuable sperm oil are far in defect of those for whale oil. Probably in consequence of the greater demand the source was earlier exhausted. The mode of the sperm-oil curve lies, in consequence, nearer the inception of the industry, and the curve is therefore far more skew. It is interesting to note that in more recent years, the imports of sperm oil have been maintained at a relatively higher point than has that of whale oil. It is quite outside my present purpose to discuss the reasons for this.

For many years, bone was of very little commercial importance. The entries for bone lie close to the base line up until about 1830, after which the imports are on a rising curve until the decade 1845–1855, after which it steadily declined notwithstanding a phenomenal increase in prices—an increase amounting to somewhere between *five thousand and ten thousand per cent. during the course of the century!*

Curves for the prices of oils need not be added. They of course show the sperm oil constantly higher than whale oil, with both showing considerable vacillations for about the first half century of the period here

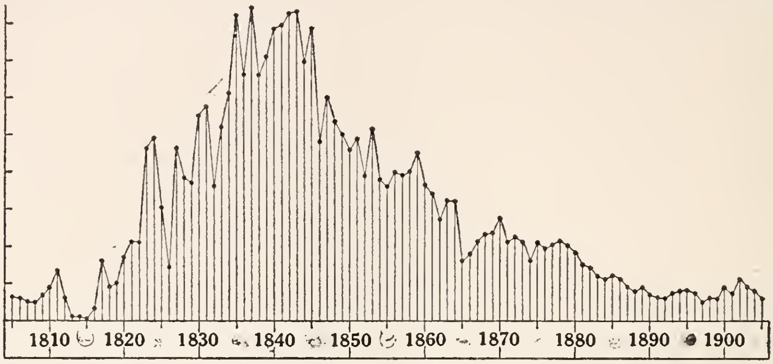


DIAGRAM 3. SPERM OIL BROUGHT BACK BY AMERICAN FLEET. Scale for ordinates the same as in the case of whale oil.

DIAGRAM 4. PRODUCTION OF WHALE BONE. Unit of scale = 500,000 pounds.

under consideration. At the time of the Civil War, with the whaling fleet rapidly decreasing and many of the vessels still in the service lying idle, the prices mounted high; but this was also the time of the establishment of the petroleum industry, by the development of which the fate of whaling was sealed. The prices gradually fell until in spite of the scarcity of the products they reached almost the level of those that prevailed when the industry was at its height.

COLD SPRING HARBOR, L. I.,
January 20, 1914

THE BAD HABIT OF HAVING LAW MAKERS AND LAWYERS

By JOHN COTTON DANA

NEWARK, N. J.

IN the process of social development early societies invented certain customs and institutions to satisfy certain more or less well-defined needs. That is to say, all customs and institutions have had their origins, in part, in sheer utility. All of them were therefore good; for they all helped, if they did nothing more, to establish and maintain that social stability which is a prime essential to progress. It is probable that we owe our present advanced position to cannibalism in precisely the same sense, though not necessarily in the same degree, in which we owe it to slavery, to polygamy, to autocracy, to monogamy and to property in land. At certain points in society's advance one and all of these customs were demanded by circumstances, were developed and gave humanity an uplift.

These several customs were adopted by social groups of a relatively low order. They were beaten out, as it were, by pressure of adverse circumstances, under the guidance of the barbarous and the semi-civilized. Crude as are many of our methods of so modifying our own customs as to meet wisely the changing conditions of our social life, the methods used in early days were very much cruder. The results were unsatisfactory. Cannibalism was doubtless a helpful custom in its day; but was not good for all time and in due course was abandoned. Slavery was more useful and for a longer period. It even helped bring to full flower a very refined civilization. But it demonstrated its own ill effects and was duly abandoned.

It is obvious that in all customs established in the early days of primitive society there are defects. Having been devised in a society of the socially unskilled they must all partake of a certain coarseness and crudity, and they must have fitted but ill the needs for which they were devised. If one of them by rare chance proved perfectly adapted to its purpose in the society for which and by which it was fashioned, it could not possibly fit the far more advanced and far more complex society into which the crude society gradually developed.

Now the law, meaning the power behind the law; and the law, meaning both rules given by legislators and judges and legislators and judges themselves; and the law, meaning the technique of its alignment as practised by a privileged class, the lawyers—the law in all these three forms or aspects, is a social eject of extreme antiquity. It is one of those ancient folkways, whose ancestry bespeaks its imperfections and whose close kinship to other folkways, long since found injurious and sloughed off, prophesies for it a like fate. It is an ancient and imperfect tool, retained thus far partly because it is still of some use in our still very imperfect society, and partly because its harmfulness is not yet fully recognized. It never fitted perfectly the purpose which it is supposed to serve. It fits less well each succeeding generation and works upon each more and more harm.

If it is said that the law in its three-fold form differs from all other institutions in that it underlies them all; that the sum of all habits is the very law itself, this answer is offered:

We speak of the bad habit of polygamy, of the bad habit of cannibalism, of the bad habit of having slaves; and we speak in the same way, and with as little thought of law, of the bad habit of having absolute monarchs. Now, the absolute monarch is the source of all law. In theory, he states it, aligns it and enforces it. Yet we conceive readily of the habit of having an absolute monarch as a bad habit, to be in due course given up.

It is precisely upon this thought of the law as a bad habit that this argument for its harmfulness is based. It was essential in a certain stage of social development that one man should rule a tribe, just as it was essential that the same tribe should eat its neighbors. It was essential that a few men—kings, nobles or what not—should rule a nation, just as it was essential that that nation should make slaves of its neighbors. It was, and in a sense still is, essential that the majority of a nation should rule the minority; just as it was, and in a sense still is, essential that the same nation wage perpetual commercial warfare with its neighbors.

Now the king, the aristocracy and the majority are each and all of the essence of the law; the cannibalism, the slavery and the commercial warfare are not. Formal statements of the existence of the latter institutions, if such were made, might be called laws; and kings, aristocracy or majority may be said to have enforced them. But the difference between them and the first three is that they are not thought of as touched with legality, with the majesty of law-givers and courts. They may be thought of directly as evil customs working harm to those who practised them. And just as we may think of having cannibalism or slavery as bad habits, so may we think of having a king or an aristocracy or a ruling majority as bad habits.

The first aspect, then of the law as I defined it—kingship, rule of man by man—is itself a habit and not an aggregate of all habits. It was born to fill a certain need, and was therefore good; but it was born of the ignorant and socially inept, and is therefore bad. Like other ancient devices, it is outliving its usefulness. Our native conservatism holds it fast long after its evil results have begun to outweigh its good results.

As to the laws themselves, being the second aspect of the law as defined, that these are full of harm is universally admitted. Ten thousand new ones are yearly made; and straightway ten thousand more are made to modify and ameliorate the first ten thousand. We confess by their constant revision and repeal that we find the law-making habit persistently injurious.

As to the law-makers themselves, they are, like kingship and cannibalism, survivals of an ancient device. The primitive tribe which conquered had learned to obey, else it had not conquered; obedience meant conformity to rules; the rules were set down by others, not by those who obeyed them. The habit of having rules which others made had its advantages. Naturally we have held fast to the habit. And now, though better equipped than ever before by virtue of our racial experience, our individual training and our inherited tendencies, to guide ourselves wisely, we hug to ourselves too closely still the bad habit of having law makers. We are to-day strengthening the habit's hold upon us instead of weakening it.

That our lawmakers can not be otherwise than blunderingly if not maliciously harmful seems a foregone conclusion, if we consider, not their origin, but merely the manner of their selection. We do not pick them for proven skill in guidance, for experience gained as leaders in great social enterprises, or for their mastery of the problems of modern society—not at all. We do not even invoke in their selection the aleatory gods and submit our legislative fortunes to the unprejudiced decisions of a hatful of black and white beans. We do not select them with the aid of signs and omens such as are granted by the flight of birds or the entrails of hens. The last two methods would have some of the advantages of chance, for they would, if honestly conducted by a government priesthood, occasionally point to a man peculiarly well fitted for the task of law making.

But while the choice of our law makers is not determined by sacrificial inspection, it is accompanied by ceremonies and incantations of a quasi-religious nature; and it turns often on the relative persistence of the several candidates in the repetition of certain formulæ and the honoring of certain taboos. The law-maker group, like the group of privileged specialists in the technique of the law's action, the lawyers, derives itself from the king as high priest, and its work, as maker of laws, has a strong ecclesiastical and even a religious flavor. This is almost more true of the judge as law giver than it is of the legislator proper. The judge seems the more direct of the two in his descent from the god-given king. About his position and his utterances there is a special odor of sanctity. While both are in large degree taboo, the greater relative sanctity of the judge is illustrated by the fact that one may quite openly condemn a legislator, or even a legislative body as a whole, and be not greatly criticized therefor; whereas openly to condemn a judge, *qua* judge, shocks certain of our quasi-religious sensibilities.

This very ancient and now quite harmful habit of ascribing a certain sanctity to law makers means that we tend to look upon them with a certain religious reverence and submission. In further accordance with this habit we select our law makers primarily or largely for their adherence to a creed and for their activity in securing converts to that creed. The intrusion of those elements of religious enthusiasm, which make for the destruction of all judicious decision, into the work of selecting our law makers is alone sufficient reason for the conclusion that they must do us much harm.

The habit of having, in the alignment of the rules the king or the majority enforce an elaborate technique, practised by a privileged class, the lawyers, has a peculiar harmfulness.

The habit of having kings, or law-enforcers in any form, and the habit of having legislators or other kinds of law makers, are both survivals and both are doing injury through their failure to fit the more civilized communities which still retain them. But both were once quite essential to progress, and seem still to possess advantageous features, even to societies as advanced as our own. The tribal chief and abject obedience to him were once quite important factors in the struggle for tribal survival. In later forms of society it was as important that the elders of the tribe lay down rules adapted to changing conditions as it was that the grand chief enforce them. That is, the habit of having laws made, and the habit of obeying the one who was there to enforce them, were once quite markedly helpful habits and have some excuse for survival even down to our own day. But for the habit of having a privileged class in charge, as it were, of the technique of the distribution of the effects of the law, of this not so much can be said.

The origin of the lawyer-having habit at once discloses to us a sufficient reason for the power and persistence of the custom of making him a privileged member of society, and points also to its harmfulness.

The tribal chief of early days took on, from his earliest appearance, certain ecclesiastical trappings and powers. He was often a god himself, either during his life or immediately after his death. He was often chief priest as well as head man. The priestly class which grew up about him performed the accustomed sacerdotal rites, led the people through the mummeries of the tribal religion, took on much of the sanctity which custom gave to the head man himself, and, inevitably, became a specialized class with peculiar powers, immunities and dignities.

The fact of the descent of the lawyer class from this priestly class is familiar enough. The lawyer's special privileges have descended directly from those enjoyed by medicine men and priests who surrounded the tribal leader and helped him to exercise his more god-like functions and shared his god-like prestige. The habit of having a privileged priestly class was never as distinctly helpful to the tribe as were the king habit and the rules-of-conduct habit, and it was also, from the very nature of its origin, inevitably touched with a power for harm which just as inevitably increased as the social organism developed, expanded and became more sophisticated. In so far, therefore, as the lawyer caste of to-day takes its peculiar and exclusive powers from its direct precursor, the priestly caste, so far is it predestined to harmfulness.

And in so far, again, as it takes its special powers by direct inheritance from a quasi-ecclesiastical source, so far is the habit of tacitly granting those powers guarded with a quasi-religious zeal by those, the ignorant populace, who hold it. The divinity that was once of the very essence of the tribal chief, hedges still the kingly majority of the present social hierarchy and that majority's priest-born, privileged law exploiters. The creed of the devout believer in the efficacy of the law in all the aspects of it I have named—the law enforcer, the law maker and the law exploiter—this creed includes by implication, if not in so many words, an article declaring the divine origin of the power of those who give, those who enforce and those who align the law.

Inevitably, in view of its origin and character, the lawyer class forms the most powerful and self-assertive of labor unions. It is the most powerful, for it has behind it the authority of both the law-enforcing and the law-formulating powers. Indeed, it is itself, as already shown, the third in the trinity of powers which constitute to-day the whole of that habit-of-having-the-law which was once the habit-of-having-an-autocrat. A labor union, possessed of some of a ruler's supreme authority, of necessity becomes, in accordance with well-known laws of human nature, arrogant, overbearing and prone to serve its own personal ends at some sacrifice of the ends for which it was constituted. For an example, one may cite that habit of procrastination in which the caste still indulges in the exercise of its functions, a habit the painful effects of which an elaborate ritual and an esoteric terminology tend somewhat to mystify but not at all to mitigate.

Gaining its authority and its sanctity largely from a remote past, being desirous of retaining both, and feeling that both are accentuated by constant reference to their ancient and noble lineage, the lawyer caste draws constantly for its pronouncements not on the merits of the case in hand, but on the whole body of ancient doctrine. Herein this caste resembles its foster sister, the ecclesiastical group; but while the latter is moved constantly to look forward, if not by the good sense of its units, then at least by the pressure of internal competition, the former is supported in its enjoyment of reminiscence and its scorn of evolution by the whole law-having habit of which it is a part.

In one aspect of the special powers of the lawyer class we find an astonishing survival of a rather special ancient custom. The tribal chieftain surrounded himself with satellites, priests, kin-folk and courtiers. He was compelled to delegate to these the exercise of some of his functions. It suited their needs to make it difficult for the common people to approach him and present their petitions and their grievances. In time it became the custom for the wealthier and more influential of those who would get word with the chief, or would, through his immediate friends, gain favor from him of a promise, a gift or a decree, to purchase, outright or indirectly, the help of an intermediary. This custom was handed down, became fixed in its details, and survives to-day in the lawyer's fee. Now as in the early days of this custom, a person specially authorized for the purpose stands between the faithful and the law-enforcing power. One may almost say that we license the door-keepers of the halls of justice and permit them to take toll of all who enter.

The chief direct beneficiaries of the survival of this law-having-habit are the lawyers. As such, one can not hope to find them zealous in modifying or weakening the habit. But lawyers are as ready as is any other special class to declare their devotion to the general welfare, and they are better situated and better fitted than is any other class to check the growth of this injurious law-having custom. And nearly all lawyers admit, when the question is of law-making by legislatures, that the law-habit is most harmful, and that it constantly grows stronger.

Ten thousand generations taught our race to love a king; we seem unable to get over the habit. We love him; we believe in him; we think he can make us prosperous, wise and happy; and when he comes to us in the guise of a legislative majority from our own political party our faith enjoys a veritable renaissance.

There was a time, say 50 or 80 years ago, when the law-having habit, among English speaking peoples at least, seemed on the decline. Then a change came, merely, one may dare hope, the inevitable temporary reaction we must always look for in such cases, and to-day we are again in the full tide of law building.

Now, are lawyers as a class attempting to check the growth of this law worshiping habit? Do they point out again and again to the populace that it is, after all, but the habit of worshiping a divinely appointed king under another nomenclature and another set of ceremonials?

In the layman's observation, they do not. They profit by the law's growing complexity. They hasten to become legislators themselves if only to equip themselves in the way of profitable legalizing.

But is there not here an opportunity for this social group, harmful in its very essence, to lessen to some degree the harm its existence causes, by attacking in an organized way this hurtful habit of worshiping the law?

HOW WE DEFEND OURSELVES FROM OUR FOES

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IN a certain sense even now in the midst of his civilized communities, mankind is waging ceaseless warfare against a number of hostile conditions, both animate and inanimate. Serious as this may be now, it must have been much more acute in the earlier times of the race.

Man had to defend himself, as best he could, from the great cosmic exhibitions of energy—the extremes of heat and cold, the tempest, the lightning, the avalanche, the earthquake and the tidal wave. Primitive man, we are assured, must have lived in the midst of alarms of all sorts and in the constant dread of attacks by fierce animals far more powerful than himself. Undoubtedly he sought shelter from wind, rain, snow and frost in those caverns in which his skeleton and the bones of the animals he slew for food and fur are yet to be found.

In many parts of the world he built his wooden hut on piles out from the shore of some lake, so that he had his food supply in the fish under the floor, and was also more secure against the wild animals when his dwelling had to be defended on one side instead of on four.

The latent powers of his nervous system permitted him to develop that speed of running in flight whereby he saved himself from the avalanche, the tidal wave or the beasts of the field. Not alone was speed necessary, but also rapidity of response on the part of his nervous system in order to take warning from the impending danger: that man lived longest who most rapidly reacted to the danger signal, stepped most agilely out of the way of the rolling boulder, skipped most briskly aside from the infuriated lion or bear.

Of course, as we know, he early devised his weapons of offence and fired his flint-tipped arrows at the animals threatening his life or destined to be his store of food for a long time to come. That man throve best who most accurately threw his stone or javelin, so that quickness of response (short "reaction-time") and accuracy of aim—both powers of the nervous system—were early in the history of our race the means of escape from enemies, or the mode of procuring a sufficiency of food.

The first human line of defence is then nervous or mental; our ancestors established themselves on the earth by means of such powers of the nervous system as speed, accuracy and coordination of movements; and these are of supreme importance even yet. He who jumps quickest out of the way of the runaway horse escapes with his life; the old gentleman, whose reaction-time age has lengthened, does not step aside from the carelessly driven motor-car sufficiently perfectly, and so gets run over. Those men who after harpooning the whale got their boat most quickly out of the reach of his tail, were most likely to reach the big ship in safety. He burns his fingers least who most rapidly drops the hot coal.

While, now-a-days, shortness of reaction-time may only occasionally contribute to the actual saving of life, yet it does assuredly contribute towards what is called "success" in life. He who most quickly grasps a situation of danger and acts accordingly, has an advantage over his neighbor with the more sluggishly reacting nervous system.

It is obviously by his development of intelligence—a power of the nervous system—that man has not only conquered nature, animate and inaminate, but has learned to use its forces, even the most hostile, in the interests of his own comfort and prosperity.

Our first line of defence is, then, mental; and the elements of time and precision are all important.

We have, however, to reckon with foes far more subtle and more often met with than the thunder-bolt, the lion, the bear or the electric eel. In some parts of the world, the living things that can poison us are very numerous—venomous snakes, scorpions, countless insects, all ready to pour their poison and acids into our skins. Mankind has learned that alkali will neutralize their acid, and has in these latter days discovered how to manufacture an *antivenin* to counteract the venin or venom of the serpents.

We fight chemical injuries by chemical means. But all these sources of danger or injury are insignificant compared with those which are absolutely and forever beyond the ken of our senses. In common with all other living things, we are surrounded by parasites and preyed upon by them continually. It seems a law of animate nature that any given living thing, vegetable or animal, should have its particular parasite or parasites. For even the vegetables have parasites: the potato has the potato-blight, a fungus; the vine has its phylloxera, another fungus, and so on. The lower plants prey on the higher, the higher on the highest. Fungi and moulds are parasites on both plants and animals. Animals are parasitic on plants: grubs eat the roots and the buds of flowers, the aphides destroy the roses, the Colorado beetle devours the potato. The gooseberry moth strips the leaves off the gooseberry plant; the oak has its galls, everything its blemishes. To such an extent is all this recognized now-a-days that a department of botany, economic vegetable parasitology, has arisen within the last few years. Expert botanists are studying the conditions under which these pests appear and therefore how we may either guard our flowers and food-vegetables from their ravages, or remove the parasites when once they have settled on their victims. The loss to farmers, fruit-growers and horticulturists each year through parasites is enormous.

Fungi and moulds are parastitic on animals as well as on vegetables; the salmon has the fungoid salmon disease, the grouse has the bacterial grouse disease, the barn-door fowl has its cholera, the swine have swine-fever, the cattle have anthrax and Rinderpest, horses "glanders" and so on.

Then animal parasites infest animals; the frog's lung harbors certain lowly creatures known as Gregarinidæ; dogs, cats, pigs, horses, all have their intestinal parasites, from which obnoxious worms man himself is by no means exempt.

Host and unbidden guest, victim and parasite—this inter-relationship runs through the whole of living nature; it is not the exception, it is the rule. Nature has indeed provided for it; the intestinal worms of the horse have actually developed an *anti*-ferment which prevents their being digested by the digestive ferments of the horse's intestine.

Attack and defence, action and reaction unceasingly, this is nature's method; there is no rest; and there is no splendid isolation; we must be attacked and preyed upon and resist—forever!

A few plants and animals have taken refuge in "protective mimicry"; the dead-nettle imitates its stinging neighbor, and so is avoided by such animals as avoid the latter; some insects imitate dead leaves, twigs, etc., and so are not devoured by insect-eating birds.

But the majority of the foes that man has to battle with are far more subtle than intestinal worms or mosquitoes, or even fungi; for there are myriads of bacteria so light that they float in air even when dust settles; so small that millions can inhabit a drop of water; so numerous that arithmetic is powerless in designating them; so powerful that they have emptied cities, decimated armies and devasted continents. The mortality of the great Boer War had been a trifling thing if the English had had only to reckon with the Mauser bullets; far more deadly the typhoid bacilli than all the guns of all the Dutchmen and their allies.

It is now common knowledge that nine out of ten diseases have an actual, physical recognizable source or cause in some particular parasitic bacillus (rod-like form) or coccus (round form). Undoubtedly some diseases are due to microscopic animal forms, such as ague (malaria), yellow fever, dysentery, the sleeping sickness; but the vast majority are due to vegetable parasites of microscopic size. All those serious diseases known as diphtheria, typhoid fever, cholera, plague, tuberculosis, pneumonia, influenza, rheumatism, common cold, and infantile paralysis, have been shown to be due to the living body being invaded by countless numbers of infinitely minute rod-like or ball-like microbes.

Of course all bacteria are not disease-bringing (pathogenic); and it is well for us that it is so, for the air, earth and water teem with bacteria of some sort. Many are quite harmless and are occupied only with getting rid of dead bodies by putrefactive fermentation.

But our present concern is with our invisible foes, and we must now try to find out how our bodies protect themselves against their presence and their poisonings.

We have three chief methods whereby we defend ourselves from our invisible foes, namely, the physical, the vital or protoplasmic and the chemical.

We possess as an outermost line of defence the intact skin and mucous membranes, the horny layer (keratin) of the skin and the mucus-covered layer on the internal surfaces being impenetrable by micro-organisms.

The living colony—the entire animal—is surrounded by armor, the body is armor-plated, the keratin of the skin is the armor-plating. Once a rift occurs in the armor, a crack, a split, a crevice, an abrasion, a cut or a puncture, it matters not which, then the entrance of our foes is a possibility, nay, a probability. These rifts need not, of course, be perceptible to the naked eye, they may be barely discernible under the microscope, but they are large enough to admit bacilli, and that is all that is needed; diminished resistance within the citadel ensures its conquest. The outer surface of the teeth, the enamel, the hardest tissue known, is indeed not able to be directly attacked by bacteria, but they force an entrance just underneath it and undermine it so that it is easily broken in.

Another physical means of defence is wetness; the wet mucous membranes of nose, throat and lungs retain the dust and bacteria which stick to them. Bacteria wetted are bacteria imprisoned; it is only when dry that they can be wafted about on their disease-bringing errands.

But the mucous membranes of the nose, throat and lungs are covered with cilia.

When we mention cilia, we pass to the second or vital means of defence. Cilia are whip-like prolongations of the cells lining the breathing passages, and they are continually lashing the mucus in which they are immersed with its dust towards the mouth and nostrils. In this way the bacteria caught in the mucus are removed from the body, and thus it is that mucus containing disease-germs should be burned and not allowed to dry, and so set free its burden of bacteria. In prolonged bronchitis, these cilia are known to be absent from the bronchial mucous membrane, thus depriving it of a valuable mode of defending itself from microorganic invasion.

The chief vital agents concerned in fighting our invisible foes are the white cells or leucocytes of the blood. These minute living things are apparently exceedingly sensitive to the presence or secretions of microorganisms, for they come out of the blood capillaries shortly after the bacteria have invaded the neighboring tissues. Their mode of attack is frontal: they literally fall upon the intruders and, swallowing them bodily, digest them, so rendering them powerless for any further activity.

If the bacteria do not prove very poisonous, the phagocytes are not killed; if however, the poison (toxin) of the bacteria is a virulent one, the leucocytes are killed and their dead bodies constitute "pus," as surgeons call it, or "matter" as other people call it. In suitable preparations for the microscope it is possible to see large numbers of microbes in a semi-dissolved state inside the white cells.

One kind of leucocyte paralyzes or kills the microbes without engulfing them.

Of course leucocytes will do their work well or ill according as they are themselves in good or bad health, vigorous or enfeebled. All exhilarating conditions tend to invigorate the leucocytes, all depressing conditions to enfeeble them.

The leucocytes are, then, the second line of defence—the rank and file of the defending army. When once the outermost physical barriers have been penetrated by the enemy, these living agents take up the defence by active, offensive measures.

The third mode of defence which we possess is the power of our body-cells to manufacture certain chemical substances having the property of neutralizing the poisons of the bacteria which have invaded us. All the body-cells cooperate more or less vigorously in this the most subtle method of dealing with the soluble toxins manufactured by the bacteria now multiplying in the blood and body-fluids of the unwilling host.

These soluble toxins affect, stimulate, the tissues of the victim, which, being living cells, react, and the expression of their reaction is the outpouring of a chemical something, appropriately called an antitoxin which, uniting with the bacterial toxin, neutralizes it and prevents it exercising its injurious powers. The infected organism thus works out its own chemical salvation by a vital, but no less chemical, response to the poison of the infection. To do this efficiently is to recover, to fail to do so is to remain infected, to be injured chemically, possibly to die.

This production of antitoxin on the part of the infected body is a vital, protective mechanism of a chemical order; it is the chemical reply to a chemical insult. If the attacked body-cells can provide sufficient of this antitoxin to neutralize *all* the toxin made by the bacteria, the individual will not merely get well, but will remain immune from that particular infection for a long time, because, when once the body-cells begin making antitoxin they make a great deal more than is needed to neutralize all the toxin which the invaders have manufactured.

Hence it is that a person who has successfully come through some infectious disease, smallpox or scarlatina, for instance, can not, for some time thereafter, be reinfected with the poison of that disease; his blood contains an *excess* of the antitoxin of that disease so that any toxin of that kind happening to be produced within him is immediately neutralized. He is immune from or refractory to this infection for a certain time, it may be years. He has fought a good fight microchemically, and his tissues now rest from their labors.

Man has taken advantage of this natural chemical immunity to confer an artificial immunity on himself. When a person gets over an attack of diphtheria, it is because his body-cells, stimulated by the poison of diphtheria (diphtheritin), produced sufficient anti-diphtheritin to neutralize the poison; but it is clear that if he can get anti-diphtheritin ready made, the diphtheritin in his body will be neutralized all the quicker. He makes use of the horse. A horse, which has recovered from an attack of diphtheria and thus has in his blood plenty anti-diphtheritin (specific antitoxin) has some of his blood drawn off. If a little of this blood, specially treated, be injected into the person suffering from diphtheria, the person will recover, or if it be injected into a person about to go into the infection of the disease, that person will not take the disease. This is conferred immunity; it has been conferred on man by the horse's blood-serum.

Thus we have three kinds of immunity from infection:

I. An original, congenital refractoriness towards the disease which may be called *natural* immunity;

II. *Actively acquired* immunity, the ordinary condition of having come successfully through an infectious illness.

III. Artificially or *passively acquired* immunity, or conferred immunity, one of the latest triumphs of biological science.

All these varieties are chemical means of defence.

Coming under the head of chemical means of defence, we have the existence of an acid in the gastric juice. It is well known that when the acid (hydrochloric) is present in the stomach in the proper quantity, it is uncommon to be infected by microorganisms through the alimentary canal. The author knew of an officer who had come through a severe epidemic of cholera in the West Indies, and who, on being asked if he had been afraid, said: "I had no fear as long as I knew that my digestion was not out of order." We and the other mammals are not the only animals whose alimentary canals are guarded by a free acid; there has been discovered in the Mediterranean a mollusc (*Dolium*

Galea) whose gastric juice contains sulphuric acid. This free grastric acid is distinctly antiseptic.

We have now disposed in a certain fashion of our modes of defence against foes from without; but it is unfortunately as true in a physical as it is in a moral sense that a man's foes are those of his own household. We are liable to chemical assaults from within, whether from poisons secreted by the bacteria inhabiting our internal organs or from poisons arising from the imperfect digestion of our food. Food may have poison in it at the time it is taken, the so-called ptomaines; but poisons may be developed in it in consequence of its not undergoing its digestion in a perfectly healthy fashion. All such digestive poisons are dealt with by the liver. The liver is a very large gland placed in such a position that all the blood coming from the organs of food-absorption must pass through it on the way to the heart.

The liver deals as best it can with the poison reaching it from the intestine; in some cases, retaining it for a time, it eliminates it in an altered form; in other cases it renders it innocuous and permits it to reach the circulation whence it is removed by the kidneys. This power of the liver is known as its *de*-toxicating power. In this way is explained the well-known condition of being poisoned when the liver is "out of order." When the liver is not doing its *de*-toxicating work sufficiently well, not trapping poisons, these pass on into the blood-stream and affect the whole body; the headache and the malaise being the result in consciousness of this general chemical poisoning. Deranged digestion, then, is responsible for the production of the poisons of auto-intoxication which the liver should seize and render harmless.

The chemical defences of some people are so feeble that they are always on the verge of just not protecting them from the poisons of their own intestines, so that such persons are hardly ever free from headache. Other people suffer from periodical outbursts of poisoning associated with one-sided headache (megrim or migraine). Some of the sufferers from this distressing condition have been amongst the most distinguished in science and literature, for Haller, Emil du Bois Reymond, George Eliot and Sir James Simpson were all victims of it.

ROGER BACON.

The great English philosopher and pioneer in science, the seven hundredth anniversary of whose birth was celebrated at Oxford on June 10. An article describing Roger Bacon's life and work by the late Dr. Edward S. Holden will be found in THE POPULAR SCIENCE MONTHLY for January, 1902.

THE PROGRESS OF SCIENCE

THE WORK OF THE GENERAL EDUCATION BOARD

The General Education Board, the foundation endowed by Mr. John D. Rockefeller, at a recent meeting made large appropriations for educational work. Following the gifts of $1,500,000 to the Johns Hopkins University and $750,000 to Washington University for their medical schools on condition that the professors of medicine and surgery shall devote their entire time to the work of the school and not engage in private practise, a gift of $500,000 has been made to the medical school of Yale University under similar conditions and the further stipulation that the school obtain control of the New Haven Hospital. Other conditional appropriations amounting to $700,000 were made to Stevens Institute of Technology, Elmira College, Hendrix College, Washington and Lee University, Wells College and Wofford College.

Increased appropriations were made to develop the work in secondary education which the board has been carrying on in the south for ten years. The board has maintained professors of secondary education in southern universities and inspectors of secondary schools who have devoted their time to the creation and development of high schools in their several spheres.

The sum of $36,500 was appropriated for the maintenance of rural school supervisors in each of the southern states. These supervisors are concerned with the improvement of country schools and with the introduction into them of industrial training and domestic science. The annual subscription of $10,000 toward the current expenses of Hampton Institute was increased to $25,000, an annual subscription of $10,000 was made to Tuskegee Institute, and one of $15,000 to Spelman Seminary, Atlanta.

Farm demonstration work on an educational basis was originated by the General Education Board. The plan was conceived by the late Dr. Seaman A. Knapp. So far as the southern states are concerned, congress now assumes the work heretofore supported by the General Education Board, objection having been made to the payment of the officers of the Department of Agriculture by a private contribution. The board will, however, continue its cooperation with agricultural colleges in the work. For this purpoose, $20,000 was appropriated for farm demonstration in six counties in Maine and for boys' and girls' clubs in that state. A further appropriation of $10,000 was made for similar work in New Hampshire.

To improve education in the rural districts the board has resolved to offer to support in connection with state departments of education, rural school agents. An appropriation of $50,000 was made for the work in fifteen states. A general agent will be appointed to keep the several state movements in touch with one another. The board resolved to authorize a study of training for public health service and of the organization of public health service in England, Germany, Denmark and other foreign countries. When the facts have been ascertained a conference will be held and a concrete scheme formulated for schools of public health.

THE CINCINNATI NEW GENERAL HOSPITAL

Large as are the gifts for hospitals and medical schools from private philanthropy, they are likely to be surpassed by public provision for the suppression of disease and the improvement of health. Of special interest is the New General Hospital at Cincinnati, for we have there the only instance in the country of a municipal university and hospital, conducted by and for the city. A medical school and hospital, cooperating in their common work and directly controlled and supported by the city, is an example which we may expect to see followed elsewhere. One may therefore note with satisfaction the admirable plans of the Cincinnati Hospital indicated in the accompanying bird's-eye view, kindly given us with some description by Dr. Christian R. Holmes, dean of the medical school and president of the new hospital commission.

The hospital will be opened in October, 1914, with 850 beds, but all administrative buildings have been built large enough to care for 1,500 patients. The buildings are located on a plot of 27 acres; adjoining this on the west and north are 38 additional acres, also belonging to the hospital, for future expansion and to be used for day camps for children or adults needing sunshine and outdoor life under medical supervision, also night camps for men with incipient or arrested tuberculosis, who are still bread winners, for, while located on high land in one of the suburbs, the grounds are easy of access.

The admitting department and outdoor clinic, surgical pavilion, kitchen and service building are located on the long axis of the group, to be easy of access from all the pavilions, and being low structures do not interfere with light and air. All the buildings (except the contagious group) are united by large well-lighted basement and first-story corridors. A patient can be taken on a wheeled stretcher all over the twenty-seven acres through the basement corridors without the use of inclines, steps or elevators.

The administration building (No. 1) contains an extensive working and reference library for the staff and students and a lecture hall suitable for meetings of various kinds, but especially for medical societies. The City thus shows its appreciation of the free service that the medical profession renders to the city's poor, by furnishing a meeting place, where not alone the staff, but every physician in the city can come and have the advantages that only a well equipped teaching hospital can furnish. They need not confine their meetings to this hall alone; use can be made of the large amphitheater where will be placed powerful projecting lanterns and every facility for demonstrations. Or they may meet in the amphitheater of the spacious pathological building where the professors of pathology and bacteriology can give demonstrations of specimens saved specially for such meetings. Thus the hospital may be made the city's center for medical education, not limited to the staff, the students and internes.

Adjoining the administration building is the admitting department and Outdoor Clinic where students can see every variety of emergency, medical, obstetric and surgical cases. They can also follow up and see final results in those who have recovered sufficiently to leave the hospital, but return as outpatients for treatment until entirely cured. The basement of the admitting department is well lighted by wide areaways. Every patient's clothing passes through the large sterilizer located here, and then goes to the tailor-shop to be cleaned, mended and pressed before being stored away; there is also a large sunstroke and poison room here with every modern facility for treating such cases. On the main floor of the admitting department and the Outdoor Clinic in addition to the examination and treatment rooms, we have two wards—one for each sex, where patients who arrive after 9:00 P.M. are kept till the next morning, in order not to disturb the ward patients. The social service department will have its office in this building. The ambulance or any public conveyance will bring the ordinary cases to the front of the build-

BIRD'S-EYE VIEW OF THE NEW GENERAL HOSPITAL, CINCINNATI.

ing, but emergency cases are brought to the rear and taken directly into the special operating room.

The colonnaded corridor shown unites all the ward buildings on their north end. The basement of this corridor is well lighted and ventilated by windows varying from two to six feet in height according to the slope of the ground. The first floor and roof of this colonnade is fourteen feet wide, paved with red quarry tiles, and will be used for the open-air treatment of both bedridden and convalescent patients. The northern end of the building or ''head house'' is four-storied. In the first three stories of the ''head house'' are located the administrative department of the ''ward unit'' and four small isolation wards. The fourth floor of the ''head house'' is a roof ward, the balance of the floor is open, surrounded by a nine-foot parapet pierced by numerous windows, permitting an extensive view of the surrounding country, and acting as a wind break when closed or permitting a free circulation of air when opened. The first 50 feet next to the ''head house'' is covered with awnings where patients can receive outdoor treatment and yet be protected from rain or snow. The arrangement of the wards and the other buildings of the great group shown in the illustration in all its details is the result of a great deal of study and the help of many hospital workers. A full description will be found in Dr. Holmes's pamphlet: ''The Planning of a Modern Hospital.''

DARWINISM, ORGANIC EVOLUTION AND THE CHURCHES

IN the June *Forum* is an article by Mr. Elmer J. Kneale entitled ''Darwin, Science and Evolution,'' which contains answers from prominent people to the questions: ''(1) Do you believe the teachings of Darwin in their general outline remain to-day as a contribution to science? (2) Do you believe that a majority of intellectual leaders are to-day inclined to accept these teachings?'' The answers to such questions, unless they are from experts, have of course no value in reference to the truth of Darwin's teachings, but they have a certain interest in revealing public sentiment. As a matter of fact, of the large number who reply, only three are decidedly adverse—prelates in the Catholic and Greek churches—though several protestant clergymen write guardedly. The identification of Darwinism with the doctrine of organic evolution in the public mind is unfortunate, for when a scientific man argues that Darwin's theory of natural selection is not an adequate causal explanation of the origin of species, this is distorted to be a "confession" that there has been no organic evolution.

Sentiment among the churches against the doctrine of evolution, especially in the south, is widespread. A curious exhibition is given in a statement recently made by a committee on behalf of the Galveston (Texas) Ministerial Association, which reads as follows:

> We wish to say to the public in general, but to the fathers and mothers of the children of Galveston in particular, that we, the committee appointed last week by the Ministerial Association to confer with the state superintendent of public instruction, with reference to the expurgation of certain statements in Tarr's New Physical Geography plainly teaching the Darwinian and atheistic theory of man's origin, have done so, and with most gratifying results.
>
> Referring to our letter to him, Mr. Doughty says: "In reply thereto, permit me to say that the copy of the book to which you refer is of the unrevised edition" (the one now in use in the schools—Committee). "Soon after assuming the duties of this office on September 1, 1913, an objection to this paragraph was referred to me as chairman of the revision committee on the adopted text, and I immediately took up the matter with the publishers and succeeded in securing a satisfactory revision of the objectionable paragraph. . . . It is my desire to do everything within my power to give the children of this state wholesome instruction, and permit me here to say that I am in hearty accord with the ideas and purposes of the Christian faith."
>
> These are noble words on the part of our state superintendent, and in them we have the pleasing assurance that the new edition to be placed in the hands of our children next fall will not contain the Darwinian theory of evolution —and this is all we have been contending for.

SCIENTIFIC ITEMS

Dr. Alfred E. Barlow, of Montreal, distinguished for his work in Archean and mining geology, with Mrs. Barlow, was drowned in the wreck of the *Empress of Ireland.* We regret also to record the deaths of Jesse J. Myers, assistant professor of physiology and zoology at the Michigan Agricultural College; of Dr. Paul von Mauser, inventor of the Mauser rifle; of Mr. Robert Kaye Gray, an electrical engineer, active in the promotion of scientific research in England, and of M. Paul Louis Toussaint Heroult, known for his work with aluminum and the electric furnace.

A committee has been formed in France, under the patronage of M. Poincaré, president of the Republic, for the erection of a monument in honor of J. H. Fabre, the famous entomologist. The idea is, not only to erect a monument at Serignan, but to preserve and to convert into a museum the estate of Harmas, the dwelling of the great naturalist. Subscriptions are asked from naturalists all over the world, and may be sent to the president of the committee, M. Henri de la Paillonne, mayor of Serignan (Vaucluse), France.

Dr. Thomas H. MacBride, professor of botany, has been appointed president of the Iowa State University by the State Board of Education.—Dr. S. J. Meltzer, head of the department of physiology and pharmacology of the Rockefeller Institute for Medical Research, has been elected president of the Association of American Physicians in succession to Dr. Simon Flexner.—The Franklin Institute, Philadelphia, on May 20, presented its Elliott Cresson medals to Dr. Edgar Fahs Smith and Dr. Orville Wright.

An additional endowment has been provided for the Rockefeller Institute for Medical Research, for the establishment of a department of animal pathology. It is to be organized and conducted by Professor Theobald Smith, of Harvard University.

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THE CELLULAR BASIS OF HEREDITY AND DEVELOPMENT[1]

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A. Introductory

HEREDITY is to-day the central problem of biology. This problem may be approached from many sides—that of the observer, the statistician, the practical breeder, the experimenter, the embryologist, the cytologist—but these different aspects of the subject may be reduced to three general methods of study, (1) the observational and statistical, (2) the experimental, (3) the cytological and embryological. Before taking up these different aspects of heredity it is important that we should have clear definitions of the terms employed and a fairly accurate conception of the processes involved.

1. *Definitions*

Heredity originally meant heirship, or the transmission of property from parents to children, and in the field of biology it has been defined erroneously as "the transmission of qualities or characteristics, mental or physical, from parents to offspring" (Century Dictionary). The colloquial meaning of the word has led to much confusion in biology, for it carries with it the idea of the transmission from one generation to the next of ownership in property. A son may inherit a house from his father and a farm from his mother, the house and farm remaining the same though the ownership has passed from parents to son. And when it is said that a son inherits his stature from his father and his complexion from his mother, the stature and complexion are usually thought of only in their developed condition, while the great fact of development is temporarily forgotten. Of course there are no "qualities" or "characteristics" which are "transmitted" as such from one generation to the next. Such terms are not without fault when used

[1] Second of the Norman W. Harris Lectures for 1914 at Northwestern University on ''Heredity and Environment in the Development of Men,'' to be published by the Princeton University Press.

merely as figures of speech, but when interpreted literally, as they frequently are, they are altogether misleading; they are the result of reasoning about names rather than facts, of getting far from phenomena and philosophizing about them. The comparison of heredity to the transmission of property from parents to children has produced confusion in the scientific as well as in the popular mind. It is only necessary to recall the most elementary facts about development to recognize that in a literal sense parental characteristics are never transmitted to children.

2. *The Transmission Hypothesis*

And yet the idea that the characteristics of adult persons are transmitted from one generation to the next is a very ancient one and was universally held until the most recent times. Before the details of development were known it was natural to suppose, as Hippocrates did, that white-flowered plants gave rise to white-flowered seeds and that blue-eyed parents produced blue-eyed germs, without attempting to define what was meant by white-flowered seed or blue-eyed germs. And even after the facts of development were fairly well known it was generally held that the germ cells were produced by the adult animal or plant and that the characteristics of the adult were in some way carried over to the germ cells; but the manner in which this supposed transmission took place remained undefined until Darwin attempted to explain it by his "provisional hypothesis of pangenesis." Darwin assumed that minute particles or "gemmules" were given off by every cell of the body, at every stage of development, and that these gemmules then collected in the germ cells which thus became storehouses of little germs from all parts of the body. Afterwards, in the development of these germ cells, the gemmules, or little germs, developed into cells and organs similar to those from which they came.

3. *Germinal Continuity and Somatic Discontinuity*

Many ingenious hypotheses have been devised to explain things which are not true, and this is one of them. The doctrine that adult organisms manufacture germ cells and transmit their characters to them is known to be erroneous. Neither germ cells nor any other kind of cells are formed by the body as a whole, but every cell in the body comes from a preceding cell by a process of division, and germ cells are formed, not by contributions from all parts of the body, but by division of preceding cells which are derived ultimately from the fertilized egg (Fig. 23). The hen does not produce the egg, but the egg produces the hen and also other eggs. Individual traits are not transmitted from the hen to the egg, but they develop out of germinal factors which are carried along from cell to cell, and thus from generation to generation.

There is a continuity of germinal substance, and usually of germinal cells, from one generation to the next. In some animals the germ cells are set apart at a very early stage of development, sometimes in the early cleavage stages of the egg. In other cases the germ cells are first recognizable at later stages, but in practically every case they arise from germinal or embryonic cells which have not differentiated into somatic tissues. Germinal continuity and somatic discontinuity of successive generations in sexually produced organisms is not a theory but an established fact. In general, germ cells do not come from differentiated somatic cells, but only from undifferentiated germinal cells, and if in a few cases differentiated cells may reverse the process of development and become embryonic cells and even germ cells it does not destroy this principle of germinal continuity and somatic discontinuity.

Thus the problem which faces the student of heredity and development has been cut in two; he no longer inquires how the body produces the germ cells, for this does not happen, but merely how the latter produce the body and other germ cells. The germ is the undeveloped organism which forms the bond between successive generations; the person is the developed organism which arises from the germ under the influence of environmental conditions. The person develops and dies in each generation; the germ plasm is the continuous stream of living substance which connects all generations. The person nourishes and protects the germ, and in this sense the person is merely the carrier of the germ plasm, the mortal trustee of an immortal substance.

This contrast of the germ and the person, of the undeveloped and the developed organism, is fundamental in all modern work on heredity. It was especially emphasized by Weismann in his germ plasm theory and recently it has been given prominence by Johannsen under the terms genotype and phenotype; the genotype is the fundamental hereditary constitution of an organism—it is the germinal type; the phenotype is the developed organism with all of its visible characters—it is the somatic type.

But important as this distinction is between germ and soma it has sometimes been over-emphasized. This is one of the chief faults of Weismann's theory. The germ and the soma are generically alike, but specifically different. Both germ cells and somatic cells have come from the same oosperm, but have differentiated in different ways; the tissue cells have lost certain things which the germ cells retain and have developed other things which remain undeveloped in the germ cells. But the germ cells do not remain undifferentiated; both egg and sperm are differentiated, the former for receiving the sperm and for the nourishment of the embryo, the latter for locomotion and for penetration into the egg. But while the differentiations of tissue cells are usually irreversible, so that they do not again become germinal cells, the differentiations of the sex cells are reversible, so that these cells, after their union, again become germinal cells.

In many theories of heredity it is assumed that there is a specific "inheritance material," distinct from the general protoplasm whose function is the "transmission" of hereditary properties from generation to generation, and whose characteristics, as compared with the general protoplasm, are great stability, independence and continuity. This is the idioplasm of Nägeli, the germ-plasm of Weismann. But there is no reason to suppose that "germ-plasm" is anything other than germinal protoplasm, which is found in all cells in early stages of development but which becomes limited in quantity or altered in quality in tissue cells. A "germ-plasm" which is absolutely distinct from and independent of the general protoplasm is a mere fiction which finds no justification in reality.

4. *The Units of Living Matter*

The entire cell, nucleus and cytoplasm, is the ultimate unit of living matter which is capable of independent existence. Neither the nucleus nor the cytoplasm can for long live independently of each other, but the entire cell can perform all the fundamental vital processes. It transforms food into its own living material, it grows and divides, it is capable of responding to many kinds of stimuli. But while the parts of a cell are not capable of independent existence they may perform certain of these vital processes.

Not only is the cell as a whole capable of assimilation, growth and division, but every living part of the cell has this power. The nucleus builds foreign substances into its own substance, and after it has grown to a certain size it divides into two; the cytoplasm does the same, and this process of assimilation, growth and division occurs in many parts of the nucleus and cytoplasm, such as the chromosomes, chromomeres, centrosomes, plastosomes, etc. In all cases cells come from cells, nuclei from nuclei, chromosomes from chromosomes, centrosomes from centrosomes, and probably plastosomes from plastosomes, etc.

Indeed, the manner in which all living matter grows indicates that every minute particle of protoplasm has this power of taking in food substance and of dividing into two particles when it has grown to maximum size. Presumably this power of assimilation, growth and division is possessed by particles of protoplasm which are invisible with the highest powers of our microscopes, though it is probable that these particles are much larger than the largest molecules known to chemistry. The smallest particle which can be seen with the most powerful microscope in ordinary light is about 250 $\mu\mu$ (millionths of a millimeter) in diameter. The largest molecules are probably about 10 $\mu\mu$ in diameter. Between these invisible molecules and the just visible particles of protoplasm there may be other units of organization. These hypothetical particles of protoplasm have been supposed by many authors to be the ultimate units of assimilation, growth and division. In so far as these units are supposed to be different in different species, or with respect to different hereditary characters, they are known also as inheritance units.

It is assumed in practically all theories of heredity that the "inheritance material," or more correctly the germinal protoplasm, is composed of ultra-microscopical units which have the power of individual growth and division and which are capable of undergoing many combinations and dissociations during the course of development, by which combinations and dissociations they are transformed into the structures of the adult. Various names have been given to such units by different authors; they are the *physiological units* of Herbert Spencer, the *gemmules* of Darwin, the *plastidules* of Elsberg and Haeckel, the *pangenes* of de Vries, the *plasomes* of Wiesner, the *idioblasts* of Hertwig, the *biophores* and *determinants* of Weismann.

With the publication of Weismann's work on the germ-plasm in 1892 speculation with regard to these ultra-microscopic units of life and of heredity reached a climax and began to decline, owing to the highly speculative character of the evidence as to the existence, nature and activities of such units. But with the rediscovery of Mendel's principles of heredity the necessity of assuming the existence of inheritance units of some kind once more became evident, and, without attempting to define what such units are or how they behave modern students of heredity invariably accept their existence. They are now called *determiners* or *factors* or *genes,* and are usually thought of as elements or units of the germ cells which condition the characters of the developed organism, and which are in a measure independent of one another; though of course neither they nor any other parts of a cell are really independent in the sense that they can exist apart from one another. They are to be thought of as we think of certain chemical radicals which exist only in combination with other chemical elements in the form of molecules, and yet may preserve their identity in many different combinations.

If there are inheritance units, such as determiners or genes, as practically all students of heredity maintain, they must be contained in the germ cells, and it becomes one of the fundamental problems of biology to find out where and what these units are. But whether we assume the existence of these units or not we know that the germ cells are exceedingly complex, that they contain many visible units such as chromosomes, chromomeres, plastosomes and microsomes, and that with every great improvement in the microscope and in microscopical technique other structures are made visible which were invisible before, and whether the particular hypothetical units just named are present or not seems to be a matter of no great importance, seeing that, so far as the analysis of the microscope is able to go, there are in all protoplasm differentiated units which are combined into a system—in short, there is organization.

5. *Heredity and Development*

The germ cells are individual entities and after the fertilization of the egg the new individual thus formed remains distinct from every other individual. Furthermore, from its earliest to its latest stage of development it is one and the same organism; the egg is not one being and the embryo another and the adult a third, but the egg of a human being is a human being in the one-celled stage of development, and the characteristics of the adult develop out of the egg and are not in some mysterious way grafted upon it or transmitted to it.

Parents do not transmit their characters, but their germ cells, to their offspring, which germ cells in the course of long development give rise to adult characters similar to those of the parents. The thing which persists more or less completely from generation to generation is the organization of the germ cells which differentiate in similar ways in successive generations if the extrinsic factors of development remain similar.

In short, *heredity may be defined as the particular germinal organization which is transmitted from one generation to the next: inheritance or heritage is the sum of all those qualities which are determined or caused by this germinal organization. Development is progressive and coordinated differentiation of this germinal organization, by which it is transformed into the adult organization. Differentiation is the formation and localization of many different kinds of substances out of the germinal substances, of many different structures and functions out of the relatively simple structures and functions of the oosperm.*

This germinal organization influences not merely adult characters, but also the character of every stage from the egg to the adult condition. For every inherited character, whether embryonic or adult, there is some germinal basis. We receive from our parents germ cells of a particular kind and constitution and under given conditions of environment these cells undergo regular transformations and differentiations in the course of development which differentiations lead to particular adult characteristics. In the last analysis the causes of heredity and development are problems of cell structures and functions—problems of the formation of particular kinds of germ cells, of the fusion of these cells in fertilization, and of the subsequent formation of the various types of somatic cells from the fertilized egg cell.

B. The Germ Cells

Observations and experiments on developed animals and plants have furnished us with a knowledge of the finished products of inheritance, but the actual stages and causes of inheritance, the real mechanisms of heredity, are to be found only in a study of the germ cells and of their development. Although many phenomena of inheritance have been discovered in the absence of any definite knowledge of the mechanism of heredity, a scientific explanation of these phenomena must wait upon the knowledge of their causes. In the absence of such knowledge it has been necessary to formulate theories of heredity to account for the facts, but these theories are only temporary scaffolding to bridge the gaps in our knowledge, and if we knew all that could be known about the germ cells and their development we should have little need of theories. In the first lecture we looked at the germ cells and their development from the outside, as it were; let us now look inside these cells and study their minuter structures and functions.

Only a beginning has been made in this minute study of the germ cells and of their transformation into the developed animal, and it seems probable that it may engage the attention of many future

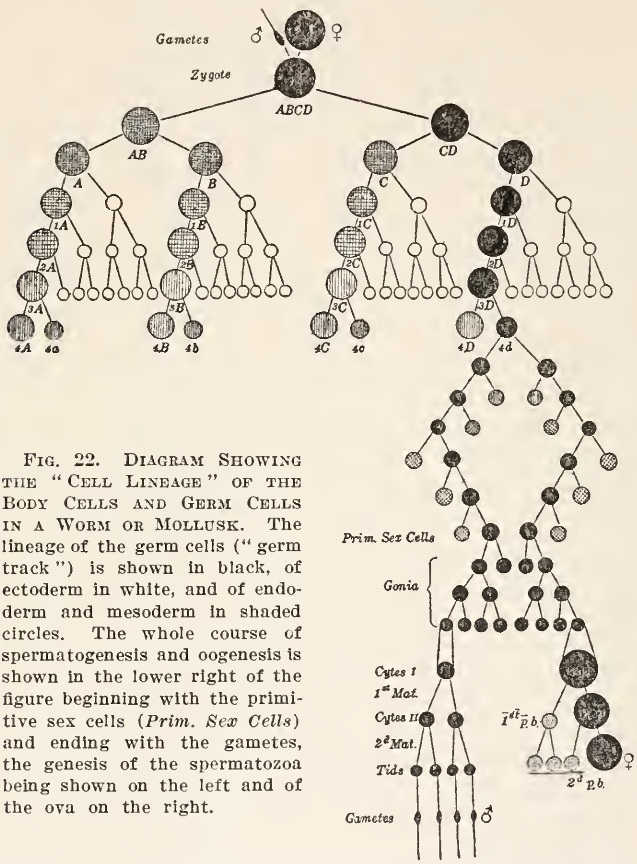

Fig. 22. Diagram Showing the "Cell Lineage" of the Body Cells and Germ Cells in a Worm or Mollusk. The lineage of the germ cells ("germ track") is shown in black, of ectoderm in white, and of endoderm and mesoderm in shaded circles. The whole course of spermatogenesis and oogenesis is shown in the lower right of the figure beginning with the primitive sex cells (*Prim. Sex Cells*) and ending with the gametes, the genesis of the spermatozoa being shown on the left and of the ova on the right.

generations of biologists, but nevertheless we have come far since that day, only about thirty-five years ago, when Oscar Hertwig first saw the approach and union of the egg and sperm nuclei within the fertilized egg. Indeed so rapid has been the advance of knowledge in this field that many of the pioneers in this work are still active in research.

1. *Fertilization*

The development of the individual may be said to begin with the fertilization of the egg, though it is evident that both egg and sperm must have had a more remote beginning, and that they also have undergone a process of development by which their peculiar characteristics of structure and function have arisen—a subject to which we shall return later. But the developmental processes which lead to the formation of fully developed ova and spermatozoa come to a full stop before fertilization and they do not usually begin again until a spermatozoon has entered an ovum, or until the latter has been stimulated by some other outside means. In some animals and plants eggs may develop regularly without fertilization, the stimulus to development being supplied by

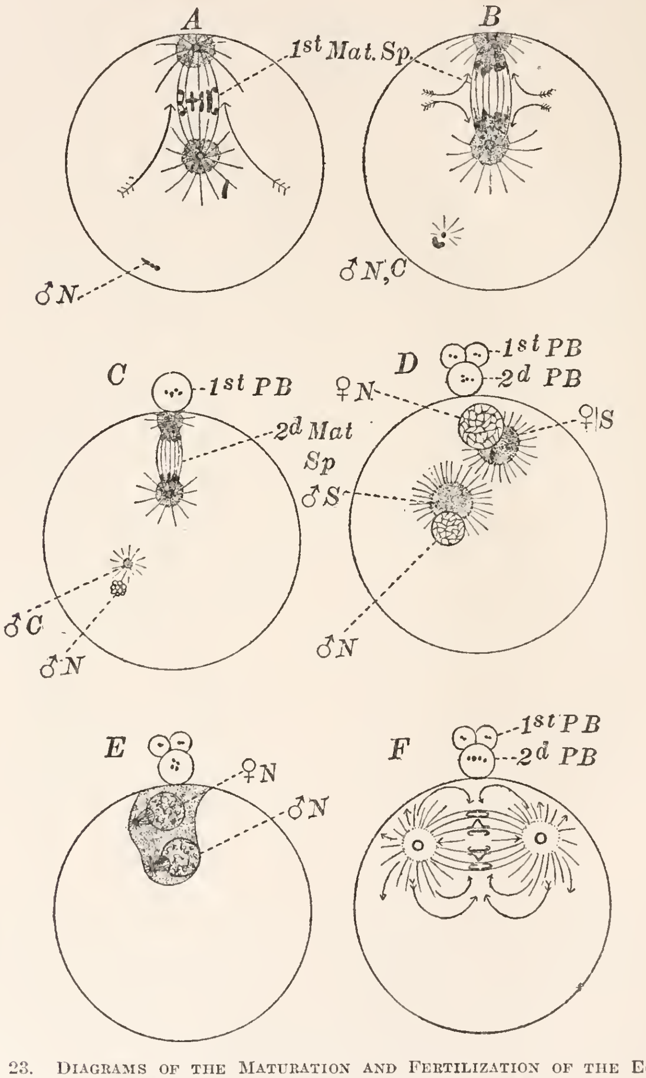

FIG. 23. DIAGRAMS OF THE MATURATION AND FERTILIZATION OF THE EGG OF A MOLLUSK (*Crepidula*). *A, B.* First maturation division (*1st Mat. Sp.*) *C.* Second maturation division (*2d Mat. Sp.*) and first polar body (*1st PB*) resulting from first division. *♂N,* sperm nucleus, *♂C,* sperm centrosome. *D.* Approach of sperm nucleus (*♂N*) and sperm (*♂S*) to egg nucleus (*♀N*) and sphere (*♀S*); the second polar body (*2dPB*) has been formed and the forest has divided (*1st PB*). *E.* Meeting of egg and sperm nuclei and origin of cleavage centrosomes. *F.* First cleavage of egg showing direction of currents in the cell.

certain external or internal conditions; in other cases, as Loeb discovered, eggs which would never develop if left to themselves may be experimentally stimulated by physical or chemical changes in the environment, so that they undergo regular development. The development of an egg without previous fertilization is known as *parthenogenesis* or virgin reproduction; if it occurs in nature it is natural parthenogenesis, if in experiments it is artificial parthenogenesis. Natural parthenogenesis is relatively rare and in the vast majority of animals and plants the egg does not begin to develop until a spermatozoon has entered it.

But the spermatozoon not only stimulates the egg to develop, as environmental conditions may also do, but it carries into the egg living substances which are of great significance in heredity. Usually only the head of the spermatozoon enters the egg (Figs. 4–7) and this consists almost entirely of nuclear material which has a strong chemical affinity for certain dyes, and hence is called *chromatin* (Figs. 23 *A* and *B*); when the egg has matured and is ready to be fertilized its nucleus also consists of a small mass of chromatin (Fig. 23 *C*). Both of these condensed chromatic nuclei then grow in size and become less chromatic by absorbing from the egg a substance which is not easily stained by dyes and hence is called *achromatin* (Fig. 23 *D* and *E*). The chromatin then becomes scattered through each nucleus in the form of granules or threads which are embedded in the achromatin; this is the condition of a typical "resting" nucleus. The spermatozoon also brings into the egg a *centrosome,* or division center, around which an *aster* appears consisting of radiating lines in the protoplasm of the egg (Fig 23 *B*).

The moment that the spermatozoon touches the surface of the egg the latter throws out at the point touched a prominence, or reception cone (Fig. 4), and as soon as the head of the sperm has entered this cone some of the superficial protoplasm of the egg flows to this point and then turns into the interior of the egg in a kind of vortex current. Probably as a result of this current the sperm nucleus and centrosome are carried deeper into the egg and finally are brought near to the egg nucleus (Fig. 23 *D* and *E*). In the movements of egg and sperm nuclei toward each other it is evident that they are passively carried about by currents in the cytoplasm; the entrance of the sperm serves as a stimulus to the egg cytoplasm which moves according to its preestablished organization.

2. *Cleavage and Differentiation*

When the sperm nucleus has come close to the egg nucleus the sperm centrosome usually divides into two minute granules, the daughter centrosomes, which move apart forming a spindle with the centrosomes at its poles and with astral radiations running out from these into the cytoplasm (Fig. 23 *F*). At the same time the chromatin granules and threads in the egg and sperm nuclei run together into a smooth thick thread, the *spireme,* which is coiled within the nucleus. At this stage it is sometimes possible to see that the spireme is composed of a series of granules, like beads on a string; these granules are the *chromomeres.* The spireme then breaks up into a number of pieces in the form of short threads or rods (Fig. 24 *C* and *D*); these are the *chromosomes.* The

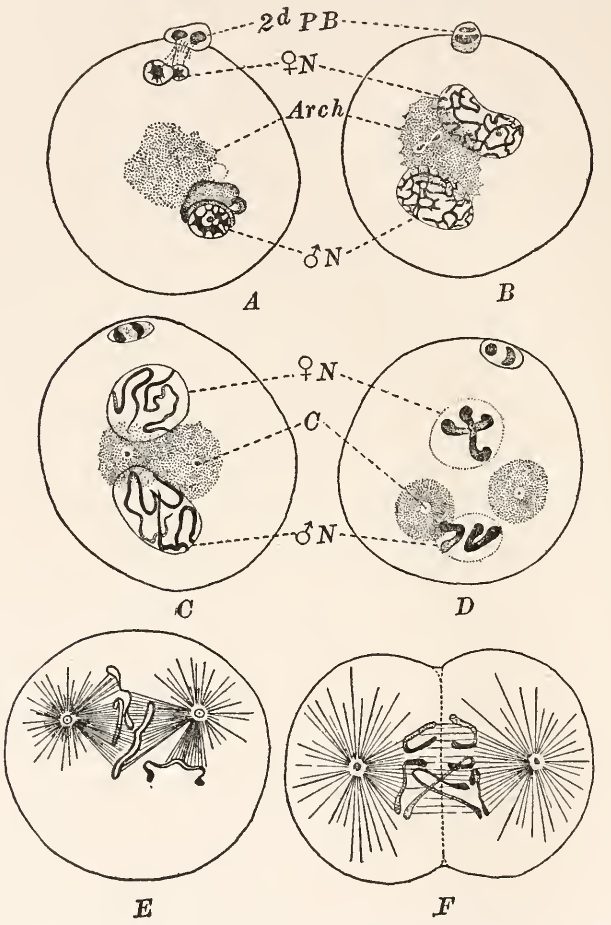

FIG. 24. FERTILIZATION OF THE EGG OF THE NEMATODE WORM *Ascaris;* ♀*N*, egg nucleus; ♂*N*, sperm nucleus; *Arch*, archiplasm; *C*, centrosome; *A, B,* approach of germ nuclei; *C, D,* formation of two chromosomes in each germ nucleus *E, F,* stages in the division of the chromosomes which are split in *E* and are separating in *F*; only three chromosomes are shown in *F*. (From Wilson after Boveri.)

number of these chromosomes is constant for every species and race, though the number may vary in different species. In the thread worm, *Ascaris,* there are usually two chromosomes in the egg nucleus and two in the sperm nucleus (Fig. 24 *D*). In the gastropod, *Crepidula,* there are about thirty chromosomes in each germ nucleus and sixty in the two. Then the spindle and asters grow larger and the nuclear membrane

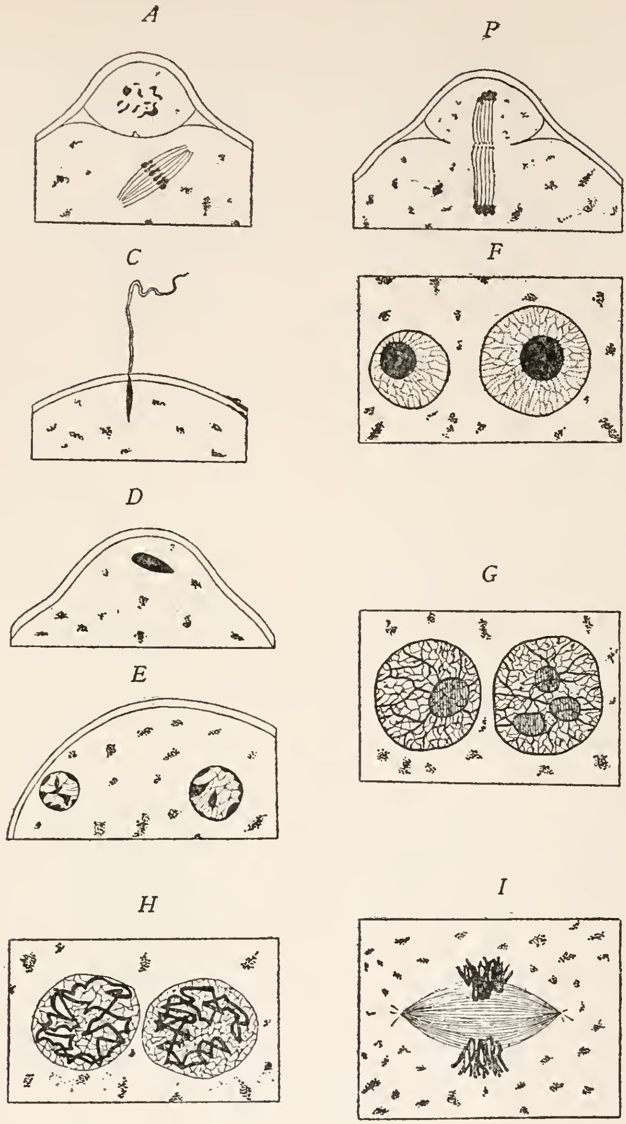

FIG. 25. MATURATION AND FERTILIZATION OF THE EGG OF THE MOUSE. *A*, first polar body and second maturation spindle; *B*, second polar body and maturation spindle; *C*, entrance of the spermatozoon into the egg; *D*–*G*, successive stages in the approach of egg and sperm nuclei; *H*, formation of chromosomes in each germ nucleus; *I*, first cleavage spindle showing chromosomes from egg and sperm on opposite sides of spindle. (After Sobotta.)

grows thinner and finally disappears altogether, leaving the chromosomes in the equator of the spindle (Figs. 23 *F*, 24 *E* and *F*, 25 *I*).

Each of the chromosomes then splits lengthwise into two equal parts, and in the splitting of the chromosomes it is sometimes possible to see that each chromomere divides through its middle. The daughter chromosomes then separate and move to opposite poles of the spindle, where they form the daughter nuclei, and at the same time the cell body begins to divide by a constriction which pinches the cell in two

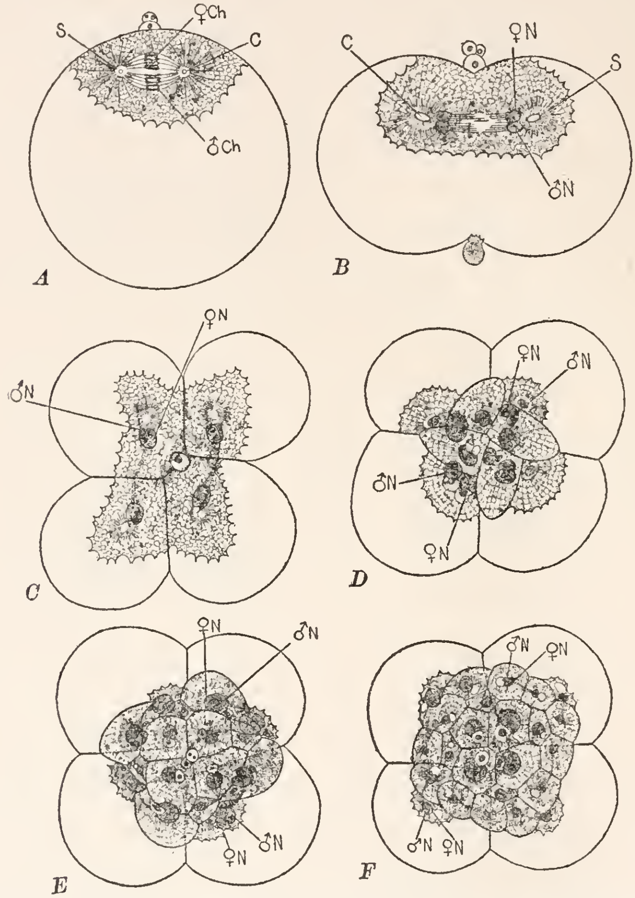

Fig. 26. Successive Stages in the Cleavage of the Egg of Mollusk (*Crepidula*), showing the separateness of the male and female chromosomes (♂ *ch*, ♀ *ch*) and the male and female halves of each nucleus (♂*N*, ♀*N*).

in the plane which passes through the equator of the spindle (Fig. 26 *B*). Finally the daughter nuclei grow in size by the absorption of achromatin from the cell body and the substance of the chromosomes is again distributed through the achromatin in the form of threads and granules and thus the daughter nuclei come back to a "resting" stage similar to that with which the division began, thus completing the "division cycle" of the cell.

During the whole division cycle it is possible in a few instances to distinguish the chromosomes of the egg from those of the sperm, and in every instance where this can be done it is perfectly clear that these chromosomes do not fuse together nor lose their identity, but that every chromosome splits lengthwise and its halves separate and go into the two daughter cells where they form the daughter nuclei. Each of these cells therefore receives half of its chromosomes from the egg and half from the sperm. Even in cases where the individual chromosomes are lost to view in the daughter nuclei those nuclei may be clearly double, one half of each having come from the egg chromosomes and the other half from the sperm chromosomes (Fig. 26 *B*).

At every subsequent cleavage of the egg the chromosomes divide in exactly the same way as has been described for the first cleavage. Every cell of the developing animal receives one half of its chromosomes from the egg and the other half from the sperm, and if the chromosomes of the egg differ in shape or in size from those of the sperm, as is sometimes the case when different races or species are crossed, these two groups of chromosomes may still be distinguished at advanced stages of development. Where the egg and sperm chromosomes are not thus distinguishable it may still be possible to recognize the half of the nucleus which comes from the egg and the half which comes from the sperm even up to an advanced stage of the cleavage (Fig. 26).

At the same time that the maternal and paternal chromosomes are being distributed with such precise equality to all the cells of the developing organism, the different substances in the cell body outside of the nucleus may be distributed very unequally to the cleavage cells. The movements of the cytoplasm of the egg which began with the flowing of the surface layer to the point of entrance of the sperm, lead to the segregation of different kinds of plasms in different parts of the egg and to the unequal distribution of these substances to different cells.

One of the most striking cases of this is found in the ascidian, *Styela,* in which there are four or five different kinds of substance in the egg which differ in color, so that their distribution to different regions of the egg and to different cleavage cells may be easily followed, and even photographed while in the living condition. The peripheral layer of protoplasm is yellow and when it gathers at the lower pole of the egg where the sperm enters it forms a yellow cap. This yellow substance then moves, following the sperm nucleus, up to the equator of the egg on the posterior side and there forms a yellow crescent extending around the posterior side of the egg just below the equator. On the anterior side of the egg a gray crescent is formed in a somewhat similar manner and at the lower pole between these two crescents is a slate blue substance, while at the upper pole is an area of colorless protoplasm. The yellow crescent goes into cleavage cells which become muscle and mesoderm, the gray crescent into cells which become nervous system and notochord, the slate-blue substance into endoderm cells and the colorless substance into ectoderm cells.

Thus within a few minutes after the fertilization of the egg, and before or immediately after the first cleavage, the anterior and posterior, dorsal and ventral, right and left poles are clearly distinguishable, and

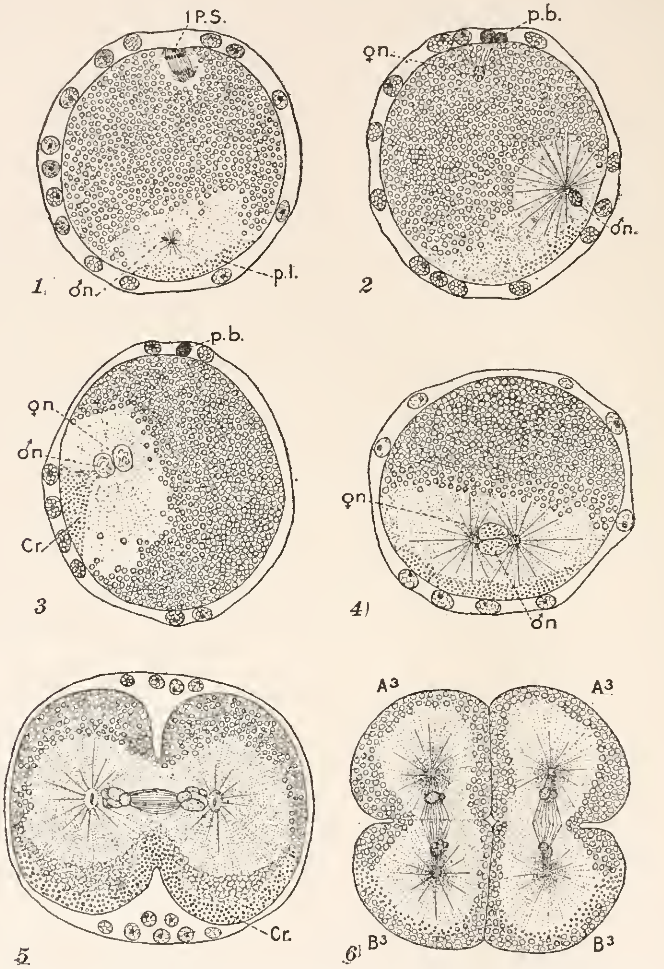

Fig. 29. Sections of the Egg of *Styela*, showing maturation, fertilization and early cleavage; *1 P. S.*, first polar spindle, *p. b.*, polar bodies, ♂*N*, sperm nucleus, ♀*N*, egg nucleus, *p. l.*, peripheral layer of yellow protoplasm, *Cr*, crescent of yellow protoplasm, A_3, A_3, anterior cells, B_3, B_3, posterior cells of the 4-cell stage. In 1 the sperm nucleus and centrosome are at the lower pole near the point of entrance; in 2 and 3 they have moved up to the equator on the posterior side of the egg; in 4 the egg and sperm nuclei have come together and the sperm centrosome has divided and formed the cleavage spindle; in 5 the egg is dividing into right and left halves in 6 it is dividing into anterior and posterior halves.

the substances which will give rise to ectoderm, endoderm, mesoderm, muscles, notochord and nervous system are plainly visible in their characteristic positions.

At the first cleavage of the egg each of these substances is divided into right and left halves (Fig. 29, 5). The second cleavage cuts off two anterior cells containing the gray crescent from two posterior ones containing the yellow crescent (Fig. 29, 6 and Fig. 30, 1). The third cleavage separates the colorless protoplasm in the upper hemisphere from the slate-blue in the lower (Fig. 30, 2). And at every successive cleavage the cytoplasmic substances are segregated and isolated in particular cells,—and in this way the cytoplasm of the different cells comes to be unlike (Figs. 30 and 31). When once partition walls have been

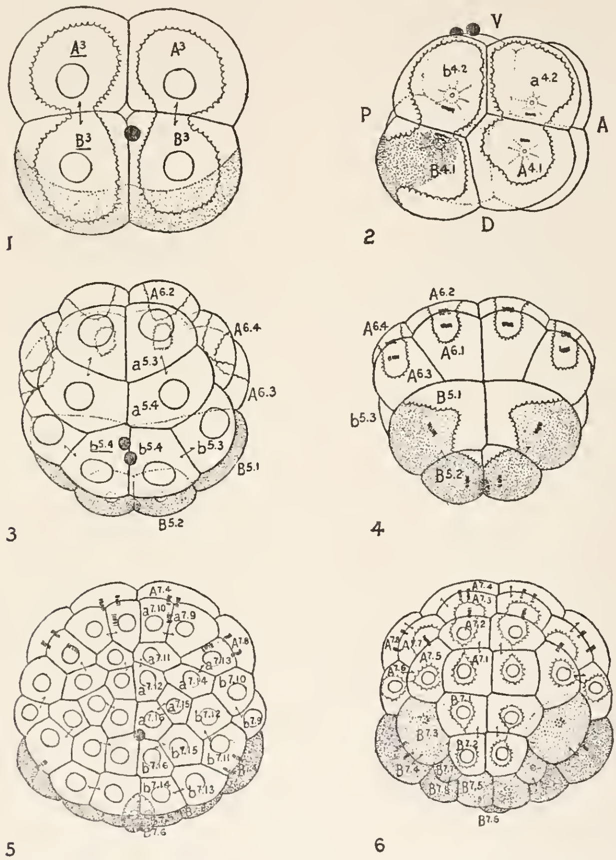

Fig. 30. Cleavage of the Egg of *Styela*, showing distribution of the yellow protoplasm (stippled) and of the clear and gray protoplasm to the various cells, each of which bears a definite letter and number.

formed between cells they permanently separate the substances in the different cells so that they can no longer commingle.

What is true of *Styela* in this regard is equally true of many other ascidians, as well as of *Amphioxus* and of the frog, though the segregation of substances and the differentiation of cells is not so evident in the last named animals because these substances are not so strikingly colored. Indeed the segregation and isolation of different protoplasmic substances in different cleavage cells occurs during the cleavage of the egg in all animals, though such differentiations are much more marked in some cases than in others.

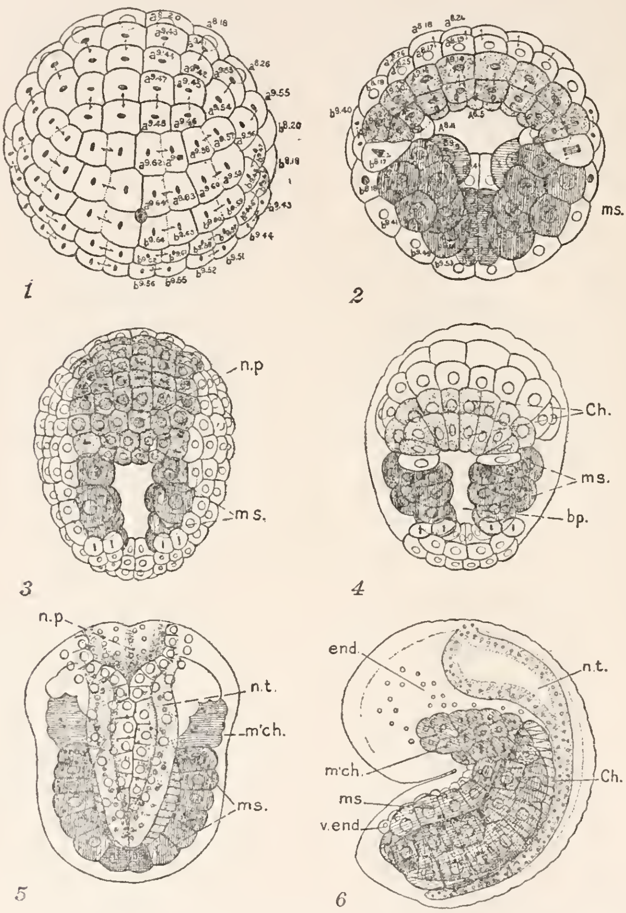

Fig. 31. Gastrula and Larva of *Styela*, showing the cell lineage of various organs, and the distribution of the different kinds of protoplasm to these organs. Muscle cells are shaded by vertical lines, mesenchyme by horizontal lines, nervous system and chorda by stiples.

This same type of cell division, with equal division of the chromosomes and more or less unequal division of the cell body, continues long after the cleavage stages—indeed throughout the entire period of embryonic development. Sometimes the division of the cell body is equal, the daughter cells being alike; sometimes it is unequal or differential—

but always the division of the chromosomes is equal and non-differential. When once the various tissues have been differentiated the further divisions in these tissue cells are usually non-differential even in the case of the cell bodies.

There can be no doubt that this remarkably complicated process of cell division has some deep significance; why should a nucleus divide in this peculiarly indirect manner instead of merely pinching in two as was once supposed to be the case? What is the relation of cell division to embryonic differentiation? In this process of mitosis, or indirect cell division, two important things take place: (1) Each chromosome, chromomere and centrosome is divided exactly into two equal parts so that each daughter structure is at the time of its formation quantitatively one half the size and qualitatively precisely like its mother structure. (2) Accompanying the formation of radiations, which go out from the centrosomes into the cell body, diffusion currents are set up in the cytoplasm which lead to the localization of different parts of the cytoplasm in definite regions of the cell, and this cytoplasmic localization is sometimes of such a sort that one of the daughter cells may contain one kind of cell substance and the other another kind. Thus while mitosis brings about a scrupulously equal division of the elements of the nucleus, it may lead to a very unequal and dissimilar division of the cytoplasm. In this is found the significance of mitosis and it suggests at once that the nucleus contains undifferentiating material, viz., the idioplasm or germplasm, which is characteristic of the race and is carried on from cell to cell and from generation to generation; whereas the cell body contains the differentiating substance, the personal plasm or somatoplasm which gives rise to all the differentiations of cells, tissues and organs in the course of ontogeny.

Weismann supposed that the mitotic division of the chromosomes during development was of a differential character, the daughter chromosomes differing from each other at every differential division in some constant and characteristic way, and that these differentiations of the chromosomes produced the characteristic differentiations of the cytoplasm which occur during development. But there is not a particle of evidence that the division of chromosomes is ever differential; on the contrary, there is the most complete evidence that their division is always remarkably equal both quantitatively and qualitatively. If daughter chromosomes and nuclei ever become unlike, as they sometimes do, this unlikeness occurs long after division and is probably the result of the action of different kinds of cytoplasm upon the nuclei, as is true, for example, in the differentiation of the chromosomes in the somatic cells as contrasted with the germ cells of *Ascaris* (Fig. 32). But while the chromosomes invariably divide equally, other portions of the nucleus may not do so. Achromatin and oxychromatin, like the cytoplasm, may divide unequally and differentially, and this is probably a prime factor in development.

On the other hand, the differential division of the cytoplasm is a regular and characteristic feature of ontogeny—indeed the segregation and isolation of different kinds of cytoplasm in different cells is the most important function of cell division in development. Thus we find in the division apparatus of the cell a mechanism for the preserva-

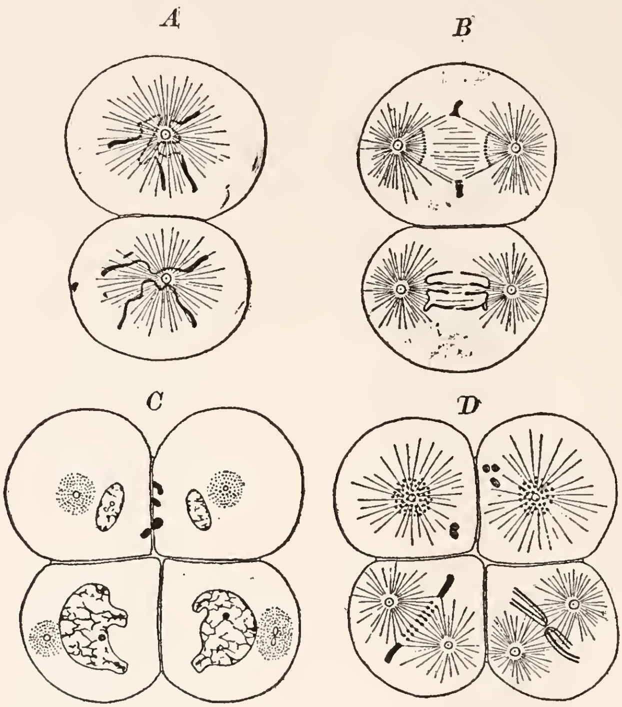

FIG. 32. DIFFERENTIATION OF GERM CELLS AND SOMATIC CELLS IN THE EGG OF *Ascaris*. *A* and *B*, second cleavage division showing that the chromosomes remain entire in the lower cell, which is in the line of descent of the sex cells ("germ track"), but that they throw off their ends and break up into small granules in the upper cells, which become somatic cells. *C*, 4-cell stage, the nuclei in the upper somatic cells being small and the ends of the chromosomes remaining as chromatic masses in the cell body outside of the nuclei, while the nuclei in the lower cells are much larger and contain all the chromatin. *D*, third nuclear division, showing the somatic differentiation of the chromosomes in all the cells except the lower right one, which alone is in the germ track and will ultimately give rise to sex cells. (After Boveri.)

tion in unaltered form of the species plasm, idioplasm or germ-plasm of the nucleus, and for the progressive differentiation of the personal plasm or somatoplasm of the cell body.

3. *The Origin of the Sex Cells*

The sex cells are the latest of all cells of a developing organism to reach maturity, and yet they may be among the earliest to make their appearance. Every sex cell, like every other type of cell, is a lineal descendant of the fertilized egg (Fig. 22), but the period at which the sex cells become visibly different from other cells varies from the first cleavage of the egg in some species to a relatively advanced stage of development in others.

(*a*). *The Division Period. Oogonia and Spermatogonia*

When the primitive sex cells are first distinguishable they differ from other cells only in the fact that they are less differentiated; they have relatively larger nuclei and smaller cell bodies—a condition which is indicative of little differentiation of the cell body since the products of differentiation such as fibres, secretions, etc., swell the size of the cell body, but do not contribute to the growth of the nucleus. These primitive sex cells or *gonia* divide repeatedly, but the *oogonia* grow more rapidly and divide less frequently than the *spermatogonia.* As a result of this difference in the rate of growth and division the spermatogonia become much smaller and immensely more numerous than the oogonia. This period in the genesis of the sex cells is known as the *division period* (Fig. 22).

(*b*). *The Growth Period. Oocytes and Spermatocytes*

This period of rapid cell divisions is followed by a period of growth without division during which the developing sex cells are called *primary oocytes* or *spermatocytes.* This growth period may be very long in the case of the oocytes, lasting, for example, in the human female from the time of birth to the end of the reproductive period; during this long time the oocytes in the ovary probably never divide—there are as many of them at birth as at any later time; during this period of growth the ovarian egg becomes relatively large, in some animals, *e. g.,* birds, the largest of all cells. The growth period of a spermatocyte lasts for a briefer time than does that of an oocyte so that the former remains relatively small (Fig. 22).

All of the cell divisions which take place during the division period are of the usual kind, in which every chromosome splits lengthwise into two and the two halves then separate and move to opposite poles of the spindle where they break up into threads and granules and form the daughter nuclei, as is shown in Fig. 24. But during the growth period of the oocytes and spermatocytes the chromosomes form a closely wound coil of long chromatin threads (Fig. 33), and when these threads uncoil later it is seen that the chromosomes have united in pairs (Figs. 33 *D* and *E,* 34 *B,* 35 *B*) ; this process is known as *synapsis,* or the conjugation of the chromosomes, and there is evidence that one member of each synaptic pair is derived from the father, and the other from the mother. The union of these chromosomes is probably not so close that they lose their identity, though there may possibly be some interchange of substance between them. By this union of the chromosomes into pairs the number of separate chromosomes is reduced to half the normal number; if there are usually 4 chromosomes, as in *Ascaris,* they are reduced to 2 pairs; if 48 chromosomes, as in man, there are 24 of these pairs.

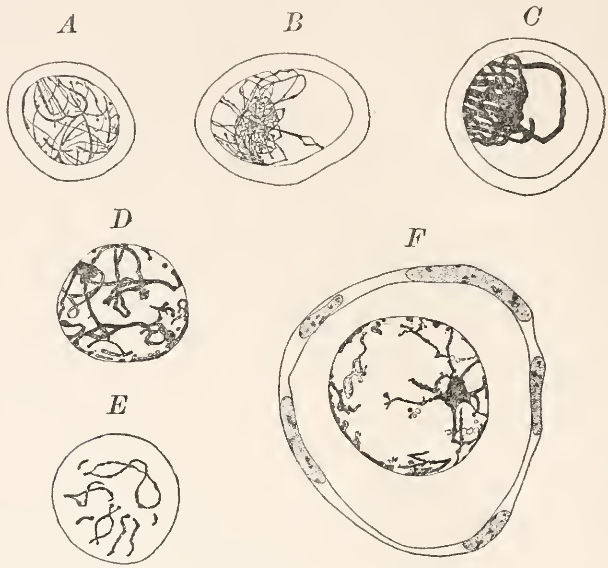

FIG. 33. DIFFERENT STAGES IN THE DEVELOPMENT OF THE EGG OF THE RABBIT. *A,* at the beginning of the growth period showing slender chromatic threads in the nucleus; *B,* later stage in which these threads ball up and parallel threads conjugate forming the shorter, thicker thread shown in *C; D* and *E,* segmentation of the long thread into chromosomes (?) each of which shows its double nature; *F,* later stage in which the distinctions of the chromosomes is temporarily lost. (After Winiwarter.)

In the conjugation of the chromosomes it is plain that, generally speaking, those chromosomes which are similar in shape and size unite; big chromosomes unite with big ones, little ones with little ones, and those of peculiar shape with others of similar shape (Figs. 34 *B,* 35 *B*). It is probable that the two members of a pair of conjugating chromosomes are homologous not merely in shape and size but also in function, though this homology does not amount to identity.

In some instances it can be proved that one member of each conjugating pair of chromosomes comes from one parent and the other from the other parent, and it is probable that this is always true. In every cell of every individual which has developed from a fertilized egg there are two full sets of chromosomes, one of which came from the sperm and the other from the egg; but when this individual in its turn produces germ cells homologous chromosomes of each set unite in pairs during the growth period.

These synaptic pairs are the *bivalent chromosomes,* and in addition to showing the line of junction by which they are united they frequently show a longitudinal split through the middle of each chromosome and

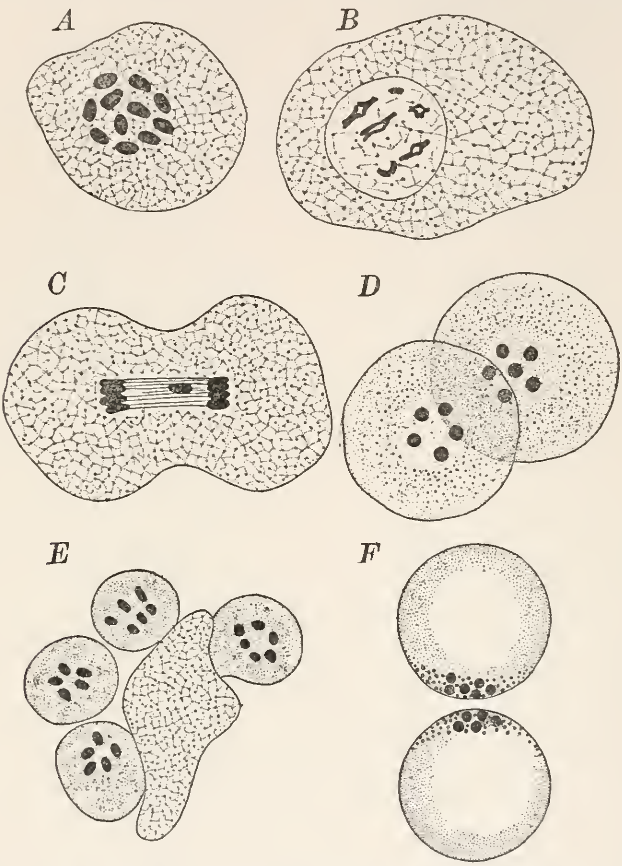

FIG. 34. SPERMATOGENESIS OF A NEMATODE WORM (*Ancyracanthus*). *A,* chromosomes of sperm mother cell, 11 in number, before their union into pairs; *B,* early stage of first division; 10 of the chromosomes have united into 5 pairs and each of these has split lengthwise; 1 chromosome remains unpaired; *C,* first maturation division after the 5 pairs of chromosomes have pulled apart; the unpaired chromosome is going entire to one pole of the spindle; *D,* two cells resulting from this division, one containing 5 and the other 6 chromosomes; *E,* four cells resulting from the division of two cells like *D,* in which each chromosome has split into two so that changing into spermatozoa, one containing 5 and the other 6 chromosomes. (After two of the cells contain 5 and two contain 6 chromosomes; *F,* two of these cells Mulsow.)

at right angles to the line of junction. It thus happens that these bivalent chromosomes are frequently four-parted and such four-parted chromosomes are known as *tetrads* (Figs. 34 *B,* 35 B).

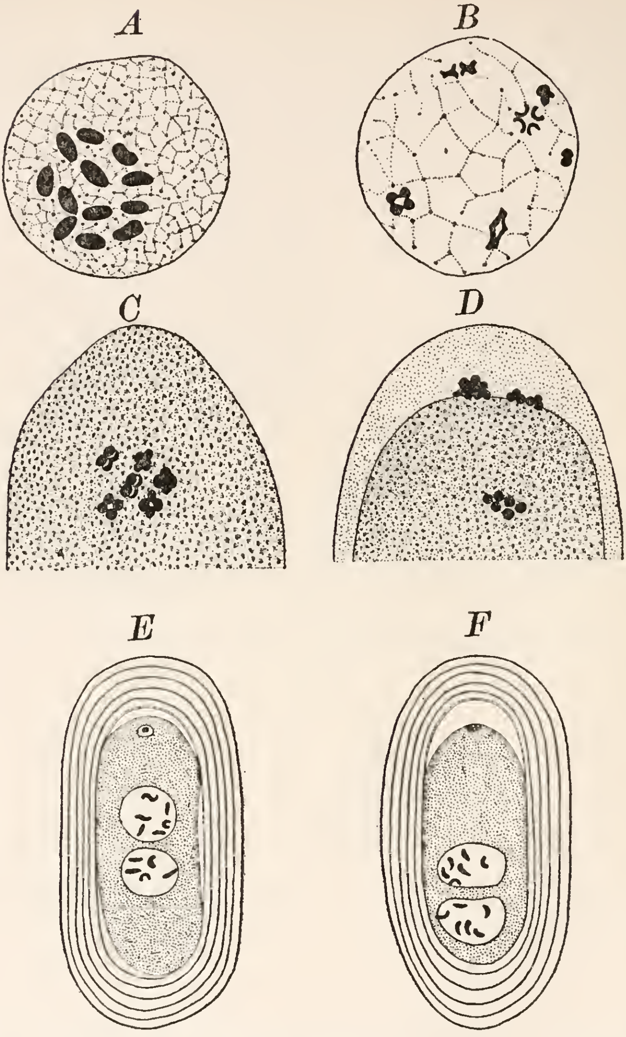

FIG. 35. OOGENESIS OF A NEMATODE WORM (*Ancyracanthus*). *A*, egg mother cell containing 12 chromosomes before their union into pairs; *B*, early stage of first maturation division; all the chromosomes have united into 6 pairs, each of which has split in two so that the pairs are really four-parted (tetrads); *C*, the six tetrads in the first maturation division; *D*, egg containing 6 chromosomes, after both first and second maturation divisions; the eliminated chromosomes are shown as the polar bodies at the margin of the egg; *E* and *F*, eggs after fertilization; the egg nucleus is above and contains 6 chromosomes, the sperm nucleus below and contains 5 chromosomes in one case and 6 in the other; the former becomes a male with 11 chromosomes, the latter a female with 12 chromosomes.

(*c*). *The Maturation Period*

Finally at the close of the growth period both oocyte and spermatocyte undergo two peculiar divisions one following immediately after the other, which are unlike any other cell divisions. These are known as the first and second maturation divisions and they are the last divisions which take place in the formation of the egg and sperm. In one or the other of these two maturation divisions the pairs of chromosomes separate along the line of junction, one member of each pair going to one pole of the spindle and the other to the other pole, so that in each of the daughter cells thus formed only a single set of chromosomes is present (Fig. 34 *C* and *D*) ; but since the position of the pairs of chromosomes in the spindle is a matter of chance it rarely happens that all the paternal chromosomes go to one pole and all the maternal ones to the other; thus each of the sex cells comes to contain a complete set of chromosomes though particular individual chromosomes may have come from the father while others have come from the mother. There is reason to believe that homologous chromosomes show general resemblances but individual differences, and consequently when the members of each pair separate and go into the sex cells, these cells differ among themselves because the individual chromosomes in different cells are not the same.

In this way the number of chromosomes in the mature egg or sperm comes to be one half the number present in other kinds of cells, and when the egg and sperm unite in fertilization the whole number is again restored. The double set of chromosomes is known as the *diploid* number, the single set as the *haploid* number, and the maturation division in which this reduction from the double to the single set takes place is the *reduction division.* It is generally held that this reduction takes place in the first of the two maturation divisions (Fig. 34, *C, D*), and that the second of these divisions is like an ordinary mitosis in that each chromosome splits into two and the halves move apart, such a division being known as an *equation division* (Fig. 34 *E*), but it is possible that some chromosome pairs undergo an equation division in the first maturation mitosis and a reduction division in the second, while other chromosome pairs may reverse this order.

It is an interesting fact that long before the reduction of chromosomes had been actually seen Weismann maintained on theoretical grounds that such a reduction must occur, otherwise the number of chromosomes would double in every generation, and he held that this reduction must take place in one of the maturation divisions; this hypothesis of Weismann's is now an established fact.

As the result of these two maturation divisions four cells are formed from each cell (spermatocyte or oocyte) of the growth period. In the spermatogenesis each of these four cells is transformed into a functional spermatozoon (Fig. 34 *E*), by the condensation of the nucleus into the sperm head and the outgrowth of the centrosome and cytoplasm to form the tail. In the oogenesis only one of these four cells becomes a functional egg while the other three are small rudimentary eggs which are called *polar bodies* and which take no further part in development (Fig. 23, *D–F*). The fertilization of the egg usually takes place coincidently with the formation of the polar bodies—and so we come back once more to the stage from which we started, thus completing the life cycle.

4. *Sex Determination*

In the formation of the sex cells one can frequently distinguish at an early stage, differences between the larger oogonia and the smaller and more numerous spermatogonia; this difference is the first visible distinction in the development of the two sexes. In the case of the human embryo this distinction can be made as early as the fifth week, and it is evident that the real causes of this difference must be at a still earlier period of development.

The cause of sex has been a favorite subject of speculation for thousands of years. Hundreds of hypotheses have been advanced to explain this perennially interesting phenomenon. The causes of sex determination have been ascribed to almost every possible external or internal influence and the world is full of people who think they have discovered by personal experience just how sex is determined. Unfortunately these hypotheses and rules are generally founded upon a few observations of selected cases. Since there are only two sexes the chances are that any hypothesis will be right half the time, and if only one forgets the failures of a rule and remembers the times when it holds good it is possible to believe in the influence of food or temperature or age, of war or peace or education on the relative number of the sexes, or on almost any other thing. By statistics it has been shown that each of these things influences the sex ratio, and by more extensive statistics it has been proved that they do not.

This was the condition regarding the causes of sex determination which prevailed up to the year 1902. Immediately preceding that year it had been found that the kinds of spermatozoa were formed in equal numbers in certain insects; one of these kinds contained a peculiar "accessory" chromosome, and the other lacked it. The manner in which these two types of spermatozoa were formed had been carefully worked out by several investigators without any suspicion of the real significance of the facts. It was shown that an uneven number of chromosomes might be present in the spermatogonia of certain insects and that when maternal and paternal chromosomes united in pairs in synapsis one "odd" chromosome was left without a mate (Fig. 34 *B*). Later, in the reduction division, when the synaptic pairs separated, the odd chromosome went entire into one of the daughter cells, and the spermatozoa formed from this cell contained one chromosome more than those formed from the other daughter cell (Fig. 34 *C* and *D*).

Chiefly because these two kinds of spermatozoa occur in equal numbers McClung in 1902 concluded that this accessory chromosome was a sex determinant. In 1905 Wilson discovered in a number of bugs that while there were two types of spermatozoa, one of which contained, and

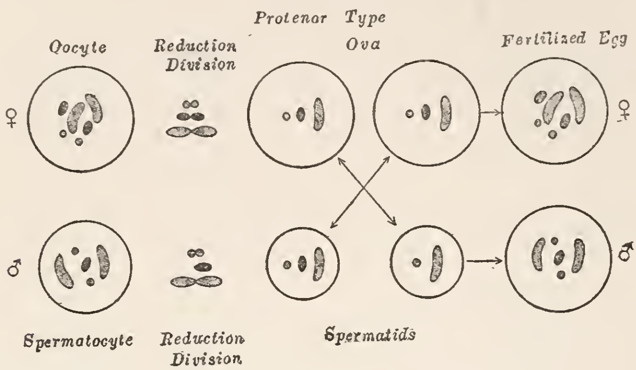

FIG. 36. DIAGRAMS OF SEX DIFFERENTIATION IN THE BUG, *Protenor*. The oocyte contains 6 chromosomes and the spermatocyte 5 chromosomes which are not yet united into synaptic pairs; the "sex" chromosomes are shown in black and white, two are present in the oocyte, but one is present in the spermatocyte. In the reduction division the synaptic pairs separate, giving rise to two types of spermatozoa, one of which has the sex chromosome and the other lacks it; all ova are alike in this regard. If an egg is fertilized by a sperm without the sex chromosome a male results; if fertilized by a sperm containing the sex chromosome a female results. (After Wilson with modifications.)

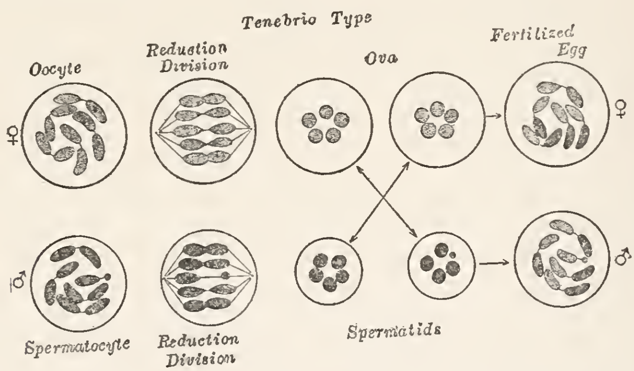

FIG. 37. DIAGRAMS OF SEX DIFFERENTIATION IN THE BEETLE, *Tenebrio*, showing 5 synaptic pairs of chromosomes (there are actually 10 pairs); in the oocyte all pairs are equal in size; in the spermatocyte one pair is unequal. These pairs separate in the reduction division giving rise to two types of spermatozoa and one type of ova; eggs fertilized by one type of sperm give rise to females, those fertilized by the other type give rise to males. (After Stevens with modifications.)

the other lacked, the accessory chromosome, there was only one type of egg, since every egg contained the accessory chromosome, and he pointed out that if an egg were fertilized by a sperm containing an accessory, two accessories would be present in the zygote, this being the condition of the female, while if it were fertilized by a sperm without an accessory there would be present in the zygote only the accessory derived from the egg (Fig. 35 *E* and *F*, Fig. 36).

In other cases Miss Stevens as well as Wilson discovered that two accessory chromosomes, differing in size, might be present in the male whereas in the female they are of equal size (Fig. 37). In such cases two types of spermatozoa are produced in equal numbers, one containing a large and the other a small accessory chromosome, whereas every egg contains one large accessory chromosome. If such an egg is fertilized

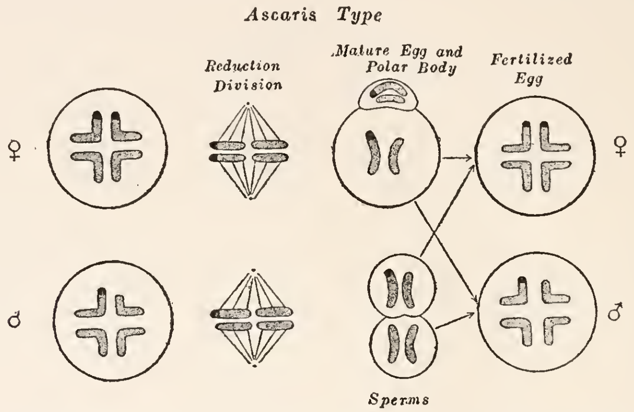

FIG. 38. DIAGRAMS OF SEX DIFFERENTIATION IN THE THREAD WORM, *Ascaris*. The sex chromosomes are here joined to ordinary chromosomes, there being two in the egg mother cell and one in the sperm mother cell. All eggs contain one of these sex chromosomes, while half of the spermatozoa have it and half do not. Eggs fertilized by one type of sperm produce females, those fertilized by the other type produce males. (From Wilson.)

by a sperm containing a large accessory (the *X* chromosome) it gives rise to a female, if by a sperm containing a small accessory (the *Y* chromosome) it gives rise to a male (Fig. 37).

In other animals one may not be able to distinguish separate *X* or *Y* chromosomes and yet such structures may be joined to one or two ordinary chromosomes. This is the case in the thread worm, *Ascaris* (Fig. 38), where two such accessory elements are present in the female, each being joined to the end of an ordinary chromosome, whereas in the male only one such element is present. Here also two classes of spermatozoa are found one with and the other without the accessory element, whereas all ova have this element, and in this case also sex is probably determined by the type of spermatozoon which enters the egg (Fig. 38).

Even in man sex is determined in the same manner according to several recent investigators. There are in the spermatogonia of man 47 chromosomes, accordingly to Winiwarter, one of which is the *X* or accessory chromosome (Fig. 39 *A*). These unite in synapsis into 23 pairs, leaving the X chromosome unpaired (Fig. 39, B) and in the reduction division the pairs separate, while the X chromosome goes entire into one of the daughter cells, which consequently contains $23 + X$ chromosomes, whereas the other daughter cell contains 23 chromosomes (Fig. 39 C and D). The former gives rise to spermatozoa with 24 chromosomes, the latter to spermatozoa with 23 chromosomes. In the female there are probably 48 chromosomes, according to Winiwarter, there being two X chromosomes, one from each parent, and after the reduction divisions every egg contains 24 chromosomes. If an egg is fertilized by a sperm containing 24 chromosomes an individual with 48 chromosomes, or a female, is produced; if fertilized by a sperm with 23 chromosomes an individual with 47 chromosomes, or a male, results (Fig. 39).

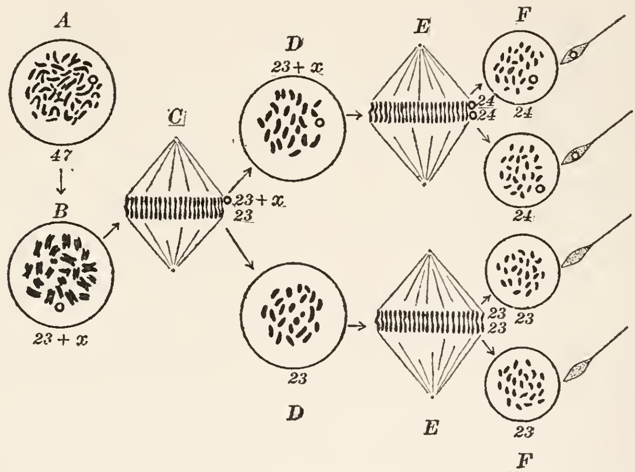

Fig. 39. Diagrams of Sex Differentiation in Man. A, spermatogonium with 47 chromosomes one of which is the "sex" chromosome. B, spermatocyte showing 23 synaptic pairs and a single unpaired "sex" chromosome. C, reduction division in which the synaptic pairs separate while the sex chromosome does not divide, consequently the second spermatocytes D and D' contain respectively $23 + X$ and 23 chromosomes. E and E', second maturation division in which every chromosome divides, giving rise to two equal classes of spermatids and spermatozoa, one of which has 24 chromosomes and the other 23. If an egg containing 24 chromosomes is fertilized by a sperm with 24, a female with 48 chromosomes is produced; if an egg with 24 chromosomes is fertilized by a sperm with 23, a male results. (From Morgan after Winiwarter.)

It must be said that other investigators, notably Guyer and Montgomery, have not found 47 chromosomes in the spermatogonia of man, but 23. Since both the latter investigators worked on negroes whereas Winiwarter worked on white men it has been suggested quite recently by Morgan and Guyer that there may be twice as many chromosomes in the white race as in the black. A similar condition in which one race has twice as many chromosomes as another race of the same species is found in two races of the thread worm, *Ascaris megalocephala,* but it is still too soon to affirm that this is true of white and black races of man, though the facts seem to point in that direction.

Similar correlations between chromosomes and sex have been observed in more than one hundred species of animals belonging to widely different phyla. In a few classes of animals, particularly echinoderms and birds, the evidence while not entirely convincing seems to point to the fact that two types of ova are produced and but one type of spermatozoa; but the general principle that sex is determined by the chance union of male-producing or female-producing gametes is not changed by such cases.

On the other hand, there are many observations which seem to indicate that the sex ratio may be changed by environmental conditions acting before or after fertilization and that therefore sex is determined by extrinsic rather than by intrinsic causes. Most of these observations, as already remarked, are now known to be erroneous or misleading, since they do not prove what they were once supposed to demonstrate. But there remain a few cases which can not at present be explained away in this manner. Perhaps the best attested of these are the observations of R. Hertwig and some of his pupils on the effects of the time of fertilization on the determination of sex. If frog's eggs, which are always fertilized after they are laid, are kept for some hours before spermatozoa are mixed with them, or if the female is prevented for two or three days from laying the eggs after they have entered the oviducts, the proportion of males to females is enormously increased. Hertwig attempts to explain this extremely interesting and important observation as due to the relative size of nucleus and cytoplasm of the egg; but in general this nucleus-plasm ratio may vary greatly irrespective of sex and there is no clear evidence that it is a cause of sex determination.

Miss King, also working on frog's eggs, has increased the proportion of males by slightly drying the eggs or by withdrawing water from them by placing them in solutions of salts, acids, sugar, etc., but the manner in which drying increases the proportion of males is wholly unknown.

Extensive statistics show that in many animals including man more males are born than females, whereas according to the chromosome theory of sex determination as many female-producing sperm are formed as male-producing. It is possible to explain such departure from the 1:1 ratio of males and females in conformity with the chromosome theory if one class of spermatozoa are more active or have greater vitality than the other class, or if after fertilization one sex is more likely to live than the other. In the human species it is known that mortality is greater in male babies before and after birth than in female babies, and if before fertilization the activity or vitality of male-producing spermatozoa is greater than that of female-producing ones it would explain the greater number of males than of females. In certain insects it is known that females only develop from fertilized eggs, and in one of these cases, viz., *Phylloxera,* Morgan has discovered that this is due to the fact that all the male-producing spermatozoa degenerate and that only female-producing spermatozoa become functional. Possibly experimental alterations of the sex ratio, such as Hertwig, King and others have brought about, may be explained in a similar way. At least the chromosomal theory of sex determination is so well established in so many cases and has been found to be true in so many instances where at first it seemed impossible of application, that it ought not be abandoned until unmistakable evidence can be adduced against it. For the present at least we are justified in concluding that sex is irrevocably determined at the time of fertilization.

(*To be concluded.*)

THE ORIGIN OF NITRATE DEPOSITS

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THE origin of all nitrate deposits was at one time accounted for by oxidation. The theory was held that the production of nascent nitrogen through the decomposition of organic matter caused a union to take place between the oxygen of the air and the nitrogen of the organic matter. Since then it has been shown that nitrates may be produced in various ways, and new theories are still being advanced from time to time to explain the origin of the nitrate deposits which occur in various parts of the world. The fact that different views have often been advanced to explain the origin of the same deposit has given rise to a great deal of discussion, and there still exists a wide difference of opinion as to the source from which the nitrogen may have been derived. By the source in this case is usually meant the preceding form in which the nitrogen appeared rather than the ultimate source of the nitrogen since this is generally admitted to be the atmosphere. The object of the present writing is to give a review of the various theories which have been advanced in this connection.

The fixation of nitrogen, that is, the transformation of elementary nitrogen into a combined state, may be brought about in the laboratory in a great many ways. Some of these processes have been shown to be profitable commercially and large quantities of nitrates and other compounds of nitrogen are now being manufactured in Europe and likewise in Canada, at Niagara Falls, but up to the present no commercial plant for the manufacture of "atmospheric nitrogen" products has yet been established in this country. These various processes of fixing nitrogen artificially may be grouped into four classes according as there is produced (1) nitrates or nitrites, (2) ammonia, (3) nitrides, or (4) cyanamid and its related compounds.

The fixation of nitrogen in nature also takes place in a number of different ways, but, unlike the technical operations just referred to, this is brought about principally by organic processes. Small amounts, however, are also fixed in nature by inorganic processes in a way analogous to some of the artificial methods, and in this way there are formed nitrates or nitrites, ammonia and nitrides.

The best known case of the inorganic fixation of nitrogen in nature occurs when nitric acid is formed in the air by lightning discharges at the time of thunder storms. The quantity of nitrogen which is combined in this way seems to differ in different parts of the world. In British Guiana during a period of twenty years the quantity so formed amounted each year on an average to 1.88 pounds per acre, while in Utah only 0.356 pounds was obtained annually for a period of three years. As a result of the decay of organic matter on the earth there is usually present in the air a sufficient quantity of ammonia to combine with all the nitric acid formed, although in the tropics the latter may sometimes be in excess. The ammonium nitrate which results from the combination dissolves in the snow and rain and in this way is carried to the earth along with other ammonium salts. Except in some parts of the tropics the total nitrogen recovered in this way is usually several times greater than the nitric nitrogen formed by the electric discharge. At Rothamsted, England, it amounted on an average during a period of eight years to 3.37 pounds per acre annually. At Ottawa, Canada, the average for the past five years amounted to 6.18 pounds per acre.

The quantity of nitrates which is thus formed in the air is small when considered locally, but in the aggregate the amount of combined nitrogen which is thus restored by nature to the surface of the earth is very great and is estimated at about 100,000,000 tons.

Other examples of nitrogen compounds which are not of organic origin are the metallic nitrides and ammonium salts which are found in the vicinity of volcanoes at the time of an eruption. It is probable that they are not carried as such in the fumes of the volcano, but are formed near the surface of the earth through exposure of molten rock to an atmosphere of nitrogen in a way analogous to the manner in which nitrogen is fixed artificially by the Serpek process, which consists in heating an ore of aluminium with carbon in an atmosphere of nitrogen. According to this view, nitrids would be formed first, and then ammonia when the former would come in contact with water. Many analyses have been made of the gases given off by volcanoes in different parts of the world, and free nitrogen has always been an important constituent, but so far as known combined nitrogen has never been reported.

A nitrogen compound of inorganic origin is also to be found in the case of a rare mineral which occurs in some parts of Arizona, and which has the distinction of being the only insoluble nitrate occurring in nature. This mineral to which the name Gerhardtite has been given is a basic nitrate of copper and is supposed to have been formed in the earth by water charged with air percolating over copper ore. It affords an illustration of an unusual way in which the fixation of nitrogen may be brought about.

The organic processes, however, are by far the most important in bringing about the fixation of nitrogen and the formation of nitrates. That nitrogen is one of the principal constituents of plants has been known since the beginning of the last century, but the source of the nitrogen was a matter of controversy for a long time afterwards. The experiments of some investigators showed that with sterilized soil and with all sources of combined atmospheric nitrogen cut off, the free nitrogen takes no part in the food supply of the plant. Other investigators arrived at just the opposite conclusion. These opposite views led to a great deal of discussion, and it was not until 1888 that Hellrigel was able to account for these conflicting results by growing leguminous plants in nitrogen-free soils. One set of plants was watered with distilled water, while to the other set was added in addition small amounts of leachings, containing only a trace of nitrogen, from a cultivated field. The plants watered with distilled water made but a small growth and soon died of nitrogen starvation, but those watered with the leachings reached a full growth and were found to contain about one hundred times more nitrogen than the seed sown. It was observed that the roots of the latter plants were covered with swellings, or nodules, which contained characteristic organisms while those which were watered with distilled water only had none. Furthermore, no nodules appeared and the plants did not develop when the soil leachings were sterilized before using. The experiments thus showed that the plants which were provided with nodules must have obtained nitrogen through the agency of the microorganisms; that these must have come from the soil leachings; and that they must have the property of fixing the nitrogen of the air. For some unknown reason these bacteria, to which the name *Bacillus radicicola* has been given, do not develop on the roots of non-leguminous plants; consequently, when plants of this kind are grown in the soil and harvested the total quantity of nitrogen present gradually becomes less. The advantage of rotating leguminous plants with crops of this kind thus becomes clear, because when a crop of the former is grown or plowed under as green manure the total nitrogen in the soil is increased. As the plants decay a part of the protein nitrogen of the plant again passes into the elementary state, part changes into ammonia, and a third part changes into nitrates. These changes are brought about by different bacteria, those responsible for the formation of nitrates being called nitrifying bacteria.

The amount of protein nitrogen which is converted into nitrates in the soil by these bacteria varies with conditions and depends on the physical condition of the soil, the quantity of organic matter present, the moisture content and the temperature. A basic element as potash, soda or lime must also be present with which the nitric acid formed may unite. On a limited scale these conditons may be so controlled that large quantities of protein nitrogen may be converted into nitrates, as is still done in India for the production of potassium nitrate to be used in the manufacture of gun-powder. The action of the nitrifying bacteria in thus leading to the formation of nitrates does not bring about any increase in the quantity of nitrogen combined, but simply brings about a transformation from one form to another.

Shortly after the discovery that the bacteria which are associated with the roots of leguminous plants are able to fix nitrogen, a great many experiments were made to determine if other bacteria have a similar function. Very conflicting results were obtained. Some investigators reported that certain bacteria are able to fix nitrogen, while others arrived at an opposite conclusion with respect to the same bacteria. Experiments along this line are still being made. It seems that most of the bacteria in the soil do not bring about any fixation of nitrogen, but there is good evidence that there are two or three kinds in addition to the *Bacillus radicicola* which are able to do this. Unlike the latter, these bacteria do not require the medium of leguminous plants, but may be active in soils which are devoid of growing vegetation. The most important of these bacteria have been called *Azotobacter chroococcum.* It has also been shown that various fungi, algæ and other organisms possess greater or less power of fixing atmospheric nitrogen.

A special study of the amount of fixation which may take place through the activities of these organisms, particularly the *Azotobacter chroococcum,* has been made by Headden[1] and others at the Colorado Agricultural Experiment Station. It was observed that in certain parts of Colorado dark-brown spots occur in which nothing will grow. From the color of the spots it was natural to assume that the cause of the spots was due to the presence of black alkali, or sodium carbonate, which is so commonly met with in the soils of arid and semi-arid countries. An analysis of the soils, however, showed little or no sodium carbonate present, but instead surprisingly large quantities of sodium, calcium and magnesium nitrates. The spots observed were not fixed, but spread rapidly and sometimes covered an area of several acres in extent. Moreover, new spots were noticed to appear in old and new localities. In some cases the amount of nitrogen accumulated, as shown by analysis, amounted to as much as one hundred tons to the acre foot. Arguments were given to show that the nitrates could not have originated with the irrigating water nor from concentration of ground water in the surface layers of the soil. That the spots are the remains of great herds of extinct animals which perished from some unknown cause, was likewise considered improbable for the reason that the areas involved are too large, and that the spots are increasing in size and appearing in localities where they were never before noted. The theory was therefore advanced that the excessive quantities of nitrates were formed *in situ,* through the nitrogen-fixing activity of micro-organisms in the soil.

It was actually shown that the power to fix atmospheric nitrogen is a property common to many cultivated Colorado soils, and that this power

[1] Col. Agri. Expt. Sta., Bull. Nos. 155, 178 and 179.

is not confined to nitrogen fixation in solution, but is manifested in soils as well. The principal nitrogen fixing organisms in the soil were identified as *Azotobacter chroococcum.* These have the power of developing a dark brown color in cultures containing organic matter and a nitrate, but give no color when the nitrate is replaced by organic nitrogen. The rate at which the fixation took place was considered sufficient to account for the formation of the nitrates found in the soil.

Exception has been taken to this view regarding the origin of these nitrate beds by Stewart and Greaves[2] who made a study covering a period of eight years at the Utah Experiment Station of the influence of irrigating water upon the production and movement of nitric nitrogen in the soil. Although the soils upon which the investigations were made were ideally adapted both chemically and biologically to support a rapid biological action, no unusual amounts of nitrates were found. A recalculation of the results reported by Headden showed that in the samples which were taken from the surface of the soil at different points in the same locality and from the same point at different depths, the nitrates and chlorides varied in the same ratio, and that whenever an accumulation of the former took place during a given period, the latter also increased during the same time in the same general proportion. It was therefore concluded that the excessive quantities of nitrates formed in the soils of Colorado were not formed *in situ,* but owe their origin to the same source as the other water-soluble salts.

Further investigations by Headden,[3] however, showed that while large amounts of chlorine generally occur with excessive nitrates, this is accidental rather than necessary, and that on the whole there is no ralation between the amount of nitrates and that of any other class of salts present. Additional evidence is given to show that the concentration in nitrates in brown spots in which nothing will grow is not due to the accumulation of preexisting nitrates, but to the action of microorganisms which are able to bring about the fixation in the soil of atmospheric nitrogen, and that the dark-brown color which is characteristic of the spots is due, not to black alkali, but to the development of pigment by the organisms.

The occurrence of nitrate deposits in caves has long been known. During the War of 1812 and again at the time of the Civil War, the "saltpeter" deposits in the Mammouth Cave, and in other caves in Alabama and Georgia, formed an important source of nitrates required in the manufacture of gunpowder. The origin of these deposits is commonly ascribed to the decomposition of animal remains, and particularly to the excrements of bats. In the southwest small deposits of guano are still to be found in some caves, but almost all deposits which are suffi-

[2] Utah Agri. Expt. Sta., Bull. No. 114.

[3] Col. Agri. Expt. Sta., Bull. No. 186.

ciently large to be of commercial value have been removed for use in the manufacture of fertilizers. Samples taken from some of the caves where the guano has undergone decomposition have been analyzed by the writer and found to run as high as 75 per cent. of potassium nitrate. Other samples have been examined which consisted of very pure elongated white crystals of calcium nitrate, and which had been taken from crevices in a cave. When placed in a humid atmosphere these soon melt in the moisture which they absorb from the air, but may be kept indefinitely in a desiccator.

While guano is usually considered to be the source of the nitrates found in caves, other theories are occasionally advanced to explain the origin of some of the deposits. Thus Hess[4] considers that guano could not be the source of the large store of nitrates which have been taken from the Mammouth Cave at distances of over five miles from any opening which leads to the surface, since bats go, as a rule, but a short distance from the entrance to the cave. Moreover, in the bottom of many caves there are to be found earths from which nitrates can be extracted, but which do not contain any animal remains as would be expected if the nitrates were derived from guano. To explain the occurrence of nitrates in caves of this kind, the view is put forward that the nitrates do not come from guano, but originate in the surface soil above the caves through the oxidation of organic matter by nitrifying bacteria. As the soil in limestone regions is usually loose and porous, the nitrates are considered to be carried down by percolating water and deposited in the floor of the caves. Air currents in and out of the caves would remove the water by evaporation, and the nitrates would consequently remain and would not be washed away so long as the inflow of water did not exceed that lost by evaporation.

A similar explanation is given for the origin of nitrate deposits under overhanging cliffs. Thus, water carrying nitrates dissolved from the soil percolates through the earth and a portion finally oozes out at the surface underneath where it evaporates and leaves the nitrates behind. Being protected from the rain in this position, the nitrates in this way are enabled to accumulate.

The theory advanced by Hess to account for the origin of nitrates in caves has not met with universal acceptance. Nichols[5] has argued that bats do frequent remote parts of caves; that cave earth does contain organic matter; and that the proportion of phosphates to nitrates in the cave earth is much too great to be accounted for on the supposition that they were brought in by percolation from the surface soil. It is considered that while small deposits may be found in the way described by Hess, the great bulk of the nitrates that are found in caves results from

[4] *Jour. Geol.*, 8, 129, 1900.
[5] *Jour. Geol.*, 9, 236, 1901.

the decomposition of bat guano. By leaching of the soluble salts from the guano, the nitrates are removed and may be concentrated in other parts of the cave or distributed elsewhere.

Because of their solubility, it is not to be expected that any large accumulation of nitrates can take place excepting in protected places such as caves, or in arid countries where there is very little rain. In such countries, however, there is very little vegetation, and consequently the organic processes which are of such importance in bringing about fixation of nitrogen in humid countries are able to operate to a much less extent in desert regions. We thus find that in the soil of such regions the total nitrogen present is usually much less than in soils which support a good vegetation.

On the other hand, the soils of desert countries have marked nitrifying powers, with the result that a large percentage of the nitrogen actually present is converted into nitrates. Furthermore, owing to the low percentage of organic matter present and to the porous nature of desert soils the anaerobic dentrifying bacteria are not so active in changing nitrates into free nitrogen, while the lack of vegetation prevents their convertion into protein nitrogen. The nitrates which are formed are thus enabled to accumulate, and either remain in the soil or are transferred by underground waters to other localities where they may be concentrated by evaporation of the water at the surface of the ground. If there has been any introduction into desert localities of organic matter from external sources, as may be brought about by the droppings or remains of animals, the accumulation of nitrates may be correspondingly increased. It thus happens for the reasons given that the largest nitrate deposits are found in desert regions.

In this country few nitrate deposits are to be found apart from those of cave origin. The most extensive so far known occur in San Bernardino and Inyo Counties, California, along the shore lines or bed beaches of what was supposed to be a former sea, but which is now geologically known as Death Valley. The region popularly known as Death Valley is that portion of the valley proper which is below sea level. The territory covered by nitrate beds has been estimated to cover an area of about 35,000 acres. Through erosive agencies the clay beds in which the nitrates were deposited have been worn into buttes and ridges of characteristic shape and color. The hills so formed vary from only 50 feet high to over 300 feet. Samples taken from the niter-bearing strata in the hills, and exposed by erosion, vary all the way from a trace to more than 50 per cent. of nitrates. It is generally agreed that these deposits have not been formed *in situ,* but have resulted from the concentration of nitrates formed from the decomposition and nitrification of animal and plant life which must have existed in the region at the time that the valley was filled with water. Owing to the limited distribution of these nitrates, they are not considered of much commercial importance, and the same may be said of all other deposits so far discovered in this country.

Small nitrate deposits are also to be found in various other parts of the world, as in the Sahara, in Russian Turkestan, and in Egypt, where nitrate earths occur which contain about 15 per cent. of calcium and sodium nitrates. The earth has long been used locally as a fertilizer, and its use is supposed to be increasing. The source of the nitrates in this region is not known.

All known deposits, however, which occur, like the ones just referred to, in various desert regions throughout the world are insignificant compared with the well-known deposits in the deserts of Atacama and Tarapaca in the north of Chile. These deposits command a great deal of interest, not only on account of their commercial importance, but also for the many attempts which have been made to explain why the quantity of nitrates in this particular region should be so large compared with any other known deposit.

The first shipment of nitrates to Europe from Chile was made in 1825. Since then the annual exportation has continuously increased until in 1912 the total quantity exported amounted to 2,485,860 tons of which 1,925,590 tons went to Europe, 469,100 tons to the United States, and 91,170 tons to other lands.

The arid region in which the nitrates are found extends for about 430 miles between 13° and 25° south latitude and lies between the Andes in the east and the Coast Range on the west. This area lying between the two mountain ranges does not form a continuous valley, but is broken up by transverse ranges into a series of elevated basins or plateaus. These plateaus are generally flat or undulating, and have an elevation from less than 2,500 feet to more than 5,000 feet. They have a general slope from the foot of the Andes towards the Coast Range, and as a result the lowest part of this plateau region, or pampa as it is called in Chile, lies along its western border where it joins the foothills of the Coast Range. It is along this zone that the nitrate deposits occur. The surface of the surrounding region is dry and sandy and vegetation is totally absent.

The nitrate beds as they occur in different parts of this region vary in thickness up to about six feet. They are usually found at or near the surface, but may in some cases be covered with an overburden to a depth as great as thirty feet. The nitrate deposits are never found pure, but are always mixed with sodium chloride and other salts, and are impregnated with insoluble earthy material. Crude nitrate may sometimes run as high as 60 to 70 per cent. of sodium nitrate, but a deposit running 50 per cent. is considered high-grade material. Material containing less than 16 per cent. is too low grade to be mined at a profit at present.

The source of these deposits is a subject which has given rise to a great deal of discussion. Many theories have been advanced to account for the origin of the nitrates, but all appear to fall short of adequately accounting for all the conditions under which the nitrates are found in Chile. It is generally considered that an organic source is the most probable, but there have not been lacking explanations for the formation of these nitrates which have been based on inorganic agencies.

Thus one of the theories advanced is that the nitrates may have resulted from electric storms occuring in the Andes. It has been suggested that the nitric acid which is formed in this way by the oxidation of the nitrogen of the air becomes changed into calcium nitrate on coming in contact with the limestone of the mountains, and that this in turn on being washed down into the pampa region has been converted into sodium nitrate in coming in contact with the sodium salts already existing there. It has also been stated that at certain seasons of the year there is a great deal of static electricity in the air over the desert region, owing to the strong winds and the extremely dry climate, and that the nitric acid which is formed as a result of this condition is carried to the ground by the moisture in fogs which drift in from the sea.

The view has also been advanced that the nitrogen in the Chilean nitrate may have come from nitrogenous fumes given off by volcanoes in the Andes. It has already been pointed out that nitrides and ammonium salts are sometimes found in the vicinity of volcanoes after an eruption, but whether these compounds result from the direct fixation of atmospheric nitrogen near the mouth of the volcano, or from some combined form of nitrogen already present in the earth is not known, but the former view is the more probable. It has been shown, however, that the source of the nitrogen is not organic.

It has been claimed by some that alkali carbonates are able to bring about the fixation of atmospheric nitrogen into nitric acid in the presence of oxidizable matter, and Pissis[6] expressed the opinion that the niter beds in Chile were formed in this way. It was pointed out that the decomposition of feldspar rock in the region of the Andes supplied alkali carbonates, while the protoxide compounds of iron which are common in the rocks of the pampa are easily oxidized under ordinary conditions to form peroxide compounds of iron. The view was accordingly put forward that the alkali carbonates in contact with rocks of this kind brought about the oxidation of the nitrogen of the air with the ultimate formation of nitrates.

Perhaps the most far-fetched attempt at an explanation of the origin of these deposits was that presented by a writer[7] in the *Comptes Rendus*

[6] "Nitrate and Guano Deposits in the Desert of Atacama," A. Pissis, London, 1878.

[7] Bordas, *Compt. rend.*, 147, 924, 1908.

a few years ago. It was observed that pieces of glass left on the ground in the vicinity of the saltpeter mines in the Province of Aconcagua, Chile, became colored blue in a short time, while samples of the same glass exposed on the roofs of buildings to the direct rays of the sun remained colorless. This suggested the possibility of the soil in the vicinity being strongly radioactive, which was thought to be confirmed by the action on photographic plates properly protected and subjected to an exposure in the ground for a month. It was suggested that the radioactivity of the soil as indicated by these experiments might have had something to do with the formation of nitrates in this part of Chile. It is now known that all soils are slightly radioactive and to approximately the same extent.

None of these views which have suggested an inorganic mode of formation for the Chilean nitrates have received very general acceptance. Much more credence is given to the theories that the nitrates found in the deserts of northern Chile have resulted from the decomposition of organic matter brought into the basins in which they are found from outside sources.

One of the most popular of these theories suggests sea-weeds as the source of the nitrates. The explanation is given that in past ages the pampa regions were sea beaches, and that an enormous amount of sea-weed was piled up on them. In course of time the beaches were elevated above sea-level, and the collected sea-weeds in decaying under arid conditions decomposed in such a way that the nitrogen present was converted into nitrates, and the iodine into iodates. It may be pointed out in this connection that immense groves of giant kelps are now to be found along the Pacific Coast of North America, and that the proportion of iodine to potash in the dry plants is about the same as is to be found in the crude niter of Chile. The ratio of nitrogen to potash in the former, however, is very much less than in the latter.

There are many objections which may be offered to this theory. Thus, if the niter came from sea-weed it must necessarily contain bromine as well as iodine, since both are present in this source, and there is no known natural process which can bring about the separation of bromides and iodides. So far as known, however, bromine has not been found in any of the nitrate deposits of Chile; whereas, from analyses made by the writer, the bromine in the giant kelps of the Pacific, for example, is of the same order as the iodine.

Again, sea shells are never found in the nitrate beds, and the stones in the neighborhood are sharp and jagged and show no signs of being worn by water as they must necessarily have been if they had at one time existed on a sea beach.

Perhaps the best known theory which has been advanced to explain the origin of these nitrates is that they have been derived from the decomposition of ancient guano deposits. In defending this theory Penrose[8] has assumed, in the same way as those who favor a marine origin for the nitrates, that the pampa region was once a part of the ocean bottom, but as the region gradually rose it became a more or less enclosed basin. At this time guano beds were supposed to have been deposited along the borders of these waters, just as they are now deposited in the neighboring shores of the Pacific. It is considered quite possible that marine plants might also have collected in the basin at the same time, and that these constituted the source of the iodine, although it is pointed out that this element might also have originated in minerals, or mineral springs occurring in the region. The formation, as suggested, of inland basins of sea-water, which would ultimately evaporate, would furnish also a source for the common salt associated with the nitrates, as well as for the soda of the nitrates.

The guano theory, however, has been objected to on the ground that no accumulation of phosphate has ever been found in the nitrate country, and such must necessarily occur in amount corresponding to the nitrates if the latter have been derived from guano. It is argued, on the other hand, that such phosphates may actually exist, but that they have not yet been discovered, and it is further explained that the absence of the remains of birds and of sea shells may be accounted for on the ground that sufficient time has elapsed since the beds were deposited to admit of the decay of all such materials.

There is still, however, a further objection which applies to both the sea-weed and guano theories. Thus, if the region was at one time a sea-beach it must have taken ages, as Newton has pointed out, for the nitrate pampa to be elevated to its present level. During these ages the region must have passed through varying climatic conditions, including most probably rains. It has, therefore, been argued that the nitrate deposits are, geologically speaking, of very recent origin.

In suggesting another organic source from which the nitrates may have been derived, Kuntze has called attention to the fact that vicuñas, and llamas, which are at home in this portion of the Andes, have the peculiar habit of always depositing their manure in one and the same place. Immense herds of these animals are supposed to have roamed over the region from time immemorial, each herd having a definite dunging place at some convenient point. As the manure accumulated its nitrification would progress rapidly under the prevailing arid conditions. The common salt would be derived from the urine and excrements, while the decomposition of rocks throughout the region is considered sufficient to account for all other salts occurring in the crude niter.

Newton[9] is of the opinion that the source of the nitrates is the

[8] *Jour. Geol.*, 18, 1, 1910.

[9] *Jour. Soc. Chem. Ind.*, 19, 408, 1900.

organic matter occurring in the soil of the great plain lying between the nitrate beds and the Andes. It is pointed out that there exists in this region all the conditions which favor the rapid conversion by nitrifying bacteria of the nitrogen of organic matter into nitrates. The soil is porous and basic in its nature, and contains organic matter chiefly of ancient vegetable origin; the temperature is high and, on account of the absence of rain, there is no growing vegetation to absorb the nitrate, and therefore it must accumulate. The mountain floods which swamp the plain once in every seven or eight years are considered chiefly responsible for transporting and concentrating the nitrates from the superficial layers of the pampa soil to the lower western part of the pampa region where the deposits are found. The nitrate deposits are thus looked upon as the concentrated fertility of the thousands of square miles of land between the watershed of the Andes and the Coast Range. It is admitted that electrically generated atmospheric nitrate may also be present.

Headden[10] has suggested that the nitrates of Chile may have been formed by the direct fixation of the nitrogen of the air by nitrogen fixing bacteria in the same way as accumulations of nitrates have been shown to have been formed in certain soils of Colorado.

It is apparent from the views which have thus been advanced to explain the origin of the Chilean nitrates that no single theory has yet been proposed which is adequate to account for all the conditions under which the deposits are found, and it seems most probable, as some have suggested, that instead of being formed in one way only, the nitrates owe their origin to several sources.

[10] Col. Agr. Expt. Sta., Bull. No. 155.

ETHNIC FACTORS IN INTERNATIONAL RELATIONS

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THERE are many factors which influence international relations. Among the most important are language, culture, religion and commerce. If the peoples of two countries speak the same language intercourse between them is much easier and sympathetic relations are likely to exist between them. If two nations are of about the same culture with respect to the development of science and art, the diffusion of knowledge, moral standards, etc., this culture is likely to serve as a bond of union. But if the cultural differences are great they may give rise to a feeling of antipathy, or, to say the least, the one nation is almost certain to look down upon the other nation as being of a lower grade of culture. If two nations are of the same religion this may serve as a bond of union. But if they are of different religions this difference may give rise to hostility, especially if one or both of these religions are of a militant sort. If two nations have commercial relations which are to the mutual benefit of both they are almost certain to remain on friendly terms with each other. But if they are rivals in commerce such rivalry is very likely to lead to hostility and sometimes to war.

In this article we are to discuss the part played by ethnic factors in international relations. That is to say, we shall try to ascertain to what extent and how ethnic differences between the peoples of nations affect the relations of those nations towards each other. These differences are with respect to external anatomical characteristics such as stature, facial features, the color of the skin, the character of the hair, etc., and with respect to the internal organs, such as the brain, and the nervous system in general, the heart, lungs, etc., all of which play a part in determining the psychic characteristics of a people. It is, however, very difficult to segregate these factors and to study their effects because they are inextricably mingled with the other factors which have been mentioned. This is true, in the first place, because these ethnic characteristics have their influence in part indirectly through the other factors. That is to say, the language, culture, religion, etc., of a people are determined in varying degrees by these ethnic characteristics. But it is very difficult to determine in any specific case to what extent this is true as compared to the influence of physical environment and such chance circumstances as relations to other peoples.

It is also difficult to determine how ethnic differences influence international relations directly. These differences frequently give rise to feelings of antipathy, as when the color of the skin or the facial features of one ethnic stock are regarded as ugly, if not repulsive, by another, or when the odor of the skin of one ethnic type is unpleasant to another. But it is evident that in some, if not all, of these cases esthetic, and sometimes moral and religious, ideas as well are involved, so that these antipathies are due in part, and perhaps sometimes entirely, to cultural differences. It would, therefore, be difficult to say in the case of any one of these antipathies whether it would exist on the basis of the ethnic difference alone if the cultural differences were lacking.

It is now evident that this article must consist largely of a study of the degree and permanence of ethnic differences. Since our interest is mainly with respect to the future the discussion may take the form of an attempt to answer two questions. The first is as to whether ethnic differences are sufficiently great to keep the contrasted ethnic stocks permanently in different cultural statuses. The second is as to whether these differences are sufficiently great to prevent a final amalgamation of all the ethnic stocks. In a word it is a question of the possibility and probability of cultural and ethnic uniformity in the future.

There have been many theories as to the part played by ethnic characteristics in determining the culture of a people. At one extreme we find such a writer as Gobineau, who in his treatise on the inequality of the human races tried to prove that there is a great deal of difference between the ethnic stocks as to their capacity for culture. At the other extreme is Boas, who insists that there is practically no difference between the ethnic types in their capacity for culture. It is evident that many of the physical differences between the ethnic types do not imply mental differences. For example, color is in the truest sense only skin deep, and is a racial adaptation to climate. Stature, the shape of the nose, etc., do not in themselves involve specific mental characteristics. But great differences in the brain and the rest of the nervous system, and in certain other of the viscera, would necessarily involve important mental differences and therefore variation in the capacity for culture. Such differences would be in the instinctive, intellectual and emotional make-up of the representatives of the type. Let us see how probable it is that there are such great differences.

There is a certain amount of variation in the size of the brain between the different ethnic types, but it is not at all certain that this variation is sufficiently great to cause any material difference in mental characteristics. This is indicated by the fact that as great variation is to be found in the brains of the members of the most civilized peoples and even among the ablest representatives of these peoples. In the structure of the brain and of its cells, also, there is probably no great variation, though such variations would be of even greater significance than variations in size. In similar fashion, in the rest of the nervous system there is probably no great variation between the ethnic types. When, however, we come to some of the other viscera, such as the heart and the lungs, controlling the circulatory and respiratory processes, the variations are probably somewhat greater as the necessary result of adaptation to climatic conditions. It is unfortunate that we do not have a larger amount of data, and more accurate data, as to ethnic differences. But what we do know seems to indicate that in the fundamental instinctive characteristics there can be no great differences between the ethnic types. In similar fashion it is doubtful if there can be very much variation in the intellectual capacity of these types. But in the emotional make-up there may be considerable variation, because, according to the prevalent psychological theory as to the nature of emotions, the emotions are determined in large part by the processes of certain of the viscera, such as the heart and lungs, and we have seen that there may be considerable variation in these viscera between the different ethnic types.

Let us now survey briefly the peoples of to-day with respect to this relation between ethnic characteristics and culture. If we take the primitive peoples the first and most important thing to be noted is that these peoples represent all the ethnic types. If there was a close correlation between ethnic characteristics and culture it would be expected that these primitive peoples would belong to one or only certain ethnic types, while the civilized peoples would belong to other types. Furthermore, studies which have been made of certain primitive peoples seem to indicate no great differences in mental characteristics from civilized people. For example, the Cambridge University Anthropological Expedition, which studied some of the most primitive peoples in the world in Australia and Melanesia, found no great differences in the senses and the mental processes of these savages. Dr. Myers, the psychologist of the expedition, came to the conclusion that so far as innate mental capacity is concerned these savages are of about the same grade as European peasants. These facts seem to indicate that the low culture of these primitive peoples is to be attributed principally to environment and to such circumstances as lack of contact with other social groups.

Turning now to the civilized peoples, we find a similar heterogeneity of ethnic type. For example, in Europe we find such heterogeneity in every nation. And yet it is popularly supposed that the culture of each people is due largely to peculiar ethnic characteristics. Thus we hear the culture of the French nation attributed to the "Gallic race," the culture of Germany attributed to the "Teutonic race," etc. But the researches of the ethnologists have revealed the fact that in France, for example, are represented all the principal European ethnic types. Thus in the north of France the Nordic race is predominant, in the central part the Alpine race is predominant, while in the southern part is to be found in large numbers the Mediterranean race. Thus it is evident how difficult it would be to trace the peculiar features of French culture to peculiar ethnic characteristics. In similar fashion in Germany the Nordic race is most prevalent in the north, while the Alpine race becomes predominant in the south. Such movements as the Pan-Germanic movement and the Pan-Slavic movement are frequently regarded as having a peculiar ethnic significance, but, for example, in the countries which constitute Pan-Slavism, namely, Russia and certain of the Balkan countries, all of the European ethnic types are represented, and also a considerable intermixture of Asiatic blood. The Jews present a similar example of this error. Most of the Jews themselves, as well as most non-Jews, regard the Jewish people as a distinct ethnic type. But ethnological research has shown that there is a great deal of variation between the Jews in different countries, so that it is evident that through intermixture the Jews have lost ethnic unity. The peculiar features of their culture are due to their history and social status rather than to these ethnic characteristics. So far as such movements as Pan-Germanism, Pan-Slavism, Zionism, etc., try to preserve characteristic cultures, they may be of great value. But when they give currency to mistaken ideas of ethnic unity they may do a great deal of harm.

Such mistaken ideas of racial identity have frequently furnished the basis for a national self-consciousness which has led to an assumption of superiority over and hostility towards other races. A realization of the fact that the cultural status of a people is frequently due mainly to its environment and circumstances rather than to its ethnic characteristics would ameliorate these hostile relations. Furthermore, these facts suggest the possibility of a uniformity of culture the world over, which possibility we shall discuss later in this article.

Let us now consider the second question proposed, namely, with regard to the possibility of a final racial amalgamation. This is, of course, largely a question of the feasibility of crossing between the principal ethnic types. There are three of these types, namely, the white or Caucasian, the yellow or Mongolian, and the black or Negro. We have already discussed how antipathies may arise between ethnic types. We have seen these antipathies may arise from cultural differences such as different esthetic ideas. Thus where antipathy is based upon difference in skin color or facial features it is largely, but not entirely, an esthetic matter. Where an antipathy is based upon such a thing as difference in odor it may seem to be innate in its origin and therefore permanent. But even such an antipathy may be partly or largely the result of a difference of taste and therefore due to cultural differences. In fact, it is very difficult to determine whether any antipathy is innate and therefore an insuperable barrier between races. If there is no such innate antipathy, with uniformity of culture all antipathies should disappear.

Such a final racial amalgamation would then seem to be possible. However, there may be other obstacles in the way, and in any case it is not necessarily advisable to work for such an end. This is a question I will discuss a little later.

Let us now consider what have been and are the actual relations between these ethnic types. The whites and the yellows have already mingled to a large extent, so that a considerable proportion of the population of Asia is a cross between the white and yellow races. They have also mixed to a slight extent in Europe. These facts seem to indicate that there is no very serious antipathy between these two types. It is true that at present there is a good deal of hostility between these two races, but this is undoubtedly due in large part to cultural differences and political difficulties.

In his relation to the black, the white has shown a good deal more antipathy. The reasons for this are very evident, since the differences between the white and the black are much more striking in appearance and much more obvious. And yet even between the white and the black there has been a good deal of mixture. In northern Africa the two races have been mixing for thousands of years, and even in Europe we find traces of a slight amount of mixture in the past. In America we find curious differences in the extent to which the white and the black has mixed. In North America, the Anglo-Saxon has, to a large extent, stood proudly aloof from the black, though he has frequently condescended to illegitimate relations with women of color. But in the southern part of North America, in Central and South America, the Portuguese and Spaniards have mixed very largely with the blacks and have displayed comparatively little of the usual antipathy. These facts suggest that this antipathy of the white to the black may not be as fundamental as it appears, and is due to esthetic ideas and cultural differences and also perhaps to the consciousness of the fact that the blacks until very recently were uncivilized and slaves.

Between the yellows and the blacks also there has been some display of antipathy, though it may not be as great as between the whites and the blacks.

I have said nothing about the American aboriginal type. In Latin America this type has been assimilated very largely by the white, while in Anglo-Saxon America it has become almost extinct.

These facts seem to indicate that these racial antipathies are not as innate or as permanent as they seem to be. But this does not mean that there are no other obstacles in the way of racial amalgamation. Each of the ethnic types evolved in a more or less characteristic physical environment, and is, therefore, adapted to such an environment. Thus the negro is adapted in his color, physiological processes and temperament, which is due largely to emotional characteristics, to a tropical climate. In similar fashion the white is adapted to a temperate climate. Now it may be that neither of these types can become permanently adapted to another climate. The evidence as to this is as yet inconclusive and rather conflicting. But even if such adaptation could finally take place it may hardly be worth while to attempt it, since the process of readjustment would be rather painful. So that for these climatic reasons it may be preferable for the principal ethnic types to remain distinct.

If these types do remain distinct, the very important question arises as to whether they can persist side by side on an equality with each other, or whether some will necessarily remain permanently subject to others. This will probably depend, in part, upon the relative prolificness of these races. That is to say, the more prolific races will, in the long run, have the advantage so far as numbers are concerned, but it will also depend, in part, upon the possibility of a uniform world-wide culture. That is to say, if a race proves incapable of attaining to as high a culture as other races, however prolific it may be, it may still remain subject to another race because of the advantage that a higher culture gives that other race. It is believed by many that this may prove to be the case for the negro race. However, we have seen that there is probably no great difference in intellectual capacity between the different ethnic types. There may, however, be a good deal of difference in emotional characteristics, which play an important part in determining temperament, so that if the negro or any other race remains subject permanently to another race it will probably be due to such emotional characteristics.

We have now discussed very briefly some of the facts and probabilities as to the part played by ethnic factors in international relations. We must now consider what practical deductions may be drawn as to international relations in the future, especially with respect to war. In the first place, a dissemination of knowledge as to the theory of evolution and of the ethnic relations between peoples ought to have much effect in lessening racial prejudice, removing many international antipathies, and promoting international comity. If it were generally known that all the ethnic types have a common ancestry, and that many nations are similar in their ethnic make-up, it should have a good deal of effect towards accomplishing these ends. For example, to take a concrete illustration, if it were generally known that northern France is more like northern Germany ethnically than it is to southern France, and that southern Germany is more like central France ethnically than it is to northern Germany, this knowledge ought to have a good deal of influence in promoting international good feeling between France and Germany.

In the second place, it will probably on the whole and in the long run be well to develop as fast as possible a world-wide cultural uniformity. I am well aware of the objections that some have to this. They fear that such a dissemination of culture will deprive the whites of their power over many subject races, and may in course of time even give these races the ascendency over the whites. It is true that such uniformity of culture will quite probably lead to the emancipation of these subject races, but this will in all probability be to the benefit of these races and may also prove to be to the benefit of the whites as well. Furthermore, it is hard to believe that such uniformity of culture could ever lead to the subjection of the whites, because the very fact of uniformity would imply equality between the races of the world.

When we turn to the question of a final racial amalgamation, it is hard indeed to draw any practical deductions. There is a great deal of difference of opinion as to the advisability of miscegenation or the crossing of races. It is, of course, to a considerable extent a question of whether the races being crossed are equal in capacity or whether the one is superior to the other. If they are equal it would appear as if there should be no loss as a result of the crossing and if anything a gain. If the one is superior to the other it may lose as a result of the crossing but, on the other hand, the inferior one ought to gain so that the loss ought not to be greater than the gain. However, we have seen that it is hard to determine whether any race is materially superior or inferior to the other races biologically and psychologically so that it may be that the races should be regarded as being practically on an equality for purposes of crossing. But regardless of the question as to whether the races being crossed are equal or not there is the further consideration as to whether their characteristics are such as to make a happy combination. We can not judge very well as to that now but Mendelian investigation may furnish us a basis for judging in course of time.

Non-biological writers usually regard human hybridism as a bad thing when it is the result of a crossing between a so-called superior and a so-called inferior race. Their opinion is based upon the fact that these half-breeds are frequently failures in society. But such failure is usually due to social factors though these writers attribute it to the inborn traits of the half-breeds. Biologists regard hybridism in general as a good thing in the animate world at large and as an important factor in organic evolution. Biologists who have discussed human problems and anthropologists who are well grounded in biology have usually regarded human hybridism as a good thing and as an important factor in human mental and social evolution. So that it is probably true that human hybridism in general is a good thing. However it would not be safe to argue from such a general principle in every specific case. It may be that under some conditions such as have been suggested above miscegenation is not a good thing. Furthermore it is true that if a general movement towards a final racial amalgamation began many difficulties would arise as a result of the intimate contact of the races during the long period which this process would take and it might be questioned whether the benefits to be gained by a final amalgamation would more than counterbalance the difficulties of the transition period. And in any case, as we have seen, for climatic reasons such amalgamation may never be possible.

It is now evident that there are three possibilities as to ethnic relations in the future. The ethnic types may always remain distinct, though there will always be a certain amount of crossing between them as there always has been, while the different cultures will also remain distinct. Or the ethnic types may remain distinct but culture will become uniform the world over. Or a final racial amalgamation may take place with a uniform world-wide culture. Uniformity of culture would be the almost inevitable accompaniment of racial amalgamation so that we need not recognize the possibility of such amalgamation with a diversity of culture. I would not dare to express an opinion as to which of these possibilities is most likely to take place. But it is to be hoped in the interests of international peace that in the course of time there will be more or less uniformity of culture at least so far as political organization, moral ideas and systems of law are concerned.

The preceding has necessarily been a very brief discussion of a great subject and I regret very much that I have not the space to apply the broad generalizations which have been suggested to concrete examples. But I hope the discussion has been sufficient to indicate the importance of taking into consideration the ethnic factors in all international relations, as, for example, in the relations of two great European nations such as France and Germany, in the relations of a powerful nation to its subject peoples as the British in India, and in the relations of a great Occidental and a great Oriental country such as the United States and Japan.

Portrait of Innocent X., by Velasquez. Doria Gallery, Rome.

PLEASURE IN PICTURES

BY ROSSITER HOWARD

I. Unaccustomed Power of Vision

OUR tastes in pictures do not by any means agree—even those of very wise critics, who ought to know the good from the bad. We might get into all sorts of difficulties with the words *good* and *bad*; but most of us look at pictures because we enjoy them, and our varying choices have some elements in common. These common factors are a sort of minimum wage which we ask in return for our attention, and our pay must be immediately convertible into pleasure.

Perhaps the requirement most nearly universal is that a picture shall look like what it is intended to represent. The popular ideal of art has always been to paint grapes so nearly like the real fruit that the birds will peck at them, and the only excuse for not responding to this widespread demand is that the artist is unskillful.

The people's doctrine has good evolutionary reason back of it. Vision was first developed in the animal by its use in recognizing objects, and recognition is still its chief function and greatest pleasure. The easier the recognition, the greater our sense of capacity; and perhaps the largest element in the enjoyment of pictures is the sense of unaccustomed capacity of vision. We notice this most easily in a portrait that is a "striking likeness;" that is, one that gives us such a sense of the person represented that we react to it more than we should to a view of the person himself, for we are not *struck* by the appearance of our friend. As we look at such a picture we have a visual experience keener than is our habit; our eyes have communicated to us the subject with great force and yet with ease. Though we may say that it is the artist who has been clever, the reason we believe so is that he has lent ability to our eyes. Our feeling is closely akin to the one we have in golf when with an easy swing of our club we feel the ball lifted and shot far beyond our expectation; we experience an unwonted power within ourselves, and a consequent sense of abundant life.

This portrait of "Innocent X." by Velasquez shows us a man with whom we are not acquainted; yet if we should enter the presence of this pope himself he could hardly have upon us the electrifying effect made by his portrait as we come upon it in a cabinet of the Doria Gallery in Rome. It is as though some vital fluid were poured through our veins. Admiration of the artist's ability plays no part in producing this first feeling. The forcefulness which causes our whole organism to react to

"St. George and the Dragon," by Carpaccio, Church of San Giorgio degli Schiavone, Venice.

this painting is nothing else than clearness of statement. A photograph with every detail perfected lacks the clearness of this powerful portrait, where the insignificant is blurred or omitted in order that we may grasp at sight the significant. The careful reasoning of a school text-book is not as lucid as the proverbs of "Poor Richard," which cause the mind to leap to a sure conclusion. In a picture the essential quality is clarity; easy recognition is our experience of it.

This is true even in a modern landscape where the rocks and trees of nature are but half revealed by morning mists. Though it seem that the charm lies in the very opposite of clearness, really the artist has presented the clearest possible statement of the conditions of nature which are the spirit of misty dawn. Every element in the landscape which would be the same at any time of day, in all weathers, in all of nature's varying humors, these he has almost obliterated in order that we shall see and feel what he saw and felt that early morning in the shimmering light. Now a man to whom a morning mist is only an obscurity will probably seek in this picture trees and rocks, and the mist will be to him a weariness of the soul; the picture to him is not clear and he finds no pleasure in it. A photograph is more like the place. On the other hand, we might be bored by the photograph's insistent detail, which dissipates the expression of any nature quality; and we should find the painting a jewel of direct presentation of the subject.

The theories of most of those ultra-modern painters who are grouped under the meaningless term "Post-impressionist" are elaborate explanations of a similar aim to isolate some phase of our experience of nature for its simpler, and therefore clearer, presentation. Such a phrase as "the expression of our plastic consciousness" implies but the effort of the Cubist painter to communicate with extraordinary simplicity and force the perception of volume. It is of no importance to this discussion if the artist does not accomplish his purpose; it is the aim that we are seeking.

Narrative pictures introduce an extension of this principle. Here is Carpaccio's "St. George and the Dragon," told with delightful vivacity. We do not believe in dragons, and we may know nothing of St. George; but here is a fight with the hero triumphant, and if we have any imagination we push on that spear as eagerly as we lean down the course while watching a hundred-yards' dash—with this difference, that we doubt the outcome of the race, but feel sure of St. George. All the relations are clear.

Our physical vision is satisfied with easy recognition of hero, horse, dragon and rescued princess; our mental vision interprets and relates these separate objects with unusual facility. Now as intellect is no less the product of evolution than is sight; as the primitive man who enjoyed its exercise developed at the expense of the lazy man; so to-day we are led forward by delight in mental facility, and the primary pleasure in any clear narrative is the sense of unusual ease in realizing and correlating objects, figures, persons and their experiences.

In proportion as a picture surpasses the usual in the clarity with which it presents its contents—things, thoughts and their relations—do we react to it, feel its force in our own enhanced physical and mental vision. Before a great work our powers seem so much more than adequate that limitation vanishes, and we have a glimpse of the infinite.

II. Constructive Emotions

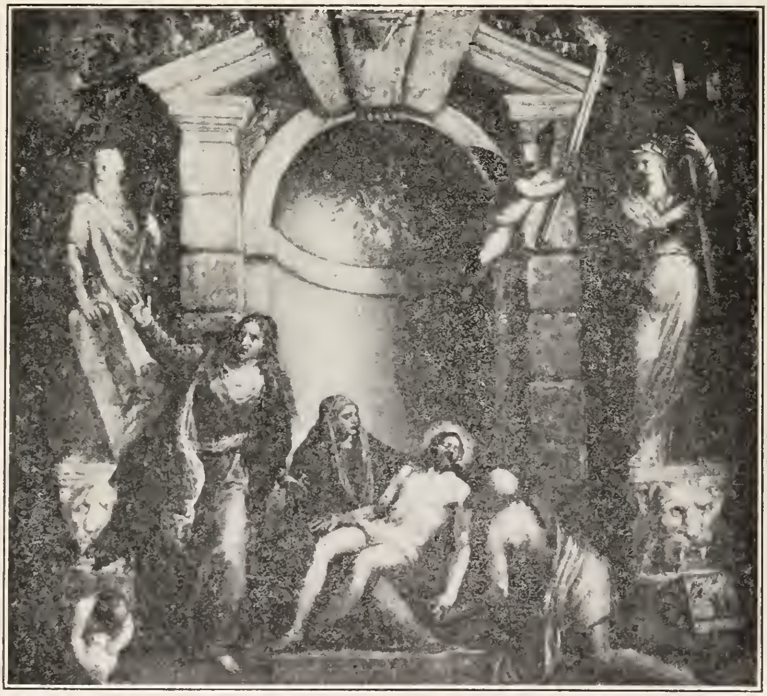
The largest part of our pleasure in pictures is to see clearly and without effort, but still it makes a difference what we see. A painter, preoccupied with his craft, may care little about the subject, and a critic not infrequently assumes the artisan's viewpoint; but the people have decided wishes. They require pleasantness, and their preference is the result not of stupidity but of instinct. To them an unpleasant subject forcefully portrayed is but the more revolting; their aversion is reflex, and based upon a principle they do not need to understand in order to feel. It is as true in art as it is in nature, that the normally pleasant is what is constructive of life, and the unpleasant is the destructive. Nature's encouragements and warnings which have prevented the animal kingdom from being wiped off the earth ages ago and which have developed man, have been at work also in art among all peoples at all times, producing similar results in absolutely unconnected schools.

Individual tastes may be warped or even perverted by prejudice of education or other accident of time or place, but underneath is the broad principle that men like what they feel is life-giving. The more life we can get at the least expenditure of effort, the better we like it; decadents and degenerates are in this respect only abnormally near-sighted, looking constantly for bargains in experience, though it shortly kill them. Mere suffering, for example, is an art subject for a decadent; the intensest experience may be had for little effort, but is inevitably followed by a loss of vitality, or by a hardening of the sensibilities, which means enfeebled capacity for life. On the other hand, suffering as a necessary condition of heroism may produce an experience of genuine life. It is less popular than the obviously pleasant only because it requires greater art to make the heroism easily distinguishable as superior to the suffering and because it requires greater intellectual vision to see it. In such art the principle is more subtly used, but it is not ignored.

We may see this most plainly in dramatic paintings. This "Pietà" "left unfinished by Titian was reverently completed by Palma," as Palma himself has inscribed it. It may stand as the type of the beautiful in tragedy. In conception it is supreme art, despite the faults of the lesser painter who finished it. The mother of Jesus looks on the body of her son with the deep, calm grief of heroic character; Joseph of Arimathea, a strong man of the formal sect of the Pharisees, is on his knees looking into the face of Jesus with the tenderness of a woman; Mary Magdalene, in uncontrolled passion, brings into relief the self-restraint and power of the Virgin; and the marble statues of the Old and New Dispensations are raised in cold contrast with the human emotions below. We are not simply shown a harrowing incident; we are led into the experience of profound love, impossible to know without this suffering and expressed in monumental power. We feel each character in relation to the others, and the incident itself becomes inseparable from these characters.

In looking on this picture we live much, live deeply and rightly. We see far more than we ever could with our own eyes. We are lifted out of the circle of our habitual thoughts, and experience the deepest emotions that have led mankind from the animal into his high estate.

In great dramatic pictures, closely associated with this principle of constructive emotions there is the element of heightened mental power. The easy grasp of the relations among the persons, and between them



"PIETA," by Titian and Palma the younger. Academy of Fine Arts, Venice.

"PORTRAIT OF THE ARTIST," by Rembrandt, Louvre Museum.

and the incident; the sense of the relations of all the thoughts in the picture—objects, figures, persons, characters, action, with the motives and results of action—built into an indissoluble organism, the infinite complexity of elements forming one great unit of thought, compelling in its clarity—this astonishing intellectual grasp which we have without effort is strongly stimulating. Our capacity is made to abound in renewed strength.

Both of these elements are present in our enjoyment of portraiture—eminently so in this picture of Rembrandt painted by himself when he was an old man. Knowing ones may pay their attention to the manner of the painting, but we laymen must feel that we are face to face with a man whose years have been rich in life.

Yet we have here sure signs of poverty and weakening physical powers. Even if we had read nothing of Rembrandt's life we might guess from this picture that he was poor and had little of the gentleman about him. No one would be better pleased, however, if he were handsome or richly clothed; and this fact is so plain that we must at once accept those unpleasant conditions as a positive factor in creating our enjoyment. These very ills clear away the conventionalities of life and help to show us the real man. The hardships, the struggles, the failures which develop man also reveal him. It would indeed be impossible to conceive of this character apart from its faults—a man led by profound desires athwart every rule of art and society into a vision calm, warm and powerful.

It is not that we learn about this man out of histories of art and then apply our knowledge to the picture, nor is it that we deduce the character from the facts that are told us in the painting; rather, though our interpretation may be indefinite, we feel it—that is, we apprehend it with our whole nervous system. Our eyes rest in quiet contemplation on the eyes of the old philosopher; if we look away, led by the line of the arm to the hands holding palette and brushes, we inevitably look back again at the head—longest and most meditatively at the far-seeing eyes. We seem to take on something of the old man's personality; involuntarily we feel ourselves standing as he is standing, though our actual physical position may not change; we forget, as he forgets, the material conditions of his life; we assume his mood and something of his larger character. Our individual readings of this picture will differ widely, according to our several temperaments and the knowledge and associations of art and life we bring to it; nor can we hope to come to an agreement through any analysis of facial expression. Even if we had a common science by which we could judge of character, Rembrandt had none; he was neither physiognomist nor phrenologist, but as he saw with the inner eye so he painted. This is true of every great painter. To analyze their works gives us no sure interpretation, but to

"Creation of the Sun and Moon," by Michel Angelo. Ceiling of the Sistine Chapel.

analyze our experience of their works intensifies it and clarifies our vision. So in viewing any portrayal of character it is not our conscious reading of it that is significant; rather it is our subconscious imitation of the character that counts, bringing out some latent quality of our own—some quality which we feel to be good, agreeable because it is life-giving.

Again: in portraiture, great painters give us an insight into essential life beyond that which we ordinarily have. While waiting for a train in a railway station we may spend our time "studying life," but how many of us, with or without great effort, can ever penetrate beneath the thinnest superficialities? Not only are we unpractised; we are bound by the accepted judgments of society, and the most we can do is to pigeonhole the several types. But these great painters present to us a person we have never before seen, and give us an immediate and strong sense of his personality. Even though we disagree about him, we do so rather less than we do about our friends; for in relation to our neighbor our sight is distorted by a hundred influences. Rules of dress, etiquette and morals have blinded us to the eternal man who lives behind and above what we can see of him. Man strives outwardly to appear as his own society would have him, the perfect type of provincial—the New Yorker of 1914, the Parisian of such and such a period, or whatever; while within him is a life at once unique and universal. The illustrator gives us the provincial man. But the great character-painters show us through imperfections and through struggles, a life based on the everlasting instincts of the race and the principles that never change with our mutable standards; through unsymmetrical development and through wreckage, we see supreme man. We put off our blinding limitations and discern clearly.

Where this heightened vision is combined with the emotions which nature has made us to enjoy because they are creative, our experience is one of abounding life.

III. Harmony

Every picture, and indeed every work of art, is like a song in that it consists of words and music—a statement and the sound, or form, through which the idea is conveyed. Half the world listens to the words and is more or less affected in mood by the music; the other half listens to the music and receives the words only as a suggestion to make definite the spirit of the music. It is not an analogy but a translation to say that the sensuous elements of a picture—lines, colors, lights—are visual music.

Michael Angelo's fresco "The Creation of the Sun and Moon" gives us a feeling of overwhelming power. A titanic figure, accompanied by a whirl of cherubim and preceded by a speeding seraph, represents the creative force of Jehovah. Infinite Deity is not reduced to the figure of a man, but divine power is expressed in transcending harmony of line and movement. The head is great, but it would hardly satisfy us as a symbol of the Creator; the body is super-human, but physical strength can never mean God: the effect on us is rather in the uniting of these elements, and above all, of the lines of the figures and draperies, into a symphonic pattern of crashing harmonies.

Let us see just what this means within ourselves, see how we react to harmony of design. The mechanical process of eye and brain we may leave to the psychologist, but we can recognize a certain sensation which we have before all things we call beautiful. It need not trouble us if we can not agree on a definition of the word "beautiful." We may not be able to bound the town we were brought up in, but we know the look of it. We know that the appearance of a flower, a Persian rug, or a great picture, entirely apart from any meaning or association, produces in us a feeling of pleasure which for the moment drives out of us physical fatigue, desire or any sense of limitation. Beauty of design has been called "supreme order," and harmony, if not the only principle involved, is by far the most important. "The Creation of the Sun and Moon" is an example of such beauty, and an analysis of the picture is helpful.

The sweeping line of the Creator's figure gives the theme of the composition. Around it is a system of repetitions of that theme, in different lengths and positions. The movement through this group and through the seraph is a larger development of the same curve. About the seraph is another system of lines, partial repetitions of the drapery fold from the left foot under the arm and continued over the back. The little folds over the seraph's back are angular, but each discord is repeated in slight variation so that we feel a clear relation between them. The great black line of Jehovah's arms is in discordant contact with the movement of the body, but the shock is a repetition of the crossings of the drapery about the figure, and the line is echoed in certain opposite diagonals. But what of it? Surely esthetic pleasure is not to be had in such dry analysis of line. Certainly not; the analysis is but a slow and painful following of what the eye feels at once,—a simple relationship of many elements. Harmony is an extraordinarily simple relationship of parts, and our experience of it is an unwonted feeling of clear vision.

It might seem at first, then, that two or three squares set side by side would constitute the most perfect harmony. They would do so only in the sense that an octave is the most perfect harmony in music. Such an arrangement would not be extraordinarily simple, but ordinary in the last degree; the eye sees it with habitual recognition. But if those squares should change their proportions so that two of them should seem to be supporting the central one, we should begin to be interested. As the complexity increases the eye finds exercise; as the simplicity increases the eye finds ease: it is the comparative simplicity of the exercise that is our experience of harmony. When our perception of this simplicity is so effortless as to give us a sense of unused capacity we feel an influx of life which we call an esthetic experience; its cause we call harmony.

We may consider the work of art as a fraction in which the denominator is the number and variety of the elements presented to us, and the numerator is the simplicity of their relationship; the effectiveness varies as the value of the fraction. Of course each of the elements of the harmony must in its turn be considered as a fraction, and so on.

When in place of an influx or life we have from harmony the pleasurable languor of an artificial nervous fatigue, the design will certainly at some time be called decadent. I once went in to the Alhambra in company with a keen-minded physician. For a moment he looked about the sensuously lovely court, and then said, "Dope; that is the explanation of all this. The delight of those old sultans was in the nervous fatigue caused by this infinite, inextricable, beautiful detail. We have the same effect in certain modern music.

"But after all this talk about harmony," says some student of theory, "the effectiveness of this picture by Michael Angelo is caused as much by rhythm." Rhythm is one form of harmony. We find it simplest in a swinging walk or easy run, in which we feel that the left foot treads stronger than the right. A child makes the form clearer by elaboration when he puts in a little shuffling hop after each step, and calls the movement "skipping." Rhythm is no more nor less than harmony between groups of impulses. The principle is the same in the simplest drum-beat and the most elaborate rhythms of Richard Straus, Botticelli, Isadora Duncan, or Shakespeare; the feeling of it communicated to you through your ear, your eye, physical action, or pure thought. The excitement of movement is changed to the stimulation of rhythm by the principle of harmony.

As with rhythm, so with all harmony—it may be expressed in lines, colors, sounds, ideas. Different systems of harmony in these and other realms, are caused by the thought-habits of their authors; and so with the different theories which explain conflicting systems. We have most of us had this difference between senses of order brought home to us. Our books and papers are arranged according to their contents; the maid comes in to clean; when we return we find everything nicely arranged according to size and color. There is some such difference between the classical painter and the impressionist; both are right and neither can hope to enjoy the harmony of the other.

But the design in "The Creation of the Sun and Moon" is not merely beautiful; it is also strongly expressive. This is so partly because when we are given the right suggestion for our feelings by the subject and by the great physical and spiritual power of the Creator and the rushing host of heaven, our sense of these things and of the mood they suggest is vastly increased by the inrush of life we experience from the harmony. Many a painter has used the same color scheme for a Nativity and a Crucifixion. But in this fresco of Michael Angelo's the lines have a tremendous sweep; we do not merely judge them appropriate; as our eye swings through them, meeting successive shocks from the cross movements, our nervous reaction is similar to that which we have in watching a stormy surf on the rocks. The expressiveness of lines and colors in a picture is in the awakening of physical reaction similar to that accompanying the moods of real life. More; if we accept the modern theory that the feeling of reflex physical reaction constitutes emotion, we must find this method of expression even more direct than that of statement, which has to pass through our intellect before we feel it. The physical causation of emotion is a separate principle from that of harmony, though the two are interactive.

In Nos. I. and II. I have tried to show that the most universal enjoyment of pictures is in the enhancement of life felt in a heightened power of vision when we see any object presented with compelling clarity; that a general element in our experience of narrative pictures is simply an enlargement of this principle to the mental perception of persons and their actions; that a further extension is found in the increased spiritual vision given us in the portrayal of character; and again in the relation of characters and events in dramatic painting. The principle of harmony is based on the same evolutionary fact—the sense of abundant life resulting from enhanced perception. It is a powerful factor in leading mankind beyond the mechanical vision of logic into the unfathomable relations of the universe.

APICULTURE IN THE TIME OF VIRGIL

By GEORGIA WILLIS READ

THE science of apiculture, as it is understood to-day, is the slow growth of centuries of human observation and investigation. For unnumbered ages it has been a work of interest to man to reclaim these singularly untamable insects from the state *feræ naturæ* to that *domitæ naturæ*, as the legal phrase has it—to render their natures sufficiently tractable to enable man to appropriate to himself the benefits of their toil. Though bees have responded to the process of domestication less readily than almost any other of the forms of wild life which man has subjected to his control— since even to-day, after thousands of years of cultivation, they slip back easily and completely into their aboriginal state when opportunity offers—man's efforts to this end have been unremitting, his interest in this task has never flagged. Who knows but that the missing link or an even more remote progenitor sacked the city of the bees for its rich spoil, and handed down to man the instinct for this conquest? Always within the memory of man, at any rate, as the ancient Romans used the phrase, meaning thereby always within the bounds of tradition, honey has been esteemed as a delicacy for the table, and as a valuable condiment in wine-making. The ancient Egyptians, whose very cities have long since crumbled to dust, prized their swarms of bees, which they kept in earthenware vases much as the natives of Africa and Asia do to-day; while it is by no means uncommon to find in histories of ancient races mention of honey as a dainty and a thing of price.

By the time that Virgil wrote his rambling treatise on bees, on their characteristics and their manners, their habits and their needs, apiculture was recognized as an important branch of husbandry. In Virgil's estimation it ranked apparently with the more universal interests of agriculture, the raising of crops and the care of cattle, since of the four books that he wrote on this group of subjects, one is entirely devoted to the culture of bees. In it he gives with patient, painstaking care, a complete guide to practical beekeeping as it was understood in those days, and adds, one can not help thinking for his own pleasure primarily, countless charming apicultural fancies and fables which he had heard. Though the theories as to the life and habits of bees which were held by the most intelligent men of that age, bear no stamp of that absolute and unimpeachable precision which exact science imparts to any subject, one can but marvel at the frequent correctness of their intuitions and the general propriety of their observations, passing over with uncensorious leniency the startling inaccuracy of certain of their conclusions.

Maeterlinck, in that remarkable life of the bee in which he weaves with threads of purest fact such a marvellous woof of poetry, passes poor Virgil's Georgic by in impatient haste as giving merely the legend of the bee. "All that we can glean therefrom, which indeed is exceedingly little," he says summarily, as he passes on to other fields. Without doubt, his conclusion is just. Virgil sang in an age whose ignorance was vast, whose myths were many, and to one who searches for knowledge from the vantage ground of to-day his poem is barren soil. But to the student of human attainment, of man's gradual triumph in wringing from the natural world the basic truths of science, the result is otherwise.

We are, perhaps, too prone to forget that all knowledge comes to us as a long-accumulated heritage in which we enjoy a life interest, in return for which, should we so desire, we may strive to add some trifle to the principal sum. The world grows in the grace of knowledge, albeit slowly; it moves at a glacier's pace, leaving stranded far behind in the trail of its moraine even those who have been great in their day. As Renan says,

> Descartes would be delighted if he could read some trivial work on natural philosophy and cosmography written in the present day. The fourth form schoolboy of our age is acquainted with truths to know which Archimedes would have laid down his life.

This is true in apiculture, as in any other branch of natural science. As Langstroth, "the father of American apiculture," declares,

> Any intelligent cultivator to-day may, with an observation hive and the use of movable frames, in a single season verify for himself the discoveries which have been made only by the accumulated toil of many observers for more than two thousand years.

To him who, laboring under these advantages, looks backward to learn how much about bees the ancients were able to ascertain from the limited means of investigation at their command, Virgil's work is rich in pleasant surprises and astounding revelations. Without microscopes, which enable us to examine perfectly the minutest organ of the bee, they yet knew that the worker bees were females (as the gender of the pronouns and adjectives which refer to them in Virgil's poem shows us conclusively), and that they never bore any young. Without movable frames, which permit the beekeeper of to-day to examine the interior of the hive at will, they nevertheless had a very clear understanding of the different functions of the bees, and of the social life of the swarm.

If Virgil were to walk through a well-kept apiary of to-day, examining its regular rows of neatly painted, dovetailed hives which take the place of the "leaky, draughty" basket-work skeps with which he was familiar, he would find cause for amazement. In his time, the bee-keeper carried for his protection in the apiary an ineffective brazier of coals; to-day, when we lift the lid from a hive, we quell the turbulent swarm within by a few puffs from a long-nosed, bellows-fitted smoker. Instead of encountering an irregular mass of unequal, crooked pieces of honeycomb built firmly to the sides and bottom of the skep, and affording no chance whatever for further examination unless cut ruthlessly from their foundations, in which case the flowing honey from the pierced cells would drown many of the swarm, we now find either eight or ten oblong wooden frames, each enclosing a straight sheet of hexagonal-celled honeycomb. Upon the surfaces of these combs the bees live, and in their cells they store the honey and raise the young bees. Thus at a moment's notice, and without in the least disturbing any function of the swarm, we can study the whole economy of the hive, whereas, hampered both by his lack of appliances and by the medieval and impracticable interior of the hive, Virgil must either have suffocated the swarm with acrid fumes in order to subdue it or have drowned it in the flowing honey of the broken combs.

Though he knew much about the life of the swarm, and understood well the different labors into which the toil of the hive is divided, his knowledge was thus of necessity gained largely by inference, without the aid of ocular proof. He might see the sentinels stationed at the entrance of the hive to intercept any robbers or bewildered strangers who might try to enter; he might also see the homecoming bees alighting at the threshold, pausing an instant to balance themselves, then darting into the hive. But he could never follow upon their track, as we can, to see them storing their loads of nectar in the half-filled cells, or placing in the compartments reserved for the purpose the tiny pellets of bright colored pollen, carried home in the little pouches upon their thighs.

Nor could he watch the deeper interests of the hive unfold themselves. The queen, attended by her little retinue of caretakers, goes about the combs performing her one duty of laying her eggs, one in the bottom of each empty cell, the male eggs in the drone cells, the female in the worker cells. One cohort of workers cares for the brood, supplying royal jelly for the nourishment of the embryo queens, if it be the swarming season; and feeding the tiny milky worker and drone grubs which have hatched from the three-day old eggs. Such of these grubs as have reached the proper age are sealed over with a porous capping under which they grow and change form until about the twenty-first day from the laying of the eggs, when the perfect, newborn bees, still gray and fuzzy, chew the waxen coverlets from their cells and traverse with slow, clinging crawl the comb about them. Other workers keep the hive tidy by carrying out the bits of wax that have dropped to the floor, or line with propolis the slight cracks between the warping boards. Others again seal over such honey as has been properly ripened, while everywhere through the hive are groups of drones, "sitting idle at the banquets of another."

These things he could never see; for him to view the life of the swarm while it was being lived was impossible. He might, by tearing it to pieces, see where and perhaps how it had been, but to do so he must use such violence as to cause a temporary if not a lasting cessation of the functions of the swarm. Yet in spite of the disadvantages under which he labored, a fairly large proportion of the theories which he advances are borne out by the knowledge of to-day. We could, as is only to be expected, set him right about numerous facts in the life of the bee, but of its general habits we could teach him but little, and of its temperament even less.

It is natural, indeed, that his reading of the nature of the bee should more nearly approximate our own, than that his theories as to the facts of its life and the most successful methods of treating it, should tally with those of the present day. For the character of the bee, to all practical purposes, is the same to-day that it has always been; neither new crosses in breeding nor the accumulative gentling effect of centuries of cultivation seems to have modified its disposition, which is to be learned now, as always, by personal observation. The main facts of its life, on the other hand, and consequently the most rational and therefore the most successful methods of treatment, have been very definitely determined by modern scientific investigation.

We know, for instance, as Swammerdam discovered with the aid of his microscope in the seventeenth century, that the "king bee" is not a king, as Virgil believed, but a queen, the only perfect female of the swarm, who gives birth to a constant stream of workers and drones, which keeps the swarm undiminished though the old bees are dying off continually. We know too that the life of the individual bee, far from being "seldom prolonged beyond the seventh summer," as Virgil thought, is often exhausted by hard work during the honey-flow in six or eight weeks, and probably seldom lasts longer, even under favorable circumstances, than six or eight months, the queen being the single exception to this rule. She sometimes lives three or four years, but is seldom sufficiently prolific to keep up the strength of the swarm properly after her second or third year.

Virgil's theory that two colonies often came forth to battle with each other is erroneous; he must have seen two swarms that happened to leave their hives simultaneously and mingled in the air, as not infrequently happens in the height of the swarming season. He may have chanced to see the queens of the two swarms fighting, a by no means necessary or even usual consequence of this chance coming together. He tells us, too,

> To the old falls the care of the towns,
> And the guarding of the combs, and the fashioning of the cunningly wrought homes.
> The younger ones return wearied late at night,
> Their legs loaded with thyme; they feed on the wild strawberries,
> The blue-gray willows, the cinnamon, the glowing saffron-flower,
> The rich linden-tree, and the iron-colored hyacinth.

Nowadays we know that, broadly speaking, it is just the other way—that the older bees gather the nectar, propolis and pollen, and the younger ones stay within the hive to feed the brood and perform there the other necessary duties. His naïve, yet not unnatural supposition that at nightfall the bees laid themselves to rest in the cells of the honey-comb, whereupon sleep seized their weary frames, we know to be unfounded. Whenever it is too chilly or too windy for them to fly out, they may be seen clustering over the surfaces of the combs, in order to incubate the unhatched brood and to enjoy the comfortable sensation of the animal heat thus generated. Moreover, any one who is familiar with the interior of the hive knows that in summer every cell in every comb is needed in a fairly strong colony for storing the incoming harvest and for raising the young bees, while during the height of the honey-flow it is questionable whether the bees can be said to sleep at all. Many beekeepers believe that unless the nights are so cold as to chill them, they work unceasingly from dusk to dawn, as well as from dawn to dusk, during this brief period.

We can see, by the brighter light of modern knowledge, how Virgil was wrong in these and in many smaller particulars, how he incorporated into his work the errors that were prevalent in his day, and endorsed the methods then in vogue, superstitious and unavailing as they too often were. But if he sometimes went astray as to his facts, traveling, as he did, over a country with but few landmarks to guide him, he retrieved himself in other fields. We approach the bees armed with facts that explain their habits and throw light upon their moods, but he was forced to solve his problem just the other way. He must observe their disposition and their ways, and then deduce his facts as best he could. It follows as a matter of course that he should speak more wisely of the things that he saw for himself than of those that he knew only by inference.

The somewhat unusual habits of the bees he read with remarkable insight. But what he understood best of all about these strange little insects, perhaps because in contemplating them he brought to bear upon them the subtle comprehension that is born of sympathy, was their character, their temperament. In this respect he speaks as a master, and as one whose teaching the shadow of years has not tarnished. Here his perceptions winged themselves to their goal as swiftly and as unerringly as the eager bees themselves fly to the hive with each load of nectar when every hour of the summer's day warns them that the golden harvest time is fleeting. He knew that work made the bees cheerful, and that sunny weather cheered their hearts; that discouragement did but make them work the harder, and that death itself, dreaded instinctively by every animate thing, was to them, when set against the common welfare, a thing of naught.

Half playfully, half affectionately, yet wholly respectfully withal, he continually likens the race of bees to the race of men.

> I will tell you of sights of tiny things to be wondered at,
> Great-hearted leaders, the customs of the whole race,
> Their passions, tribes, and battles,

he says in his opening paragraph. In the course of his pages, "grandsires of grandsires are numbered," "the hearts of the bees are agitated in war," "the kings turn to the foe great souls in tiny breasts," "sad funeral rites are conducted." Often in the course of the poem he refers to their homes, their dwellings, their waxed realms and rich storehouses, their palaces and cities—a picturesque phraseology which Maeterlinck repeats with great effect.

"Behold," says Virgil, giving us in one long paragraph a far from uncreditable résumé of the life and labors of the bee,

> Behold, I will now describe the natural traits
> Which Jupiter himself has given to the bees as a reward
> For their harmonious humming . . .
> When they fed the king of the sky in the Dictean cave.
> They alone have a common offspring, a common building of the city,
> And spend their lives under powerful laws.
> They alone know their country and their settled home;
> Mindful of the coming winter, they endure toil in summer,
> And put aside for the common advantage what they have gained.
> Some direct their attention toward the provisions,
> And by agreement labor in the fields;
> Others within the home place the nectar of narcissus
> And the sticky sap from bark for the foundation of the comb,
> And thence draw downward the tenacious wax;
> Others raise to maturity the young, the hope of the race;
> Others ripen the honey, and fill the cells with nectar;
> To some has fallen by lot the guardianship at the gates. . . .
> The work seethes, and the sweet-smelling honey is fragrant with thyme. . . .
> An inborn love of harvesting urges on the Cecropian bee,
> Each in his own function. . . .
> There is one time of toil, one rest from work, for all.
> In the morning they rush out from the gates; there is no delay;
> Again when evening has warned them to cease
> From feeding in the fields, they seek their dwellings,

They refresh themselves; a humming sound arises,
They sing about the entrances and the thresholds. . . .
Nor do they retire very far from the hive when rain threatens,
Nor trust to the sky when the east winds begin to blow,
But all around under the walls of the city,
They safely fetch water and venture upon short expeditions. . . .
You will wonder indeed at this custom of the bees,
That they do not idly relax their bodies in love,
Or bring forth offspring with labor;
Instead they gathered their sons
From the leaves and the fragrant herbs,
They themselves supply a king and little subjects
And refashion their palaces and waxen realms.
Often, too, in wandering over the rough, flinty rocks
They have worn away their wings,
And voluntarily given up their lives under their burden.
Such is their love of flowers and their glory in making honey!
Therefore, though the limit of brief life overtakes them,
Yet the race remains immortal,
And the fortune of the home endures through many years. . . .
Furthermore, not Egypt, nor great Lydia, nor the people of the Parthians,
Nor even the Median Hydaspes, so honor their king.
While he is unharmed, all are of one mind;
If he is lost, they break their faith. . . .
They surround him with incessant hummings, and attend him
In great numbers, and expose their bodies in war,
Seeking a beautiful death through their wounds.

(It is true that bees have this feeling for the queen, understanding that without her there is no hope for the future prosperity, or even existence, of the swarm.) From these signs, Virgil says in conclusion, some have maintained that the bee has a part of the divine intelligence and that it too, in common with flocks, herds, men, and all the race of beasts, has drawn in at birth its tiny vital spark from the god that penetrates the earth and the sea and the profound skies—"esse apibus partem divinæ mentis et haustus ætherios."

Again he tells:

The more they are exhausted, the more zealously all will set about
To repair the ruin of the fallen family
To fill the cells and to build storehouses for the honey,

as indeed they will. He also says, when speaking of an old Corycian who made a paradise for himself out of a few waste acres by setting out flowers and fruits and esculent plants to grow among the brambles,

He therefore was the first to abound in prolific bees and numerous swarms,
And to force the foaming honey from the pressed combs.
He had linden-trees and many pine trees;
With just so many blossoms as each tree
Was decked in in the spring,
Just so many ripe fruits it held in autumn.

It does not seem to be forcing the meaning of this passage to infer from it that Virgil had some knowledge of the valuable services of bees in fertilizing plants of all kinds.

To have learned all that he tells us about bees, Virgil must have mastered the subject of apiculture as it was understood in his time. That he gained his information at first hand, or at least verified it by personal observation, seems indubitable. For here and there all through his work are convincing bits of description, sometimes merely felicitous phrases, that recall the life of the hive forcibly to any one familiar with it. He says:

> As for what is left when the golden sun has put winter to flight
> Beneath the earth, and has revealed the sky with summer light,
> Immediately they (the bees) wander over all the glades and forests,
> And rifle the bright-hued flowers, and lightly-moving,
> Drink from the surfaces of the streams.
> From this time, joyful from I know not what delight,
> They cherish their family and their home,
> And make the ripened honey.

This could not fail to paint vividly for any beekeeper the yearly awakening of the bees, when, shaking off the torpor of winter, they prepare with eagerness for the advent of summer, that fraction of the year in which alone they lead a full and active life. His description of the listlessness and apathy of bees which are diseased at once suggests the appearance of a colony which is suffering from the ravages of bacillus alvei, or foul brood, the terrible, almost pestilential malady of the apiary. He says:

> But indeed life has brought our misfortunes to the bees;
> If their bodies shall droop with a sad disease: . . .
> The sick are of a different color;
> A dreadful leanness marks their appearance;
> They carry forth from the dwellings those bereft of life,
> And conduct sad funeral rites;
> Or clinging together by the feet, hang at the thresholds,
> Or delay within their house, and are listless with hunger
> And inactive from the cold which they have caught.

Again he says, when speaking of the life of the bees during the harvest season, "the work seethes, and the sweet-smelling honey is fragrant with thyme." The work does seethe; his phrase exactly describes the abnormal, all-pervading activity of the swarm during the honey-flow. Often at that time we can tell by the delicate aroma, one might almost say the bouquet, of the honey, from what kind of flowers it is being made. To-day only that of the mountain sage resembles in fragrance and flavor the honey of the ancients which was made from thyme, of which the fabled honey of Hymettus was the finest type.

Interspersed throughout Virgil's discourse are numerous precepts for the guidance of the apiculturist, some of them still as sound as can be devised, others again being incomplete or obsolete. He knew that certain things conduced to the prosperity of the bees, and therefore to the profit of the owner. The requisite points of a suitable situation for an apiary, a highly important factor in successful beekeeping, he covers very well. A dry, well-drained slope, shelter from the wind, pools of flowing water, water being essential in raising the brood, and protection from the heat of the sun, were necessities upon which he insisted. "Do not trust them to a deep swamp," he cautioned his disciples, "nor where the hollow rocks resound when struck, and the echo of the voice rebounds."

Let there be flowing fountains and pools bright with moss,
So that when the new kings lead out the swarms
And the young bees, released from the honey-combs, sport about,
The neighboring bank may invite them to withdraw from the heat,
And the tree in their way shelter them with its leafy hospitality.
Across the center of the stream, whether it pauses here or flows swiftly,
Place willows athwart, and lay in large rocks,
That they may alight on frequent bridges,
And open their wings to the summer sun,
If perchance the east wind has scattered the laggards
Or plunged them headlong into the stream.

He mentions also the need of having plenty of pasturage, though this he proposes to provide by setting out suitable plants and shrubs:

Let him who makes such things his care bring thyme and pine trees
From the lofty mountains, and plant them far and wide about the dwellings;
Let him bruise his hands with hard toil; let him set out these shrubs
And irrigate them with friendly showers—

while to-day, when bees are kept in any numbers, a location must be chosen near great fields of some honey-yielding plant, such as clover or buckwheat.

He appeared to know that with bees, as with every other form of life, the breed must be kept up from the best stock;

But when you have recalled both leaders (kings) from the battle,
Give to death him who seems inferior, lest he be a hindrance;
Permit the better one to reign in the empty halls.
For there are two kinds; the one shining with scales of gold,
Distinguished both by his shape and by his ruddy, golden hue.
The other is terrible with sloth.
As the figures of the two kings, so are the bodies of their peoples.
For the one kind is horribly ugly; . . . while the others
Shine and glitter, aglow with gold,
And their bodies are marked with even bands.
This is the better breed; from this source at the proper season
You may extract the dulcet honey from the combs.

To-day, after a lapse of nearly two thousand years, the Italian breed remains distinct, its special characteristic being its superiority over all other breeds in gathering honey; the particular marking of its best strain is still the glistening, golden color of the three largest of the rings of horny substance that encase the body of the bee. Even now we know no better rule to follow in requeening an apiary than to select for the purpose the offspring of the most beautiful and the most efficient queens at our command.

Again he tells us:

> When the inconstant swarms fly about and sport in the air,
> Condemn their hives, and leave their cold dwellings,
> You should restrain their unsettled minds from this vain play.
> Nor is it a great task to control them;
> Remove the wings of the king; while he remains behind
> None of the bees will dare to follow the path through the air,
> Or to tear up the standard from the camp.

In the spring bees are sometimes guilty of this "vain play," or swarming out, as it is called now-a-days, when feeling that summer is unduly delayed and that their store of honey has dwindled distressingly, they leave their hive, only to die of hunger or cold unless rescued by the apiarist. The point of interest here, however, is that one of the most approved of the modern methods of controlling the swarming impulse of the bees, is to clip the wings of the queen on one side, thus preventing her from flying away with the swarm and so necessitating its return to the hive, since, as Virgil knew, the bees will not desert the queen. Though he understood this principle which has become so important in the treatment of swarming, his method of making a swarm settle is, oddly enough, obsolete. We no longer beat the cymbals, as he directed, or sprinkle bruised herbs upon the ground to cause the bees to cluster and alight.

In view of the fact that artificial feeding is a very important factor in modern beekeeping, it is interesting to note that Virgil speaks of this process. Now-a-days the intelligent beekeeper feeds his bees not only to keep them from starving in case their stores run low; he also supplies them with trays of sugar syrup in the spring to stimulate them to raise broods sooner than they would otherwise do, so that they may be ready in large numbers to gather the harvest as soon as it comes. Virgil suggested to his followers that they should introduce honey into the hives by means of hollow reeds.

He understood remarkably well, in the main, what was necessary for the comfort and tranquillity of the bees. He knew that they needed constant sunshine to keep in a healthy condition, and that it was but poor economy to stint their food supply by taking too much honey from the hive. He thought that their homes should be kept in such neat and tidy shape as would make it easiest for them to protect themselves from their enemies. "Who will hesitate," he asks, "to fumigate with thyme and to cut away the empty comb?" He gives, in two divisions, a list of those apicultural pests whose depredations the beekeeper should try to prevent, or at least to control. Among the minor dangers that threaten bees in the form of insects or small animals that have a taste for honey or that eat the bees themselves, he mentions swallows, bee-martins, newts, lizards, hornets, and spiders. When one considers the number of bees in a single colony, however,—upwards of ten thousand in the winter and several times as many in the summer—one can easily see that the combined losses from these sources are insignificant.

He mentions also the bee-moth, "shunning the light;" an accurate description, since its custom is to remain hidden during the day. It does not attempt to enter the hive until dusk, when the bees can not see to attack it. This moth is a really dangerous enemy, being able to harass seriously a strong colony, and often to destroy entirely one that has lost its queen. As Langstroth says of it:

> The bee-moth has for thousands of years supported itself on the labors of the bee, and there is no reason to suppose that it will ever become exterminated.

It is rather curious that Virgil nowhere makes any mention of the bee-louse, which, to-day at least, is a source of considerable trouble to the beekeepers of Italy, although in this country it is almost unknown.

His description of that disease of the bees already referred to—so serious a scourge as to make it one of the chief dangers that threaten them—completes his list. For there is very little reason to doubt that this disease of which he speaks is the same as that now known as foul brood, or else closely analogous to it. This is a highly contagious disease, attacking first the brood, which decays instead of hatching; the bees also become infected, and presently die. This malady was doubtless known to apiculturists as long ago as Virgil's time; Aristotle, in his "History of Animals," describes it briefly but in no doubtful terms. Even to-day it is a justly dreaded enemy to apicultural prosperity. It is scarcely to be wondered at that, when we have not yet devised a very satisfactory method of dealing with it, Virgil's remedies should be of no avail. To stamp it out, its spores and bacilli must be destroyed by fire or some other equally efficient agent. His directions as to the various herbs steeped in liquids, and the roots boiled in wine, which were to be fed to the bees to cure this fell disease, were worthless. This treatment, like certain precautions that he advises taking for the welfare of the bees, such as being careful to cut down all the yew-trees near the bee-yard, and never to burn red crabs in the fire, could not have been of the slightest use save perchance to afford to the zealous beekeeper of those times, who conscientiously followed these instructions, the salutary sensations that follow duty done.

Unwittingly he sometimes directed his disciples wrong; yet he labored faithfully in their service, nursing his didactic impulse carefully until he had given them, as well as he was able, an insight into the life of their pets. This store of sterner precepts conscientiously discharged, he turns most willingly to those of mythological suggestion, proceeding to tell his followers how to restock their apiaries, should they chance to lose all their bees. He gives as a practical measure to be followed, yet naming it a tradition withal, the old, old myth of bees springing from dead cattle, "how the tainted life-blood of a dead bullock has often borne bees;"—the same old riddle, "out of the strong came forth sweetness, and out of the eater came forth meat." Virgil says of it:

First a place small and sheltered for this very purpose is chosen;
This they enclose with a low roof of tiles and with walls,
And they add four windows of slanting light toward the four winds.
Then they seek a two-year old bullock, whose horns are just beginning to curve.
His nostrils and his mouth are covered over
Though he struggles greatly, and after he has been slain by blows,
The battered entrails are crushed within the unbroken skin.
Thus they leave him, laid in the enclosure,
And they place under his sides branches of thyme and fresh wild cinnamon.
This is done as soon as the driving zephyrs roughen the waves,
Before the meadows brighten with new colors,
Before the chattering swallow hangs her nest from the beams.
Meanwhile the liquid, warmed in the young frame, heats
And animals of a wonderful kind are to be seen,
Lacking in feet at first, but soon whirring with wings;
They mingle, and more and more take to the thin air,
Until they have burst forth as a storm poured from summer clouds,
Or as arrows from the vibrating bowstring,
When the swift Parthians first begin to fight.

Thereupon he drops easily and contentedly into that vein of poetry that comes so gracefully from him, stringing upon a slender connecting thread the story of the loss and the recovery of Aristæus the shepherd's bees, into which he introduces the whole tale of Orpheus and Eurydice. With him, we accompany Aristæus on his pilgrimage for aid to his mother, a water-nymph, who sits spinning with her maidens of euphonious names, Drymo and Phyllodoce, Clio and Lycorias, Xantho and Beroe, in their translucent, glass-colored chamber in the depths of the sea, while one of their number recounts the "numerous lovers of the gods, from Chaos down." In his company we follow the fortunes of Aristæus to their happy conclusion, when, having obeyed the oracle, he is rewarded by seeing clouds of bees come forth on the ninth day from the bullocks that he has slain, and cluster at the top of a tree, ready to be hived.

Filled the marvelous charm of his closing pages, it is with an effort that we turn to consider the value of his discourse. It is a very captivating field over which he has taken us; apiculture in his time was a picturesque occupation, even when seriously pursued. His picture of it is pleasing, not only as a thing beautiful in itself, but also as affording an interesting contrast to the apiculture of to-day, as enabling us to measure our present growth by an ancient scale. Practical beekeeping is indeed far different now from what it was in those days; apiculture at present shows many new features, and lacks many that distinguished it then. Yet in one respect it remains the same, and, I venture to think, will always do so; that is, in the enthusiasm of the bee-keeper for his bees. Even as Aristæus, we to-day are grateful for our teeming hivefuls With Virgil we cry,

> Averter of thieves and birds, protect them.
> Let gardens breathing with saffron flowers allure them,
> Let the guardianship of Hellespontaic Priapus, with his willow scythe,

AVAILABLE FOOD SUPPLIES

By Professor J. F. LYMAN
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THE food problem is distinctly a modern one in the United States. Two generations ago no such problem was clearly recognized. Fish were plentiful; pigeons, deer, wild turkeys, water-fowl, quail and buffalo were abundant; wild berries, fruits and nuts could be obtained easily and in large quantities. Naturally food was cheap and there was enough for all, and of a kind sufficiently varied to suit the taste of any. All this has changed. Game animals have practically disappeared. Wild berries, fruits and nuts are no longer of importance in our dietaries. We have seen our population increase at the rate of over twenty per cent. every ten years until the increase in production of food products no longer keeps pace, but lags far behind, and we realize that there is such a thing as a food problem.

If the present rate of increase continues, the population of the United States will approximate five hundred million at the end of the present century. Is it possible to feed that number of persons on the products of our three million square miles? China and India both support a population as dense; but both of these countries are distinctly agricultural. The mass of people live on the land and are engaged in producing food. In this country the great increase in population is in the cities; while the food-producing class is increasing comparatively slowly. The reports on agricultural products exported from the United States illuminate the food problem in an instructive way. If we compare the exports in 1912 with those for 1900, we find that the amount of cheese shipped abroad declined 85 per cent. in that period, beef products declined 65 per cent., pork products declined 30 per cent., corn declined 80 per cent., wheat declined 57 per cent. What do these figures tell? Simply that we have needed the food at home to supply our increasing millions and hence had less to sell in the markets of the world. Can we continue to feed our people by reducing the exports in food stuffs? Obviously not, and in many instances they have been reduced already near the vanishing point. We have even actually begun to import meat and corn. It is significant also that free government land suitable for agricultural purposes is no longer available; hence we can not look for relief by bringing under the plow large tracts of virgin soil.

Is there likely, then, to be a scarcity of food in this country in the near future? No, there is and will be plenty of food, but some changes in dietaries undoubtedly will have to be made. Let us notice. In 1910 for every man, woman and child in the United States there was produced seven bushels of wheat, thirty-two bushels of corn, four bushels of potatoes, and forty pounds of sugar. There were six tenths cattle for each person, six tenths sheep, and seven tenths swine. Add to this the fruits, vegetables, poultry and dairy products, oats, and other small grains and we see that there is plenty of food to go around and to spare.

There was grown in the United States in 1912 corn, which if assembled in one immense field might have covered Germany or France entirely with its rustling phalanx. How many millions might be nourished by the produce of this tremendous acreage! Here is a great source of human food at present utilized in a very slight degree.

Man takes food first of all that pleases the palate. We can no longer make our choices on the basis of palatability alone, and a study of the principles of nutrition must be pursued to help us out of those difficulties which arise from a restricted supply of food. Food has two primary functions in the body; first, to supply material out of which the body is built; and, second, to furnish energy to warm the body and to drive its machinery. Perhaps the second function is the more important. Plants alone have the power to collect solar energy and store it up in a latent or dormant form in their seeds and other parts. Animals may, by eating and digesting these plant materials, liberate and utilize this stored-up energy. When corn is fed to a steer under favorable conditions three per cent. of the energy of the corn may be recovered as meat in the edible portion of the carcass. The remaining ninety seven per cent. was used by the animal in its various activities and lost as far as the nutrition of man is concerned. In pork the recovered portion amounts to sixteen per cent.; and with the dairy cow eighteen per cent. of the energy of the food is found in the milk produced. Obviously this is a wasteful process, this conversion of grain into meat and milk. It has its justification only in the greater palatability and digestibility of the final products. Doctor Armsby, of the Pennsylvania Experiment Station, draws the conclusion: "all the edible products which the farmer's acres can yield will be needed for human consumption and the function of the stock-feeder in a permanent system of agriculture will be to utilize those inedible products in which so large a share of the solar energy is held and to render at least a portion of the latter available for human use."

But shall we solve our food problem as it has been handled in some densely populated countries such as India and China? With an area nearly twice that of either of these countries, the capacity of the United States to maintain a population on the same standard as obtains in China, for instance, would be perhaps relatively as great. It would mean a great change in our standard of living, one to which we should not take kindly, and one which we hope need never be adopted in this country.

What would the liberty-loving American think had he to subsist on the restricted fare of the Chinaman as described by Mr. Chester Holcombe in "The Real Chinaman."

> Their daily food consists of rice steamed, cabbage boiled in an unnecessarily large amount of water, and, for a relish, a few bits of raw turnip, pickled in a strong brine. When disposed to be very extravagant and reckless of expense, they buy a cash worth of dried watermelon seeds, and munch them as dessert. . . . The description answers with entire accuracy for the food consumption of the great masses of the Chinese people—not for the beggars or the very poor, but for the common classes of industrious workingmen and their families, whether in the great cities or in the rural districts. . . . The only luxuries of which they dream are an ounce or two of meat at very rare intervals with their invariable food of rice and cabbage, and the necessary tea and tobacco.

Or would the fare of India please better? Colonel Sir Thomas H. Holditch tells us:

> Probably three fourths of the entire population live on the grain of the millets, or various kinds of pulse. In lower Bengal, and in parts of Madras and Bombay, in Burma and Ceylon, rice is the staple food of the people, . . . elsewhere it is reserved for the consumption of the wealthy.

Even in Greece the food supply is much restricted, for we read in the Consular Report on Industrial Conditions by Horton, 1908:

> At night the family dines on a few cents worth of rice, boiled together with wild greens and olive oil, and bread, or wild greens boiled in olive oil and eaten with bread or some similar inexpensive dish. Meat is eaten by the laboring classes as a general thing three times a year, Christmas, Easter and on the so-called "Birth of the Virgin." Such a family as I am describing, the average laboring man's family of Greece, rarely if ever see such things as butter, eggs and milk.

The corn crop alone of the United States in 1912 was sufficient to supply nourishment for two hundred and thirty million people living on the standard maintained by the working class in China, India and some other countries. The American, however, in general has never appeared to relish corn as a direct article of food. A prejudice has prevailed that corn was unfit for human food and useful only in the barn and stable for their less discriminating occupants. The reports of government experts to the effect that corn is as digestible and nutritious as wheat have apparently made few converts to the greater use of corn. But we shall learn to eat more corn, not because we are told of its nourishing qualities, but because it will be prepared in an attractive form and because it will be cheap.

Machinery has been perfected for the milling of wheat so that the digestible portions are separated from the indigestible and a superior human food prepared. Wheat flour stands supreme among the cereal flours and it is likely to maintain this position, still it is undoubtedly in the development of industrial processes that we shall find the solution of the problem of economically converting corn and similar products into human food which will be palatable and nourishing. A good beginning has already been made in the manufacture of starch and glucose as well as breakfast flakes from corn. These and similar industries are bound to grow rapidly. Nor is corn the only material which might be appropriated directly as human food and which is used at present little or not at all for that purpose. Oats, barley, rye, soy beans and peanuts and various by-products such as cottonseed and linseed cake might be utilized more largely. Modern science will very likely devise methods for extracting the valuable constituents from these products in such a way that they will be available for human food in an attractive form and nourish man in a state of highest efficiency. Some progress has already been made along this line, but it is barely a beginning.

Does this mean that we shall all in time turn vegetarian? No, there will always be food for domestic animals and meat and dairy and poultry products will always be important items of human diet. The grasses, clovers, straws, stovers, and certain by-products of the refining processes of seeds, etc., will always be directly unavailable as food for man and can probably best be utilized by converting them into animal products of various kinds. The amount of meat consumed, doubtless, will decline and a reduction in this respect may take place without danger and without detriment to the race.

Long ago Daniel, the prophet, and his companions demonstrated the virtue of a simple vegetable diet when they refused to eat the king's meat and wine, provided for the boys of the court, and chose rather pulse and water. At the end of the training period, when the boys were examined, the faces of the Hebrew children were found to be plumper and their minds more alert and keen than those of their companions who had dined more sumptuously, but who had, perhaps, studied less diligently.

The study of human nutrition has not yet produced a simple formula for man's guidance in the selection of his food. Such formulæ have been successfully used in the feeding of rats, and the skillful stockman in his feeding operations carefully follows charts and rules provided him by experts on animal nutrition. We may expect that similar rules will obtain more and more in human nutrition and there will be, some time in the future, such a thing as scientific feeding of men.

THE SMALL COLLEGE AND ITS FACULTY

BY ONE OF THE PRESIDENTS

THIS president has been reading an article in the POPULAR SCIENCE MONTHLY for May entitled "The Small College and Its President"—hence these words.

Probably it is rarely the case, when a number of alumni, each more than fifty years of age, foregather and begin to talk over old times, that some one doesn't tell the story of the time he and others put a cow in the college chapel. These stories can not all be true—there haven't been cows enough. Probably they are more or less fictitious variants of some fundamental cow-myth which originated under those vague conditions commonly described as "mists of antiquity." In a similar way it may fairly be questioned whether the awful condition described in the article to which allusion has been made really exists in concrete form and precisely as set forth in any particular institution.

If there is a college such as is described in this May article it should certainly be abolished at once. It is a disgrace to the whole system of education in America. It is very difficult to believe that, because of their athletic prowess, athletes are given marks higher than they deserve. It is difficult to believe that the sons of wealthy patrons are unfairly marked in the professors' classbooks and on the registrar's records. Whatever trustees and faculties might think, no body of normal undergraduates would stand for any such treatment of that larger part of their number neither athletic nor rich.

But the object of this writing is to describe briefly another small college which is believed to be more nearly like the typical American small college. It is something less than one hundred years old. Its undergraduate body numbers perhaps less than three hundred. It is governed by a rather large board of trustees. All but two of them are college graduates, and most of them are graduates of the college over which they now preside. It includes clergymen, lawyers or judges, and business men—bankers, insurance men, manufacturers, merchants—in proportion as the numbers 10, 16 and 20. It is under no ecclesiastical control. The president of the college is *ex-officio* president of this board of trustees. His powers are nowhere stated or defined in the charter or statutes of the college. It takes a two-thirds vote of the trustees to dismiss him, and he is *ex officio* a member of various committees. He has two votes in the faculty if he cares to use them—one regularly and another in the case of a tie. To the faculty, which consists of all the permanent officers of instruction, is, by the statutes, "committed the government of the students." This term "government" is considered to include both the disciplinary and the instructional functions of the college officers.

The courses of study, prepared originally by the faculty, are prescribed by the supreme governing body and changes are from time to time made by the faculty under the authority of the trustees. Within ten years at least there has been no case in which the wishes of the faculty in these matters have been overruled by the trustees.

It is probably true that the president has a good deal of practical authority. It is based upon nothing except the feeling of the faculty that as the president is in a peculiarly responsible position both to the trustees and to the public, because his view is necessarily wider and more comprehensive than that of the professors through his relation to the public, because there are after all other considerations than those of any particular classroom which must affect the college policies—for these and other reasons his wishes are entitled to some weight. The president has no veto over the action of the faculty. For many years there was a provision giving him this authority. It was repealed at the request of an earlier president, and the present president refused to have it restored when some of the trustees were rather disposed to restore it.

As for the unhappy athletes in this small college it is unquestionably true that they get less consideration than anybody else. Any excuse asked by an athlete, or request for special consideration, any explanation of failure or misconduct offered by such a person is regarded with peculiar suspicion—almost enough to justify the statement in a very amusing book of college stories that "a college professor always hates a man who weighs over one hundred and seventy-five pounds."

Similarly, it is unthinkable that this faculty should modify a student's marks according to the social or financial prominence of his family. One of the most excruciating and most frequent tasks of the president is to write letters to his personal friends and to wealthy patrons of the college explaining that their sons have been dropped on account of deficiency in scholarship. It is not a pleasant job and the performance of it goes far to justify the somewhat larger salary which the president receives. Indeed, quite antithetically to the situation in the college described last May, it is the president who has to take most of the "knocks" arising from the actions of the governing body of the college, the faculty, whether or not he happens to be personally in sympathy with all that is done. Again and again has he found himself obliged to defend acts and policies with which he was by no means in accord.

At present there seems to be a good deal of unrest among college professors. It is a little difficult to see why; for, after all, the president and the professors alike are hired men engaged for a consideration to discharge fairly definite duties. It is difficult to see why a college professor should make so much more fuss about losing his position than is commonly made by an officer in a bank or an insurance company or a corporation or in the public service. The college professor is not necessarily an expert in education or in college administration as carried on in these later days. He is apt to be a specialist, knowing something, indeed, of many subjects and a great deal about some restricted range of intellectual activity. Often he is absolutely without qualification for formulating a course of study suitable for the average boy, for advising the average student as to the studies that are best for him, or for the construction of any educational policy whatever.

The fact that A is one of the highest living authorities on clam shells needs to be supplemented by other facts before this man can expect much importance to be given to his views on the training of youth or concerning the apportionment of funds among a dozen or fifteen different departments. In most faculties, however, there are men not disqualified by personal disposition or training for work other than that in their own specialty. It is the policy of our faculty to utilize the qualifications of these men by distributing them as chairmen of active committees to which are referred questions of discipline, choice of electives, and similar important matters.

Probably we might do well to think twice about the importance to the professor or to the college of much of that which is called research work. A man can not teach well if he stops learning. Undoubtedly it is much pleasanter to work in the library or in the laboratory, and much pleasanter to work in one's own study, than it is to try to convey information to a body of rather careless young men who would prefer not to be instructed. But, after all, in the small college at least, the instruction of youth is the principal object of the professor's connection with the institution. There are not many professors whose research work is of any value whatever except to themselves. Those who are competent to enlarge the boundaries of human knowledge constitute a different class and are few in number. Such should have every opportunity and every facility. Generally these men are such wretchedly poor teachers that they have no place in the college faculty. Their service to mankind must be rendered elsewhere and under different conditions. Of course the college professor must have opportunity and time for continuous self-improvement, but he mustn't be allowed to forget that his job is that of a teacher.

It is questionable also whether the faculty should have too much to say about its own membership. In our college, the president, when an appointment is to be made, confers freely and with entire candor with the professors whose work is most like that which is to be done by the new incumbent, and some decision is generally arrived at by a sort of mutual understanding arising without formal rules. Nevertheless it has happened again and again that appointments must be made under conditions absolutely precluding any considerable conference with members of the faculty. It is probably true that professors have means of finding out things about candidates from other institutions which lie beyond the range of the president's powers of investigation; but there is one difficulty about the circumstances brought to light by professors investigating each other. A good deal of the information thus collected is not true. It is based upon personal jealousies, pique, personal likes and dislikes—all of which give a certain pleasant tang to life in the college faculty but which are very misleading when allowed to count for much in judging the man who is leaving one faculty for another.

We are hearing a good deal just now of that freedom of thought and of the expression of it which ought to be enjoyed by college professors. Evidently college professors must be allowed to think without restraint within very broad limits. The expression of their thoughts should not be criticized or at least should not be used as a reason for dismissal from college because some trustee happens to disagree with them. Nevertheless, it must not be forgotten that even college professors sometimes talk very foolishly, and if a professor or a president makes himself and the institution which he represents ridiculous there would seem no very great injustice in suppressing him. Isn't it a possibility that college men are all too thin-skinned, too sensitive, too jealous of each other, too considerate of the persons whom they think themselves to be.

Various recent developments seem to indicate a regrettable tendency on the part of college professors toward something like class feeling; toward the notion that they are somehow different from other people. It will be a great misfortune if this idea is allowed to prevail, if it is allowed to become permanent. When we forget that everybody is pretty much like everybody else, when any persons employed in a particular fashion get to think that they are otherwise than just folks, there is trouble brewing. This president feels pretty sure that the average college professor is too sensible to allow himself to be betrayed for long into such an untenable position.

Within the last ten years there have been in this small college of ours thirty-seven men who have held permanent appointments as well as a good many who have taken a small amount of work in emergencies or who have been here temporarily while professors have been away on leave of absence. Of these thirty-seven twenty are now in the faculty. Of the seventeen who have left three were dismissed either for inefficiency in teaching or for the exhibition of grave defects of character. In each case there was substantial unanimity on the part of trustees and faculty. Two of the seventeen have retired on their pensions. One withdrew on account of a breakdown in his health, eleven resigned, to our great regret, to accept considerably more lucrative positions elsewhere. We rejoiced in this evidence of their distinction and tried to fill their places with men equally good. Some of these we shall probably lose by and by in the same way.

On the whole, isn't this a pretty good small college? There have been evidences of weakness in discipline in years past, due in each case to the mistaken leniency of the faculty. This has never been due to outside pressure. One can't help wondering whether this small college which was discussed last May is not suffering more from morbid and unfounded fears on the part of the professors than from any real danger of autocratic action by president or trustees.

THE GEOGRAPHICAL DISTRIBUTION OF AMERICAN GENIUS

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THE last few years have witnessed a friendly controversy between the champions of nature and the champions of nurture, over the forces that are responsible for greatness. The nature advocates have insisted upon the importance of heredity in shaping men's lives. The nurture advocates have laid equal emphasis upon environment. Each of these groups has relied upon New England as one proof of the contention.

Both parties to the controversy are willing to admit that New England has produced a considerable proportion of the great men of America. Those scientists who throw emphasis on the importance of heredity hold that New England, having made a contribution to the number of distinguished men in the United States wholly out of proportion to its population, stands as a substantial proof of the importance of race qualities. Those scientists who adhere to the opposing view maintain with equal positiveness that the supremacy of New England has long been exaggerated. There was no time, these men insist, at which New England had an immense lead in the production of greatness over the other sections of the country, if its percentage of population at that time was taken into consideration. Furthermore, so the argument continues, the supremacy of New England in the production of distinguished men is being rapidly taken over by the middle west. It is in that section that the leaders of the next generation are being born.

The contention is, in its nature, both interesting and endless, unless some facts can be obtained which will throw some light upon the questions at issue. These, I take it, are three:

1. Was there ever a time when the number of distinguished men born in New England was greater in proportion to its population than the proportion for other sections of the United States?

2. Has there been any change in the proportion of distinguished persons contributed by New England?

3. What contributions of distinguished persons are now being made by the various sections of the United States?

These questions can not be answered with certainty. The available facts make unimpeachable conclusions impossible. Nevertheless, approximations may be made which should throw some light on the questions.

The volume entitled "Who's Who in America" for 1912–13 contains

18,794 names.[1] This list purports to include the distinguished men from every walk of life in the United States. The compilation is necessarily incomplete. There are, of course, omissions; while the mere classification of a name in "Who's Who in America" is no guarantee of distinction. On the whole, however, it may justly be said that the proportion of distinguished men whose names are inserted in "Who's Who in America" is about the same for the various professions. Furthermore, there is no reason to suppose that the proportion secured from different sections of the country would show any material variation. All things considered, these 18,794 names seem to offer the most available basis for a study that would answer the questions regarding the supremacy of New England in its production of distinguished persons.

A study of the data in "Who's Who" was made in the following manner. A schedule was arranged to show, first, the profession; second, the decade of birth; and third, the place of birth of the consecutive names, beginning with the first page of the volume. In order to make the information as usable as possible, the returns for each state were separately tabulated, as were the returns for those cities which reported a population of more than 20,000 in 1850. These items of information were secured for the first 10,000 native-born persons. The generalization from the first 10,000 names can safely be applied to the remainder of the volume.

The first point of interest arises in connection with the number and per cent. of distinguished persons from each section of the United States and the per cent. of the total population of the United States in the respective sections. These figures (Table I.) show at a glance the proportion of distinguished persons born in the various localities.

These returns, on their face, accord to New England a lead in the total number of distinguished persons produced that is little short of phenomenal. With less than a fourteenth of the population, New England has been the birthplace of almost a quarter of the total number of distinguished persons whose names appear in "Who's Who." The Middle Atlantic States, with a fifth of the population, report somewhat less than a third of the distinguished men; the East North Central States report almost equal proportions of distinguished persons and of population; while the other sections show a proportion of population considerably above the proportion of distinguished persons born. There are

[1] "Who's Who" is published in Chicago. The editor, Albert Nelson Marquis, was born in Ohio. "The standards of admission to 'Who's Who in America' divide the eligibles into two classes: (1) Those who are selected on account of special prominence in creditable lines of effort, making them the subjects of extensive interest, inquiry or discussion in this country; and (2) those who are arbitrarily included on account of official position—civil, military, naval, religious or educational—or their connection with the most exclusive learned or other societies." From a statement following the preface, 1912–13 edition.

TABLE I

NUMBER AND PER CENT. OF EMINENT PERSONS BORN IN THE VARIOUS GEOGRAPHICAL DIVISIONS OF THE UNITED STATES WITH THE PER CENT. OF THE TOTAL POPULATION OF THE UNITED STATES IN EACH DIVISION IN 1910[2]

Geographical Division	Eminent Persons		Per Cent. of the Total Population of the United States, 1910
	Number	Per Cent.	
United States	10,000	100	100
New England	2,311	23	7.1
Middle Atlantic	2,974	30	21.0
East North Central	2,225	22	19.8
West North Central	542	5	12.7
South Atlantic	1,091	11	13.3
East South Central	546	6	9.1
West South Central	161	2	9.6
Mountain	28	—	2.9
Pacific	122	1	4.6

therefore three sections of the United States—New England, the Middle Atlantic States, and the East North Central States—in which a comparatively large number of distinguished persons were born. These three groups of states lie in a contiguous territory, in the northeastern section of the United States. Of the three groups, New England, in proportion to its population, has by far the largest proportion of distinguished persons.

The figures in Table I. are manifestly incomplete. Changes in population have been rapid during the past few decades. The tide of westward movement has materially altered the population center. No final conclusion regarding the position of New England as a contributor of distinguished persons can be reached unless the gross result is corroborated by the facts showing the time at which the distinguished persons were born, and the proportion of the population in the various sections of the country at that time.

TABLE II

NUMBER AND PER CENT. OF EMINENT PERSONS WHO WERE BORN AT CERTAIN TIMES

Time of Birth	Number	Per Cent.
Before 1850	2,818	28
1850–1859	2,715	27
1860–1869	2,717	27
1870–1879	1,304	13
1880–1889	95	1
1890–1899	2	—
Unknown	349	4
Total	10,000	100

[2] Of these 10,000 eminent persons, 779, or 7.8 per cent., were women. Sex will not be considered in the present article.

A surprisingly large number of the eminent persons whose names appear in "Who's Who in America" were born before 1850. Table II. gives the time of birth by decades.

The eminent persons who were alive in 1912–13 are, for the most part, well along in life. Only one in a hundred was born sinee 1880; only fourteen in a hundred were born since 1870. Men born before 1870 were at least forty-two years old in 1912. In so far as time records are coneerned, this study must deal with the period prior to 1870, sinee the great body of eminent persons was born before that date. More than a quarter of the total eminent persons was born before 1850, making them at least sixty-two years old. More than four fifths of the entire number were born before 1870; that is, they are at least forty-four years of age. In so far as time is a faetor, interest centers in the periods before 1850, 1850–1859, and 1860–69.

The total returns give New England a material lead in the production of eminent persons. Is that lead maintained when the totals are broken up into time periods? The relation between the decade of birth, the plaee of birth, and the proportion of population in eaeh section at the time of birth appears in Table III. The proportion of eminent persons born before 1850 is eompared with the population in 1850. The proportion born between 1850 and 1859 is eompared with the population of 1860. The population figures, in eaeh case, refer, not to the time of birth—sueh a eomparison is manifestly impossible. The total born in eaeh deeade is compared with the population at the end of that decade. This method should militate slightly in favor of New England, whose population in eaeh deeade eonstitutes a slightly smaller proportion of the total population of the United States.

Table III

Geographical Division	Per Cent. Born Before 1850	Per Cent. of Pop. 1850	Per Cent. Born 1850–1859	Per Cent. Total Pop. 1860	Per Cent. Born 1860–1869	Per Cent. Total Pop. 1870	Per Cent. Born 1870–1879	Per Cent. Total Pop. 1880	Per Cent. Born 1880–1889	Per Cent. Total Pop. 1890
United States	100	100		100		100		100		100
New England	30	11.8	23	10.1	19	9.1	19	8.1	12	7.5
Middle Atlantic	33	25.4	32	23.8	26	22.9	25	20.9	37	20.2
East North Central	17	19.5	23	22.1	27	23.7	23	22.3	25	21.4
West North Central	2	3.8	4	6.9	8	10.0	10	12.2	6	14.2
South Atlantic	12	20.2	10	17.2	11	15.2	12	15.1	11	14.1
East South Central	5	14.5	5	12.3	5	11.4	5	11.1	4	10.2
West South Central	1	4.1	2	5.6	2	5.3	2	6.7	2	7.5
Mountain	—	.3	—	.6	—	.8	1	1.3	—	1.9
Pacific	—	.5	1	1.4	2	1.6	3	2.3	3	3.0
Total names	2,818		2,715		2,717		1,304		95	

A perusal of Table III. reveals several very evident situations. The first three groups of States—New England, the Middle Atlantic States and the East North Central States—are plainly in a class by themselves. Among these states, in every instance except one (the East North Central States, 1850), the proportion of eminent persons born in those groups of states is higher than the proportion of the total population found in those states at the same time. Among the other groups of states, in every case except two (Pacific States, 1870 and 1880), the proportion of eminent persons born is lower than the proportion of the total population found in the states. It therefore appears that of the eminent persons born up to 1890, the vast proportion were in that northeastern section of the United States bounded by the Mason and Dixon line on the south, and the line of the Mississippi-Missouri River on the west.

Among these northeastern groups of states New England holds a unique position. Throughout the entire period she appears as the birthplace of a far larger proportion of eminent persons, in proportion to her population, than either of the other groups. During the early years her lead was little short of remarkable. Of the distinguished persons born before 1850, she produced almost one third, while her population in 1850 was but one ninth of the total population of the United States. The Middle Atlantic States, with a quarter of the population, produced only a little more than a quarter of the eminent persons. The same relation between the two sections holds true of the decade from 1850 to 1859. In this period New England has one tenth of the population, and one fourth of the distinguished persons, while the Middle Atlantic States have a quarter of the population, and about a third of the distinguished persons. Even as late as 1880 the ratio between the proportion of eminent men and of population is higher in New England than in any other section except the Middle Atlantic States. At the same time, the East North Central States, with the single exception of the years before 1850, report a proportion of distinguished persons born only a little higher than their proportion of the population. During the first three periods the relative proportions of eminent persons born and of population are fairly similar in the Middle Atlantic and the East North Central States, but at the same time very markedly below the standard set by New England.

The considerable lead of New England and the marked lead of the Middle Atlantic States and the East North Central States over the other sections of the country may be tested in various ways. Instead of comparing the proportion of eminent persons in the various sections with the total population, a comparison may be made with the native white population. This seems particularly fitting in view of the large negro population in the south, which has contributed so little to the number of eminent persons in the country. Such a comparison is likewise desirable in those states of the north where there is a large proportion of foreign-born persons. A comparison appears in Table IV., where the number of eminent persons per one hundred thousand of total population and of native white population is given.

TABLE IV

THE GEOGRAPHICAL AREAS IN WHICH UNUSUALLY HIGH PROPORTIONS OF DISTINGUISHED PERSONS WERE BORN

Geographical Area	Total Distinguished Persons	Distinguished Persons	
		Per 100,000 Total Population 1880	Per 100,000 Native White Population 1880
United States	10,000	19.9	27.1
New England	2,311	57.6	72.4
Middle Atlantic	2,974	28.4	35.9
East North Central	2,225	19.9	24.4
West North Central	542	8.6	10.9
South Atlantic	1,091	14.2	24.3
East South Central	546	9.8	15.3
West South Central	161	4.9	7.8
Mountain	28	4.3	6.0
Pacific	122	10.9	16.3
Vermont	219	65.9	75.5
Massachusetts	1,123	62.9	85.8
New Hampshire	189	54.5	63.1
Connecticut	334	53.6	69.2
Maine	319	49.2	54.3
Rhode Island	127	45.8	64.8
New York	1,778	34.9	46.6
Pennsylvania	941	21.9	26.1
Ohio	859	26.8	31.5
Delaware	41	27.8	37.0
Maryland	218	23.3	33.9
Virginia	266	17.5	30.7

The facts appearing in Table IV. do not in any material way change the apparent status of New England with respect to the other sections of the United States. As regards both the number of eminent persons per 100,000 of total population, and of native-born population, New England appears far in the lead among the other sections of the country. New England's lead is even more marked when the situation is studied in the individual states. The individual states appearing in Table IV. are those which showed a proportion of eminent persons higher than that for the United States at large. Without a single exception, these states are in the northeastern portion of the United States. The list contains every one of the New England States, a portion of the Middle Atlantic and the East North Central States, and no other state. Furthermore, each of the New England States, taken individually, shows a higher proportion of eminent persons than any other single state, or than any other group of states. The supremacy of New England lies, not in any one state, or in any one locality. Vermont leads the list; Rhode Island brings up the rear; yet the proportion of eminent persons born in Rhode Island per 100,000 of total, and of native-white population, is 30 per cent. above New York, the state outside of New England coming next in rank.

There is another test to which the figures may be subjected. There may conceivably be some relation between the educational advantages offered in cities and the proportion of eminent men developed in any population. The champions of environment as the modifying factor in life insist that the influences of city life go far to outweigh heredity qualities. Therefore, since the northeastern portion of the United States was the original center of educational activity, and since it now contains the largest proportion of city population, it might well be expected to produce the largest proportion of eminent persons.

There were twenty-seven cities which reported a population of more than 20,000 in 1850. A separate tabulation for these gives an excellent idea of the proportion of eminent persons born in city and rural districts. In passing, it is interesting to note that of these twenty-seven cities,

4 were in New England,
10 were in the Middle Atlantic States,
4 were in the East North Central States.

The other six geographical divisions of states have but nine of the twenty-seven cities.

TABLE V

EMINENT PERSONS WHO WERE BORN IN THE CITIES OF THE UNITED STATES WHICH HAD A POPULATION OF 20,000 OR OVER IN 1850, WITH THE PER CENT. OF THE TOTAL POPULATION OF THE UNITED STATES LIVING IN THOSE CITIES IN 1850 AND IN 1880

Time of Birth	Total Eminent Persons	Eminent Persons Born in 27 Leading Cities	Per Cent.
Before 1850	2,818	599	21.2
1850–1859	2,715	610	22.5
1860–1869	2,717	591	21.7
1870–1879	1,304	363	27.8
1880–1889	95	38	40.0
No age	351	123	——
Totals	10,000	2,324	23.2

During the entire period under consideration, these twenty-seven cities contained from one twelfth to one eighth of the population of the United States. The proportion of the total population of the United States living in these twenty-seven cities was,

In 1850	8.7 per cent.
In 1860	11.2 per cent.
In 1870	12.8 per cent.
In 1880	13.1 per cent.

These percentages afford a striking contrast to those in Table V. The percentage of population living in these twenty-seven cities was never more than one seventh of the total population of the United States. During this time they reported never less than one fifth of the eminent persons born. Whatever the cause of this preponderance of eminent persons who come from a city environment, the facts are certainly remarkable. The cities appear to be far in the lead as producers of eminence.

There is no absolute correspondence between the proportion of urban population and the proportion of eminent persons born.[3] An analysis of the per cent. of population which is urban shows that while New England is far in the lead of the other sections of the country, there are a number of states which report a large proportion of eminent persons born and a comparatively small proportion of urban population. The reverse condition is also true. Rhode Island, with the lowest proportion of eminent persons reported by any New England State, has the highest percentage of urban population (93.5 per cent.) of any state in the union. New Hampshire, with the highest proportion of any New England state, has only 38.9 per cent. of the population urban. New Jersey, with a percentage of 53.7 urban, reports the lowest proportion of eminent persons of any state in the Middle Atlantic group.

Any tendency to attribute the supremacy of New England in the proportion of distinguished persons which it has contributed to the presence of large urban populations is offset by an examination of the figures for the cities themselves. The New England States are in the lead of the other states, but the New England cities are not in the lead of cities from other sections of the country. Indeed, an examination of Table VI., which contains a statement of the total eminent persons per 100,000 of the population in 1870 for the various cities, as well as the total born in each of the specified decades, shows very clearly that the cities in other sections of the country are decidedly in the lead. Boston and Providence alone, among the New England cities, have a proportion of eminent persons higher than that for the United States at large.

Whatever the cause of New England's position as the undisputed

[3] Per Cent. of Population (1880) which is Urban in Those Sections and States Having the Highest Percentage of Eminent Persons

Division	Per Cent. Urban Population
United States	29.5
New England	68.7
Middle Atlantic	49.9
East North Central	27.5
West North Central	18.1
South Atlantic	15.1
East South Central	8.4
West South Central	12.2
Mountain	23.6
Pacific	36.2

mother of American greatness, it apparently is not due to the presence of a large percentage of urban population. The facts showing urban and rural population point in no conclusive direction.

TABLE VI

RATIO BETWEEN THE NUMBER OF EMINENT PERSONS BORN IN CERTAIN CITIES AND THE POPULATION OF THOSE CITIES

Geographical Area	Decade 1850–1859	Decade 1860–1869.	Decade 1870–1879.
United States	8.9	7.0	2.6
New England	19.6	15.0	6.2
Middle Atlantic	11.4	8.1	3.1
East North Central	9.1	7.8	2.7
Boston	39.5	23.9	8.3
Cleveland	41.2	18.3	1.0
Providence	35.6	17.4	9.5
Washington	31.2	21.9	13.6
Syracuse	28.6	11.6	7.7
Milwaukee	24.4	14.1	3.6
Detroit	24.1	20.2	6.1
San Francisco	21.1	11.4	5.6
Chicago	18.3	14.4	6.3
Baltimore	12.4	14.2	6.0
Cincinnati	15.5	10.6	5.9
Philadelphia	14.5	10.8	5.6
St. Louis	14.3	6.4	3.7
Brooklyn	13.2	10.7	4.2
Richmond	13.2	9.8	4.7
Portland	11.4	25.8	8.7
Troy	17.9	10.9	7.1

To guard against the objection that the supremacy of New England was due to the inclusion of an undue number of preachers and school teachers in the "Who's Who" figures, an analysis was prepared of the statistics by professions. The 10,000 persons are divided rather evenly over the different professions, with the two exceptions of educators and lawyers. Table VII. contains the figures for the professions at large.

TABLE VII

NUMBER AND PER CENT. OF EMINENT PERSONS WHO WERE IN CERTAIN PROFESSIONS

Profession	Number	Per Cent. of Total
Educators	1,932	19.3
Lawyers	1,354	13.6
Business men	998	9.9
Public office holders (except Army and Navy)	916	9.2
Authors	908	9.1
Clergymen	732	7.3
Doctors	619	6.2
Scientists	614	6.1
Journalists	595	6.0
Army and Navy	430	4.3
Miscellaneous	902	9.0
Total	10,000	100.0

The returns do not show on their face any justification for the belief that the various professions have been so picked as to militate in favor of New England. Indeed, it is apparent that all of the leading professions are well represented. Therefore, if New England makes a fair showing in a goodly number of the professions, the conclusion may be justifiably drawn that New England stands out in specific instances, as well as in general, as the producer of eminent persons.

The figures in Table VIII. contain a statement of the proportion of persons in the different professions for each of the geographical divisions of the United States.

TABLE VIII

PER CENT. OF EMINENT PERSONS IN THE FIVE PROFESSIONS HAVING THE LARGEST NUMBER OF NAMES IN "WHO'S WHO," CLASSIFIED BY PLACE OF BIRTH, FOR THOSE SECTIONS HAVING THE HIGHEST NUMBER OF EMINENT PERSONS

Place of Birth	Educators	Lawyers	Business Men	Public Office Holders	Authors	All Professions
New England	24.2	17.1	26.8	16.9	26.5	23.1
Middle Atlantic	25.2	29.8	33.3	20.1	30.7	29.8
East North Central	25.7	22.0	21.6	23.8	21.5	22.2
West North Central	5.7	4.9	5.1	7.3	5.7	5.5
South Atlantic	12.7	13.2	7.9	15.4	6.5	10.9
East South Central	5.0	8.2	3.0	9.6	5.4	5.4
Other Sections	1.5	4.8	2.3	6.9	3.7	3.1
	100.0	100.0	100.0	100.0	100.0	100.0

The supremacy of the northeastern section of the United States is again amply demonstrated. Throughout the period under consideration, this section of the country has contained less than three fifths of the total population.[4] There is an almost equal percentage of educators in the three sections. The Middle Atlantic States lead notably in the percentage of lawyers and business men, while among public office holders, authors and all other eminent men, the three sections are on comparatively equal terms.

The time has now come when the three questions propounded at the outset of this paper may be answered with some color of authority. The answers are not final, but they are significant in so far as "Who's Who" is authoritative.

The answer to question one is clear and unequivocal. "Was there ever a time when the number of distinguished men born in New England was greater, in proportion to its population, than the production for the other sections of the United States?" In the past New England has

[4] In 1850 the New England States, the Middle Atlantic States and the East North Central States contained 56.7 per cent. of the population; 55.7 per cent. in 1860; 55.5 per cent. in 1870.

towered head and shoulders above the other sections of the United States in her production of eminent persons. Two other sections, the Middle Atlantic and the East North Central States, alone approach her record, and they lag far behind her pace.

The second question is not so susceptible of positive answer—"Has there been any change in the proportion of distinguished persons contributed by New England?" Such a change has undoubtedly taken place. Until 1880 New England took first rank. Up to that time her supremacy can not even be disputed. With that decade, New England drops behind the Middle Atlantic States. Whatever the cause of the change, the change is itself forcing the New Englander's lead very hard.

The third question: "What contribution of distinguished persons is now being made by the various sections of the United States?" may not be answered in any dogmatic way. New England is evidently contributing a less high proportion of distinguished persons. The Middle Atlantic States, the East North Central States, and the Pacific States are striding rapidly to the front. Thus far (the decade of 1880–1889) the Middle Atlantic States lead, with New England second, and the East North Central States third.

All the facts at hand point to New England as the one-time birthplace of the largest proportion of distinguished persons. The center is shifting, however, into New York, Pennsylvania and Ohio. That New England once held the palm is a statement that must go without challenge. That she can or will continue to hold it seems doubtful. Meanwhile, of the persons whose names found their way into "Who's Who in America" an overwhelming proportion seem to have been born in that section of the northeastern United States bounded by the Mason and Dixon line on the south, and the Mississippi-Missouri River on the west.

THE RÔLE OF SEX IN THE EVOLUTION OF MIND

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THE reason for the existence of sex is one of those biological problems which has long perplexed the scientific world, and to-day its solution seems as remote as it did a century ago. Many remarkable discoveries have been made in regard to the microscopic structure and development of the germ cells. We have learned much of the general biology of sex, and the probable evolution of sex in the organic world. And substantial progress has been made in respect to the old problem of the determination of sex. But to the question, Why came there to be two sexes at all? or, in other words, Why did not organisms continue to reproduce asexually as it is probable they once did? we can only offer answers that, at best, are very hypothetical. The bacteria and the blue-green algæ, so far as careful investigation has yet ascertained, reproduce exclusively by the asexual method, usually by fission or the formation of spores. But among the higher plants and in nearly all animals we find the existence of two sexes of very general occurrence. While the fact that sex is absent in the lowest forms of life indicates that evolu- has proceeded, at least a certain distance, without its aid, and suggests the possibility of the evolution of sexless forms of a high degree of organization, yet the general prevalence of sex in all but the most primitive organisms points to the conclusion that sex has played a fundamental rôle in the evolution of the organic world. There are many theories as to the part which sex has played, but the profound disagreement among several of these which have secured the widest following is significant of how little is positively established in regard to this subject.

While the cause of the development of sex may remain obscure, it is not difficult to point out some of its consequences, although it would be futile to attempt a very accurate picture of what the organic world would be had sex never been evolved. Even if the processes of variation and selection had gone on to the same extent—which is scarcely probable—the absence of sex would have given a very different direction to evolution from that which was actually followed. Many of the most complex structural arrangements of organisms have especial reference to the union of the germ cells. The color and scent of flowers, and their many and beautiful adaptations to secure cross fertilization would never have appeared if plants were propagated exclusively by the asexual method, and this would doubtless have entailed more or less extensive changes in other parts of the organism. In animals the structural peculiarities associated with sex are as a rule among the most complex features of the body. Some animals, to be sure, simply discharge their sex cells into the water, leaving their union to chance, but in the majority of cases, especially in higher forms, there exist elaborate mechanisms to insure the meeting of these cells. Correlated with these structures we find mating instincts which frequently manifest themselves in complex modes of behavior. More acute senses have been evolved in many cases very largely for effecting the meeting of the sexes. The large antennæ of male moths, the large eyes of the common drone bee, and the auditory apparatus of the male mosquito are a few of the countless illustrations of this fact. The various apparatus in insects for making sounds which are found in crickets, locusts, cicadas, etc., are devices for securing the meeting of the sexes, and the complementary development of the auditory apparatus in the same insects has doubtless been furthered through the evolution of these structures.

Much of the elaborate organizations of the imago stage of insects has reference, directly or indirectly, to activities concerned in mating and depositing the eggs in the proper environment for the development of the young. There is a relatively long larval or nymphal period chiefly devoted to the vegetative functions of assimilating nutriment and growth; in many cases the imago takes no food, or need take none, before the eggs are fertilized and laid; and in several species the mouth parts have become so completely atrophied that food taking is impossible. Mating not infrequently occurs soon after the insects emerge from the pupal covering. In the may-flies, which live but a short time in the winged state, in order to mate and deposit their eggs it is probable that the imago stage would long ago have disappeared were it not retained as a means of effecting the union of the sexes. The same is doubtless true of many other insects. The activities of the imago state, broadly speaking, are primarily altruistic; they are concerned mainly with the welfare of other members of the species. They are also expensive. In the winged state numerous new enemies are encountered and many lives are lost. In the pupa stage which prepares for it there is commonly an extensive tearing down of old structures and the building up of new ones, during which the insect is helpless against many enemies.

Mating activities are almost everywhere among the most complex performances of an animal's life. The opposite sex must be distinguished from all other creatures and responded to accordingly. Often pursuit and capture or winning over are the necessary preliminaries to sexual union. All this puts a premium, so to speak, on the sharpening of the senses, the development of strength and activity, and the evolution of the higher psychical qualities. Consider the mating activities of crustaceans, the courtship of spiders, the breeding habits of fishes, and still more the elaborate wooing of male birds, and it will become manifest how greatly the institution of sex has stimulated the evolution of complex modes of behavior.

All the facts here cited are trite enough, even to the non-biological reader. But while it is sufficiently evident that the differentiation of the sexes has promoted the development of behavior in relation to mating, it may be well to point out the enormous indirect consequences of this development in respect to the evolution of mind in general. In the evolution of behavior one kind of instinct grows out of another just as new organs are usually formed through the elaboration of some preexisting structure. A general elaboration of instinctive reactions in regard to any one sphere of activity affords, therefore, a basis for the differentiation of more complex and specialized behavior in respect to other activities. To take a concrete illustration: The primary function of the voice in the vertebrates was to serve as a sex call, as is now its exclusive function among the Amphibia. Later and secondarily it came to be employed in relation to the protection of the young (through various instinctive calls) and as a means of communication with other members of the species. Finally in man it afforded the means of articulate language. It is not improbable, therefore, that the evolution of the voice, with all its tremendous consequences with respect to the evolution of mind, is an outgrowth of the differentiation of sex. Were it not for its value in effecting the mating of the lower vertebrates the voice might never have been evolved and man never have become man.

While the specialization of senses which in certain cases at least has been carried on mainly for sexual purposes has doubtless afforded the basis for the elaboration of many instincts, it is practically impossible to trace in detail how various instincts, sexual and other, have acted and reacted on one another's development. But we can discern enough of the influence of sex differentiation on the evolution of behavior to feel assured of its importance. The necessity for solving the one problem that confronts all diœcious animals which do not simply shed their sexual products at random into the water, has tended to keep behavior in one sphere up to a certain minimum standard. The male must find and impregnate the female, and this fact sets a certain limit to his degeneration, at least in some period of his life, because any further degeneration would involve fundamental changes in the method of reproduction which may not be possible. But besides acting as a check to degeneration, the necessity for mating has in general been a constant force making for the evolution of activity, enterprise, acuity of sense, prowess in battle, and the higher psychic powers. One can not pretend, except in the most general terms, to gauge its rôle in the evolution of mind, but it has evidently been a factor of enormous potency.

THE PROGRESS OF SCIENCE

THE MARINE BIOLOGICAL LABORATORY

Louis Agassiz established in 1873 a marine biological laboratory on the Island of Penikese in Buzzard's Bay, south of Wood's Hole. Following his death the school was abandoned, but the plan was renewed in 1880 by the establishment of a seaside laboratory at Annisquam, in which Alpheus Hyatt was especially active. In 1888, the laboratory was reorganized and placed at Wood's Hole, where Spencer Baird had in 1881 established the marine laboratory of the U. S. Fish Commission. The natural advantages of fauna, climate and accessibility make Wood's Hole an ideal situation, and under the direction of C. O. Whitman a group of investigators gathered there in the summer who made the laboratory the chief center of biological research in this country and elsewhere only rivaled by Naples. After the death of Whitman, Professor Frank R. Lillie, of the University of Chicago, was made director, and later Professor Gilman A. Drew became assistant director, residing permanently at Wood's Hole. The laboratory has continued to grow in size and influence until last year there were 122 investigators and 69 students at work. If they were paid for their investigations at the rate other research institutions pay the cost would be more than half a million dollars a year.

As a matter of fact the laboratory has been conducted practically without endowment and with the simplest buildings and equipment. Some thirty universities and other institutions have cooperated in a modest way, but the work of the laboratory has been essentially a contribution of the biologists working there. There was urgent need of a fire-proof building that could remain open in the winter, and this has now been provided by Mr. Charles R. Crane, of Chicago, who in recent years has been the generous and sympathetic patron of the laboratory.

The building, an illustration of which is here shown, was planned by Mr. Charles Coolidge, of Boston, his designs being a gift to the laboratory, of which he has long been a trustee. The detailed arrangements are the result of much study with the help of many biologists and other laboratory men, and they have been admirably carried out by the assistant director, Dr. Drew. The building—50 × 90 feet—is constructed of tapestry brick with wide joints resting on a granite foundation, and trimmed with gray stone. It faces south on the Wood's Hole Harbor, about 150 feet away. The basement contains the chemical-supply room, janitor's quarters, heating plant, packing room and toilets. The first floor is divided into research rooms for zoology and physiology. A library with shelving for 20,000 volumes occupies the south half of the second floor with accession and storage rooms. The remainder of the floor and the third floor are occupied by research rooms. The roof carries a tank house with two tanks for salt water of 10,000 gallons each. The entire interior construction is of steel and reinforced concrete, with partitions of tile and granolithic floors, completely fire-proof.

The salt-water circulation is driven by electric automatically controlled motors, which open into two hard rubber pumps with a daily capacity of 75,000 gallons each. A gasolene engine is held in reserve in case of breakdown of the electric power service. The pipes and valves are all of lead, so that metallic contamination of the water can not possibly occur; the harbor water is

New Building of the Marine Biological Laboratory.

of exceptional purity, owing to the strong tidal currents.

Each research room has a cement floor tank 5 × 3 feet, with a cement water table above, heavy birch tables surrounding the outside walls on which they are carried on iron brackets; gas and electricity for lighting or power, automatic telephone service to all other rooms in the building and to other buildings, steel shelving, fresh-water sink, etc.

The dedication exercises took place on July 10, and occupied the entire day. In the morning all the buildings were open for inspection and parties of visitors were conducted through by guides. The laboratory steamer took out a dredging party. Lunch was served to about 600 guests in the laboratory mess. The afternoon exercises were held in a large tent, with music by the Russian Balalaika Orchestra from New York. Mr. Crane presided and three short addresses were made by Professor Lillie, Professor Conklin and Dr. Hugh M. Smith, the U. S. Fish Commissioner, followed by an address on "The Needs of Research," by Dr. R. S. Woodward, president of the Carnegie Institution.

THE ST. PAUL MEETING OF THE NATIONAL EDUCATIONAL ASSOCIATION

So far as can be gathered from the meager despatches from St. Paul, the recent meeting of the National Educational Association was successful in attendance and in programs and maintained the progressive policies which have gained ascendancy in recent years. It will be remembered that the so-called "old guard" was definitely defeated in Boston, when the official nomination to the presidency of Mr. Z. X. Snyder, president of the Colorado Normal School, was superseded by the election of Mrs. Ella Flagg Young, superintendent of the Chicago Schools. *The New York Evening Post* says editorially that it is "astounding" and "wholly unexpected" that the association should vote in favor of the right of suffrage for women, but a similar resolution was passed unanimously at Chicago two years ago.

Among other principles and policies—commonplaces or radical innovations in accordance with one's point of view—which the association has favored are increased powers for the National Bureau of Education and the establish-

ONE OF THE OLD BUILDINGS OF THE MARINE BIOLOGICAL LABORATORY.

ment of a national university; increased national support of instruction in agriculture and domestic economy, such as congress has provided in this session; federal legislation in regard to child labor, marriage and divorce; for instruction favoring international good will and against military training in the schools; the use of the public school houses and grounds as social and recreation centers for the community; school district parks with instruction in gardening; vocational training and vocational guidance; instruction in sex hygiene in normal schools, but not in public schools, and the acceptance by the college of the education supplied by the high school. The association is naturally in favor of increased salaries for teachers and it endorses equal pay for equal work by men and women.

This year a resolution was passed condemning the activities of the General Education Board and the Carnegie Foundation for the Advancement of Teaching. Like the recent action of congress in forbidding cooperation between the Department of Agriculture and the General Education Board and in refusing a charter to Mr. Rockefeller's new foundation, this may in part be due to antagonism to men whose names have been associated with business methods and results which are no longer approved. But there is a wide-spread aversion to the meddling of these corporations with public education, or even to their dictating policies to other endowed institutions.

There was elected as president of the association for the next year, Dr. David Starr Jordan, from its establishment president and now chancellor of Stanford University, distinguished equally for his work in science, in education and for social progress.

MAJOR LEONARD DARWIN'S ADDRESS BEFORE THE EUGENICS EDUCATION SOCIETY

IN his address as president of the British Eugenics Education Society given at the annual meeting held in London on July 2, Major Darwin said that as citizens they must aid in the

Dr. David Starr Jordan,
Chancellor of Leland Stanford Junior University, President of the National Education Association.

cure of the sick and in the alleviation of the destitute even though they saw that the multiplication of the less desirable types of humanity might thus be encouraged. One consideration, however, made them hope that eugenic advantages would not infrequently spring from reforms intended to affect human surroundings. The philanthropist's efforts resulted in the more easily cured or reformed being separated out from those less amenable to environmental influences. As social reform proceeded, and as the unfit were thus more and more clearly marked out from the nation at large, the numbers to be considered with reference to eugenic reform would be proportionately diminished, and racial progress would thus be facilitated. Social reforms producing these eugenic by-products must be utilized, as for example the proposed changes in the treatment of the habitual criminal. Improvement in environment would, no doubt, cause a diminution in crime, but a remnant of habitual criminals would remain, whose strong natural tendencies, being subject to the laws of natural inheritance, would infallibly tend to reappear in their descendants. To lessen their fertility seemed, therefore, within the scope of eugenic reform. Crime had a marked tendency to run in families.

Individuals endowed with those natural qualities, mental or physical, which render resistance to crime more than ordinarily difficult, are often brought into bad surroundings, mental or physical; this bad environment reacted on them, dragging them down in body and mind, and this action and reaction continuing either in the individual or generation after generation, the final resultant of these forces often was a long series of short imprisonments. The aim of the social reformer was, when possible, to break the vicious circle by at once removing the link of bad environment; whilst the eugenist would at the same time also strive to strengthen the innate characters of the individuals composing the coming generations. This latter result might be obtained by selective breeding.

A study of criminal family statistics surely must make the believer in environmental effects demand the segregation of the criminal-parent, both to safeguard the lives of those children who have been born into foul surroundings and to lessen the numbers of those children who would be born to face the perils thus arising. In short that seemed to be the right policy to adopt from whatever direction they approached this subject.

Much would have to be done before the machinery established under the mental deficiency act would produce the best possible results, and unquestionably this was the field to which the eugenist could now most usefully turn his attention. They could not form any trustworthy estimate of the number of criminals who would be dealt with under the provisions of the act, and they would sooner or later be driven to enquire whether some steps ought not to be taken with regard to the remainder of their habitual criminal population. If he could only be proved to be either very stupid, very weak or utterly worthless, was the man who committed crime after crime to be allowed to go on breeding freely? Few who had studied these questions with care had any doubt that habitual criminals ought to be detained for longer periods than at present, whilst every effort should be made to make that detention more curative in its effects.

The foregoing considerations had led many criminologists to advocate the system of "indeterminate sentences" in the case of habitual criminals. A reform much more easily obtainable, and one which the eugenist ought to endeavor to promote, would be the amendment of the prevention of crimes act in such a manner as to make it more readily applicable to the man of many minor offences. This act could easily be amended so as to make it easier to increase the periods of detention of those thousands of unfortunate persons who possessed defects of character which drove them whenever free to a life of crime and made them an intolerable nuisance to society—defects which would inevitably reappear to some extent in their descendants if they had any. If they could get the paramount racial duty which they owed to posterity incorporated as an essential part of the moral code of the nation, then they would be on the high road to success.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Frederick W. True, assistant director of the Smithsonian Institution, known for his contributions to zoology, especially of the Cetacea; of Professor Seth Eugene Meek, assistant curator of zoology at the Field Museum of Natural History, Chicago, who was an authority on fishes and reptiles; of Dr. Rupert Norton, assistant superintendent of the Johns Hopkins Hospital; of Dr. Joseph Reynolds Green, F.R.S., known for his researches in plant physiology, and of Professor Hugo Kronecker, of Berlin, distinguished for his contributions to physiology.

At the recent meeting of the American Medical Association, its gold medal was conferred on Surgeon General William Crawford Gorgas, who has also received honorary doctorates of laws from Princeton and Yale Universities.—The degree of LL.D. was bestowed by the University of California on commencement day on Eugene Woldemar Hilgard, from 1874 to 1906 professor of agriculture and dean of the College of Agriculture; on George Holmes Howison, Mills professor of intellectual and moral polity from 1884 to 1909.

Mrs. Morris K. Jesup, who died on June 17, bequeathed $5,000,000 to the American Museum of Natural History and made other bequests to public institutions amounting to $3,450,000.

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AN EXPEDITION TO THE CORAL REEFS OF TORRES STRAITS

By ALFRED GOLDSBOROUGH MAYER

EARLY in September, 1913, the expedition of the Department of Marine Biology of the Carnegie Institution of Washington arrived at Thursday Island in Torres Straits off the northern end of Cape York.

Thursday Island owing to the deep water in its vicinity has grown to be a busy port of call, although it is barely a mile in length and is so completely surrounded by the larger members of the archipelago that only the most detailed British Admiralty charts records its name, and even the painstaking Captain Cook who first sailed past it in the "Endeavour" in 1770, merely notes it as one of the Prince of Wales Islands.

Yet to our eyes it seemed an important place. Four of us—Clark, Harvey, Mayer and Tennent, together with Mr. John Mills, the able engineer of our naptha launch, had come nearly half the distance around the world from the eastern states of America, while Mr. Potts had left his cloistered quarters in Trinity Hall, Cambridge, and Mr. E. M. Grosse, the artist, had joined the expedition in Sydney.

Thursday Island was the intended objective of our journey for Saville-Kent in his beautifully illustrated book upon the Great Barrier Reef of Australia had especially designated it as being the site *par excellence* from which to study the coral reefs of Torres Straits.

Our surprise and disappointment was great therefore when we found the coral reefs to be overwhelmed with a layer of mud above which only the largest corals could raise their heads and thrive. The region seemed an ideal one only for masses of fleshy, dull olive-green alcyonaria (*Sarcophyton*) superficially resembling huge lichens several feet in diameter. The remarkably strong currents with their freight of silt and mud were fatal to luxuriant coral growth and the echinoderm life was hopelessly deficient, so that even the cheerful Clark, as enthusiastic a collector as ever lived, was in despair.

Fortunately, Mr. Charles Hedley, of Sydney, the distinguished student of coral reefs, had in a measure prepared us for disappointment and had kindly told us of the clear blue ocean water and rich coral reefs surrounding the Murray Islands 120 miles from Thursday Island, within 5 miles of the outer edge of the Great Barrier Reef and 75 miles south of the coast of New Guinea.

To the Murray Islands therefore we saw we must go with all speed, a feat, however, somewhat easier to plan that to accomplish, for in the intervening region were hundreds of uncharted coral reefs, and of all the fleet of schooners at anchor in Thursday Island harbor but one would venture to undertake the hazard of the voyage.

No sooner did the owner of this daring craft agree to take us, however, than he and his vessel disappeared in the night, leaving us stranded upon Thursday Island.

In response to kind letters of introduction from the British Ambassador Lord Bryce, the officers of the Australian government were most cordial in their efforts in our behalf, and never did we appreciate their generous aid more deeply than in the present emergency, for at the request of the Honorable W. M. Lee-Bryce, Esq., resident of Thursday Island, Messrs. Arthur and Hockings permitted the use of their power schooner *Kestrel* to transport Messrs. Clark, Grosse, Harvey, Potts and Tennent to Darnley Island only 25 miles from the Murray Islands.

In the meantime, Mr. Mills and the director of the expedition set out to sea in a small launch to search for the truant schooner which we finally found snugly anchored in the lee of the peak of a beautiful palm-clad island within 25 miles of Endeavor Strait.

The "recapture" of the schooner was speedily effected and soon we were scudding over the waters toward the elusive Murray Islands. Our crew were black, very black, and each man's nose was pierced so as to confer as romanesque an outline as it is possible to attain with an originally negroid nasal organ. Moreover, the captain's ears were slashed and torn in a manner to delight the heart of a rat-catching terrier. His weather-beaten face bore many a scar, and one eye seemed to have seen better days, but more perfect discipline one never saw maintained upon a schooner than that enforced by our erstwhile head-hunting commander. They sprang to obey his almost whispered orders with an alacrity that would have done credit to the crew of a man-of-war.

Without chart or compass we sailed over a sea marked "dangerous" on the maps we might have had but chose to dispense with.

Each day we threaded our way among the intricate passages between jagged coral reefs, keeping in the deep blue between the patches of emerald-green edged with foaming breakers; and always the steady southeast trade wind urged us onward. At night, we lay at anchor close

Map of Torres Straits.

under the lee of reefs and the drowsy roar of the ocean lulled us into sleep.

At Darnley Island we found our associates most comfortably housed in the home of the magistrate, Mr. T. Arnold Williams, from which hospital roof, indeed, they were most unwilling to be "rescued."

But at last the peaks of the three extinct volcanoes which constitute the Murray Islands loomed through the tropic haze, and still struggling among the maze of reefs, we made for Maër Island, the largest of the group and anchored under the lee of the mountain wall by the side of its palm-edged beach.

As our naptha launch approached the shore, the sands became black with natives all gesticulating in much excitement, but we were most cordially and kindly received by the magistrate and school teacher, John Stewart Bruce, Esq., who for more than twenty years has lived alone among the natives laboring to fit them to meet the oncoming of civilization. Throughout our stay on Maër Island, the constant kindness and excellent advice of Mr. Bruce was indispensable to the success of our studies, and incidents exhibiting his rare personal charm and high character we shall always recall as the happiest of our memories.

Through the kind permission of the government, we were allowed to occupy the courthouse and the jail for laboratory quarters.

The courthouse was an airy, cheerful one-roomed concrete building which the natives under the leadership and instruction of Mr. Bruce had succeeded in erecting after four years of the most strenuous and concerted effort in the history of the island.

The jail, on the other hand, was a flimsy hut of pandanus thatch, but it served admirably as a storehouse for our apparatus and supplies.

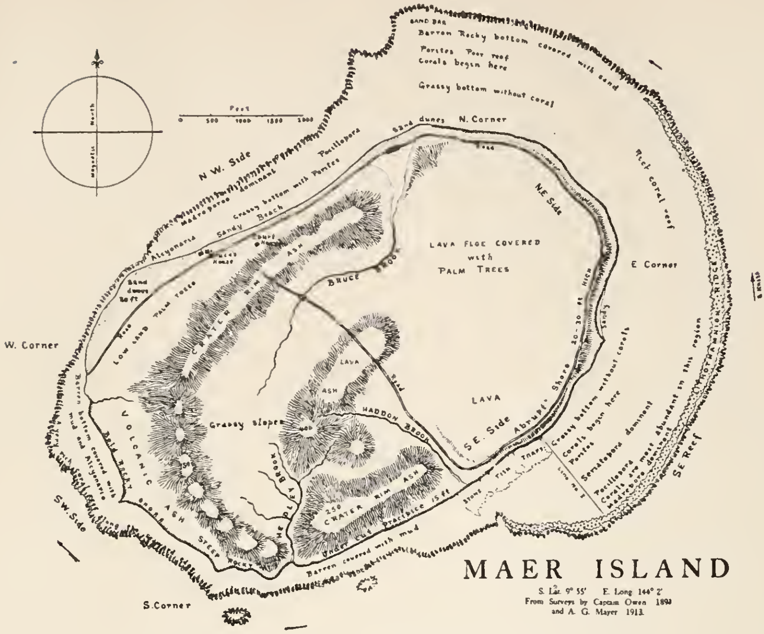
As may be imagined, our visit put an end to the orderly administration of island justice. Deferred jail sentences were henceforth the only sort that could be enforced upon wife-beaters and other disturbers of the serenity of the island, but an even more dreadful punishment was quickly devised by the chief, or Mamoose, who condemned malefactors to work for us.

This punishment, however, soon lost its sting in proportion as the fame of the achievements of Jimmie, our cook, became spread abroad. Four cups of strong coffee, five fish balls, a large piece of turtle meat, four bananas and a yam constituted an average 5:30 A.M. "breakfast" for our native assistants, so it may be imagined that starvation was not the rule of our camp.

The impression should not arise, however, that our native servants were reprobates, for those whom we chose were good and faithful. Indeed, we employed the same men who had served Professor Haddon, whose accounts have made the anthropological and geological aspects of the islands so well known.

Fortunately one of our party could claim the honor of Professor Haddon's personal friendship, an "open sesame" to the Islander's highest consideration, but despite the initial respect thus inspired, the natives soon decided that we of the scientific staff were all hopeless but quite harmless lunatics who were being taken around the world under the guidance of our engineer, Mr. Mills. Indeed the wonderful behavior of the launch and the miraculous achievements of "Johnmills" who could "saw iron" were soon immortalized in song and will doubtless remain as a revered tradition of the island.

Maër Island is an extinct volcano which in its active days burst through the old limestone floor of the wide Barrier Reef plateau which



as has been shown by Andrews, Griffith-Taylor and Hedley, was once above the sea but is now submerged to a depth of from 90 to 180 feet. Shattered fragments of the old limestone are found imbedded in the ash crater of the volcano.

On the western side of the island, the crater rim rises to a height of about 750 feet, the seaward slope being steep and evidently determined by the angle of repose of the ejected ash.

In later times, however, the volcano appears to have exploded and destroyed the northern part of the crater rim, out of the break in which there flowed a tongue-shaped mass of lava which now constitutes the northern half of the island. The last volcanic activity issued from a small ash-cone in the cup of the old crater, and then the island lapsed into its unbroken quietude.

A luxuriant growth of cocoanut palms, and forest trees now covers the old lava, while coarse grass grows rankly over the ash slopes of the crater. The torrential rains of the wet season from November to March

N.W.-S.E., Section of Maër Island. (Diagrammatic.)

have cut three ravines down the slopes, and in former times, before the coral reef grew seaward to protect the island, the sea commenced to cut into the shores, forming a precipice about 20 feet high along the southeastern side of the island.

But, after the volcanic fires had ceased, corals began to grow along the shores and soon the island was surrounded by a fringing reef. The steep seaward slope and outer edges of this reef provided the best foothold for the growth of corals, and no sooner did the old ones die than new growths took possession of the coveted space and thus the reefs pushed seaward from the shores and the old volcano was protected from the attack of the breakers which now break impotently upon the outer edge of the ever-widening reef.

As is always the case under these conditions, the reef advanced seaward most rapidly against the wind, for corals thrive best in agitated water which is free from silt. Thus the reefs are three times as wide on the southeastern as on the northwestern sides of the island, for not only is the water too calm for the most luxuriant coral growth on the leeward side, but the mud which is washed over the reef-flats during the rainy season interferes seriously with coral growth. It is due also to this fact that the reef—or platform—is narrow wherever the silt from the streams washes over it, and wide wherever it is covered with pure ocean water and exposed to the full force of the breakers.

Maër Island is oval, about three miles long and one and a half wide and the southeast trade-wind causes the water currents to sheer in opposite directions from the middle of the southeast shore, and eddies are formed at both ends of the island, and these deposit water-washed sand along the leeward side, thus forming dunes at the ends and a sand beach along the middle of the leeward side, and converting the originally oval shape of the island into a crescent with its horns and concavity directed down the wind. Indeed Hedley and Griffith-Taylor, and Wood-Jones have shown that the crescentic shapes of coral atolls are formed in this manner in obedience to the direction of the prevailing winds and currents.

In short, the width and character of the reefs surrounding Maër Island are determined by the shore conditions; and it is quite clear that the island has not developed in the midst of a preexisting reef-flat, but that the volcano was formed before the modern reefs began to grow around it. Moreover, they are all fringing reefs that have grown outward from the shore and thus the "lagoon" of the great southeast reef is only 18 inches deep and its bottom is of hard coral with none of the mud and occasional reef patches seen in the bottoms of all lagoons between barrier reefs and the shore.

Indeed according to a theory which has been put forth by Penck, and more recently by Professor R. A. Daly, barrier reefs originated in a manner quite different from that of the recent fringing reefs of the Murray Islands. According to these students water was abstracted from the sea to form the great polar ice caps of the glacial epoch, and Professor R. S. Woodward has demonstrated mathematically that a still further lowering of level in tropical seas must have resulted from the attraction of the ice caps for the ocean surrounding them.

Thus the level of the tropical oceans may have been about 120 feet lower than at present. Now under these conditions the oceans would wash away the shores forming platforms along the tropical coasts at a level which would be about 120 feet below the present surface of the water.

Then when the ocean began again to rise, after the close of the glacial epoch, corals would grow along the outer edges of these platforms and thus Atolls and Barrier Reefs have been formed; the Atolls growing upon the truncated summits of mountains.

Andrews called attention to the fact that the platform upon the outer edge of which the Great Barrier Reef has grown, extends southward far beyond the latitude of corals, and Vaughan has observed that the platform of the Florida reef extends far northward beyond the last coral reefs. Also we may observe the Barrier Reef platform extends northward to the coast of New Guinea although the corals are killed in the wide region of the Bligh Entrance by the silt of the Fly and other great Papuan rivers. Thus it appears that the corals have merely grown as break-waters upon the seaward edges of platforms which were formed before the reefs themselves developed.

In some respects, the Pacific reefs are markedly different from those of the Atlantic. In the Pacific, one misses the beautiful sea fans and gorgonians that wave in languid grace to the rhythm of the surges in the crystal waters of Florida and the Bahamas. Instead, we find large areas of leathery-looking alcyonaria, or fleshy eight-rayed corals, *Sarcophyton* and *Alcyonium,* and in the crevices one often sees the giant clams *Tridacna,* their valves opened to show the beautiful mantle edges of malachite green, or blue, yellow or mottled with brown in a gamut of color, no two individuals being alike.

There are almost twice as many kinds of corals in the Pacific as in the Atlantic, and some of the more fragile of these grow luxuriantly down to depths of 60 feet or more, whereas in the Atlantic the coral reefs thrive well only in shallow water not over 20 feet in depth.

But the most striking feature which distinguishes the Pacific reefs is the development of a ridge which actually projects half a foot or more above low tide level and extends along the outer seaward edge of the reef-wall wherever the breakers dash. In the Paumotos, this ridge is dull reddish pink in color, and it is composed of a mass of stony seaweeds or nullipores of the sort called *Lithothamnion,* and also of

THE LITHOTHAMNION RIDGE ALONG THE SEAWARD FACE OF THE SOUTHEAST REEF OF MAËR ISLAND, MURRAY ISLANDS.

bryozoa which are remarkable lime-secreting organisms related more closely to the worms than to any other phylum of the animal kingdom.

This lithothamnion ridge thrives only where the breakers strike in full force upon its living barrier, and it serves as the chief protector of the island, breaking the force of every wave that approaches the windward shore.

Clustered in the tide pools of this lithothamnion ridge, with the waves dashing constantly over them one finds living corals which cling tenaciously to the shallow crevices and grow into thin encrusting forms instead of into dome-like shapes as in more protected waters; or their branches are remarkably short stump-like and gnarled and tend to bend inward toward the shore after the manner of the ragged trees that survive along a wind-swept coast.

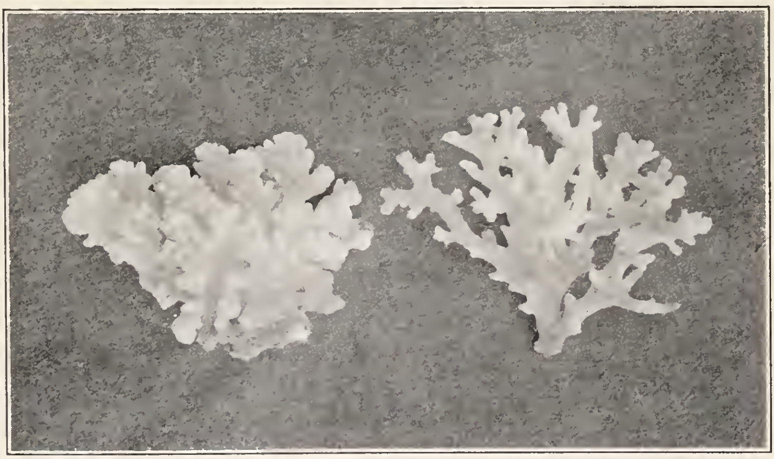
At Maër Island, the lithothamnion ridge extends along the extreme outer edge of the southeastern reef between 1,800 and 2,200 feet from shore, and it forms a veritable dam which prevents the escape of the water from the basin of the reef-flat at the lowest tides, so that at the low tide of the springs, one finds here a great shallow marine lake about 1,700 feet wide, 2½ miles long, and only about 18 inches deep.

About 3,600,000 coral heads grow upon the hard rocky bottom of this natural aquarium, and in the middle region of the reef-flat, 1,000 feet from shore, fully 50 per cent. of the bottom is covered with heads the dominant species being the delicate and profusely branched *Seriatopora histrix* which forms a veritable coral forest, growing so luxuriantly that no other species can thrive so well in this region as it does nearer shore or farther out upon the reef. It is evident that there is a struggle for existence between the different sorts of corals, and the *Seriatopora* wins in this strife for place in the region 1,000 feet from shore. It is, however, very sensitive to high temperature, and the warm shallows close to shore are fatal to it so it can not survive within 550 feet of the beach. Also, being very slender, it can not survive the rush of the breakers and, thus it disappears about 1,670 feet out from shore where the surges shatter its fragile stems. Delicate and sensitive to high temperature, to silting, and to agitated water as it is, however, if conditions be ideal for its existence, it thrives so well that all other corals, even those that can live anywhere over the reef-flat, must give way to it.

The amount of food required to support the vast coral population of this reef-flat must be very great, especially, as Dr. Vaughan discovered, corals are strictly carnivorous and will not even attempt to capture plants. The minute floating animal life of the ocean is therefore the chief source of food for corals. Moreover, Dr. Vaughan showed that it is possible at a glance to tell the difference between a fat-looking, well-fed coral and the thin, drawn appearance of a starved one. The corals of the southeast reef of Maër Island, however, all seem to be well fed, and thus it appears that the question of food has little or nothing to do with their struggle for existence.

There are, however, no large heads upon this reef, only a vast array of small ones.

Now the Murray Islands are in a fortunate region which is never visited by hurricanes, and thus the corals grow on for ages undisturbed by severe storms. Along the entire southeast beach only two small coral heads were found tossed ashore by the waves, a striking fact in contrast with the great heaps of dead coral ten feet high, found strewn along the shores of the Paumotos Islands where severe hurricanes occur.



Pocillopora damicornis. The fragile specimen on the right grew in the calm waters of the reef flat. The rigid one on the left grew in a tide pool among the breakers. Murray Islands, Torres Straits.

Bridal Veil Falls, Gavett's Leap, in the Blue Mountains of New South Wales, showing the characteristic block faulting seen along this part of the Australian coast.

There are, however, parts of the Great Barrier Reef region which are afflicted periodically by hurricanes and the reefs in these regions consist of *large* coral heads quite *far apart* instead of great numbers of small ones close together. Moreover, the pure ocean water of the Murray Islands is fairly free from silt, whereas that of Thursday Island bears a vast amount of mud in suspension and this, also, is fatal to corals and buries the small heads more readily than the large, and thus the reefs of Thursday Island are not rich, but the coral heads are of large size and are widely separated.

It is interesting to see how the 40 or more species of corals that grow upon the southeast reef-flat are distributed, and in order to gather a census of the corals, a line was surveyed across the reef, and at intervals of 200 feet, squares of 50 feet on the side were staked off and all the coral heads on each square were counted.

The shallows within 350 feet of the shore lack corals, the bottom being covered with a thin layer of limestone mud which supports a vigorous growth of a short-bladed eel grass, *Posidonia australis.*

On the square whose center was 400 feet from shore, only three small coral heads were found, and these were growing upon loose corroded limestone blocks which had been washed shoreward from the outer parts of the reef-flat. As one goes outward, however, the coral heads steadily increase in number becoming a maximum at 1,425 feet from shore where there were 1,838 coral heads on the square. Even the crest of the lithothamnion ridge 1,750 feet from shore had 201 living coral heads clinging to the bottom of its shallow tide pools, although the ridge itself was here fully six inches above the level of the lowest tides.

There must be some cause for this tendency on the part of the corals to grow best at considerable distances from shore. The truth of the matter is that corals are very sensitive to changes of temperature and an ocean as cold as 56° or as warm as 98° F. would be fatal to all the reef-building forms. The more delicate corals such as the finely-branching *Seriatopora* or the "stag horns," formerly known as *Madre-*

PORT MORESBY, PAPUA, showing the drowned character of the coast.

The Interior of New Guinea from the Shore Ridge above Port Moresby, showing the lines of mountain ranges running parallel with the coast.

pora but now called *Acropora,* are killed at 97.5°, and cease to take food at about 90.5°, while the more resistant forms such as various species of *Siderastrea,* and *Porites* and some of the brain corals, survive to 100°, or even 102° F., but cease to feed at from 95° to 97.5° F. Now, in general, those corals which are most sensitive to high temperature are correspondingly so to the smothering effects of silt. The more delicate forms such as *Acropora, Pocillopora* and *Seriatopora* are killed by being buried for only 10 to 14 hours beneath the mud, whereas, those corals which die at 100° can withstand as much as 40 to 50 hours of burial and *Siderastrea radians* of the Atlantic, which dies at 102°, can survive being buried 72 hours without apparent injury. It seems, therefore, that high temperature may produce death by causing asphyxiation, and thus those corals which can withstand the highest temperature are usually those which are best able to resist being covered by mud and silt, and these are the very corals which live in the hot, muddy shallows near the shore, while corals which require pure water live far out upon the reef, where the temperature is lower.

It will be recalled that Winterstein who studied frogs decided that the nervous paralysis that results from high temperature was caused by asphyxiation; but later Babàk, and Amerling showed that some of the frogs and toads are very resistant to lack of oxygen but easily paralyzed by heat, while the reverse is the case with others. Becht also casts doubt upon the asphyxiation theory by showing that recovery from heat paralysis can take place in the absence of oxygen in the water surrounding the nerves of the frog or of the horse-shoe crab (*Limulus*). Oxygen may however have been derived from the tissues themselves.

Among corals we find that *Favia fragum* and *Mœandra areolata* are more resistant to the effects of CO_2 or of silt than one would expect from their death temperatures, which are fairly low. If however they be buried in the sand and then heated they are still nearly as resistant as if in the open water, whereas sensitive corals such as *Acropora* or *Orbicella* are killed at lower temperatures if buried than if heated in the open water.

The explanation may be that *Favia* and *M. areolata* can survive at a low as well as at a high rate of metabolism, in other words "hibernate" under the mud; and thus be almost as well able to resist heat in this condition as when living at a higher rate of oxygen-consumption in the free water of the ocean.

We still incline to the belief, therefore, that high temperature may produce death in corals by asphyxiation, although other factors may complicate the matter, as is so often the case in physiological reactions.

Vaughan, indeed, has shown that those corals which live in muddy regions are quite able to free themselves from silt by means of the cilia which cover their surfaces, but those forms which live in the pure water of the outer parts of the reef are not so efficient in this respect.

TERMITE'S NEST, PRINCE OF WALES ISLAND, TORRES STRAITS.

We saw that there is evidence of a struggle for existence between the various kinds of corals, and according to Darwin's theory, we would expect this to have improved the corals. The Australian forms must withstand a very high temperature during the calm, hot days of the "northwest" season, while those of Florida must suffer annually from cold "northers." Yet, our experiments show that the Australian corals are quite as sensitive to high temperature as are those of Florida, and conversely the Florida corals can not withstand cold any better than can those of tropical Australia. In other words, natural selection has not improved the heat-resisting or cold-withstanding powers of the corals and yet temperature is a factor of primary importance in determining the life or death of reef corals. Of late years we have been steadily losing respect for the efficacy of natural selection as a means of developing morphological or physiological adjustments.

We must conclude that "corals are corals," and their behavior is essentially alike both in Florida and in Australia.

As we have seen, the "lagoon" of the reef flat on the southeast side of Maër Island is shallow, being only about 18 inches deep at the lowest tide, although covered by about 8 feet of water at high tide. When the low tide falls at the hottest part of the day, at about 3 o'clock in the afternoon, the water of the reef flat is several degrees warmer than the air, but in the early morning before sunrise, the water is always colder than the air. This shows that the lagoon water derives most of its heat during the day from direct solar radiation, and at night the surface of the water radiates heat into outer space and thus becomes colder than the air. It has been commonly supposed that the temperature range of ocean water is less than that of the air, but this is evidently not the case in shallow lagoons in the tropics where the range in air temperature is slight. Indeed, during five weeks in September and October at the Murray Islands, the difference in air temperature between the hottest day and coolest night was only 10° F., the hottest being 86° and the coolest 76°; but during the same time the water over the southeast reef-

NATIVES OF KURANDA, QUEENSLAND, standing in front of their house. Australian aborigines.

flat ranged through 21°; the hottest being 93° and the coolest 72° F. Thus the reef-flat corals must be able to withstand a considerable range in temperature.

In the Pacific, the lithothamnion ridge always grows along the seaward face of reefs, provided the reef is exposed to the breakers, for the lithothamnion can thrive only in strongly agitated water. This ridge at Maër Island is only about six inches above low tide, for the breakers are not very high, the force of the rollers being partially spent upon the reefs of the Great Barrier six miles to the eastward of the Murray Islands.

We saw that at low tide the southeast reef flat of Maër Island is a wide shallow lake dammed in by the lithothamnion ridge. Now as the reef grew seaward this lithothamnion ridge always remained as a narrow boundary wall upon its advancing edge.

Thus in former times when the reefs began to grow outward, the lithothamnion ridge must have been close to the shore, whereas now it is from 1,800 to 2,200 feet out to sea. The lagoon behind this ridge is about eighteen inches deep and it is evident that as the reef advanced outward the shoreward edge of the lithothamnion ridge must have disintegrated or dissolved and has thus disappeared. Indeed, the disintegration of the dead inner edge of the lithothamnion ridge is very apparent in its ragged outline and the many loose blocks which are detached from it and washed shoreward, the process of disintegration being accelerated by the boring of numerous echinoderms; and it is evident that in same manner, a thickness of about two feet of limestone has disappeared so that the bottom of the present lagoon is now about eighteen inches below the crest of the lithothamnion ridge.

Sir John Murray and Alexander Agassiz believed that limestone was dissolved by sea water, but Dr. T. Wayland Vaughan collected samples of water from the lagoon of Tortugas, Florida, for an entire month and these were analyzed by Mr. R. B. Dole, who decided that they contained no free carbon dioxide. Now, without carbonic acid, or some other free acid, sea-water can not dissolve limestone.

The Tortugas is peculiar in being surrounded by wide areas of chalky mud and, moreover, the surface waters of the Florida-Bahama contain, according to Drew and Kellerman, great numbers of bacilli which cause a precipitation of calcium carbonate composed of such minute colloidal particles that they float for some time before sinking to form the impalpable limestone ooze of the sea bottom, and, finally, to change into oolite in the manner explained by Linck and by Vaughan, oolite being a rock composed of small calcium carbonate balls causing it to resemble fish roe.

One might expect therefore that the excessive amount of calcium carbonate in the water would hold the carbon dioxide in chemical combination, but Dr. Shiro Tashiro working with his marvelously sensitive bromites, finds that carbon dioxide is set free, and discharged into the air, from the Tortugas sea-water at ordinary atmospheric pressures and temperatures. The whole question as to the condition of the carbon dioxide within the ocean itself is therefore thrown open to be determined by future researches. It is still possible, however, that the sea-water of Florida can not dissolve limestone and if this be true, the lagoons of the Florida-Bahama region were not formed by marine solution; but as yet no direct tests have been made to determine the efficacy of the water of the reefs as a limestone solvent, although the writer has begun a series of experiments to test this at Tortugas.

It seems that the limestone of the shallow southeast reef-flat of Maër Island must dissolve, for the disintegrated coral sand disappears *in situ*, there being very little sand either on the hard, rocky bottom of the lagoon or on the beach.

There are, however, several factors other than sea-water which might cause such solution, for it is well known that when rain-water percolates through dead leaves it gains a considerable charge of carbonic acid and this has been the cause of the solution which has resulted in the formation of the numerous caverns seen in all limestone regions. It is evident that the torrential rains of the wet season at Maër Island cause a great outpouring of fresh water from the shores over the reef flat and this must dissolve the limestone. This is not necessarily injurious to the living corals, however, for experiments made at Maër Island show that all species can survive being in sea-water diluted with an equal volume of rain-water for at least four and a half hours, and most of the forms can survive twelve hours of such treatment. The fact that there is but little coral sand along the southeast beach indicates that after it is cast ashore it is soon dissolved by the terrestrial drainage in the wet season.

There are, also, other agencies which dissolve limestone, for Professor Treadwell finds that worms which form burrows in dead coral heads are decidedly acid, and many sponges and boring plants are well known to dissolve the shells of molluscs. In addition, Stanley Gardiner, Wood-Jones, and others have observed that echinoderms which swallow large amounts of calcareous sand probably dissolve a certain percentage of it in their digestive tracts. We thus see that limestone is built up by some agencies and destroyed by others and the resultant condition of the reefs represents the balance between these antagonistic tendencies.

This leads us to the question of the rate of growth of corals, a subject which has been studied in greatest detail by Dr. Vaughan at Tortugas, Florida, and in the Bahamas, but upon which many other students have worked in a less exhaustive manner. For example, in 1890, Saville-Kent measured and photographed certain corals off Vivien Point, Thursday Island, and some of these we succeeded in identifying and remeasuring in November, 1913, and it appeared that a brain coral, *Symphyllia*, which

NATIVES OF THE MURRAY ISLANDS, TORRES STRAITS, WEARING "DARIS." Papuans of the Fly River Delta type.

was 30 inches in diameter in 1890 had increased to be 74 inches in 1913. Also, a huge coral which Saville-Kent called "*Porites astræoides*" was 19 feet in diameter in 1890 and 22 feet and 9½ inches in 1913. On the other hand, a certain gray-green *Goniastrea*, which was 8 feet, 2 inches wide in 1890 had not grown during the intervening 23 years. Indeed, Dr. Vaughan's growth experiments upon Florida corals show that perhaps all corals grow to well-defined sizes and then cease to enlarge. However, the corals that did grow at Vivien Point had increased in diameter from 44 to 45½ inches in 23 years, or about 1.9 inches per annum.

Thus charts of channels which are only occasionally used, and the bottoms of which are covered with corals, should state that an upward growth of at least one inch per annum may be expected.

But other studies apart from those upon coral reefs were conducted at the Murray Islands. Dr. Hubert Lyman Clark, of Harvard, found many species of the delicate feathery "sea lilies" or crinoids, which live among the coral heads below low tide. These crinoids were, by some, supposed to be sedentary animals but Dr. Clark found that at least certain forms can swim actively through the water using their long graceful arms as oars. In cretaceous times crinoids were abundant along our own shores but are now common only in the depths of the Atlantic Ocean and in the shallow water of the western tropical Pacific and Malayan region northward to Japan.

There were also great numbers of slender serpent stars, rapidly moving forms which usually live in crevices among the rocks and scuttle off

GOVERNOR MURRAY'S SERVANTS. Natives of Port Moresby, Papua. Types of the natives of the S.E. coast of New Guinea.

Hanuabada Village, Port Moresby, Papua. The flimsy nature of the buildings illustrates the immunity of the region from hurricanes.

with great rapidity when disturbed. They are often called "brittle stars," for if one seizes an arm it is promptly cast off, permitting the major portion of the animal to escape. Their beautiful sculpturing, rich colors, and the ornate patterns of their disks were admirably figured in color by Mr. E. M. Grosse, who executed more than 100 beautiful drawings which will serve to illustrate Dr. Clark's purposed paper upon the Echinoderms of Torres Straits. Indeed, Dr. Clark aptly called the region "a paradise for echinoderms," and it appears to be the richest known locality in the world for shallow-water forms of these animals, for Dr. Clark found 51 species at Maër Island alone, and in addition, he collected 26 others at Badu, Darnley and Thursday Islands; making 177 from Torres Straits. Thus his collection is a notable addition to that of the Museum of Comparative Zoology at Harvard, which was probably already the greatest gathering of specimens of echinoderms in the world. In almost every instance Mr. Grosse's figure is the only colored drawing of these Torres Straits species, and thus Dr. Clark's paper will be a classic upon the subject of tropical Pacific echinoderms.

117 species had been previously recorded from Torres Straits, and of these, Dr. Clark found only 42, but in addition he found at least 45 not previously known to science, so that at present fully 250 echinoderms are known from this extraordinary region.

As is well known to physiologists, the important subject of the penetration of living cells by alkalies has for several years engaged the attention of Dr. E. Newton Harvey, of Princeton, and his results essentially support Overton's lipoid theory, namely, that those substances which are most readily dissolved in fat-solvents enter living cells most readily; and this leads one to suspect that the cell surface may be lipoid, or fat-like in nature.

No one had been able to test this hypothesis for acids, until Dr. Harvey discovered a holothurian at the Murray Islands, *Stycopus ananas,* the intestines of which are purplish-red. If placed in acid, however, they turn bright red, and in alkalies dark purple; and these changes are reversible and may take place in weak acids or alkalies without killing the cells. Dr. Harvey used 24 different kinds of acids in dilute solutions upon this animal and found that those which are most poisonous penetrate most rapidly, and all the acids penetrate about in the ratio of their degree of toxicity. There is, on the other hand, no relation between the degree of dissociation of an acid and its rate of penetration of the living cells; and there is only a fair but by no means perfect agreement between the rate of penetration and the solubility of an acid in xylol.

Overton's theory applies, however, with the majority of acids, but the agreement is not perfect, and hence Harvey concludes that the power of penetration of an acid depends not only on its lipoid solubility but also upon the affinity of the acid for certain protein substances of the cell surface.

Mr. Frank A. Potts, of Trinity Hall, Cambridge University, reports that he found at the Murray Islands a small lobster-shaped crustacean called *Alpheus* which lives among the arms of crinoids and usually resembles the rich brown or mottled color of its host. Upon examining some of these *Alpheus*, Mr. Potts noticed numerous small pink sac-like bodies attached to their legs and these sacs contain the eggs and young larvæ of a barnacle-like animal which is evidently a parasite infesting the *Alpheus*. In fact this degenerate barnacle grows within the tissues of the *Alpheus*, and losing all semblance to a crustacean, changes into a mass of root-shaped branches which at intervals send out sac-like genital organs, these being the only special organs it possesses. When the *Alpheus* moults, the sacs are cast off and each little larva is doubtless liberated to wander for a time as a free-swimming minute crustacean and finally to find an *Alpheus* and to enter its body and change into a root-like parasite, losing its eyes, legs, antennules, and all organs of special sense to grow into a mere root-like form which sends out its genital sacs upon the legs of its unfortunate host. The name of this very degenerate creature is *Thylacoplethus*.

Another curious animal which attracted the attention of Mr. Potts was a crab called *Hapalocarcinus*, the female of which settles down while still very small and immature among the branches of the *Pocillopora* coral. Here the breathing of the crab produces a water current and this causes the branches of the coral to thicken and finally to enclose the crab in a capsule, leaving only a small aperture far too small to permit of its escape, but large enough to admit the minute male of the species who visits the chamber at the time the female moults.

Professor David Hilt Tennent, of Bryn Mawr College, while at the Tortugas Laboratory in Florida, discovered that the hybrid larvæ of certain echini can be caused to resemble either their father or their mother in response to definite changes in the alkalinity of the sea-water. The cytology of this matter has attracted much attention and discussion, and Professor Tennent went with us to the Murray Islands to continue studies of similar import and to study other hybrid crosses between echinoderms.

He caused an artificial cross to occur between a crinoid and an echinus and carried the larvæ farther than had previously been done.

Some of Professor Tennent's best studies were carried out upon Badu Island where members of the expedition enjoyed the privilege of being the guests of the Reverend F. W. Walker, the able managing director of the "Papuan Industries, Limited," which is devoted to developing arts and crafts among the natives thus to enable them to become self-supporting in the broad civilized sense of the term, and to restore that self respect and interest in life which the too sudden introduction of civilization has in large measure crushed out among them. Interesting and hopeful results are being achieved by this sociological, rather than purely religious, enterprise. The natives must first learn how to earn a living before they can make any real advance in the development of a moral and social standard to which they can hold as things of their own initiation. At present a mere semblance of civilization has been forced upon them from outside, but a race to survive must be the father of its own ideals.

After leaving the Murray Islands, Mr. Potts and the leader of the expedition went to Port Moresby, Papua, where His Excellency, the Honorable John H. P. Murray, the governor, was so kind as to invite us to be his guests at Government House during the entire period of our visit.

The English deserve the greatest credit for the altruistic government which is being administered to benefit and uplift the native population. "Fair play for the Papuan" is the watch-word of the colony.

Malaria is still the dreaded pestilence of Papua, and for generations yet to come many noble English lives must be extinguished by its ravages, but despite the dull heat, the certainty of ennervating illness, and the vast areas yet unknown to any save the savage in the stone age, this little band of high-minded men has not lost heart but year by year intertribal wars, cannibalism and sorcery are becoming things of the past, and the natives are slowly but willingly acquiring their first lessons in civilization.

Without detracting from the honor due the missionary who leaves home and friends and seeks the degraded places of the earth, let us not forget the equally altruistic civil servant whose hardships and dangers and devotion to duty we are all too apt to belittle or overlook, yet whose service though less conspicuous than that of his religious co-worker is equally significant for the raising of England's standard of freedom before the eyes of the whole earth.

THE CELLULAR BASIS OF HEREDITY AND DEVELOPMENT. II

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C. The Mechanism of Heredity

The mechanism of heredity, as contrasted with the mechanism of development, consists in the formation of particular kinds of germ cells and in the union of certain of these cells in fertilization. We have briefly traced the origin, maturation and union of male and female sex cells in a number of animals, and in these phenomena we have the mechanism of the hereditary continuity between successive generations. But in addition to these specific facts there are certain general considerations which need to be emphasized.

I. *The Specificity of Germ Cells*

The conclusion is inevitable that the germ cells of different species and even those of different individuals are not all alike. Every individual difference between organisms must be due to one or more differentiating causes or factors. Specific results come only from specific causes. These causes may be found in the organization of the germ cells or in environmental stimuli, *i. e.*, they may be intrinsic or extrinsic, but as a matter of fact experience has shown that they are generally intrinsic in the germ. In the same environment one egg becomes a chicken and another a duck; one becomes a frog, and another a fish, and another a snail; one becomes a black guinea-pig and another a white one; one becomes a male and another a female; one gives rise to a tall man and another to a short man, etc. Since these differences may occur in the same environment they must be due to differences in the germ cells concerned.

On the other hand, different environmental conditions may be associated with similar developmental results. Loeb and others have found that artificial parthenogenesis may be induced by a great variety of environmental stimuli, viz., by salt solutions, by acids and alkalies, by fatty acids and fat solvents, by alkaloids and cyanides, by blood serum and sperm extract, by heat and cold, by agitation and electric current. There is certainly nothing specific in these different stimuli. Similarly, Stockard has discovered that cyclopia, or one-eyed monsters, may be produced by magnesium salts, alcohol, chloretone, chloroform, and ether. In all such cases it is evident that the specific results of such treatment are due to a specific organization of the germ rather than to specific stimuli.

Why does one egg give rise to a chicken and another to a duck, or a fish, or a frog? Why does one egg give rise to a black guinea-pig and another to a white one, though both may be produced by the same parents? Why does one child differ from another in the same family? Why does one cell give rise to a gland and another to a nerve, one to an egg and another to a sperm? If these differences are not due to environmental causes, and the evidence shows that they are not, they must be due to differences in the structures and functions of the cells concerned.

Many differences in the material substances of cells are visible, and many more are invisible though still demonstrable. These differences may not be detectable by chemical or physical tests, and yet they may be demonstrated physiologically and developmentally. The most delicate of all tests are physiological, as is shown by the Widal test in typhoid fever, the Wassermann reaction in syphilis, the reactions of immunized animals to different toxines, etc. Lillie has recently shown that egg cells give off a substance which he calls *fertilizin,* which can be detected only by the way in which spermatozoa react to it. No chemical or physical test can distinguish between the different eggs or spermatozoa produced by the same individual, but the reactions of these cells in development prove that they are different. Undoubtedly chemical and physical differences are here present, but no chemical methods at present available are sufficiently delicate to detect them. The developmental test proves that there must be as many kinds of germs as there are different kinds of individuals which come from germs. It is one of the marvelous facts of biology that every individual which has been produced sexually is unique, the first and last of its identical kind, and although some of these individual differences are due to varying environment, others are evidently due to germinal differences, so that we must conclude that every fertilized egg cell differs in some respects from every other one.

But are there molecules and atoms enough in a tiny germ cell, such as a spermatozoon, to allow for all these differences? Miescher has shown that a molecule of albumin with 40 carbon atoms may have as many as one billion stereoisomers, and in protoplasm there are many kinds of albumin and proteins, some with probably more than 700 carbon atoms. In such a complex substance as protoplasm the possible variations in molecular constitution must be well-nigh infinite, and it can not be objected on this ground that it is chemically and physically impossible to have as many varieties of germ cells as there are different kinds of individuals in the world.

Even with regard to morphological elements which may be seen with the microscope it can be shown that an enormous number of permutations is possible. It seems probable, as Boveri has shown, that different chromosomes of the fertilized egg differ in hereditary potencies, and where the number of chromosomes is fairly large the number of possible combinations of these chromosomes in the germ cells becomes very great. In woman, where there are probably 48 chromosomes, and, after synapsis, 24 pairs of maternal and paternal ones, the possible number of permutations in the distribution of these chromosomes to the different egg cells would be $(2)^{24}$, or 16,777,036, and the possible number of different types of fertilized eggs or oosperms which could be produced by a single pair of parents would be $(16,777,036)^2$, or approximately three hundred thousand billions. But probably other things than chromosomes differ in different germ cells, and it is by no means certain that individual chromosomes are always composed of the same chromomeres, or units of the next smaller order, and in view of these possibilities it may well be that every human germ cell differs morphologically and physiologically from every other one, in short that every oosperm and every individual which develops from it is absolutely unique.

Indeed, the production of unique individuals seems to be the chief purpose and result of sexual reproduction. In a sexual reproduction the individual variations which occur are chiefly, if not entirely, due to environment, but in sexual reproduction they are also due to new combinations of hereditary elements. The particular germinal organization transmitted from one generation to the next depends upon, (*a*) The ancestral organization, (*b*) The particular character of the cell divisions by which the germ cells are formed, (*c*) The particular kinds of egg and sperm cells which combine in fertilization. The ancestral organization determines all the general characteristics of race, species, genus, order, phylum. It determines the possibilities and limitations of individual variations. Given a certain ancestral organization, the individual peculiarities of the germ cells are determined by the particular character of cell division by which the germ cells are formed, and the peculiarities of the individuals or persons which develop from these cells are determined in large part by the particular kinds of germ cells which unite in fertilization.

The behavior of chromosomes in maturation and fertilization is like the shuffle and deal of cards in a game, and apparently with the same object, namely, never to deal the same hand twice. To make this comparison more complete suppose that kings be discarded from the pack, leaving 48 cards of two colors, red and black, which we will compare to the 48 maternal and paternal chromosomes in the human oocyte; suppose that in the shuffling of these cards corresponding cards of the red and the black suits are temporarily stuck together so that the ace of diamonds is united with the ace of clubs, the queen of hearts with the queen of spades, etc., thus forming 24 red-black pairs of the same denominations. If these cards are then dealt into two hands, one card of each pair going to one hand and the other to the other hand, we will have two cards of each denomination in each hand, but if the cards are dealt indiscriminately some of them will be red and some black. This description parallels what takes place in the maturation of the human ovum, except that there is no evidence that there are more than two suits of chromosomes, one maternal and the other paternal.

To carry out this comparison in the case of the maturation of the human sperm where there are only 47 chromosomes it is necessary to take another pack and discard an additional card, say the queen of clubs; then in the union of corresponding red and black cards into pairs the queen of hearts unites with the queen of spades, but the queen of diamonds remains alone, and when the cards are dealt into two hands as before one hand will contain 24 cards and the other 23.

If now we complete this comparison by extending it to what takes place in fertilization we must take one hand from each of these deals and put them together into one pack; though this pack would contain cards of every denomination there would be varying numbers of red and black cards and a mixture of cards from two distinct packs. In no game of cards do corresponding cards from different packs have slightly different values nor are half of the cards taken from one pack and half from another (at every game), but this is just what happens in the shuffle and deal of the chromosomes. Because of the mixture of chromosomes from distinct individuals in every generation, each of which has its own peculiar value, the game of heredity becomes vastly more complex than any game of cards.

This illustration may serve to make plain the fact that the purpose of maturation and fertilization is, in part, this shuffle and deal of the chromosomes, and its result is that every oosperm and every individual which develops from it is different from every other one.

This conception of the specificity of every germ cell, as well as of every developed individual, sets the whole problem of heredity and development in a clear light. The visible peculiarities of an adult become invisible as development is traced back to the germ, but they do not wholly cease to exist. Similarly, the multidinous complexities of an adult fade out of view as development is traced to its earliest stages, but it is probable that they are not wholly lost. In short, the specificity of the germ applies not merely to those things in which it differs from other germs, but also to characters in which it resembles others—in short, to hereditary resemblances no less than to hereditary differences.

The mistake of preformation was in supposing that germinal parts were of the same kind as adult parts; the mistake of epigenesis was in maintaining the lack of specific parts in the germ. The development of every animal and plant consists in the transformation of the specific characters of the germ into those of the adult, but not in the formation of structures or characters *de novo*. From beginning to end development in a series of morphological and physiological changes, but not of new formations or creations. It is only the incompleteness of our knowledge of development which allows us to say that the eye or ear or brain begin to form in this or that stage. They become visible at certain stages, but their real beginnings are indefinitely remote.

II. *Correlations Between Germinal and Somatic Organization*

All the world knows that the organization of the germ is not the same as that of the developed animal which comes from it, and yet the specificity of the germ indicates that there must be some correlation between the germinal and the developed organization—in short, there is not identity of organization, but correlation of organization between the germ and the adult. What correlations are known to exist between the oosperm and the developed animal?

1. *Nuclear Correlations*

Many biologists maintain that the nucleus and more particularly the chromosomes are the exclusive seat of the "inheritance material" and that all the "determiners" of adult characters are located in them.

There are certain general and *a priori* reasons for assuming that the chromosomes are important factors in heredity and differentiation; (1) they come in approximately equal numbers from the father and the mother, (2) one half of each of the maternal and paternal chromosomes is distributed to each cell of the developing organism, (3) in the formation of the egg and sperm cells the normal number of chromosomes is reduced by one half, and (4) in fertilization the normal number is restored by the union of the chromosomes of the egg and sperm. It is a remarkable fact that the determiners or factors of certain inherited characters come in equal numbers from both parents and that in spite of their ultimate association in an individual they may be separated or "segregated" in the formation of that individual's germ cells. Such inheritance is known as Mendelian and will be treated at length in the next lecture, but it may be said here that the association, distribution and segregation of Mendelian factors and of maternal and paternal chromosomes is exactly parallel. This is strong evidence that these factors are associated with the chromosomes.

There are also certain special reasons for considering that the chromosomes are important factors in heredity and development. (5) Boveri has studied the abnormal distribution of chromosomes to different cleavage cells in doubly fertilized sea-urchin eggs, and has found evidence that the hereditary value of different chromosomes is different.

(6) McClung, Stevens and Wilson have discovered that the determination of sex is associated with the presence or absence of a particular chromosome, the X-chromosome, in the spermatozoon which fertilizes

the egg. If an egg is fertilized by a sperm which lacks the X-chromosome a male is produced; if fertilized by the other type a female results. (7) Finally, Morgan has found that there is a linkage of certain somatic characters with sex in the fruit fly, *Drosophila,* which can be readily explained by assuming that the determiners for these characters are in some way associated with the sex chromosome.

We have in these facts a remarkable correlation between the distribution of the chromosomes and the occurrence of certain characters of the adult animal. The association of maternal and paternal chromosomes in fertilization and their segregation in the maturation of the germ cells is parallel to the association of Mendelian characters in the zygote and their segregation in the gametes; if the distribution of chromosomes in cleavage is abnormal the larva shows abnormal characters (Boveri); sex determination is associated with the distribution of a particular chromosome to one half of the spermatozoa, and the fertilization of the egg by one type or the other of spermatozoa (Wilson); the linkage of certain chaiacters with sex finds a ready explanation by assuming that these characters are associated with the sex chromosome (Morgan).

2. *Cytoplasmic Correspondences*

On the other hand, the most direct and the earliest recognized correlations between the oosperm and the developed animal are found in the polarity and symmetry of the fertilized egg and of the animal to which it gives rise.

(*a*) *Polarity*

In all eggs there is a polar differentiation, one pole, at which the maturation divisions take place, being known as the animal pole, and the opposite one being known as the vegetative pole. The substance of the egg in the vicinity of the animal pole usually gives rise to the ectoderm, or outer cell layer of the embryo; the portion of the egg surrounding the vegetative pole usually becomies the endoderm or inner cell layer. The axis which connects these poles, the chief axis of the egg, becomes the gastrular axis of the embryo and in every great group of animals bears a constant relationship to the chief axis of the adult animal. The polarity of the developed animal is thus directly connected with the polarity of the egg from which it came (Figs. 23, 26, 29, 30, 40, 41).

(*b*) *Symmetry*

In many cases the symmetry of the developed animal is foreshadowed in the symmetry of the egg. The eggs of cephalopods (Fig. 40) and of insects (Fig. 41) are bilaterally symmetrical, while they are still in the ovary; in other cases, such as ascidians, amphioxus and the frog, bilateral symmetry appears immediately after fertilization (Fig. 29, 1, 2), though in some of these cases there is reason to believe that the eggs are bilateral even before fertilization; in still other cases bilaterality does not become visible until later in development and we do not now know whether it is present in earlier stages or not; but wherever it can be recognized in the earlier stages it is certain that the bilateral

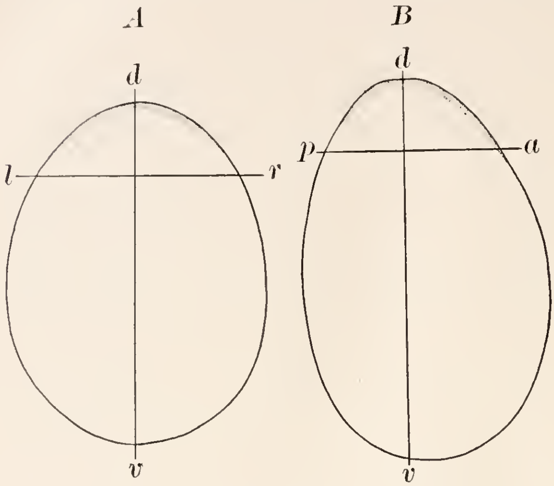

FIG. 40.

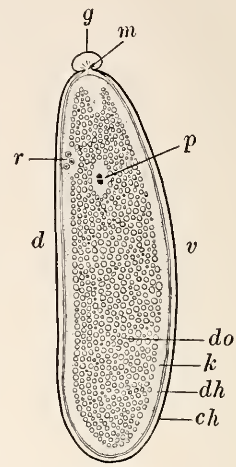

FIG. 41.

FIG. 40. OUTLINES OF THE UNFERTILIZED EGG OF A SQUID, *Loligo*, showing the polarity and symmetry of the egg with reference to the axes of the developed animal; *d*, dorsal; *v*, ventral; *l*, left; *r*, right; *a*, anterior; *p*, posterior. (After Watasé.)

FIG. 41. MEDIAN SECTION THROUGH EGG OF A FLY, *Musca*, just after fertilization, showing the relations of the polarity and symmetry of the egg to the axes of the developed animal; the long axis of the egg corresponds to the antero-posterior axis of the animal; *d*, dorsal; *v*, ventral; *m*, micropyle through which sperm enters the egg; *g*, glutinous cap over the micropyle; *r*, polar bodies; *p*, egg and sperm nuclei; *do*, yolk; *k*, peripheral layer of protoplasm; *dh*, vitteline membrane of egg; *ch*, chorion. (After Korschelt and Heider.)

symmetry of the egg bcomes the bilateral symmetry of the developed animal.

(c) *Inverse Symmetry*

In most animals bilateral symmetry is not perfect, certain organs being found on one side of the mid line and not on the other, or being larger or differently located on one side as compared with the other; among all such animals variations occasionally occur which show a complete reversal of these asymmetrical organs, *i. e.*, in man the heart and arch of the aorta may occur on the right side instead of the left, the pyloris and chief portion of the liver on the left instead of the right, etc. Among certain snails this inversion of symmetry may occur regularly in certain species and not in others, the inverse form being known as sinistral and the ordinary form as dextral (Fig. 44). In these sinistral snails, and probably in all animals showing inverse symmetry, the embryo is inversely symmetrical and every cleavage of the egg from the first to the last is the inverse of that which occurs in dextral snails (Figs. 42, 43). There is good reason to believe that in such cases the unsegmented egg is also inversely symmetrical as compared with the more usual type (Fig. 42). In all of these cases there is a direct correspondence between the polarity and symmetry of the

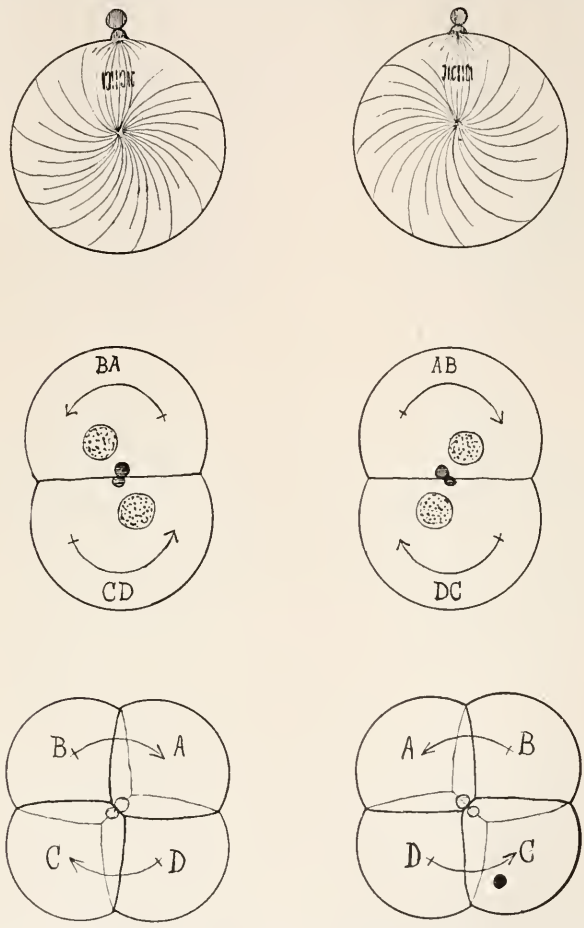

FIG 42. INVERSE SYMMETRY IN THE UNSEGMENTED EGG AND IN THE FIRST AND SECOND CLEAVAGES. Figs. 42, 43, 44. The cause of inverse symmetry in snails. In each case the right-hand column represents dextral forms, the left-hand column sinistral ones.

oosperm and the polarity and symmetry of the developed animal (Fig. 40–44).

(*d*) *Localization Pattern*

In many animals the ectoderm, endoderm and mesoderm may be traced back to areas of peculiar protoplasm in the oosperm, but in addition to this one can recognize in the ascidian egg areas of peculiar protoplasm which will give rise to mesenchyme, muscles, nervous system and notochord, and these substances are present in the oosperm in the approximate positions and proportions which they will have in the embryo and larva (Figs. 28–31).

Indeed, there are types of localization of these cytoplasmic materials in the egg which are characteristic of certain phyla; thus there are the ctenophore, the flat-worm, the echinoderm, the annelid, mollusk and the chordate types of cytoplasmic localization (Fig. 45). The polarity, symmetry and pattern of a jelly fish, star-fish, worm, mollusk, insect or vertebrate are forshadowed by the characteristic polarity, symmetry and

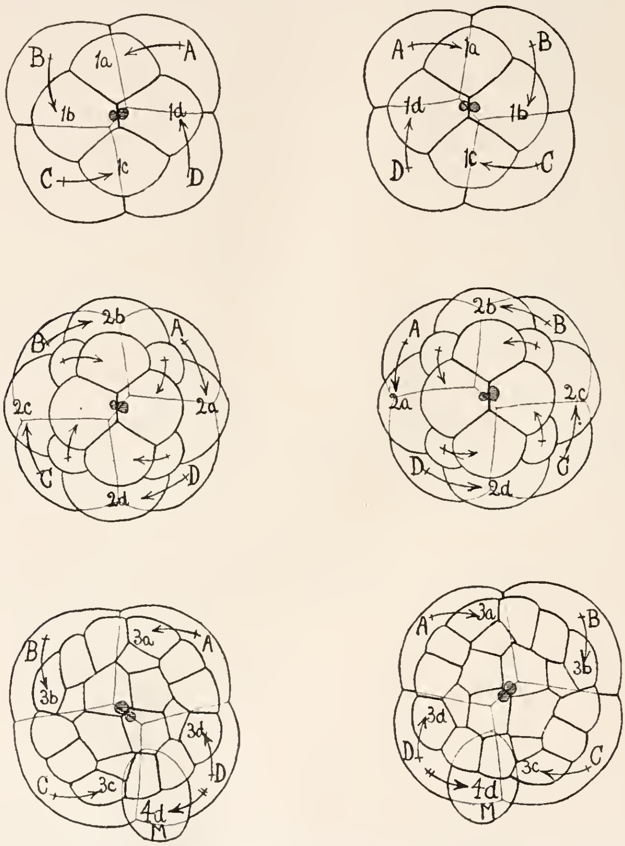

FIG. 43. INVERSE SYMMETRY OF THE 3D, 4TH, 5TH AND 6TH CLEAVAGES. The cells *1a–1d*, *2a–2d* and *3a–3d* give rise to all the ectoderm; *4d* or *M* gives rise to mesoderm; *A*, *B*, *C*, *D* to endoderm.

pattern of the cytoplasm of the egg either before or immediately after fertilization. In all of these phyla eggs may develop without fertilization, either by natural or by artificial parthenogenesis, and in such cases the characteristic polarity, symmetry and pattern of the adult are found in the cytoplasm of the egg just as if the latter had been fertilized. The conclusion seems to be justified that these earliest and most fundamental differentiations which distinguished the eggs of various phyla are not dependent upon the sperm.

All of these correspondences between the polarity, symmetry and pattern of the egg and of the developed animal are found in the cytoplasm. It is possible that the polarity may be carried over from generation to generation through the egg cell, but the symmetry and localization

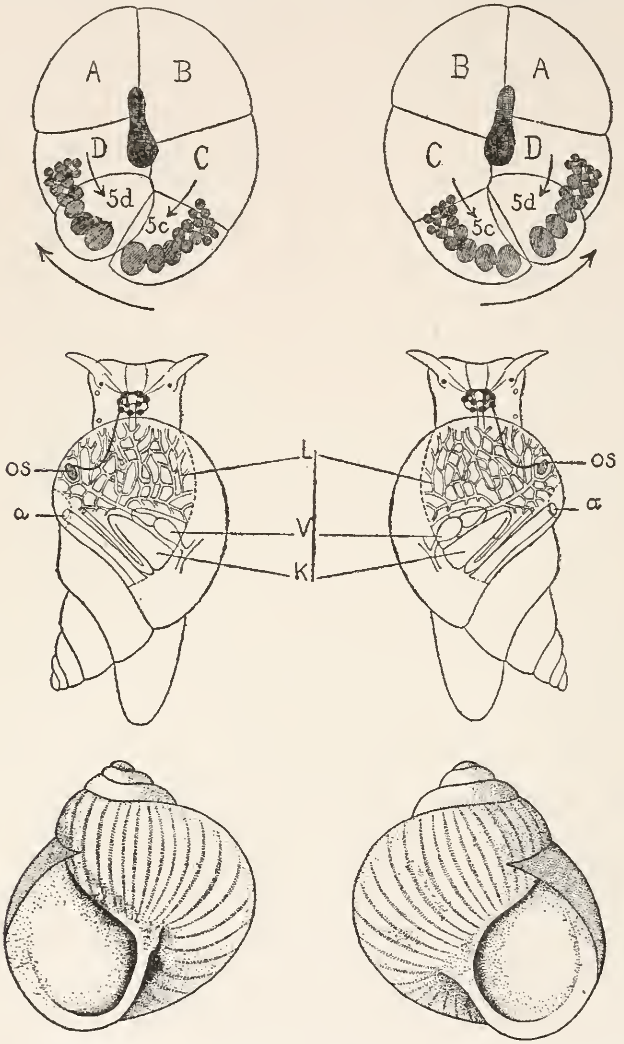

FIG. 44. INVERSE SYMMETRY IN LATE EMBRYOS AND ADULT STAGES. In 1, cross hatched area is blastopore; cells shaded by lines mesoderm, other cells endoderm; the spiral twist of the snail begins in opposite directions in the two embryos. In 2 the adult organization is shown with all organs inversely symmetrical; *os*, olfactory organ; *a*, anus; *L*, lung; *V*, ventricle; *K*, kidney. In 3 sinistral and dextral shells of adult snails are shown.

pattern develop in the ovum before or just after maturation. In this differentiation and localization of the egg cytoplasm it is probable that certain influences have come from the nucleus of the egg, and perhaps from the egg chromosomes. There is no doubt that most of the differentiations of the egg cytoplasm have arisen during the ovarium history of the egg, and as a result of the interaction of nucleus and cytoplasm;

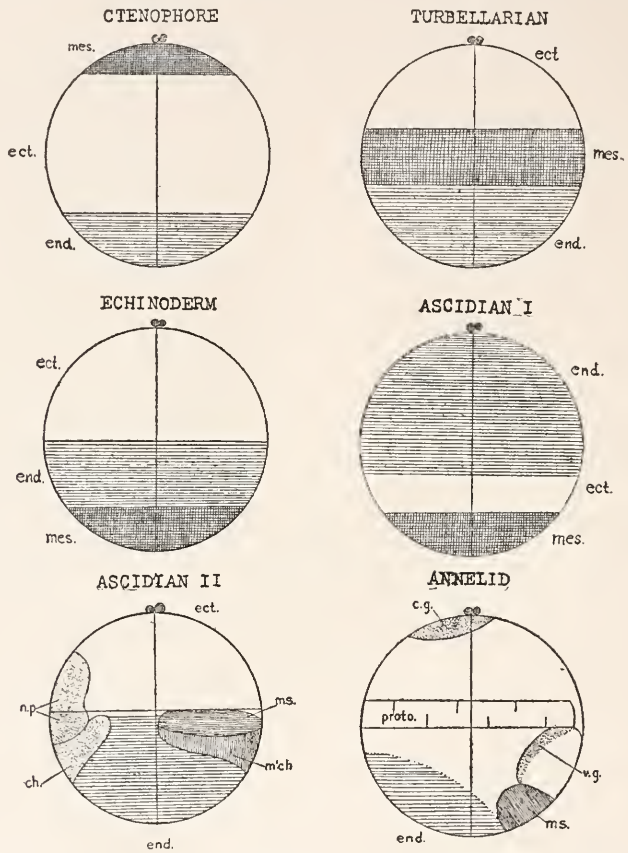

Fig. 45. Types of Egg Organization in Different Phyla; cross-hatched area, mesoderm or mesenchyme (*mes*); horizontal lines, endoderm (*end*); clear area, ectoderm (*ect*). In the first four figures the pattern of localization is that which is found at the close of the first cleavage; in the annelid egg the localization of later stages is projected upon the egg.

but the fact remains that *at the time of fertilization the hereditary potencies of the two germ cells are not equal, all the early stages of development, including the polarity, symmetry, type of cleavage, and the pattern, or relative positions and proportions of future organs, being foreshadowed in the cytoplasm of the egg cell, while only the differentiations of later development are influenced by the sperm. In short, the egg cytoplasm fixes the general type of development and the sperm and egg nuclei supply only the details.*

We are vertebrates because our mothers were vertebrates and produced eggs of the vertebrate pattern; but the color of our skin and hair and eyes, our sex, stature, and mental peculiarities were determined by the sperm as well as by the egg from which we came. There is evidence that the chromosomes of the egg and sperm are the seat of the differential factors or determiners for Mendelian characters, while the general polarity, symmetry and pattern of the embryo are determined by the cytoplasm of the egg.

It will be observed that the correlation between chromosomes and adult characters is different in kind from that between the cytoplasm of the egg and the adult characters; in the latter case polarity, symmetry and pattern are of the same kind in the egg and in the adult, and the correspondence is comparatively close; in the latter there is no correspondence in kind between the chromosomal peculiarities and the peculiarities of the adult. This fact might suggest that the chromosomal organization may be more fundamental than that of the cytoplasm. There are reasons for believing that many substances of the cell are formed by the interaction of nucleus and cytoplasm, and most probably the chromosomes are an important factor in this process. But in no case is the cytoplasm a negligible factor—in no case does it serve merely as food for the chromosomes. The entire cell, nucleus and cytoplasm, is concerned in heredity and differentiation.

D. The Mechanism of Development

Development consists in the transformation of the oosperm into the adult. What is the mechanism by which this transformation is effected? There is progressive differentiation of the germ into the developed organism, but by what process is this differentiation accomplished?

Many different processes are concerned in embryonic differentiation. From the standpoint of the cell the most important of these are (1) the formation of different kinds of substances in cells, (2) the localization and isolation of these substances, (3) the transformation of these substances into the various structures which are characteristic of the different kinds of tissue cells. We shall here describe only the first and second of these processes which are of more general interest than the last.

1. *The Formation of Different Substances in Cells*

Differentiation consists primarily in the formation of different kinds of protoplasm from the proptoplasm of the germ cells. It is plain that different kinds of protoplasm are present in the two germ cells before they unite in fertilization, but in the course of development the number of these substances and the degree of difference between them greatly increase.

Actual observation shows that by the interaction with one another of substances or parts originally present and by their reactions to external stimuli new substances and parts appear which had no previous existence, just as new substances result from chemical reactions. This is "creative synthesis" in philosophy, epigenesis in development. Differentiations appear chiefly in the cytoplasm, but only as the result of interaction between cytoplasm and nucleus. Similarly, it may be argued, smaller units of organization, such as chromosomes or chromosomeres, do not in themselves give rise to any adult part, but only as they interact upon one another are new parts formed.

In many cases the first formation of such new substances appears in the immediate vicinity of the nucleus and, like assimilation itself, is evidently brought about by the interaction of nucleus and cytoplasm. In certain cases it can be seen that the achromatin and oxychromatin which escape from the nucleus during division take part in the formation of new substances in the cell body, and since the oxychromatin is derived from the chromosomes of the previous cell division, it is probable that the chromosomes are a factor in this process.

Weismann maintained that the chromosomes and the inheritance units contained in them undergo differentiation by a process of disintegration and that these disintegrated units escape into the cell body and there produce different kinds of cytoplasm in different cells. A somewhat similar view was advanced by deVries in his theory of intracellular pangenesis. However, as we have seen already, there is good evidence that the chromosomes do not undergo progressive differentiation in the course of development; they always divide with exact equality, and even in highly differentiated tissue cells their number and form remain as in embryonic cells.

On the other hand, the cytoplasm undergoes progressive differentiation, and when by pressure or centrifugal force such differentiated cytoplasm is brought into relations with strange nuclei the differentiations of the cytoplasm are not altered thereby, thus showing that the different nuclei are essentially alike and that differentiations are mainly limited to the cytoplasm. Thus the differentiations of cells are not due to the differentiations of their nuclei, but rather the reverse is true,—such differentiations of nuclei as occur are due to differentiations of cytoplasm in which they lie. Nevertheless, differentiations do not take place in the absence of nuclear material, and it seems probable that the interaction of nucleus and cytoplasm are necessary to the formation of the new cytoplasmic substances which appear in the course of development.

2. *Segregation and Isolation of Different Substances in Cells*

But differentiation consists not only in the formation of different kinds of substances in cells, but also in the separation of these substances from one another. This separation is brought about to a great extent by flowing movements within cells which are associated especially with differential cell division.

In all these processes of heredity and development cell division plays a particularly important part. If cell divisions were always exactly alike there could be no initial difference between the daughter cells, and unless acted upon by different stimuli all cells would remain exactly alike. But there is much evidence that daughter cells are often unlike from the time of their formation, and that different stimuli act upon them to still further increase this initial difference.

(*a*) *Differential and Non-differential Cell Division*

When each half of any dividing unit is like the other half the division is non-differential. So far as we now know the divisions of all the smallest elements of the cell are of this sort; there is no good evidence that the plastosomes, the chromomeres, or the chromosomes ever divide into unlike halves, though in the maturation divisions the separation of whole chromosomes leads to the appearance of a differential division of the chromosomes. But while all of the cell elements may be supposed to grow and divide into equivalent halves, there may be an unequal distribution of these halves in cell division, so that the two daughter cells are unlike. This is what is known as differential cell division and it plays a most important part in differentiation. While the chromosomes are equally distributed to the daughter cells, except in the case of the maturation divisions, the achromatin and the oxychromatin of the nucleus are not always distributed equally and this is probably a most important factor in development. The divisions of the cytoplasm of the egg are frequently differential and such divisions are known to play a great part in the embryonic differentiation.

In the differential divisions of the cytoplasm unlike substances become localized in certain parts of the cell body, chiefly by means of definite flowing movements of the cytoplasm, and when cell division occurs these substances become permanently separated by partition walls. In this way irreversible differentiations are formed. If the formation of partition walls is prevented, the different substances within the cell body may freely commingle, especially during nuclear division when the cytoplasmic movements are especially active; in such cases differentiation is arrested even though nuclear division continues. In the developing eggs of most animals partition walls between daughter cells are necessary to prevent the commingling of different kinds of substances, which are sorted by the movements within the cell and are isolated by the partition walls. In some cases, as for example, in certain protozoa, the commingling of different kinds of protoplasm within a cell may be prevented by the viscosity of portions of the protoplasm, or by the formation of intracellular membranes, or by a reduction to a minimum of the mitotic movements within the cell by the persistence of the nuclear membrane during division. In general the degree of differentiation may be measured by the degree of unlikeness btween different cells, and by the completeness with which the protoplasm of different cells is prevented from intermingling.

All the phenomena of life, including heredity and development, are cellular phenomena in that they include only the activities of cells or of cell aggregates. The cell is the ultimate independent unit of organic structure and function. The only living bond between one generation and the next is found in the sex cells and all inheritance must take place through these cells. Inherited traits are not transmitted from parents to offspring but the germinal factors or causes are transmitted, and under proper conditions of environment these give rise to developed characters. Every oosperm as well as every developed organism differs more or less from every other one and this remarkable condition is brought about by extremely numerous permutations in the distribution of certain parts of the sex cells in maturation and fertilization. Sex is an inherited character dependent upon an alternative distribution of certain chromosomes of the nucleus. There is much evidence that the factors for all sorts of alternative characters are associated with the chromosomes. The differentiation of the oosperm into the developed organism is accomplished in part by the associations and dissociations of germinal units which lead to the formation of new materials and by the segregation and localization of these materials in definite cells.

Germ cells and probably all other kinds of cells are almost incredibly complex. We know that former students of the cell greatly underestimated this complexity and there is no reason to suppose that we have fully comprehended it. What Darwin said of the entire organism may now be said of every cell.

> An organic being is a microsome—a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven.

THE DECREASING POPULATION OF FRANCE

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I. The Present Status of the Population

ONE of the leading newspapers of France, in an editorial in February, 1912, declared that the day on which the results of the next quinquennial census were known would be one of national mourning for the people of France. The Parisian journals in commenting on the census returns when they were made public in May, 1912, characterized the conditions which they revealed by such terms as "deplorable," "profoundly desolating," "extremely disquieting," "lamentable" and "dolorous." The prevailing tone of their comments was as if the country had experienced some great calamity or had suffered a national bereavement. So profoundly impressed was the government that it proceeded at once to appoint an extra-parliamentary commission (the second since 1902), to "investigate the question of depopulation, and to recommend measures for combatting the evils which threaten the extinction of the nation." M. Klotz, minister of finance, in his address to the commission, urged upon it the necessity of prosecuting its investigations with celerity, for, he said, "depopulation is no longer a vague menace to our country; it is a national danger, at once pressing and immediate, and one which demands rapid and efficient measures." M. Léon Bourgeois, addressing the Congress for Social Hygiene about the same time, spoke in a similar tone, declaring that France was threatened with two dangers, one foreign and one domestic. While she was prepared to make any sacrifice, he said, for the cause of national defense, she must also consider seriously the danger with which the country is confronted by the decline of the birth-rate and the comparatively high rate of mortality among the French people. Speaking before the same congress, Senator Ribot, a former premier, declared that "our people must be instructed in the perils that menace us; it will require all the resources and strength of the government to combat successfully the dangers which now imperil the very existence of the French people." No one can read the comments of the statistical experts, sociologists, economists and publicists on the census returns of 1911 without feeling that the nation is really alarmed at the seriousness of the danger with which it is confronted. The census revealed the fact that in 64 of the 87 departments into which France is divided the population had decreased during the past five years and that the number of births during the preceding year in the nation at large was inferior by 34,869 to the number of deaths. True, the total population of the republic increased during the quinquennial period (1906-11), but this increase represented almost entirely the growth of Paris and a few other large cities, itself a result of foreign immigration, which now averages over 120,000 persons a year. Only 23 departments (the number was 55 in 1910) showed any increase at all, and except in those departments containing large cities, the increase was trifling. The departments of Upper Loire, Lot and Yonne each lost about 11,000 inhabitants, Allier and Manche, over 11,000, Somme, 12,400, Nièvre, 14,600 and Ardèche over 15,000.

The disquieting feature of the situation is that while the population of France has long been practically stationary and is now beginning to decline, that of her neighbors continues to increase by leaps and bounds. While the French population since 1872 has increased only from 36,102,000 to 39,601,000, or only about three and a half millions, that of Germany has increased from 40,000,000 to 65,000,000, or a gain of 15,000,000 souls, and this in spite of the several millions that Germany has lost by emigration to foreign lands. During this period the population of the United Kingdom has increased from 31,840,000 to more than 45,000,000; Austria-Hungary from 35,700,000 to more than 49,000,000, and Russia from about 80,000,000 to 155,000,000 (1908), and all this notwithstanding the heavy loss which these countries have sustained through emigration to foreign countries and to their colonies.

M. Bertillon, speaking before the Society of Friends of the University of Paris, in 1912, called attention to the fact that in 1815 the French constituted 18 per cent. of the civilized people of the world; now they constitute only 10 per cent. Against 50,000,000 people who speak French, there are to-day, he says, 120,000,000 who speak German and 150,000,000 who speak English. In 1789 France stood first among the powers of Europe in respect to population; to-day she stands sixth and is followed closely by Italy. M. Bertillon pointed out the economic and other consequences to the nation that must result from this loss of population. French exports have almost ceased to increase for lack of producers and manufacturers, while those of Germany have nearly doubled during the last thirty years. In case of war Germany now has fifty per cent. more conscripts than France to put into the field whereas forty years ago the two countries were in this respect on a footing of practical equality. France has no men available to send to her colonies and few to spread French influence abroad. M. Bertillon calls attention to the fact that technical and scientific works whose readers are necessarily limited in numbers but which nevertheless are the essential marks of progress will be published in the language spoken by the largest number of people. For Europe this language was once French, but it has ceased to be such. During the past century, while the birth-rate of all the other countries of Europe greatly increased, that of France steadily declined. In 1801, the number of births in France was 1,007,000, by 1836 the number had fallen to 927,000, in 1876, it was 847,000; in 1896, 807,000; in 1901, 857,114 and in 1911, 742,114. In 1897 the number of births exceeded the number of deaths by 108,000; in 1902 the excess was 83,000; in 1906 it was only 26,000 and in 1911 there was, as I have said, a deficit of 34,869, an amount equal to the loss of a city the size of Lunéville, Verdun or Bar-le-Duc.

While the natural increase in the population of France has for many years been a negligible quantity, the average annual excess of legitimate births over deaths in Germany is at present in the neighborhood of 750,000 (last year it was 900,000); in Austria-Hungary more than 600,000; in the United Kingdom nearly 500,000 and in Italy more than 300,000. The fact that Germany in particular is adding by natural increase nearly a million souls to her human resources every year, while France is not only adding nothing to hers, but, on the contrary, is losing a portion of what she has, is not only a source of disquietude, but of genuine alarm. In a sense Von Moltke did not exaggerate when he said Germany is gaining every year a battle over France by reason of the addition to her population of nearly a million souls. Nor did M. deFoville, of the Institute, when he declared that France is losing every fifteen years four army corps.

The recent census statistics show a declining birth-rate in all the departments without exception. In many of them the rate of mortality exceeds the birth-rate by a third, while in some it is twice as great. From 1810 to 1911, the birth-rate for France, as a whole, decreased from 31.8 per thousand to 19.6, while in some departments, like Garonne, it is only 13.6; in certain parts of Normandy and Gascony it is as low as 10.9 and even 8. According to statistics published by the city of Paris in April of last year there was an average of but one birth in the capital for every thirty families during the past year.

Parallel with the decreasing birth-rate has gone a steady diminution in the size of French families. In 1800 each household had an average of 4.24 children; in 1860 it had fallen to 3.16, now it is slightly more than two and among many categories of persons like the wealthy of Paris, poorly paid state employés and small landed proprietors in certain provinces it is still smaller, in some cases being as low as 1.5.

According to official statistics published in 1908 by the ministry of labor, there were 1,804,710 families in France that had no children; 2,966,171 that had only one child; 2,661,978 that had two; 1,643,415, that had three, and only 987,392 that had four. Altogether there were only 2,238,780 families having four or more children, leaving 9,076,274 families having from but one to three or none at all.

II. Causes

A variety of causes, hygienic, social, economic and legal, have been offered in explanation of the conditions described above in respect to the state of the French population. First of all, an unnecessarily high rate of mortality among the French people is said to be partly responsible. For all France the number of deaths per 1,000 of population is in the neighborhood of 20, whereas in England, Holland, the Scandinavian countries, Germany and Switzerland it is considerably lower, the rate being as low as 14 in Norway and 17 in Sweden. Infantile mortality is especially high in France, one third of all deaths occurring before the end of the third year. The ravages of tuberculosis among the French also contribute greatly to the elevation of the death rate. M. Bourgeois recently stated before the Congress of Social Hygiene that although the death-rate from tuberculosis had fallen in England and Germany from 11 per 10,000 of the population, the rate in France was 22.5. The rate of mortality on account of this disease is especially high in Paris, where in 1908 there were 13,600 deaths therefrom.

Alcoholism was declared by the Klotz commission to be partly responsible for the high infantile mortality and to some extent also for the small birth-rate. The commission produced statistics to show that in those departments where there has been a large increase in the consumption of alcohol, there has been a corresponding increase in the rate of infantile mortality. Senator Ribot declares that alcoholism and tuberculosis are fast obliterating the French race and this opinion is supported by the testimony of a number of noted specialists in alcoholic diseases. Statistics show that there has been an enormous increase in the amount of alcohol consumed in France (the average per capita consumption is about fourteen litres per year and in certain cities of Normandy it is as high as twenty-nine) and they also show that a large percentage of the inmates of the hospitals and insane asylums are alcoholics. But as M. Bertillon has declared, while alcoholism is undoubtedly exerting a terrible effect upon the quality of the young and is contributing to race degeneracy, it is not an immediate cause of sterility and does not necessarily affect the number of births. Moreover, there are other nations where the evil of alcoholism is equally great, for example, England, Germany and Belgium, and yet those countries have a relatively high birth-rate.

The decline of religious faith and of traditional beliefs among the French is regarded by many persons, among whom may be mentioned the distinguished economist, Paul Leroy-Beaulieu, as one of the contributory causes for the small birth-rate. The scriptural injunction to multiply and replenish the earth no longer has the moral influence upon the French mind which it once had. The obligation to rear families which has always been regarded as a religious duty naturally rests lightly upon a people who have all but repudiated religion. The adversaries of religion, however, place the responsibility for the low birth rate at the door of catholicism which has not only withdrawn from married life a large portion of the population both male and female, but does not encourage marriage among the laity. The latter charge the catholics emphatically deny, and as evidence that catholicism is not responsible they point to Brittany, Finistère and other strongly catholic provinces where the birth-rate is the highest in France. If the birth-rate for all France, says M. Leroy-Beaulieu had been since 1871 equal to that of Finistère, France would have to-day 53,000,000 inhabitants instead of only 39,000,000. Moreover, the catholics point out that in Quebec, a strongly French catholic province, the birth-rate is more than twice as high as that of France, and that Belgium with its comparatively high birth-rate is a country where catholicism is strongly intrenched. It is sometimes complained that one cause of the evil is to be found in the paucity of marriages, but the statistics show that there has been a steady increase in the number for many years (*e. g.*, from 269,332 in 1890 to 307,788 in 1911, and this notwithstanding the fact that there was little increase of population during this period), yet the birth-rate has declined. It seems clear that it is not more marriages that France needs, but more productive marriages; it is infecundity that is responsible for the diminishing population and not lack of marital unions.

Some students of the question, like M. Henri Joly, see in the granting of divorces, the number of which steadily increases every year, one of the secondary causes; but this may be doubted. On the contrary, it might be argued that divorce conduces to the increase of the birth-rate by permitting the dissolution of sterile unions and the contracting of others. Moreover, there was no divorce law in France before 1884, yet the population had long since ceased to increase except in trifling proportions. Finally, divorce is practised in other countries where the birth-rate is high; if it contributes to the diminution of the population in France, why does it not have the same effect elsewhere? The prohibition of the judicial determination of paternity in the case of illegimate children has long been regarded as a secondary cause of the low birth-rate, since it encourages illicit cohabitation in the place of lawful marriages. This legal incentive to "free unions" has been removed, however, during the past year by the enactment of a law empowering the courts to ascertain and determine the father of an illegitimate child which he refuses to recognize. The enactment of this law, says the *Temps,* was a great victory in the interests of morals and humanity and one which required fifty years to achieve.

The spirit of luxury and ease and the high state of wealth are also held responsible for the disinclination among the French to rear children. The census statistics show that in the richest regions of France, like Normandy, Burgundy and the Valley of the Garonne, the birth-rate is the lowest, while in the poorest provinces like Brittainy, the Nord and Lozère it is the highest. They show also that it is twice as high among the poor of Paris as among the rich and that it is fifty per cent. higher among fishermen and sailors than among landlords and the professional classes. But this is a phenomenon not peculiar to France; it is found in all countries where there is a high state of civilization and therefore does not explain why the birth-rate is lower in France than in other countries where similar conditions prevail.

Our conclusion, therefore, is that the principal causes of the low birth-rate are not due to external conditions, social, legal or religious, but are the result of the general attitude of the French toward family life. The relatively high rate of mortality, inadequate hygienic conditions, alcoholism, divorce and the other causes mentioned may be contributory factors, but the chief reason is that the French people do not desire to have children. This attitude has been powerfully accentuated by the neo-Malthusian propagandists who by personal solicitation and the distribution of literature encourage the voluntary limitation of births and the practise of abortion, under the pretext of hygiene and the dissemination of philosophic and scientific doctrines. Limitation of the population is to them a legitimate means of combatting poverty and misery, a policy all the more justifiable, they argue, because of the high cost of living and the increasingly hard struggle for existence. Quality rather than quantity of population, they maintain, is the true test of civilization and national greatness. Moreover, the population of France is already as large as its resources can adequately support and therefore nothing is to be gained by producing a surplus to be forced by necessity to emigrate to America or to Madagascar and to the colonies of Africa. This very active propaganda is now being vigorously combatted as a national crime by men like Jules Lemaître, Edmond Perrier, Senator Berenger and others, and a bill for its suppression is being considered by the senate with every likelihood of becoming a law at an early date. Statistics seem to leave no doubt that the propaganda in favor of race suicide is exerting a marked influence on the birth-rate in many parts of France. In Roubaix, for example, where it has been particularly active, the number of births decreased from 3,837 in 1897 to 2,568 in 1906. Likewise in Turcoing the birth-rate has fallen from 34 per 1,000 inhabitants to 19 since the beginning of the propaganda in that city. This propaganda, says Dr. Lebec, is costing France an army corps every five years. Senator Paul Strauss in reporting the conclusions of the extra-parliamentary commission on depopulation recently referred to the "agonizing results" of the Malthusian crusade, and declared that statistics collected by Dr. Doleris showed that between 1898 and 1904 the number of cases of abortions treated in the maternity hospitals had tripled and that the number represented 18 per cent. of all cases treated in such institutions. In Paris the number of abortions is estimated to exceed the number of births and fully two thirds of these are said to be provoked. Dr. Georges Bertillon estimates that the annual number of such cases is not less than 50,000 for all France, and Premier Barthou in the course of the discussion during the past summer of a proposed law to restrain the practises of the Malthusians asserted that the number of abortions was probably as high as 100,000 per year.

One undoubted reason for the voluntary limitation of the number of births is to be found in the small incomes of the laboring classes and the petty employés of the state. That a laborer who receives but 80 cents a day or a letter carrier whose salary is only 200 or 250 dollars a year can not rear a family, especially in a city like Paris, however much he may desire to do so, is a proposition which is scarcely controvertible. Consequently they feel under an economic necessity of limiting the size of their families. It is notorious that the number of functionaries in France is excessive (nearly one million, or one fortieth of the total population) and that they are miserably paid, their average salary being scarcely more than 500 dollars per year. This explains why the birth-rate among them is lower than that of any other class except the rich, the average number of children per family being but one and a half.

Students of the depopulation problem are all agreed that another important cause of the voluntary limitation of births is the excessive spirit of economy and the passion for saving which prevails among all classes in France and especially among peasants, shopkeepers and small proprietors. Statistics show that in those communities where the number of certificates of deposit in the savings banks is the largest, the birth-rate is the lowest. Every father feels under the necessity of providing a dot for his daughter and it is one of his chief ambitions to leave an inheritance for his sons. Among the poorer classes this ambition can be realized only when the number of children is limited. There is also among the French an extreme reluctance to see their fortune divided through the operation of inheritance laws. As the existing law does not permit free testamentary disposition, but allows each child an equal share of the inheritance, the only way by which the father can prevent the division of his estate after his death is to leave but a single child to inherit it. The French peasant loves his land more than he loves children, and his ideal is, therefore, a single heir married to a single heiress. He is willing to have his name disappear with his death if his heir is a girl, rather than see his estate divided, which must necessarily be the case if he leaves several children. Therefore he leaves only one. M. Paul Leroy-Beaulieu, who since the death of M. Levasseur is probably the highest authority in France on matters relating to population, attributes the low birth-rate to the new democratic conception of the family—a view which regards children as a burden and which desires that the family from one generation to another shall rise in the social scale. Every parent desires that his children shall occupy a higher social position than he himself did. The laborer's ambition is to see his son a landlord or a functionary; the peasant wants his son to be a *monsieur,* an advocate, a doctor or a merchant; and the *petit bourgeois* has similar ambitions. The only means of realizing such ambitions is to limit the number of children to whom the fortune is to be left. This *capillarité sociale*—this striving of each social molecule to rise higher in the organism—is, he thinks, the principal cause of the infecundity of the French race, at least during recent years.

III. Proposed Remedies

Such are the more important causes to which are attributed the declining population of France. Turning now to a consideration of the proposed remedies, we find that they are as various as the causes and are hygienic, legislative, administrative, fiscal and social in character. First of all, the death-rate, especially among infants, may, and should be, reduced to the level attained in other countries of Europe. More than one sixth of the children born in France, or between 150,000 and 170,000, die every year, and of these one third die during the first month after birth. This is a "veritable disaster" to the nation, says the commission on depopulation, and it should be met by better sanitary measures, medical surveillance, more effective inspection of the milk supply and gratuitous assistance to the poor. Maternal nourishment should be encouraged by every means, in default of which measures should be taken to assure a supply of sterilized milk to children who are dependent upon the dairy for their nourishment. Furthermore, legislation should be enacted forbidding the employment of mothers in industrial establishments at least six weeks before and after *accouchement,* and such establishments should be required to provide places at which babies may be nourished by their mothers.[1] By such measures as these at least 50,000 children, it is claimed, could be saved for the nation every year.

State aid and initiative in the construction of cheap tenement houses for large families, in the cities where rents are high and the cost of living excessive, has been advocated by many social reformers. Last year the parliament adopted a building code governing the erection of such houses, and it contained special provisions in favor of large families. During the past year a law was also passed providing for public assistance for large families and making the expense of such assistance obligatory upon the departments, but providing also that the state and the communes should share a portion of the cost. The law enacts that every head of a family having more than three legitimate children and

[1] Such a law has been enacted since the above was written.

the resources of which are insufficient for their support shall receive an additional grant for every child above the third under thirteen years of age. The amount of the allocation is to be determined by the municipal council subject to the approval of the Council General and the Minister of the Interior, but it can not be lower than 60 francs per year for each child nor superior to 90 francs.

More effective measures for combatting tuberculosis, the abolition of divorce, legislation permitting the judicial determination of paternity in the case of illegitimate births and the suppression of convents with their 60,000 female celibates are some of the other secondary remedies proposed, but it is certain that such measures will not reach the real cause of the evil. As I have said, the parliament passed a law during the past summer authorizing the judicial determination of illegitimate paternity and its results will be watched with interest. In regard to the suppression of convents, M. Bertillon has remarked that at best it would not result in the addition of more than four or five thousand children annually to the population, whereas France needs at least 500,000 more births per year.

The restoration of religious sentiments would, according to many students of the problem, result in a new attitude toward the obligation to rear families. Among those who share in this view is M. Leroy-Beaulieu who, in a recent article in the *Journal des Débats,* protested against the government's hostile attitude toward the traditional religious beliefs of the people. It is necessary, he declared, that our statesmen should at once abandon the absurd and odious war which they have waged for a quarter of a century, and particularly during the last fifteen years, against our country's traditional religious beliefs.

The criminal suppression of the methods now being employed by the Malthusian propagandists is another proposed remedy. During the past year the senate has had under consideration a law for this purpose and one which proposes to give the correctional tribunals jurisdiction of cases of abortion, with a view to rendering convictions in such cases more certain. Senator Barthou, Premier and Minister of Justice, in advocating the adoption of this law in 1912 said: "I am certain that the senate will understand that the proposed law is a measure of public safety and national salubrity." There is little doubt that the suppression of provoked abortions and of infanticide would have important results upon the increase of the population, and it is equally certain that the best public sentiment of France demands legislation for this purpose, but its enforcement would obviously be attended with great practical difficulties.

Simplification of the formalities of marriage with a view to encouraging an increase in the number has also been advocated. It may be added that by laws passed in 1896 and 1897 a number of the old rigorous requirements of the civil code were abolished, notably those relating to age, residence in the commune and consent of parents, and the removal of these restrictions was actually followed by a large increase in the number of marriages (from an average of 281,000 per year prior to 1896 to 323,000 since 1907), but there is much complaint that the formalities still required and the legal fees exacted are excessive and constitute a real hindrance to marriage. But, as I have remarked, the number of marriages is already comparatively large in France and there has been a wholesome increase from year to year. In all probability, therefore, such a remedy would not produce any appreciable results.

The modification of the naturalization laws with a view to facilitating the acquisition of French nationality and thereby encouraging immigration has also been advocated as a means of increasing the population. The existing requirements are too rigid, says M. Leroy-Beaulieu; France, he thinks, could well afford to naturalize 50,000 foreigners a year since the density of her population is far less than that of Germany, Italy and Belgium, and by thus encouraging immigration the country would find a new source from which its declining population could be recruited. Reform of the inheritance laws so as to allow the father a right of free testamentary disposition, as is the rule in other countries of Europe, has been widely urged in recent years. The existing provisions of the civil code, as I have said, compel the division of the inheritance when there is more than one child, and the general reluctance among small proprietors of having their estates split up into parcels conduces to the voluntary limitation of their offspring. All those who have investigated the question are of the opinion that the proposed change would result in a marked increase of the birth rate. M. Bertillon goes further and proposes a more heroic remedy, namely, the treating of single children in respect to an inheritance as if they had brothers and sisters; he would, for example, impose a tax of 30 per cent. on the inheritance when there are two children and 60 per cent. when there is but one. In other words, where there is but a single child he would have the state confiscate that portion of the inheritance which would go to the other children if there were any.

A more reasonable proposal of this kind has been made by Colonel Toutee, namely, that the law should regulate the inheritance according to the size of the families of the heirs. Thus if two heirs are left, one of whom has three children and the other none, the estate should be divided into five parts, of which four should go to the first heir and one to the second.

The suggestion has often been made that the state should offer bounties for the production of children and numerous bills have been introduced into the parliament for this purpose. One of the more recent was a proposal by M. Messimy, a former minister of war, providing for the payment of a bounty of $100 for every child above the fourth. But for fiscal reasons such proposals have not been favorably received. A proposed measure which has many advocates is the employment of the taxing power for the purpose of chastising celibates and the heads of families without children. The rearing of children, says M. Bertillon, one of the strongest advocates of the taxation of celibacy and infecundity, should be considered as a public duty in the same way as service in the army and the payment of taxes. The act of rearing a child should be considered as equivalent to the payment of a tax; he who does not discharge this duty should be subject to a sur tax; those who do, should be wholly or partially exempted from taxation. The statistics show that there are more than 1,500,000 male celibates over 25 years of age in France, nearly 2,000,000 families without any children at all, nearly 3,000,000 which have but one child each, and 2,500,000 which have but two each.

A sur tax on such persons would be to a large extent a tax on the rich and well-to-do and it would make possible a reduction of the taxes on the comparatively small number of large families which are to be found, for the most part, among the poorer classes.

Fiscal measures whose purpose is to discriminate and to punish celibacy and infecundity are, however, objectionable to many persons who believe that the better remedy consists in measures of a more elevated character addressed to the moral sentiments—measures which will tend to reward and honor fecundity and which shall have the character of a mark of recognition by the state of its esteem for those who have contributed to its strength and perpetuity by the rearing of families. Such a measure is the oft-repeated proposal to give the preference in the matter of appointments to the lower posts in the public service which do not require special qualifications, to the heads of families and especially to the heads of families containing more than three children. This proposal has been advocated by Messrs. Bertillon, Leroy-Beaulieu, Levasseur, Senators Lannelongue, Piot and many others and has been the subject of numerous bills in parliament. M. Leroy-Beaulieu has, I believe, even proposed that no one be appointed a functionary who does not have at least three living children. This proposal recalls the action of a former prefect of the Seine, M. Poubelle, who refused to appoint to certain inferior positions, any man who was not the father of at least three children. But this is a rather heroic remedy, hardly conducive to administrative efficiency, and would scarcely be practicable unless the state should increase the present miserably low scale of salaries now allowed its employés, many of whom find it impossible to support a family of three children out of their official incomes.

A more moderate proposal is that the state should take account of the size of the family in fixing the salaries and retiring pensions of public functionaries. This suggestion has been made by the commission on depopulation and by many writers and social reformers. Bills embodying this idea have frequently been before parliament, and in 1908 the Chamber of Deputies adopted a resolution inviting the government to introduce a *projét* for granting to the employés of the state receiving small salaries an allocation in proportion to the size of their families. Some of the administrative departments have in fact already adopted such a policy. Thus in the department of indirect taxes, every employé whose salary is less than $440 a year and who has three or more children under eighteen years of age receives a subsidy of $12 a year. Likewise in the post-office department and in the customs service there is a similar grant of $9.00 per year. Somewhat similar allowances are made by the state railroads and other branches of the public service. Thus the principle has already been given an extended application, though on a somewhat small scale. Not very different in principle and without the objections which characterize punitive taxation of celibacy and infecundity is the proposal advocated by M. Leroy-Beaulieu and others to take into account the size of the family in fixing the amount of the personal tax, which, in France, is mainly a tax on habitation and one which therefore weighs heavily upon renters having large families. This principle has been embodied in the tax systems of various continental states, notably in the German income tax law which allows a reduction of $12.50 in the amount of the tax for every child under fourteen years of age. The abolition of the tax on doors and windows, letters patent, the *octroi* and others of a similar character which are peculiarly burdensome to the poor would be, as has often been asserted, conducive to the rearing of larger families.

IV. Conclusions

Such are some of the means that have been proposed for combatting the conditions which threaten France with depopulation. Some of them, like discriminating measures against celibates, the payment of bounties for the production of children, the exemption of heads of families from certain public impositions, and the partial confiscation of inheritances where there is but a single child, were tried by the Romans, but they were largely illusory and of little effect. Of the other measures proposed, some are impracticable, others are impossible of execution and still others would be productive of but slight results. The true remedy lies not in legislative, administrative or fiscal measures, though some of these may contribute toward the checking of the evil, but in a reform of the morals and customs of the French people. There must be a fundamental change in the attitude of French men and women toward the obligation to rear families; there must be an awakening to the duty which devolves upon the citizen to contribute to the perpetuity of his race through the rearing of children as to defend it in time of war or to pay taxes for the maintenance of government. Any and all measures which shall contribute toward an awakening of the people to the importance of this national duty are worthy of encouragement and of adoption. The solution of the problem is not dependent upon external measures and remedies; it is to be found almost entirely in the moral sentiments and social customs of the people themselves. Zola did not exaggerate when he said: "France will never be depopulated unless she wishes to be." The late Emile Levasseur once remarked that it was "truly humiliating to think of a nation of thirty-eight million souls, which by its age, its industry and commerce is one of the wealthiest of the globe and which by its intellectual activity, its arts and its sciences is one of the most capable of enlightening the world and which under republican government has during the last quarter of a century recovered in the European concert the place of a great power, is a nation which, according to the statistics is destined to disappear." Mr. Roosevelt's warning at the Sorbonne in 1907 that "neither luxury, nor material progress, nor the accumulation of wealth, nor the seductions of literature and of art, should take the place of those fundamental virtues the greatest of which is that which assures the future of the race" made a deep impression at the time it was delivered and has not been entirely without result. It is no exaggeration to say that at no time in the past have so many thoughtful Frenchmen been aroused to a realization of the consequences that must inevitably result from the continued decline of the population. This is fully attested by the organization of societies to increase the population, by the formation of parliamentary groups with the same end in view, by the appointment of parliamentary and extra-parliamentary commissions to study the question and to search for the remedies, by legislative and administrative measures of various kinds and by the discussions and publications of scientific bodies and of economists, sociologists and publicists. No one can read the extensive literature to which the discussion of the problem has given rise without feeling that the question is now regarded as a serious and pressing one and that the nation proposes to grapple with it as such.

THE RISE OF A NEW PROFESSION

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IF we consider the industrial history of the United States, for the span of a long generation, dating backward from this year of grace to about 1840, we can distinguish at least three great movements which have occupied the minds of men in industry.

The Age of the Pioneer

The first period was still engaged, as previous decades had been, in the process of settling the country, and of starting those simple basic industries which are the foundation of civilized life.

In 1840 Boston was not yet connected with Albany by rail, nor Albany with Buffalo. The grain elevator had not yet been devised; and no coke ovens yet existed near Connellsville. The first steamboat had just been seen at the Soo; and in Iowa they were plowing a furrow from the Mississippi river west 100 miles to guide settlers. A few pioneers were beginning to pass over the Oregon trail; and Fremont was just describing Utah in the papers. It was not until 1845 that copper was produced in upper Michigan. It was only in 1852 that Chicago was connected with the East by railway. The locomotive did not reach the Missouri river until 1859, nor the Pacific coast until ten years later.

The mention of the pioneers calls for a word of tribute. Our nation's first industrial task was the stupendous one of clearing the farms, and of building the common roads, and of establishing villages and cities, and opening outlets for the marketing of surplus products. Perhaps the history of the pioneers was, indeed, but "The short and simple annals of the poor." Carlyle dismissed America with the contemptuous summary, "Hitherto She but plows and hammers." The work of opening the country was simply the first duty. But it was not industry of the cramped mechanical sort which Carlyle knew in the grimy manufacturing towns of Scotland. The pioneers partook somewhat of the nature of the explorers. Their advance westward had the stirring quality of a military reconnaissance directed against the hostile forces of nature which were entrenched in the wilderness. The victory was not to mere economy and patience, and the weaker virtues, but to industry animated with boldness, directed by invention, and ennobled by sacrifice for the future. The pioneers were rugged, self-reliant men and busy contented women. Into the enjoyment of the fruits of their labors we have all of us entered.

The Age of Mechanism

The second industrial movement of the period we are considering centered upon the task of providing an adequate mechanical equipment. Its purpose was to develop inanimate sources of power, by means of which the burden of physical toil could be, to some extent, lifted from human shoulders.

Accordingly, the second act transfers the scene of industry from the field to the factory. The first billet of Bessemer steel was produced in America in a little furnace at Wyandotte, near Detroit, in 1864. The first band-saw was brought from Paris to New York in 1869. The first middlings purifier was built in Minneapolis in 1870. The twine-binder was invented in 1874. In the wonderful Centennial year of 1876, there was given to the country the telephone, the incandescent light, the typewriter and the first steel-frame building. Since those years, the American farmer has come into the possession of a well-nigh perfect equipment of agricultural implements. Our factories have been filled with machinery, our offices with appliances, and our stores with furnishings, until it is generally conceded that no people of the world excel the Americans in the use of mechanical facilities.

The Age of Administration

And now that these achievements are no longer in their origins, and the issues called up by them are recognized as virtually settled, and there is no longer any opposition to try men's souls in establishing and defending them, a third great industrial problem can be seen to emerge and become the center of interest. This is the question of administration. Upon this generation is laid the task of discovering, testing and establishing in general use those methods of organization and management by which the great productive agencies now within the possession of industry can be united, subjected to proper control, stimulated, guided, inspected, instructed and rewarded, to the end that they may serve society with efficiency. In short, the problem is that of originating and formulating a science of administration which shall comprise those basic principles and practical policies required for the guidance of great affairs.

Self-Made Men

This administrative phase of our industrial evolution has, of course, already a history of value, and this history is concerned with the doings of a very interesting generation of men. For years the United States, with its enormous domestic market, its ample capital, its freedom from tradition and its colossal daring, has been perhaps the most favorable spot in the world for trying out new ideas of organization and management.

The men who first took advantage of these conditions were, for the most part, self-made men. We often refer to them as captains of industry. The majority of them were individuals of motor temperament, endowed with exceptional talents, who fought their way upward and gained eminence, through a rough-and-ready struggle for the survival of the fittest.

These men seized leadership by right of ability, but, technically speaking, they secured it as the perquisite or privilege arising from the ownership of great fortunes. They lived in a day when men generally managed their own capital. In most cases they were the first to build up institutions of great size in the lines of industry with which they were connected. These circumstances involve the point that had not these men built up fortunes they could not, individually, have become administrators. The price of their economic power was to make everything bend to the getting of money. In other words, they had to create the kingdoms over which they later ruled.

Their policies were, therefore, like those of most conquerors, simple, often crude and sometimes morally abominable. They were often drive-masters, and not infrequently they resorted to the intellectually contemptible methods of unfair trade. Yet we do not withhold admiration for the splendid independence and energy which they exhibited. They generally possessed a thorough knowledge of details, due to the small beginnings from which they had started. They had the ease and speed of decision due to long experience and gradually imposed responsibility. The names of the leaders of this generation of giants will long remain household words in America.

If we pause to consider broadly this introductory period of administration, we can see that it was marked by strenuous rather than finely calculated action, and by physical rather than intellectual tests. Most important of all, it was characterized by a confusion or conflict between the principles of the true art of administration and the requirements of the process of amassing a fortune. We are so accustomed to measure mastership in industry by the increase of the wealth of the individual, that it is difficult to perceive that there can be any such thing as an independent art, with principles and ideals of its own. If we turn to politics we are able to see that a man's record for efficiency as a mayor of a city does not depend upon his getting rich in office. Neither do we measure the skill of our military leaders by their strategy in gathering private booty, nor the capacity of our statesmen by their ability to insure tranquillity and prosperity to themselves, rather than their country. In all of these cases we have the conception of the requirements of an art or polity. The standards of judgment are entirely distinct from the state of the private fortune of the administrator. It is this method of judging which is beginning to make itself felt in industry. That we have not more generally used such tests hitherto is one of the reasons why broad and intellectually respectable principles have been so slow in gaining control of industrial action, and why it has been so difficult to detect the really capable administrators among the crowd of men who are merely, and perhaps even accidentally, rich.

The early administrators, living in a highly individualistic and self-confident society, worked out rules of action each man for himself. Many of them were rather builders than administrators, emphasizing the builder's tests of size and growth. They made many mistakes which they could not perceive because, living in a community which had broken sharply with the past, and which had little applicable history of its own, they thought little of lessons drawn from the past. As they were devoted to little else than business, they saw few analogies between the administration of industry and of other forms of social action.

Being so much in a world of their own creation, they looked upon the administration of the organizations with which they were connected as their own private business. Such organizations were, therefore, in many cases, no more than mere extensions of themselves, incapable of serving as the object of the loyalty of the various classes of persons which might become connected with them. While these men sometimes made notable technical achievements, and claimed the title of super-men, they were, many of them, mere master mechanics, putting men and equipment together into corporations in a wooden way and driving them with their individual will power, rather than true administrators with a social sense.

And so it is that, in spite of the magnificent physical development of industry, and the more noble spirit which now begins to animate it, the conduct of affairs is often thought of as something cold, mechanical, and out of line with the ethical feeling of the time—as a matter of endless negotiations and compromises and makeshifts which can not bottom themselves on permanent principles. And, because it has received this reputation, many fine spirits keep clear of it, as they do also from politics. And many others who take part in it do so without making a fair effort to comprehend its possibilities.

New Conditions

Since the ranks of the first generation of administrators have begun to be seriously thinned by death, a notable change has been taking place in the character of our industrial leadership and in the conditions under which it is exercised. The natural growth of businesses into units embracing, under a single administration, hundreds and even thousands of stockholders and employees, and which must unite many minds in operations requiring long periods of time for their completion, calls for searching tests and clear and stable policies. The use of the corporate form of organization, which makes the business unit the dependent creature of the state, coupled with the increasing sensitiveness of public opinion to the probity of the financing and the humanity of the operative policies employed, unite to demand a more skillful diplomacy, and methods which will bear public inspection. The question of getting adequate administration has now become pressing.

Administrative Helps

If the task of the executive is now more difficult than before, there have been provided various helps to assist in its performance. In the first place, the physical sciences have been applied to industrial operations in a multitude of ways in recent years. They assist in the testing of materials, the refining of productive processes, the preservation of the health of the operative, the sharpening of technical standards, and the provision of new forces and instrumentalities. A second aid is the greatly improved systems of accounting and cost accounting, and the developing theories of valuation, which serve as the administrator's chief instruments of precision, where problems of value rather than problems of physical processes or of human nature are concerned. A third aid is what is commonly called "system"; a somewhat indefinite mass of rules of procedure, together with appropriate equipments, relating especially to office work, and representing the accumulated experience of innumerable official minds. The most recent aid is "scientific management" which, taking its rise as a philosophy of the shop, has culminated in a group of principles constituting an encouraging earnest of a forthcoming more fully developed science of administration.

The Professional Administrator

The large business enterprises now required to meet society's need are gathering the money of hundreds of investors, so that individual or family domination resting upon ownership must decline as a system. Between the multitude of stock and bond holders, on the one side, constituting the proprietors, and the still greater multitude of employees, on the other, there is being created a central strategic position to be occupied by the professional administrator. The whole situation of industry now conspires to create an opportunity for a new race of executives which shall justly appreciate the various classes of responsibilities resting upon it. Upon these men will rest a sort of trusteeship to preserve the property entrusted to them, and a sort of leadership to guide and guard their employees. Upon them will also rest a general responsibility to the public to help this day to live its life, and this generation to make its contribution to progress.

Wanted, therefore, new leaders for industry, who shall unite with native talent, trained minds. Who shall believe that the sea of affairs can be charted, and can be sailed by the aid of eternal principles and a fine exact technique of diplomatic and humane methods, and who shall be at least as much devoted to the ennoblement of their art as to their own advancement.

Transitional Difficulties

The new order always evolves out of the old with pain and misunderstanding. The new is long looked upon from the inadequate viewpoint of the old. The exigencies of the new situation are always upon us before the teachings of the old have been sufficiently deliberated upon to yield a settled philosophy of action. It is not surprising that this generation should be embarrassed in finding new maxims and ideals, while it is yet blinded by the brilliant achievements of the age of the captains of industry. The shadows of the great founders still fall upon the present-day executive in many forms. In one case it is the tradition of methods once successful, and of conceptions and tests once considered adequate. In another case it is embodied as the incompetent heir, invested with an estate and the glamor of a successful name, and set as an amateur to rule over experts. Again, the shadow of a departing order takes the form of a vast enterprise, which was, perhaps, originally builded with enthusiasm to great size and power, but which is now a shell with many a sheltered spot within, where weak men may vegetate as clerks, perpetually referring matters from one to another, or strong men may be induced to trust to "the impulse of an early start," or to "interlocking directorates," or "banking control," or "dominating influence on the market," or to "predatory competition," or to anything else than service.

Perhaps the chief hinderance to the development of the scientific administrator in America will prove to be what we may call the danger of the entrenched position. The significance of this danger was long ago pointed out by Machiavelli, who warned his ideal prince of the harm wrought by strong fortresses. His words, written in 1513, are still full of significance. He said,

> Whenever either princes or republics are afraid lest their subjects should revolt, it results mainly from the hatred of the subjects on account of the bad treatment experienced from those who govern them; and this comes either from the belief that they can best be controlled by force, or from lack of sound judgment in governing them. And one of the things that induce the belief that they can be controlled by force is the possession of fortresses with which to menace them; and thus the ill treatment that engenders hatred in the subjects arises in great measure from the fact that the prince or republic hold the fortresses, which (if this be true) are therefore by far more injurious than useful. For, in the first instance, they cause you to be more violent and audacious towards your subjects; and next, they do not afford the security which you imagine.

And, further, he says:

A good and wise prince, desirous of maintaining that character, and to avoid giving the opportunity to his sons to become oppressive, will never build fortresses, so that they may place their reliance upon the good will of their subjects, and not upon the strength of citadels.[1]

Whence the Supply Will Come

In this day of large and permanent undertakings, industry can not afford the risk of administrators who, being ignorant of principles, must govern by extempore decrees. Nor can it endure to educate those who will become wise only through disasters. Society is no longer satisfied to prepare its physicians or lawyers or engineers by an unregulated process of learning through experience. If administration is an intellectual pursuit, it is not sufficient to trust to such processes for administrators.

Furthermore, business experiences now less than formerly offer themselves as an educational ladder apt for the upward climbing of the growing mind. It is only in the world of small independent business that responsibility increases gradually and *pari passu* with ability. The typical captain of industry advanced step by step. As his experience and powers of mind grew, his business increased and enlarged his responsibilities by almost imperceptible increments. In the end he emerged, as a scholar might graduate from a carefully graded school, having passed through a finely graduated scale of functions, extending from the simplest to the most difficult things. Business experience less and less offers this encouraging educational aspect. Superior minds are as much wanted as ever, but they are wanted already trained in those general principles of administration which the last generation only grasped as the result of prolonged experience. Young men must now expect to enter some department of an organization which is already large, and to remain for long periods engaged in highly specialized functions, making such upward advance as is made by sudden leaps.

Already the dearth of administrators, who are grounded in general principles, is keenly felt in industrial affairs. The late Mr. Dill once said that he could secure a million dollars ten times while he was finding a man with the capacity to administer the affairs representing a million dollars at work. One of the reasons for the excessive concentration of administrative control in American business is the lack of an adequate supply of executives. And this is also one of the reasons why we overload good men and wear them out so rapidly.

What natural processes fail to do for us we must accomplish by educational agencies. To make education effective, however, we must establish the principles and policies which are to be mastered, so that training may form the mind of the executive more certainly, more rapidly, and more thoroughly than unregulated experience can do.

[1] "Discourses," Bk. II., Ch. XXIV.

New Conceptions

Great leaders come in response to great issues. When the school can present to its students a stimulating view of life, a superior raw material is attracted to it as by a lodestone. In the struggles of life men are inspired to great exertions when new ideals become vivid to them. War produces capable generals, intellectual conflict breeds a generation of acute thinkers, prophets arise to preach new gospels. It matters little what difficulties there are. "Truth," says Nietzsche, "does not find fewest champions when it is dangerous to speak it, but when it is dull." Industry insists upon efficiency, but efficiency may be chiefly insured by discovering great inspiring tasks.

The old ambition to build up big business units, and to accumulate great fortunes, is now no longer quite as fresh and full of zest as it once was. It does not get the response, and call out the best men, as in the old dramatic buccaneering days. To simply repeat what the last generation did in the way of piling up fortunes, and to do it on the same intellectual and ethical and esthetic plane, but without the novelty of being the first to do it, nor the freedom of action of the day of *laissez faire,* is not to set forth a very exciting aim. In the sphere of the intellect there is nothing especially notable about doing it. The hungry intelligence of industry is asking for great new objectives worthy of effort, like the opening of the continent or the building of the railroads. A new and larger conception of the function of industrial leadership is called for. The great resources of the country subdued by the pioneers, and the elaborate equipment provided by the engineers, combine to set the stage for a high statesmanship and for a fine diplomacy to begin to play their rôle in industry. Since it inherits ample physical equipment, the new generation can be less material in its aim, and give itself to providing an intellectual equipment. As we live in a more advanced stage of society, the thought of the administrator should be less of equipment than of policies governing operations, less of operations than of ultimate ends, less of his own part in those ends than of the harmony of the ends themselves with the aspirations and constructive tendencies of society. The result of this can be nothing less, ultimately, than a body of broad, permanent, and socially beneficent principles of action, to which superior minds, forming an aristocracy in industrial affairs, will swear allegiance.

The administrator who is willing to take part in this movement will find himself upon an intellectual frontier, with the opportunity opened before him, as before his forefathers, to become a pioneer. It is not now a frontier of axe and plow, nor of engines and machinery, but of principles and policies. The administrative problems awaiting solution are almost innumerable. The executive who carries the scientific spirit into his work will find an opportunity to make more clear the conception of authority and responsibility, and to formulate the rules of their distribution. He will study the coordination of mutually functioning agencies, and the means of their supervision. He will find need to more precisely determine the basis upon which rests the division of labor between administration and operation, and between principal matters and details. He will concern himself with the meaning and use of standards and sequences and schedules, and will attack the great problem of framing a theory of rewards and punishments adequately adjusted to the moral sense of the time.

The Fellowship of Administrators

What the military leader was in the ancient days of constant war, and the statesman in the period of the formation of great empires, the industrial executive may be considered to be in this commercial age. He is the leading exponent of organized action in the world. He should dignify his task, boldly conceiving it on the highest plane of which he is capable. He is the intellectual heir of all the executives of the past, and has resting upon him the mandate not to disgrace the succession. It is open to him to maintain a stimulating communion with his predecessors—with all the great military leaders and statesmen and diplomats whose history is preserved for us—and from their experience to gather basic principles of action. Why should not the business executive practise Cæsar's leniency, and his art of making common cause with his men, or endeavor whether Napoleon's celerity may not be used in the bloodless battles of economic service? Why should he not be stimulated by Richelieu's example to strive for coolness in analysis, or be moved by Sir Philip Sidney's charm to practise the art of winning friends?

Brought into contact with the thoughts and deeds of great minds, the business executive need not feel alone in the smallest village or the most distant engineering camp. He will find that before him the great company of the world's executives has had to deal with the same weaknesses of human nature as those against which he combats, and has relied upon such virtues and employed such methods of organization and administration, in bringing men to effective joint action, as are open equally to him. The fields of leadership may, indeed, have been different, but the fundamental principles have been largely the same.

Viewed thus, work again becomes a challenge. The function of the business executive is seen to lose its isolated and empirical character, and acquire a history, and an intimate relation with all other branches of society's organized effort. It is lifted onto the plane of an intellectual achievement, and so offers a foundation upon which to erect ideals of a professional character.

The Outlook

A previous age witnessed the industrial revolution, which introduced the machine, and through it worked the entire reconstruction of society; now a second industrial revolution is in progress, which aims to lay a foundation of administrative principles underneath business practise, and which will inaugurate a new era of progress.

It lies within the power of this generation to end much of the drudgery and antagonism from which the operative classes suffer, by devising more just methods of partnership with the other factors in industry, and by harmonizing administrative methods with the requirements of human nature. It will be possible to unlock much of the energy of administrators, which is at present unused, because of the lack of an enthralling object of effort. It will be possible to raise the general tone of industry, by setting forth new ideals of efficiency, distributive justice and democracy.

THE PICTURE AND THE TEXT

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THE place of illustration in book-making is found to vary through a wide range of values as one reviews a series of volumes at haphazard. In some the pages are flooded with pictures, from thumb-nail sketches on the margins to full-page prints in the natural colors of the original; in others page succeeds page in unbroken letter-press, without an illustration from cover to cover. Here, too, the picture is a true illustration of the text it accompanies; there it has scarcely more relation to the contents of the page it fronts than the engraving on a drawing-room wall bears to the volumes that may lie on a table before it. The significance of the picture, as an illustration, varies as much as, let us say, the artistic merit of its execution; and its value in any individual case may lie anywhere between zero and ideal adequacy.

The reasons for such fluctuation in the employment of illustration are of course legitimate as well as illegitimate. In one case, illustration may be indispensable, in another, inadmissable; the book-maker, whether author or publisher, is guided by the nature of his subject. In general, the material dealt with must be picturable if illustration is to be practicable. Only a small part of what the mind deals with in representative thought is thus picturable, and reflection itself is but one of the many interests which life comprises. To be presented in this spatial and visible manner the subject must be both concrete and material. Not all such subject-matter, indeed, can be successfully represented; but to conform to the conditions of picture-making it must at least fulfill these requirements.

Much of our interest, both speculative and practical, falls outside this field of sensible reality. The relations and laws of things in the material world, for example, are abstractions which we formulate from the observation of a series of such individual concrete objects; and these abstractions, or generalizations, can not be represented pictorially, except figuratively, in a symbolic scheme. Such principles are aspects of the material world, though unpicturable; but there is another range of reality which does not offer itself to such treatment at all. Subjective experience has no sensible or representable content upon which to seize as the basis of an appeal to the eye. The absurdity of such a conception may be indicated by asking the shape of a thought, the color of anger, or the speed of a desire. When things belonging to this realm are written of, some other phase of the reader's understanding must be appealed to than that of visual imagination.

If the elementary content of subjective reality be unpicturable, much less can its abstract aspects be rendered in spatial forms and relations. Thus scientific and logical analysis, explanation and philosophical reflection, and the whole literature of appreciation are debarred by the nature of their subject-matter from direct appeal through illustration. Works on logic and metaphysics—proverbially hard thinking—are rendered more unrelievedly so by the pages of close-packed type which follow one another in unbroken succession from beginning to end of the book. Yet it is just in such fields as this that illustration is most needed. Discussion of concrete things is readily apprehended by the ordinary mind, for it finds little difficulty in representing its substance in imagination; but to follow a process of abstract thought for any continuous period necessitates a more sustained act of attention and a mind disciplined by reflection. To make them generally comprehensible such abstract works imperatively demand illustration; and since a pictorial commentary is out of the question exposition must proceed by an exemplification of the concept or law to which the term illustration in its wider sense is of course commonly extended.

Pure science labors under the same difficulty as logic and metaphysics. The work of reflective thought, in all its forms alike, is to extract from a multitude of vivid but confusing facts some common type or law to which they conform, and the elaboration of norms and principles in this field is found by the average mind hardly less repellant than in philosophy itself. The process is laborious; it is insecure; it is unsubstantial. Works on pure science are not read as are those on experimental science and natural history, because their abstractness makes them more difficult; and the writer, especially if he appeal to a technical class of readers, feels that his concern is primarily in making clear the theory he is developing, together with its evidence—not in illustrating each aspect of it by concrete examples.

The limits of illustration and the function it logically performs thus involve a certain contradiction. Its availability and its desirability stand in inverse relations. Where it is least needed—that is, when the concrete things of the sensible world are dealt with, it is entirely feasible to introduce it; but where it is most needed—in facilitating apprehension of abstract conceptions, its use is practically impossible. There is therefore to be expected a surfeit of pictures in the one case and a dearth, if not a complete absence, of them in the other.

Within the field where pictorial illustration offers itself as an adjunct to literary treatment the further question arises of the relation which text and picture logically bear to one another, and the specific service which illustration renders to the reader. It may be assumed that the function is thus specific, and that text and picture theoretically form parts of a single exposition. The crudest defect in illustration is a neglect of this fundamental requirement, yet it is a fault which has wide prevalence in certain forms of book-making to-day. A fixed amount of illustration per chapter, or hundred pages, is supposed to be expected by the reader, and an illustrator is engaged to furnish the required number of pictures. In the class of books where this custom prevails—for example, in light fiction—the quality of the demand for illustration falls to its lowest point. There is practically no situation the understanding of which requires visual exemplification. The story itself is commonly little more than a succession of pictures, each relatively simple and having a completely obvious relation to its neighbors. It is partly, at least, because the reader's demand is so far from exacting that such slight consideration is given to the really illustrative character of pictures in works of this class

When the primary function of the picture has thus lapsed, the reason for its introduction is to be sought elsewhere; for value of some kind it must possess if its introduction is not to be regarded as a sheer misconception of the reader's desire. This reason is to be found, it need hardly be said, in the mere decorative function of the picture. It is a trivial motive, which also ignores a fundamental canon of esthetics, yet one which has a distinct psychological value. It neglects the requirements of esthetics, for if the making of a book be treated as a work of art, everything which appears between its covers should be instrumental to the development of the central conception for which the work stands. No picture, from this point of view, is admissible which does not help—in the strictest sense, which is not indispensable—to make the meaning clear. But if the principle of function be neglected, a multitude of pictures may be introduced in a merely illustrative, as opposed to explanatory, way. One might, for example, insert the picture of a pen or inkstand each time the article was mentioned, though an acquaintance with these things on the part of the reader is fairly to be assumed. Such illustration of course has its place wherever the objects in question are unfamiliar and the reader is liable to construct in imagination a wrong representation of them.

Further, if the principle of unity be ignored the illustrations which are introduced may be chosen in virtue of any element of desirability which they possess. Value of this kind has a wholly indefinite range. It may be merely quantitative: so many pictures to so many pages of text; no bunching of illustrations in one part of the work while another is left bare; and the like. But such rules refer only to the distribution of pictures, not to their introduction itself. If illustration be not invariably an elucidation of the text, as it clearly is not, it must satisfy some other human need, or pictures would not then be found in books. One such motive has already been mentioned: the decorative sense. The picture satisfies an elementary esthetic demand. It is introduced as the picture is placed on the wall, because it has a beauty in itself. An illustrated book is more attractive to casual inspection than one which lacks such an adjunct. One likes to look at pictures even when dissociated from sustained interest and lacking a common thread of connection. The occupation makes little demand upon mental energy and is accompanied by a sense of ease, while the vivid or novel aspects of the world which are passed in review give rise to a pleasurable state of consciousness through the mild and equitable stimulation which they afford.

The picture thus becomes in a way correlative with the text, each adding an independent element of value to the whole. Within its own field each then seeks a characteristic excellence, and a set of canons is developed in regard to the making of such illustrations. In the first place, they are enriched in their positive values as pictures. They must be well composed and correctly drawn; they must have vigor and refinement in their execution; if colored, the tones must have splendor and harmony; and so on. In the second place, as in literary art dignity in the surroundings, noble birth, beauty and virtue in the characters are invoked to deepen the impression, so in this use of book-illustration the backgrounds must be rich, the scenery beautiful, the figures of either dignified age or noble youth. The men are all handsome, according to the illustrator's individual conception of good looks, the women in a like manner beautiful; the dress worn is irreproachable in fit and of the latest pattern. All the accessories of success, luxury and style reinforce the more direct values of health, vigorous action and beauty. Or, if this special class of effects be not involved, the esthetic appeal is still to some equally general and elementary sense, such as that of romantic pity in which a certain stereotyped pathos affords the underlying motive of treatment.

The illustrations, in such a case, become a gallery of pictures by a single artist who commonly emphasizes, in a highly conventional way, a particular style of treatment or specific human type. When such an illustrator has achieved a vogue his work is likely to be sought by publishers for the meretricious excellence of these features, however poor his illustrative capacity may be.

The high degree of mechanical development which process reproduction has attained tends to foster this use of illustration. One can not imagine a book overloaded with mere diagrams which in no way help in the elucidation of the text, for such drawings have no other value which can be substituted for this primary service. So long also as the illustrator's art is crude, or the process of reproduction difficult and expensive, pictures will be introduced only where there is an evident purpose to be served, and little abuse of illustration will arise. Photographic, chromo-lithographic and other processes, however, have made possible such a high degree of success in transferring to a prepared surface of paper the features of the original in all their refinement of details and values that to look on the reproduction in a book is now comparable with looking on the scene or composition itself. The result has been a still further widening of the breach between text and illustration; and the temptation must often be great to introduce a picture because it is good in subject and admirably reproduced, though in its composition little regard has been paid to the situation which it is intended to represent. This defect is no less noticeable in the flotsam of periodical literature and the daily press than in the more elaborate composition of book-illustrations. When pictures are looked for, pictures will be forthcoming, whether appropriate or not. The waste corners of the newspaper are often filled with odds and ends of wit, humor and anecdote, in which the union of text and illustration too often suggests that the items have been thrown together and then drawn forth in pairs at haphazard.

The significance of such variations in the place of illustration, as well as the factors in their production, will perhaps be more clearly apprehended if the changes of value which the picture undergoes in individual mental development are recalled. In adult literature the text has complete meaning in itself, the picture has not; the text is made first, then the picture is composed; for the latter aims simply to present in a concrete visual image what has been set forth through verbal analysis in the text. The picture is thus completely subordinate to the text; it serves only to reinforce a feeble visual imagination in its effort to get before the mind a scene which the writer of necessity presents in fragments by successive statements.

But this is not the primitive way of conceiving the relation between these two constituents, nor is it the association which at first existed for the child. The picture, in those earliest days, was primary, the text secondary. For the adult the picture illustrates the text; for the young child the text explains the picture—it is needful only in case the picture can not be understood by itself. The text marks the imperfection of the picture, or series of pictures, in telling a story, and is added to supplement its deficiencies.

Pictures have a meaning for the child long before he begins to read or understand printed words. From babyhood they form part of his perennial delights, and are among the most treasured of his sources of pleasure. They have splendor of color and never-failing variety of forms; they represent objects of enduring interest, whether familiar or novel; they are full of action or suggestive of manifold and significant relationships; they tell, singly or in series, stories vivid and direct in their appeal, which are made scarcely the less alluring by their partial incomprehensibility.

The appreciation of pictures is a part of the child's introduction to language and representative thought. They have something of the controllability of images and, except for motion, the vividness and natural-ness of real objects. Through them the absent world is brought back, each picture affording the point of departure for a supplementary imaginative process which grows richer and richer as the years pass. Pictures thus form a natural mode of transition from the intuition of the world to its representation in thought by means of the conventional symbols of written language.

In primitive peoples as well as in the life of the child the line of development is through pictorial representation of reality to its description in analytic terms by means of verbal symbols. The evolution of language is marked by an increasing importance in the rôle played by the explanatory text and a corresponding decline in the use made of pictures. In the stages of barbaric culture picture and text are habitually associated. Vast series of figures, on temple wall and tomb and tablet, represent the scenes and events to be recorded, while beneath or at the side is put the running commentary of lettering or other text—the text itself commonly a modified picture-series, as in hieroglyphs and ideographs. Among civilized peoples the picture drops back to a purely accessory position. The text is now completely intelligible by itself—at least it aims to be so; while the introduction of pictures either marks a sense of insufficiency in the verbal medium or reflects purely an appeal to esthetic values.

The child, if not the barbarian, apprehends and employs pictures in a way different from the adult, as regards their relation both to the text and to other pictures. This difference marks a characteristic distinction between the two mental types; for the individual's conception of illustration and its function reflects from year to year the nature and development of the mind. At any moment the child will be interested in those pictures which appeal to the needs and impulses then dominant, and at each successive stage of his history only such as conform to the conditions and limitations of his mind will be intelligible. If a picture exhibit the complex relations of many component figures it will not be appreciated by a mind incapable of apprehending the synthetic unity of a complex group or multitude; and if it represent a single phase in such a connected system of actions or events as can be presented only in a series of pictures, it can not be apprehended by a mind that lacks the capacity to seize their unity in a dramatic concept and thus in imagination to construe the successive elements as a single action.

For such a mind the complex composition will exist only as a multitude of separate figures, among which indeed the mind may wander renewing its delight as each attracts attention, but which receive no added significance through their synthesis as members of a common system. The various pictures which represent the successive phases of a dramatic action will likewise be apprehended only in isolation from one another, each being treated as a story or situation in itself or, if the mind be elementary enough, as a mere collection of individual figures and objects.

The way one expresses himself in pictures or writing, and the way one interprets illustration or text, thus reflects the level of organization which the mind itself has reached. The single figure, the composition, the pictorial series and the textual description mark successive stages in the evolution of representative functions in the individual human mind. The child passes through each of these stages in turn as he advances toward maturity in synthetic thought, and a customary dependence upon any given type fixes the developmental level which has then been reached.

The aim of education in this regard is to develop in the individual a capacity to represent experience and to express thought adequately through a system of analytic and verbal symbols. It seeks also an ability to translate these symbols fluently into terms of significant thought when they are thus employed by others and to create imaginatively the forms of original experience which they are designed to describe. It marks an arrest of development in the mind not to be thus a master of words, whether in their use or their understanding. To need pictures in order to make the thought plain means either that the writer has not mastered his craft thoroughly and does not know how to use his tools, or that the reader's mind is immature or has momentarily lapsed from the habits which characterize maturity.

The child's love of pictures obviously persists in adult life; it is eradicated in few, if any, natures and to their distinct loss. We, as well as they, on taking up a book, often look first to see the pictures, and turn to the text only when the illustrations have been explored. The pictures are a mental appetizer which whets our appetite to a keener edge as we approach the solid courses of the printed page. How often, too, when we are tired or disinclined for strenuous mental effort, do we explore the pictures of an illustrated book or magazine, which can be understood and enjoyed without exertion! It is not only at such moments of intellectual idling, however, that we thus turn to pictures in connection with our reading. How often, when a point of difficulty arises do we long for a pictorial representation which would make all plain to us, as by a flash of lightning the dark landscape is revealed at night! How gratefully do we turn to a satisfactory illustration and find there the realization of our own conception which the artist has made still more rich and splendid by his craft! And when the subject matter is such as to put our logical reflection under severe or continuous strain, how constantly do we have recourse to the device of tabulating or schematizing the substance of discussion in some spatial way that shall present it concretely and visibly!

Illustration has thus a distinct and important place in literature. The use of pictures is twofold—they serve understanding and they increase enjoyment. In the latter case, however, they are not, in the proper sense, part of the discussion which they accompany, but form an independent source of value. Their service to the understanding is also twofold— they make clear to us relations too complex to be successfully conveyed by words, or conveyable only at inordinate length. Of this class of pictures the spatial diagram is typical. Their second function is to bring before us a scene whose splendor and richness can not be successfully represented in imagination. The latter bears to material content the relation which explanatory diagrams sustain to formal synthesis. Pictures of buildings and natural scenery, of the human figure and organic forms at large, indeed all concrete objects which are either unfamiliar or present subtle complications and gradations of quality, fall within this category.

While pictures have their own distinct place in literature, they can not be substituted for the textual description in any degree without affecting the place of the whole composition in the evolutionary scale. Language sets as its ideal the development of an adequate system of symbols for the representation of experience. The spoken sentence has fulfilled its function only when, through its own elements and syntactical form alone, it has adequately expressed the content of meaning intended by him who utters it. Writing is a transliteration of speech, and merely substitutes another medium in its performance of the same ideal office. Each in its own field aims at the development of a pure system of symbols, that is, a system which without accessories is capable of indicating the whole range of distinctions with which thought is concerned. Among civilized peoples both speech and writing approach adequacy in this regard, but in so far as pantomime persists in the one case, or illustration is relied on in the other, it marks a deficiency in the medium. In its ideal form language should no more depend upon gestures and pictures than upon the presence of the original objects and relations themselves which it seeks to represent through conceptual forms.

One has mastered the uses of language only when he is able to make a continuous translation of experience into its symbols and, with a similar facility, to interpret these signs in terms of their ideal meanings. In writing, then, such mastery is attained when adequacy in the expression of thought has been secured without any recourse to pictures, diagrams, models or objects. It is part of the mental training at which a cultivation of language aims to render the mind so far as possible independent of pictorial or other concrete ways of presenting the materials with which discourse deals. Like the use of the abacus in numbering, these aids may be indispensable in certain forms and at particular stages of development, but they must be superseded if any high degree of attainment is to be secured

Language will doubtless always fall short of this ideal aim. Speech will continue to be made more picturesque as well as intelligible by gesture, and illustration will enrich while it illuminates the printed page.

Nevertheless to make use of a picture where a verbal description can be given is to fall back upon a more primitive mode of representing experience, and the tendency to do so marks a degeneration either in the mental habits of those who employ such methods or on the part of the readers to whom they are addressed.

The function of the picture, in a certain large class of writings, has recently been undergoing change, and the direction of this modification seems to indicate a loss of intellectual fiber in the commonalty of readers. The present day is marked by an enormous increase in the amount of illustration which accompanies the text we read. In our books no less than in the daily press, in what is written for adults equally with what is prepared for children, in technical journals and scientific monographs as well as in popular magazines, this progressive encroachment of picture upon text is apparent. The newspaper strives for illustration in connection with all classes of news, and its staff of photographers rivals the corps of reporters in numbers and importance. Every page has its pictures, and even the gist of editorial comment is sometimes indicated by thumb-nail sketches used as paragraph-spacing.

It is probably materially true—and if so it is a significant fact—that the cheaper the journal the greater the amount of space given to pictorial matter. In such cases the aim seems often to make the story intelligible by means of pictures alone, with only secondary dependence upon the text. The appeal to pictorial representation in this way includes an immensely greater range of cases than newspaper and magazine illustration; and in this larger field its uses are of course legitimate as well as vicious. When we advertise, everything which can be represented is pictured within a frame of type or spread upon the poster, the fences and the farm-buildings. When we go abroad, our correspondence no longer takes the form of twelve-page letters, but that of a dozen picture post-cards. Our records of travel do not consist in a description of places and people or a dramatic recital of events, but in a gallery of representations of cities and buildings, of landscapes and portraits. We never describe a thing if we can procure a photograph of it; for writing an account of any occurrence—though it presents phases of the event which no picture can ever convey—is difficult and time-consuming.

Our popular magazines no longer depend upon the excellence of their literary contributions as their sole claim upon attention, but are filled with varied and mechanically admirable pictures. With the increasing dependence upon illustration the value of the text has correspondingly declined. In cheaper periodicals the contents are not uncommonly reduced to a group of departments—travel and places, the drama, celebrities, oddities, jokes—in each of which the substance is largely composed of detached pictures with minor explanatory comment. How far this demoralization has gone is indicated by the character of the text in such periodicals; for where it is not a mere commentary on the illustrations it is still commonly a scrap-work—of information, humor, anecdote, etc., with the sketch or short story as the climax of its demands upon synthetic thought.

The mere change in average length of article which, with a few striking exceptions, has steadily declined during the past generation, is suggestive of this alteration of attitude; and the rise of the short story to a dominant place in our popular magazines is probably part of the same intellectual reaction. We seem no longer to desire sustained attention and consecutive thought. As a consequence we turn from criticism, reflection upon human affairs and constructive theory to fiction, which as a class of literature presents its materials concretely and pictorially; while in fiction itself we prefer the short story, which must deal with a single dramatic action or situation, rather than the novel with its more complex plot and sustained analysis of character and motive.

Lapsing still further, we demand that our intellectual food shall be put up in the form of mouthfuls, or boluses, in notes of travel, places, events; in anecdote, verse, personalia and the like; until each page of the publication exists in practical isolation from the rest. In such connection "mental pabulum" is a misnomer. No real intellectual stimulation, enlightenment or discipline enters into the case. Mental activity is practically limited to the pleasurable sensation of the moment. Reading becomes a stimulant, not in the sense of arousing a heightened intellectual functioning, but only in its provoking a momentary excitement of the imagination; and the mental content of the reader is reduced to a series of such crudely exhilarating moments, unprovocative of subsequent reflection and without any enduring illumination of mind. One who falls into such a habit has become an intellectual drug-fiend, for the securing by artificial means of a heightened or quieted consciousness is not restricted to the use of the needle and the pipe alone. It is a matter of common experience that we turn from the editorial page and critical discussion to more trivial and inconsequential items as the mental energies flag, and for many of us the approach of exhaustion is marked by an assiduous and almost involuntary reading of the advertising columns of our daily paper. Men of intellectual force have similarly confessed to a habit of devouring shilling shockers when tired from a long bout of work, the jaded mind still craving an activity which it was unable to sustain and finding satisfaction in the violent stimulation and elementary situations which yellow-back literature offered.

The significance of certain changes in the place of illustration to which attention has already been called in the case of books and periodicals is still more strikingly exhibited in the recent history of platform speaking. The public lecture has been an important factor in the development of American culture. Before the multiplication of periodical literature and the rise of the illustrated magazine its position was supreme. Upon the system of Lyceum lecturing the intelligent public largely depended for the dissemination of general knowledge as well as for the presentation of social and political problems. It afforded an almost ideal method of developing a vigorous and independent public opinion through the stimulation of reflection and discussion. The limitations of opportunity which made the lecture course a characteristic form of entertainment in New England during the greater part of the nineteenth century had the fortunate effect of fostering an appreciation of good thinking and a demand for it in public speakers. By intellectualizing amusement it stimulated the habit of criticism, and through the inducements it offered to scholars and thinkers of the first rank it secured the spread of philosophical ideas and helped to sustain general interest in public questions.

One has only to contrast with all this the popular lecture of to-day to realize how far we have traveled from these earlier intellectual preoccupations. Leaving out of question the field of political discussion, which has had an unlike as well as independent development, and limiting consideration to matters of common interest, to general information and culture, science, art, literature and philosophy—the transformation will not only be found radical, but will be seen to follow a course parallel to that which has been traced in magazine and book-making. Dependence is no longer upon the substance of what is presented alone; in many cases it has not even chief place. In lyceum days the lecturer relied upon his own resources. Success and failure turned upon the question of his ability alone; there was no dispersion of responsibility. Except for rhetoric and wit he had no means of tricking out his wares. There was no second line of defenses to fall back upon; for his discussion of art was not illustrated with music and Greek dances, nor his lecture on natural history supplemented by lantern slides and moving pictures. What the speaker had to say was all that counted, and it is only when audience and lecturer stand in this direct relation that the intellectual quality of public speaking can be sustained.

That it has not been sustained is beyond question, and its decline is closely associated with the increased use of pictures. Practically all popular lectures are now illustrated. One scarcely dares come on the platform alone or in full light; whatever one's subject, the text must be supplemented by pictures. If a human life is to be studied, not only are portraits secured, but pictures of parents, birthplace, and associates, copies of autographs and human documents of all kinds. If history is to be discussed, archives and museums are similarly ransacked for illustrative materials which are reproduced upon the screen. If countries are to be described, their physical features, cities, monuments, architecture, dress, customs and industries are pictured; and an exhibit of natives in their national garb as well as of their implements and products is not infrequently brought upon the stage.

All this, in the first place, has of course added an extraordinary richness and definition to our imaginative representation of the distant and unseen. Places and persons, forms of life and manufacturing processes are thus brought actually before our vision, if not before our senses, in their completeness. We are made familiar in advance with things which are to be seen only later in life, if at all; and our sympathetic participation in affairs at large is deepened as well as broadened. The greater world must be brought to the individual through the imagination if he is to come into contact with it at all, and pictorial representation vitalizes and reinforces this sense of understanding and community with mankind.

In more specific relations the picture-supplement facilitates our understanding, and this service has made it indispensable in bringing before the mind objects or processes whose constitution is too complex to be presented analytically, or to be reconstructed from a purely verbal description. In the lecture, just as in the book, illustration has a place not only legitimate, but important. Comprehension begins in intuition, and our sense of security in any general conception is weakened in proportion to the vagueness which marks our mental picture of its field. So long as photographs, stereopticon views and moving pictures perform this service, their use by the platform lecturer must be welcomed. Nevertheless, their function is a distinctly subordinate one—namely, the illustration of a theme which is itself still the essential preoccupation of the mind.

This relation has now significantly altered; the picture is advanced to the front rank and the theme has correspondingly fallen back. The very relation of speaker and screen in the illustrated lecture symbolizes this change. The lecturer stands in an obliterating shadow while all the energy of illumination is concentrated upon the stereopticon sheet. Even in its most elementary physical relations the focus of attention is thus shifted, and the change is significant of a profound modification in the relations of audience and lecturer. Language is an appeal to the mind, not to the eye; and its function is imperiled whenever this fact is obscured. The focusing of vision plays an important part in maintaining this intimate spiritual contact, and nothing more effectual in destroying it can well be conceived than the substitution of another point of regard so violent and alluring as the illuminated screen.

The extraordinary mechanical perfection of photography, its extension into the fields of panoramic, telescopic and micro-photography, and above all the development of motion pictures, have accelerated this adoption of a new attitude and the creation of a novel demand on the part of the audience. For one does not merely introduce a new medium in substituting pictures for discourse; the appeal is to a different side of human nature and satisfies an independent craving. Confronting facts is different from understanding them. Merely to go into the fields is not to study botany, and unless we carry that definite aim with us the stroll is much more likely to add to our dumb enjoyment than to extend our knowledge. The eye may be filled while the mind is left untouched; for it is just when sense is thus completely satisfied that reflection is most likely to lie unstirred.

The vogue of illustration, as an adjunct of public lecturing, marks such a change of habitual attitude. We go to the lecture, as to the theater, to be entertained, not to be instructed; and are so absorbed in looking that we cease to think. A swift succession of vivid impressions, resplendent in color or palpitating with motion, passes before the gaze. There is as little leisure for reflection as directive stimulation to thought. The senses are stimulated and at last jaded, as picture succeeds picture and topic replaces topic; until, breathless with the dizzying rush of scenes, we are at last tossed back, momentarily bewildered, into normal relations with the world about us.

Under such conditions the verbal commentary of the lecturer becomes a matter of secondary importance, and we accept a mediocrity of merit, or even a literal incoherence, which would never have been tolerated under the more exacting conditions of the lyceum. Indeed, if the pictures be only chosen skilfully enough the text may be rendered wholly negligible, as the kinetoscopic theater indicates by its elimination. In a word, the speaker has been replaced by the picture-machine, and a corresponding change in our conceptions of merit has accompanied the substitution. We require better and ever better pictures and promote a race for mechanical perfection. We stimulate the ingenuity of inventors to devise fresh marvels of reproduction; color is added to form, and motion to color; but still we demand more. The world is ransacked for its treasures of picturesqueness or beauty, and men's brains racked to conceive new dramas and burlesques of action. As a result these pictorial and esthetic demands finally supersede the lecturer's original function of interpretation.

This trend has perhaps been most striking where it has been least justifiable, in connection with the presentation of scientific materials. The change is at least suggested in the subordination of theoretical to experimental and demonstration methods in teaching. The aim of scientific instruction is to put the mind in possession of a system of explanatory concepts. These are necessarily abstract and can not be set forth in the form of concrete examples. There is therefore a danger that attention, detained by its purely picturesque aspects, may recall the demonstration merely as an impressive spectacle, and thus lose sight of the principles which it illustrates. The use of demonstration methods in the class-room, however, presents less subversion of aim than that of platform illustration. The lantern-slide has won a secure place in the technique of instruction, within the school system as well as beyond it, and it is only its abuses that are to be deplored. But these have not only crept into the rapidly growing extra-mural work of higher institutions, but even pervade the programs of scientific societies themselves.

With the preferences of an audience which confessedly seeks entertainment one can not well quarrel on the ground that it ought to desire instruction instead; one can only note the appearance of new predilections in the social habits of a people. But against an institution devoted to the advancement of knowledge, or the fostering of an interest in science, protest lodges whenever these aims are lost sight of or subordinated. The past decade has seen a rapidly growing tendency on the part of such societies to allow the presentation of purely illustrative materials to trespass upon the formal discussion of their common subject matter. The change is one which affects the very ideals for which these bodies stand. The science of geology, for example, has perfectly definite aims which are not attained by the photographic reproduction, however copious or admirable, of rock strata and erosion effects, of talus slopes and detritus, of shifts, faults, dykes and lava-flow—though an acquaintance with all these things is essential to the prosecution of its general undertaking. The science of geography, likewise, is no more adequately represented in the flood of charming pictures to which we have grown accustomed in periodicals and platform lectures alike than is a knowledge of the development of any people embodied in the impressions one carries away from those ingenious pageants to which—still as picture lovers—we are turning with equal enthusiasm in the field of history.

In public lecturing and the methods of instruction, as in magazine and book-making, these phenomena have a common significance. They indicate a change in the point of support on which the speaker rests, as well as in the nature of his appeal to the hearer. The new demand is not less strenuous than the old, but it is of a different kind. Instead of requiring a definite constructive activity, stimulated and directed—but never supplanted—by the mind of the speaker, it titillates the imagination with a series of agreeable shocks. The mind is not taxed but appeased; the soi-disant teacher exerts himself to anticipate the moment of flagging attention, and out of an abundant store to supply it at each turn with a novel and pleasurable stimulus. Education and discipline are not attainable by any such process. It is only by thinking that knowledge comes, and thought is a function that can neither be assumed by a deputy nor taken over by any other faculty. Instruction and entertainment, though equally essential to human life, can not be confused as specific aims without the sacrifice of their several values. Every normal individual resents the instruction that is disguised as entertainment; but the ultimate effects of a systematic pretense that entertainment is instruction are no less to be feared.

DETERMINING EDUCATIONAL VALUES

By Professor M. V. O'SHEA
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IT will probably not be questioned by any one that the most complex business society can undertake is to train the rising generation effectively. The human mind is an extremely complicated thing. It is so intricate, indeed, that it has been found impossible thus far to discern many of the laws according to which it evolves and functions. "What a marvelous piece of work is man," expresses the feeling of the poet as well as the view of the student of any phase of human nature. The problem of preparing a child for happy and effective adjustment to the world in which he must live is immeasurably more difficult than the hardest engineering problem, say, which men in any age have yet undertaken. The engineer has only to deal with physical laws, which are relatively simple and easily determined as compared with the laws governing mental activity and efficient mental development. The engineer is usually able to ascertain whether or not he has correctly apprehended and dealt with any law of nature. At every step he can control his work, because the effects of his action are immediately measurable. But it is entirely different with the educator. He can not directly measure the outcome of his methods. Most of his training produces noticeable effects only after a long lapse of time, and then only in an obscure and entangled manner. Any one, then, whose duty it is actually to mould a human mind according to the most desirable pattern, and who realizes the complexity of his task, is apt to be more or less awed and even mystified by his problem.

But the man on the street, looking at the business from the outside, is apt not to feel much mystery about it. The whole matter is likely to seem clear and simple to him. He can dash into his office, and in a few minutes give instructions how to deal with problems which are probably inscrutable to one who for years has been seriously trying to solve them with due regard to all the factors involved. The tendency of the non-expert in any field is to resist the idea that he is incompetent to form an opinion about matters in that field. Witness how the layman and even the drug doctor have ridiculed the theory that disease is largely of bacterial origin. It is the same way with legislation. The layman proposes to solve social ills by some simple, drastic legislation. He resists taking the point of view that social relations are extremely complex, and that the new difficulties which arise with the increasing complexity of society demand more and more subtle forms of treatment, in order to cause justice to prevail among men, and at the same time not to arrest the evolution of society.

The layman usually feels more confident to give advice regarding education than he does regarding medicine or legislation or even religion; and this is the chief cause of the vast amount of conflict over teaching in these days. Those who are working on the inside, who may be said to have the expert point of view, are introducing changes in courses of study, in the methods of presenting subjects, and in the modes of organizing and conducting school systems, which they think are demanded in order to meet the changing conditions in the social organism. New subjects are being added in the belief that they are essential in order to give the pupil an appreciation of contemporary life. It is seen that the conditions for which the school must prepare its pupils are very different to-day from what they were fifty years ago; though the layman sometimes indicates his view of educational policy by saying that "the little red school house produced the greatest men the world has yet seen; and why not let good enough alone." He apparently does not consider that these men may have attained their greatness in spite of, or at least independent of, the school. As a matter of fact, some of the most distinguished of these men were self-taught.

The man immersed in affairs in his own field is apt not to take account of the fact that knowledge, practical knowledge, is rapidly increasing in many fields which were hardly opened up fifty years ago. Everything affecting human welfare is becoming more complex; and even if a relatively simple school régime a half-century ago was adapted to the needs of men in those days, such a régime might be entirely unsuited to the conditions of to-day. The student of education sees what has happened to society in the countries of the old world in which the school has kept to the simple, traditional curriculum. The pupils come out of the schools in such places quite unaware of much that exists in the world to-day, and they are unable to cope with modern conditions as created by progressive nations. If the advice of a large proportion of the lay and non-expert critics of the schools should be followed, it is as certain as anything can be that we should in a brief time, as such things go, come to an arrest in our development, much like that to be observed in Italy or Spain at the present time.

Of all the fault-finding regarding contemporary education, the most persistent is that which charges the schools with devoting much of their time and energy to "fads" and "notions." It is probable that some at least of those who write this criticism have never been inside a modern school building, and they doubtless have but a very imperfect conception of the principles underlying the evolution which is taking place in the curriculum, and in methods of teaching. Such men are apt to pose as authorities on every subject engaging the attention of people. They know they can strike a more or less popular chord when they denounce prevailing tendencies in teaching, so they ridicule prevailing methods and praise those of bygone days. It has become a sort of fashion now for certain newspapers, when they find themselves short of other material, to run something on "fads and frills in the schools."

Recently an editor printed a series of articles on the schools in a western city. He said they were being "honeycombed with fads and notions." When asked to name a conspicuous "fad" in the schools, he replied with general statements, but without hitting the mark once in his criticisms. He was asked whether the teaching of history was a "fad." "Of course not," he said. "Is the reading of English classics a 'frill'?" "No." "Or the teaching of children to sing a few minutes every day?" "This is all right, too." "Is it a 'notion' to teach them to express themselves through drawing?" He thought this was proper for most children, at any rate. "Is it wrong to have some memorizing of literary gems every day?" "No, this should be practised more than it is." "Where then are the 'fads?'" Apparently he realized he was in a tight place; and yet it was impossible to keep him from declaiming on the more thorough teaching of spelling, arithmetic, etc. The fact is this man, and there are others like him, had only a vague knowledge of the thing he was writing about. Unfortunately this writing tends to corrupt the minds of the people, and so to render it all the more difficult to secure educational evolution in response to the demands of the times.

It ought to be said at this point that the majority of laymen and a good proportion of teachers do not view the subject of educational values in any critical way whatever. The very fact that grammar, say, has been long taught in the elementary school is a sufficient guarantee for such people of its superior worth, and especially since they were taught the subject themselves. Most people settle the question of values in education much as they settle any problem of dress or of household management—they consider that to be right and best which is in general practcise, and which they have been accustomed to themselves. As a rule, though not always, the non-expert in education (and the principle holds for other interests) is conservative. He dislikes reform in studies or methods, because he can keep himself better adapted to a permanent and stable than to a changing order of things. However, this is not likely to be true in respect to the particular interest in which he is most vitally concerned, as in manufacturing, say, where the keenest sort of competition makes him realize that if he does not alter his methods to meet new conditions he will be crushed by his competitors. Keen necessity makes him dynamic, aggressive, radical. But in all those interests which he touches only incidentally, as it were, in which he does not feel serious competition, he often seems incapable of appreciating that progress is necessary, or even desirable. So in education, as in hygiene, religion, politics, etc., we must expect that the majority of people who have not become particularly interested in the business will vote to have things continued as they have been, or as they now are. They will resist innovations. They will cry, "Fads!" "Frills!" etc., whenever any new topic gains a foothold in the curriculum, though they may be progressive enough in their own special field, where they can appreciate the value of new methods suited to contemporary needs.

The diversity of opinion regarding values in education, to which attention has been called above, suggests that laymen as well as teachers must look at the matter involved from different points of view. The writer has asked individuals and groups in many sections of our own country, and some of the countries across the sea, what they consider the proper standards in determining the value of any study, or any method of teaching, or any principle of discipline; and the responses have impressed the fact that there is no universal mode of appraising values, which is adopted by laymen in deciding any educational problem. Some persons say that a study is valuable in the measure that it confers "culture" upon the one who pursues it. Other persons say that the true value of any educative material depends upon the extent to which it trains the mind. Still others feel that no study is of worth which does not contribute to the individual's efficiency in practical life.

All sorts of figures of speech are used by people in striving to express their conception of the nature of mind and the function of education. The present writer has heard the remark made time and again that what we must do in the schools is to "strengthen the faculties"; or we must "polish" the mind, for until it has been so treated it is like a "rough diamond," or we must "cultivate" it as we would a field, in order that it may become "fertile"; or the subjects of study should "nourish" the mind, as food nourishes the body; or we should "sharpen" the faculties as we would sharpen an edged tool. The list of figures of speech based on physical objects and phenomena and used to describe educational work might be extended almost *ad libitum*. The mind is so subtle and complex that we endeavor to make our thinking about it definite and concrete by ascribing to it, at least for purposes of definition, physical properties and characteristics. And individuals as well as communities tend to employ the physical conceptions most familiar to them in their reactions upon their own environment. People who live on the sea will employ figures of speech different from those who live in the mountains or on the prairies or in the city. The mechanic will draw his figures of speech from his particular work, and the same will be true of the miner or the merchant or the woodsman.

Let one ask the people whom he meets on the street, in the reception hall, or in academic halls, what effect the mastering of arithmetic, say, has upon the mind of the one who assimilates it. The majority of the responses he receives will be based upon an argument something like this: Arithmetic is an exact science; everything in it can be definitely proved; accuracy is absolutely essential in resolving arithmetical problems; therefore, the pupil who learns arithmetic will be trained in accuracy of thinking more thoroughly than he could be in assimilating history or geography or music. And since accurate thinking is the first requirement for success in life, it follows that this subject constitutes the most valuable study in the curriculum. People who reason about education in this manner will assign to algebra, geometry, trigonometry and other branches of mathematics the first place in the high-school curriculum, because they are all concerned with principles which are apparently exact; and *the learner takes on the quality of the material which he learns.* Those who proceed in this manner in determining values do not think it needful to observe whether, even if a pupil in assimilating algebra is trained to be accurate in his thinking, this kind of accuracy is of service to him in the practical situations of every-day life.

If one will examine the opinions of lay writers on teaching since Plato's day, he will find that many of them have regarded the materials and the methods of education in a purely *a priori* manner. They have analyzed the matter of any subject of study, as mathematics, and they have naïvely inferred that the properties of any special material, viewed objectively, will be grafted on to the mind and character of the individual who masters it. Take, for instance, the view held by some older writers, that it is debasing to study what is to-day called natural science, because of the baseness of physical objects; one who studies these things will take on their qualities. On the other hand, if the individual in his education is made to learn things that relate to the spirit, he will become more highly spiritualized. Persons who gain their notions in this manner do not think it necessary actually to observe what effect the study of any subject has upon an individual, whether as a fact it exalts him spiritually or debases him; whether it makes him more of a friend to his fellows or cultivates unsocial and selfish attitudes. He *infers* that a certain result *must* follow from the study of any branch, because of the nature of the material learned.

This logical, analytic method is the popular one in use among laymen and among some teachers to-day, as it has been in all times. It is in principle like the method which has been followed heretofore in the study of values in nutrition. The older nutritionists worked out tables of food values based entirely on chemical analyses of different articles. They said, to cite a typical instance, "Cheese contains 70 per cent. of albumen; albumen is an essential element in nutrition; therefore cheese constitutes a valuable food." These analysts went through with all the articles of food in order to determine their chemical constituents;

and then they assigned them to a place in the scale of values according to the results of this analysis. They did not think it imperative to observe whether or not the organism would easily and economically assimilate any particular food, or whether the factor of appetency should be taken account of. They did not inquire whether there were elements in cheese, say, which the organism might resent, so that instead of this being a good article of food it might be nearer a poison.

We seem to-day to be abandoning the practise of relying wholly upon the analytic method of determining food values. We are now attaching chief importance to observing how the organism reacts upon any article of food when it is taken into the system. This method is likely to modify greatly our conception of food values. It is of special significance for our purpose that it seems already to have been shown that an article of food which may be of great service to the organism at one period of its development may be relatively valueless or positively detrimental at another period. It has been shown, for example, that while a calf may thrive on milk during the first months of its life, still if it be kept on a milk diet too long it will begin to decline, and it will literally starve unless other foods are added to the dietary. But the chemical methods of determining the values of foods make out milk to be a valuable food without regard to age or individual differences.

The principle under consideration can be illustrated further by referring to the methods employed in an earlier day in the study of the parts of speech in children's language. Men like Hale and others wrote down the words an eighteen-months old child, say, used in his daily expressions. Then they went to work and classified these words according to their grammatical properties, so that they found that 60 per cent. of the words a child used were nouns, 20 per cent. were adjectives, and so on. Then they inferred that the child's thought relates mainly to objects as contrasted with actions, and qualities, and spacial relations, since nouns predominate in his vocabulary, and they denote things. But to-day we appreciate that the outward form of a word does not furnish clear evidence of the way it functions in the child's expression. He may use the word "cat," say, with verbal, adjectival, and exclamatory as well as pure nominal function. That is to say, the fact that "cat" is grammatically a noun does not show that the child employs it as such. Indeed, it is certain that at the outset he does not use it with strict nominal function. The only effective way to determine the parts of speech in a child's vocabulary, viewing the matter from the standpoint of the *function* of words in expressing thought, is to observe the child as he reacts upon his environments when he uses particular words, so that we may notice what his attitudes are when he employs them.

This principle is mentioned here simply to impress it as of special importance in application to the study of educational values. In order to determine these values in any effective way, we must take account not only of particular subjects and methods of instruction, but we must keep in view especially how the individual reacts upon these materials when they are presented to him according to different methods and what effect they have on his activities.

Manifestly, in the present light of our knowledge on the subject, one can not speak with certainty regarding much of the material of education. The factors determining efficiency in adjustment are too complex and involved to permit of detailed analysis, and the function of each definitely estimated. While the pupil is in school he is also in the home and on the street. He is having much experience for which the school is not in any way responsible; though it has been the common practise in discussing values to ignore all experience except that gained within the school. One frequently sees persons who naïvely infer that whatever ability they possess in using arithmetic, say, in daily life, was gained in the school; but it is easily possible that most if not all of it was developed through the necessity of dealing with real situations outside of the school. In the same way, they maintain that their skill and efficiency in the use of the English language was developed through the study of grammar in the school, whereas it is probable that their linguistic ability is due mainly to the give-and-take of life in the home, and in the other real situations of life.

But while one can not assume a dogmatic attitude in the discussion of these problems to-day, nevertheless one may proceed in confidence upon the proposition that the individual will be benefited in school education only to the extent that the sort of experience he has in the school is the same kind as that which he will have outside in adjusting himself to the conditions of daily life. This means that in respect to the material of education, and also to some extent to the method of teaching, there must be diversity depending upon sex, upon existing social conditions, and particularly upon the sphere of life in which individuals will be placed. For a child being trained in Italy, say, any given subject would be likely to have a somewhat different value from what it would have for a child being trained in America. It is impossible then to say what the value of any special subject or method is until one knows what the needs of the pupils are. Of course, in any given country at any particular time individuals can be grouped into classes, all the members of which will have substantially the same needs; and the needs of any one member will be ministered to effectively if he has the experiences which will work out well for the group to which he belongs. His individual needs may not be provided for in every detail; but there will not be much waste in his case provided that the general needs of the group are adequately met. In a dynamic, developing social organism, there will be constant differentiation among individuals, so that for some members new needs will be arising which will not be fully taken care of if they are confined to what is essential for the group as a whole. This implies that in any plastic society the number of groups which must be provided for in the school will be constantly enlarging as society grows more complex and new forms of social service are required.

So one who attempts to estimate educational values in America to-day must appreciate that his work can not endure for all time, except in respect to certain fundamental needs, which must be reasonably permanent for all people under all conditions. But it is manifestly impossible to say in detail what will be essential in the schools fifty years from now. As society becomes differentiated, new needs will arise which will require the establishment of institutions for the training of new groups. If the school is thoroughly plastic, it will from decade to decade revise its curriculum and its methods in respect to the details of its procedure. What is going on in America to-day in the modification of curricula and methods is inevitable in a civilization like our own; and it is bound to continue. Topics of study of importance a hundred years ago may be of relatively little importance to-day. On the other hand, on account of changing social conditions, many topics and subjects may be of worth to-day which would have been of little account a hundred years ago. If the school fulfills its mission, there must be constant evolution, in respect alike to the materials taught and the methods of teaching and of discipline. Nations in which this is not true must sooner or later become decadent.

THE PARADOX OF THE EAST WIND

By Professor ALEXANDER McADIE
BLUE HILL METEOROLOGICAL OBSERVATORY

ABOUT ten miles south of Boston, on the highest land within sight of the sea from Maine to Florida, is a well-known meteorological observatory, founded some thirty years ago by a young graduate of the Massachusetts Institute of Technology. The founder, Lawrence Rotch, became in time the pioneer explorer of the upper air, contributing much to our knowledge of air motion at different levels. In collaboration with Teisserenc de Bort, he may be credited with inaugurating the campaign which resulted in the important discovery of the double character of our atmosphere, as shown by the two great divisions of the stratosphere and the troposphere.

A few years before his death, Rotch, who was then professor of meteorology at Harvard, remodeled the Blue Hill Observatory and on the walls of the new library placed eight symbolized figures of the winds. These were copies in relief of the winged human figures on the frieze of the not-too-well-known Tower of the Winds, which has stood for twenty-odd centuries at the base of the hill crowned by the Acropolis.

The Greek was a past-master in the art of personifying natural phenomena and these figures of the winds are ornamented, clothed and posed so as to suggest the characteristic feature of the particular direction represented. Boreas, an old friend, representing the north wind, is a determined-looking fellow, warmly clad but active in spite of his many wraps and heavy buskins. He carries a conch shell and has been blowing it. The sculptor meant, of course, to represent the boisterous roaring of the north wind, especially noticeable where the air in its passage comes over some range or group of hills. Of all the winds, Boreas is the noisiest. But it is not so much with Boreas, or his companion on the left and fellow noise-maker, the ruffian Skiron, warder of the northwest winds, that we are concerned, as with the east wind, the hopeful, open-faced Apheliotes. Apheliotes Nov. Ang. is perhaps an unfamiliar phrase yet it is only the classical rendering of a very familiar expression, namely, the east wind of New England. And many speak of the east wind as if it belonged to New England alone, associating this stream of surface air, a very shallow current, as we shall show later, with the coast north of Cape Cod, although it prevails along the entire Atlantic seaboard.

It is a wind from the sea, and whether it comes as the gentle, welcome sea-breeze of summer or as the *sea-turn* due to the advancing cyclone from the west, it is still a recognizable ocean wind. Such winds are regarded in most lands with favor. Why then, do we, of the eastern states, hold it in ill repute? At Athens, the east wind, the wind from the sea—the Apheliotes of the Tower—is typified by a young man with hair flowing in every direction. The youth has a fine open countenance and holds with both hands the skirts of his mantle which is filled with fruits and flowers. Along the shores of the Ægean, tillers of the soil, prone to take the weather *an-cha-Allah* (as Allah wills), bow when the east wind blows, echoing the words of one Dervish Mustapha in his greeting

> This is a divine wind, for it wafts the blessings of Allah to us from Mecca.

On the Atlantic coast, as elsewhere in the United States, the prevailing winds are westerly. In fact the general movement of the surface air in temperate northern latitudes is from west to east. It is interesting and perhaps worth while to speculate on the climatic changes which would occur if the prevailing flow of air were reversed and the surface current moved from east to west. Then the east wind, the Apheliotes Nov. Ang. would become the prevalent wind. It would not be as now, a shallow intermittent current, but would extend to some height. The Atlantic states would have a balmy, equable climate, with occasional storms from the sea preceded by west winds, rather dry, and followed by moderate east winds and showers. The climate would be like that of Bermuda. East of the Mississippi there would be fewer hot spells, likewise fewer freezes. The cold wave which now follows the "low" would be unknown. The climate of the country west of the Rocky Mountains, however, would be rigorous. Temperature changes would be pronounced on the Pacific coast.

Let us examine now the records of the flow of the air from sea to land and from land to sea, at different levels, as shown by the Blue Hill records. Owing to the sensitiveness of the instruments and the open character of the scales employed, also because there has been no change in exposure or methods, the data are thoroughly comparable and in themselves constitute a unique and valuable contribution to American ærology. It is doubtful if at any other station in our country records of wind direction and velocity are so detailed and complete. Checked by numerous experiments with kites and balloons, the records show that *there is twice as much wind from the west as from the east.* This will surprise many, for the impression is widespread that the climate of the Atlantic seaboard. is determined primarily by the east wind. On the contrary, west winds dominate and control both by duration and velocity. The indictment may seem somewhat sweeping; but so far as we can at present determine, the west and northwest winds are responsible for the severity of our winter; and the southwest wind for the heat of summer. Counting the actual hours of flow of air in different directions, it appears that the west prevails one fifth of the time, the northwest, nearly as long, and the southwest, one sixth of the whole period. In a year, the west wind blows 1,739 hours, the northwest 1,609 and the southwest 1,412. The total duration of all winds from easterly points of the compass is but 1,950; and the ratio of east to west is as four to ten. The east wind by itself prevails only six hours in a hundred and so can hardly be a controlling factor of the climate. But some one may say: "Granting that the east wind does not blow as long as the winds from other quarters, possibly it blows harder?" No, just the opposite is the case. The mean velocities in meters per second from sea-level up to a mile, are NW. 12, W. 12, SW. 11, N. 11, S. 10, NE. 9, SE. 9 and E. 6. This proves that the east wind is the feeblest of all the winds. Moreover easterly winds blow more frequently in summer than in winter. The east wind is also the current of most uniform velocity, *i. e.,* the least gusty, while our friends Boreas and Skiron true to their reputations are genuine gust makers. The period of greatest gustiness or instability, is the afternoon. All the winds increase in velocity with elevation up to a certain height; but the east and northeast winds are not deep and at an elevation of two kilometers (6,562 feet) these winds rarely occur. There are two kinds of east wind, the cyclonic wind which is moderately strong; and the sea-breeze which is only a few hundred feet in depth. The latter occurs on clear, warm, quiet days and never when the pressure distribution is favorable for turbulent conditions. It does not originate on land but comes in from the sea and seems to push away slowly the quiet, stagnant air in front. The ripples on the water as the breeze works its way landward look like schools of mackerel. On very quiet warm mornings the breeze may arrive as early as ten o'clock. It veers slightly as the sun gets half-way down and dies away as gently as it began. It does not penetrate far inland and its effect in lowering the temperature is limited to a few miles back from the shore. It comes too at a season when the air-gods seemingly are willing to rest, when the storm frequency is a minimum, when the Atlantic and the land have respite from the strenuous succession of storms. Then ceases for a while the rapid alternation of "high" and "low," the alternation which causes the characteristic changeableness for which the east wind is made scapegoat.

Truly men have much to learn about the medium in which they live, the very air they breathe. Paradoxically the orchardist blames the frost, as he sees it, for the damage to his crop, whereas the congealed water in the process of solidifying retards the fall in temperature, giving out in the unequal fight its own latent heat of fusion, some 80 calories per gram of ice, plus the latent heat of condensation, some 596 calories per gram of water. Similarly men blame the breath of old ocean, the invisible vapor brought in by the east wind, calling it chilly, damp and disagreeable; forgetting that the cold has been caused primarily by the wide-sweeping western winds. Certainly Apheliotes is a water-bearer; he bears and pours, ministering to the desiccate air even as the garden lover bears and pours upon the parched and thirsty beds. For the service rendered, this wind from the water gets small praise, while noisy Boreas and blustering Skiron driving all warmth and moisture before them pass approved of men as health givers.

WAR AND PEACE

A League of Peace

THE futility of war as a means of producing peace between nations has often been dwelt upon. It is really the most futile of all remedies, because it embitters contestants and sows the seeds of future struggles. Generations are sometimes required to eradicate the hostility engendered by one conflict. War sows dragons' teeth, and seldom gives to either party what it fought for. When it does, the spoil generally proves Dead Sea fruit. The terrible war just concluded is another case in point. Neither contestant obtained what he fought for, the reputed victor being most of all disappointed at last with the terms of peace. Had Japan, a very poor country, known that the result would be a debt of two hundred millions sterling loading her down, or had Russia known the result, differences would have been peacefully arbitrated. Such considerations find no place, however, in the fiery furnace of popular clamor; as little do those of cost or loss of life. Only if the moral wrong, the sin in itself, of man-slaying is brought home to the conscience of the masses may we hope speedily to banish war. There will, we fear, always be demagogues in our day to inflame their brutal passions and urge men to fight, as a point of honor and patriotism, scouting arbitration as a cowardly refuge. All thoughts of cost or loss of human life vanish when the brute in man, thus aroused, gains sway.

It is the crime of destroying human life by war and the duty to offer or accept peaceful arbitration as a substitute which need to be established, and which, as we think, those of the church, the universities, and of the professions are called upon to strongly emphasize.

If the principal European nations were not free through conscription from the problem which now disturbs the military authorities of Britain, the lack of sufficient numbers willing to enter the man-slaying profession, we should soon hear the demand formulated for a league of peace among the nations. The subject of war can never be studied without recalling this simplest of all modes for its abolition. Five nations cooperated in quelling the recent Chinese disorders and rescuing their representatives in Pekin. It is perfectly clear that these five nations could banish war. Suppose even three of them formed a league of peace—inviting all other nations to join—and agreed that since war in any part of the civilized world affects all nations, and often seriously, no nation shall go to war, but shall refer international disputes to the Hague conference or other arbitral body for peaceful settlement, the league agreeing to declare non-intercourse with any nation refusing compliance. Imagine a nation cut off to-day from the world. The league also might reserve to itself the right, where non-intercourse is likely to fail or has failed to prevent war, to use the necessary force to maintain peace, each member of the league agreeing to provide the needed forces, or money in lieu thereof, in proportion to her population or wealth. Being experimental and upon trial, it might be deemed advisable, if necessary, at first to agree that any member could withdraw after giving five years' notice, and that the league should dissolve five years after a majority vote of all the members. Further provisions, and perhaps some adaptations, would be found requisite, but the main idea is here.

The Emperor of Russia called the Hague conference, which gave us an international tribunal. Were King Edward or the Emperor of Germany or the President of France, acting for their governments, to invite the nations to send representatives to consider the wisdom of forming such a league, the invitation would no doubt be responded to and probably prove successful.

The number that would gladly join such a league would be great, for the smaller nations would welcome the opportunity.

The relations between Britain, France and the United States to-day are so close, their aims so similar, their territories and fields of operation so clearly defined and so different, that these powers might properly unite in inviting other nations to consider the question of such a league as has been sketched. It is a subject well worthy the attention of their rulers, for of all the modes of hastening the end of war this appears the easiest and the best. We have no reason to doubt that arbitration in its present optional form will continue its rapid progress, and that it in itself contains the elements required finally to lead us to peace, for it conquers wherever it is tried; but it is none the less gratifying to know that there is in reserve a drastic mode of enforcement, if needed, which would promptly banish war. . . .

Let me close by quoting the words of Lincoln. When a young man, employed upon a trading boat, he made a voyage of some weeks' duration upon the Mississippi. He visited a slave market, where men, women and children were not slaughtered, as formerly in war, but were separated and sold from the auction block. His companion tells that after standing for some time Lincoln turned and walked silently away. Lifting his clenched hand, his first words were, "If ever I get a chance, I shall hit this accursed thing hard." Many years passed, during which he never failed to stand forth as the bitter foe of slavery and the champion of the slave. This was for him the paramount issue. He was true to his resolve throughout life, and in the course of events his time came at last. This poor, young, toiling boatman became president of the United States, and was privileged with a stroke of his pen to emancipate the slaves last remaining in the civilized world, four millions in number. He kept the faith, and gave the lesson for all of us in our day, who have still with us war in all its enormity, many of us more or less responsible for it, because we have not hitherto placed it above all other evils and concentrated our efforts sufficiently upon its extinction. Let us resolve like Lincoln, and select man-slaying as our foe, as he did man-selling. Let us, as he did, subordinate all other public questions to the one over-shadowing question, and, as he did, stand forth upon all suitable occasions to champion the cause. Let us, like him, keep the faith, and as his time came, so to us our time will come, and, as it does, let us hit accursed war hard until we drive it from the civilized world, as he did slavery.—Andrew Carnegie in the Popular Science Monthly for May, 1906.

THE MORAL EQUIVALENT OF WAR

HAVING said thus much in preparation, I will now confess my own utopia. I devoutly believe in the reign of peace and in the gradual advent of some sort of a socialistic equilibrium. The fatalistic view of the war-function is to me nonsense, for I know that war-making is due to definite motives and subject to prudential checks and reasonable criticisms, just like any other form of enterprise. And when whole nations are the armies, and the science of destruction vies in intellectual refinement with the sciences of production, I see that war becomes absurd and impossible from its own monstrosity. Extravagant ambitions will have to be replaced by reasonable claims, and nations must make common cause against them. I see no reason why all this should not apply to yellow as well as to white countries, and I look forward to a future when acts of war shall be formally outlawed as between civilized peoples.

All these beliefs of mine put me squarely into the anti-militarist party. But I do not believe that peace either ought to be or will be permanent on this globe, unless the states pacifically organized preserve some of the old elements of army-discipline. A permanently successful peace-economy can not be a simple pleasure-economy. In the more or less socialistic future towards which mankind seems drifting we must still subject ourselves collectively to those severities which answer to our real position upon this only partly hospitable globe. We must make new energies and hardihoods continue the manliness to which the military mind so faithfully clings. Martial virtues must be the enduring cement; intrepidity, contempt of softness, surrender of private interest, obedience to command, must still remain the rock upon which states are built—unless, indeed, we wish for dangerous reactions against commonwealths fit only for contempt, and liable to invite attack whenever a center of crystallization for military-minded enterprise gets formed anywhere in their neighborhood.

The war-party is assuredly right in affirming and reaffirming that the martial virtues, although originally gained by the race through war, are absolute and permanent human goods. Patriotic pride and ambition in their military form are, after all, only specifications of a more general competitive passion. They are its first form, but that is no reason for supposing them to be its last form. Men now are proud of belonging to a conquering nation, and without a murmur they lay down their persons and their wealth, if by so doing they may fend off subjection. But who can be sure that *other aspects of one's country* may not, with time and education and suggestion enough, come to be regarded with similarly effective feelings of pride and shame? Why should men not some day feel that it is worth a blood-tax to belong to a collectivity superior in *any* ideal respect? Why should they not blush with indignant shame if the community that owns them is vile in any way whatsoever? Individuals, daily more numerous, now feel this civic passion. It is only a question of blowing on the spark till the whole population gets incandescent, and on the ruins of the old morals of military honor, a stable system of morals of civic honor builds itself up. What the whole community comes to believe in grasps the individual as in a vise. The war-function has grasped us so far; but constructive interests may some day seem no less imperative, and impose on the individual a hardly lighter burden.

Let me illustrate my idea more concretely. There is nothing to make one indignant in the mere fact that life is hard, that men should toil and suffer pain. The planetary conditions once for all are such, and we can stand it. But that so many men, by mere accidents of birth and opportunity, should have a life of *nothing else* but toil and pain and hardness and inferiority imposed upon them, should have *no* vacation, while others natively no more deserving never get any taste of this campaigning life at all—*this* is capable of arousing indignation in reflective minds. It may end by seeming shameful to all of us that some of us have nothing but campaigning, and others nothing but unmanly ease. If now—and this is my idea—there were, instead of military conscription a conscription of the whole youthful population to form for a certain number of years a part of the army enlisted against *nature*, the injustice would tend to be evened out, and numerous other goods to the commonwealth would follow. The military ideals of hardihood and discipline would be wrought into the growing fiber of the people; no one would remain blind as the luxurious classes now are blind, to man's real relations to the globe he lives on, and to the permanently sour and hard foundations of his higher life. To coal and iron mines, to freight trains, to fishing fleets in December, to dishwashing, clothes-washing and window-washing, to road-building and tunnelmaking, to foundries and stoke-holes, and to the frames of skyscrapers, would our gilded youths be drafted off, according to their choice, to get the childishness knocked out of them, and to come back into society with healthier sympathies and soberer ideas. They would have paid their blood-tax, done their own part in the immemorial human warfare against nature, they would tread the earth more proudly, the women would value them more highly, they would be better fathers and teachers of the following generation.

Such a conscription, with the state of public opinion that would have required it, and the many moral fruits it would bear, would preserve in the midst of a pacific civilization the manly virtues which the military party is so afraid of seeing disappear in peace. We should get toughness without callousness, authority with as little criminal cruelty as possible, and painful work done cheerily because the duty is temporary, and threatens not, as now, to degrade the whole remainder of one's life. I spoke of the "moral equivalent" of war. So far, war has been the only force that can discipline a whole community, and until an equivalent discipline is organized, I believe that war must have its way. But I have no serious doubt that the ordinary prides and shames of social man, once developed to a certain intensity, are capable of organizing such a moral equivalent as I have sketched, or some other just as effective for preserving manliness of type. It is but a question of time, of skillful propagandism, and of opinion-making men seizing historic opportunities.

The martial type of character can be bred without war. Strenuous honor and disinterestedness abound elsewhere. Priests and medical men are in a fashion educated to it, and we should all feel some degree of it imperative if we were conscious of our work as an obligatory service to the state. We should be *owned,* as soldiers are by the army, and our pride would rise accordingly. We could be poor, then, without humiliation, as army officers now are. The only thing needed henceforward is to inflame the civic temper as past history has inflamed the military temper. H. G. Wells, as usual, sees the center of the situation. "In many ways," he says, "military organization is the most peaceful of activities. When the contemporary man steps from the street, of clamorous insincere advertisement, push, adulteration, underselling and intermittent employment, into the barrack-yard, he steps on to a higher social plane, into an atmosphere of service and cooperation and of infinitely more honorable emulations. Here at least men are not flung out of employment to degenerate because there is no immediate work for them to do. They are fed and drilled and trained for better services. Here at least a man is supposed to win promotion by self-forgetfulness, and not by self-seeking. And beside the feeble and irregular endowment of research by commercialism, its little short-sighted snatches at profit by innovation and scientific economy, see how remarkable is the steady and rapid development of method and appliances in naval and military affairs! Nothing is more striking than to compare the progress of civil conveniences which has been left almost entirely to the trader, to the progress in military apparatus during the last few decades. The house-appliances of to-day, for example, are little better than they were fifty years ago. A house of to-day is still almost as ill-ventilated, badly heated by wasteful fires, clumsily arranged and furnished as the house of 1858. Houses a couple of hundred years old are still satisfactory places of residence, so little have our standards risen. But the rifle or battleship of fifty years ago was beyond all comparison inferior to those we possess; in power, in speed, in convenience alike. No one has a use now for such superannuated things." [1]

Wells adds[2] that he thinks that the conceptions of order and discipline, the tradition of service and devotion, of physical fitness, unstinted exertion and universal responsibility, which universal military duty is now teaching European nations, will remain a permanent acquisition, when the last ammunition has been used in the fireworks that celebrate the final peace. I believe as he does. It would be simply preposterous if the only force that could work ideals of honor and standards of efficiency into English or American natures should be the fear of being killed by the Germans or the Japanese. Great indeed is fear; but it is not, as our military enthusiasts believe and try to make us believe, the only stimulus known for awakening the higher ranges of men's spiritual energy. The amount of alteration in public opinion which my utopia postulates is vastly less than the difference between the mentality of those black warriors who pursued Stanley's party on the Congo with their cannibal war-cry of "meat! meat" and that of the "general staff" of any civilized nation. History has seen the latter interval bridged over: the former one can be bridged over much more easily.—William James in the POPULAR SCIENCE MONTHLY for October, 1910.

WAR AND MANHOOD

THOSE who fall in war are the young men of the nations, the men between the ages of eighteen and thirty-five, without blemish so far as may be—the men of courage, alertness, dash and recklessness, the men who value their lives as naught in the service of the nation. The man who is left is for better and for worse the reverse of all this, and it is he who determines what the future of the nation shall be.

However noble, encouraging, inspiring, the history of modern Europe may be, it is not the history we should have the right to expect from the development of its racial elements. It is not the history that would have been made by these same elements released from the shadow

1 "First and Last Things," 1908, p. 215.

2 *Ibid.*, p. 226.

of the reversed selection of fratricidal war. And the angle of divergence between what might have been and what has been, will be determined by the percentage of strong men slain on the field of glory.

And all this applies, not to one nation nor to one group of nations alone, but in like degree to all nations, which have sent forth their young men to the field of slaughter. As with Greece and Rome, as with France and Spain, as with Mauritania and Turkestan, so with Germany and England, so with all nations who have sent forth "the best they breed" to the foreign service, while cautious, thrifty mediocrity filled up the ranks at home.

In his charming studies of "Feudal and Modern Japan," Mr. Arthur Knapp, of Yokohama, returns again and again to the great marvel of Japan's military prowess after more than two hundred years of peace. This was shown in the Chinese war. It has been more conclusively shown on the fields of Manchuria since Mr. Knapp's book was written. It is astonishing to him that, after more than six generations in which physical courage has not been demanded, these virile virtues should be found unimpaired. We can readily see that this is just what we should expect. In times of peace there is no slaughter of the strong, no sacrifice of the courageous. In the peaceful struggle for existence there is a premium placed on these virtues. The virile and the brave survive. The idle, weak and dissipated go to the wall. "What won the battles on the Yalu, in Korea or Manchuria," says the Japanese, Nitobe, "was the ghosts of our fathers guiding our hands and beating in our hearts. They are not dead, these ghosts, those spirits of our war-like ancestors. Scratch a Japanese, even one of the most advanced ideas, and you will find a Samurai." If we translate this from the language of Shintoism to that of science we find it a testimony to the strength of race-heredity, the survival of the ways of the strong in the lives of the self-reliant.

If after two hundred years of incessant battle Japan still remained virile and warlike, that would indeed be the marvel. But that marvel no nation has ever seen. It is doubtless true that war-like traditions are most persistent with nations most frequently engaged in war. But the traditions of war and the physical strength to gain victories are very different things. Other things being equal, the nation which has known least of war is the one most likely to develop the "strong battalions" with whom victory must rest.

As Americans we are more deeply interested in the fate of our mother country than in that of the other nations of Europe.

What shall we say of England and of her relation to the reversed selection of war?

Statistics we have none, and no evidence of tangible decline that Englishmen will not indignantly repudiate. When the London press in the vacation season fills its columns with editorials on English degeneration, it is something else to which these journalists refer. Their problem is that of the London slums, of sweat-shops and child-labor, of wasting overwork and of lack of nutrition, of premature old age and of sodden drunkenness—influences which bring about the degeneration of the individual, the inefficiency of the social group, but which for the most part leave no trace in heredity and are therefore no factor in the degeneration of the race. Such degradation is at once cause, effect and symptom—a sign of racial inadequacy, a cause of further enfeeblement and an effect of unjust and injurious social, political and industrial conditions in the past.

But the problem before us is not the problem of the slums. What mark has been left on England by her great struggles for freedom and by the thousand petty struggles to impose on the world the semblance of order called "Pax Britannica," the British peace?

To one who travels widely through the counties of England some part of the cost is plain.

> There's a widow in sleepy Chester
>   Who mourns for her only son;
> There's a grave by the Pabeng River—
>   A grave which the Burmans shun.

This is a condition repeated in every village of England, and its history is recorded on the walls of every parish church. Everywhere can be seen tablets in memory of young men—gentlemen's sons from Eton and Rugby and Winchester and Harrow, scholars from Oxford and Cambridge, who have given up their lives in some far-off petty war. Their bodies rest in Zululand, in Cambodia, in the Gold Coast, in the Transvaal. In England only they are remembered. In the parish churches these records are numbered by the score. In the cathedrals they are recorded by the thousand. Go from one cathedral town to another—Canterbury, Winchester, Chidester, Exeter, Salisbury, Wells, Ely, York, Lincoln, Durham, Litchfield, Chester (what a wonderful series of pictures this list of names calls up!), and you will find always the same story, the same sad array of memorials to young men. What would be the effect on England if all of these "unreturning brave" and all that should have been their descendants could be numbered among her sons to-day? Doubtless not all of these were young men of character. Doubtless not all are worthy even of the scant glory of a memorial tablet. But most of them were worthy. Most of them were brave and true, and most of them looked out on life with "frank blue Briton eyes."

This too we may admit, that war is not the only destructive agency in modern society, and that in the struggle for existence the England of to-day has had many advantages which must hide or neutralize the waste of war.

It suggests the inevitable end of all empire, of all dominion of man over man by force of arms. More than all who fall in battle or are wasted in the camps, the nation misses the "fair women and brave men" who should have been the descendants of the strong and the manly. If we may personify the spirit of the nation, it grieves most not over its "unreturning brave," but over those who might have been but never were, and who, so long as history lasts, can never be.

It is claimed that by the law of probabilities as developed by Quetelet, there will appear in each generation the same number of potential poets, artists, investigators, patriots, athletes and superior men of each degree. But this law has no real validity. Its pertinence involves the theory of continuity of paternity, that in each generation a percentage practically equal of men of superior force or superior mentality should survive to take the responsibilities of parenthood. Otherwise Quetelet's law becomes subject to the operation of another law, the operation of reversed selection, or the biological "law of diminishing returns." In other words, breeding from an inferior stock is the sole agency in race degeneration, as selection natural or artificial along one line or another is the sole agency in race progress.

And all laws of probabilities and of averages are subject to a still higher law, the primal law of biology, which no cross-current of life can overrule or modify: Like the seed is the harvest.

And because this is true, arises the final and bitter truth: "Wars are not paid for in war time. The bill comes later!"—David Starr Jordan in the POPULAR SCIENCE MONTHLY for January, 1911.

SCIENCE AND INTERNATIONAL GOOD WILL

SCIENCE with its applications has been one of the principal factors leading to peace and international good will. Science, democracy and the limitation of warfare are the great achievements of modern civilization. They have advanced together almost continuously from the beginnings of the universities of Bologna, Paris and Oxford in the twelfth century to their great triumphs in the nineteenth century and the present promise of their complete supremacy. It may be urged reasonably that science is the true cause of democracy and that science and democracy together are the influences most conducive to permanent and universal peace.

The applications of science in industry, agriculture and commerce, in the prevention of disease and of premature death, have abolished the need of excessive manual labor. It long ago became unnecessary for the great majority of the people to be held in bondage in order that a few free citizens might have education and opportunity, and slavery has been gradually driven from the world. The vast progress of scientific discovery and invention in the nineteenth century has reduced to a moderate amount the daily labor required from each in order that all may be adequately fed, clothed and housed. The death-rate has been decreased to one half; the ensuing lower birth-rate has freed nearly half the time of women and reduced proportionately the labor of men. The period of childhood and youth may be devoted to universal education, and equality of opportunity can be given to all. It is no longer needful to depend on a privileged class to conduct the affairs of government and to supply men of performance. Those selected from all the people as most fit can be given the preparation and opportunity needed to enable them to become leaders, and every one can take an intelligent share in political affairs and in appreciation of the higher things of life.

In giving us democracy science has made its greatest contribution to the limitation of warfare. It must be admitted that a democratic people may be inflamed into a mob mad for war; but this is not likely to happen in the case of a war of policy or of aggression. In the past wars have been more often due to the ambitions, difficulties and intrigues of kings and princes than to the passions of the people, and the decrease of wars has been largely a result of the establishment of constitutional governments and of the legalization of the methods of conscription and taxation. If a declaration of war or an ultimatum leading to war were subject to a referendum, the vote being taken not too promptly, and if the estimated cost of the war were collected in taxes in advance, there would not be many wars.

We are still far from having a true political and social democracy. The production of wealth has increased rapidly; but we have not learned to distribute it justly or to use it wisely. The education supplied by our schools is inadequate and inept. We may be confident that a complete democracy will be the strongest force for peace that the world has seen. Even now the great mass of the people, most of them having some education and some property, are the true guarantees against wanton war. A king can no longer summon his nobles and the chiefs gather together their retainers to invade a foreign country. A war which, with its accompanying pestilence and famine, would reduce the population of a country to one half, as in the case of the thirty years' war, is now almost inconceivable. And this we owe to social and political democracy, which in turn we owe to science.

As a result of scientific progress and invention, the law of Malthus has been reversed. The means of subsistence increase more rapidly than the population. The sinister voluntary limitation of childbirth, which may give rise to racial deterioration and actual depopulation, is unnecessary. As population increases under a given condition of culture, the number of men of genius and talent competent to make the labor of each more efficient increases in proportion; as their inventions are of benefit to all, the means of subsistence tend to increase as the square of the population. As the level of education and culture is raised, and as democracy is perfected, so that each is given opportunity to do the work for which he is fit, the wealth and means of subsistence increase still more rapidly. The law of Malthus and the law of diminishing returns, like the law of the degradation of energy, may ultimately prevail, but not in any future with which we are concerned. The population of a civilized country, in which science is cultivated, need not be limited by famine, pestilence or war. Over-population and the need of expansion by conquest are obviated by democracy and science; the cause of war which may be regarded as inevitable and legitimate is thus abolished. In providing adequately for the subsistence of an increasing population, science has made a contribution to peace the magnitude of which can not be easily overstated.

Another great service for peace to be credited to science is the development of commerce, travel and intercommunication. Steam and electricity are handmaids of peace. Trade disputes and the misadventures of missionaries, travelers and immigrants may serve as causes or pretexts of wars, but the balance of commerce, travel and immigration is large on the side of peace. With the existing commerce among the nations, each dependent on every other, a war of any kind does injury to all. A nation at war destroys its own property throughout the world, and all the nations suffer. A neutral nation can no more afford to countenance a needless war than mobs burning its own cities and killing its own citizens. In New York, London, Berlin and Paris are business houses and representatives of every country in the world. How could any nation wish to destroy or to permit the destruction of these cities? . . .

Science has given us democracy, it has given us ample means of subsistence, it has given us commerce and intercommunication, and these three achievements are the principal factors which have lessened warfare and will eventually lead to its complete abolition. Other contributions of science, though less momentous, are by no means unimportant. Warfare is now in large measure applied science, and this tends towards its decrease. Wars between nations with scientific equipment and savage and barbarous peoples are no longer waged on equal terms and are of short duration. The extermination, despoliation and subjugation of the non-Caucasian races may be the world's great tragedy, and in so far as some of these peoples are able to adopt our science there will be a readjustment which may be written in blood or may be a triumph of common sense and justice. However this may be, the invincibility that science has conferred on the western nations has made them safe from attack and invasion, and while it may on occasion have led to wanton aggression, it has, on the whole, limited warfare. If we call to mind the centuries of invasion and threats of invasion by Northmen, Ottomans and Saracens, we can appreciate the value of the means of defense which science has given to the civilized nations.

The making of warfare an applied science by the western nations and by one eastern nation has tended also to prevent war between nations so equipped. When war is a game of skill rather than of chance, it is likely to be undertaken only after careful consideration of the conditions and consequences. The cost is enormous and must be carefully weighed. The interests of the money lenders are usually on the side of peace and become increasingly so as war continues. If war does occur between two great nations it is likely to be of short duration. It can not drag on through tens of years as formerly. Its horrors are also reduced; non-combatants are not so much concerned, and soldiers suffer less from disease—far more dreadful than violence—owing to the shorter duration of wars and to hygiene, medicine and surgery. It may be hoped that science has accomplished, on the whole, more for defense than for aggression; torpedoes, mines, submarines and aeroplanes are more effective for protection than for attack. The cost of modern armaments is so immense that this in itself will lead to their limitation and to the settlement of difficulties otherwise than by appeal to arms.

There is a psychological aspect of modern scientific warfare, which tends to discredit it. The heroism and the bravery, the excitement of personal contact and the exhibition of personal prowess, the romance and the occasional chivalry, are largely gone. Men cooped up in battleships or displayed like pawns on the field are not much greater heroes to themselves or to others than workers in a mine exposed to nearly equal danger. Officers under constant instructions from the seat of government and telegraphing their orders from a point of safety fall to the level of ordinary men of affairs. Tin soldiers will not forever stir the imagination of children in the nursery. Providence is on the side favored by the money lenders and having the best organized commissariat. War becomes brutal and disgusting; at its best like the business of the hangman, at its worst like infanticide.—J. McKeen Cattell in the Popular Science Monthly for April, 1912.

THE PROGRESS OF SCIENCE

THE MAD WAR

An obscure French war of the fifteenth century is known to historians as the *guerre folle*, but no carnage so well deserves to be called the "mad war" as the international slaughter now raging in Europe. There existed an inevitable conflict of inherited memories between Germany and France, an inevitable commercial conflict between Germany and Great Britain, an inevitable racial conflict between Teutons and Slavs. But these conflicts might have been carried forward to the benefit of civilization instead of for its subversion. The decrease in the death rate, the maintenance of the birth rate, the care and education of children, the improvement of the condition of the laboring classes, the lessening of pauperism, waste, vice and crime, the decrease of debts and the accumulation of wealth, the progress of science and its applications to manufactures and commerce—these are the conditions of national greatness, and each nation as it advances adds to the welfare of its rivals even while it may outstrip them.

Warfare results in the reverse of all these, scarcely less for the nations which win than for those which lose. It is terribly obvious that the death rate is increased both by violence and by disease. The birth rate must decline for a time and afterwards venereal disease is spread broadcast. A recent test in England showed that only one man in a hundred of those apparently in good health gave the reaction for syphilis, while 19 per cent. of those who had been in the army showed the signs of infection. In time of war children are neglected and their interests perverted. In the Franco-German war a hundred and fifty thousand men died, leaving a corresponding host of widows and orphans.

> Lass sie betteln geh'n,
> Wenn sie hungrig sind.

"Let them beg if they are hungry." Women are in time of war thrust back from their slow advance to equality with men. The laboring classes have the bonds of their industrial slavery more closely drawn. The rich also suffer, though there are always vultures who glut themselves. In the Franco-German war England supplied to half a million French soldiers shoes with paper soles. In the present war the international commerce of Germany, amounting to over three billion dollars a year, will be annihilated. Great Britain, Germany and France have each voted already credits of a billion dollars for the taxing of future generations and a paper wealth by which the well-to-do exploit the poor. Each day of the war more money will be wasted than is needed to endow a university such as Berlin. Everywhere the energies of men are diverted from scientific and social progress to destruction.

Even a pan-European war does not mean the bankruptcy or suicide of civilization. The hundred and fifty thousand men of France who died in their war are after all a lesser sacrifice than the three million children who each year die needlessly in Russia. Alcohol costs more in wealth and health and lives than any war. Warfare is only a vast dramatic exhibition of our savage origin and semi-barbaric condition. In spite of their bureaucratic military organizations, the great nations of Europe had postponed war for more than forty years. Even now both the governments and the peoples of Great Britain, Russia, Italy and Belgium were disposed to peace. In the United States no mob spirit of war was stirred by the president's invasion of Mexico, and the sympathies of our people are against the aggressor in the wanton war of Europe. There we may look for a second Napoleon the little rather than for a second Napoleon the great. Never again will there be a thirty years' war, destroying over half the population of a great nation. Slowly but surely the energies of men are turning toward peace on earth and good will among its nations.

THE RACES OF THE EUROPEAN NATIONS AND THEIR NATURAL INCREASE

THE official German justification of the mad and wanton European war is that it is a defense of the Teutonic culture and people against the semi-Asiatic and barbaric Slav hordes. The verdict of history will probably be that it was a war of calculation for caste and national aggrandizement and a war of miscalculation. The German emperor and his bureaucratic military entourage probably held that the time was ripe for an extension of German influence in the Balkans and towards Asia Minor, with an increase of its African possessions at the expense of France. But it is by no means clear why, if the serpent was prepared to use its fangs, it did not show its alleged wisdom. If after the rough ultimatum and attack of Austria on Servia, Germany had waited in preparation, it would apparently have been in far better position. If Russia had attacked Austria on behalf of Servia, Germany could have gone to the defense of Austria and had its will in the Balkans. If France had then attacked Germany, Italy could only have avoided war on France by breaking its treaty; Great Britain and Belgium would probably have remained neutral.

The calculation in Berlin was probably that the time had come for the use of its perfected military machine for its glorification at home and abroad. They knew that the Balkan states were at odds with one another, that there were internal disorders in Russia, which was improving its military system and would have four dreadnoughts ready in the autumn, that France had made large appropriations for defensive works and armaments and had increased the period of military service, that England was on the edge of civil war; they assumed that they would have the support of Italy and Turkey, that Japan was not in question, that Belgium would permit the use of its territory, that Great Britain might submit, that a quick and crushing attack on France would give them a war indemnity and new possessions in Africa and that they would then be able to turn the whole force of their arms on Russia. In so far as this was the calculation at Berlin, it has in part, miscarried; the rest lies on the knees of the gods.

A glance at the accompanying map shows roughly the distribution of the races in Europe. National sentiment is somewhat dependent on racial origin, on language, on religion and on other institutions; but only in a temporary and limited way. All the nations of Europe are composed of peoples of complex racial descent. Switzerland maintains admirably its national homogeneity with diverse races and languages. Protestant Prussia has united with catholic Bavaria. Austria is a complex of nations, languages and races. New York is a collection of cities of diverse nationality, race, language, religions and institutions. In the present war there can be no real conflict of Teuton and Slav, when the Austrian population is more Slav than Teuton and German dominion has already encroached on Slavic population to the east. There may result a change in national boundaries, but scarcely of racial dominance. Germany has already as an evil inheritance from Bismarck a small French population on its west. It can only annex the northern coast of France and Belgium at an untold cost for a future generation; the same holds for Russian Poland and the Baltic provinces. Russia has better claims to reconstruct an autonomous Poland and annex parts of Austria.

We may hope in the interest of future peace that the map of Europe will not be considerably altered. The chief changes are likely to be in Africa where apart from the English and Dutch in the south there are no real colonies, only exploiting "protectorates." Great Britain controls nearly 2,800,000 square miles, France some 2,300,000 square miles, Germany nearly 1,000,000 square miles; Belgium, Portugal and Italy possess large areas. If Germany loses in the war, Great Britain is almost certain to seize German East Africa to control the path from the Cape to Cairo. France, Belgium, Italy and Portugal will probably increase their holdings at the cost of Germany. If Germany should dominate Europe, it will seek to control Africa and to increase instead of losing its possessions in the far east. It will aim to supplant Great Britain as a world-wide empire.

But the time has probably gone by when Germany can establish colonies as Great Britain did. It may rule subject races as Great Britain does in India, but it can not supply men for colonies such as Canada and the Australian commonwealth. In 1850 German-born residents of the United States outnumbered a hundredfold those born in Austria-Hungary, Russia and Italy together, now the immigration from each of these nations is ten times that from Germany. There are some 13,000,000 Germans in North and South America, but the total emigration from Germany to the United States has de-

From the N. Y. *Evening Post.*

BOUNDARIES OF CENTRAL EUROPE AND THE DISTRIBUTION OF RACES.

From the N. Y. *Sun*.

THE EUROPEAN POSSESSIONS IN AFRICA.

creased to 25,000 and to all other non-European countries to one or two thousand. The birth rate in the city of Berlin has fallen from 40 per thousand to 20 per thousand. Germany has no larger population than it can provide for and needs at home. It has none to spare for emigration, still less for the field of battle.

The birth rate and the natural increase of population are the fundamental factors in racial advance. The Slavs have overrun northwestern Europe and will continue to spread to the south and west. Their natural increase of population far exceeds that of Germany, and will do so increasingly as the death rate declines in Russia and the birth rate continues to decline in Germany. There are now three Russian children born for each German child. How can Germany's army of four million soldiers contend against a surplus of five million children born each year in Russia? If Germany had waited a little longer for its war, England would have been on its side. But nothing except a decline in the Russian birth rate can check its ultimate triumph. We can only hope that it will be a victory of peace and civilization.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. Francis Humphreys Storrer, long professor of agricultural chemistry at Harvard University; of the Rev. Horace Carter Hovey, known for his publications on caverns; of Dr. Frederic Lawrence Kortright, professor of chemistry at the University of West Virginia; of Professor Franklin William Hooper, director of the Brooklyn Institute of Arts and Sciences; of Professor Albert Smith Bickmore, emeritus head of the department of public instruction of the American Museum of Natural History; of the Rev. Osmond Fisher, at one time tutor of Jesus College, Cambridge, known for his important contributions to geology, and of Professor Paul Reclus, the distinguished Paris surgeon.

Dr. Charles W. Eliot, president emeritus of Harvard University, has been elected a corresponding fellow of the British Academy.—Professor Elie Metchnikoff, assistant director of the Institut Pasteur, will next year celebrate his seventieth birthday and the fiftieth anniversary of his doctorate. A committee has been formed, under the presidency of Dr. Roux, director of the Institut Pasteur, for the celebration of the anniversary which will include the publication of a "Festschrift."

The following American scientific men have accepted invitations to attend the Australasian meeting of the British Association as the guests of the New Zealand government: Dr. C. G. Abbot, Smithsonian Institution; Dr. L. H. Bailey, Cornell University; Mr. Lyman J. Briggs, Department of Agriculture; Professor A. P. Coleman, University of Toronto; Dr. Edwin G. Conklin, Princeton University; Dr. Charles B. Davenport, Carnegie Institution; Professor William M. Davis, Harvard University; Dr. George A. Dorsey, Field Museum of Natural History; President G. C. Creelman, Ontario Agricultural College, Guelph; Professor R. T. Ely, University of Wisconsin; Professor E. C. Franklin, Stanford University; Professor P. H. Hanus, Harvard University; President E. F. Nichols, Dartmouth College; Dr. Ira Remsen, The Johns Hopkins University; Professor William M. Wheeler, Bussey Institution, Harvard University.

Mr. Asa G. Chandler has given $1,000,000 and citizens of Atlanta have guaranteed $500,000 for the establishment of an Atlanta University, under the auspices of the Methodist Church. It is said that a theological school will be the first to be opened.

THE POPULAR SCIENCE MONTHLY.

OCTOBER, 1914

PHENOMENA OF INHERITANCE[1]

By Professor EDWIN G. CONKLIN

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A. OBSERVATIONS OF INHERITANCE

THE observations of men in all ages have established the fact that in general "like produces like," and that, in spite of many exceptions, children are in their main characteristics like their parents. And yet offspring are never exactly like their parents, and this has led to the saying that "like does not produce like but only somewhat like." What is meant is that there are general resemblances but particular differences between parents and offspring.

Individuals and Their Characters

In considering organic individuals one may think of them as wholes or as composed of parts, as indivisible unities or as constituent characters; either aspect is a true one and yet neither is complete in itself. Formerly in discussions on heredity the individual was regarded in its entirety and when all hereditary resemblances and differences were averaged it was said that one child resembled the father, another child the mother. This method of lumping together and averaging resemblances and differences led to endless confusion. In heredity, no less than in anatomy, it is necessary to deal with the constituents of organisms; in short, the organism must be analyzed and each part studied by itself. Francis Galton was one of the first to bring order out of chaos by dealing with traits or characters singly instead of treating all together. He made careful studies on the inheritance of weight and size in the seeds of sweet peas, and on the inheritance of stature, eye-color, intellectual capacity, artistic ability and certain diseases in man. At the same time that Galton was thus laying the foundations for a scientific study of heredity by dealing with characters separately,

[1] Third of the Norman W. Harris Lectures for 1914 at Northwestern University on "Heredity and Environment in the Development of Men," to be published by the Princeton University Press.

another and even greater student of heredity, Gregor Mendel, was doing the same thing in his experiments with garden peas, but inasmuch as Mendel's work remained practically unknown for many years, Galton has been rightly recognized as the founder of the scientific study of heredity.

Of course, neither Galton nor any one else, who has followed his method of dealing with the characters of organisms singly, ever supposed that such characters could exist independently of other characters and apart from the entire organism. This is such a self-evident fact that it may seem needless to mention it, and yet there have been critics who have believed, or have assumed to believe that modern students of heredity attempt to analyze organisms into independently existing characters, whereas in most cases they have done only what the anatomist does in treating separately the various organs of the body.

Hereditary Resemblances and Differences

The various characters into which an organism may be analyzed show a greater or smaller degree of resemblance to the corresponding characters of its parents. Whenever the differential cause of a character is a germinal one, the character is, by definition, inherited; on the other hand, whenever this differential cause is environmental the character is not inherited. While it is true that inheritance is most clearly recognized in those characters in which offspring resemble their parents, even characters in which they differ from their parents may be inherited, as is plainly seen when, in any character, a child resembles a grandparent or a more distant ancestor more than either parent. Sometimes actually new characters arise in descendants which were not present in ascendants, but which are thereafter inherited. Accordingly inherited characters may be classified as resemblances and differences, though both are determined by germinal organization, or heredity. There is, therefore, no fundamental difference between inherited similarities and dissimilarities. Heredity and variation are not opposing nor contrasting tendencies which make offspring like their parents in one case and unlike them in another; really inherited characters may be like or unlike those of the parents.

On the other hand, many resemblances and differences between parents and offspring are not due to heredity at all, but to environmental conditions. By means of experiment it is possible to distinguish between hereditary and environmental resemblances and differences, but among men where experiments are generally out of the question it is often difficult or impossible to make this distinction.

I. *Hereditary Resemblances*

1. *Racial Characters.*—All peculiarities which are characteristic of a race, species, genus, order, class and phylum are of course inherited,

otherwise there would be no constant characteristics of these groups and no possibility of classifying organisms. The chief characters of every living thing are unalterably fixed by heredity. Men do not gather grapes of thorns nor figs of thistles. Every living thing produces offspring after its own kind. Men, horses, cattle; birds, reptiles, fishes; insects, mollusks, worms; polyps, sponges, microorganisms—all of the million known species of animals and plants differ from one another because of inherited peculiarities—because they have come from different kinds of germ cells.

2. *Individual Characters.*—Many characters which are peculiar to certain individuals are known to be inherited, and in general use the word inheritance refers to the repetition in successive generations of such individual peculiarities. Among such individual characters are the following:

(*a*) *Morphological Features.*—Hereditary resemblances are especially recognizable in the gross and minute anatomy of every organism in the form, structure, location, size, color, etc., of each and every part. The number of such individual peculiarities which are inherited is innumerable and only a few of the more striking—of the greatest and smallest of these can be mentioned.

It is a matter of common knowledge that unusually great or small stature runs in certain families, and Galton developed a formula for determining the approximate stature of children from the known stature of the parents and from the mean stature of the race. However his statistical and mathematical formulæ give only general or average results, from which there are many individual departures and exceptions.

In the same way the color of the skin, the color and form of hair, and the color of eyes are, in general, like those of one or more of the parents or grandparents. We all know that certain facial features such as the shape and size of eyes, nose, mouth and chin are generally characteristic of certain families.

But the inheritance of anatomical features extends to much more minute characters than those just mentioned. In certain families a few hairs in the eyebrows are longer than the others; or there may be patches of parti-colored hair over the scalp; or dimples in the cheek, chin, or other parts of the skin may occur; and these trifling peculiarities are inherited with all the tenacity shown in the transmission of more important characters. Johannsen has found races of beans in which the average weight of individual seeds differed only by .02 to .03 gram, and yet these minute differences in weight were characteristic of each race and were of course inherited. Jennings has found races of paramecium which show hereditary differences of .005 mm. in length (Fig. 46). Nettleship says that the lens of the human eye weighs only about 175 milligrams, or about one three millionth part of the body weight, and in hereditary cataract only about one twentieth part of the lens becomes opaque, and yet this minute fraction of the body weight shows the influence of heredity. Even the size, shape and

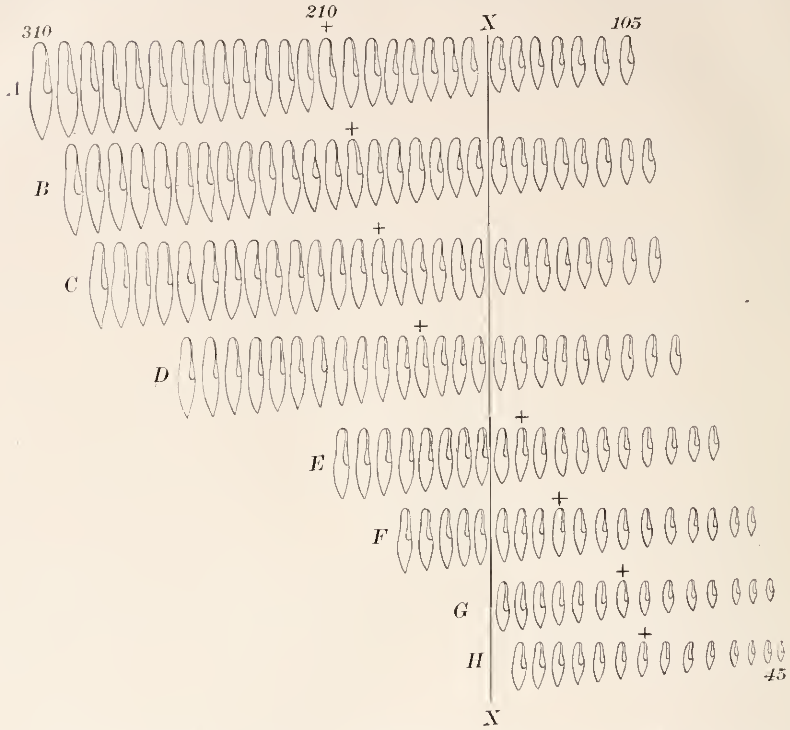


FIG. 46. DIAGRAM OF EIGHT DIFFERENT RACES OF PARAMECIUM, EACH HORIZONTAL ROW (*A–H*) REPRESENTING A SINGLE RACE. The individual showing the mean size in each race is indicated by + ; the mean of all the races is shown by the line *X–X*. The numbers are the length in microns (one thousandth of a millimeter), × 43. (After Jennings.)

number of the cells in certain organs, and in given embryonic stages, may be repeated generation after generation; and if our analysis were sufficiently complete we should doubtless find that even the minute parts of cells, such as nuclei, chromosomes and centrosomes, show individual peculiarities which are inherited.

(*b*) *Teratological and Pathological Peculiarities* are really only unusual or abnormal anatomical characters, but of such interest and importance as to deserve special mention. Many such abnormalities are undoubtedly inherited, among which are the following: polydactylism, in which more than the normal number of digits are present; syndactylism, or a condition of webbed fingers and toes; brachydactylism, in which the fingers are short and stumpy and usually contain less than the normal number of joints; acondroplasy, or short and crooked limbs, such as occur in certain breeds of dogs and sheep and in certain human dwarfs; myopia in which the eyeball is elongated; glaucoma or swelling of the eyeball; coloboma, or open suture of the iris; otosclerosis, or thickened tympanic membrane, causing "hardness of hearing"; some forms of deaf-mutism, due to certain defects of the inner ear; and many other characters too numerous to mention here. On the other hand many abnormal or monstrous conditions are due to abnormal environment and are not inherited.

The question of the inheritance of diseases may be briefly considered here. If a disease is due to some defect in the hereditary constitution, it is inherited; otherwise, according to our definition of heredity, it is not. Of course no disease develops without extrinsic causes but when one individual takes a disease while another under the same conditions does not, the differential cause may be an inherited one, or it may be due to differences in the previous conditions of life. There is no doubt that certain diseases run in families and have the appearance of being inherited, but in this case as in many others it is extremely difficult in the absence of experiments to distinguish between effects due to intrinsic causes and those due to extrinsic ones. Where the specific cause of a disease is some microorganism the individual must have been infected at some time or other, almost invariably after birth. In few instances, is the oosperm itself infected, and even when it is this is not, strictly speaking, a case of inheritance, but rather one of early infection. Pearson has found that there is a marked correlation (represented by the number .55 when complete correlation is 1) between the tuberculous parents and tuberculous children, but there is very little evidence that the child is ever infected before birth. What is inherited in this case is probably slight resistance to the tubercle bacillus. There is evidence that almost all adult persons have been infected at one time or another by this bacillus, but it has not developed far in all of them because some have superior powers of resistance. Such greater or smaller resistance, stronger or weaker build, is inherited, and while diminished resistance is not the direct cause of tuberculosis it is a predisposing cause. The same is probably true of many other diseases, the immediate causes of which are extrinsic, while only the more remote, or predisposing causes, are hereditary.

(*c*) *Physiological peculiarities* are inherited as well as morphological ones; indeed function and structure are only two aspects of one and the same thing, namely, organization. For all morphological characters there are functional correlatives, for functional characters morphological expressions, and if the one is inherited so is the other. But there are certain characters in which the physiological aspect is more striking than the morphological one. For example, longevity is a physiological character which is undoubtedly dependent upon many causes, but in the case of species which differ greatly in length of life there can be little doubt that we are dealing with an inherited character. The great differences in the length of life of an elephant and a mouse, of a parrot and a pigeon, of a cicada and a squash bug, are as surely the result of inherited causes as are the differences in structure between those animals. Within the same species different races or lines show characteristic differences in length of life; in the case of man the average length of life is much greater in some families than in others, and life insurance companies take account of this fact. Even within the same organism certain organs or cells are short-lived, whereas others are long-lived; some cells and organs live only through the early embryonic period, while others live as long as the general organism.

Obesity is another physiological character which may be inherited; the members of certain families grow fat in spite of themselves, while other families remain thin however well fed they may be. Here also many factors enter into the result, but it seems probable that the differentiating factor is a hereditary one. Baldness affects the male members of certain families when they have reached a given age, while in others neither care, dissipation nor age can rob a man of his bushy top. Hemophilia, or excessive bleeding, after an injury, which is due to a deficiency in the clotting power of the blood, is strongly inherited in the male line in certain families. Fecundity and a tendency to bear twins or triplets, left-handedness, a peculiar lack of resistance to certain diseases, and many other physiological peculiarities are probably inherited.

(*d*) *Psychological characters* appear to be inherited in the same way that anatomical and physiological traits are; indeed all that has been said regarding the correlation of morphological and physiological characters applies also to psychological ones. No one doubts that particular instincts, aptitudes and capacities are inherited among both animals and men, nor that different races and species differ hereditarily in psychological characteristics. Certain breeds of dogs such as the mastiff, the bull dog, the terrier, the collie, and many others, are characterized by peculiarities of temperament, affection, intelligence and disposition. No one who has much studied the subject can doubt that different human races and families show characteristic differences in these same respects. It is quite futile to argue that exceptional individuals may be found in one race with the mental characteristics of another race; the same could be said of different races of dogs, or of the sizes of different races of beans or of paramecia. The fact is that racial characteristics are not determined by exceptional and extreme individuals but by the average or mean qualities of the race; and measured in this way there is no doubt that certain types of mind and disposition are characteristic of certain families.

There is no longer any question that some kinds of feeble-mindedness, epilepsy and insanity are inherited, and that there is often a hereditary basis for nervous and phlegmatic temperaments, for emotional, judicial and calculating dispositions. Nor can it be denied that strength or weakness of will, a tendency to moral obliquity or rectitude, capacity or incapacity for the highest intellectual pursuits, occur frequently in certain families and appear to be inherited. In spite of certain noteworthy exceptions, which may perhaps be due to remarkable variations, statistics collected by Galton show that genius is hereditary; while the work of certain recent investigators, particularly Goddard, Davenport and Weeks, proves that feeble-mindedness and epilepsy are also inherited; and the careful work of Mott and of Rosanoff leaves no room for doubt that certain types of insanity are hereditary. It frequently happens that families in which hereditary insanity occurs also have other members afflicted with epilepsy, hysteria, alcoholism, etc., which would indicate that the thing inherited is an unstable condition of the nervous system which may take various forms under slightly different conditions. Woods has collected data concerning "Heredity in Royalty" which seem to show that very high or low grades of intellect and virtues may be traced through the royal families of Europe for several generations.

The general trend of all recent work on heredity is unmistakable, whether it concerns man or lower animals. The entire organism, consisting of structures and functions, body and mind, develops out of the germ, and the organization of the germ determines all the *possibilities* of development of the mind no less than of the body, though the actual realization of any possibility is dependent also upon environmental stimuli.

II. *Hereditary Differences*

There are many limitations or exceptions to the general rule that children resemble their parents. Sometimes these differences are due to new combinations of ancestral characters, sometimes they are actually new characters not present so far as known in any of the ancestors, though even such new characters must arise from new combinations of the *elements* of old characters, as we shall see later.

1. *New Combinations of Characters.*—In all cases of sexually produced organisms new combinations of ancestral characters are evident. Usually a child inherits some traits from one parent and other traits from the other parent, so that it is a kind of mosaic of ancestral traits. Such inheritance, bit by bit, of this character from one progenitor and that from another was described by Galton as "particulate" (Fig. 47). On the other hand Galton supposed that in some instances a child might inherit all or nearly all of his traits from one parent; such inheritance he called "alternative" (Fig. 47).

In other cases the traits of the parents appear to blend in the offspring, as for example, in the skin color of mulattoes; such cases were called by Galton "blending" inheritance (Fig. 47). Sometimes characters appear in offspring which were "latent" in the parents but were "patent" in one or more of the grandparents; such skipping of a generation, during which a character remains "latent," has long been known as "atavism." At other times characters which were present in distant ancestors, but which have since dropped out of sight, or have remained "latent," reappear in descendants; such cases are known as "reversions."

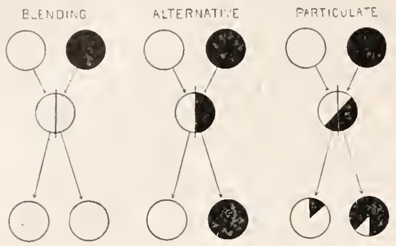


FIG. 47. DIAGRAM OF GALTON'S "LAW OF ANCESTRAL INHERITANCE." The whole heritage is represented by the entire rectangle; that derived from each progenitor by the smaller squares; the number of the latter doubles in each ascending generation while its area is halved. After Thompson.)

In still other cases certain characters appear only in the male sex, others only in the female, this being called "sex-limited" inheritance; while in some instances characters are transmitted from fathers through daughters to grandsons or from mothers to sons, all such cases being known as "sex-linked" inheritance.

2. *New Characters or Mutations.*—But in addition to these permutations in the distribution and combination of ancestral characters new and unexpected characters sometimes develop in the offspring, which were not present, so far as shown, in any of the ascendants, but which, after they have once appeared, are passed on by heredity to descendants. Such inherited variations are usually of two kinds, continuous or slight, and discontinuous or sudden variations. The latter are especially noticeable when variations occur in the normal number of parts, as in four-leaved clover, or six-fingered men, and such numerical variations have been called by Bateson "meristic." However sudden variations may include any marked departure from the normal type, in color, shape, size, chemical compositions, etc. Such sudden variations have long been known to breeders as "sports," and both Darwin and Galton pointed out the fact that such sports have sometimes given rise to new races or breeds, though Darwin was not inclined to assign much importance to them in the general process of evolution. Galton, on the other hand, maintained that variations, or what would now be called "continuous variations," can not be of much significance in the process of evolution, but that the case is quite different with "sports." [2]

More recently the entire biological world has been greatly influenced by the "mutation theory" of deVries, which has placed a new emphasis upon the importance of sudden variations in the process of evolution. At first deVries was inclined to emphasize the degree of difference be-

[2] "Hereditary Genius," Prefatory Chapter.

tween discontinuous and continuous variations, but in later works this distinction is given a minor place as compared with the distinction between inherited and non-inherited variations. Inherited variations, whether large or small, are called by deVries "mutations," whereas non-inherited variations are known as "fluctuations," the former are caused by changes in germinal constitution, the latter by alterations in environmental conditions; the former represents changes in heredity, the latter changes in development.

3. *Mutations and Fluctuations.*—This clear cut distinction between mutations and fluctuations marks one of the most important advances ever made in the study of development and evolution. Thousands of fluctuations occur which are purely somatic in character and which do not affect the germ cells, for every single mutation or change in the hereditary constitution; and yet only the latter are of significance in heredity and evolution. This distinction between variations due to environment (fluctuations) and those due to hereditary causes (mutations) was recognized by Weismann and many of his followers, but the actual demonstration on a large scale of the importance of this distinction is due largely to deVries.

All hereditary variations, whether due to new combinations of old characters or to the appearance of actually new characters, whether small and continuous, or large and discontinuous, have their causes in the organization of the germ cells, just as do inherited resemblances. Heredity is not to be contrasted with variation, nor are hereditary likeness and unlikeness due to conflicting principles; both are the results of germinal organization and both are phenomena of heredity.

4. *Every Individual Unique.*—As a result of the permutations of ancestral characters, the appearance of mutations, and the fluctuations of organisms due to environmental changes, it happens that in all cases offspring differ more or less from their parents and from one another. No two children of the same family are ever exactly alike (except in the case of identical twins which have come from the same oosperm). Every living being appears on careful examination to be the first and last of its identical kind. This is one of the most remarkable peculiarities of living things. The elements of chemistry are constant, and even the compounds fall into definite categories which have constant characteristics. But the individuals of biology are apparently never twice the same. This may be due to the immense complexity of living units as contrasted with chemical ones, indeed lack of constancy is evident in itself of lack of analysis into real elements or of lack of uniform conditions, but whatever its cause the extraordinary fact remains that every living being appears to be unique.

There seems to be no reason to doubt that all the extraordinary dif-

Reproduction is the generation of unique beings that are, on the average, more like their kind than like anything else (Brooks).

ferences which organisms show, as well as all of their resemblances, are due to differences or resemblances in the hereditary and environmental factors which have been operative in their development. But in view of this universal variability of organisms it is not surprising that inheritance has seemed capricious and uncertain—"a sort of maze in which science loses itself."

B. STATISTICAL STUDY OF INHERITANCE

Francis Galton was one of the first who attempted to reduce the mass of conflicting observations on heredity and variation to some system and to establish certain principles as a result of statistical study. He was the real founder of the scientific study of inheritance, he created characters singly and he introduced quantitative measures. Galton's researches, which were published in several volumes, consisted chiefly in a study of certain families with regard to several selected traits, viz., genius or marked intellectual capacity, artistic faculty, stature, eye color and disease. As a result of his very extensive studies two main principles appeared to be established:

1. *The Law of Ancestral Inheritance* which he stated as follows:

> The two parents contribute between them on the average one half of each inherited faculty, each of them contributing one quarter of it. The four grandparents contribute between them one quarter, or each of them one sixteenth; and so on, the sum of the series $1/2 + 1/4 + 1/8 + 1/16 \ldots$ being equal to 1, as it should be. It is a property of this infinite series that each term is equal to the sum of all those that follow: thus $1/2 = 1/8 + 1/16 + \cdots$, $1/4 = 1/8 + 1/16 + \ldots$, and so on. The prepotencies of particular ancestors in any given pedigree are eliminated by a law which deals only with average contributions, and the various prepotencies of sex with respect to different qualities are also presumably eliminated.

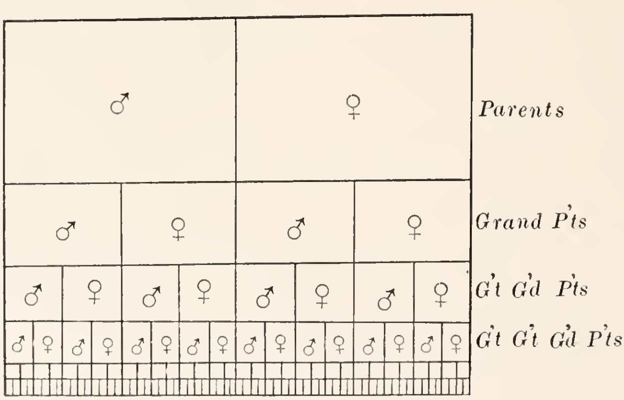


FIG. 48. SCHEME TO ILLUSTRATE GALTON'S "LAW OF FILIAL REGRESSION" AS SHOWN IN THE STATURE OF PARENTS AND CHILDREN. The mean height of all parents is shown by the dotted line between 68 and 69 inches. The circles through which the diagonal line runs represent the heights of graded groups of parents and the arrow heads indicate the average heights of their children. The offspring of undersized parents are taller and of oversized parents are shorter than their respective parents. (From Walter.)

The average contribution of each ancestor was thus stated definitely, the contribution diminishing with the remoteness of the ancestor. This Law of Ancestral Inheritance is represented graphically in the accompanying diagram (Fig. 48). Pearson has somewhat modified the figures given by Galton, holding that in horses and dogs the parents contribute $\frac{1}{2}$, the grandparents $\frac{1}{3}$, the great grandparents $\frac{2}{9}$, etc.

Theoretically the number of ancestors doubles in each ascending generation; there are two parents, four grandparents, eight great-grandparents, etc. If this continued to be true indefinitely the number of ancestors in any ascending generation would be $(2)^n$, in which n represents the number of generations. There have been about 57 generations since the beginning of the Christian Era, and if this rule held true indefinitely each of us would have had at the time of the birth of Christ a number of ancestors represented by $(2)^{57}$ or about 120 quadrillions—a number far greater than the entire human population of the globe at that time. As a matter of fact, owing to the intermarriage of cousins of various degrees the actual number of ancestors is much smaller than the theoretical number. For example, Plate says that the present Emperor of Germany had only 162 ancestors in the 10th ascending generation, instead of 512, the theoretical number. Nevertheless this calculation will serve to show how widespread our ancestral lines are, and how nearly related are all people of the same race.

Davenport concludes that no people of English descent are more distantly related than 30th cousins, while most people are much more closely related than that. If we allow three generations to a century, and calculate that the degree of cousinship is determined by the number of generations less two, since first cousins appear only in the third generation, the first being that of the parents and the second that of the sons and daughters, we find that 30th cousins at the present time would have had a common ancestor about one thousand years ago or approximately at the time of William the Conqueror. As a matter of fact most persons of the same race are much more closely related than this, and certainly we need not go back to Adam nor even to Shem, Ham and Japhet, to find our common ancestor.

2. The second principle which Galton deduced from his statistical studies is known as the *Law of Filial Regression*, or what might be called the tendency to mediocrity. He found that on the average extreme peculiarities of parents were less extreme in children. "The stature of adult offspring must, on the whole, be more mediocre than the stature of their parents, that is to say more near to the mean or mid of the general population"; and again, "the more bountifully a parent is gifted by nature, the more rare will be his good fortune if he begets a son who is as richly endowed as himself." This so-called law of filial regression is represented graphically in Fig. 49 in which the actual

stature of individual parents is shown by the oblique line, the stature of children by the dotted curve, and the mean stature of the race in the horizontal dotted line.

One of the chief aims and results of statistical study is to eliminate individual peculiarities and to obtain general and average results.

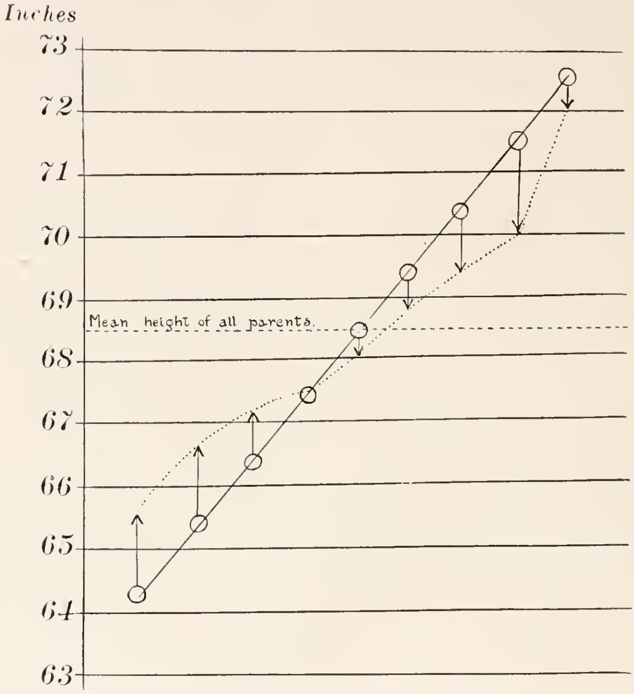


FIG. 49. DIAGRAM TO ILLUSTRATE THREE KINDS OF INHERITANCE DESCRIBED BY GALTON. (After Walter.)

Such work may be of great importance in the study of heredity, especially where questions of the occurrence or distribution of particular phenomena are concerned; but the causes of heredity are individual and physiological, and averages are of less value in finding the causes of such phenomena than is the intensive study of individual cases.

By observation alone it is usually impossible to distinguish between inherited and environmental resemblances and differences, and yet this distinction is essential to any study of inheritance. If all sorts of likenesses and unlikenesses are lumped together, whether inherited or not, our study of inheritance can only end in confusion. The value of statistics depends upon a proper classification of the things measured and enumerated, and if things which are not commensurable are grouped together the results may be quite misleading and worthless. Unfortunately Galton and Pearson, as well as some of their followers, have not carefully distinguished between hereditary and environmental characters.

Furthermore much of their material was drawn from a general population in which were many different families and lines not closely related genetically. Consequently their statistical studies are of little value in discovering the physiological principles or laws of heredity. Jennings (1910) well says,

> Galton's laws of regression and of ancestral inheritance are the product mainly of a lack of distinction between two absolutely diverse things, between non-inheritable fluctuations, on the one hand, and permanent genotypic differentiations, on the other.

In the case of man we have few certain tests to determine whether the differential cause of any character is hereditary or environmental, but in the case of animals and plants, where experiments may be performed on a large scale it is possible to make such tests by (1) experiments in which environment is kept as uniform as possible while the hereditary factors differ, and (2) experiments in which, in a series of cases, the hereditary factors are fairly constant while the environment differs. In this way the differential cause or causes of any character may be located in heredity, in environment, or in both.

The observational and statistical study of inheritance helped to outline the problem but did little to solve it. Certain phenomena of hereditary resemblances between ascendants and descendants were made intelligible, but there were many peculiar and apparently irregular or lawless phenomena which could not be predicted before they occurred nor explained afterwards. For example when Darwin crossed different breeds of domestic pigeons, no one of which had a trace of blue in its plumage, he sometimes obtained offspring with more or less of the blue color and markings of the wild rock pigeon from which domestic pigeons are presumably descended. He described many cases of dogs, cattle and swine, as well as many cultivated plants, in which offspring resembled distant ancestors and differed from nearer ones; such cases had long been known and were spoken of as "reversion." He observed many cases in which certain characters of one parent prevailed over corresponding characters of the other parent in the offspring, this being known as "prepotency"; but there was no satisfactory explanation of these curious phenomena. They did not come under either of Galton's laws, and their occurrence was apparently so irregular that every such case seemed to be a law unto itself.

C. EXPERIMENTAL STUDY OF INHERITANCE

I. *Mendelism*

The year 1900 marks the beginning of a new era in the study of inheritance. In the spring of that year three botanists, deVries, Correns and Tschermak, discovered independently an important principle of heredity and at the same time brought to light a long neglected and forgotten work on "Experiments in Plant Hybridization" by Gregor Mendel, in which this same principle was set forth in detail. This principle is now generally known as "Mendel's Law." Mendel, who was a monk and later abbot of the *Königskloster,* an Augustinian monastery in Brünn, Austria, published the results of his experiments on hybridization in the *Proceedings of the Natural History Society of Brünn* in 1866. The paper attracted but little attention at the time although it contained some of the most important discoveries regarding inheritance which had ever been made, and it remained buried and practically unknown for thirty-five years. Plant hybridization had been studied extensively before Mendel began his work, but he carried on his observations of the hybrids and of their progeny for a longer time and with greater analytical ability than any previous investigator had done. The methods and results of his work are so well known through the writings of Bateson, Punnett and many others, that it is unnecessary to dwell at length upon them here. In brief Mendel's method consisted in crossing two forms having distinct characters, and then in counting the number of offspring in successive generations showing one or the other of these characters.

During the eight years preceding the publication of his paper in 1866 Mendel hybridized some twenty-two varieties of garden peas. This group of plants was chosen because the different varieties could be cross-fertilized or self-fertilized and were easily protected from the influence of foreign pollen; because the hybrids and their offspring remained fertile through successive generations; and because the different varieties are distinguished by constant differentiating characters. Mendel devoted his attention to seven of these characters, which he followed through several generations of hybrids, viz.,

(1) Differences in the form of the ripe seeds, whether round or wrinkled.

(2) Differences in the color of the food material within the seeds, whether pale yellow, orange or green.

(3) Differences in the color of the seed coats (and in some cases of the flowers also), whether white, gray, gray brown, leather brown, with or without violet spots.

(4) Differences in the form of the ripe pods, whether simply inflated or constricted between the seeds.

(5) Differences in the color of the unripe pods whether light to dark green, or vividly yellow.

(6) Differences in the positions of the flowers, whether axial, that is distributed along the stem, or terminal, that is bunched at the top of the stem.

(7) Differences in the length of the stem, whether tall or short.

1. *Results of Crossing Individuals with one Contrasting Character.* —Having determined that these characters were constant for certain varieties or species Mendel then proceeded to cross one variety with another, by carefully removing the unripe stamens, with their pollen, from the flowers of one variety and dusting upon the stigma of such flowers the pollen of a different variety. In this way he crossed vari-

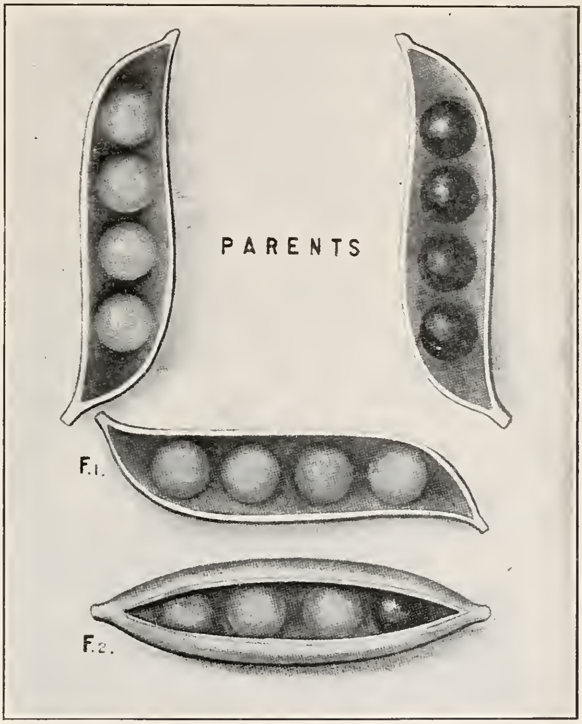


Fig. 50. Diagram Showing the Results of Crossing Yellow-seeded (Lighter Colored) and Green-seeded (Darker Colored) Peas. From Morgan after Thompson.)

eties of peas which differed from each other in some one of the characters mentioned above, and then studied the offspring of several successive generations with respect to this character.

In every case he discovered that the plants that developed from such a cross showed only one of the two contrasting characters of the parent plants, *i. e.,* all were round-seeded, yellow seeded, tall, etc., although one of the parents had wrinkled seeds, green seeds, or short stem, etc.

Those characters which are transmitted entire or almost unchanged in the hybridization are termed *dominant* and those which become latent in the process, *recessive.*

These hybrids[3] when self-fertilized gave rise to a second filial generation of individuals some of which showed the dominant character and others the recessive, the relative numbers of the two being approximately three to one. Thus the hybrids produced by crossing yellow-seeded and green-seeded peas yielded when self-fertilized 6,022 yellow seeds and 2,001 green seeds, or almost exactly three yellow to one green (Fig. 50). The hybrids produced by crossing round and wrinkled seeded varieties yielded in the second filial generation 5,474 round and 1,850 wrinkled seeds, or approximately three round to one wrinkled (Fig. 53). The hybrids from a tall and short stemmed cross produced in the second filial generation 787 long stemmed and 277 short stemmed, or again approximately three tall to one short. And in every other case Mendel found that the ratio of dominants to recessives in the second filial generation was approximately three to one. These recessives derived from hybrid parents are pure and are known as "extracted" recessives; when self-fertilized they produce recessives indefinitely. One third of the dominants are also pure homozygotes, or "extracted" dominants, and when self-fertilized produce pure dominants indefinitely. On the other hand, two thirds of the dominants are heterozygotes and when self-fertilized give rise in the next generation to pure dominants, mixed dominant-recessives and pure recessives in the proportion of 1:2:1. These general results are summarized in the accompanying diagram (Fig. 51)

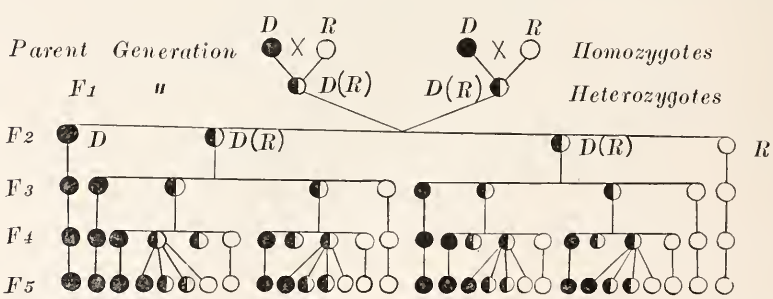


FIG. 51. DIAGRAM SHOWING RESULTS OF MENDELIAN SPLITTING WHERE THE PARENTS ARE PURE DOMINANTS AND PURE RECESSIVES (HOMOZYGOTES). All pure dominants are represented by black circles, all pure recessives by white ones, while mixed dominant-recessives (heterozygotes) are represented by circles half white and half black. Successive generations are marked F_1 F_2, F_3, etc.

in which dominant characters are indicated by the letter *D*, recessive characters by *R*, and mixed dominant-recessives, with the recessive character unexpressed, by *D* (*R*); while *DD* or *RR* indicate extracted dominants or recessives, that is, pure dominants or recessives which have

[3] Bateson introduced the term *homozygote* for *pure bred* individuals resulting from the union of gametes which are hereditarily similar, and *heterozygote* for *hybrids* resulting from the union of hereditarily dissimilar gametes. The gametes formed from a homozygote are all of the same hereditary type, those formed from a heterozygote are of two or more different types.

separated out from mixed dominant-recessives, $D\ (R)$. The parental generation is indicated by the letter P, and the successive filial generations by F_1, F_2, F_3, etc.

In the case of the peas studied by Mendel the hybrids of the F_1 generation show only the dominant character, the contrasted recessive character being present but not expressed. However in certain cases it has been found that the hybrids differ from either parent and in successive generations split up into both parental types and into the hybrid type; thus Correns found that when a white flowered variety of Mirabilis, the four o'clock, was crossed with a red flowered variety all of the hybrids in the F_1 generation had pink flowers and from those in the F_2 generation there came white-flowered, pink-flowered and red-flowered forms in the proportion of 1 white : 2 pink : 1 red, as shown in Fig. 56. This is a better illustration of Mendel's principle of splitting than is offered by the peas, since in this case the mixed dominant-recessives $D(R)$ are always distinguishable from the pure dominants DD.

In the F_2 generation and in all subsequent ones the pure dominants, and the pure recessives always breed true when self-fertilized, whereas the mixed dominant-recessives continue to split up in each successive generation into pure dominants, mixed dominant-recessives and pure recessives in the proportion 1 : 2 : 1. The result of this is that the relative number of dominants and recessives increases in successive generations, whereas the relative number of mixed dominant-recessives decreases, and in a few generations a hybrid race will revert in large part to its parental types if continued hybridization is prevented. On the other hand there is no tendency for the relative number of dominants to increase and of recessives to decrease in successive generations; an equal number of pure dominants and pure recessives is produced in each generation.

With remarkable insight Mendel recognized that the real explanation of the splitting of pure recessives and pure dominants from hybrid parents must be found in the composition of the male and female sex cells. Since such extracted dominants and recessives breed true, just as pure species do, it must be that their germ cells are pure. In the cross between pure races of white and red-flowered *Mirabilis* the germ cells which unite in fertilization must be pure with respect to white and red, though the individual which develops from this cross is a pink hybrid. But the fact that one quarter of the progeny of this hybrid are pure white, and another quarter pure red, and that these thereafter breed true, proves that the hybrid produces germ cells which are pure with respect to red and white. Furthermore the fact that one half the progeny of this hybrid are themselves hybrid may be explained by assuming that they were produced by the union of germ cells carrying pure white and pure red, as in the first cross in the parental generation.

Mendel therefore concluded that individual germ cells are always pure with respect to any pair of contrasting characters, even though those germ cells have come from hybrids in which the contrasting characters are mixed. A single germ cell can carry the factors, or causes, for red *or* white flowers, for green seeds *or* yellow seeds, for tall stem *or* short stem, etc., but not for both pairs of these contrasting characters. The hybrids formed by crossing white and red four o'clocks carry the factors for both white and red, but the individual germ cells formed by such a hybrid carry the factors for white *or* red, but not for both: these factors segregate or separate in the formation of the germ cells so that one half of all the germ cells formed carry the factor for white and the other half that for red.

This is the most important part of Mendel's Law—the central doctrine from which all other of his conclusions radiate. It explains not only the segregation of dominant and recessive characters from a hybrid in which both are present, but also the relative numbers of pure dominants, pure recessives, and mixed dominant-recessives in each generation. For if all germ cells are pure with respect to any particular character the hybrid offspring of any two parents with contrasting characters will produce in equal numbers two classes of germ cells, one bearing the

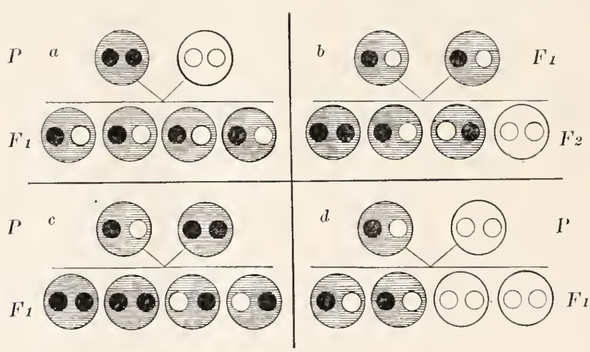


Fig. 52. Diagram of Mendelian Inheritance, in Which the Individual is Represented by the Large Circle, the Germ Cells by the Small Ones, Dominants Being Shaded and Recessives White. *a*, Pure dominant × pure recessive = all dominant-recessives, *b*, Dominant-recessive × dominant-recessive = 1 pure dominant: 2 dominant-recessives: 1 pure recessive, *c*, Dominant-recessive × pure dominant = 2 pure dominant: 2 dominant-recessive, *d*, Dominant-recessive × pure recessive = 2 dominant-recessive: 2 pure recessive.

dominant and the other the recessive factor, and the chance combination of these two classes of male and female gametes will yield on the average one union of dominant with dominant, two unions of dominant with recessive and one union of recessive with recessive, thus producing the typical Mendelian ratio, $1DD:2D(R):1RR$, as shown in the accompanying diagram (Fig. 52, *A*, *B*).

Other Mendelian Ratios

When a pure dominant is crossed with a mixed dominant-recessive all the offspring show the dominant character, though one half are pure dominant and the other half dominant-recessives. Thus if a pure round-seeded variety of pea is crossed with a hybrid between a round and a wrinkled seeded one, all the progeny are round-seeded, though one half of them carry the factor for wrinkled seed; this may be graphically represented as follows:

♀ germ cells *R* ╲╱ *R*
| ╳ | = Possible
♂ germ cells *R* ╱╲ *W* combinations
$2RR : 2R(W)$.

In subsequent generations the progeny of the pure round (RR) breed true and produce only round-seeded peas, whereas the progeny of the hybrid round and wrinkled (RW) split up into pure round, hybrid round and wrinkled, and pure wrinkled in the regular Mendelian ratio of $1RR : 2R(W) : 1WW$ (Fig. 52, *C*).

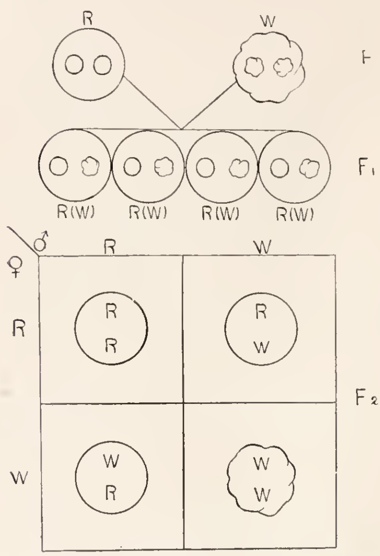
When a pure recessive is crossed with a mixed dominant-recessive another typical ratio results. Thus if a wrinkled-seeded variety of pea is crossed with a hybrid between a round and wrinkled seeded one, round-seeded and wrinkled-seeded peas are produced in the proportion of 1 : 1. This is due to the fact that the hybrid produces two kinds of germ cells, the pure-bred but one, and the possible combinations of these are as follows:

♀ germ cells *W* ╲╱ *W*
| ╳ | = Possible
♂ germ cells *R* ╱╲ *W* combinations
$2RW : 2WW$

This ratio of 1 : 1 is approximately the ratio of the two sexes in many animals and plants, and there is good reason to believe that sex is a Mendelian character of this sort, in which one plant is heterozygous for sex and the other homozygous.

2. *Results of Crossings where there is more than one Contrasting Character.*—It rarely happens that two individuals differ in a single character only; more frequently they differ in many characters and this leads to a great increase in the number of types of offspring in the F_2 generation. But however many pairs of contrasting characters the parents may show each pair may be considered by itself as if it were the only contrasting pair, and when this is done all the offspring may be classified according to the regular Mendelian formula given above.

But when two or more contrasting characters of the parents are followed to the F_2 generation many permutations of these characters occur thus giving rise to a larger number of types of individuals than when a single pair of characters is concerned. When there is only one pair of contrasting characters there are usually but two types of offspring apparent in the F_2 generation, viz., dominants and recessives in the ratio of 3:1 (Fig. 53); where there are two pairs of contrasting



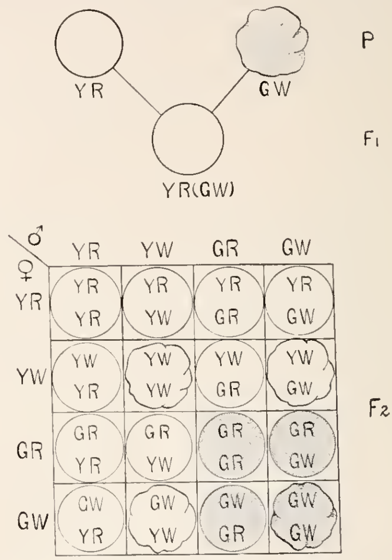


FIG. 53. MONOHYBRID DIAGRAM SHOWING RESULTS OF CROSSING ROUND (*R*) SEEDED WITH WRINKLED (*W*) SEEDED PEAS. Large circles represent zygotes, small ones, or single letters, gametes. In F_1 all individuals are round but contain round and wrinkled gametes. In F_2 the ♂ gametes are placed above the square, the ♀ ones to the left, and the possible combinations of ♂ and ♀ gametes are shown in the small squares, the relative numbers of different types being 1 *RR* :2 *R*(*W*) :1 *WW*.

FIG. 54. DIHYBRID DIAGRAM SHOWING RESULTS OF CROSSING PEAS HAVING YELLOW-ROUND (YR) SEEDS WITH OTHERS HAVING GREEN-WRINKLED (GR) ONES. Four types of germ cells are formed by such a hybrid, viz., YR, YW, GR, GW, and the 16 possible combinations (genotypes) of these ♂ and ♀ gametes are shown in the small squares. Since recessive characters do not appear when mated with dominant ones these 16 genotypes produce 4 phenotypes in the following relative numbers: 9YR : 3YW : 3GR : 1GW. There is 1 pure dominant (upper left corner), 1 pure recessive (lower right corner), 4 homozygotes in diagonal line between these corners and 12 heterozygotes.

characters in the parents there are four types of offspring in the F_2 generation in the ratio of $(3:1)^2 = 9:3:3:1$; when there are three pairs of contrasting characters in the parents there are eight types of offspring apparent in the F_2 generation in the proportions of $(3:1)^3 = 27:9:9:9:3:3:3:1$, etc. Thus when Mendel crossed a variety of peas bearing round and yellow seeds with another variety having wrinkled and green seeds all the offspring of the F_1 generation bore round and yellow seeds, round being dominant to wrinkled, and yellow to green.

But the plants raised from these seeds, when self-fertilized, yielded seeds of four types, round and yellow (*RY*), wrinkled and yellow (*WY*), round and green (*RG*), and wrinkled and green (*WG*) in the proportion of 9 : 3 : 3 : 1 as shown in figure 54.

In this case also this ratio may be explained by assuming that the germ cells (ovules and pollen) are pure with respect to each of the contrasting characters, round-wrinkled, yellow-green, and therefore any combination of these may occur in a germ cell except the combinations *RW* and *YG*. Accordingly there are four possible kinds of germ cells as follows: 

i. e., *YR*, *YW*, *GR*, *GW*. Each one of these four kinds of pollen may fertilize each one of the same four kinds of ovules giving rise to sixteen combinations, no two of which are alike, as shown in Fig. 54. The dominant characters are in this case round and yellow, and only when one of these is absent can its contrasting character, wrinkled or green, develop. Accordingly the sixteen possible combinations yield seeds of four different appearances and in the following proportions: 9*RY* : 3*RG* : 3*WY* : 1*WG*. Only one individual in each of these four classes is pure (homozygous) and continues to breed true in successive generations; in Fig. 54 these are found in the diagonal from the upper left to the lower right corner. All other individuals are heterozygous and show Mendelian splitting in the next generation.

When parents differ in three contrasting characters a much larger number of combinations are possible in the F_2 generation. Thus if a pea with round (*R*) and yellow (*Y*) seeds, and with tall (*T*) stem is crossed with one having wrinkled (*W*) and green (*G*) seeds, and dwarf (*D*) stem all the progeny of the F_1 generation have round and yellow seeds and tall stem, *R*, *Y* and *T* being dominant to *W*, *G* and *D*. But in the F_2 generation there are sixty-four possible combinations (genotypes) of these six characters; but since a recessive character does not develop if its contrasting dominant character is present there are only eight types which come to expression (phenotypes) and in the following numbers: 27*RYT* : 9*RYD* : 9*RGT* : 3*RGD* : 9*WYT* : 3*WYD* : 3*WGT* : 1*WGD*. Of these sixty-four genotypes only eight are homozygous and breed true (those lying in the diagonal between upper left and lower right corners in Fig. 55), while only one is pure dominant and one pure recessive (in the upper left and lower right corners of Fig. 55).

When the parents differ in one character only, the offspring formed by their crossing are called monohybrids, when there are two contrasting characters in the parents the offspring are dihybrids, when three, trihybrids, and when the parents differ in more than three characters the offspring are called polyhybrids. There are certainly few cases in which parents actually differ in only a single character, but since each contrasting character may be dealt with separately, as if it were the only one, and since the number of types of offspring increases greatly when more than one or two characters are considered at the same time, it is customary to deal simultaneously with only one or two characters of hybrids, even though the parents may have differed in many characters.

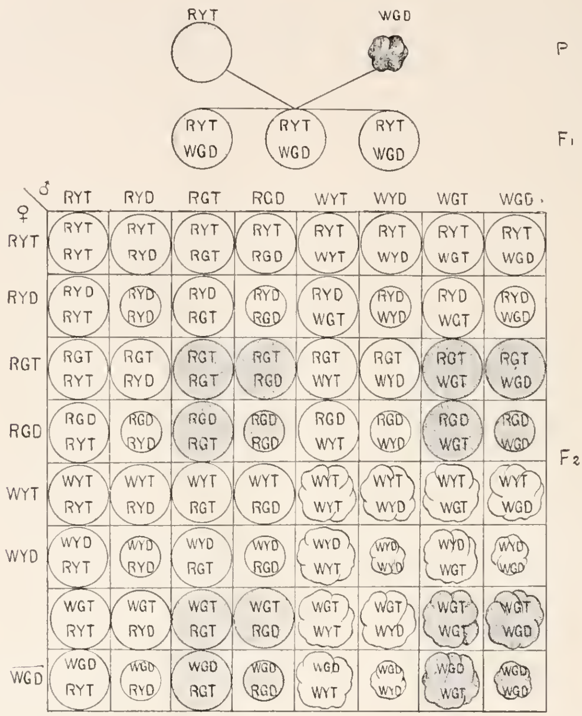


FIG. 55. TRIHYBRID DIAGRAM SHOWING RESULTS OF CROSSING PEAS HAVING ROUND-YELLOW SEEDS AND TALL STEM (RYT) WITH PEAS HAVING WRINKLED GREEN-SEEDS AND DWARF STEM (WGD). Eight types of germ cells result from such a hybrid, as shown in the ♂ gametes above the square and the ♀ ones to the left of it, and the possible combinations (genotypes) of these ♂ and ♀ gametes are shown in the 64 small squares of which only 1 is pure dominant (upper left corner), 1 pure recessive (lower right corner) and 8 homozygotes (in diagonal line between these corners). The relative numbers of the different phenotypes are 27 RYT: 9 RYD :9 RGT :9 WYT :3 RGD :3 WYD :3 WGT :1 WGD.

3. *Inheritance Formulæ.*—Mendel represented the hereditary constitution of the plants used in his experiments by letters employed as symbols, dominant characters being represented by capitals and recessives by small letters. The seven contrasting characters of his peas could be represented as follows:

Seeds, round (*A*), or wrinkled (*a*); yellow (*B*); or green (*b*); with gray seed coats (*C*), or white seed coats (*c*).

Pods, green (*D*), or yellow (*d*); inflated (*E*), or constricted (*e*).

Habit, tall (*F*), or dwarf (*f*).

Flowers, axial (*G*), or terminal (*g*).

It is possible for one plant to have all of these dominant characters or all of the recessive ones, or part of one kind and part of the other. The inheritance formula of a plant having all seven of the dominant characters is *ABCDEFG;* of one having all of the recessive characters *abcdefg.* When two such plants are crossed the inheritance formula of the hybrid is *AaBbCcDdEeFfGg,* and since the dominant and recessive characters (or rather determiners of characters) represented by these seven pairs of letters separate in the formation of the gametes, and since each separate determiner may be associated with either member of the other six pairs, the number of possible combinations of these determiners in the gametes is $(2)^7$ or 128. That is, in this case 128 kinds of germ cells may be produced, each having a different inheritance formula; and since each of these 128 kinds of male germ cells may unite with any one of the 128 kinds of female germ cells, the number of possible combinations is $(128)^2$ or 16,384, which represents the number of combinations of these characters which are possible in the F_2 generation. Every one of these more than sixteen thousand genotypes may be represented by various combinations of the letters *ABCDEFG* and *abcdefg.*

When many characters are concerned it is difficult to remember what each letter stands for, and consequently it is customary in such cases to designate characters by the initial letter in the name of that character. By this form of short hand one can show in a graphic way the possible segregations and combinations of hereditary units in gametes and zygotes through successive generations, and as a result many modern works on Mendelian inheritance look like pages of algebraic formulæ.

Some progress has been made, as was pointed out in the last lecture, in identifying certain structures of the germ cells with certain hereditary units, but quite irrespective of what these units may be and where they may be located it is possible, by means of the Mendelian theory of segregation of units in the germ cells and of chance combinations of these in fertilization to predict the number of genotypes and phenotypes which may be expected as the result of a given cross.

4. *Presence and Absence Hypothesis.*—Mendel spoke of the presence of *contrasting* or *differentiating characters* in the plants which he crossed, such as round or wrinkled seeds, tall or short stems, etc. Many other writers regard these contrasting characters as positive and negative expression of a single character, and consequently they speak of the *presence or absence* of single characters; thus round seeds are due to the presence of a factor for roundness (A) while wrinkled seeds are characterized by the absence of that factor (a). Round seeds are wrinkled seeds plus the factor for roundness. Most of the phenomena of Mendelian inheritance are more simply stated in terms of presence or absence of single characters than in terms of contrasting characters.

When both gametes carry similar positive factors the zygote has a "double dose" of such factors and is said to be *duplex;* when only one of the gametes carries such a factor the zygote has a "single dose" and is *simplex,* when neither gamete carries a positive factor or factors, the zygote receives only negative factors and is said to be *nulliplex.* Thus the union of gametes *AB* (♀) and *AB* (♂) yields zygote *AABB,* which is duplex in constitution; gametes *Ab* (♀) and *aB* (♂) yield zygote *AaBb,* which is simplex; gametes *ab* (♀) and *ab* (♂) yield zygote *aabb,* which is nulliplex.

In some instances a character comes to full expression only when it is derived from both parents, that is, when it is duplex; if derived from one parent only, that is, if simplex, it is diluted in appearance and is intermediate between the two parents. For example, when white-

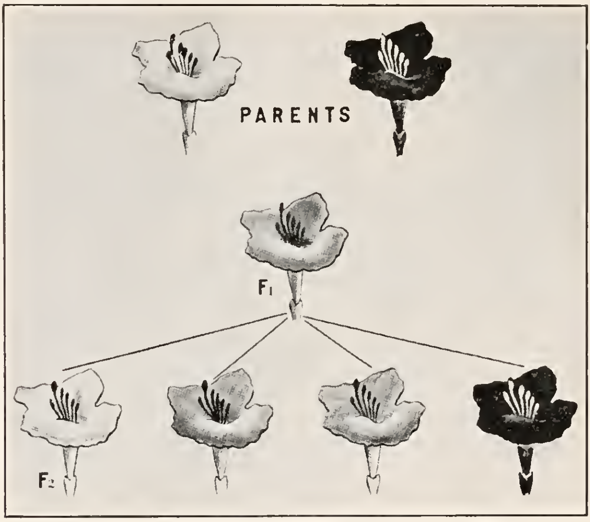


FIG. 56. RESULTS OF CROSSING WHITE-FLOWERED AND RED-FLOWERED RACES OF *Mirabilis Jalapa* (FOUR O'CLOCKS), giving a pink hybrid in F_1, which when inbred gives in F_2 1 white, 2 pink, 1 red. (From Morgan, after Correns.)

flowered four o'clocks which are nulliplex are crossed with red-flowered ones which are duplex the progeny, which are simplex, bear pink flowers; in this case red flowers are produced only when the factor for red is derived from both parents, pink flowers when it is derived from one parent, white flowers when it is derived from neither parent (Fig. 56).

5. *Summary of Mendelian Principles.*—Since the rediscovery in 1900 of Mendel's work many investigators have carried out similar experiments on many species of animals and plants and have greatly extended our knowledge of the principles of inheritance discovered by Mendel, but in the main Mendel's conclusions have been confirmed

again and again, so that there is no doubt that they constitute an important rule of inheritance among all organisms.

In brief the "Mendelian Law of Alternative Inheritance" or of hereditary "splitting" consists of the following principles:

(*a*) *The principle of unit characters.*—The total heritage of an organism may be analyzed into a number of characters which are inherited as a whole and are not further divisible; these are the so-called "unit characters" (deVries).

(*b*) *The principle of dominance.*—When contrasting unit characters are present in the parents they do not as a rule blend in the offspring, but one is dominant and usually appears fully developed, while the other is recessive and temporarily drops out of sight.

(*c*) *The principle of segregation.*—Every individual germ cell is "pure" with respect to any given unit character, even though it come from an "impure" or hybrid parent. In the germ cells of hybrids there is a separation of the determiners of contrasting characters so that different kinds of germ cells are produced, each of which is pure with regard to any given unit character. This is the principle of segregation of unit characters, or of the "purity" of the germ cells. Every sexually produced individual is a double being—double in every cell—one half having been derived from the male and the other half from the female sex cell. This double being, or zygote, again becomes single in the formation of the germ cells only once more to become double when the germ cells unite in fertilization.

(*To be concluded*)

THE CONIFEROUS FORESTS OF EASTERN NORTH AMERICA

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IN eastern North America about thirty species of coniferous trees make up at least two thirds of the existing forest, while the remainder comprises something like 250 hardwood or broad-leaved species. About 70 per cent. of the lumber sawed in the eastern United States at the present time is of conifers or softwoods, and if the statistics for eastern Canada and for fuel, pulp-wood, cross-ties, poles, etc., were included the preponderance of softwood in the area under consideration would be still more evident. Most of the houses in the United States and Canada are built of coniferous wood, most of our paper comes from the same source, and, in all but the most densely populated regions, most of the domestic fuel.[1]

From the relative abundance and number of species it is evident that the average conifer spceies is represented by a much larger number of trees than the average hardwood. It happens that most of our conifers form pure stands of greater or less extent in some parts of their ranges at least, so that there are about as many types of coniferous forest as there are species of conifers. All but a few of the rarer or less important types will be described below, beginning with the northernmost, which are mainly confined to the glaciated region, and ending with those confined to the coastal plain, and one whose range extends southward into the tropics. The treatment of each type will include geographical distribution, correlations with soil, water, climate, fire,[2] etc., and notes on the economic aspects of the trees themselves and the regions in which they grow.

[1] A map between pages 488 and 489 of the 9th volume of the Tenth Census shows the distribution of coal and wood fuel in the United States three decades ago.

[2] Forest fires have generally been looked upon as regrettable accidents, and much more thought has been given to devising means to prevent them than to studying their geographical distribution and historical frequency. But those that start from natural causes seem to be just as much a part of Nature's program as rain, snow and wind (which like fire may do both good and harm at the same time), and to be subject to more or less definite laws. Their frequency, extent and effects vary greatly in different parts of the country and in different types of forests, as will be shown below, and nearly every species of conifer seems to have become accustomed or adjusted to a certain amount of fire, as to other environmental factors.

The Forest Types in Detail

The Boreal or Spruce Type.—The northernmost type of forest, which covers almost the whole of eastern North America from the arctic tundra down to latitude 45°, with many more or less isolated areas farther south, especially in the mountains, is mainly composed of jack pine (*Pinus Banksiana*), tamarack (*Larix laricina*), two or three species of spruce (*Picea*), balsam fir (*Abies balsamea*), and arbor-vitæ

Dense Growth of Spruce (*Picea Mariana*) and Arbor-vitæ (*Thuja*) in a Cold Swamp, Cheboygan Co., Michigan. August, 1912.

or northern white cedar (*Thuja occidentalis*). In places some one of these may cover considerable areas exclusively (this is especially true of the pine), but usually two or three of them are mixed together. They have much in common in general appearance, mature trees being as a rule spindle-shaped or narrowly conical in outline, with more or less deflexed branches, and leaves an inch or less in length. The tamarack is deciduous, and the rest evergreen.

Forests of similar aspect, and made up mostly of trees of the same genera, cover large areas in all the cooler parts of the northern hemisphere. Doubtless on account of the abundance of such trees in northern Europe, where most of our Anglo-Saxon traditions originated, the spindle-shaped tree has become firmly established as the conventional type of conifer. Illustrations of these trees in their native haunts abound in publications dealing with outdoor life in the extreme northern states and Canada printed since the invention of the half-tone process, about thirty years ago.

In the United States the jack pine prefers coarse sand and the other trees above mentioned are found mainly in peat bogs; but farther north they may grow in almost any kind of soil, wet or dry. (In Alaska even some of the glaciers are said to be partly covered with spruce forests.) The regions where they grow are characterized by cool and moderately humid climates, with an average temperature of 45° F. or less, and an average growing season (*i. e.*, period free from killing frosts) of not

Burned Spruce Swamp, With Living Trees in Background, Cheboygan Co., Michigan. August, 1912.

more than 150 days. The ground freezes several feet deep in winter, and temperatures of —30° F. or lower are likely to be experienced by each tree many times during its life.

The average annual precipitation is 20 inches or more, and in most places in the boreal conifer region there is more of it in summer than in winter, which tends to keep the soil moist throughout the year.

A climatic factor which involves both temperature and precipitation is the amount of snowfall; and it appears from statistics of the snowfall of the United States recently published that the type of forest under consideration can be correlated pretty closely with an average annual snowfall of 50 inches and upward. Although it would not be exactly correct from a biological standpoint to say that the narrow conical form of these trees is an adaptation to heavy snows, like the steep roofs of Norway, for example, it would be difficult to imagine any other form of evergreen tree with the same amount of wood and foliage which would be less liable to injury from snow and ice than the spruces and balsams. The tamarack has an additional safeguard in that it loses its leaves in winter; and at the northern limit of the forests it is said to grow comparatively tall and straight while the spruces around it are much stunted.

Burned areas, in which all the trees have been killed by fires sweeping through their crowns, are and always have been, from all accounts, common throughout the spruce region (not only in the East, but also in the Rocky Mountains, where forests of different species but similar aspect predominate); and many great fires, involving loss of life and much property, have become historic.[3] In northern Michigan and doubtless in many other places where spindle-shaped conifers abound posters warning against the dangers of allowing fire to spread greet the traveler at every turn;[4] and some of the western railroads print similar advice in their time-tables.

Although at the present time the origin of most of the northern forest fires can be ascribed to human agencies, lightning is known to cause a considerable proportion of them (estimated by Plummer at 15 per cent.), and in prehistoric times it must have been the principal cause.[5] From all the evidence available it would seem that the normal frequency of fire at any one spot in the boreal conifer forests is about once in the average lifetime of a spruce tree, which may be between 50 and 75 years. The average extent of a single fire must be several square miles.

In the untold ages that fire has been a factor in the life-history of these forests there has developed a class of plants known as fireweeds, consisting of a score or more of herbs, shrubs, and short-lived deciduous trees, such as birch and aspen, which quickly take possession of burned areas and flourish until the dominant, but more slowly growing conifers have time to reestablish themselves. When the foliage of the conifers is consumed by fire the potash and other mineral nutrients stored up in several years' growth of evergreen leaves is returned to the soil in readily available form, and this must be a significant factor in the rapid growth of the fireweeds. Quite a lengthy chapter could be written about this

[3] See Pinchot's "Primer of Forestry" (U. S. Forestry Bulletin 24), Part 1, pp. 79–83, 1897; also U. S. Forestry Bulletin 117, by F. G. Plummer, 1912, especially map on page 22.

[4] Several such posters are reproduced in colors in *American Forestry* for November, 1913.

[5] See papers by Dr. Robert Bell in *Forest Leaves* for October, 1889, and the *Scottish Geographical Magazine* for June, 1897, and Bulletins 111 and 117 of the U. S. Forest Service, by F. G. Plummer, 1912. The second of Dr. Bell's papers, which is on the forests of Canada, contains much valuable information on other subjects than fire.

phenomenon, which has almost no counterpart in the coniferous forests farther south, where fires are nearly always ground-fires, and do not kill the trees outright.

The economic aspects of these northern forests are numerous and varied. The soil and climate are not very favorable for agriculture, so that the farmer, the greatest enemy of forests in this country, has done little damage, and the timber is in no immediate danger of exhaustion. The trees are used to a considerable extent for lumber, and almost as much for pulp-wood; nearly all the large paper mills in North America being located not far from such forests. Logging is nearly all carried on in winter, when the snow facilitates hauling the logs to the nearest river or railroad. The Christmas trees used in northern cities are nearly all brought from the same region. The same forests furnish our spruce gum and Canada balsam, and among them are found the most important peat deposits in North America.[6]

The boreal conifer region is a favorite resort for hunters, trappers, fishermen, berry-pickers, campers, canoeists, hay-fever sufferers, etc., most of whom migrate northward in summer from the densely populated regions a little farther south. At certain times and places mosquitoes and black-flies make life in the north woods somewhat burdensome, but the mosquitoes are at least not of the malarial variety, and poisonous snakes and some other pests are conspicuous by their absence.

The White Pine (*Pinus Strobus*) ranges from Newfoundland and Manitoba to the mountains of Georgia, and associates with many other trees, mostly hardwoods, in various parts of its range; pure stands of it being the exception rather than the rule. It grows in almost any kind of soil except the richest and poorest, wettest and driest, but seems to prefer that containing a moderate amount of humus. From its distribution we may infer that it is confined to climates where the average temperature is less than 55° F., and the growing season not more than half the length of the year: climates pretty well suited for apples but not for cotton.[7]

This species is rather sensitive to fire, at least when young, and perhaps up to middle age. In northern lower Michigan and doubtless elsewhere there are large areas said to have been covered with white pine forests up to about thirty years ago, when the lumberman came along and felled them. Since then fires, mainly of human origin, have been too frequent to allow the pine to reproduce itself except in protected places like islands and shores of lakes and streams, and the uplands are

[6] Bulletin 16 of the U. S. Bureau of Mines, by Dr. Charles A. Davis, 1911, contains a large colored map showing the distribution of peat in the United States. The Canadian deposits are still more extensive.

[7] The range of the white pine perhaps does not overlap that of the cotton crop at all, though they can be seen within a mile of each other at the western base of the Blue Ridge in northern Georgia.

covered with a worthless scrub of birch, aspen, bird cherry, and other fireweed trees, averaging about ten feet tall.

The white pine is one of the world's most important timber trees. It was originally so abundant, and its wood is so easily worked, that it has been used for almost every purpose that does not require great strength, hardness or durability. Millions of houses have been built of it, and probably hundreds of millions of dry-goods boxes. On account of its growing within easy reach of some of the oldest and most thickly settled parts of this country the value of its lumber which has been placed on the market in the last 300 years doubtless exceeds that of any other North American tree.[8] At the present time the leading states in the production of white pine lumber are Minnesota, Wisconsin, Maine, Michigan, New Hampshire, Massachusetts, New York and North Carolina, in the order named. But if the figures for the last census had been computed on a basis of equal areas, Massachusetts would rank first, New Hampshire second, and Minnesota third.

The Red or "Norway" Pine (*Pinus resinosa*) has a range approximately concentric with that of the white pine, but smaller. It is confined to the glaciated region, except that it has been reported from two or three counties in central Pennsylvania and one in West Virginia. In some places in the neighborhood of the upper Great Lakes it forms pure stands with little undergrowth,[9] something like the long-leaf pine forests of the south; but it is more commonly mixed with jack pine, white pine, or other trees. It grows in dry, usually sandy soil, nearly devoid of humus. Its climatic relations are perhaps sufficiently indicated by its distribution.

This species withstands fire almost as well as some of the southern pines to be discussed later, and it resembles them in general appearance, too. In mature trees the branches and foliage are too high up to be injured by ground fires, and the bark is thick enough to be reasonably fireproof. But even when the bark is burned through by a severe fire, making a large scar, the tree is not necessarily killed. At what age it becomes immune to brush fires has not been determined, but in the devastated pine lands of Michigan above mentioned there are many vigorous red pine saplings among the birches and aspens, as well as occasional tall trees of the same species which must have survived many fires.

The wood is so similar to that of the white pine that it is not usually

[8] For valuable notes on the economic history of this and other pines see Bulletin 99 of the U. S. Forest Service, by Hall and Maxwell, 1911.

[9] There are two illustrations of such forests in Minnesota in THE POPULAR SCIENCE MONTHLY for November, 1912 (p. 535), and another on page 10 of a report on the Wood-using industries of Minnesota published by the State Forestry Board in 1913.

distinguished in the lumber market or in the census returns. But reports on the wood-using industries of Michigan, Wisconsin and Minnesota, prepared in recent years by members of the U. S. Forest Service and published by the respective states, give the amount of each kind of wood used by manufacturers (*i. e.*, that which passes beyond the stage of rough lumber, even if it is merely planed) in each state in a year, and distinguishes between lumber cut within the state and that

YOUNG TREES OF RED PINE (*Pinus resinosa*) IN BRUSH LAND SUBJECT TO FREQUENT FIRES, CHEBOYGAN CO., MICHIGAN. August, 1912.

brought in from other states. From these we learn that the manufacturers of Michigan use in a year about 10 million feet of home-grown red pine, those of Wisconsin something over 6 million, and in Minnesota 167 million. (The corresponding figures for white pine are 70, 72 and 455; and both added together are less than half the total lumber production of the two species for these states as reported by the Tenth Census.)

The Hemlock (*Tsuga Canadensis*)[10] has a distribution very similar to that of the white pine, except that it is a little more southerly. It grows in several counties of Alabama, in which state the white pine is unknown. It commonly grows mixed with various hardwood trees and sometimes with white pine besides. It prefers moderately dry soils with considerable humus, perhaps more than any other eastern conifer. (The

[10] Also called "spruce pine" in Georgia and Alabama, if not farther north. The settlement of Spruce Pine, Ala., takes its name from this tree (see *Bull. Torrey Bot. Club*, 33: 524. 1906), and the same may be true of the place similarly named in North Carolina and even of Spruce, Ga.

states which according to the last census cut more hemlock lumber than white pine—making due allowance for the inclusion of more than one species under the same name—have richer soils, on the whole, than those in which the reverse is true.)

This tree is confined to situations rarely or never visited by fire, being protected either by the scarcity of undergrowth, or by the topography, or both. It is probably very sensitive to fire, especially when young.

Formerly the hemlock was valued chiefly as a source of tanbark, and it was once, and still is in many places, as far apart as Michigan and Georgia, a common practise to cut the trees for their bark alone, and leave the logs to rot in the woods. At present it is used largely also for lumber and pulp-wood. The leading states in the production of hemlock lumber in 1909, in proportion to area, were Pennsylvania, Wisconsin, West Virginia, Michigan, New Hampshire, Vermont, Maine, New York, Massachusetts, Connecticut, Maryland and Virginia, in the order named. (The first four of these, as well as Vermont, New York and Maryland, cut more hemlock than white pine.)

The Pitch Pine (*Pinus rigida*) ranges from New Brunswick and Ohio to the mountains of Georgia, but seems to form extensive pure

PITCH PINE (*Pinus rigida*) NEAR LAKEHURST, N. J. Typical New Jersey pine-barrens. Trees in background killed by fire. August, 1909.

stands only in southeastern Massachusetts, eastern Long Island, and southern New Jersey. Such forests usually have a dense undergrowth of two shrubby oaks (*Quercus ilicifolia* and *Q. prinoides*), with poor sandy soils, and the ground-water level fairly constant throughout the year.

In its relations to fire the pitch pine seems to be intermediate between the spruces already mentioned and some of the southern pines. The pine-barrens of Long Island and New Jersey everywhere bear the marks of fire, which seems usually not to kill the older trees. Further studies of this point are needed.

This tree is usually too small, crooked or knotty to be of much value for lumber, but where it is abundant it has been used for many purposes, especially in the early days before transportation facilities enabled better woods to compete with it so strongly. The soil in which it grows is of little value for ordinary agriculture, but in wet places among the pines, especially in Massachusetts and New Jersey, large crops of cranberries are gathered. The pine region of New Jersey formerly produced considerable quantities of bog iron ore[11] and glass sand.[12]

The Red Cedar (*Juniperus Virginiana*) grows nearly throughout

RED CEDAR (*Juniperus Virginiana*) AND VARIOUS HARDWOOD TREES, AMONG LIMESTONE ROCKS ON MOUNTAIN SLOPE NEAR SCOTTSBORO, ALABAMA. March, 1913.

eastern North America between—but hardly overlapping—the boreal forests of high latitudes and altitudes and the tropical forests of southern Florida. It is most abundant on the northwestern flanks of the

[11] There is an interesting sketch of the old iron industry in southern New Jersey by Gifford in THE POPULAR SCIENCE MONTHLY for April, 1893.

[12] See THE POPULAR SCIENCE MONTHLY, 42: 442, 830. 1893.

Alleghanies, in what might be called the interior hardwood region, and forms nearly pure stands, commonly called cedar glades, in Middle Tennessee and northern Alabama. (Of the numerous places named Lebanon in the United States it is altogether probable that those in Ohio, Kentucky, Tennessee, Alabama and Florida, if not most of the others, were named from the presence of cedar trees, although our cedar bears little resemblance to *Cedrus Libani,* the classical cedar of Lebanon.)

The soil in which this tree grows is usually dry, and nearly always thin or rocky, but it varies greatly in chemical composition. In Alabama, Tennessee and some other parts of the country the cedar is believed to prefer calcareous soils, but this does not seem to be true throughout its range, for it grows in many places where no lime can be detected without a careful chemical analysis.

This species is very sensitive to fire, and the places frequented by it, such as pastures, fence-rows, edges of marshes, dunes, rocks, bluffs, hammocks, etc., are all pretty well protected from fire in one way or another. In fact exemption from fire seems to be the only significant character that its diverse habitats have in common, from which we may conclude that that governs its local distribution more than anything else.[13]

The wood of the cedar is very durable, but now used mostly for pencils, in which this quality is not taken advantage of. Representatives of the pencil-makers have scoured the country pretty thoroughly for it, and few large straight-grained trees have escaped them, even in small groves in the most out-of-the-way places in the South. Although it is not separated from some other species in the census returns, the cedar cut in 1909 in Tennessee (8,927,000 feet), Missouri (2,984,000 feet) and Alabama (2,869,000 feet) must be all or nearly all of this species.

The Southern White Cedar or "Juniper" (*Chamæcyparis thyoides*) is the only conifer that grows both in the glaciated region and in the coastal plain and nowhere else. It ranges from New Hampshire to Mississippi, but is not known more than 200 miles inland, or southeast of a straight line drawn from Charleston to Apalachicola (which excludes most of Florida); and there are several large gaps in its range. It usually grows in dense colonies of several hundred trees or more, much like the spruces farther north.

It is strictly a swamp tree, growing naturally only in permanently saturated soil, or peat. The water of these swamps is exceptionally free from mud, lime (perhaps also sulphur) and other mineral substances, but is usually colored dark brown by vegetable matter. Cities as far

[13] This was discussed at some length in *Torreya,* 12: 145–154, July, 1912. The most complete treatise on red cedar is Bulletin 31 of the Division of Forestry of the U. S. Department of Agriculture, by Dr. Charles Mohr, 1901.

apart as Brooklyn, N. Y., and Mobile, Ala., get part of their water supply from streams in which *Chamæcyparis* grows; and the water of Dismal Swamp—one of the best-known localities for this species—used to be preferred for drinking purposes on ships sailing from Norfolk on long voyages. The manufacture of paper is an industry which seems to require good water in large quantities, and the only paper mills in the coastal plain known to the writer (viz., at Hartsville, S. C., and Moss Point, Miss.) have juniper growing in their immediate vicinity.

The relations of this species to fire have been little studied, but what evidence there is seems to indicate that they are much the same as in the case of the boreal forests already described.

The wood is very durable, and therefore used largely for poles, shingles, woodenware, etc., but it is not separated from that of arbor-vitæ and red cedar in the latest census returns.

The Scrub Pine (*Pinus Virginiana*), also known as Jersey pine, spruce pine, nigger pine, cliff pine, etc., bears considerable resemblance

Pinus Virginiana on Rocky Bluffs along Warrior River, Tuscaloosa Co., Alabama. March, 1911.

to the jack pine previously mentioned, but does not grow within 200 miles of it. It ranges from just south of the terminal moraine in New York and Indiana to central Alabama, nearly always forming dense groves or thickets with little admixture of other trees. It is common in the coastal plain of Virginia north of the James River, but farther south seems to be confined to the highlands. In Alabama its distribution is approximately coextensive with the coal region, where it is a familiar feature of the landscape. It grows in rather dry, poor, often rocky soil, but not quite the poorest. In Maryland and Virginia it is very common in abandoned fields, but toward its southern limits it prefers steep rocky bluffs.

This pine, like others with very short leaves, has a thin bark and is quite sensitive to fire, though a light ground fire does not necessarily injure mature trees. In young thickets fire sometimes sweeps through the tops of the trees and kills them outright, as in the boreal conifer forests first mentioned. Its local distribution seems to be governed largely by fire, as in the case of the red cedar, for the places where it grows are usually pretty well protected by their isolation, as in abandoned fields, by topography, as on bluffs, or by the sparseness of the undergrowth.

This tree does not often grow large enough to be useful for anything but fuel, charcoal and wood-pulp.[14]

The Southern Short-leaf Pines.—Two species (*Pinus echinata* and *P. Tæda*), which although they are easily distinguished have much in common, are called short-leaf pine in the South. The latter is distinguished in the literature of botany and forestry as "loblolly pine," a name which does not seem to be used much by lumbermen and other "natives."

Pinus echinata ranges from Staten Island and southern Missouri to northern Florida and eastern Texas, ascending the mountains of

FOREST OF SHORT-LEAF PINE (*Pinus echinata*) A FEW MILES NORTHEAST OF TALLAHASSEE, FLORIDA. April, 1914.

[14] The most complete account of it available is Bulletin 94 of the U. S. Forest Service, by W. D. Sterrett, 1911.

Georgia to an altitude of about 3,000 feet, while *Pinus Tæda* grows from Cape May to Arkansas, Texas and Central Florida, rarely more than 1,000 feet above sea-level. The former grows in dry soils somewhat below the average in fertility, while the latter prefers or tolerates a little more moisture and humus. Both are usually more or less mixed with oaks and hickories, or with each other, so that opportunities for getting satisfactory photographs of them are not very numerous.

The distribution of *P. echinata* corresponds approximately with mean temperatures of 55°–70°, and *P. Tæda* with about 60°–72°. The latter does not seem to be capable of enduring temperatures much below zero (Fahrenheit). It may be regarded more appropriately than any other as the typical tree of the South. Where it abounds cotton is the principal money crop, about half the population is colored, and a large majority of the white voters are Democrats. In South Florida, where it is unknown, there are no cotton fields, few negroes, few southern traditions, and many northern people; and substantially the same might be said of the southern Appalachian region, western Texas, and several other places just outside of the range of this tree.

Both species when mature have bark thick enough to withstand any ordinary forest fire, and the dead leaves in the woods in which they grow are likely to be burned nearly every year, with little apparent injury to the trees. Trees of either species less than ten years old probably suffer somewhat from fire, though.

Both are very abundant and important timber trees, not far inferior to the long-leaf pine mentioned below, and together they are now being cut at the rate of several billion feet annually. Probably even more trees have been cut by farmers than by lumbermen, for the soil in which they grow is adapted to many staple crops. They reproduce themselves very readily in abandoned fields, though, so that they are in no immediate danger of exhaustion.

The Black Pine[15] (*Pinus serotina*), which looks very much like *P. Tæda*, but is more closely related to *P. rigida* (whose range it overlaps very little if at all), is strictly confined to the sandier parts of the coastal plain, where the summers are wetter than the winters. It is frequent from southeastern Virginia to central Florida and southeastern Alabama, but not very abundant except in eastern North Carolina, where it is the dominant and characteristic tree of the "pocosins." Its favorite habitat is sour sandy or peaty swamps, where the water-level varies little throughout the year.

Its relations to fire have not been specially investigated. Its wood is similar to that of *P. Tæda*, from which it is not usually distinguished in the lumber markets.

[15] This is the name by which it goes in Georgia. In the books it is designated as "pond pine," a rather inappropriate and perhaps wholly arbitrary name.

The Cypress (*Taxodium distichum*) is one of our most interesting trees, from several points of view, and a great deal has been written about it. It ranges from Delaware and southwestern Indiana to Florida (within two degrees of the Tropic of Cancer) and Texas, and is almost

CYPRESS (*Taxodium distichum*) WITH KNEES, IN A CREEK SWAMP, PICKENS CO., ALABAMA. Taken in early spring when trees were leafless. February, 1913.

confined to the coastal plain. It is usually abundant where it grows, but more or less associated with other deciduous trees.

This is a swamp tree, growing naturally only where the ground is alternately dry and overflowed. It can stand flooding to a depth of eight or ten feet for a few weeks at a time, and 25 feet for a few days, but does not seem to grow on the immediate banks of the Mississippi and other large rivers whose high-water periods last too long; except near their mouths where the seasonal fluctuations are necessarily less than they are farther up. Its occurrence on the banks of ox-bow lakes which were once part of the Mississippi River may therefore be used as evidence of the minimum age of such lakes.[16] It prefers soil that is rather rich, either from the amount of mineral plant food in the strata penetrated by its roots, or from alluvium deposited by streams.

The regions where this species grows have a mean temperature of about 53°–75°, a growing season of 180 to 360 days, and an average annual rainfall of 38 to 65 inches. It is successfully cultivated, however, not only in New York or even farther north of its natural range, but at the same time in ordinary dry soil of parks and streets.[17]

The cypress swamps are pretty well protected from fire most of the time by the wetness of the soil or the absence of inflammable material on the ground, but occasionally in a very dry season fire gets into the edge of such a swamp from the neighboring uplands and kills some of the trees, whose thin bark renders them rather sensitive.

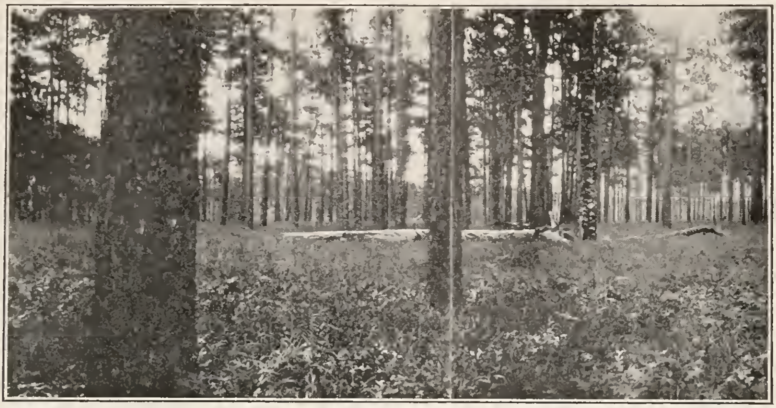
The wood of our cypress, like that of the Old World tree of quite different appearance which bore the same English name long before ours was discovered by civilized man, is very durable and easily worked, and therefore cut in large quantities for shingles and other articles which are to be exposed to the weather or placed in contact with the soil. The last census reports 955,635,000 feet of cypress as having been sawed in 1909, nearly two thirds of this amount coming from Louisiana. Next in order were Florida, Arkansas, Mississippi, South Carolina, North Carolina, Missouri and Georgia. (Some of this amount, however, possibly 10 per cent., should be credited to the other species of cypress discussed a little farther on.) The soil in which cypress is found is usually too wet for cultivation and not easily drained, so that in spite of the tree's slow growth and the rapid rate at which it is being cut the supply will probably not be exhausted for many years.

The Long-leaf Pine (*Pinus palustris*), also known as yellow or Georgia pine, extends through the coastal plain from extreme southern Virginia to the vicinity of the Caloosahatchee River in Florida and the Trinity River in Texas, and also inland to the mountains of Georgia and Alabama, nearly 2,000 feet above sea-level. (It almost meets the white pine in Georgia.) In the greater part of its range it is the most abundant tree, and there are or have been many places where it is the only tree in sight. It probably was originally, and may be even yet, the most abundant tree in eastern North America. The long-leaf pine forests, or southern pine-barrens, differ from most others in their open park-like character. Even in a virgin forest of this kind one can usually see about a quarter of a mile in every direction; and the ground is carpeted with wire-grass or other coarse grasses, or with low shrubs.

16 See *Science*, II., 36: 760–761, November 29, 1912.

17 In such situations its characteristic "knees," the tops of which in a state of nature seem to indicate the greatest height of water to which the tree is accustomed, are developed on a very small scale if at all.

This species grows best in poor soils, rather dry and sandy and devoid of humus, but never in the very poorest, such as sand dunes. The region covered by it has a warm-temperate climate, with very little



PARK-LIKE VIRGIN FOREST OF LONG-LEAF PINE (*Pinus palustris*), COLQUITT CO., GEORGIA. August, 1903.

snow, and more rain in summer than in winter, except in northern Georgia and Alabama.

After reaching the age of four or five years the long-leaf pine seems to withstand fire better than any other tree known, with the possible exception of one or two of its near relatives to be discussed below; and what is more, it probably could not perpetuate itself very long with-

LONG-LEAF PINE FOREST WITH ALMOST NO UNDERBRUSH, IN SOUTHERN PART OF LIBERTY CO., FLORIDA. June, 1909.

out the aid of fire. All forests of it bear the marks of frequent ground fires, which in some places come nearly every year. At the present time, of course, most of the fires are of human origin, but those set by lightning in prehistoric times could spread over much larger areas than they do now, on account of the absence of clearings, roads, and other

Pure Stand of Black Pine (*Pinus serotina*) in the Dover Pocosin, Jones Co., North Carolina. August, 1913.

artificial barriers, so that the frequency of fire at any one spot may not be much greater now than it was originally. A fire every year during the lifetime of the tree would be likely to prevent its reproduction, but in any area that escapes burning for a few years once in fifty years or so there is opportunity for a new crop of trees.

If fire were withheld too long the oaks and other hardwoods which grow in the long-leaf pine regions would take possession of the ground and gradually crowd the pine out, for its seedlings do not thrive in shade. Proofs of this can be seen in many places in the coastal plain, where fire is barred by the topography, as on bluffs bordering swamps, or by water, as on islands and narrow-necked peninsulas. Such places, in which the soil must have been originally much the same as in the neighboring pine forests, are nearly always occupied by what is known as "hammock" vegetation, consisting mostly of hardwood trees, which make a rather dense shade and cover the ground with humus.[18]

[18] The idea that fire is essential to the long-leaf pine has been expressed long ago by a few other observers in the south, but has never been generally ac-

Few trees in the world are used by more people or in more different ways than the long-leaf pine. For strength and durability combined its wood has no superior among the pines, and it ranks equally high as a fuel. The same tree is our chief source of "naval stores" (*i. e.*, turpentine and rosin).[19] In the regions where it abounds the log cabin of the small farmer and the mansion of the wealthy lumberman or naval-stores operator are mostly built (from sills to shingles), painted, fenced and heated with the products of this tree. It supplies cross-ties, bridges, depots, cars and freight to many railroads, and motive power to some.[20] The masts, decks, and cargo of many a schooner on the Atlantic Ocean are of this species, and some of the busiest streets of our large cities have been paved with blocks of its wood in the last few years. Turpentine and lampblack from it are found in every drug-store.

As this pine grows mostly in comparatively level ground and almost unmixed with other trees, it has been cut as ruthlessly and wastefully as the northern white pine, and most of the once magnificent forests of it are now scenes of desolation. Although some other pines are mixed with it in the census returns, it is probably safe to say that at the present time the annual cut of it exceeds that of any other North American tree. Of the 2,736,756,000 feet of "yellow pine" cut in Louisiana and 1,100,-840,000 feet cut in Florida in 1909 probably at least 75 per cent. was of this species.

The future prospects for it seem brighter than those of the white pine, for, as already pointed out, it is not affected much by fire, the greatest scourge of some of the northern forests. The long-leaf pine's worst enemy at present is the farmer, who in the last two or three decades has been taking possession of the once despised sandy pine lands very rapidly.[21] Notwithstanding the comparative poverty of the soil, the ease with which it can be cultivated and the mild climate are

cepted by writers on forestry, most of whom live in regions where the normal frequency of forest fires is much less. For more extended discussions of the problem see *Bull. Torrey Bot. Club*, 38: 515–525, 1911; Geol. Surv. Ala. Monog., 8: 25–27, 83, June, 1913; *Literary Digest*, 47: 208, August 9, 1913; *American Forestry*, 19: 667–669, October, 1913.

[19] The old method of extracting turpentine has been described in THE POPULAR SCIENCE MONTHLY for April, 1887, and February, 1896; and the modern cup-and-gutter method by Dr. C. H. Herty, the inventor thereof, in Bulletin 40 of the U. S. Bureau of Forestry, 1903.

[20] A generation ago pine wood seems to have been the prevailing fuel for locomotives in the coastal plain, but most of the railroads have had to abandon it on account of its growing scarcity.

[21] The "wire-grass country" of Georgia, an area of about 10,000 square miles near the center of the range of this tree, increased in population about 60 per cent. between 1890 and 1900, and 35 per cent. between 1900 and 1910, which necessitated the creation of ten new counties in that part of the state since 1904. Somewhat similar developments have been taking place in the corresponding parts of Florida, Alabama and Mississippi at the same time.

powerful attractions; and where the soil is given over to agriculture the production of timber of course stops.[22]

The Pond Cypress (*Taxodium imbricarium,* or *ascendens*) is con-

Pond Cypress (*Taxodium ascendens*) in Very Shallow Flatwoods Pond (Dry at this Time), Pasco Co., Florida. April, 1909. This species is readily distinguished from *T. distichum* by its crooked trunk and coarser bark, among other things.

fined to the coastal plain, from eastern North Carolina (perhaps as far north as the Dismal Swamp) to southern Florida (south end of the Everglades) and eastern Louisiana. It extends over 150 miles inland in the Carolinas and Georgia, but apparently not over 100 miles in Alabama or 60 miles in Mississippi. It seems to be most abundant in Georgia, where it does not form large forests, but is often the dominant

22 For valuable information about the economic aspects of the long-leaf and several other southeastern pines see Bulletin 13 of the Division of Forestry, U. S. Department of Agriculture, by Dr. Charles Mohr (1896 and 1897).

tree over several acres, especially in Okefinokee Swamp, where it seems to attain its maximum dimensions.[23]

It grows in poor soils, usually sand, inundated part of the year, but rarely if ever to a greater depth than five or six feet. (High-water mark is indicated by the height of the enlarged base of the trunk rather than by the knees, which are less characteristically developed in this species than in *T. distichum.*) Its favorite habitats are shallow ponds which dry up in spring, and the swamps of coffee-colored (*i. e.,* not muddy) creeks and small rivers. The regions where it grows have an average temperature of 60°–75°, a growing season of 240 to 360 days, and an annual rainfall of 40 to 65 inches, over 40 per cent. of which falls in the four warmest months, June to September.

The pond cypress has a thicker bark than its better-known relative, and mature trees are practically immune to fire. The ponds in which it grows are likely to be swept in the dry season by fire, which chars the bark at the bases of the trees a little, but does no perceptible harm.

The wood is very similar to that of *T. distichum* (a little stronger and heavier, if anything), and not satisfactorily distinguished in the lumber trade, but the tree is usually too small, crooked or hollow to be worked up into lumber profitably. It is used principally for shingles, posts, poles, piles, cross-ties, etc. No statistics of its production are available, but it is evidently cut most extensively in Georgia and Florida.

The Southern Spruce Pine (*Pinus glabra*) is sometimes called white pine, or "bottom white pine," on account of its resemblance to the well-known northern tree, to which it is not very closely related, however. It ranges from southern South Carolina to central Florida and eastern Louisiana, in the coastal plain, and never forms pure stands, but associates with hardwood trees, especially the magnolia. It prefers soils well supplied with humus and protected from fire, like the white pine and hemlock, and is usually found in hammocks.

Its wood is softer than that of most other southern pines, and might be used as a substitute for white pine if it were more abundant and better known.

The Slash Pine (*Pinus Elliottii*) is also strictly confined to the coastal plain, ranging from southern South Carolina to southeastern Mississippi, inland about 165 miles in Georgia, and southward to about latitude 27° in Florida. It is sometimes the only tree on several acres, but is commonly associated with the pond cypress just mentioned, in shallow ponds or in swamps of small streams that are never muddy.[24]

23 See *Science,* II., 17: 508, March 27, 1903; *Bull. Torrey Bot. Club,* 32: 113, 1905; THE POPULAR SCIENCE MONTHLY, 74: 603, 604, 607, 612, June, 1909; *The Auk,* 30: 485–487, October, 1913.

24 There is an illustration of a forest of this species in the THE POPULAR SCIENCE MONTHLY for June, 1909, p. 607.

Although it grows naturally only in saturated soil, it sometimes takes possession of comparatively dry ground from which long-leaf pine has been cut off; a circumstance which has led some uneducated people to believe that the long-leaf does not reproduce itself after lumbering, but mutates into another species. Some writers on forestry also have been misled into thinking that *P. Elliottii* is destined to take the place of *P. palustris* in the not distant future. But the range of the slash pine is much the smaller of the two, and it has shown no evidence of extending its boundaries since it was first recognized as a distinct species, about 35 years ago.

It is not injured perceptibly by fire, except when very young. Its economic properties are practically the same as those of the long-leaf pine, from which it is seldom distinguished in the lumber and naval stores markets. Its distribution corresponds approximately with that of the sea-island cotton crop, except that this cotton is not now raised west of the Chattahoochee River, while the pine extends nearly to the Pearl River.

The Florida Spruce Pine (*Pinus clausa*), a near relative of *P. Virginiana,* is the least widely distributed of all the eastern conifers, being

INTERIOR OF A FLORIDA SPRUCE PINE (*Pinus clausa*) FOREST ON A PENINSULA OF LAKE TSALA APOPKA, CITRUS CO., FLORIDA; taken from a point about twenty feet from the ground. March, 1914. The abundance of "Spanish moss" (*Tillandsia usneoides*) indicates the infrequency of fire.

almost confined to one state. It ranges from Baldwin County on the coast of Alabama to Dade County, Florida, about latitude 26°. Like the somewhat similar jack pine of the north, it is confined to the most sterile soils imaginable, where other pines are scarce or absent. Its favorite soil, about 99 per cent. white sand, is most extensively developed in the lake region of peninsular Florida, where it supports a peculiar type of vegetation known as "scrub," consisting mostly of this pine, two small evergreen oaks (*Quercus geminata* and *Q. myrtifolia*), saw-palmetto and several other evergreen shrubs, with very little herbaceous growth: grasses and leguminous plants especially being conspicuous by their

Pinus clausa in "Scrub," Lake Co., Florida. May, 1909.

absence. Outside of the lake region this type of soil and vegetation is principally confined to old stationary dunes near the coasts.

Fire sweeps through the scrub on the average about once in the lifetime of the trees, as in the boreal conifer forests, and kills the pines completely; but their cones, which normally remain closed for years, then open and discharge seeds for a new crop.

The wood of this pine is of little value, and the soil in which it grows is worthless for ordinary crops. But on the east coast of Florida south of latitude 28°, where frost is sufficiently rare to make such

Pure Stand of *Pinus Caribaea* With Dense Undergrowth of Saw-palmetto, Near Punta Gorda, Florida. February, 1909.

Pinus Caribaea on Top of a Limestone Cliff Near Cocoanut Grove, Dade Co., Florida. March, 1909.

ventures profitable, large areas of old dunes have been cleared of their spruce pines and planted in pineapples. The pineapple is peculiar in belonging to a family of air-plants (*Bromeliaceæ*), and taking very little nourishment from the soil.

Our southernmost conifer, *Pinus Caribæa,* seems to have no distinctive common name in general use. (It has been called "Cuban pine" by several writers on forestry in recent years, but that name would be more appropriate for *Pinus Cubensis,* a species confined to eastern Cuba.) It is abundant in South Florida, and may extend along the coast to Georgia and Mississippi, though this point has not yet been determined beyond question. It is said to occur also in the Bahamas, western Cuba, the Isle of Pines, and British Honduras. It grows in pure stands, like the long-leaf, and south of the Caloosahatchee River it is almost the only pine, and more abundant than all other trees combined. It is confined to low regions within 100 feet of sea-level, and the saw-palmetto is usually the most conspicuous feature of the undergrowth (in Florida, but not in the tropics, for this palmetto does not grow farther south).

It grows mostly in sandy soil north of Miami, and on limestone rock south of there, where sand is scarce. Although it occupies the driest soils within its range (quite unlike its near relative *P. Elliottii*), the country where it grows is so low that there is usually water within two or three feet of the surface. The climate is subtropical, with no snow and little frost, and the summers are much wetter than the winters.

This species withstands fire about as well as *P. palustris* and *P. Elliottii* do, or perhaps even better, and is exposed to it as often.

Its wood is similar to that of the long-leaf pine, except that it is more resinous and brittle, and therefore is not used much for lumber except locally where there is no other pine within easy reach. The gum does not flow readily, and consequently very little turpentine is obtained from this species; but it is not unlikely that the increasing scarcity of long-leaf pine may before long bring about the invention of some method for utilizing *P. Caribæa* as a profitable source of naval stores. The range of this species lies almost entirely south of the cotton crop, but the soil or rock in which it grows is being planted extensively to grape-fruit, mangoes, avocadoes, and other tropical fruits.

THE VALUE OF RESEARCH IN THE DEVELOPMENT OF NATIONAL HEALTH[1]

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THE history of medical science presents to the curious student a remarkable development commencing in the latter half of the nineteenth century, and one worthy of special study, both on account of the light that it sheds on the present position and the illumination it affords for future progress.

If any text-book of medicine or treatise on any branch of medical science written before 1850 be taken up at random its pages will reveal that it differs but little from one written a full century earlier. If such a volume be compared with one written thirty-five years later, it will be found that the whole outlook and aspect of medicine have changed within a generation.

Erroneous introspective dreams as to the nature of diseases as "idiopathic" as the many strange maladies which their authors are so fond of describing have been replaced by fast-proven facts and medicine has passed from an occult craft into an exact science based upon experimental inquiry and logical deduction from observation.

What caused this rapid spring of growth after the long latent period of centuries, and are we now reaching the end of the new era in medicine, or do fresh discoveries still await the patient experimentalist with a trained imagination who knows both how to dream and how to test his dreams?

It is but a crude comparison that represents the earlier age as one of empiricism and imagination, and the later period as one of induction and experiment. Empiricism has always been of high value in science, it will ever remain so, and some of the richest discoveries in science have arisen empirically.

Imagination also is as essential to the highest scientific work to-day as it was a century ago, and throughout all time the work of the genius is characterized in all spheres of human endeavor by the breadth and flight of the imagination which it shows. The great scientist, whether he be a mathematician, a physicist, a chemist, or a physiologist, requires imagination to pierce forward into the unknown, just as truly as does the great poet or artist. Also, the inspired work of poet or painter must be concordant with a system of facts or conventions, and not outrage

[1] Address of the president to the Physiological Section of the British Association for the Advancement of Science, Australia, 1914.

certain canons of his art, as certainly as the true and lasting work of the scientist must accurately accord with natural laws.

The scientist is as little able to prove the fundamental truth or existence of the groundwork upon which modern physical, chemical and physiological theories are built, as the artist is to prove the ethics, or perfect truth, or perfect beauty, of those conventions upon which poetry, painting or that great group of studies termed the "humanities" find their basis. But the artist or philosopher knows that, using these conventions as the best at present discovered, he can produce works of which the beauty and consistency appeal to all educated human minds capable of appreciation. Similarly, the conventions of natural science, properly understood, appeal to the imagination of the scientist, call forth new ideas to his mind, and suggest fresh experiments to test those ideas; or, a chance empirical observation of an experimental nature, which without theory and scientific imagination would remain isolated and sterile, placed in relationship to the rest of the scheme of science, awakens thought, and may lead to a fresh departure and a long train of important discoveries.

It was this correlation of the imagination with experimentation and the tracing out of relationship from point to point so as to develop the evolution of phenomena that characterized the science of medicine when new-born about seventy years ago and differentiated it from the older nosological medicine in which imagination and experimentation, while both existing, seemed to possess independent existences and pay little regard the one to the other.

It seems well-nigh forgotten nowadays by the majority of people that science and religion originally began together from a common thirst for knowledge, and usually in the same type of mind endowed with a divine curiosity to know more of the origin and nature of things.

Every great religion worthy of the name contains some account of the natural history and creation of the world, in addition to its metaphysical aspects, and reflects the degree of knowledge of natural science possessed by the nation in which it arose at the time of its birth.

The fundamental error throughout the ages of human conceptions, both in science and religion, was that of a non-progressive world to which a stereotyped religion, or science, could be adapted for all time. Perfection was imagined where perfection, we are now happy to realize, was impossible, and, believing in this imaginary perfection and that all things new deviating from it were damnable men were prepared to burn one another at the stake rather than allow error to creep into the world in either science or religion. Thus there have been martyrs for the scientific conscience just as for religious belief, and at this distance in time we can perhaps better understand both inquisitor and martyr and realize that both were fighting for great ideals.

Evolution has taught us that as knowledge broadens we must be prepared to have wider vision and abandon old theories and beliefs in the new-born light that makes the world better to-day than it was yesterday, and that also will show things up to our mental vision more clearly to-morrow than they stand out to-day. To the members of any great craft, or profession, or religious order, this scientific outlook which accepts as fundamental a progressive world and insists that its votaries should adapt their lives to such a doctrine, is peculiarly difficult of assimilation. Routine fixes all men, and so when any new discovery appears to demand change from that order to which the mind has become accustomed, it is immediately looked upon with suspicion, and there being little plasticity of mind remaining, it is rejected as heretical or revolutionary after but scanty critical examination. The cry of the craft in danger has been used efficaciously on many occasions since the days of the Ephesian silversmiths, nor is such a cry at once to be set down to pure selfishness. A craft is often worth preserving long after the forces which have called it into being have commenced to slumber, and conservatism of this type is at times an important factor in social progress. However, there are certain limits which must not be surpassed, room must be made by adaptation for the new knowledge, or it will establish a craft of its own iconoclastic to much worth preserving in the older system.

It is important to insist upon these limitations, because a too reactionary spirit abroad in medicine between 1860 and 1880 prevented the world from benefiting from those remarkable discoveries by Pasteur and their proposed applications by Lister, which laid the foundations of modern medicine and modern surgery. These pioneers of the new age in medical science had to wage for many years a stern and bitter fight against the strong forces of ignorance and prejudice. But for this illogical resistance by men who would not even test the new discoveries, and instead spent their time in sneering at the new geniuses who had leadership to give the world, France and Germany would have been saved many thousands of brave lives in the great war of 1870–71. Even thereafter, the slow struggle continued of the few who knew against the many who refused to be taught, and a perusal of any orthodox text-book of medicine published between 1875–80—that is, more than a decade after Pasteur's great discovery—will show that the etiology of scarcely a single infectious disease had become known, and that medical science was, for example, as ignorant of the nature of tuberculosis as we are to-day of the nature of carcinoma. Take, as an example, the following quotation from a well-known text-book of the theory and practise of medicine published in 1876: "It is now, however, generally admitted that tubercle is no mere deposit, but, on the contrary, a living growth as much as sarcoma and carcinoma are living growths." The tubercles were the only initial lesion observed, the infecting organism was entirely unknown, and the pathologists of this comparatively recent date argued at length as to whether tubercles were to be classed as "adenomata" or were something *sui generis.*

There is a gleam of sunlight for the future in this retrospect at the ignorance of the past, for, if men were as ignorant regarding tuberculosis thirty-eight years ago as to-day they are about cancer, then it may be argued that a generation hence as much may be known about cancer as is known now about tuberculosis.

It is particularly important at the present moment, when so much interest is being taken in national health, to point out the urgent necessity of allowing as little lagging behind as possible to ensue between the making of discoveries and the practical application of the results by organized national effort for the well-being of the whole community.

It must sadly be admitted that it is craftsmanship in imaginary danger fighting hard for the old methods unchanged which were in vogue fifty years ago, that stands most prominently in the way of advance. As great a harvest as that which followed the application of the principle of antisepsis in surgery awaits the application of the self-same principle in national sanitation to-day, but the very profession which ought to be urging forward the new era apparently stands in dread of it, and seems to prefer to reap its harvest from disease rather than to seize the noble heritage won for it by the research of pioneers and so stand forth to the world as the ministry of health. Fortunately it can not be, the bourne has been passed, and there is no going backward. The advances that have already been made have awakened statesmen and people alike to the needs of the situation, and all have resolved to be disease-ridden no longer. The laws of health must be made known to the people at large, and schemes laid before them for a national organization for the elimination of disease. Disease is no longer an affair of the medical profession, it is a national concern of vital importance. The problem is not a class question, all humanity stands face to face with it now in the light of modern research as it never has faced it before. It has been realized that disease never can be conquered by private bargains for fees between individual patient and individual doctor. Research into diseases of unknown causation can not be subsidized upon such individualistic lines, and in the case of diseases of known etiology and modes of propagation the passage of disease from individual to individual can not be controlled by such private methods as that of the afflicted individual subsidizing the doctor for his own protection. Cost what it may, a healthy environment must be produced for the whole mass of the population, and the laws of physiology and hygiene must be taught not only to medical students, but to every child in every school in the country. People can not live healthy lives in ignorance of the fundamental laws of health merely by paying casual visits to physicians, and no one class in the community can be healthy until all classes are healthy.

The problem of national health is one of peculiar interest to physiologists, and to the exponents of those experimental branches of medical science which have sprung from the loins of physiology, for it was with them that the new science of medicine of the last fifty years arose, and they ought to be the leaders of the world in this most important of all mundane problems.

It is well worth while to consider our opportunities and responsibilities and raise the question whether our present system and organization are the most suitable for attaining one of the most sublime ambitions that ever appealed to any profession. By definition, our science studies the laws of health and the functions of the healthy body, therefore, it is ours to lead in the quest for health. Is this object best achieved if we confine ourselves to research in our laboratories, and to the teaching of the principles of physiology to medical students, while we leave the community as a whole uninstructed as to the objects of our research and its value to every man, and trust the medical students whom we turn out to communicate, or not communicate as they choose, the results of their training and our research to the world at large?

There is little question that much of the ignorance abroad in the world, and much of the fatuous opposition to our experimental work and research, arise from this aloofness of ours. Here also lies the cause of much of the latent period in the application of acquired knowledge to great sociological problems, and the presence of untold sickness and death which could be easily prevented if only a scientific system of dealing with disease could be evolved.

The position occupied by scientists in medicine at the present day is largely that of schoolmasters to a medical guild, and even at that, one constructed upon lines which have grown antiquated by the progress of medical science. It ought now to become the function of the scientist to remodel the whole system so as to fight disease at its source. The whole situation at the moment calls out for such a movement. On the one hand, there exists a widespread interest on the part of an awakened community in health questions, evidenced by recent legislation dealing with the health of school-children, with the health of the worker, with the sanitary condition of workshops, with the questions of maternity and infant mortality and with the communication of infectious diseases. On the other hand, there is chaos in the medical organization to meet all these new demands, and the ample means recently placed at the command of the nation and of municipal authorities are being largely wasted by overlapping and misdirection for lack of skilled leadership. Surely it is a time when those who have laid the scientific foundations for the new advances should take counsel together, assume some generalship, and show how the combat is to be waged, not as a guerilla warfare, but as an organized and coordinated campaign.

There are two essentials in the inception of this organized campaign against disease on a scientific basis. The first is to demonstrate clearly to the public mind that modern scientific medicine arose from the experimental or research method, that it was only when experimental observation of the laws of health and disease, in animals and man, commenced on an organized and broadcast basis that medicine and surgery leaped forward and the remarkable achievements of the past fifty years began. Also that it is only by the organization and endowment of medical research that future discovery and advancement are possible. The second essential is to convince the public that a national system must be evolved placing medical science and medical practise in coordination, so that the discoveries of science may be adequately applied in an organized scheme for the prevention and treatment of disease. The method in which discoveries have been made in the past suggests an amplification and organization along similar lines for the future, and the banishment of many diseases by public health work in the past suggests that it is more efficiently organized and widespread public health work in the future, extended from the physical environment to the infecting individual, that will be most fruitful in banishing other diseases.

If it be queried by any one here, what has physiology to do with disease, it may be replied that the question comes at least fifty years too late. The methods evolved first by physiologists in experimentation upon animals have become the methods of all the exact sciences in medicine. Bacteriology is the physiology of the bacterium, and the study of protozoan diseases the physiology of certain groups of protozoa. Organo-therapy had its origin in physiology, and many of its most brilliant discoveries were made by physiologists, and all by scientists who used physiological methods. Serum therapy, experimental pharmacology, and the great problems of immunity all arose from the labors of men with expert training in physiology who branched out into practical applications achieved by the extension of the experimental, or research, method. The modern methods of medical diagnosis and the brilliant technique of contemporary surgery, what has opened the door to these but the experimental method? From the days of the first successful abdominal operation to the present day research in laboratory or in the operating theater has pioneered the way, and the sooner this simple truth is known to all men the better for medical science. Every time any surgeon first tries a new operation there is in it an element of experiment and research of which the ethical limits are well-known and definable, and any person who logically thinks the matter out must see that it is the research method which has placed the science and art of surgery where it stands to-day. Exactly the same thesis holds for medicine. How could any physician predict for the first time, before he had tried it experimentally on animal or man, the action of any new drug, the effect of any variation in dosage, the result of any dietary, of the employment of any course of physical or chemical treatment, or of anything in the whole of his armamentarium? Yet the public are rarely told any of these wholesale truths but are rather left to speculate that each medical and surgical fact sprang forth as a kind of revelation in the inner consciousness of some past genius in medicine or surgery, who, in some occult way, knew of his own certain foreknowledge what would be the definite effect of some remedy or course of treatment before he tried it for the first time on a patient, or perhaps had the ethical conscience and genuine humanity to test it on a lower animal before he administered it to man.

It may, in short, be taken as an axiom of medical science that everything of value in medicine and surgery has arisen from the applications of experimental research. Nor can future advance be made by any other method than the research method. It is true that accident may teach occasionally, as it did, for example, in the dreadful burns unwittingly inflicted on themselves and patients by the early experimenters in X-ray therapy and diagnosis. But accident is only the most blundering type of experimentation, and results obtained by its chance agency do not really invalidate the universal law that man only learns by experience or, in other words, by research. Research is, after all, only the acquisition of fresh experience by the trained expert, usually led on to his experiment by inductance from other known facts.

It has been said above that all that is valuable in medical science has been acquired by research; the converse may now be pointed out, that much that was valueless, dangerous, and even disgusting in medicine in earlier days was incorporated into the medical lore of the time and often remained there for generations stealing lives by thousands because physicians had not yet adopted the research method, and so based their practise upon ignorant and unfounded convention. It is noticeable in literature that up to somewhere in the beginning of the nineteenth century physicians and surgeons were often as a class looked upon by scholars and educated people with a certain amount of contempt. There were notable and fine exceptions in all ages, but, taken as a whole, the profession of medicine was not held in that high esteem and admiration that it is amongst all classes to-day. Take, for example, Burns's picture of Dr. Hornbook or Sterne's account of Dr. Slop in "Tristram Shandy," and similar examples in plenty are to be found in the Continental literature. The reason for the change is to be found in the comparative growth of medical science as a result of the research method. The physicians of those days were very often ignorant quacks employing the most disgusting and dangerous remedies, or methods of treatment, based upon no experimental knowledge and handed own in false tradition from ignorant master to ignorant and often almost illiterate apprentice. It is only necessary to peruse the volumes written on materia medica of this period to shudder at the nature of the remedies apparently in common use; the details are unfit for modern publication.

Even in the first half of the nineteenth century patients were extensively bled almost to exhaustion in a vast variety of diseases in which we now know with certainty that life would be endangered by such treatment and chance of recovery diminished. Thus, in a text-book published in 1844 by the professor of medicine in the most famous university in medicine of our country, and a physician in ordinary to her Majesty Queen Victoria, it is said that in the treatment of pneumonia

> the utmost confidence may be placed in general Blood-letting which should always be large and must almost always be repeated sometimes four or six times or even oftener. Blistering and purging, under the same cautions as in the Bronchitis, are to be employed; and two other remedies have been much recommended—Opium, especially combined with Calomel, and the Solution of Tartar Emetic.

It seems scarcely creditable to us nowadays that about this same period a low diet, blood-letting, emetics and purgatives were employed as a treatment in phthisis, yet such is the case. It is in keeping with the above, and in strange contrast to modern treatment, to find it recommended that if the patient can not winter abroad he is ordered "strict confinement within doors in an artificial climate, as near as possible to 60° Fahr., during at least six months of the year in Britain." From the text-books of medicine of this period, only seventy years back, instances of wrongful and even dangerous treatment in most of the important diseases might be produced. There is no basis of accurate scientific knowledge of physiology, biochemistry or bacteriology underlying the visionary notions about disease. The real causes of the diseases being obscure, they are commonly set down to so-called diatheses or habits such as the "hæmorrhagic diathesis" or the "scrophulous habit." Also, the action of infective organisms and the intimate relationships in regard to infection of members of the same family being unknown or forgotten, such "habits" are erroneously set down as hereditary. When there is no other channel of escape the word "idiopathic" is coined to cover the ignorance of the learned.

If now we pass onwards about thirty years in time, halving the distance between the above period and our own time, and consult an important text-book of medicine published in 1876 by a Fellow of the Royal College of Physicians, a physician and lecturer at a famous London Medical School, and a lecturer on pathology and physiology, we find that the progress attained by research in physiology, and physiological chemistry, and a growing belief in the possibility of infection in many diseases by the microorganisms, now demonstrated so clearly in certain cases by Pasteur and his followers, have commenced to do their beneficent work in medical practise. The heroic bleedings and leechings and the scarcely less violent druggings with strong drugs have disappeared. The patient is less harassed by his doctor, who is more content to assist the natural processes of recuperation as his knowledge of applied physiology and hygiene teach him, rather than to thwart them and to lessen resistance as his predecessor often did a generation ago when he knew no physiology and less hygiene. Still, the comparison between the text-book of even forty years ago and one of the present day shows a wonderful advance, all flowing from the use of the research method in the intervening years, both in knowledge of the origins and in the treatments of the diseases.

Time and space forbid going into details, but the whole of serum, vaccine and organo-therapy were unknown, with the single exception of vaccination for variola. Enteric fever has been separated from typhus, but its etiology is still obscure, and, to a large extent as a consequence, the mortality from it is fifteen to sixteen per cent., or quadruple present-day figures, and it is one of the commonest of diseases. The cause of diphtheria is unknown, although it is now recognized as a "contagious" disease, and as yet research in bacteriology has supplied no cure for it. The unity of the various forms of tuberculosis is unsuspected, the infecting organism is unknown, and, as a result, it is not even recognized as an infectious disease and heredity figures most strongly in a dubious etiology leading up to a vacillating treatment. Pneumonia is not recognized as due to a microorganism, and is described as one of the "idiopathic" diseases. The cause of syphilis, and its relationship to *tabes dorsalis*, and general paralysis are unknown, and generally it may be said that the causes of disease are either entirely unknown or erroneously given in at least three quarters of the very incomplete list of diseases that are classified and described.

This, after all the centuries, was the doleful position of medical science in the year 1876, when suddenly light began to shine upon it, brought not by the agency of any member of the medical profession, but by a physiological chemist, and he was led to his great discovery, not in an attempt to solve some problem of practical medicine, but by scientific observations devoted to an apparently purely philosophical critical research into the supposed origin of life in a particular way.

It was the experimental or research method in biochemistry supported by physiological experiments on animals which in the hands of Louis Pasteur laid the foundations of true knowledge, and transformed medicine from what has been described above into the glorious, living, evolving science that we possess to-day.

The men who fought side by side with Pasteur in his famous struggle against orthodoxy in medicine as represented by the leading physicians and surgeons of the period between 1860 and 1880 were mainly chemists, biologists and physiologists, such as Claude Bernard, Paul Bert, J. B. Dumas, Biot, Belard and Sainte-Claire Deville, in his own country, and Tyndall and Huxley in ours. A few physicians and surgeons of scientific training in France and England recognized the importance of his discoveries, such as Alphonse Guérin, Villemin and Vulpin, in his own country, while Lister in ours was already at work, had experimented widely and wrote his memorable letter of congratulation to Pasteur in 1874, informing him of the work he had been doing in introducing antiseptic surgery in England during the preceding nine years. Against this intrepid little band of experimental scientists were massed all the batteries of orthodox medical nescience served by the distinguished physicians and surgeons of the time; but truth is mighty and must prevail. Davaine applying Pasteur's principles in a medical direction had found out the bacterial origin of anthrax, and although he was violently attacked by oratorical arguments in opposition to experimental proofs, and accused, as many physiologists are to-day of having "destroyed very many animals and saved very few human beings," his facts held fast, and combined with the later experiments of Koch and of Pasteur, not merely established the etiology of anthrax as we know it to-day, but gave a support and forward growth to that newborn babe, Bacteriology, which without such animal experiments could never have grown into the beneficent giant that it is to-day in all its glorious strength for the weal of humanity.

Pasteur himself meanwhile was hard at work in the small ill-equipped laboratory of physiological chemistry of the Ecole Normale at Paris from which the fame of his discoveries began rapidly to spread and shed a new light forth on the medical world. Pasteur at this stage had already largely rehabilitated the national prosperity of his own country by his successful researches on silk-worm disease and on fermentation maladies and the diseases of wines. All this effect upon national industries, it is to be noted, followed on from an inquiry of apparently no practical importance on spontaneous generation. He now turned his genius towards disease, there also utilizing the same discovery arising from a research that contained at first sight no possible applications to disease and the remainder of his life was devoted to the extension of these studies. The subsequent history of this discovery is the science of bacteriology with all its ramifications and manifold applications in industry, in agriculture, in medicine and in public health, investigated by the experimental method by thousands of willing workers all over the civilized world. Who but the ignorant Philistine, who knows not what he prates about, can deny the profound influence of animal experimentation, and the philosophic application of the principle of research upon the history of the world?

Let us now, from the vantage-point of the present, look back at the past and glean from the study of the manner in which this science took origin some knowledge to guide us, first, as to how research may be fostered and encouraged in the future, and secondly, as to how the results of research may be applied for social advantage.

The first and perhaps the finest thought of all is that research must be pursued with the highest ideals of the imaginative mind apart from all desired applications or all wished for material advantages. If we might personify nature, it would seem that she does not love that researcher who only seeks her cupboard, and never shows her finest treasures to him. She must be loved for her own beauty and not for her fortune, or she will ne'er be woed and won. Not even the altruistic appeal of love for suffering mankind would seem to reach her ears; she seem to say: "Love me, be intimate with me, search me out in my secret ways, and in addition to the rapture that will fill your soul at some new beauty of mine that you have discovered and known first of all men, all these other material things will be added, and then I may take compassion on your purblind brothers and allow you to show them these secret charms of mine also, so that their eyes may perchance grow strong, and they, too, led hither by you, may worship at the shrine of my matchless beauty." By all the master's discoveries in all the paths of science, Nature is ever teaching us this great doctrine to which we have closed our ears so long. She tells us the creation of the world is not finished, the creation of the world is going on, and I am calling upon you to take a part in this creation. Never mind that you can not see the whole, love that you see, work at it, and be thankful that I have given you a part to play with so much pleasure in it, and so doing you will rise to the highest ideal.

This is religion with thirst for knowledge as its central spring; does it differ much from those aspirations which have made men of all nations worship throughout all the ages? Anthropology teaches us that the religious system of a race of men gives a key to their advancement in civilization. If this be so, growth in natural knowledge must elevate our highest conceptions, furnish purer ideals and give us more of that real religion that is to be found running so strongly in the minds of great individuals such as Isaac Newton, Michael Faraday, Louis Pasteur, Auguste Comte. A great man may be strongly opposed to the orthodox creeds of his day, he may even sneer at them, he may be burnt at the stake by their votaries, and yet be a man of strong religious feelings and emotions which have furnished the unseen motive power, perhaps unsuspected even by himself, that leads to a whole life of scientific heroism and enthusiasm.

The practical lesson for us to learn from all this is that we must consider research as sacred and leave it untrammelled by fetters of utilitarianism. The researcher in functional biology, for example, must be left free to pursue investigations as inspiration leads him on any living structure from a unicellular plant to a man, and must not be expected to devise a cure for tuberculosis or cancer. In his research he must think of something higher even than saving life or promoting health, or he is likely to prove a failure at the lower level also.

As an example of the wrong attitude of mind towards science, there may be taken the point of view of those utilitarians who complain of the amount of time and discussion at present being given to the problem of the origin of life. These wiseacres with limitations to their brains say "that it is an insoluble problem, we shall never get to the bottom of it, let us simply assume, since it is here, that life did originate somehow, and, taking this as an axiom, proceed to some practical experimental problem; the origination of life does not lend itself to experimental inquiry."

Now it is, strange to say, just those problems that appear most insoluble upon which the inquiring type of mind loves to linger and spend its energies, and, although the problems never may be solved, the misty solitudes to which they lead are glorious and the fitful gleams of half-sunshine that come through are more kindling to the senses of such men than the brightest sunshine on the barest of hills. It is here, and in such quests, that the biggest of human discoveries are made and not all of them are in natural science alone.

The search after the mystery and origin of life had profound influence in raising man from a savage to a civilized human being, and is found as an integral part in all religions above a certain level of savagery. Much of the system of morals and ethics of civilized nations is unconsciously grouped round this problem, and we owe the existence of that social conscience which makes each of us our race's keeper to our interest in the nature of life, and our ties with other lives. Leave such a problem alone and attend to routine researches! Why, the human intellect can not do it, such problems compel attention! What, it may be asked, was it that started all this routine research in biology, in favor of which we are asked to abandon the search after the origin of life? The routine research would not exist, but for a discovery made in investigating whether life originated in a certain alleged way.

If the whole science of bacteriology emerged from a proof that a certain alley did not lead to the origin of life, how much more glorious may that knowledge become that finally leads us to this goal, or even one step onward in our true path towards it. The search after the origin of life is an experimental inquiry, it leads straight to research, that is all the physicist or chemist demands of a theory, it should be enough for the biologist. We who search for this are not occultists whatever may be said of those who oppose.

Let us then learn to have a catholic spirit about research, and try to convince the world that it commands devotion not merely because of material advantages which it may bring, but because it is the most lovely and most holy thing that has been given to man. So may we clear the fair name of science of the false charge of materialism that is so often brought against it by those who do not know and judge science purely by mechanical inventions.

Next let us consider the applications of scientific discovery and see if we cherish aright the gifts of the fairy godmother, for her gifts are dangerous if wrongly used. Consider, if this be doubted, the enormous advantages given by mechanical and chemical contrivances in producing the material comforts necessary to civilized human existence, and then turn your eyes to the reeking slums of our great cities. It is clear that natural science can not go on successfully alone, it must take sociology with it if our world is to be a better world to live in because of the gifts brought by scientific discovery.

Nor is the ideal and the outlook different in the least from that given above for pure research, when we come to consider its applications, the same high spirit must prevail in all our endeavors, or we shall defeat our own ends and miserably fail. Selfishness here, as everywhere, must recoil on the culprit, who only deadens his own soul. Health is needed not to grow wealthy or to prolong to greater length a "lingering death" as Plato puts it, but to fill life with happiness, and beckon the bold and adventurous forward to higher things. Here we must copy Nature's own plan and take care of the race as a whole instead of spending our energies upon single individuals or favored classes. Nor need any one fear that any individual or any particular class in the community is going to suffer from the adoption of the true scientific attitude towards disease. The penalty taken by nature on the more comfortable classes who have hitherto enjoyed the greater share in government for allowing the existence of poverty, disease and slumdom, is to utilize this negelected area as a culture-ground for diseases, which invade the classes above. Nature is still at work creating, still conducting evolution at the highest level, and disease is at present the tool with which she is working. So long as those poverty-stricken slums are allowed to remain, just so long is she grimly prepared to take her toll of death and suffering from those who ought to know how to lead on and do it not. The disease and the crime below are to the social community what pain is to the individual, and just as the special senses become more highly organized and sensitive as the nervous system becomes more highly developed, so as the civilization of the community intensifies does the public conscience awaken to forms of mischief and crime in one generation that were unsuspected in a previous one. So social evils become intolerable and finally are removed. How then are we employing our knowledge as to the causation of disease to the public problem of its removal or abatement?

In regard to the physical environment much has been done during the past generation towards applying the laws of hygiene, as is shown in the sanitation of our great cities, and especially in regard to the question of water-supply. It is good, for example, that Glasgow goes to Loch Katrine for her water-supply, Manchester to the English lakes, and Liverpool to the Welsh hills. Each of these great cities carries for many miles the pure distillate of the hills to its million of inhabitants. It has cost much in pounds sterling, though not more than if each family had a pump in its backyard. On the other hand, think of the disease and suffering and death prevented, enteric fever almost gone where thousands would have died of it, and tens of thousands been debilitated, and these of the best of the citizens, for disease is no eliminator of the unfit. Think of all this, and then say, Did it not pay these great cities to bring the pure water from the lakes in the hills?

But why do these good cities content themselves to allow their little children at a most susceptible age to be supplied still with milk which contains the bacillus of tuberculosis in so large a percentage as five to ten per cent.? And why does the law of the land prevent these corporations from searching out tubercular cows in all the areas supplying them with milk? If it is part of the business of a municipality to see that its citizens have a pure water-supply, why should it not also be allowed to see that they have a clean milk supply?

Long ago the power to make the lame to walk was regarded as a divine gift. When is mankind going to awake to the fact that science has placed this gift in its hands? Much more than half of the lame and spinally-deformed children in our midst are in that condition because of infection of joints or spine with the bacillus of tuberculosis. By open-air hospitals and open-air schools we seek and succeed in curing a percentage of them, but how much better it would be if we took the fundamental problem of tubercular infection in hand and prevented them from becoming lame and deformed?

There is at present on foot in England a great scheme to enable the blind to read, and it deserves our support because it is our fault that these people are blind. The sad fate of the man born blind appeals to all kind hearts; but men are not born blind, they become blind within a week or two of birth because of an infectious disease contracted from the mother at birth. Science knows and has taught the world how this blindness can be quite prevented, and it is because of our faulty organization for attending to maternities amongst the poor that these people are blind. By proper organization practically all blindness arising at the time of birth can be prevented. Why is it not done? Thus our modern science can make the blind to see and the lame to walk, but it is so manacled by ancient ways and customs that it is left powerless, and so there are these maimed and darkened lives of innocent people, and they are left partially burdening the community which has only its own folly to blame for the whole stupid position.

Let us consider lastly a disease which collects the last toll from one seventh of humanity, and debilitates and enfeebles the lives of many whom it does not entirely destroy. At all ages, in infancy, in the prime of life, and in life's decline, it snatches away the best of our fellowmen. How are we organizing our campaign against tuberculosis? Bacteriology has taught us that it is an infectious disease and has isolated the organism. It is an undoubted fact, proven to the hilt by many inquiries and observations, that infection passes from individual to individual. How is this knowledge being applied, and how are we attempting to stem the tide of infection? In the United Kingdom alone about 70,000 persons die annually of the disease, and all over the civilized world the total death roll of human kind annually from tuberculosis probably does not fall short of a million souls. This tide of infection is kept up, year in, year out, and every 70,000 dying annually in Britain must have infected 70,000 fresh victims before they themselves are carried away. Can it not be stopped, this foul tide of infection? What is being done to stop it? Sanatoria are being provided for the early cases, the bad and most infectious cases are largely being left alone to sow infection broadcast and then die. This is the chief means being used at present to stop the tide. The early non-infectious case is deemed the more important to look after, and the well-advanced, open, thoroughly infectious case is left to itself to infect others and then to die. This is the condition of our public health attitude in regard to tuberculosis. It is a travesty on the application of all biological laws, and in direct opposition to all laws of racial preservation. Industrial conditions have produced an artificial environment and enhanced the chances of infection by the organism of this disease; it should be our plan to copy nature's method and safeguard the interests of the community, and to do this we must proceed on the plan of separating the source of infection—that is to say, the infectious individual from the sound individual. This is done with success in the case of smallpox and cholera, and this plan has eradicated hydrophobia; why should it not be carried out in the case of tuberculosis? Under present conditions men, women and children are going on unwittingly infecting one another by the thousand with tuberculosis in school, workshop and home, and we who know it take no public action and raise no clamant outcry against it. It is of more value to the community to isolate one pauper far advanced in tuberculosis than to send ten early cases to sanatoria. This disease must be stopped at its source as well as dealt with on its course. No disease has ever been eradicated from a community by discovering cures for it, and none ever will; many diseases have disappeared because their sources have been cut off.

Let us be scientific, let us search out the truth; having found it, let us act upon it, and let us conceal nothing that is true.

THE CULTIVATION OF WASTE LAND[1]

By A. D. HALL, M.A., F.R.S.

THE president of a Section of the British Association has two very distinct precedents before him for his address; he can either set about a general review of the whole subject to which his section is devoted or he can give an account of one of his own investigations which he judges to be of wider interest and application than usual. The special circumstances of this meeting in Australia have suggested to me another course. I have tried to find a topic which under one or other of its aspects may be equally interesting both to my colleagues from England and to my audience who are farming here in this great continent. My subject will be the winning of new land for agriculture, the bringing into cultivation of land that has hitherto been left to run to waste because it was regarded as unprofitable to farm. To some extent, of course, this may be regarded as the normal process by which new countries are settled; the bush is cleared and the plough follows, or under other conditions the rough native herbage gives way to pasture under the organized grazing of sheep or cattle. I wish, however, to deal exclusively with what are commonly termed the bad lands, inasmuch as in many parts of the world though recently settled, agriculture is being forced to attack these bad lands because the supply of natural farming land is running short. In a new country farming begins on the naturally fertile soils that only require a minimum of cultivation to yield profitable crops, and the newcomers wander further afield in order to find land which will in the light of their former experience be good. Before long the supply is exhausted, the second-class land is then taken up until the stage is reached of experimentation upon soils that require some special treatment or novel form of agriculture before they can be utilized at all. Perhaps North America affords the clearest illustration: its great agricultural development came with the opening up of the prairies of the Middle West, where the soil rich in the accumulated fertility of past cycles of vegetation was both easy to work and grateful for exploitation. But with the growth of population and the continued demand for land no soils of that class have been available for the last generation or so, and latterly we find the problem has been how to make use of the arid lands, either by irrigation or by dry-farming where the rainfall can still be made adequate for partial cropping, or, further, how to convert the soils that are absolutely poisoned by alkali salts into something

[1] Address of the president to the Agricultural Section of the British Association for the Advancement of Science, Australia, 1914.

capable of growing a crop. You yourselves will supply better than I can the Australian parallels, at any rate we in England read that the wheat-belt is now being extended into districts where the low rainfall had hitherto been thought to preclude any systematic cropping.

Now, the fact that the supply of naturally fertile land is not unlimited reacts in its turn upon the old countries. During the 'eighties and 'nineties of the last century the opening up of such vast wheat areas in America, Argentina, Australia, and the development of the overseas trade reduced prices in Europe to such an extent that in Great Britain, where the full extent of the competition was experienced, the extension of agriculture came to an end despite the continued increase of population. The area of land under cultivation has declined but little despite the growth of the towns, but the process of taking in the waste lands stopped and much of the land already farmed fell back from arable to cheaper pasture. But as soon as production in the newer countries failed to keep pace with the growth of population prices began to rise again, and we are now in the old world endeavoring to make productive the land that has hitherto been of little service except for sport and the roughest of grazing. Even the most densely populated European countries contain great areas of uncultivated land; within fifty miles of London blocks of a thousand acres of waste may be found, and Holland and Belgium, perhaps the most intensively cultivated of all western countries, possess immense districts that are little more than desert. Of the European countries, Germany has taken the lead in endeavoring to bring into use this undeveloped capital; her population is rising rapidly and her fiscal policy has caused her to feel severely the recent increase in the prices of foodstuffs, which she has determined to relieve as far as possible by extending the productivity of her own land. It has been estimated that Germany possesses something approaching to ten million acres of uncultivated land, and a government department has been created to reclaim and colonize this area.

Before dealing with the processes by which the rough places of the earth are to be made straight there is one general question that deserves consideration—Is it more feasible to increase the production of a given country by enlarging the area under cultivation or by improving the methods of the existing cultivators? There is without doubt plenty of room for the latter process even in the most highly farmed countries: in England the average yield of wheat is about 32 bushels per acre—a good farmer expects 40; the average yield of mangolds, a crop more dependent upon cultivation, is as low as 20 tons per acre when twice as much will not be out of the way with good farming. A large proportion of the moderate land in England is kept in the state of poor grass—even as grass its production might be doubled by suitable manuring and careful management, while under the plough its production of cattle-food might easily be trebled or quadrupled. Why, then, trouble about adding to the area of indifferent land when so much of what has already been reclaimed, upon which the first capital outlay of clearing, fencing, roadmaking, etc., has been accomplished, is not doing its duty? We are at once confronted by the human factor in the problem. The existing educational agencies which will have to bring about better farming will only slowly become effective, and however imperfect they still may be in England, they are mainly so because of the lack of response upon the part of the farmers. The present occupiers of the land do obtain in many cases a very inadequate return from it, but they make some sort of a living and they hold it up against others who, though they want land, can not be guaranteed to use it any better. Improved farming means more enterprise, more knowledge, often more capital, and the man who can bring these to the business is far rarer than the man who, given a piece of land even of the poorest quality, will knock a living out of it by sheer hard work and doggedness. While, then, there should be no slackening in our efforts to improve the quality of the management of existing land, there is a case for also using every effort to increase the cultivable area; indeed, it is probable that for some time to come the second process will add most to both the agricultural production and the agricultural population.

Let us now consider what are the factors which determine the fertility of the land that is first brought into cultivation and remains the backbone of farming in the old settled countries. Foremost comes rainfall, and the distribution is almost as important as the amount. Winter rain is more valuable than summer, and though cereal-growing is none the worse and may even obtain better results with a rainless summer, stock-raising and the production of fodder crops are the better for a rainfall that is distributed fairly evenly throughout the year. Rainfall, again, must bear some relation to temperature; some of the best farming in the eastern counties of England is done on an average rainfall of 20 inches; there are great areas in South Africa with the same average rainfall that are little better than desert. In temperate regions we may say that the naturally fertile land requires a rainfall of from 20 to 50 inches per annum, not too much segregated into seasons and some at least falling in the winter.

If the rainfall is excessive or the drainage inadequate to carry it off, the formation of peat is induced, resulting in such uncultivated areas as the bogs of Ireland and the moors of eastern England, Holland and Germany.

Given suitable rainfall and temperature the texture of the soil becomes a factor of importance; if too coarse and sandy, so little of the rainfall is retained that we get all the effects of drought secondarily produced. In itself the open texture of a coarse sandy soil is favorable to plant development; under irrigation, or where the situation is such as to result in permanent water a short distance below the surface, fine crops will be produced on sandy soils that would remain almost barren if they only depended upon the rainfall for their water. In western Europe large areas of heaths and waste land owe their character to the coarse and open texture of the soil. At the opposite extreme we find clays so heavy that their cultivation is unprofitable; such soils, however, will carry grass and are rarely left unoccupied. For example, in the southeast of England there are a few commons, *i. e.*, land which has never been regarded as worth enclosing and bringing into particular ownership, situated on heavy clay land; most of such land is pasture, often of the poorest, or, if at any elevation, has been covered with forest from time immemorial.

One last factor in the soil is of the utmost importance to fertility and that is the presence of lime—of calcium carbonate, to be more accurate—in quantities sufficient to maintain the soil in a neutral condition. Old as is the knowledge that lime is of value to the soil, we are only now beginning to realize, as investigation into the minute organisms of the soil proceeds, how fundamental is the presence of lime to fertility. A survey of the farming of England or western Europe will show that all the naturally rich soils are either definitely calcareous or contain sufficient calcium carbonate to maintain them in a neutral condition even after many centuries of cultivation. Examples are not lacking where the supply of calcium carbonate by human agency has been the factor in bringing and keeping land in cultivation. I have discussed one such case on the Rothamsted estate and several others have come under my notice. The amelioration of non-calcareous soils by treatment with chalk or marl from some adjacent source has been a traditional usage in England and the north of France: Pliny reports it as prevailing in Gaul and Britain in his day, and the farmer of to-day often owes the value of his land to his unknown predecessors who continuously chalked or marled the land. Upon the presence of carbonate of lime depends the type of biological reaction that will go on in the soil, the beneficial bacterial processes that prepare the food for plants only take place in a medium with a neutral reaction. The Rothamsted soils have provided two leading cases. I have shown that the accumulation of fertility in grass-land left to itself and neither grazed nor mown, so that virgin conditions were being re-established, was due to the action of the organism called Azotobacter, which fixes free nitrogen from the atmosphere, and was indirectly determined by the presence of calcium carbonate in the soil, without which the Azotobacter can not function. Examination of typical examples of black soils from all parts of the world, the prairies of North America, the steppes of Russia and the Argentine, New Zealand and Indian soils, showed in all of them the Azotobacter organism and a working proportion of carbonate of lime. Now, as we know, all virgin soils are not rich, and only in a few parts of the world are to be found those wonderful black soils that are often several feet in depth and contain 10 to 20 per cent. of organic matter and 3 to 5 parts per thousand of nitrogen. These soils are all calcareous, they occur in regions of a moderate rainfall inducing grass-steppe or bush conditions, and the annual fall of vegetation provides the organic matter which the Azotobacter requires as a source of energy in order to fix nitrogen. Non-calcareous soils under similar climatic conditions do not accumulate nitrogen and become rich; in the absence of carbonate of lime the nitrogen-fixing organisms are not active, and the soil only receives from the annual fall of vegetation the nitrogen that was originally taken from it. There is but a cyclic movement of nitrogen from the soil to the plant and back again, whereas in the calcareous soils there is also continuous addition of fresh nitrogen derived from the atmosphere, in which process the carbonaceous part of the annual crop supplies the motive power.

The other leading case to be found at Rothamsted is that of certain grassplots which have artificially been brought into an acid condition by the continued application of sulphate of ammonia. In these soils nitrification is suspended, the nitrification organisms have even disappeared, though the herbage still obtains nitrogen because most plants are able to utilize ammoniacal nitrogen as well as nitrates. The interesting feature, however, is that the decaying grass on these acid soils passes into the form of peat, a layer of which is forming upon the surface of the soil, though nothing of the kind is found on adjacent plots where the use of lime or of alkaline manures has prevented the development of acidity. From this we may learn that the development of a surface layer of peat, independent of waterlogging (when another kind of peat forms even under alkaline conditions), is determined by the acidity of the soil, when certain of the bacterial processes of decay are replaced by changes due by micro-fungi which do not carry the breaking-down of organic matter to the destructive stage. This affords us a clue to the origin of many areas of upland peat in the British Isles, where the remains of ancient forest roots and stumps of trees are found on the true soil surface below the layer of peat, but where there is no waterlogging to bring about the death of the trees and the formation of peat. We may suppose that when the land-surface became fit for vegetation at the close of the glacial epoch it covered itself with a normal vegetation, chiefly dwarf forest, because of the rainfall and temperature. The soil, however, being without carbonate of lime, would in time become acid with the products of decay of the vegetable matter falling to the ground, and as soon as this acid condition was set up peat would begin to form from the grassy surface vegetation. The process would continue until the acid conditions and the depth of the accumulating layer of peat would kill the trees, the stumps of which would remain sealed up below the peat. I am far from thinking that this explanation is complete, but at least we have facts in sight which could lead one to suppose that a non-calcareous soil originally neutral and carrying a normal vegetation can naturally become acid, alter the character of its vegetation and clothe itself with a layer of peat. The point of economic importance is that these peaty acid soils are of very little value as long as they are acid, though they take on a quite different aspect if they are limed and made neutral.

Of all the soil factors making for fertility I should put lime the first; upon its presence depend both the processes which produce available plant food in quantities adequate for crop-production at a high level and those which naturally regenerate and maintain the resources of the soil; it is, moreover, the factor which is most easily under the control of the agriculturist.

I need say little about those cases in which infertility is due to the presence in the soil of some substance which is actually injurious to plant-growth, because such substances are nearly always due to the physical environment of the soil, to too much or too little water. In water-logged situations we may find in the soil peaty acids, iron salts, sulphides, etc., inhibiting the growth of plants; in arid regions the soil may still be charged with an excess of soluble compounds of the alkalis and alkaline earths, resulting from the decomposition of the rocks that have been broken down to form the soil, but which through the inadequate rainfall have never been washed out. The establishment of normal conditions of growth, irrigation in the one case, drainage in the other, will speedily result in the removal of the deleterious substances. Practically, only bodies that are soluble can get into a plant to injure it, hence such bodies can be removed from the soil by water, provided that the water can find its way through the soil and escape.

Let us now consider the various methods by which land suffering from one or other of the disabilities we have just discussed is nowadays being brought into cultivation. The most important, if we consider the area affected, is the extension of cropping into regions of deficient rainfall by means of what has been termed dry-farming. As far as its immediate methods go, dry-farming consists in nothing more than the application of the principles of husbandry worked out by English farmers in the east and southeast of England, principles first expounded by Jethro Tull, though a complete explanation was not then possible, even if it is now. In the first place, the tilth must be made both deep and fine, thus whatever rain falls will be absorbed and the conditions favoring a deep and full root range will have been established. Next, the soil below the surface, though finely worked, must be compact, because only thus can the water present travel to the roots of the plant. Lastly, a loose layer must be maintained on the surface, which, though dry itself, acts as a screen and a barrier to prevent loss of water from the effective soil below by any other channel than that of the plant. Granted these methods of cultivation, the new feature about "dry-farming," which has been introduced by settlers in the arid districts of Australia and North America, is the use of a year of bare fallow in which to accumulate a supply of water for the next year's or two years' crop. This raises the fundamental question of how much water is necessary for the growth of an ordinary crop. The first investigation that Lawes and Gilbert carried out at Rothamsted dealt with this very point; they grew the usual field crops in pots, protected the surface of the soil from evaporation so that all the loss of water proceeded through the plant, weighed the water that was supplied from time to time, and finally weighed the produce, expressing their results as a ratio between the dry matter produced and the water transpired by the plant. These experiments have been repeated under different climatic conditions by Hellriegel in Heidelberg, by Wollny in Vienna, by King and others in America. Now the two processes in the plant, carbon assimilation and transpiration, are not causally connected, though as both are carried out in the leaf and have some factors in common they are found to show some constancy in their relative magnitudes. Lawes and Gilbert obtained a ratio of about 300 lbs. of water transpired for each pound of dry matter harvested, but the other investigators under more arid conditions found much higher figures, up to 500 and even 700 to 1. Now, a crop yielding 20 bushels of wheat per acre will contain about a ton of dry matter per acre, so that, taking the high ratio of 500 to 1, no more than 500 tons of water per acre or 5 inches of rain will have been consumed in the production of this crop. It is, of course, impossible to ensure that all the rain falling within a year shall be saved for the crop, much must evaporate before it reaches the subsoil where it can be stored, and only when the crop is in full possession of the land can we expect that all the water leaving the soil shall go through the crop. What proportion the waste bears to that which is utilized will depend not only on the degree of cultivation but upon the season at which the fall occurs; summer showers, for example, that do not penetrate more than a few inches below the surface will be dissipated without any useful effect. When the climatic conditions result in precipitation during the winter, the water will be in the main available for crop-production; and it has been found by experience that cereals can be profitably grown with as small a rainfall as 12 inches. The necessary cultural operations consist in producing such a rough surface as will ensure the water getting into the subsoil, hence autumn ploughing is desirable. Where the precipitation is largely in the form of snow, a broken surface also helps both to absorb the thawing snow and to prevent it being swept into the gullies and hollow places by the wind. On some of the Russian steppes it has become customary to leave a long stubble in order to entangle as much snow as possible, but probably a rough ploughing before the snowfall would be even more effective. When the rainfall drops to the region of 12 to 16 inches and occurs during the summer months, then dry-farming methods and the summer fallow become of the first importance. The deep cultivation ensures that the water gets quickly down to the subsoil away from danger of evaporation, and the immediate renewal of a loose surface tilth is essential in order to conserve what has thus been gained.

In connection with this dry-farming there are several matters that still require investigation before we can decide what is the minimum rainfall on which cultivation can be profitable. In the first place, we are only imperfectly informed as to the relation between rainfall and evaporation. At Rothamsted there are three drain-gauges side by side, the soil layers being 20, 40 and 60 inches deep, respectively. The surface is kept rough and free from growth, though hardly in the condition of looseness that could be described as a soil mulch. Yet the evaporation, even under a moist English atmosphere, amounts to one half of the annual rainfall, and the significant thing is that the evaporation is approximately the same from all of the gauges and is independent of the depth of subsoil within which water is stored. Evaporation then would seem to be determined by surface alone, but we are without systematic experiments to show how variations in the surface induced by cultivation will alter the rate of evaporation. A knowledge of the evaporation factor would then inform us of what proportion of the rainfall reaches the subsoil; we then want to know to what extent it can be recovered and how far it may sink beyond the reach of the crop. It is commonly supposed that the subsoil below the actual range of the roots of the crop may still return water by capillarity to the higher levels that are being depleted, the deeper subsoil thus acting as a kind of regulating reservoir absorbing rain in times of excess and returning it when the need arises. But some work of Leather's in India and Alway's on the great plains of North America throw doubt on this view, and would suggest that only the layer traversed by roots, say, down to a depth of 6 feet, can supply water to the crop; the water movements from the deeper layers due to capillarity being too slow to be of much effect in the maintenance of the plant. The evidence on either side is far from being conclusive and more experiment is very desirable.

It would also be valuable to know how far evaporation from the bare soil can be checked by suitable screens or hedges that will break the sweep of the wind across the land. In England hedges have always been looked at from the point of view of shelter from stock; we find them most developed in the grazing districts of the west, while bare open fields prevail in the east and south. Yet the enormous value of a wind-screen to vegetation can be readily observed, and the market-gardeners both in England and the still dryer districts of the south of France make great use of them. Lastly, we must have more knowledge about the relation between transpiration-water and growth: we do not know if the high ratios we have spoken of hold for all plants. Xerophytic plants are supposed to be possessed of protective devices to reduce loss of water: Are they merely effective in preserving the plant from destruction during the fierce insolation and drying it receives? and do they enable a plant to make more growth on a given amount of water? Wheat, for example, puts on its glaucous waxy bloom under dry conditions: Is this really accompanied by a lower rate of transpiration per unit surface of leaf? and is it more than defensive, connoting a better utilization of the water the plant evaporates?

The cultivation of these soils with a minimum rainfall necessitates varieties of plants making a large ratio of dry matter to water transpired and also with a high ratio between the useful and non-useful parts of the plant. Mr. Beaven has shown that the difference in the yields of various barleys under similar conditions in England is due to differences in their migration factors: the same amount of dry matter is produced by all, but some will convert 50 per cent. and others only 45 per cent. into grain. This migration ratio, as may be seen by the relation between corn and straw on the plots at Rothamsted, is greatly affected by season; nevertheless Mr. Beaven's work indicates that under parallel conditions it is a congenital characteristic of the variety and therefore one that can be raised by the efforts of the plant-breeder. The needs of dry-land-farming call for special attention on the part of the breeder to these two ratios of transpiration and migration.

Closely linked up with the problems of dry-land-farming are those which arise in arid climates from the use of irrigation-water on land which is either impregnated with alkaline salts to begin with or develops such a condition after irrigation has been practised for some time. The history of irrigation-farming is full of disappointments due to the rise of salts from the subsoil and the subsequent sterility of the land, but the conditions are fully understood and there is no longer any excuse for the disasters which have overtaken the pioneers of irrigation in almost every country. Sterility may arise from two causes—overmuch water which brings the water-table so close to the surface that the plants' roots may be asphyxiated, or the accumulation by evaporation of the soluble salts in the surface layer until plants refuse to grow. The annual cutting off of the cotton crop in Egypt as the water-table rises with the advance of the Nile flood affords a good example of asphyxiation, but in the neighborhood of irrigation canals we also find many examples of sterility due both to the high water-table and an accompanying rise of salts. The governing principle is that drainage must accompany irrigation. Even if free from salts at the outset the land must accumulate them by the mere evaporation of natural waters, and they will rise to the surface where they exert their worst effect upon vegetation, unless from time to time there is actual washing through the soil and removal of the water charged with salt. Without drainage the greater the quantity of water used the greater the eventual damage to the soil, for thereby the subsoil water-table carrying the salts is lifted nearer to the surface. With a properly designed irrigation system the danger of salting ought not to occur; there are, however, many tracts of land where the supply of water is too limited to justify an expensive scheme of irrigation channels with corresponding drainage ditches at a lower level. Take the case of a single farmer with some water from an artesian well at his disposal, with perhaps little rainfall, with land subject to alkali, and no considerable natural fall for drainage. If he merely grades the land and waters it, sterility rapidly sets in; the only possibility appears to be to take a comparatively limited area and to cut out drainage ditches or tile drains 4 or 5 feet below the surface, even if they have to be led into a merely local hollow that can be abandoned to salt. The bed thus established must then be watered at any cost until there is a flow in the drains, after which the surface is immediately cultivated and the crop sown. There should be no further application of water until the crop covers the land, the use of water must be kept to a minimum, and by the ordinary methods of dry cultivation evaporation must be allowed only through the crop, not merely to save water but to prevent any rise of salt. With a loose surface and wind-breaks to minimize evaporation it has thus proved possible to grow valuable crops even on dangerously alkaline land. Superphosphate and sulphate of ammonia have proved to be useful fertilizers under these conditions; both tend to prevent the reaction of the soil becoming alkaline, and the calcium salts of the superphosphate minimize the injurious effects of the sodium salts that naturally accumulate in the land. On the other hand, nitrate of soda is a dangerous fertilizer. Attempts have been made to reduce the salts in the land by the growth of certain crops which take up a large proportion of mineral matter, but I have not been able to ascertain that much good can be thus effected. Sugar-beet and mangolds do appreciably reduce the salt content, but are hardly valuable enough to pay for such special cultivation and the limited irrigation-water; the best thing appears to be to grow salt-bush on the non-irrigated margin of such areas, if only to prevent the efflorescent salts from blowing on to the cultivated portion.

Let us now turn to the problem of land reclamation as it occurs in northwestern Europe. There are two main types of land that have hitherto been left waste, the peaty and the sandy areas. Of the peaty areas we can distinguish again between the low-lying moors bordering the lower courses of the great rivers; for example, in England near the mouth of the Trent, and the upland peat-bogs of which Ireland furnishes so many examples. They have these features in common—an excess of water, a deficiency of mineral salts, and, particularly in the upland bogs, a strongly acid reaction; but they possess great potential wealth in their richness in nitrogenous organic matter. It is in Germany and Holland that the methods of bringing into cultivation these moors have been most completely worked out; in Germany, for example, it is estimated that there are about five million acres of moorland of which about 10 per cent. are now under cultivation. The reclamation process must begin by drainage, which may be carried out by open ditches, but is most satisfactorily effected by pipes, despite the greater cost. The water-table must be kept some 3 feet below the surface. In districts which afford a market for peat, as, for example, on the Teufelsmoor near Bremen, the reclamation often begins by cutting out the peat, the lower layer of firm peat being won, dried, and sold for fuel. The upper spongy peat can be used for litter, but some part at least must be thrown back. Where the burning peat is thus extracted the excavation is in places pushed further until the underlying sand is reached, and enough of this is dug to spread over the reclaimed area to a depth of 4 or 5 inches and mixed by cultivation with the spongy peat. Even when the peat is not removed, pits are often made in order to sand the land, so great an improvement does it effect in the character of the crops. However, sanding is not possible everywhere, and there are great areas under cultivation where the reclamation begins with drainage, followed by the cultivation of the immediate surface without either sanding or the removal of the burning peat, which indeed are impossible over large areas, but are carried out by the owners of small farms little by little. Special tools are required: certain forms of disc-ploughs and harrows give the best results; heavy tools for large scale cultivation by steam or electricity are furnished with broad roller-like wheels; even the horses must wear broad wooden shoes.

The next stage is the manuring, and it has only been the development of the artificial fertilizer industry during the last half-century that has rendered the cultivation of this type of land possible. On the alluvial moors where the ground water has always been alkaline, the peat is rich in calcium and no treatment with lime and marl is necessary (the English fens afford an example of this type of soil), but on the true peat-bogs (Hochmoor of Germany) the manuring must begin with a good dressing of burnt lime, or, better, of marl or ground chalk. For meadows and pastures two tons per acre of lime, or twice as much of carbonate of lime, should be applied; the amounts may be halved for arable land. This must be followed by about 5 to 8 cwt. per acre of basic slag and an equal amount of kainit, which applications should be renewed in the second year, but then diminished in accord with the cropping. However, some phosphoric acid and potash salts must be continuously supplied, with occasional dressings of lime or chalk on the acid peaty areas. These latter also require in their earlier years nitrogenous manures, for the peat is slow to yield up the nitrogen it contains. The fertilizers should be nitrate of soda or lime, never sulphate of ammonia. The whole success of the reclamation depends on the use of these manures, as the peat in a state of nature is almost devoid of both phosphoric acid and potash; on the acid peats, again, normal growth is only possible after a neutral reaction has been attained by the use of lime or marl. With this manuring it is found to be easy to establish a good meadow herbage in a very short space of time; it is not even necessary to get rid of the surface vegetation of *Erica* and other heath and bog plants. The manure is put on and the surface is worked continuously with disc-harrows and rollers, but never deeply; a seed-mixture containing chiefly red, white and Alsike clovers, *Lotus uliginosus*, rye-grass, timothy and cocksfoot, is sown in the spring and soon succeeds in choking the native vegetation.

It is impossible to say what is the cost of the reclamation of moorland in this fashion; the big expense is the drainage and the construction of roads, both of which are entirely determined by local conditions. But of the value of the process when accomplished there can be no doubt. I have seen a case quoted from the *Ostfriesische Zeitung*, where a piece of moor bought for £75 was reclaimed and sold for £900; and, best test of all, one may see in places like the Teufelsmoor near Bremen, families living in comfort on thirty to forty acres of what was once merely wild moor with no productive value.

Of even greater interest in England is the reclamation of heathland, which has of late years been proceeding apace in Germany. In this category we may include all land which owes its infertility to the coarse grade and low water-retaining power of the particles of which the soil is composed, the soil being at the same time as a rule devoid of carbonate of lime, and covered in consequence with heather and similar calcifuge plants. In England there exist extensive tracts of uncultivated land of this character in close proximity to the considerable populations, but the process of reclaiming such land for agriculture seems to have come to an abrupt conclusion somewhere about 1850, when the developing industries of the country began to offer so much greater returns for capital than agriculture. That land of the kind can be cultivated with success is evident from the mere fact that everywhere prosperous farms may be seen bordering the wastes, possessing soils that are essentially identical with those of the wastes. These were brought under cultivation when labor was cheaper, often without calculation of the cost because the work was done piecemeal at times when the men would otherwise have been idle. Were any strict account to be framed, the reclamation probably did not pay its way for many years, and it has only become possible again because of modern advances in science and machinery. As examples of the type of land, I may instance the Bagshot Sands on which, in north Surrey, in Berkshire and Hampshire, and again in its southern development in the New Forest, lie so many thousands of acres of uncultivated heath. No systematic reclamation has taken place, but everywhere farms have been carved out on this formation often by the industry of squatters, and within reach of London the vast supplies of town manure which used to be available have converted some of it into fertile land. The crystallization of common rights into charters for public playgrounds, its growing appreciation for residential purposes, will now always stand in the way of the utilization of most of the Bagshot Sands for agriculture, but further afield there are many areas of similar character. The Lower Greensand is perhaps equally discounted by its residential value, but on the Tertiaries of Dorset, the Crag and Glacial Sands of Suffolk and Norfolk—the brak, the Bunter Beds of the Midlands, lie many expanses of waste that are convertible into farming land, just as Lincoln Heath and much of the beautifully farmed land of Cheshire have been gained for agriculture within the past century. Equally possible is an attack upon the sandy areas, warrens or links, behind the sand-dunes on many parts of the English and especially the Welsh coasts; not all of them are wanted for golf, and many can be fitted for market-gardening. Of old the only way of dealing with such land was merely to clear it, burn the rubbish, and start upon the ordinary routine of cultivation, but for a long time on such a system the crops will hardly pay their way from year to year, and the permanent deficiencies of the soil in lime and mineral salts remain unrepaired. In Cheshire the enormous value of marl and bones in such a connection was early recognized; it has been the later discovery of the potash salts that renders reclamation a commercial proposition to-day. The method that is now followed is to begin by clearing the land of shrubs, burning off the roughest of the vegetation, and turning over a shallow layer in the summer, leaving the heathery sod to the killing and disintegrating action of sun and frost until the following spring. The manure is then put on—lime or ground chalk or marl as before, basic slag and kainit, and the sod is worked down to a rough seed-bed on which lupins are sown, to be ploughed in when they reach their flowering stage. The growth of the lupins makes the land, they supply humus to bind the sand together and retain moisture, they draw nitrogen from the atmosphere and with the phosphoric acid and potash form a complete manure for succeeding crops. Sometimes a second crop of lupins is ploughed in, but usually the land is put immediately to an ordinary rotation of rye, oats, potatoes and clover. When the heath-land is divided among small tenants in an unreclaimed state, cropping often begins without the lupins, the necessary nitrogen being imported by nitrate of soda, but for years the land shows inferior results. Only the tenant can rarely afford to lose the year the lupin crop involves, and so great is the demand for land in Germany that the State finds it preferable to let the tenant reclaim than to reclaim for him, and charge him as rent the cost of the more thorough process. And now as to the finance of the operation: the reclaiming down to the ploughing in of the lupin crop costs from £5 to £6 an acre, the bare heath costs from £5 to £7 an acre, the reclaimed land after a few years' cultivation would sell at £20 to £30 an acre. Meantime the State has probably made a free grant for drainage, looking to get some interest back in increased taxation; the local authority has also made roads for which the increased rating due to a new agricultural community must be the only return. It is a long-sighted policy which will only find its full justification after many years when the loans have all been paid off and the State has gained a well-established addition to its agricultural land and its productive population. In comparing English with German conditions there are certain differences to be taken into account—in the first place the work of reclamation will be dearer in England because of the higher price of labor, then the land will not be so valuable when won because the higher scale of prices for agricultural products enhances the price of land in Germany. Next, I doubt, in view of the great industrial demand for men in England, if we have the men available who will bring to the land the skill and power of drudgery that I saw being put into these German holdings of thirty to forty acres in their earlier years of low productivity. Moreover, in Germany these heaths are generally bordered by forests, in which the small holder gets occupation for part of the year while his wife and children keep the farm going. For this, if for no other reason, afforestation and land reclamation and settlement should go on together. But, despite these drawbacks, I am still of opinion that the reclamation of such heath-lands is a sound commercial venture in England, either for a landowner who is thinking of a future rather than of a present return on his capital, or for the state or other public body, wherever the waste land can be acquired for less than £5 an acre. The capitalized value of its present rental rarely approaches that figure, but the barrenest heath is apt to develop the potentialities of a gold-mine when purchase by the state comes in question. The map of England is so written over in detail with boundaries and rights and prescriptions that the path of the would-be reclaimer, who must work on a large scale if he is to work cheaply, can only be slow and devious. There are other possibilities of winning agricultural land even in England, from the slob land and estuaries, from the clays nowadays too heavy for cultivation; but the problems they present are rather those of engineering than of agricultural science. What I should like in conclusion once more to emphasize is, that the reclamation of heath and peat-land of which I have been speaking—reclamation that in the past could only be imperfectly effected at a great and possibly unremunerative expense of human labor—has now become feasible through the applications of science—the knowledge of the functions of fertilizers, the industrial developments which have given us basic slag and potash salts, the knowledge of the fertility that can be gained by the growth of leguminous plants. From beginning to end the process of reclamation of moor and heath, as we see in progress in northwestern Europe, is stamped as the product of science and investigation.

HOME RULE THE HOPE OF MUNICIPAL DEMOCRACY

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IF the final test of democracy in America is to come in the cities, as Jefferson phophesied in his "Notes on Virginia," it would seem that the test should at least be a fair one. Yet the municipal machinery of the average American state permits anything but a fair trial of the democratic principle. For, every student of contemporaneous municipal conditions knows that, barring those progressive communities that have adopted some form of commission government, city government is still cursed with the curse of divided responsibility, is still in the hands of men who can not apply the rules of municipal efficiency because they are bound by the rules of the partisan game. In these cities men are still elected to office by national party organizations without regard to questions of local policy, and men are still appointed to municipal positions because of what they have done for their party rather than because of anything they can do for their city.

Deplorable as it is, the worst thing about this system of city government is that it is not the free choice of the cities that are the victims of it, but an imposition by an outside authority—the state legislature. For, under the ordinary state constitution, the city is not, in theory of law, a self-governing community, but a subject province exercising its limited powers by sufferance of the state legislature, and having this or that form of government as may be superimposed by the outside sovereign. The municipality does not even possess the right to its own existence; it exists only by grace of the state legislature, which, if it pleased to do so, could withdraw its lease of life at will.

Thus the city takes its right to existence, its form of government and its governmental powers from the state, and what the state can give the state can take away. The legal validity of any act by the city, such as the issuing of bonds, the contracting for a municipal waterworks or the granting of a municipal franchise, is not determined by the expressed desire of its citizens, but by the voice of the legislature as set out in some statute. The real seat of municipal authority, therefore, is not in the citizens, but in the state legislature; the city lives and moves and has its being in the will of the state.

Under this system of constitutional law the cities exercise those powers that are enumerated in the state legislature grants, and only those powers. If the city wants to exercise a specific power of local government for the satisfaction of a local need, it must search the statutes for permission, and if the statutes are silent on the point, it must appeal to the state legislature for the requisite power. Thus, if a city in my own state of Indiana, for example, wishes to furnish ice to its citizens in the heat of summer, establish a pension fund for its teachers or institute a civil service test for its employees, it must make its humiliating appeal to the legislative Cæsar at Indianapolis; for these powers are not nominated in the bond. No wonder an exasperated Indiana city official was once led to remark that "the only creatures without rights under our law are outlaws, wild beasts and municipalities." Yet, that local communities shall have the fullest right of local self-government is a maxim of American institutions.

Not only must the city in the exercise of its enumerated powers keep strictly within the limits set by the state legislature, it must follow only such administrative methods as the legislature has prescribed. Even in the determination of the fundamental framework of their government the citizens have no legal voice. A certain city may desire the commission plan or the city manager plan; but, of its own action, it can not get what it wants. It must take what it gets from the state house, and in the large number of states of which I am writing it gets an antiquated form of city organization that renders increasingly difficult the municipal problem. And not only the general framework, but the minutest detail of the administrative machinery, is often prescribed by legislative act.

Generally the legislature groups the cities in classes according to their population, and then imposes a detailed plan of administrative organization and powers upon each class. This frequently means that a particular city is saddled with an administrative machinery ill-fitted to its local conditions, or with administrative methods ill-adapted to its local needs. Any one who is familiar with municipal conditions knows that even cities of the same general size often reveal the greatest diversity of conditions and needs, and that what is good for one city is often bad for another. Moreover, to imprison the city in the strait-jacket of uniform legislation checks its inventiveness, for it deprives it of the opportunity of wholesome experiment with municipal methods. It impairs its individuality, for it takes from it the chance to shape its own life and development. It lessens its sense of responsibility, for it relieves it of the responsibility of working out its own civic salvation. Common sense joins with the principle of local self-government in the demand that local institutions be permitted to conform to local conditions.

To meet the needs of modern social and economic development the American city without right of self-government is compelled by the state constitution to appeal at every turn to the legislature for relief; but that constitution never guarantees that the city's prayer shall be answered, or that it shall even be considered on its merits. Who can deny that politics-ridden legislatures have often refused to hear the appeal of the city for no other than a purely partisan reason? Who will deny that, just as burdensome laws have often been imposed upon the city for partisan purpose, so needed legislation has often been denied the city for partisan advantage? The legislative history of every state abounds with testimony to show that legislative dominion over municipal affairs has been as discreditable to the state as it has been unhealthy for the city.

Not only does the partisan character of the state legislature disqualify it for the function of guiding the administrative development of the cities, but the individual legislators have neither the time nor the knowledge of local conditions nor the proper sense of responsibility to the urban constituency necessary to a constructive treatment of the municipal problem. Members of the legislature are largely from the rural districts and can not in reason be expected to understand the perplexing problems of municipal government. Yet, to these men, untrained in the intricacies of municipal administration, unfamiliar with actual city conditions and busy with many problems of state policy, has been intrusted the tremendous task of controlling the city's administrative development. It is no reflection upon the ability or intelligence of our legislators to say that they are ill-fitted for this task of absentee law-making.

Aside from making impossible an effective solution of the municipal problem, this legislative dominion over the city impairs the efficiency of the legislative members in the other work which they have to do. In Indiana, for example, the legislative desks for years have groaned under the burden of bills having for their object to grant to cities relief from the restrictive provisions of our state constitution and laws. During the past few sessions a perfect flood of measures dealing with matters of a purely local nature engrossed legislative time and energy that should have been put upon important matters of general state policy. We have rid ourselves by a federal constitutional change of one great obstacle to legislative efficiency—the indirect election of United States Senators; it now remains to rid ourselves by state constitutional change of another great obstacle—the legislative regulation of municipal affairs. This can be done by writing into the state constitution provisions for municipal home rule. Already several states have adopted this needed reform.

What does "municipal home rule" mean? It means, in the first place, a reversal of the existing legal presumption against the powers of the city. Instead of possessing only such powers as are granted to it by the state legislature, the city, under the "home rule" system, is invested by the constitution with all powers of local government consistent with the general laws of the state. In this way is created an unmolested sphere of local self-government in which the city may exercise all powers necessary to its own complete development, without the necessity of recourse to any outside authority and without the danger of interference from any outside authority. Municipal home rule means further that the city may determine its own form of government, or as Herbert Bigelow put it, "may cut out its own municipal suit of clothes." Thus the city decides for itself, by means of a charter convention and ratification election, whether it will have the commission plan, the city manager plan, the mayor-and-council system or any other form of municipal organization.

And why not? Who know better than the citizens of Indianapolis the needs of Indianapolis and the administrative agencies that are adapted to those needs? Who can determine better than the citizens of Lexington, Kentucky, the activities of public welfare in which the government of Lexington should engage? If Terre Haute, Indiana, wants a non-partisan form of city government why should not Terre Haute have that form? There appears to be no reason for excepting cities from the operation of the principle of self-government that does not apply with equal force against the principle of democracy itself.

Ours are the only English-speaking cities in the world that are denied the right of self-government. One can not imagine, for example, legislative intermeddling in the affairs of an English city, which is permitted by Parliament to develop in its own way and according to its own ideas of administrative organization. English cities since 1832 have been among the best governed in the world and American cities have been among the worst governed. What accounts for this difference between the municipal experience of two English-speaking peoples? The main reason is that English cities are self-governed and American cities are state-governed. The citizens of Birmingham govern Birmingham; the legislature of Indiana governs Indianapolis.

Home rule for cities means municipal self-government, but it does not mean municipal independence in the sense that there are created independent sovereignties within the state. It does not mean that the state government loses its control over matters that concern the general state welfare. Thus home rule does not require that the state surrender entirely its control over elections in which state officers are chosen, for the people of the commonwealth as a whole are vitally interested in maintaining the purity of the ballot and in the prevention of corrupt and fradulent practices. It does not mean that the state resigns its power to pass laws relative to the health, safety and general welfare of its citizens. The state at large is vitally interested in the prevention of crime and disease and in the education of the people, and, although it may leave the city free to provide its own administrative machinery and allow a wide diversity in methods, it must maintain a general supervisory control over these subjects. In other words, the city government is not only an organ for the satisfaction of local needs, but an agent of the state for the performance of state functions. The doctrine of home rule recognizes this. It renders to the city the things that are the city's, and to the state the things that are the state's.

So defined—and it has been so defined by the states which have written it into their fundamental law—the principle of municipal home rule may be regarded as the first step in the direction of a responsible and efficient city government. Wherever it has been put into the constitution of a state a larger municipal vision has been created and a new brand of municipal administration has appeared. Thus it is a significant fact that many of the most advanced forms of city government have grown up in the cities which have enjoyed constitutional home rule. Given the right to determine its own destiny, the city becomes the hope, instead of the despair, of democracy. And the test which democracy receives will be a fair one.

THE POLITICAL MIND OF FOREIGN-BORN AMERICANS

By ABRAM LIPSKY, Ph.D.
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An election is a psychological experiment on a large scale. The trouble with most elections, however, as psychological tests, is that the questions submitted are vague, complex and variously understood. If one could put a simple and unequivocal question such as "Are you in favor of capital punishment?" or, "Do you prefer co-operative to family housekeeping?" the answers might be of great informative value as to the mind of the population. If such questions could be submitted, it would then be interesting in analyzing the returns to look for the influence of economic, social and racial factors.

The City of New York, as it happens, is an excellent laboratory for studying the responses of several foreign nationalities. There are, according to the Thirteenth Federal Census, 340,765 Italians in New York who were born in Italy, 484,189 foreign-born Russians, 278,114 foreign-born Germans, 252,662 Irish, born in Ireland. These nationalities are not evenly distributed over the area of the city. Here and there exist communities as large as good-sized cities composed almost entirely of people of one nationality, and these communities constitute distinct political units, to the extent that a ward or an assembly district is a distinct political unit. Thus there were in the eighth assembly district in 1910, 51,438 foreign-born Russians; 83.8 per cent. of the males of voting age were foreign-born and naturalized; only 2.5 per cent. were native born, of native parents. In the third assembly district there were 33,531 foreign-born Italians; in the sixteenth there were 9,144 Irish from Ireland; in the third district of Queens County there were 15,548 Germans born in Germany. We are thus enabled to pick out districts in which one or other nationality largely predominates and from the election returns can determine how the district voted upon every candidate or proposition submitted.

Candidates are but rarely propositions. Only when they are does an election take on the character of an experiment in social psychology. Now, the election of November, 1913, was one of the rare sort. The issues were clear, simple, unequivocal, understood very generally in the same sense. The propositions for which the candidates stood might have been formulated as follows: (1) Are you in favor of government by an organization such as Tammany? (2) Are you in favor of Socialism? (3) Do you read the

Hearst newspapers regularly? These questions have not in recent years been put so clearly—not in 1910 when the campaign for the governorship was complicated by the intervention of Roosevelt in favor of Stimson, not in 1911 when only minor officials were elected, not in 1912 when the personal element again was paramount.

In view of the prevalent solicitude concerning the effect of racial conglomeration upon American national life, it is of great practical importance to ascertain as definitely as possible what the behavior of different races constituting the American population is in response to specific appeals. Does nationality play any part in determining the point of view of our foreign communities in political matters? Will American problems be dealt with in the same way by one of the foreign districts as by a community of native Americans born of native parents?

From the Thirteenth Census, which gives the number of specified nationalities in each assembly district, and also the number of naturalized voters, one can deduce approximately the percentage of voters belonging to each nationality in every district.

We shall first consider the answers of the chief constituent nationalities of New York to the question: "Are you in favor of government by political organizations of the Tammany kind?"

We present to begin with a table giving the ten districts in which the voters of native parentage were found in the greatest numbers. The first column gives the borough and district, the second, the per cent. of all the voters constituted by the Americans of native parentage, the third, the per cent. of the whole vote in each district given to the Tammany candidate for mayor. In the fourth, the vote for Dix, Tammany candidate in 1910, is added:

Assembly District	Native of Native parents	1913, McCall	1910, Dix
M 15	45.3	33.7	58.1
M 19	40.0	33.2	52.3
M 25	44.1	35.3	48.4
M 27	51.5	37.6	55.8
Q 4	41.3	31.1	46.2
B 17	45.6	24.7	43.6
B 11	38.0	34.9	50.5
B 18	39.0	28.3	46.3
B 5	38.1	25.3	44.1
B 10	38.6	36.6	53.3

These districts of mainly American voters answered "nay" to Tammany, throwing in every case over sixty per cent. of their votes against it. In 1910 Dix received a little over 50 per cent. in half of these districts, but as has been said, Tammany was not then the sole issue.

There is no difficulty in finding a dozen districts in which the Russians alone far exceed every other nationality in number. As is well known, the Russians are nearly all Jews, and so are the Austrians who in large numbers inhabit some of these districts. The next table is similar to the first except that Russians and Austrians are substituted for native Americans.

Assembly District	Russians	Austrians	Both	1913, McCall	1910, Dix
M 8.........	54.4	14.2	68.6	40.2	52.3
M 6.........	30.4	30.8	61.2	22.8	40.
M 4.........	35.6	25.2	60.2	51.1	61.7
M 26.........	34.6	6.7	41.3	30.0	41.0
M 2.........	35.6	1.4	37.0	57.6	67.5
M 10.........	22.3	12.5	36.8	29.3	52.2
M 24.........	20.6	3.9	23.9	49.7	56.8
M 31.........	12.9	4.9	17.8	24.1	44.7
B 21.........	31.2	5.9	37.1	27.1	48.6
B 23.........	33.3	3.9	37.2	25.7	40.9
B 14.........	16.1	5.9	22.0	46.6	61.5
B 22.........	13.0	3.0	16.0	24.3	38.5

In only two of these districts did McCall receive more than 50 per cent. In two thirds of the districts he received much less than the average for the entire city which was 38 per cent. The Russians, too, emphatically said "nay" to Tammany in 1913.

Let us now put the same question to the Italians. There are four assembly districts in which the Italians far outnumber every other nationality; there are two others in which they exist in great numbers, although by the side of one or other nationality that rivals or exceeds them numerically. The following table gives the figures as in the preceding tables:

Assembly District	Italians	1913, McCall	1910, Dix
M 3.................	30.3	67.6	77.7
M 1.................	25.2	59.6	67.8
M 28.................	26.8	42.6	55.8
B 3.................	23.2	63.7	73.1
B 2.................	13.4	60.0	67.7
M 2.................	18.5	57.6	67.4

In three of these districts the Tammany candidate received over 60 per cent. of the votes; in two over 50 per cent. and in one over 40 per cent. It is evident that the Italian districts said "yea" to Tammany as emphatically as the districts of the Russians and native Americans said "nay."

Statistics are hardly necessary to teach the student of politics how Irishmen are inclined to answer the question we have been considering. Our figures support the view that they are for the Tammany organization. We take for study the five districts in which the foreign-born Irish are most numerous. It should be remembered, however, that our figures underestimate the voting strength of the Irish in these districts;

first, because the percentage of naturalization of the Irish is much greater than that of Italians or Russians on account of their being older immigrants and also more at home in the peculiar political milieu of New York; second, the native Irish of foreign parents usually outnumber the foreign born, whereas the opposite is true of the relation between native-born and foreign-born Russians and Italians. Besides, the Irish are widely scattered and massed in only a few districts. However, these are the districts we have, at present, in view, as giving a strong clue to what occurs less perceptibly where the concentration is less dense. The table follows:

Assembly District	Irish	1913, McCall	1910, Dix
M 13	16.4	61.0	58.1
M 16	14.0	51.7	61.4
M 11	12.2	55.6	60.5
M 14	12.4	54.7	61.2
M 5	11.2	64.4	67.6

We have only five districts in which the naturalized Irishmen constitute clearly over 10 per cent. of the voting population. In every one the Tammany candidate received over 50 per cent. of the district's vote. Although not an exact measure of the strength of the Irish predilection for the organization, it is a clear indication of the tendency sufficiently demonstrated in other ways.

The Germans, like the Irish, are more diffused than the Russians and Italians. We find them constituting more than 10 per cent. of the voters in six districts. In two of these they far outnumber every other nationality—the third of Queens and second of Manhattan. In these they formed considerably more than twenty-one per cent. of the voters.

Assembly District	Germans	1913, McCall	1910, Dix
Q 3	21.4	31.1	49.8
B 20	20.2	26.8	41.8
B 19	13.6	31.9	48.3
B 33	11.2	34.6	49.4
Q 1	11.1	41.4	55.2
M 22	21.2	38.4	50.5

Every one of these districts decisively rejected Tammany.

Summarizing the answers given to the first question put to the voters, which was "Are you for or against Tammany" we are able to say that a decided "no" was given by native Americans of native parents and by the Russians and Germans; a decided "yes" was given by the Italians and Irish.

Two other questions came sharply to the fore in 1913. One was radicalism in the form of socialism; the other was Hearstian radicalism.

How do the foreigners stand towards these movements? There is a widespread though vague impression that socialism is a phenomenon of foreign growth. We can be more specific.

The city at large gave the socialist candidate for mayor in 1913 five per cent. of the total vote. Let us take those districts in which he received over ten per cent. There are just ten such districts. Let us also put down the approximate percentage of the voters in these districts belonging to the principal nationalities. The following table gives these figures with the percentage of the vote given to the socialist candidate for mayor in 1913 and for governor in 1910:

Assembly District	Socialist Vote		Native of Natives	Austr.	Ger.	Irish	Italian	Russian
	1910	1913						
B 21....	12.4	16.1	12.6	5.9	4.1	0	9.1	31.2
B 23....	12.5	15.8	19.8	3.9	2.2	1.6	4.6	33.3
B 19....	11.0	12.8	12.6	.8	13.6	0	9.9	11.9
M 4....	12.6	11.9	7.0	25.2	.4	1.1	2.5	35.6
M 26....	10.2	11.8	7.1	6.7	4.6	3.8	1.4	34.6
M 8....	14.6	11.7	2.5	14.2	.7	0	4.1	54.4
M 22....	13.1	11.7	10.6	4.6	21.2	5.3	1.6	3.6
M 6....	10.0	11.2	2.4	30.8	1.1	.7	.7	30.4
M 24....	10.4	11.2	11.1	3.9	4.3	6.2	11.1	20.6
M 10....	11.1	10.8	5.9	12.5	4.7	0	13.9	22.3

It will be seen from the table, first, that the percentage of native born of native parents is less in every district than that of some foreign nationality; second, that in every district but two the percentage of Russians far exceeds that of any other nationality; third, that in those two exceptional districts it is the Germans that predominate. The Austrians should be added to the Russians, because, as said before, both Russians and Austrians in these districts are practically all Jews. Our conclusion therefore, is that the bulk of the socialist vote is derived from the foreign Jewish element, and to a much less degree from the Germans. This position is supported from the other end. The districts in which the socialists received the fewest votes, from 1 to 2 per cent., are those in which the natives, the Irish and the Italians are strongest—the first, third, fifth, seventh, ninth, thirteenth, fifteenth, twenty-fifth and twenty-seventh of Manhattan; and such districts as the second and third of Brooklyn.

The other branch of the question on radicalism resolves itself into this, "What voters are susceptible to influence from the Hearst newspapers?" One of the principal candidates in 1913 was bitterly opposed by these papers and a candidate of their own was nominated by the Independence League. Do the replies run to any extent along lines of national cleavage?

A study of the figures seems to justify the following observations: The districts in which the voters of native parentage are comparatively few—less than one third of all the voters—are those in which the Hearstians are strongest. On the other hand, they are not strongest where the foreign-born voters are most numerous. Their hold is upon the native-born of foreign parentage. If we take the districts giving the Hearst candidates the largest percentage—say over eight per cent.—we find the foreign-born Germans and Irish far outnumbered by the natives of German and Irish parentage. If we take those giving the lowest percentages—say, less than four per cent.—we find the foreign-born of all nationalities greatly outnumbering the native. Along with these facts we find that several of those districts among the half dozen giving the highest socialist vote are also among the half dozen giving the lowest Hearstian vote, showing that socialism and Hearstism are but weakly correlated.

The half dozen districts highest for Hearstism, and half dozen lowest, with the percentage vote given both in 1913 and 1910 (when the league ran a candidate for governor) are given below.

Highest for Hearst Candidate

Assembly District	1913	1910
B 9	10.1	9.0
B 22	9.8	9.6
Bx 33	9.5	11.1
Bx 34	9.3	9.1
B 20	9.3	9.5
B 16	9.2	6.4

Lowest for Hearst Candidates

Assembly District	1913	1910
M 6	.5	3.6
M 4	1.2	3.0
M 8	1.6	3.2
M 3	2.9	3.4
M 2	3.0	3.4
M 27	3.2	2.9

Hearstism we conclude is a mode of thought that is attractive chiefly to members of the transition species between the immigrant and the American of native parents.

Finally, how do our naturalized citizens stand towards that latest phase of reform represented by the Progressive party? The answer to this question is made difficult by complicating circumstances. In 1912 the personal issue played an over-shadowing part; in 1913 interest was centered at other points, the aims of the Progressive party for the time being coinciding with those of other political elements. One or two facts in the election of 1912, however, are extremely suggestive even though they do not cover the whole ground. In that election Roosevelt ran ahead of Wilson in only four districts in the city. One was the twenty-third of Manhattan, in which Taft also ran ahead of Wilson—a strong Republican district. The other three were the sixth, the eighth and the twenty-sixth, the three districts in which the Russians and Austrians constitute the great majority of the electorate.

It appears, therefore, from the experiment in social psychology conducted by the state in November, 1913, that, firstly, feudal politics as exemplified by Tammany is disapproved by native Americans (native born of native parents), by Russians and by Germans; it is favored by Irish and Italians; secondly, socialism is not a general foreign phenomenon, being preferred chiefly by Russians and, to a less extent, by Germans, getting no support from the Irish and but little from the Italians; thirdly, Hearstism is a transition phenomenon manifested by a considerable number of foreigners in process of becoming Americanized.

THE EVOLUTION OF SERVICE BY UNION AND COOPERATION, CONSERVATION AND EXCHANGE

By Professor WILLIAM PATTEN

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THE specialist, who has wandered far into the wilderness of created things, seeking the solution of his problem at its source, must pause now and again to note the location of the sun and the direction in which the streams are flowing. Having done so, he well may greet his distant colleagues and send a field-note of progress to his friends at home. Herewith is such a greeting and such a field-note of progress.

Part I

I. *Evolution and the Conduct of Life*

The theory of evolution is now accepted by all classes of intellectual leaders. Its transforming influence has penetrated society far beyond the point where the theory is formally recognized, or the meaning of the term even vaguely understood. It has destroyed old standards for the interpretation of life; erased old formulas for the conduct of life; and has compelled us to make new standards and formulas more in harmony with our new conceptions of nature and her methods.

With the disappearance of the old landmarks, the acknowledged leaders of humanity, of all kinds of belief and training, are groping about seeking a new standard for the interpretation and the conduct of life; a standard that is based on the best of the old religious, and on the best of the new knowledge; one that is not in downright conflict with the common-sense teachings of every-day life, nor with the conduct of affairs in which these leaders are the acknowledged experts; nor with the vision of the modern prophets who foresee the coming of a new man.

It is therefore again time to enquire what is the nature of the underlying processes common to the evolution of the living and of the non-living world? What, after all, constitutes progress in nature, and how it is accomplished? In what directions are the great evolutionary streams of plant life, and animal life, moving? What are the ethics and morals of nature, if indeed she has any? What has science to offer the trustees of tradition in place of that which it seems to have destroyed? What have the students of nature, and of life at large, learned, however elemental, that will be to all mankind a fundamental truth and a guiding principle to right living? Is mankind to live, and make progress in his manner of living, by following the same laws other living things have followed in their progress; or must he create out of his own compelling needs new methods of living, new principles, new laws of conduct, that are solely applicable to himself?

To these questions science has given various answers, for life, as well as nature, has many sides, and science sees them through diverse eyes.

II. *The Mosaic Vision of Science*

Nature is, indeed, so vast, so intricate, that one science can see but a very small part of her; and since no science can long preserve its images undimmed, nor adequately utilize the vision of other sciences, our mental picture of nature is a mosaic patchwork of flickering images; a changing, composite caricature, that exaggerates her most conspicuous features, her most discussed and most recently discovered phases.

But yesterday, nature seemed to be the essentially unchanging product of a precipitative creative fiat; to-day, the still changing product of a slow process of growth; and to-morrow, what will the image be? Which science will throw the high lights of nature on the mind of man? Which one will cast the shadows?

The great naturalists of the preceding generation—those brilliant students of interwoven lives playing their varied parts on shifting scenes of forest, field, and shore—gave us our first vivid picture of an ever-changing nature. It was largely their testimony, and the overwhelming evidence gathered from their point of view, that won the verdict for evolution. After the great naturalists came the modern schools of biologists, exploring the streams of life to their source, and by greater refinements of methods seeking in the seclusion of the laboratory to obtain a nearer and a larger view of nature in accouchement: now scrutinizing with microscope and blazing lights the minutely woven fabric of egg, and sperm, and embryo; now seeking the first throbs of nascent life in cell and organ; now, by artful and instantaneous killing, striving to fix in their order the mincing steps of life, and to preserve them for more deliberate inspection; now striving to view the steps of life in action; and again, by mimicking the processes of life, hoping to catch their meaning, or perhaps the meaning of life itself.

The field naturalists and the modern schools of biologists survey a particular phase of life through a particular medium, or facet, and each school has evolved a set formula, or diagram, for the one thing it most clearly sees; notably the Lamarckians, who see the inheritance of acquired characters, and the moulding influence of habit and of the external environment; the Darwinians, who see little else than "natural selection" and the "survival of the fittest"; the Weismannians, who specialize in an omnipotent, but obedient, "germ plasma," and who insistently deny the inheritance of acquired characters; the morphologists, who see their own cubist diagrams, instead of living, growing things; the cytologists, breeders and experimentalists, with their thumbnail sketches of the minute machinery of life, and of heredity; with their now widely familiar Mendelism, chromosomes, tropisms, artificial parthenogenesis and eugenics.

The precise methods of the modern biologist may give us commendably accurate pictures of some particular point, or phase, of life, as life is at the present moment. They have, no doubt, greatly stimulated and enriched the science of biology; but they have not clarified it, nor unified it to a corresponding degree, because they have not given us large pictures of the processes and products of evolution; and because their formulas, when widely applied, are contradictory and often meaningless. They lack perspective, and for that reason they have not taken, nor can they take, the place of the descriptive and historic sciences, such as geology, paleontology and comparative anatomy. They alone can show us approximately what life was like in the remote past, the wonderful progress it has made, its method of making progress, and the order of its accomplishment.

Thus the multiplicity, and the changing intensity, of the images formed by the compound eye of modern science have created much confusion in the mind of the scientist and the layman; one that is augmented by a prevalent opinion that certain points of view, and certain methods of studying nature, are more "scientific," more truthful and more trustworthy than others.

It is clear that the microscopic, telescopic and panoramic methods of studying nature have their respective virtues and the defects of their qualities, for each method, and each point of view, shows important things the other fails to reveal. In their attempts to portray nature, biologists often forget the weakness of the one and fail to utilize the strength of the other. By thus limiting their field of vision; by exaggerating the minute, the local, the dramatic, and the tragic incidents of life, they overlook the most significant teachings of nature, although they are familiarly and universally proclaimed by her. The layman is always a loser thereby, for while the sicklied germs of truth fly far and wide on the white wings of explanatory lies, the mature plant is too deep rooted and ponderous to be successfully transplanted.

III. *Tragic, Cooperative, and Benevolent Nature*

The picture of nature painted by the field naturalists was a warring, hostile nature, "red in tooth and claw with ravine." Its merciless struggle for existence, its wanton destruction and tragic incident, as portrayed by their disciples, deeply moved both scientist and layman, and greatly influenced the conduct and the interpretation of human life.

But the attention of the naturalists was mainly focused on the fifth act of life's drama, not on the body of the play; on the tumult and the decisive battles of a complex, mature life whose work was nearly done, not on its earlier, more primitive phases, nor on the silent, constructive processes, the building up of cell on cell, and organ on organ, that were taking place during the long and peaceful periods of preparation.

They gave us the now familiar picture of life's tragic side, and like all one-sided representations, it was but a caricature, true indeed to the life they portrayed, but misleading in the omission of the truth. They showed us the shameless selfishness; the needless toil and suffering; the wanton wastefulness of life; the endless competitions of strength and skill, in shifting alliance with cunning, hypocrisy and deceit; with blind chance in the background awarding death to the vanquished and to the victor life's bitter spoils.

With master strokes, and with the convincing accuracy of the trained observer, they painted the "disastrous chances" of a tumultuous life; the "moving accidents by flood and field"; the spectacular catastrophes of failure. But they did not portray the slow and benevolent processes of construction; the peaceful cooperations, the careful conservations, and the successful sacrifices of self to higher service. Some writers have indeed recognized the element of benevolence in the cooperation that forms such an important feature of social organization; but usually it has been regarded as something peculiar to the association of a few highly organized animals, and to man, not as something inherent to all stages of organic and inorganic nature.

But a new phase of the primeval method of nature, a new instinct, one that proclaims the universal brotherhood of man with man, and the brotherhood of man with all life and with nature, is seeking expression in the heart of man. It demands the so-called "humanitarian" methods of benevolent union, of cooperative exchange, of sympathy and service. The hand hesitates to obey the heart's commands, because the false prophets of science still dictate the use of nature's crudest, least effective methods, saying that progress can be made only through appropriation, elimination and destruction; through competition and then more competition; through mastery by brute force, or strategy; through selfishness; and the license of freedom uncontrolled. I challenge this interpretation of the order. It is not the real teaching of life, nor of nature. It places the emphasis in the wrong place and on the wrong thing. It measures the cost, but does not see the gain. It counts the failures, but does not recognize the manner of achieving success.

There is nothing new, essentially new, or unlike nature's methods, in the "humanity" of man, for the "humanitarian methods" of making progress through sympathetic, or harmonious, action; through benovelent union; through cooperative exchange and service, are as old as the universe; and it is on these methods alone and with them alone, the universe is built. All evolution is a process of more and more successful union, and more and more effective cooperation. All manner of living is a fabric of cooperating services. In every sphere of nature, be it chemical, or physical, or organic, or social, or "spiritual," and at every stage in its progress, evolution is achieved through union, not disunion; through construction, not destruction; through sympathetic and harmonious action, not discord; through organization, not disorganization; through cooperation, not competition; through the bondage of service, not the license of freedom; through service that leads the way to more service, not through dominion and freedom from service.

The processes that produce evolution, as distinct from those that do not, are essentially benevolent and moral processes, for evolution is a progressive triumph of right, or successful methods of self giving. Every forward step is a constructing and a conserving process, whether it be the union of cosmic matter to form solar systems; or atoms to form chemical compounds; cells and organs to form a body; or man to form society. In all cases the forward step is the result of a successful giving, or surrender of self, to form a part of something that is larger, and better equipped for a wider service. Every living thing has its two great periods; one when it is receiving all it is, the other when it is giving all it has. The broader, more elaborate, each life is, the longer and more elaborate is the process of giving by the parents, and of receiving by the offspring; and the better all organs of both parent and offspring cooperate for a wider service of the whole.

Nor does "blind chance" rule in nature, for the dice are loaded in favor of things in the right time and place, as against those in the wrong time and place; in favor of things that cooperate and serve, as against those that do not cooperate and serve. In its broadest sense, union, even if it is primarily by "chance," tends to become progressive, or cumulative, because of the increased stability of each new product of union. Both union and cooperation are cumulative and directive; cumulative, because order tends to exclude from itself whatever is in conflict with it; directive, because the larger unit tends to control the smaller unit, and to incorporate it into its own system.

Progressive union and progressive cooperation, or progressive benevolence, harmony and service are, therefore, inherent properties of life and matter.

IV. *Creation, Evolution and Service*

Thus union and cooperation are the great creative, the great constructive, and the great conservative forces in nature. They tend to give community of action, and harmony of action to her constituents; to give stability and rest. They express themselves in an evolution that leads toward completion; toward the fulfilment of the inherent possibilities of nature; toward perfection.

Creation then is the birth of new things through the union and cooperation of preexisting things. Its product may be a new star; a chemical compound; an inanimate machine; a living mechanism with the properties of growth and renewal; or any one of the many kinds of cooperating groups, or associations, of men. We may not correctly use the term "Creative Evolution," for there can be no creation without evolution and no evolution without creation. The ceaseless flow of creative processes is evolution, and evolution is serial creation.

While nature's methods of creating are always the same, the quality of her products is as unknowable, and the extent of her resources as unpredictable, to-day as they were yesterday and as they will be to-morrow. The first cooperative union of hydrogen and oxygen to produce water created a new substance, with new properties and qualities, with new potentialities for world service, in no wise comparable with those of its constituents. This familiar process, whereby a substance, such as water, is produced by the cooperative union of things that appear to us so utterly unlike it, is no more or less mysterious in its power to create new things, new properties, new possibilities for further creation, than the cooperative union of a much larger number of elements to form protoplasm, with its newly created properties called "vitality."

As the formal chemistry of cooperating elements creates new chemical substances, with new properties and new powers for world service, so the super-chemistry of cooperating lives creates new organisms whose sum total of reactions may be expressed in unified bodily, or social activities, or in terms of bodily or of social consciousness, with their new powers for world service. These new properties, born of the cooperative union of a group of cells to form a "living body," or of a group of men to form a "team," a college, a city, or a state, constitutes the distinctive properties, or what is often called the "soul" or "spirit," of that group: and just as the properties of water and the "vitality" of protoplasm are new things, unlike anything else in the whole world, so are the essential, distinctive properties of each class of cooperating things unlike anything else in the whole world; hence they can only be measured, or compared, in terms of themselves.

The only attribute common to each class, and to all classes of nature's manifestations, is the inherent power, through the union and cooperation of their respective constituents, to create new things with new properties and with new powers for world service. The only common measure of their powers for service is the extent of the unions and cooperations that created them, and the extent of the new unions and cooperations they, in turn, create.

Progress therefore in organic evolution, as in cosmic evolution, consists in a measurable approach towards uniting the maximum number of constituents into the most economic system of foreign and domestic cooperation.

Whatsoever conditions of time, space, materials and mode of action tend to give greater unity and better cooperation in nature, is world-service. Service, then, constitutes the real basis of ethics and of morality for the attainment of service is, to that extent, the actual fulfilment of the possibilities of nature; and all service is the fruit of a measurably perfected process of cooperative union.

Science, therefore, finds no time, nor place, nor thing set apart and alone sanctified by one instantaneous, all-embracing creative act. Cosmic evolution and organic evolution, the growth of suns and stars, of earth, and plant, and man, are continuous parts of one process. The formal chemistry of earth, and sea, and air; the flowing chemistry of protoplasmic cell and organ; the moulding discipline of associated nerve and muscle; of eye and hand; the alchemy of associated lives in nature's household, are but different phases of one living, all pervading, process of creation.

Nebulæ stiffen into stars, and suns give birth to drooling planets, larva smeared. Throbbing tides of sea and air, the heart-beats of a planet, drive the humid breath of oceans over the mountain skeleton, and through the capillaries of earth, clothing her ribs in clay, and spreading her first gardens of ooze. Earth labors in her kitchen, and with equal skill in synthesis, brings forth atoms tied in squads, or regiments; minerals, straight-edged and steadfast; soft proteids and albumens, with rounded forms and yielding sides; dancing specks and wriggling threads, prophets of the life to come; sprawling, self-constructing, self-consuming, protoplasm, free to rove, or wrapped in walls, or bound in glowing brotherhood of cells together; naked, hand-free, high-headed man, armored and armed with conscience and with vision. Scrutinize as best she may, science finds no seam in this universal fabric; no patchwork of dead and alive, honored or dishonored in creation; no boundaries between what was, and is, and shall be.

Thus all nature is a moving conflict for more intimate union, better cooperation, wider service. An unending strife to gain stability, or peace, where peace is won only through union and cooperation that lead to further conflict and wider service. All evolution is the product of service, and its progress is measured in terms of service. The essential character of all natural processes is a striving for perfection through organized service.

There should be no conflict between the teachings of science and the dictates of an enlightened humanity as expressed in the broad term religion, for science and religion are dual reflections of a universal natural law; their methods and aims are the same; they differ only in the manner in which they seek for, discover and express the same things.

Science seeks truth and discovers righteousness. Religion seeks righteousness and discovers truth. Both acquire knowledge of nature's right and wrong methods of making progress, and both point the same way to right living.

Science is the deliberate, conscious interpretation of nature. Religion is the instinctive, unconscious expression of natural law in terms of feeling.

Religion is the instinctive feeling for truth, justice and righteousness. Nature is truth, and her way is the way of justice and righteousness. Science takes cognizance of it in measured terms.

Religion is the feeling of wonder, adoration, gratitude and humility. It is largely justified and satisfied by the contemplation of nature through science.

Religion is the recognition of our own imperfections, and a desire for perfection. Nature is a conflict of imperfections. Science shows that the conflict is aimed at, and moves toward, perfection.

Religion demands service. Nature is a growing fabric of cooperating services. Science surveys the process and points the way toward higher service.

In science and religion, there is strife through organized service to discover and attain perfection. Each reflects in its own way the essential character of a universal natural law.

* * * * * * *

We are at present in a better position to use the panoramic vision of science than ever before, because we have now reached a point where the outlook on the evolution of life extends to the horizon, and we may see mapped out in broad perspective the grand preliminaries to life, and the general trend of life's highways.

These great highways of organic evolution, that run back for many millions of years, through the whole gamut of vertebrate and invertebrate life, from man to the simplest and minutest kinds of living things, show us in large terms what organic evolution really is and how it has been accomplished. They reveal to us the ethics and the morals of nature, the fundamentally right and the fundamentally wrong methods of living, for throughout all the highways of progress nature declares, and declares with insistent repetition, that the actual creation of new things and of new powers for service, or the evolution of the varied products and activities of nature, is never compassed by competition and selfishness; never by destruction, nor by discord, nor by dominion; but by union and by cooperation; by sympathy, submission and mutual service. Until some other being appears, greater than man, the age long processes that have produced him are justified by their product, and are thereby standardized as righteous and moral processes.

(*To be continued*)

THE PROGRESS OF SCIENCE

THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE meeting of the British Association for the Advancement of Science in Canada, in South Africa and now in Australia exhibits those national traits which led to the founding and development of these dominions, and year after year the president of the association represents the leadership in science which the British races have so continuously maintained since the time of Roger Bacon. Recent advances in biological science are scarcely parallel in importance to the newer developments in physics, recounted before the association by Dr. Lodge last year, but the experimental and quantitative methods now being applied in genetics, as clearly explained by Professor Conklin in the present issue of this journal, are a beginning from which much may be expected. Professor William Bateson has been a leader, perhaps the chief leader, in this work, and his presidential address deserves attention both for the advances which he recounts and for the speculations in which he indulges.

The address—which in this country has been printed in full in *Science*—was divided into two parts, or it may rather be said that two addresses were made, one at Melbourne and one at Sydney. The first describes Mendelian genetics with special reference to its evolutionary aspects and its destructive side, the second is largely concerned with applications to man and to society. Professor Bateson tells us that in biological science we are just about where Boyle was in the nineteenth century; we can dispose of alchemy, but we can not make more than a quasi-chemistry. Still, he is pretty positive, not only in his destructive criticism, but also about the wide implications of his quasi-chemistry.

If, as Professor Bateson tells us, genetic research can only obtain new varieties by crossing, and if new traits can only be exhibited by the loss of inhibiting factors, we are certainly put to ignorance in regard to the entire process of evolution. This is doubtless where we have always been, for no biologist now supposes that natural selection can account for the origin of variations. Darwin did not, but assumed variability to be a natural function of organisms. Mendelism is supplying a vast amount of new and exact knowledge in regard to the results of crossing and hybridization, but in so far as it can not explain the origin of those variations which have led to new species and organic evolution, it only exhibits our failure in this direction. Professor Bateson says: "We have to reverse our habitual modes of thought. At first it may seem rank absurdity that the primordial forms of protoplasm could have contained complexity enough to produce the diverse types of life." But this is what the mechanical theory of life presupposes, and how we are helped by assuming, as Professor Bateson does, that the differentiation that gives rise to new species is due entirely to the loss of factors rather than to the addition of factors, it is difficult to see. The proposition that we all have the genius of Shakespeare and Newton, but that they were able to exhibit it owing to the loss of inhibiting elements appears to be purely mythological.

Professor Bateson and other Mendelians are doubtless correct in regarding the doctrine of natural selection and the survival of the fittest as a kind of philosophical truism, but it is not clear why this is more true of separate traits than of the organism as a whole, or how the theory is affected by modern work in experimental genetics. Indeed, the occurrence of mutations makes it easier to understand the results of natural selection, for the larger variations may have a definite value to the species when the smaller variations which might have lead up to them would not.

In his second address Professor Bateson says that at every turn the student of political science is confronted with problems that demand biological knowledge for their solution, but it does not appear that most of Professor Bateson's own generalizations—whether correct or not—are based on genetic research. For example, he urges that it can not be granted without qualification that the decline in the birth-rate of the intelligent and successful part of the population is to be regretted. He says that if the upper strata of the community produce more children than will recruit their numbers, some must fall into the lower strata and increase the pressure there. But it is by no means certain that there is too great pressure of population in France, Germany, England and the United States, and it would seem that an increase of intelligence and energy in the so-called lower classes would be a gain.

In so far as the small birth-rate of the upper classes is not so disastrous as some authors urge, it is because these classes owe their position to privilege rather than to ability, and if the privileged classes do not produce enough children to fill the positions of influence, men of greater ability may be found.

Professor Bateson says: "Modern statesmanship aims rightly at helping those who have got sown as wildlings to come into their proper class; but let not any one suppose such a policy democratic in its ultimate effects, for no course of action can be more effective in strengthening the upper classes whilst weakening the lower." Here and elsewhere Professor Bateson seems to misunderstand the proper meaning of democracy, which is not that all individuals are equal, but that each should have opportunity according to his ability.

A COMPREHENSIVE STUDY OF A DESERT BASIN

THE making of the modern Salton lake in the sink of the Cahuilla basin in 1905 and 1906 was due directly to the opening of canals for irrigation from the Colorado River leading into the bowl and a coincidence of flood water from the main tributaries of the river. The director of the Desert Laboratory of the Carnegie Institution, Dr. D. T. MacDougal, formulated a plan for systematic measurement of the various physical and biological changes accompanying the recession of this lake and the results of the activities of the members of the staff of the Desert Laboratory and other collaborators are given in Publication 193 of the Institution.

Scarcely had the level of the lake begun to fall and the salts to become more concentrated, when it was noted (in 1911 that calcium was being lost from a solution not near the saturation point for carbonate, and in 1911 a distinct coating of lime was recognized on the branches of submerged trees. Such deposition seemed to be associated with the activities of certain bacteria and algæ, and to constitute the first stage in the formation of the travertine left by previous lakes. Investigation of this matter is still in progress, as well as that of the disappearance of potassium from the lake water which is now plainly apparent. The principal changes in plant tissues submerged in the Salton were studied by President M. A. Brannon, of the University of Idaho, who found bacteria of the Amylobacter group were present, which produced a hydrolyzing action on the unlignified parts of vegetable tissues. Coincidently, Professor G. J. Peirce, of Stanford University, followed the behavior of some of the organisms which endure the entire range of variation from fresh to brackish water and finally to brine in

Saltorn at Bottom of Salton Sink in the Cahuilla Basin, February, 1903.

the pools around San Francisco Bay, with a view to anticipating events in the slower concentration of the Salton, which has now reached a stage of slightly more than one per cent. brine.

It is eloquent of the arid conditions of the Cahuilla that the sink, or the region formerly occupied by Blake Sea, with an area of over two thousand square miles, bears only 8 species of trees, 33 shrubs and woody plants, and 81 herbs, or a total of 122 species, about the number that might be expected in a square mile in the Mississippi Valley, or on the eastern sea-board. Small as this number may be, the stage seems to be set for the appearance of new ones, as evidenced by the number of endemic forms. *Striplex Saltonensis, Sphæralcea orcuttii, Cryptanthe costata, Astragalus limatus, A. aridus* and *Chæmæsyce Saltonensis* occur so far as known in this sink, which must have been occupied by Blake Sea within four or five centuries. That they have ever lived elsewhere or before this can not be demonstrated, and their occurrence suggests most strongly a recent localized origination. The modifications in *Aster exilis, Prosopis glandulosa, Striplex canescens,* and *Seirpua paludosus* shown by individuals on emerged

Rank of Vegetation at Upper Margin of Terrace Formed by Recession of Salton Lake During 1911.

Desert Formation on Strand Three or Four Hundred Years Old near Travertine Point. Ancient high level shore-line of Blake Sea on cliffs.

strands and abandoned shores of the present lake are additional facts of interest in this connection.

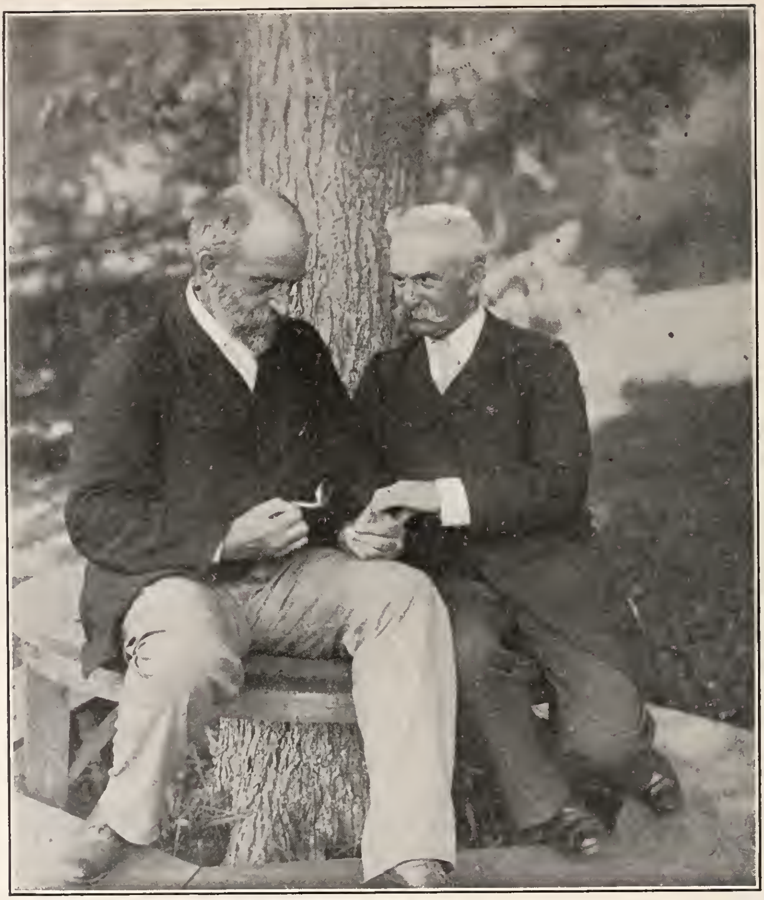
Not since the sterilization of the island of Krakatoa by a volcanic explosion has an opportunity been offered for the study of the biological reoccupation of such an area, and in this case the entire course of change has been kept under careful observation. Sixty species of plants appeared in dense strand formations on the beaches during the first seven years. Successions were rapid toward the desert, and within three years after the emergence some strands bore two species which were characteristic of the beach ranks four centuries old.

Even greater interest attaches to the revegetation of hills emerging as islands and which had been seed-sterilized. To these were borne seeds by winds and waves, but not with certainty by birds. Conjoined observation and experiment showed that the seeds for many plants which float or sink germinate, and the buoyant seedlings float for weeks, when stranded by chance their active roots strike into the mud within a few hours, making this an effective type of dissemination which appears to have escaped attention hitherto.

SCIENTIFIC ITEMS

We record with regret the death of James Ellis Gow, professor of botany in Coe College; of Mr. Alfred John Jukes-Brown, F.R.S., lately of the English Geological Survey; of Dr. Edouard Reyer, professor of geology at Vienna, and of Lieutenant Sedoff, while leading an Arctic expedition to Franz Josef Land.

The American Chemical Society is unable to hold the meeting which had been planned for Montreal in September. Nearly all international scientific congresses and conferences, including the International Congress of Americanists, which was to have met in Washington in October, have been postponed. The New Zealand meeting of the British Association has been abandoned. A number of distinguished American men of science went to attend the meeting as guests of the New Zealand govern-



This photograph, taken on the summit of Mount Washington twenty years ago, shows Professor Hugo Kronecker, the distinguished physiologist of the University of Berne, whose recent death is deplored by many students throughout the world, feeling the pulse, at that time intermittent, of Professor Henry Pickering Bowditch, of Harvard University, long the leader of physiology in the United States.

ment.—It is announced that the British universities will open as usual in the autumn, though about half the students have enlisted in the army. The Rhodes scholars from the United States and from the British colonies are expected to be in attendance at Oxford.—It is said that all German universities will be closed.

In future the distribution of the Nobel prizes will take place on June 1 instead of in December, as hitherto. The next distribution has been fixed for June 1, 1915.

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TREE DISTRIBUTION IN CENTRAL CALIFORNIA

By Dr. W. A. CANNON
DESERT BOTANICAL LABORATORY

IT has frequently been observed that the shrubs in dry regions occur isolated from one another, with the effect that the landscape as a whole has a spotted appearance. This in certain regions is very striking. For example, on drainage slopes or bajadas of the mountains of southern Arizona or southern California, one sees a discontinuous vegetal covering, conveying the idea that there are more plants than is actually the case. The remote cause of the sparseness of such plant covering, as is well known, is to be traced to a precipitation amount which is inadequate to support a dense shrub population. The immediate cause, however, is to be sought in competition between plants for ground water. The roots of neighboring plants intermingle and lie in the same soil horizon, seeking the same soil moisture. Such shrubs as have the most efficient root system, either as seedlings or mature forms, survive. Thus, here, as elsewhere in nature, the victory is to those which are best adapted to the particular environment.

As one leaves such marked arid regions behind, and journeys to regions which are less arid, as in the valleys of Central California, the interrupted distribution of the shrubs gives way to a dense shrub population, the chaparral, or pygmy forest. But in this portion of California one finds trees growing in open forests with park-like effect, in a manner exactly comparable to the open stand of the desert shrubs. This observation applies to the valley floors or the lower slopes of the mountains or low hills. In the more moist regions, as in the mountains, forest covering may be relatively, or actually, dense. Also the species to which the observation applies are, in the main, oaks. It will be shown in this note that the three species of oaks especially spoken of will have each a different and characteristic distribution and will have a different and characteristic relation one to another. It will also be shown that these are in part dependent on the character of the root-systems of the

Fig. 1. Cultivation in a Natural "Forest" in the Salinas Valley, Central California. The open stand is characteristic of the groves of the coastwise valleys. The taller centrally placed trees of the figure are *Quercus lobata,* the roble oak, and the others are *Q. agrifolia,* the encina oak.

species, as well as on the depth to perennial soil-moisture, or in other words, the water relation.

The three species of oaks referred to are *Quercus agrifolia,* the encina oak, *Q. lobata,* the roble oak, and *Q. Douglasii,* the blue or Douglas oak. The roble oak and Douglas oak are deciduous. The encina oak is the familiar live-oak of the coastwise valleys.

The roble oak is the valley oak *par excellence,* and is probably the largest California species of the genus. The largest specimen reported is 150 feet in height and 25 feet in circumference four feet above the ground.[1] The writer also saw a specimen near Clear Lake, which had a spread of top estimated to be 144 feet. In addition to being of large size, the roble oak is unusually beautiful and graceful, with long and slender pendant secondary branches, which occasionally nearly sweep the ground. If not strictly confined to moist soils, it at least attains its best development where the soil is moist and the depth to the level of perennial water is not so great as to be beyond the reach of the roots.

The encina oak is the species characteristic of the valleys of the coast ranges, where it finds its greatest development. It is disposed in open groves and it is to this species, mainly, that the park-like appearance of the coast valleys is due. In form, the encina oak is more compact than the roble oak, and has low, rounded tops, as is indicated by the accompanying figure.

As distinguished from the two other species of oaks just mentioned, the blue oak occurs characteristically on dry, rocky soils, "which are excessively arid in the rainy season."

> Not in itself an attractive tree, the blue oak, by reason of its form, color and habit, plays a strong and a natural part in the scenery of the yellow-brown foothills.[2]

Like the encina oak, the blue oak occurs singly or in open groves. The characteristic appearance of the tree and its distribution are shown in Figure 1.

However the species of oaks may differ from one another in habit, or however different the habitats they frequent may be, they agree in the one particular which has already been mentioned, namely, in the open character of the stand. This phase of the study of the oaks received particular attention at the hands of the writer in 1913, and the leading conclusions will be presented in the subsequent paragraphs.

Quercus lobata

An examination of the roots of the three species shows a striking difference in the position occupied by them in the ground, as well as in the general character of development. That of the roble oak is more of

[1] Jepson, "The Sylva of California."

[2] Jepson, *l. c.*

Fig. 2. Roots of *Quercus lobata* Growing by a Stream in Lake County. Owing to the washing away of the bank the tree has lost a portion of its former support and has leaned toward the streamway. The generalized character of the root system is fairly well shown.

the usual type, in that there is large development of the tap-root, from which extend at various depths large laterals in comparatively large numbers. The secondary roots may also penetrate fairly deep, although occasionally they lie near the surface also. In large specimens, superficial roots as long as 70 feet have been observed. Secondary roots usually branch relatively little. In a word, the root-system of the roble oak is especially well adjusted to take advantage of the more deeply-lying soil moisture, while at the same time the more superficially placed roots can absorb water from the more superficial soil layers. As will be shown below, the root habit of the plant is one well calculated to close adjustment with the peculiar habitat frequented by the species.

Quercus agrifolia

The root-system of the encina oak is characterized by an especially well-developed superficial portion, which consists of numerous relatively short and relatively slender roots, which are placed, for the most part, within three feet of the surface of the soil. There are also more deeply penetrating roots, but these are relatively few in number. In young trees, however, the tap-root, or a few laterals, are rather deeply placed, and appear to predominate in numbers. The formation of the more superficial portion of the root-system, therefore, is a response which comes with the aging of the tree. In the case of the blue oak also, there can be traced a very intimate relation between root character of the open stand of forest and the water relation.

Quercus Douglasii

As in the case of the root-system of the roble oak, that of the blue oak is composed of relatively few roots, which are usually coarse. The tap-root is sometimes well developed and there are relatively few laterals. The root-system of the blue oak, however, differs from that of the roble oak in that the roots of the species, in the proper habitat, are confined to the upper soil strata. The tap-root is also shallowly placed. The relation of the roots of the blue oak, as well as the root-system of the two other species, to soil moisture, will be taken up immediately.

Root Variation

The brief characterization of the root-systems of the oaks, as just given, does not take into account the possible variation of the roots. Owing to the impracticability of excavating the roots, it was impossible to study the variation exactly. For some reasons, however, it does not seem probable that there is marked variation in root type.

Fig. 3. Superficial Absorbing Roots of *Quercus agrifolia* Growing on the Lower Slope of the Santa Cruz Mountains near Stanford University.

For example, when the roble oak and the encina oak are growing together, and the ground is cultivated beneath them, there is a difference in response of the cultivated plants, which appears not to be directly traceable to the fact that one of the oaks is deciduous and the other is evergreen. Thus, it is known that such cultivated plants, when given water artificially, may thrive beneath the roble oak, while they may dry readily beneath the encina oak, thus indicating that the roble oak does not form a marked superficial root system, even under such conditions. Under such conditions, also, the encina oak absorbs water freely and grows vigorously. Whether, on the other hand, the

FIG. 4. *Quercus Douglasii* ON AN ARID HILL NEAR SAN MIGUEL, WHERE THE WATER TABLE LIES AT A DEPTH OF ABOUT 75 FEET. The shallow placing of the roots, as well as their general character, are shown in the figure.

converse condition would obtain if *agrifolia* were grown in the habitat especially characteristic of *lobata* has not been observed. From the nature of the development of the root system of the species, and its plasticity, this might be expected. The characteristic root development of the blue oak would lead one to suspect, also, that, given abundant soil moisture and adequate depth of soil, the roots might be induced to penetrate deeply. This condition, however, has not been actually observed.

GROUND WATER

The depth to the water table in the valleys is variable, and, in the habitats characteristic of the three species of oaks, unlike. In the valleys inhabited by *Quercus agrifolia,* the water table usually lies 35 feet or more beneath the surface. Sometimes it is much greater than this, although it is rarely less. The availability of the soil moisture which is derived from the water table to the roots does not depend wholly upon the depth of the water table, but largely on the character of the soil which intervenes between the plant roots and the water table. For example, there may be strata of sand or gravel above the level of perennial water which effectually separate the water table from the root system. For this reason, the depth to perennial ground water is not always of itself a criterion as to whether the moisture is available to the plant or not. In such cases, as has been intimated above, the plants are wholly dependent upon the water coming directly from the rains or on what water is derived from run-off or by seepage from higher ground. This, for the most part, does not penetrate beyond approximately 3 to 4 feet. The plant, therefore, is obliged to develop an extensive superficial system, in order to make use of such surface water. For this reason, the roots of adjacent trees compete for the ground water in a manner exactly comparable to the competition, as already pointed out, which occurs among the desert shrubs. Thus it follows that, because of a relative paucity of water, the trees come to have an open stand.

In the habitats where *Q. Douglasii* occurs, the water table is wanting, or so deeply placed as to be quite beyond the possible reach of the plant's roots, so that here again, the species is wholly dependent on surface water for its water supply. It follows, therefore, that the blue oak forms a very open stand, as has been seen to be the case in the encina oak, and for the same reason.

The conditions of the water supply of the roble oak, on the other hand, are diametrically opposed to those of the two other species. The best development of the roble oak occurs where the perennial ground water lies within 10 to 20 feet of the surface of the soil, or where the soil is practically homogeneous, so that the ascent of capillary water is great and where it is possible for the roots of the species to penetrate to a great depth. A characteristic example of this species, although of medium size, was seen by the edge of Putah Creek, where the July-level of the stream was less than twelve feet beneath the surface of the flood-plain, and where the flood-level of the stream must occasionally have washed the base of the tree itself.

From this brief outline of the root-characters of the three most prominent species of oaks of Central California and from the sketch of the ground water relations of the species, it appears that there is an intimate relationship between root character and the characteristic local distribution of the species.

The Relation of Ground Water to Forest Distribution

It has been pointed out in another place[3] that the depth to perennially moist soil, which is usually regulated by the depth of the water table, undoubtedly plays an important rôle in the distribution of forests as a whole. Thus, where the moist soil lies too deep to be tapped by the roots of the trees, other factors being equal, forests are usually wanting, but where the water table lies near enough to the surface, so that the perennially moist soil above it can be reached by the roots of the trees, forests are present. In southern Arizona it has been found that, given a practically homogeneous soil, the mesquite assumes a tree habit with the water 35 feet, more or less, beneath the surface, but that where the soil is not homogeneous, and is stratified, so that a portion of the strata are dry, or where the water table is more than 35 to 40 feet beneath the surface, the species has a shrub-like habit. An analogous condition obtains in the coastal plain of Texas and in the treeless middle-west. In the latter region the deciduous forests are almost wholly confined to the flood-plains of streams, while the adjacent upland is treeless. Thus, over a wide area where the climate is arid or semi-arid, the depth to perennial water is an important factor in determining the presence of forests. Where the trees are unable to attain to such moist soil, they usually develop xerophytic characters or special adjustments by which they are enabled to survive. How true this generalization may be found to be can not at present be told, but that it applies to such regions as central California, there can be no doubt. Among the adjustments, as has been pointed out in this note, are to be included those of the root-system by which they are especially adapted to make use of the superficial waters.

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[3] *Science*, N. S., Vol. XXXVII., p. 420, 1913.

PHENOMENA OF INHERITANCE

By Professor EDWIN GRANT CONKLIN
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II. Modifications and Extensions of Mendelian Principles

IT is a common experience that natural phenomena are found to be more complex the more thoroughly they are investigated. Nature is always greater than our theories, and with few exceptions hypotheses which were satisfactory at one stage of knowledge have to be extended, modified or abandoned as knowledge increases. This observation is well illustrated in the case of the Mendelian theory. The principles proposed by Mendel were relatively simple, but in attempting to apply them to the many phenomena of inheritance now known it has become necessary to modify or extend them in many ways. And yet the general and fundamental truth of these principles has been established in a surprisingly large number of cases, and they have been extended to forms of inheritance where at first it was supposed that they could not apply.

1. *The Principle of Unit Characters and Inheritance Factors.*—There has been much criticism on the part of some biologists of the principle of unit characters. It is said that unit characters can not be independent and discrete things; the organism itself is a unity and every one of its parts, every one of its characters, must influence more or less every other part and every other character. Certainly unit characters can not be absolutely independent of one another; the various parts and organs of the body and even the organism, as a whole, is not absolutely independent, and yet there are varying degrees of independence in organisms, organs, cells, parts of cells, hereditary units and characters which make it possible for purposes of analysis to deal with these things as if they were really independent, though we know they are not.

Of course characters of adult individuals do not exist as such in germ cells, but there is no escape from the conclusion that in the case of inherent differences between mature organisms there must have been differences in the constitution of the germ cells from which they developed. For every inherited character there must have been a germinal cause in the fertilized egg. This germinal cause, whatever it may be, is often spoken of as a *determiner* of a character. But the character in question is not to be thought of as the result of a single cause nor as the product of the development of a single determiner; undoubtedly many causes are involved in the development of every character, but the *differential* cause or combination of causes is that which is peculiar to the development of each particular character.

Again it is not necessary to suppose that every developed character is represented in the germ by a distinct determiner, or inheritance unit, just as it is not necessary to suppose that every chemical compound contains a peculiar chemical element; but it is necessary to suppose that each hereditary character is caused by some particular combination of inheritance units and that each compound is produced by some particular combination of chemical elements. An enormous number of chemical compounds exists as the result of various combinations of some eighty different elements, and an almost endless number of words and combinations of words—indeed, whole literatures—may be made with the twenty-six letters of the alphabet. It is quite probable that the kinds of inheritance units are few in number as compared with the multitudes of adult characters, and that different combinations of the units give rise to different adult characters; but it is certain that every inherited difference in adult organization must have had some differential cause or factor in germinal organization.

Mendel did not speculate about the nature of hereditary units, though he evidently conceived that there was something in the germ which corresponded to each character of the plant. Weismann postulated a determinant in the germ for every character which is independently heritable, and many recent students of heredity hold a similar view.

But it is evident that there is not an exact one-to-one correspondence of inheritance units and adult characters. Many characters may be decided by a single unit or factor; for example, all the numerous secondary sexual characters which distinguish males from females are decided by the original factor which determines whether the germ cells shall be ova or spermatozoa.

On the other hand, two or more factors may be concerned in the production of a single character. In many cases among both plants and animals the development of color appears to depend upon the presence in the germ cells and the cooperation in development of at least two factors, viz. (1) a pigment factor *P* (for black *B*, for brown *Br*, for yellow *Y*, for red *R*, etc.), and (2) a color developer *C*. When both of these factors are present color develops; when either one is absent no color appears.

Such cases have been described for mice, guinea-pigs and rabbits as well as for several species of plants. Bateson and Punnett found two varieties of white sweet peas which were apparently alike in every respect except the shapes of their pollen grains, one of them having long and the other round pollen. But when these were crossed a remarkable thing occurred, for the progeny, "instead of being white, were purple, like the wild Sicilian plant from which our cultivated sweet peas are descended." This is apparently a typical case of reversion and its cause was found in the fact that *at least* two factors are necessary in this case for the production of color, a pigment factor *R* and a color developer *C*. One of these was lacking in each of the white parents, their gametic formulæ being *Cr* and *cR*, but when these two factors came together in the offspring a purple-flowered type was produced with the gametic formula *Cc Rr*. These F_3 plants produced colored and white F_2 plants in the proportion of 9 colored: 7 white and the colored forms were of six different kinds (Fig. 57). For the production of these six colored forms five different factors must be present in the gametes, according to Punnett, viz.: (1) a color base (*R*), (2) a color developer *C*, (3) a purple factor *B*, (4) a light wing factor *L*, (5) a factor for intense color *I*. When all of these factors are present the result is the purple wild form with blue wings, while the omission of one or more of these factors leads to the production of six forms of colored and various types of white flowered plants of the F_2 generation.

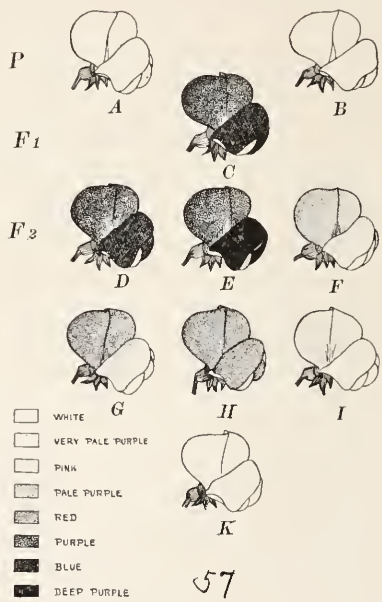

Fig. 57. Results of Crossing two Different Races (*A*) and (*B*) of White Sweet Peas; all the F_1 hybrids (*C*) are purple with blue wings like the wild ancestral stock; in F_2 six colored varieties are formed ranging from purple with blue wings (*D*) to tinged white (*I*) and several kinds (genotypes) of white varieties (*K*). (After Punnett.)

Castle found that eight different factors may be involved in producing the coat colors of rabbits; these are:

C a common color factor necessary to produce any color.

B a factor acting on *C* to produce *black*.

Br a factor acting on *C* to produce *brown*.

Y a factor acting on *C* to produce *yellow*.

I a factor which determines *intensity* of color.

U a factor which determines *uniformity* of color.

A a factor for *agouti*, or wild gray pattern, in which the tip of every hair is black, below which is a band of yellow, while the basal part of the hair is gray.

E a factor for the extension of black or brown but not of yellow.

Plate found that all of these factors except the last, *E,* are also involved in the production of the coat colors of mice. Baur has recognized more than twenty different factors for the color and form of flowers in the snap-dragon, *Antirrhinum.*

These factors are probably complex chemical substances which preserve their individuality in various combinations, just as groups of atoms or radicals do in chemical reactions; they may be dropped out or added, substituted or transposed, just as chemical radicals may be in chemical compounds. To this extent they maintain continuity and independence, but they are not absolutely indepeudent, for they react upon one another as well as to environmental changes, so that the characters of the developed organism are the results of all these reactions and interactions.

Inheritance Factors and Germinal Units

It is obvious that there must be things in germ cells which correspond to the inheritance factors: furthermore, these things must be material particles even though they be only atoms or molecules and their combinations or dissociations. And yet there are many students of the phenomena of heredity who know little about germ cells and to whom all parts of a cell are hypothetical structures, to whom "chromosomes are aiticles of faith," and who protest rather violently against any attempt to find the factors of inheritance in any of the structures of the germ cells. And yet it is perfectly evident that if there are inheritance units they must exist in the germ cells as discrete particles, even if they are only molecules, by whose associations or dissociations in response to intrinsic or extrinsic conditions the various characters of the developed organism arise. It is certainly legitimate to ask what the germinal elements are which correspond to inheritance factors.

There was a time when the cell was the *ultima thule* of biological analysis and when the contents of cells were supposed to be "perfectly homogeneous, diaphanous, structureless slime." Then the nucleus was discovered within the cell, then the chromosomes within the nucleus, then the chromomeres within the chromosomes, and there is no reason to suppose that organization ceases with the powers of our present microscope. With every improvement of the microscope and of microscopical technique, structures have been found in cells which were undreamed of before, and it is not probable that the end has been reached in this regard. We know that cells contain nuclei and chromosomes and chromomeres, centrosomes and plastosomes and microsomes, and we know that some of these parts differ in function as well as in structure. And there is no reason to doubt that if we had sufficiently powerful microscopes we should find still smaller and smaller units until we came at last to molecules and atoms.

The manner in which inheritance units from the two parents unite in fertilization and later segregate in the formation of gametes, so that the latter are pure with respect to any character, is a familiar part of Mendelian inheritance (Fig. 58). What are these units in terms of

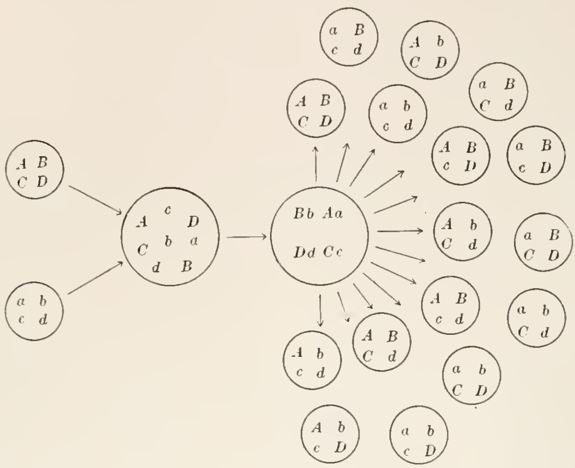

FIG. 58. DIAGRAM SHOWING UNION OF FACTORS IN FERTILIZATION AND THEIR SEGREGATION IN THE FORMATION OF GERM CELLS. With 4 pairs of factors (*Aa, Bb, Cc, Dd*), 16 types of gametes are possible, as shown in the two series of small circles at the right. (From Wilson.)

cell structures and where are they located in the cell? We have in the chromosomes, as Wilson especially has emphasized, an apparatus which fulfils all the requirements of carriers of Mendelian factors (Fig. 59). Both factors and chromosomes come in equal numbers from both parents; both material and paternal factors and chromosomes pair in the zygote and separate in the gamete, as shown in diagrams 58 and 59; and so far as known the chromosomes are the only portion of the germ cells which fulfil these conditions. Furthermore, there is much additional evidence that the chromosomes are especially concerned in heredity, as was pointed out in the last lecture, and it is not reasonable to suppose that this remarkable coincidence between the distribution of Mendelian factors and of chromosomes is without significance.

Of course Mendelian factors are not all the factors of development, but merely the *differential* factors which cause, for example, one guinea-pig to be white and its brother to be black. Very many factors are involved in the production of white or black color, but there is at least one *differential* factor for every unit character, and this alone is the Mendelian factor. Of course there is no such thing as a "sex-producing chromosome," sex being the result of the interaction of the X-chromosome upon other chromosomes, and of all of these upon the cytoplasm. The X-chromosome is only one factor in the determination of sex, but if it is a factor which differs in the case of the two sexes it is a "sex-determining factor." There are many parts of a germ cell, all of which may be concerned in heredity and development, but the chromosomes appear to be the seat of the differential factors for Mendelian characters.

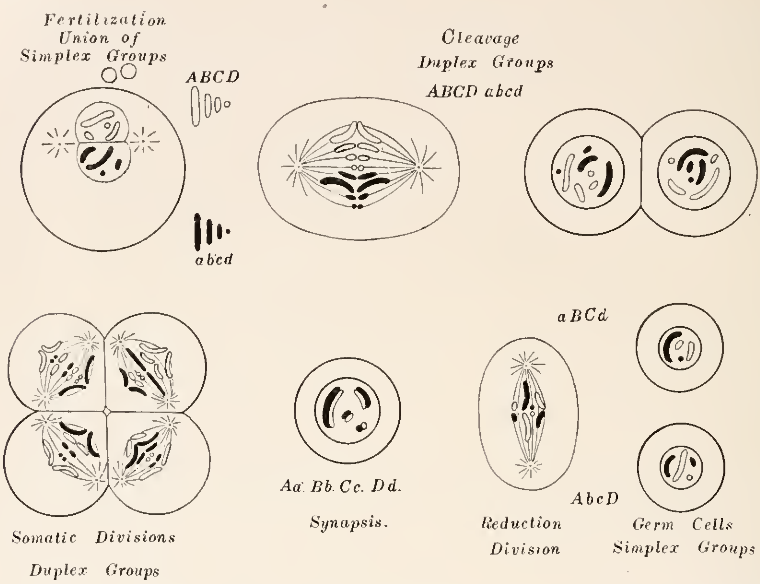

Fig. 59. Cellular Diagram Corresponding to Fig. 58, Showing the Union of Maternal Chromosomes (*ABCD*) and Paternal Ones (*abcd*) in Fertilization, their distribution in cleavage, their union into 4 pairs (*Aa, Bb, Cc, Dd*), in synapsis and the separation of the pairs in the reduction division. Only 2 of the 16 possible types of germ cells are shown. (From Wilson.)

2. *Modifications of the Principle of Dominance.*—A great number of animal and plant hybrids show one contrasting character completely dominant over the other one, as Mendel observed in the case of his peas. But in a considerable number of cases this dominance is incomplete or imperfect. When white-flowered strains of four-o'clocks are crossed with red-flowered ones the F_1 plants bear neither white nor red flowers, but pink ones, and the F_2 plants bear white, red and pink flowers. The whites and reds are always homozygous, the pinks heterozygous; pure white and pure red are produced only when their factors are duplex (WW), (RR); when they are simplex (WR) pink is produced. In this case red is not completely dominant over white, but the hybrid is more or less intermediate between the two parents (Fig. 56).

It has long been known that the breed of fowls called Blue Andalusian does not breed true, but in each generation produces a certain number of blacks and whites as well as blues. Bateson found that the blues are really hybrids between blacks and whites in which neither of the latter is completely dominant. Black and white appear only when they are pure (homozygous), blue only when both black and white are present (heterozygous).

Again, a cross of red and white cattle produces roan offspring, but the latter when interbred give rise to reds, roans and whites in the proportion of 1 : 2 : 1, showing that the roans are heterozygotes in which red is not completely dominant over white, while the reds and whites are homozygotes and consequently breed true.

Lang found that when snails with uniformly colored shells were crossed with snails having bands of color on the shells the hybrids were *faintly banded,* thus being more or less intermediate between the two parents; but when these hybrids were interbred they produced banded, faintly banded and uniformly colored snails in the ratio of 1 : 2 : 1, thus proving that Mendelian segregation takes place in the F_2 generation, and that dominance is incomplete in the heterozygotes. Many other similar cases of incomplete dominance are known.

Sometimes dominance is incomplete in early stages of development, but becomes complete in adult stages. Davenport found that when pure white and pure black Leghorn fowls are crossed the chicks are speckled white and black, but in the adult fowl dominance is complete and the plumage is black. Similar conditions of delayed dominance are well known in the color of the hair and eyes of children, though dominance may become complete when they have reached adult life.

In a few instances a character may be dominant at one time and recessive at another. Thus Davenport found that an extra toe in fowls is dominant under certain circumstances and recessive under others. Tennent found that characters which are usually dominant in hybrid echinoderms may be made recessive if the chemical or physical nature of the sea water is changed. Such cases seem to show that dominance may sometimes depend upon environmental conditions, sometimes upon a particular combination of hereditary units.

Sex and Sex-limited Inheritance

Sex and sex-limited inheritance may be considered here, since they involve questions of dominance. There is good evidence, as was shown in the last lecture, that sex is a Mendelian character, in which the female has a double dose of the determiner for sex, whereas the male has only a single dose. Consequently in the formation of the gametes every egg receives one sex-determiner, while only one half of the spermatozoa receive such a determiner, the other half of them being without it. If, then, an egg is fertilized by a sperm without one of these determiners, a male results; but if an egg is fertilized by a sperm with one of these determiners, a female is produced. This is graphically represented in diagram 60, in which X represents the sex determiner, which is duplex in the female and simplex in the male, and the chance unions of male and female gametes yield females (XX) and males (XO) in equal numbers.

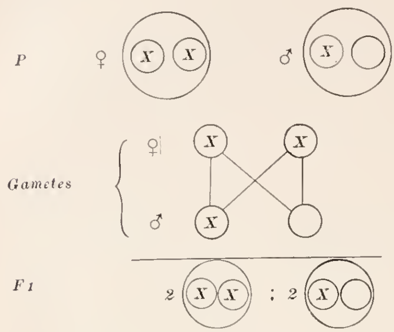

FIG. 60. DIAGRAM SHOWING SEX AS A MENDELIAN CHARACTER, THE FEMALE BEING HOMOZYGOUS, THE MALE HETEROZYGOUS FOR SEX. The female forms gametes all of which contain the X-chromosome; the male forms two sorts of gametes one half of which contain the X-chromosome and the other half lack it. All possible combinations of these gametes give a 2 : 2 or 1 : 1 ratio of females to males.

In either sex many secondary sexual characters of the other sex are present during development, and traces of these may persist in the adult; but one set of these characters develops in the male and another in the female, so that they may be called *sex-limited*. The development of the secondary sex characters is usually determined by the ovaries or testes, which are the primary sex characters, though in some instances they may develop in animals which have lost their ovaries or testes, but in the last analysis both primary and secondary sex characters are dependent upon the sex determiner. Sex and sex-limited inheritance are only special cases of Mendelian inheritance in which conditions of dominance differ in the two sexes, depending upon whether the factor for sex is duplex or simplex.

Sex-linked Inheritance

In this connection we may consider another class of characters, which are linked with sex but are in no wise connected with sexual reproduction. Such characters are not necessarily limited to one sex or the other, as are many primary and secondary sexual characters, but they may appear in either sex, though they are usually transmitted from fathers to daughters, or from mothers to sons ("criss-cross" inheritance) in exactly the way in which the sex chromosomes (X) are transmitted. Morgan has therefore concluded that the factors for these characters are carried by the sex chromosomes and has named them *sex-linked* characters. In the fruit fly, *Drosophila*, he has discovered more than twenty-five such characters, applying to the color of the eyes and of the body, to the length of the wings, etc. A typical case is shown in Figs. 61 and 62. The eye color of this fly is normally red, but mutations have arisen in which the eye is white. Such a mutation always appears in males, though it may later be transferred to females, as we shall see. If now a white-eyed male and a red-eyed female are crossed all the F_1s are red eyed, but if these F_1s are interbred all the females of F_2 have red eyes while half of the males have red eyes and the other half have white eyes (Fig. 61). On the other hand, if one of the F_1 females of this cross is bred with a white-eyed male half of the females of F_2 are

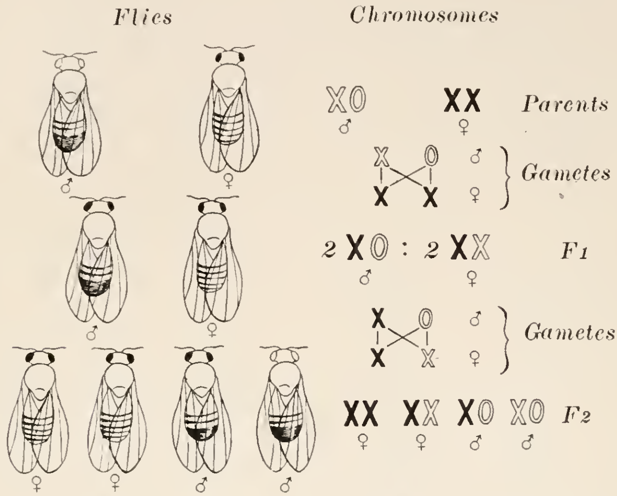

FIG. 61. SEX-LINKED INHERITANCE OF WHITE AND RED EYES IN *Drosophila*. Parents, white-eyed male and red-eyed female; F_1, red-eyed males and females; F_2, red-eyed females and equal numbers of red-eyed and white-eyed males. The distribution of sex chromosomes is shown to right of flies; X carries the factor for red eyes, **X** the factor for white eyes, O stands for absence of X. (After Morgan.)

red eyed and half are white eyed, and half of the males are red eyed and half are white eyed.

If now one of these white-eyed females is bred with a red-eyed male all the females of the F_1 generation are red eyed and all the males white eyed ("criss-cross" inheritance) and if these are interbred there are produced in the F_2 generation equal numbers of red-eyed and white-eyed males and females (Fig. 62).

The distribution of the maternal and paternal sex chromosomes (X) exactly parallels this distribution of this sex-linked character, as is shown in the right half of each of the figures, 61 and 62, and this is certainly very strong evidence that the differential factors for these characters are carried in these chromosomes.

Another case of sex-linked inheritance is found in an abnormal condition in man known as *hæmophilia,* which is characterized by a deficiency in the clotting power of the blood, and consequently by excessive bleeding after injury. "Bleeders" are almost always males, though the defect is always transmitted to a son from his mother, who does not usually show the defect because it appears in females only when both parents were affected. The manner of inheritance of this character is exactly similar to the inheritance of white eyes in *Drosophila* and is in all probability associated with the distribution of the maternal and paternal sex chromosomes.

One of the most striking cases of sex-linked inheritance is that form of color-blindness known as Daltonism, in which the affected person is unable to distinguish between red and green. It is known that males are more frequently affected than females, and that color-blindness is in some way associated with sex. It requires two determiners for color-blindness, one from the father, the other from the mother, to produce a color-blind female, whereas only a single determiner is necessary to

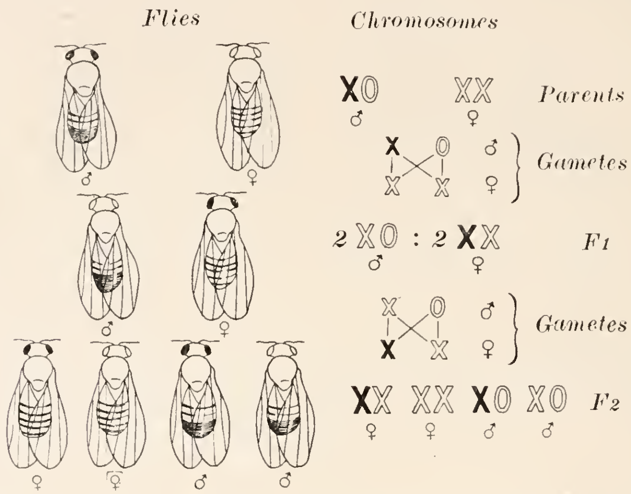

FIG. 62. RECIPROCAL CROSS OF FIG. 61. Parents, white-eyed ♀ and red-eyed ♂, F_1, red-eyed ♀ and white-eyed ♂ ("Criss-cross inheritance"), F_2, equal numbers of red-eyed ♀ and ♂ and white-eyed ♀ and ♂. The distribution of sex chromosomes is shown on the right, as in Fig. 61.

produce a color-blind male, just as is true of sex. The accompanying diagrams illustrate the method of inheritance of color-blindness. As in the previous diagrams **X** represents the sex determiner, O its absence, and X the sex determiner which carries the factor for color-blindness. (Diagrams from Morgan.) It will be seen that a color-blind father and a normal mother have only normal children, but the father transmits to his daughters and not to his sons the sex determiner which carries the factor for color-blindness. But since color-blindness does not develop in females unless it is duplex (*i. e.*, comes from both father and mother), whereas it develops in males if it is simplex (*i. e.*, comes from either parent) all the daughters will appear normal although carrying one determiner for color-blindness, while all the sons will be normal because they carry no determiner for color-blindness. But these daughters transmit to one half of their children the single determiner for color-blindness, and if any of those receiving this determiner are males they will be color-blind. Consequently we have the curious phenomenon of simplex color-blindness appearing only in males and being transmitted to them only through apparently normal females.

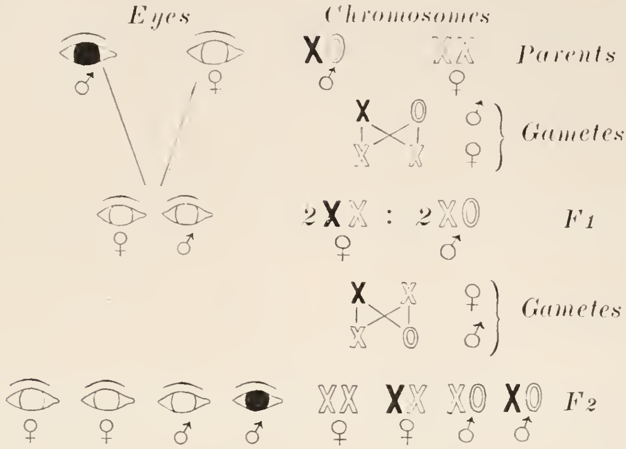

FIG. 63. DIAGRAM OF INHERITANCE OF COLOR-BLINDNESS THROUGH THE MALE
A color-blind male (here black) transmits his defect to his grandsons only. The corresponding distribution of the sex chromosomes is shown on the right, the one carrying the factor for color-blindness being black. (After Morgan.)

On the other hand, if a female is color-blind she has inherited it from both father and mother, *i. e.*, the character in her is duplex, and in all of her children by a normal male the character will be simplex: accordingly, all of her sons will be color-blind and all of her daughters will be normal, though carrying the simplex determiner for color-blindness.

In all cases dominance means merely the development in offspring of certain characters of one parent, while contrasting characters of the other parent remain undeveloped. The appearance of any developed character in an organism depends upon many complicated reactions of germinal units to one another and to the environment. Under certain conditions of the germ or of the environment some characters may develop in hybrids to the exclusion of their opposites, whereas under other conditions these results may be reversed or the characters may be intermediate. The principle of dominance is not a fundamental part of Mendelian inheritance. Even when the characters of hybrids are intermediate between those of their parents, if the parental types reappear in the F_2 generation we may be certain that we are dealing with cases of Mendelian inheritance.

3. *The Principle of Segregation.*—The individuality of inheritance units, and their segregation or separation in the sex cells and recombination in the zygote are fundamental principles of the Mendelian doctrine.

Indeed, the evidence for the individuality and continuity of inheritance units is based entirely upon such segregation and recombination, so that the entire Mendelian theory may be said to rest upon the principle of segregation. If there are cases in which such segregation does not take place they belong to other forms of inheritance than the Mendelian: if segregation occurs in every instance there is no other type of inheritance than that discovered by Mendel. Are there cases which do not segregate according to Mendelian expectation?

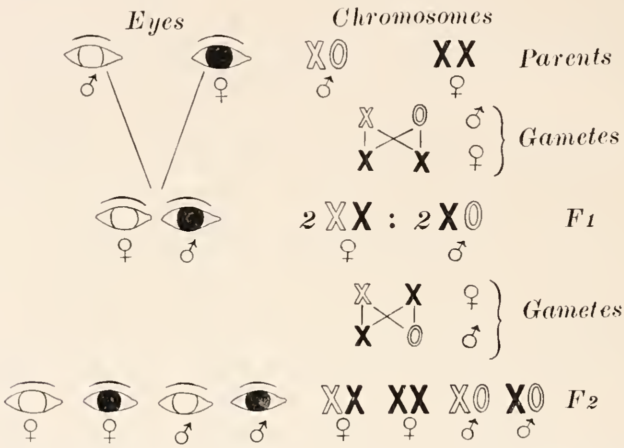

FIG. 64. DIAGRAM OF INHERITANCE OF COLOR-BLINDNESS THROUGH FEMALE. A color-blind female transmits her defect to all her sons, to half of her granddaughters and to half of her grandsons. Corresponding distribution of sex chromosomes on right. (After Morgan.)

When the Mendelian theory was new it was generally supposed that there were forms of inheritance which differed materially from the Mendelian type; indeed, it was supposed that the latter was one of the less common forms of heredity and that blending of parental traits and not segregation was the rule. All cases in which the characters of the parents appeared to blend in the offspring, or in which there was not a clear segregation of the parental types in the F_2 generation or in which the ratio for a monohybrid differed from the well known 3:1 ratio, were supposed to be non-Mendelian.

However, further work has shown that some of these are really Mendelian. Sometimes offspring are intermediate between their parents owing to incompleteness of dominance, rather than to incompleteness of segregation; in such cases the parental types reappear in the F_2 generation as in the cross between red and white four-o'clocks. Sometimes departures from the 3:1 ratio are caused by the fact that two or more factors of the same sort are involved in the production of a single character. Nilsson-Ehle found that when oats with black glumes were crossed with varieties having white glumes the ratio of 3 white to 1 black was usually found in the second generation; but one variety of black oats when crossed with white gave in the second generation approximately 15 blacks to 1 white, which is the dihybrid ratio. From this and other evidence he concludes that in this variety of oats two hereditarily separable factors are involved in the production of black. In crosses between red-grained and white-grained wheat he usually got in the second generation the monohybrid ratio of 3 red : 1 white, but three strains gave the dihybrid ratio of 15 : 1 and two gave the trihybrid ratio of 63 : 1. Consequently he concludes that while the red color of wheat grains is usually due to one factor for red, it may in some cases be due to two or even three factors; notable departures from expected ratios may thus be explained.

Blending Inheritance

But the most serious objections which can be presented against the universality of the Mendelian doctiine are found in phenomena of "blending" inheritance. In some instances contrasting characters of parents appear to blend in offspring and even in the F_2 in subsequent generations the descendants remain more or less intermediate between the parents. One of the best known illustrations of this is found in the skin color of the mulatto, which is intermediate between the white parent and the black one, and even in the F_2 and in subsequent generations mulattoes do not usually, if ever, produce pure white or pure black children, though the children of mulattoes show considerable variation in color. Here there is an apparent failure of the Mendelian principle of segregation.

But white skin is not really white nor is black skin ever perfectly black. Davenport has shown that there is a mixture of black, yellow and red pigment in both white and black skins, though the amount of each of these pigments varies greatly in negroes and whites. A white person may have a skin color composed of black (b) 8 per cent., yellow (y) 9 per cent., red (r) 50 per cent., and absence of pigment or white (w) 33 per cent. On the other hand a very black negro may have *b* 68 per cent., *y* 2 per cent., *r* 26 per cent., *w* 4 per cent. The nine children of two mulattoes, the father having 13 per cent. of black and the mother 45 per cent., ranged all the way from 46 per cent. to 6 per cent. of black—the latter so far as skin color is concerned being virtually white. On the other hand, where both parents have about the same degree of pigmentation the children are more nearly uniform in color; thus seven children of two mulattoes, the father having 36 per cent. and the mother 30 per cent. of black, ranged only from 27 per cent. of 39 per cent. of black.

Such variations in color in the F_2 and in subsequent generations is exactly what one would expect in a Mendelian character in which more than one factor is involved, as, for example, in the case of the color of the sweet peas shown in Fig. 59. Davenport, who has made an extended study of this case concludes that "there are two double factors (*AA BB*) for black pigmentation in the full-blooded negro of the west coast of Africa and these are separably inheritable." These factors are lacking in white persons (this being indicated by *aa bb*). Since the germ cells carry only single factors and not double ones, the cross between negro and white would have only one set of these factors for black color, as shown by the formula $AB \times ab = ABab$; hence the color of the F_1 generation is intermediate between that of the two parents. In the F_2 generation there should be a variety of colors ranging all the way from white to black, though pure white or pure black would be expected in only a small proportion of the offspring. As a matter of fact it is known that the children of mulattoes vary considerably in

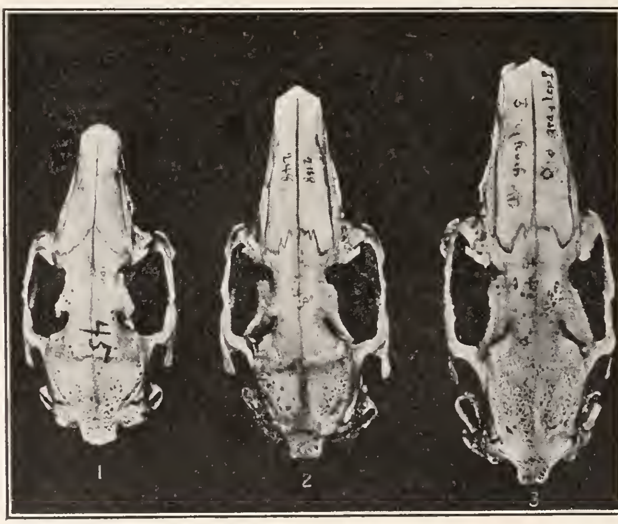

FIG. 65. BLENDING INHERITANCE OF SIZE IN RABBITS; the skulls of two parents are shown in 1 and 3, of their intermediate offspring in 2. (From Castle.)

color, and in some cases a child may be darker or lighter than either parent, which would indicate that segregation does actually occur. It is very probable that this classical case of "blending" inheritance is really Mendelian inheritance in which several factors for skin color are involved.

Similar blending inheritance is found in certain other cases where the parents differ in form or size. Thus Castle found that when long-eared rabbits were crossed with short-eared ones the offspring have ears of intermediate length, and in all subsequent generations the ear length remained intermediate between that of the parents. He found the same thing true of length and breadth of the skull (Fig. 65) and of the size of other portions of the skeleton, and he concluded that such quantitative characters are not inherited in Mendelian fashion.

Quite recently MacDowell, working on the inheritance of size in rabbits, concludes that this, as well as other quantitative differences between parents which appear to blend in the offspring, such as Castle's case of ear length in rabbits, is due not to a single factor, as in the case of Mendel's tall and dwarf peas, but to several factors. Consequently, in the formation of the germ cells there is not a clear segregation of all the factors for tallness, or large size or long ears, in half the germ cells, and their total absence in the other half of those cells, but some of these factors go into certain cells and others into others, as in the case of dihybrids, trihybrids or polyhybrids. As a result offspring appear more or less intermediate in size between their parents.

Thus it is possible to explain even "blending" inheritance as due not to the real fusion or blending of inheritance factors, but to varying combinations of numerous or multiple factors, according to the Mendelian rules. The Mendelian principle of segregation has been found to be of such general occurrence that there is a strong inclination among Mendelians of the stricter sort to make it universal, and to explain all cases of blending inheritance as due to incomplete dominance and to multiple factors. Whether or not such attempts may prove completely successful it is still too soon to say.

III. Mendelian Inheritance in Man

The study of human inheritance must always be less satisfactory and conclusions less secure than in the study of lower animals for the following reasons: In the first place there are no "pure lines," but the most complicated intermixture of different lines. In the second place experiments are out of the question and one must rely upon observation and statistics. There have been less than 60 generations of men since the beginning of the Christian era, whereas Jennings gets as many generations of *Paramecium* within two months and Morgan almost as many generations of *Drosophila* within two years. Finally the number of offspring are so few in man that it is difficult to determine what all the hereditary possibilities of a family may be. Bearing in mind these serious handicaps to an exact study of inheritance, it is not surprising that the method of inheritance of many human characters is still uncertain.

Davenport and Plate have catalogued more than sixty human traits which seem to be inherited in Mendelian fashion. About fifty of these represent pathological or teratological conditions, while only a relatively small number are normal characters. This does not signify that the method of inheritance differs in the case of normal and abnormal characters, but rather that abnormal characters are more striking, more easily followed from generation to generation, and consequently statistics are more complete with regard to them than in the case of normal characters. In many cases statistics are not sufficiently complete to determine with certainty whether the character in question is dominant or recessive, and it must be understood that in some instances the classification in this respect is tentative. A partial list of these characters is given herewith:

MENDELIAN INHERITANCE IN MAN

NORMAL CHARACTERS

Dominant	*Recessive*
Hair:	
Curly.	Straight.
Dark.	Light to red.
Eye Color:	
Brown.	Blue.
Skin Color:	
Dark.	Light.
Normal pigmentation.	Albinism.
Countenance:	
Hapsburg type (thick lower lip and prominent chin).	Normal.
German type.	Jewish type.
Temperament:	
Nervous.	Phlegmatic.
Intellectual Capacity:	
Average.	Very great.
Average.	Very small.

TERATOLOGICAL AND PATHOLOGICAL CHARACTERS

General Size:	
Achondroplasy (dwarfs with short stout limbs but with bodies and heads of normal size).	Normal.
Normal size.	True Dwarfs (with all parts of the body reduced in proportion).
Hands and Feet:	
Brachydactyly (short fingers and toes).	Normal.
Syndactyly (webbed fingers and toes).	Normal.
Polydactyly (supernumerary digits).	Normal.
Skin:	
Keratosis (thickening of epidermis).	Normal.
Epidermolysis (excessive formation of blisters).	Normal.

Hypotrichosis (hairlessness associated with lack of teeth).	Normal.
Kidneys:	
Diabetes insipidus.	Normal.
Diabetes mellitus.	Normal.
Normal.	Alkaptonuria (urine dark after oxidation).
Nervous System:	
Normal condition.	General neuropathy, *e. g.*,
	Hereditary epilepsy.
	Hereditary feeble-mindedness.
	Hereditary insanity.
	Hereditary alcoholism.
	Hereditary criminality.
	Hereditary hysteria.
Normal.	Multiple sclerosis (diffuse degeneration of nerve tissue).
Normal.	Friedrich's disease (degeneration of upper part of spinal cord).
Normal.	Meniere's disease (dizziness and roaring in ears).
Normal.	Chorea (St. Vitus dance).
Huntington's chorea.	Normal
Muscular atrophy.	Normal
Normal.	Thomsen's disease (lack of muscular tone).
Eyes:	
Hereditary cataract.	Normal.
Pigmentary degeneration of retina.	Normal.
Glaucoma (internal pressure and swelling of eyeball).	Normal.
Coloboma (open suture in iris).	Normal.
Displaced lens.	Normal.
Ears:	
Normal.	Deaf-mutism.
Normal.	Otosclerosis (thickened tympanum with hardness of hearing).

SEX-LINKED CHARACTERS

Recessive characters, appearing in male when simplex, in female only when duplex.

Normal.	Gower's muscular atrophy.
Normal.	Hæmophilia (slow clotting of blood).
Normal.	Color-blindness (Daltonism; inability to distinguish red from green).
Normal.	Night blindness (inability to see by faint light).
Normal.	Neuritis optica (progressive atrophy of optic nerve).

Summary

The principles of heredity established by Mendel are almost as important for biology as the atomic theory of Dalton is for chemistry. By means of these principles particular dissociations and recombinations of characters can be made with almost the same certainty as particular dissociations and recombinations of atoms can be made in chemical reactions. By means of these principles the hereditary constitution of organisms can be analyzed and the real resemblances and differences of various organisms determined. By means of these principles the once mysterious and apparently capricious phenomena of prepotency, atavism and reversion, find a satisfactory explanation.

Before the establishment of Mendel's principles, heredity was, as Balzac said, "a maze in which science loses itself." Much still remains to be discovered about inheritance, but the principles of Mendel have served as an Ariadne thread to guide science through this maze of apparent contradictions and exceptions in which it was formerly lost.

RUBBER: WILD, PLANTATION AND SYNTHETIC

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AN industry can not be wholly uninteresting which involves the consumption yearly of about $250,000,000 worth of raw material in the production of goods worth $750,000,000 which has grown to nearly double its size in seven years, which involves the cultivation of three quarters of a million acres or more of land, worth about $130 an acre, but half of which has during a boom been capitalized at double its value, an industry whose center will be speedily shifted from the banks of the Amazon, half way round the world, to Ceylon and the Malay States, unless very heroic measures are taken to prevent it, among which heroic measures the importation of 50,000 Chinese coolies into the Amazon valley has been suggested.

Such is the rubber industry. When it is added that the price, which for a number of years had been a little above a dollar a pound, went up during 1910 to over three dollars and last September fell as low as fifty cents; and that in connection with the rubber trade there have been some of the most sensational stories of inhumanity and barbarity in the Congo district and on the upper Amazon, it will be seen that the economist and the social reformer must be specially interested.

There are, too, features of interest for the botanist, since rubber is got from plants and its function in the plant is obscure. Moreover, there are notable peculiarities in its extraction which offer opportunities for further research. The chemist is interested not only from the point of view of the conversion of the raw product into a material suitable for the many purposes to which it is applied, but also from the fact that he sees here one more opportunity to replace the work of nature and to do in a small laboratory covering only a few acres what now requires thousands of square miles.

A book appeared in Spain early in the seventeenth century (1601–15) describing the voyages of the Castillians, from 1492–1554, in which a game played by the natives of Hayti with balls made from the gum of a tree was mentioned. About the same time Juan de Torquemada described a rubber tree of Mexico, the *Castilloa elastica,* and stated that the Indians used the rubber for medicinal purposes and that the Spaniard used it for waterproofing coats. Rubber trees of various kinds were soon discovered in Brazil, French Guiana, Madagascar and other places.

Chemists attempted to find industrial uses for the product of the rubber tree, and it may be added that the search in the future is likely to be more vigorous than it has ever been in the past. The difficulty of discovering a good solvent baffled chemists for a time, but in 1761 Herissant and Macquer used oil of turpentine and said that ether might also be employed. The name rubber seems to date from Priestley's discovery in 1770 of its power to erase pencil marks, the name caoutchouc being apparently a modification of the Indian name cahucha. In Priestley's time rubber could not be considered a plentiful article of commerce, its price being twenty shillings an ounce.

Though patents for the use of rubber as waterproofing had been taken out as early as 1791, Macintosh in 1823 seems to have been the first to make the industry a commercial success and the firm then started in Glasgow and afterwards removed to Manchester remains to this day as one of the most important in the rubber industry.

The next important step was taken by Hancock in England and Goodyear in America about 1840, the date being a little inexact because the process seems to have been in use before being patented. This was the addition of sulphur to rubber by which it is made capable of standing the hottest summer temperature without becoming sticky or losing its elasticity.

It was not till about 1886 that a process was discovered for depriving rubber of the smell which restricted its use for waterproofing. The rubber industry received an impetus when pneumatic tires came into use for bicycles, and the employment of rubber as an insulator in electric installations also increased the demand, but the dominating factor in the consumption of rubber has of late years been the automobile business. The very sudden demand in 1910 caused a tremendous rise in prices, and whereas during a portion of 1909 the price in London was 2s. 9d. in 1910 it reached 12s. 6d.

The growth of the rubber industry is indicated by the following figures. Import of crude rubber into Great Britain was in

1830	23 tons
1850	381 "
1870	7,656 "
1910	43,848 "

The rubber plant grown in houses for ornamental purposes is usually *Ficus elastica*, which is native mainly to southern Asia. This is not the plant chiefly used for the production of rubber. Four different orders of plants provide commercial rubber and there are eleven genera belonging to these given in Thorpe's "Dictionary of Applied Chemistry." By far the most important is *Hevea brasiliensis* which provides the "fine Para" rubber of South America the standard of rubber in the trade. To the same order, Euphorbiaceae, belongs *Manihot Glaziovii* also found in a small section of Brazil. It produces the Ceara rubber of commerce.

Another interesting source of rubber is the genus *Landolphia,* of which there are several species noteworthy as being creepers. This genus provides most of the Congo rubber and belongs to the order Apocynaceae. *Ficus elastica* spoken of above is one of the genera of the order Urticaceae of which another genus is *Castilloa* also already mentioned as found in Mexico and one of the very first plants to attract attention as a rubber producer.

Rubber, though found to a slight extent as a solid deposit in the woody fiber of certain species, is almost entirely obtained from the latex of the rubber-bearing plants. The latex is a fluid usually more or less viscous which is carried in vessels, the laticiferous vessels, lying in the inner bark just a little outside of the cells which carry the sap. The caoutchouc itself is in globules of microscopic or sub-microscopic size, being from 1/50,000 inch to 1/6,000 inch in diameter, and forms an emulsion with the suspending liquid. A familiar example of latex is the exudation of the milkweed. The function of latex in the plant itself is unknown. It may be an excretion, it may be intended for the preservation of the tree from attack by fungus or insects or other enemy. The process of raw rubber manufacture consists in the collection of the latex and the coagulation from the serum of the emulsified particles. In tapping the trees the essential thing is to cut deep enough into the bark to sever the laticiferous vessels, but not to cut into the cambium, the living layer of cells from which both the wood and the bark of the tree are produced. In the Amazon Valley this is usually done by a small axe, the incisions being of a V shape, the first being made at a height of about six or seven feet. Later incisions are made at intervals of about two inches below the previous ones, till the base of the tree is reached. Then tappings are begun on the other side of the tree in the same order as before. The latex is collected in a small cup fixed to the tree by moist clay and is removed from time to time. Five pounds of latex is considered a large amount from one tree during the season. The latex is gathered from the cups into a pail and is cured by the smoke of a fire rich in tarry and acid matter. A long wooden rod has rubber latex poured over it and the thin layer which sticks to the rod is dried in the smoke. Over the sheet thus formed is poured more latex, which is also dried in the smoke. Thus layer after layer is produced till a ball weighing from twenty to one hundred pounds is obtained. Thus is made raw fine Para rubber. Some of the latex coagulates on the tree, forming a scrap rubber which is collected and compressed into irregular masses called "negroheads."

It is not my purpose to describe all the processes through which raw rubber passes before it appears in the shape of golf balls or automobile tires or in any of the many forms in which it comes into commerce, but a very brief outline may be given. First, the raw rubber is cut into small pieces, steeped in warm water and run through washing rolls, after which it is dried. Rubber thus obtained is mainly a hydrocarbon of the empirical formula C_5H_8, that is, it contains sixty parts by weight of carbon to eight of hydrogen. There is a small amount of resin, a very little protein and somewhat less than one per cent. of inorganic matter which forms an ash when the rubber is burned.

Freshly coagulated rubber has a spongy or reticular structure, due to the way in which the particles come together. This shows even in dried rubber and the particles can still be seen in globular form after solution, but films made by the evaporation of the solvent from the solution have apparently lost the reticular character. Rubber on being heated becomes sticky and if cooled to near the freezing point of water (about 40° Fahr.) it becomes hard and loses its elasticity. Stretched rubber has the very peculiar property of contracting on being heated. This curious property was predicted from theoretical considerations and was later confirmed by experiment. A suitable way to carry out the experiment is to stretch a rubber tube to nearly double its length by means of a heavy weight and then to pass steam through the tube. A tube a couple of feet in length will under these circumstances contract several inches.

Pine rubber softens too readily with rise of temperature and hardens before the temperature has fallen much below normal; the range of temperature through which it retains its properties of toughness and elasticity is too limited, but by the addition of sulphur the range of temperature can be very much extended. Rubber can be made to take up sulphur in various ways, the process being called "vulcanization." One method is by heating with sulphur, another is by treatment in the cold with a mixture of chloride of sulphur and carbon bisulphide. The properties of vulcanized rubber vary with the amount of sulphur, soft rubbers contain 3–4 per cent., while hard rubber, or ebonite, contains 20–30 per cent. The sulphur seems to be combined in some form, at least partially with the rubber. No matter how much sulphur may be mixed with the rubber or what the temperature or length of time, the maximum of combined sulphur is about thirty-two per cent.

The main source of rubber supply, almost up to the present, has been the wild-growing trees and vines. In 1906 about 400 tons (approximately one per cent. of the whole) were obtained from plantations, by 1909–10 the amount had risen to about five per cent.; now plantation rubber has almost overtaken that derived from uncultivated plants. Java produced 73 tons in 1910 and 491 tons in 1911, while, during the first three months of 1912, the Malay States produced 3,810 tons, and during the corresponding three months of 1913 the amount was 5,625 tons, or over a half more. The rapid increase is due to the fact that each year more and more of the trees are reaching the productive age.

In 1876, some seeds of *Hevea brasiliensis* were sent from Brazil to Kew Gardens, and some young plants from these seeds were shipped the same year to Ceylon, where they were planted in low land and the grove then started is now historic, for it was the beginning of the later industry. Up till 1899 there were only about 750 acres of rubber plantation in Ceylon and these were apparently not intended for commercial purposes. In 1899 the first company in the Malay States was formed and it declared a dividend of 75 per cent. in 1908, and owing to the high prices or rubber in 1909 the dividend was 250 per cent.

The large amount of rubber required for automobile tires naturally stimulated the planting of rubber areas. According to figures given in a U. S. Consular Report in January, 1913, the acreage in Ceylon in 1912 was 220,000 and in the Malay States 430,000, while in other countries over 100,000 acres were under cultivation. Figures given later in the year by *The Economist* were higher. The larger part of this area is not yet productive, and some of it will not yield for five or six years.

The source of cultivated rubber is almost entirely *Hevea brasiliensis*, which seems to be adapted to wide differences of conditions. In Ceylon, though first planted in low land, it grows on hills with large boulders, in the Malay district it thrives on flat land with hardly a stone. On the Malay hills, where heavy rains would carry away the young trees, contour drains are constructed. The genus *Castilloa* does not grow so readily in the East; it takes longer to reach the producing stage and it does not produce so much rubber when it has attained its proper growth. It has, however, been largely planted in its original home, Mexico. *Manihot-Glaziovii* is planted in dry regions, where *Hevea* does not flourish.

Hevea is not fit for tapping till it is seven years old. As the seven or eight feet nearest the bottom of the trunk are richest in latex, the object in cultivation is to produce short trunks of large circumference. With this end in view, the trees are planted far apart, at a distance of about twenty feet from each other, giving approximately a hundred trees to the acre. They are induced to fork at a height of about ten feet, and it is said that the best arrangement is a tripartite forking of the main trunk, each branch in turn forming three subordinate branches. In places where there are high winds, however, this style of forking may provide so large a surface that the trees may be blown over.

There are various methods of tapping, the most satisfactory apparently being full or half "herring bone." A vertical groove is made in the bark of the tree from the base to a height of five or six feet. Then parallel incisions are made from this vertical groove in an upward slanting direction, in the case of the half-herring bone, on one side, and in the case of the full herring bone, on both sides. So important is it to cut through the laticiferous vessels without injuring the cambium layer and so difficult is it to accomplish this kind of incision, that dozens of different knives have been invented for the purpose. The half-herring bone method is considered the better as being less severe on the tree.

A very curious phenomenon was observed in the early experiments on tapping. It was found that if a second incision was made in the bark of *Hevea*, near one cut a couple of days previously, there was a greater flow of latex than if the second incision were made at a distance, say, on the other side of the tree. More than that, the latex flowed more freely than on the first incision. In a particular experiment on four trees, tappings were made at intervals of five days, and the volume of latex increased from 61 c.c. at the first tapping to 449 c.c. at the fourteenth, when the series was ended. In view of the fact that the latex from later tappings is thinner than that from the first, another series of experiments was made on ten trees which were tapped every day for a fortnight and the rubber content of each tapping determined. This rose from $6\frac{1}{4}$ oz. on the first day to $33\frac{3}{4}$ oz. on the fourteenth. Within limits a thin latex is the most satisfactory, the latex from the first incision often being of little use because it coagulates before reaching the proper receptacle and so gets mixed with the bark of the tree and other foreign matter. Sometimes drip pans are fastened to the tree above the incisions, and water dropping upon the incisions prevents the latex drying on the tree.

The peculiar action of *Hevea* owing to which subsequent tappings near the previous incisions produce a greater flow of latex is called "wound response," and no other rubber-bearing plants show wound response in anything like the degree shown by *Hevea*; in fact, it may be doubted whether the phenomenon occurs in the other genera at all. As compared with *Hevea, Castilloa* gives a greater flow of latex on the first incision, some five or six times as much. But if, after a couple of days, a further incision is made near the former one, little or no latex flows from it, while, as we have seen, there is in the case of *Hevea* a greater supply than before, roughly about twice as much, which persists through subsequent tappings. Accordingly, in tapping trees a very thin paring (about one twentieth of an inch) is removed each day or each alternate day. As the first incisions are made about a foot apart, it takes some two hundred and forty parings before the bark is all removed from this part of the tree, and as by the half-herring-bone system only about a quarter of the tree is tapped it takes about four years to remove all the bark and by that time operations can be begun again on the new bark that has formed in the meantime.

The arrangement of laticiferous vessels in *Castilloa* is different from that in *Hevea*; in the former the vessels all connect in a somewhat similar manner to that of veins and arteries in the body. Hence, when the vessels are cut, there is likely to be a drain from a large area. In *Hevea* the tubes arise from a breaking down of cell walls which occur from time to time and so the latex does not flow out so freely at first. Possibly, the increased flow when the second incision is made near the first is because latex has flowed to the wound in order to repair it.

Though *Hevea* seems to be in general the best rubber-producing tree, there is a little doubt whether it should be everywhere introduced; for instance, in Africa, where another species is native. African labor is less intelligent than that in the Malay States and the African natives can not tap the trees so successfully. The native trees and vines are usually cut down.

Moreover, experiments should be made with plantations of from three to five thousand trees before a decisive judgment is given, for it is possible that in large plantations diseases might rise and spread which have not appeared in small plantations. In very large estates, protective belts of other trees either of the original forest or of *another genus* of planted rubber should be made use of to prevent spread of diseases.

While, as stated above, in the Amazon valley five pounds of latex containing approximately two pounds of caoutchouc is considered a large yield, on the plantations trees ten years old are expected to yield three or four pounds of rubber. During 1908 nine thousand trees in the Cicely estate, one of the older Malay companies, gave an average of six pounds per tree, though the trees were between five and ten years old. In the Perah State there were eight trees seventeen years old, of an average girth of 55 inches, which yielded 28½ pounds of rubber each. From the economic point of view the yield per acre is of more importance than the yield per tree. Six-year-old trees will yield about a hundred pounds per acre, while ten-year-old trees will yield three or four times as much.

In the East, rubber is coagulated from the latex by acetic acid. Smaller quantities of other acids would serve the same purpose, but an excess prevents coagulation, while with acetic acid the quantity may vary within fairly wide limits. When coagulation is brought about by acetic acid either pains must be taken to dry the rubber very thoroughly or some antiseptic must be put in. The method of smoking carried out in the Amazon district provides both acetic acid and the antiseptic fumes of creosote. Coagulation could be brought about by simple drying, but in this case the rubber is apt to become moldy and putrid. The precise cause of coagulation by acid is not certain. It has been ascribed to the small amount of protein in the latex, but, on the other hand, it is claimed that if the protein is removed the rubber can still be coagulated. The rubber produced has a composition something like the following: 94 per cent. caoutchouc, 3 per cent. resin, 2.5 per cent. protein, and 0.5 per cent. each of moisture and ash. One should perhaps add that what is usually called protein may not really be that substance, but some other which contains nitrogen.

The competition between Amazon hard Para rubber, which is so far the standard, and plantation rubber is keen. The latter is the purer, but the conditions for vulcanizing and otherwise treating Para rubber are better known and rubber manufacturers will probably agree with the opinion expressed to me by one of them that plantation rubber is not so easily worked. Para rubber is said to be harder and "nervier" in the mixing rolls and is more consistent in quality. What causes the difference is unknown; whether the immaturity of the plantation trees, or the method of curing or some other factors. The difference is exhibited not only in the ways indicated, but also by the action of some chemical reagents. In a series of experiments, the part of Para rubber soluble in petroleum ether was in one sample 51 per cent., in another 57 per cent., while of Ceylon biscuit 58 per cent. and 68 per cent. were soluble, and of Malayan crêpe 72 per cent. and 86 per cent. The part dissolved from the Para rubber was much more viscous than that from the other kinds.

The price of plantation rubber in the London market is lower than that of Para rubber, but this is probably due, at least partly, to the method of sale by auction. According to *The Economist,* during the first eight months of 1913, Para averaged 3s. $10\frac{1}{4}$d. while plantation rubber averaged 3s. $5\frac{1}{4}$d. and, curiously enough, when plantation rubber dropped in September to 2s. a pound, Para was 3s. 7d.

Though up to the present plantation rubber is not equal in quality to the best Para rubber, it will be remembered that a considerable quantity of the rubber from the Amazon district itself is not of the highest grade. One quarter or more is of inferior quality. The price in general has dropped till it leaves little margin above the cost of production. While the export from the Amazon district has increased little, if any, since 1909, being in the neighborhood of 42,000 tons, plantation rubber, which in 1909 was 4,000, amounted in 1912 to 30,000 tons. The total rubber consumption in 1912 was about 108,000 tons, part of it being wild rubber from Mexico and various places in Africa, part being old rubber reclaimed. In the season 1912–13, according to the U. S. Consular Reports, the Amazon district exported 2,200 tons more than in the previous season, but the same reports predicted a decrease in the season 1913–14 and, according to the *Journal of Commerce,* during July, August and September, the first three months of the 1913–14 season, the export was 7,161 tons as compared with 8,553 tons of the year before. The statement is made in the Consular Reports that this year for the first time other countries will produce a greater amount of plantation rubber than the Amazon Valley of wild rubber.

Mr. Akers, a British rubber expert, estimates that in 1916 plantations could yield 173,000 tons and in 1919, about 300,000 tons. He also estimates that if rubber falls to two shillings a pound 150,000 tons or perhaps 200,000 tons might be consumed for the present uses, but unless new uses not now apparent are discovered the supply will much exceed the demand.

At present the cost of production of Para rubber is 72 cents, including the export tax, which amounts to 24 cents. This high cost is partly due to the cost of living, partly to difficult transportation, partly to scarce labor and inefficient methods of gathering the rubber. Mr. Akers recommends the importation of 50,000 Chinese coolies, the employment of a number of Malayan planters to instruct the collectors in the best methods of tapping, and the abolition or, at all events, reduction of the export tax. The Brazilian government has given a large sum of money to improve navigation on the Amazon and to provide premiums for the construction of rubber factories and refineries, engaging to buy from these refineries all the rubber required for the army and navy. They doubtless feel chary about reducing the export tax, as it is a great, if not even the greatest, source of revenue.

The future of the rubber industry causes anxiety not only to the Amazon district and those interested in it, but to the thousands of stockholders in eastern plantations. The great demand for rubber for automobile tires caused a boom and, according to *The Economist,* £40,000,000 was invested in boom prices "whose only justification is the few years of grace before the supply surpasses the demand." On September 20, last, the same paper remarks:

> The collapse of the rubber boom is one cause for the lack of business in the Stock Exchange. Hundreds of thousands of pounds poured into the plantation rubber industry by the British public are represented by huge stocks of certificates, the depreciation on which, reckoned from the price at which the public got them, will serve as a painful lesson till the next boom, from whatever quarter it may spring up, comes along.

A large meeting of the leading people in the rubber world was held in London on October 23, and stocks went up just before the meeting, only to fall when it was learned that no solution of the difficulty could be found. The cost of bringing an estate into bearing condition is between twenty and thirty pounds an acre, and *The Economist* estimates over seven hundred thousand acres in the East capitalized at from £54 to £76 an acre.

It will not pay to produce rubber to sell in the world's markets at two shillings a pound, unless the cost of production can be reduced. In some very favored estates, in Ceylon, the cost is only sixpence a pound and, when all the trees are yielding, the average cost may be 8d, though in 1911 it was 1s. 4d. Mr. Akers considers that in Java the cost will not go below 1s. 2d. for several years. In Ceylon labor is more easily obtainable than in the Malay States and Java. In the Malay States a good deal of the labor is done by coolies from southern India along with some Chinese. An economic question arising here is the relative value of indentured and unindentured labor.

The artificial production of rubber is not yet a matter of commercial interest. Dr. Gerlach, of Hanover, a practical manufacturer, thinks it may be twenty years before artificial, or, as it is sometimes called, synthetic rubber can compete with the natural. He points to the fact that it took at least as long a time for synthetic indigo to reach the commercial stage after it had been first produced in the laboratory. Millions of dollars were expended in the investigations by one firm alone. But as we have had the romance of the alizarine industry, by which a product of coal tar replaced the extract of the madder root and ended its cultivation in France, and the romance of the indigo industry which has so largely affected the growth of the indigo plant in India, so we may have the romance of the synthetic rubber industry, but many a long and weary investigation must be carried on, many patents will be abandoned and much money will be spent, apparently in vain, for no process can be considered commercial unless it can produce rubber not only more cheaply than it can now be obtained from the plantations, but more cheaply than there is any likelihood of its ever being produced from natural sources. Probably twenty cents a pound should be considered the maximum cost of a commercial process for synthetic rubber.

Rubber was found to yield on heating the substance isoprene among others. This substance has the same percentage composition as rubber, but its molecular structure is considered to be simpler and to be represented by the formula

$$\begin{array}{l} CH_2 = \underset{\displaystyle CH_3}{\underset{|}{C}} - CH = CH_2 \end{array}$$

Isoprene was accidentally found to change into rubber apparently upon long standing, and efforts were made to produce rubber from isoprene at will. It was found that by heating at a high temperature with acetic acid in closed tubes the change takes place and later a small amount of sodium was found to produce a similar effect at a lower temperature.

The problem of synthetic rubber is then two-fold: first, to get cheap isoprene; second, to convert isoprene cheaply into rubber. The most natural source of isoprene seems to be oil of turpentine, which has the same percentage composition, but it has not proved satisfactory and its formation from isoamyl alcohol gives greater promise. Isoamyl alcohol is one constituent in fusel oil, whose presence in raw spirits renders them so injurious. It is obtained to a small extent in the ordinary fermentation of potatoes and other starchy substances. Professor Fernbach, of the Pasteur Institute, has discovered a method of fermenting starch which, instead of yielding a large amount of ordinary alcohol and a small amount of fusel oil, produces fusel oil with practically no ordinary alcohol. This fusel oil, however, instead of having a large quantity of isoamyl alcohol consists chiefly of butyl alcohol, from which butadiene,

$CH_2 = CH - CH = CH_2$, can be made in just the same way as isoprene from isoamyl alcohol. Butadiene is the next lower homologue of isoprene, and when it is treated with sodium it produces a substance very like rubber which is called nor-caoutchouc. It is said that its quality is even superior to that of ordinary rubber. As there are a number of alcohols homologous to butyl and isoamyl alcohol, a number of substances similar to isoprene and butadiene can be made from them, and from these by the action of sodium a *series* of rubbers. It is said that the rubber produced by the action of acetic acid on isoprene is identical with natural rubber, and that the rubber made by the action of sodium is slightly different in its chemical reactions. It may be that all natural rubbers are not identical and that the difference between Para rubber and plantation rubber may depend upon some slight differences in the caoutchouc itself and that what the chemist does with extreme difficulty when he changes starch into rubber, nature does with ease, and, as the chemist may get slightly different products by pursuing different methods, so nature may get different products under different circumstances.

It was said at the beginning of this paper that rubber has the empirical formula C_5H_8. It seems that the formula is more correctly written $C_{10}H_{16}$ and that the name 1.5 dimethyl cyclooctadiene 1.5 represents the structure of Para rubber, while the rubber produced by the action of sodium on isoprene is

1.5 dimethyl cyclooctadiene 1.3
or 1.5 dimethyl cyclooctadiene 1.7

Dr. Duisberg, of Elberfeld, stated in his address to the Congress of Applied Chemistry at New York in 1912 that he had for some time used tires of artificial rubber on an automobile. The German Emperor has also received a present of similar tires. The rubber can be made, but it is still far too expensive to compete with natural rubber.

Closely connected with the history of the rubber industry are the Congo atrocities. Congo rubber is not so good for most purposes and commands a lower price, though, being softer, it is said to be better as a filling for driving belts and for other uses. It is obtained from *Landolphia* vines, which are not usually tapped, but cut off, the latex being extracted all at once. This fact may be partly responsible for the atrocities, since, the more accessible sources of supply having been depleted, the natives have been obliged to go farther and farther in order to obtain the rubber demanded of them.

In the sixties and seventies of the last century, central Africa became known to Europe, and the commercial interests of the various nations led to what is termed the "Scramble for Africa." Stanley's discovery of the Upper Congo induced King Leopold to form the "International African Association" and he sent several investigating expeditions at his own expense, commanded for the most part by Englishmen and Germans and represented to the world as being entirely for scientific purposes. Later Leopold proposed forming the association into a state and obtained the sympathy and support of the British Chambers of Commerce by promising perfect freedom of trade, and of the protestant missionary societies of England and America, of the aborigines' protection association, and of the philanthropic world in general by his protestations of the highest type of philanthropy.

Several years before that time, Sir Robert Morier suggested to Lord Beaconsfield to recognize the claims of Portugal to the southern bank of the Congo, while the northern bank was to become British. Lord Beaconsfield, however, did not favor this plan, and when, in 1875, the consul Lieutenant Cameron proclaimed, on his own initiative, the taking possession of the basin of the Congo, his act was repudiated by Lord Carnarvon. Portugal and England had historic claims on the country, and the two governments made an agreement in 1883 by which Portugal was to gain the basin of the Congo on both sides for a certain limited distance from the mouth, engaging to give freedom of trade to the world and religious freedom to all inhabitants of the country. The treaty was denounced by the British Chambers of Commerce and the British philanthropic world. The British government was accused of betraying national interests, and in Portugal the Portuguese government was accused of the same thing. France was ready to step in and take the district, in which case foreign trade would be handicapped. King Leopold seized the opportunity, and Stanley, acting on his behalf, renewed the advances made before to England. The English government was now more ready to listen to the proposal, but, being anxious to secure freedom of trade and protection of the natives, fell in with the invitation of Bismarck to an international conference at Berlin. This conference was held from November 25, 1884, to February 26, 1885, and guaranteed the formation of the Congo association into a state. The representatives of the different powers may be almost said to have wept for joy at having found so disinterested and philanthropic a ruler for the state as King Leopold promised to be. On August 1, Leopold notified the powers that the International African Association would henceforth be known as the Congo Free State.

King Leopold began to form an army, and by 1889 two thousand regulars had been recruited and were armed with modern rifles, and the proposal for the next year was to raise eight thousand more. The King's officials were given a bonus for each recruit obtained, and these recruits were gathered by armed raids on the villages.

In 1891 a regulation was issued forbidding the natives to sell ivory and rubber (the main products of the country) to European merchants, and the officials were given a bonus for the amount of rubber supplied by them, the rubber becoming the property of the state and the bonus being the greater the less the cost of the rubber. A similar bonus was given on ivory and gum copal. This was a direct stimulus towards extortion on the part of the officials. Villages were taxed for a certain amount of rubber, and if it was not forthcoming punishments of all kinds were inflicted, a common one being the cutting off of hands, another, the carrying off of the women as hostages.

Such a feeling was aroused in Europe by reports from missionaries and others of the atrocities, that King Leopold was compelled to appoint a commission of enquiry, which reported in 1905 or early 1906. This report tells that the native peoples are "exhausted" through the demand made upon them for headcarriage in the transport of government material and that they are threatened with partial destruction. Captain Baccari, envoy of the King of Italy, traveled through that region and says, "we have all the ghastly scenes of the slave trade, the collar, the lash, and the pressgang." A lieutenant in the Italian army who spent three years in the Congo Free State and served in Leopold's African army writes:

> The caravan road between Kasongo and Tanganyika is strewn with corpses of carriers, exactly as in the time of the Arab slave trade. The carriers, weakened, ill, insufficiently fed, fall literally by hundreds; and, in the evening, when there happens to be a little wind, the odor of bodies in decomposition is everywhere noticeable, to such an extent, indeed, that the Italian officiers have given it a name ''Manyema perfume.''

The commission reports that the direct causes of the miseries of the natives are the requisitions in rubber and the requisitions in staple food supplies "everywhere on the Congo, and, notwithstanding certain appearances to the contrary, the native gathers india rubber only under the influence of direct or indirect force." It indicates what is meant by force, namely, indiscriminate massacre, settlement of soldiers in rubber-producing villages, uncontrolled and unhampered in the execution of their instructions, taking of hostages, imprisonment of women and children, flogging, illegal fines and punishments and so on. The condition of the rubber gatherer is described:

> In the majority of cases he must, every fortnight, go one or two days' journey and sometimes more, to reach the place in the forest where he can find in fair abundance the rubber vine. There the gatherer passes some days in a miserable existence. He must construct an improvised shelter which can not obviously replace his hut; he has not the food to which he is accustomed; he is deprived of his wife, exposed to the inclemencies of the weather and to the attacks of wild beasts. He must take his harvest to the station of the government or the company, and it is only after that that he returns to his village, where he can barely reside two or three days before a new demand is made upon him.

This is taken from the report of King Leopold's own commission, which naturally does not overstate the case. I could easily have quoted a much more lurid description of the facts. I shall merely add one sentence from Professor Cattier's famous volume upon the Congo which was discussed in the Belgian House of Representatives, along with the Report of the Commission. He says:

> The impositions in rubber and foodstuffs which weigh upon more than half the territory, that is to say, over an area three or four times as large as France, subject the natives to a well-nigh-continuous slavery, a slavery more severe than that imposed by the Arabs.

In 1908 the Congo was made over by King Leopold to Belgium, and the transfer was recognized by practically all the Great Powers, except Britain, who withheld her sanction till 1913. On May 29, 1913, Sir Edward Grey announced to the House of Commons the intention of the British Government to recognize the annexation of the Congo by Belgium and said that they were now fully satisfied that the condition of affairs had completely changed. While it shocks us that the atrocities should have gone on so long, it is probably true that at no previous stage in the world's history would the condition of uncivilized savages have been so much a matter of concern to the millions who had no personal interest in them.

Atrocities have been reported in the Putumayo district of Peru on the upper Amazon, some of the newspapers describing them as worse than those on the Congo. This is probably an exaggeration, but there have doubtless been very great cruelties inflicted upon the Indians there. But as the matter has been the subject of investigation not only by religious missions, but by a commission of the Peruvian government, as well as by a British government commissioner and by a select committee appointed by the House of Commons, it is to be hoped that the inhumanity is now at an end.

RECENT MATHEMATICAL ACTIVITIES

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MATHEMATICAL research generally thrives best in seclusion. The results are often embodied in a language which but few understand, and are then stored with a quietude secured and maintained by their own attributes. Now and then there are instances when unsolved mathematical questions get involved with enough external matter to attract general attention. This external matter often consists of an array of names of noted mathematicians who have been unsuccessful in their efforts to solve these questions.

When the solutions of such questions become possible, through special ingenuity or through the gradual development of the necessary elements, there is usually a stir in which mathematicians join the more heartily on account of its novelty. This fact may be illustrated by the famous memoir on the problem of three bodies by a Finnish mathematical astronomer named Karl F. Sundman, which the president of the Paris Academy of Sciences mentioned during the annual public session held on December 13, 1913.

This academy had previously appointed a committee to examine the work of Sundman, and the committee reported, through the noted French mathematician Émile Picard, that the memoir was epoch making for analysis and for mathematical astronomy. In accord with the recommendation of this committee, the Paris Academy awarded to Sundman the Pontécoulant prize, doubling its usual value. The report of the committee directed attention to the fact that Sundman achieved his results by means of classic mathematical methods.

In the April, 1914, number of *Popular Astronomy* Professor F. R. Moulton, of the University of Chicago, gave a very interesting popular account of the problem of three bodies and of the actual contribution made by Sundman towards its complete solution. From this account it is easy to see that a long list of eminent names are connected with this problem, including those of Newton, Euler, Lagrange and Poincaré, as well as that of one of the most illustrious American mathematical astronomers—the late G. W. Hill.

About two years ago a certain geometric question relating to the problem of three bodies came suddenly into prominence through an article by H. Poincaré, written shortly before his death, in which he called attention to the fact that he had not succeeded in finding a general solution of this question. It is interesting to note that a young American mathematician, Professor G. D. Birkhoff, of Harvard University, had been thinking along similar lines and soon succeeded in finding a general solution. An article containing this solution was published in the *Transactions of the American Mathematical Society*, 1913, and a French translation of this article appeared recently in the *Bulletin of the French Mathematical Society*.

A number of important unsolved mathematical questions are constantly kept before the mathematical public by means of prizes offered by various foreign academies for definite contributions. The prominence of the Paris Academy of Sciences along this line is well known, and it would be difficult to determine the extent of the good influence exerted by these prizes. Moreover, special prizes are not infrequently instituted. The king of Sweden has recently authorized such a prize to be awarded, for important developments in the theory of analytic functions, during the meeting of the sixth international mathematical congress, which is to be held at Stockholm in 1916.

The monetary value of these prizes varies very much, but it generally does not exceed a thousand dollars. For instance, the prize offered by King Gustav V, of Sweden, to which we have just referred, consists of a gold medal and three thousand crowns (about eight hundred dollars) in money. The main value attached to these prizes is the recognition of the importance of the work of the authors honored in this manner, and this is especially valued by the younger investigators.

While prizes have greatly stimulated research activity in mathematics they have not furnished the main stimulus. The opportunities offered by the various journals to make useful development and interesting discoveries promptly known have doubtless furnished a stronger and more permanent stimulus, especially in those cases where the standing of the editors of the journals inspired great confidence. In America we have two journals which have rendered, and are now rendering, preeminent service along this line; viz., the *American Journal of Mathematics*, founded in 1878 with J. J. Sylvester as editor-in-chief, and the *Transactions of the American Mathematical Society*, founded in 1900 with E. H. Moore as editor-in-chief.

A current mathematical undertaking whose bigness would seem to entitle it to general interest is the publication of a large encyclopedia devoted to pure and applied mathematics. This work is being published, in parts, in the German and French languages. The first part of the German edition appeared in July, 1898. Since this time a large number of other parts have appeared at irregular intervals, aggregating at present about ten thousand large pages. Several additional parts are now in press, and it seems too early to predict when the entire work will be completed or how large it will become. The published parts would now make twenty large volumes, each containing about five hundred pages.

While this work may appear extensive for an encyclopedia which aims to give in a *concise* form the fully established mathematical results, yet the French edition promises to become still more extensive. The first part of this edition appeared in August, 1904, and the aggregate of the published parts is at present only about one half as large as that of the German edition. On the other hand, most of the subjects which have been treated in both editions are treated with much more completeness in the French than in the German edition, as might be expected from the fact that the former edition is, in the main, based on the latter. According to the latest announcements some parts of the German edition are to be based on parts which have already appeared in the French edition.

The magnitude of these undertakings is certainly not the main element of interest to the educated man. In fact, the question has been raised whether these encyclopedias are not becoming too large to fulfil one of the main objects in view; viz., to provide a work by means of which the student can determine *quickly* what has been done along various lines in the mathematical sciences. A keen observer recently made the following significant remark, "the whole encyclopedia, whether German or French edition, seems of late to have run riotously and fruitlessly to leaves."[1] In this connection it may be observed that a big and vigorous tree has normally more leaves than a little one.

One of the main elements of interest in such big educational undertakings is the cooperation which it implies. This is especially true as regards a subject like mathematics, where the certainty and the permanence of conclusions tend to inspire unusual self-reliance and independence. The fact that the directors of these encyclopedias have secured the cooperation of nearly three hundred mathematicians of various nationalities implies that in this field also there is substantial evidence of organized effort on a large scale. It is of interest to observe that American mathematicians are fairly well represented among these collaborators.

A big current mathematical undertaking which affects directly a much larger number of people than the encyclopedias mentioned above is the work which is being done under the direction of the "International Commission on the Teaching of Mathematics." This commission was created during the sessions of the fourth International Congress of Mathematicians, which was held at Rome in April, 1908, and has for its main object a study of the methods and plans of mathematical instruction in different nations. At first it was intended that the commission should confine its work to secondary mathematics, but

[1] E. B. Wilson, *Bulletin of the American Mathematical Society*, Vol. 18 (1911–12), p. 465.

it soon appeared desirable to include all mathematical instruction in the scope of its investigation.

Sub-commissions were appointed in various countries. The American sub-commission is composed of D. E. Smith, Columbia University; W. F. Osgood, Harvard University, and J. W. A. Young, Chicago University. Under the general direction of these sub-commissions a vast amount of material relating to the mathematical instruction has been collected and published. In our own country this material was published by the U. S. Bureau of Education in the form of thirteen reports. Some of the other countries have not yet completed their work, but about one hundred and sixty such reports have already been published in the twenty-six countries which have joined in this vast undertaking.

In addition to securing these valuable reports the central commission has arranged international meetings for the discussion of some of the fundamental questions relating to mathematical instruction. Such a meeting was held in Paris, France, in April of the present year, and the two subjects under consideration were: (1) The results obtained by the introduction of differential calculus in the advanced classes of the secondary schools, and (2) the place and the rôle of mathematics in higher technical education.

Some of the leading French mathematicians (including Appell, Darboux, Borel and d'Ocogne) took an active part in the deliberations. Professor Borel emphasized the fact that mathematics is not composed of a linear sequence of theorems such that each depends upon the preceding one. If this were the case, the only possible changes in methods of instruction would relate to what theorems could be omitted in this sequence or what theorems could be substituted for others. On the contrary, the number of different routes leading from first principles to an advanced mathematical proposition is often exceedingly large, and hence arises the possibility of employing widely different methods to achieve the same general results.

In other words, mathematics is a network formed by intersecting thought roads and the chief aim of the International Commission on the Teaching of Mathematics is to secure extensive information as regards the choice of roads in various nations. The Italian member of the central committee, G. Castelnouovo of Rome, stated explicitly in his address during the recent conference at Paris, that the commission did not aim to bring about any great reforms, but aimed to gather facts as regards existing conditions in order that the various nations might be enabled to profit by the experiences of other nations in instituting their own reforms.

In describing mathematics as a network of a certain type of thought-roads, it is not implied that thought is conveyed along these roads as the products of a country are conveyed on a railroad train. On the contrary, thought is developed along these mathematical roads, and the traveler finds continually new difficulties whose solution depends largely upon those encountered earlier. In constructing these roads mathematics is not seeking an intellectual monopoly in order to collect toll from the rest of the intellectual world in succeeding ages. In fact, in most of the newer regions the travelers are too few to encourage such thoughts even if they were not intrinsically repugnant.

There is, however, a considerable number of mathematicians who are interested in constructing unusually attractive toll roads, especially in those regions where travelers are most abundant. Whether the prospects of tolls derived from small royalties constitute the best means to secure improvements in our elementary text-books and whether this system is apt to continue to be efficient are questions which present many difficulties. There appears to be an enormous waste along this line at present resulting from unfruitful duplication.

The financial questions involved in mathematical publications have doubtless much in common with those relating to the publication in other subjects. The journals depend largely upon the universities and the mathematical societies for financial assistance. Lately the *American Mathematical Monthly,* a journal of collegiate grade, has received financial assistance from more than a dozen colleges and universities, and it has thus been enabled to make many improvements. The *Annals of Mathematics,* which is a journal of a somewhat more advanced grade, is being published since 1911 under the auspices of Princeton University.

The large mathematical encyclopedias, mentioned above, are being published under the auspices of the Academies of Göttingen, Leipzig, Munich and Vienna, while various governments have been asked to assume the expense of the publication of at least some of the reports prepared under the general direction of the International Commission on the Teaching of Mathematics. The Japanese reports are published both in the Japanese and in the English languages; and all these reports, aggregating already more than ten thousand pages, are for sale by Georg & Co., Geneva, Switzerland.

While mathematical societies generally support publication of advanced grade, they usually have other functions. In many instances membership implies attainments of comparatively high order and hence is attractive in view of the honor and exclusive privileges which it involves. Recently an international mathematical society has been organized with the sole purpose of supporting the publication of the complete works of the most prolific mathematical writer, Leonhard Euler, who died in 1783. Each member of this society is expected to pay at least ten francs annually until this publication is completed, which is expected to require about fifteen years.

Several years ago it was estimated that the complete works of Euler would fill from forty to forty-five volumes, and that the expense would be about half a million francs. As funds had been provided to cover this expense, the publication was begun, but it soon appeared that the estimates were entirely too low and that the expense would be almost twice as large as the original estimate, in view of the additional material found at various places.

The great permanent value of the works of Euler has encouraged the "Schweizerische Naturforschende Gesellschaft zu Lausanne" to make an appeal to all mathematicians, and others interested, to join hands by means of the society mentioned above in securing the completion of this monumental publication. This society seems to be unique in the history of mathematics, but it bespeaks forcibly the spirit of cooperation which has led in recent years to much bigger mathematical undertakings than were possible in former years. The reflex action of these big undertakings on the mathematicians themselves is an element of considerable interest.

The mathematical activities to which we have directed attention in the present article were selected, in the main, on account of their special interest at the present time. The most important activities, however, are those whose permanency has secured for them a place among the fundamental elements which enter unnoticed into our intellectual life, and whose effectiveness is increased by the fact that they are not impeded by effusion. As mathematics is such an old science, the educator naturally looks to its activities with a view to predicting in some measure the future activities of the younger sciences. Hence it is especially interesting to note those activities which imply vigor, and promise for still greater achievements in the mathematical sciences.

THE ULTRA-SCIENTIFIC SCHOOL

By B. HOROWITZ
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(The Ultra-scientific School)
"Problems of Life are Problems of Matter."—Schäfer.

(The Conservative School)
"To me the meanest flower that blows can give
Thoughts that do often lie too deep for tears."—Wordsworth.

THE addresses before the British Association for the Advancement of Science by Schäfer and Lodge have surely had the effect of stimulating still further our interest in the problem of problems—the origin of life. That the most profound differences of opinion exist not merely between scientists and non-scientists, but among scientific men themselves, adds but another factor to the general interest in the subject, though many factors to the general confusion.

The ultra-scientific school, at the head of which are Loeb and Schäfer, trace the origin of their ideas chiefly to Huxley. As far back as 1870 this philosopher wrote:

> With organic chemistry, molecular physics and physiology, yet in their infancy, and every day making prodigious strides, I think it would be the height of presumption for any man to say that the conditions under which matter assumes the properties we call "vital" may not, some day, be artificially brought together.[1]

That was before Emil Fischer began his work on the structure of the protein molecule; before Kossel commenced his celebrated investigations into the composition of nuclear material; long before Loeb startled the world with his experiments on parthenogenesis. With that intuitive spirit with which he was singularly gifted, Huxley foresaw—so claim our ultra-scientists—the results of modern research. Our chemistry, our physics, our physiology, have already reached that stage where we can say with confidence: the data necessary is within sight. Within these three sciences a complete explanation is to be found. Hence, outside factors need not be considered.

True, the mere fact that we can give no satisfactory definition of life can be of little avail in the present controversy. It may well be argued that we can do no better in the case of electricity, and yet our control of that is well-nigh complete.

It should be made clear, in justice to our ultra-scientists, that their aspirations at present run no higher than to bring the phenomena of life within the category of established laws. Their aim is to regulate

[1] Huxley, "Discourses" (Chapter on Biogenesis and Abiogenesis).

forces. To understand them is, they admit freely, beyond their ken. Thereby, even if their own problem were solved, a purely materialistic view would hardly be appreciably advanced.

But to return. Life, like electricity, can not be defined, but, like it, manifests itself in certain ways. Movement, metabolism, growth and reproduction are held to be characteristic properties of life by a large class of physiologists; but the insurgent group, with Wöhler's artificial production of urea—wherein he overthrew the idea that organic substances possess a "vital" force—as its foundation stone, is bent upon showing us that there is no such barrier between the animate and the inanimate. Is it movement that you are considering? Have we not that in organic mixtures, in oil drops, in globules of mercury? And are these not all explicable by changes in surface tension? Is it metabolism—the taking in of food and the giving out of waste products? If so, what of osmotic conditions, where solutions are separated by semi-permeable membranes and where there is an interchange of substance? Is it growth and reproduction? If so, consider the growth and multiplication of crystals.

It is this argument by analogy that has led the ultra-scientific school to its present theory with regard to the origin of life. Rightly brushing aside the meteoric theories of Kelvin, Helmholtz and Arrhenius as irrelevant in so far as origin goes—for in their attempt to explain the first sign of life on this planet they presuppose the existence of the germ elsewhere—Schäfer boldly upholds the hypothesis that life originated as a result of the gradual evolution of inanimate material. In process of time the simple substance became more and more complex and ultimately emerged as the living germ—the nitrogenous colloid.

But Schäfer goes a step further. Why are we to suppose that this happened but once, as all theories with regard to origin have thus far assumed? Why are we to suppose that at one time in the dim past a series of fortunate accidents made life possible? Is it not more logical to assume that these evolutionary processes are going on to-day and will continue to do so?[2]

Though even Huxley was of the opinion that at one time there was "an evolution of living protoplasm from not living matter," the idea that we should not relegate the process to some remote period in the past is a comparatively new one, and has not by any means received the approval of many otherwise loyal chemico-physiologists. These argue with no small show of reason, that continuous life production would imply similar terrestrial conditions throughout the ages; and this we know not to be the case.[3]

[2] E. A. Schäfer, "Life: Its Nature, Origin and Maintenance," Smithsonian Report, Publication 2213.

[3] Giving fancy full reign, Macallum pictures for us "a gigantic laboratory where there had been a play of tremendous forces, notably electricity, which

As growth and multiplication are by far the most characteristic features of the living organism, it is little wonder that the fiercest antagonism centers around this point. Mitchell, one of the mildest critics, takes exception to the crystal comparison, on the ground that living matter is a mixture of substances chiefly dissolved in water, and that therefore it would be far more appropriate to take liquids as the basis for comparison.[4]

Armstrong and Haldane, the one a chemist and the other a physiologist, and both among the most eminent in their respective professions, flatly refute the analogy. In crystal growth there is a mere piling up of simple units, and, under the proper conditions, there is no limit to the growth of the crystal. Nothing corresponding to cell division, nor to the complexity of organic growth, is ever met with. Bergson, whose knowledge of the exact sciences makes him an exceedingly competent critic, argues that whereas the living organism is composed of unlike parts and performs diverse functions, the crystal neither consists of the one nor performs the other.[5]

Of course, Bergson repudiates Schäfer's whole hypothesis, but in this he is in agreement with many a scientific authority. For example, Professor Wilson, whose book on cell development is a classic, sums up his views in these words:

> The study of the cell has, on the whole, seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world.[6]

Sir William Tilden, the English chemist, is equally emphatic from the chemical standpoint. He writes:

> Far be it from any man of science to affirm that any given set of phenomena is not a fit subject of inquiry, and that there is any limit to what may be revealed in answer to systematic and well-directed investigation. In the present instance, however, it appears to me that this [the origin of living matter] is not a field for the chemist, nor one in which chemistry is likely to afford any assistance whatsoever.[7]

Let it at once be stated clearly and emphatically that the ultra-scientific view is based primarily upon analogy—a very valuable method provided it is not carried to excess, and provided, also, sufficient experimental data are at hand. Mendeleëff's periodic classification tended to show that cæsium, rubidium, sodium and potassium were closely allied,

might have produced millions of times organisms that survived but a few hours, but in which, also, by a favorable conjunction of those forces, what we now call life might have come into existence.'' No less fanciful is Armstrong himself (see H. E. Armstrong, ''The Origin of Life: A Chemists' Fantasy,'' Smithsonian Report, Publication 2214). And yet we speak of the dry-as-dust scientist!

4 P. C. Mitchell, ''Encyclop. Brit.,'' 11th ed., article on ''Life.''

5 Bergson, ''Creative Evolution,'' p. 12.

6 E. B. Wilson, ''The Cell in Development and Inheritance,'' p. 330 (1907).

7 Tilden, *London Times*, September 10, 1912.

a fact which was known before Mendeléeff's time purely as a result of experimental work on these elements. The movement of oil drops and the interchange of substance in osmosis are certainly quicksand foundations upon which to build inter-relationship theories of the animate and the inanimate. This superficial connection fails to stand the test of adaptation and coordination—to name two characteristic features of the *vital* substance. Indeed, our knowledge is so remarkably extensive that we can not as yet state the simplest *vital* manifestation in terms of science.

But this does not make a discussion of this kind any the less valuable. The impetus to research that it gives is productive of the highest good to mankind, for if the results do not solve the problem, the *scope* of the problem becomes so much clearer. The whole, which is made up of many coordinated components, eludes the grasp, but the individual components are gradually revealing many of their secrets to the untiring scientific explorer. With the physiologist ever attentive in his study of the human mechanism, with the chemist carefully analyzing and synthesising the more complex forms of matter so intimately associated with life's activity, with the scientific philosopher investigating the laws common both to animate and inanimate substance, who would venture to foretell the outcome?

The present situation may be summed up in some such way as this:

1. (*a*) Chemistry and physics may possibly contain all the necessary factors, our ignorance being due to our inadequate knowledge of these sciences, especially chemistry; or (*b*) There may be an outside factor.

2. Whilst no definite theories as to the origin of life can as yet be advanced, it is not unreasonable to suppose that in process of time, with consequent development, a better insight into (*a*), or an idea of (*b*) will be obtained. Fancy may well picture even the acquirement of new faculties, which will bring within range many of nature's present secrets, unattainable by present methods.

3. At present we know of no better way of pursuing our search than through the sciences. But here we are only safe when we apply them to the things we can grasp. The application of scientific methods to the spirit world (the methods of Crookes, Lodge and others) have thus far been barren of result. Science, *as we understand it,* rules in the world of matter, but it does not beyond. Whether this "matter" is but a manifestation of the "spirit," whether there is any relationship between them, or whether, indeed, they spring from the same source, time may, and time may not tell. Our duty is to plod the weary way, irrespective of where it leads to, or what the outcome of it may be. Patience, diligence and truth are our guiding stars.

ARABIAN AND MEDIEVAL SURGERY[1]

BY DR. JOHN FOOTE
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AFTER the conquest of Alexandria, when the victorious Mohammedans were feeding the fires of the city baths with the priceless treasures of the Alexandrian library, a young man who had been a student at the now dismantled university was writing a medical work, the sixth volume of which dealt with surgery. Little work has been done by the Byzantine authors other than the copying of preceding works which might otherwise be lost to us, and the works of Oribasius and Ætius on surgery and the medical writings of Alexander of Tralles have little more than their Greek contact to commend them. But the work of Paul, called from his birthplace, Paul of Ægina, was more than a mere copy. The rough, untutored Arabs who conquered Asia Minor, were not long in being, in turn, conquered by Greek culture and Greek science. Rapidly as this was assimilated, it is well to remember that an important text-book on surgery had been written by one of the conquered before the Hellenization of the Arab had taken place. Gurlt considers this a momentous work, and it describes among other things original treatment for foreign bodies in the esophagus, the operation for tracheotomy, and has an article on hernia. Of course this surgeon had an operation for the radical cure, which included peritoneal suture and drainage in its technique. Paul devised a gynecological speculum, was credited with special knowledge of women's diseases, and indeed was known as "The obstetritician."

The Nestorian monks had christianized many Arabs and these Christian Arabs figure most prominently in the first period of Arabian medicine as both translators and practitioners. The Bachtischua family, the name being derived from Bocht Jesu, servant of Jesus, had several illustrious members, the first, George, being physician to the caliph El Mansur at Bagdad, and his son, as well as his grandson Gabriel, serving Haroun al Raschid in a like capacity. This physician claimed to have received over $10,000,000 in fees, and the largest single fee on record, $125,000, is credited to him. Perhaps the best known writers of this period were Serapion, the Elder, who lived during the ninth century, and Honein Ben Ischak, or Johannitius, whose accurate translations of the old authors caused him to be called the Erasmus of the Arabian renaissance. Serapion describes an operation for stone in the kidney in which

[1] Read before the Medical History Club of Washington, D. C., December 27, 1913.

an incision is made in the groin and the pelvis incised and explored. He did a ligation operation for hemorrhoids, wrote in detail on the use of the catheter, and considered the suprapubic opening of the bladder for stone a simple procedure if we can believe him.

The Jewish physicians are important figures in this period of the history of medicine. Many of their scholars attained distinction as surgeons and writers; the best known of these, Maimonides, or Moses Ægyptius, was surgeon to Saladin and lived in the twelfth century. Spain, the rich Roman province which had produced Lucan, the Senecas, Martial and Quintillian, did not entirely lose its traditions of culture after the barbarians from the north fell upon it, and the Moors, hungry for knowledge, came to a feast of which they were soon the masters.

The most distinguished Arabian surgical writer of the ninth century was Rhazes, a Persian by birth, who was a singer until he was thirty. He was a follower of Aristotle and Galen and wrote some 200 works, including a complete system of medicine and surgery. He treated fractures with intelligence and discussed the treatment of wounds of the intestine. Vesalius thought so well of his principal work that he translated it, but later destroyed the translation. Ali Abbas, who succeeded Rhazes in prestige, wrote a book, the Liber Regis, dedicated to his patron the Sultan. This was the leading Arabian textbook until the Canons of Avicenna appeared. A method of ligating the median basilic vein in troublesome hemorrhage after venesection is described, as well as the technique of tapping the peritoneal cavity in ascites. This work was translated by Constantine, and printed in Venice in 1492.

Albucasis, a Spanish Moor, born, like Maimonides, near Cordova, was probably the greatest of the Arabian surgeons. He lived in the second half of the tenth century, and is reputed to have attained the age of 101. While his writings cover the entire field of medical knowledge, his three volumes on surgery are most original, and are the first illustrated surgical writings that have come down to us. Fabricius, Harvey's teacher, declared that he owed most of his knowledge to three writers, Celsus, Paul of Ægina and Albucasis. Albucasis emphasized the importance to the surgeon of a knowledge of anatomy. In discussing the treatment of hemorrhage he advises the use of the cautery, complete division of the partially severed artery, hemostatic applications and bandaging. He classifies nasal polyps, advises the snare for their removal, has ingenious methods for removing foreign bodies from the ear, makes some advances in genito-urinary surgery, and differentiates between epitheliomata and condylomata. He talks of the extirpation of varicose veins, but wisely says this operation should not be resorted to unless absolutely necessary. He diagnoses fracture of the pubic arch, and when it occurs in the female he advises a vaginal tampon of wool, or of a blown up sheep's bladder. Avicenna, the author of the "Canons," was a medical rather than a surgical writer, and his text-book was used for nearly five centuries after it was written.

Bagdad and Cordova had now become the destination of many a European scholar. The number of anatomical terms of Arabian origin translated into Latin, according to Hyrtl, is surprising, and this more especially in view of his assertion that "the Arabs paid very little attention to anatomy, and, of course, because of the prohibition of the Koran, added nothing to it." He continues:

> Whatever they knew they took from the Greeks and from Galen. . . . They delighted in theory rather than practise.

This is a terse summing up of the general influence of Arabian medicine. Taken as a whole, the Arabs were copyists and dialecticians; by their very virtues of erudition and scholarship they impressed upon their medieval successors the supremity of Galenical tradition rather than the desire for anatomical and bedside inquiry into the cause of disease.

Constantine Africanus, who was first a traveler and a student, next a professor in the University of Salerno, and finally a Benedictine monk in the great abbey of Monte Cassino, is the connecting link between Arabian and western medicine. His familiarity with oriental languages, and his connection later with the great Benedictine order celebrated for its libraries and zeal in copying books, gave him unique opportunities for the translation and circulation of his medical writings. He was born at Carthage early in the eleventh century, and died near its close. After his travels he acted as physician and secretary to Duke Robert of Salerno, and was made professor of medicine at the university. After teaching for ten years he retired to the monastery, obtaining there both the quiet and the material assistance which he needed in order to pass his heritage of knowledge on to succeeding generations. The "Liber Pantegni," a translation of Ali-Ben-el Abbas, as well as certain works of Hippocrates and Galen, were among his best-known books. His original work is better known through the writings of his students Afflacius, Bartholemew and numerous others.

In view of this it is a seeming contradiction to have Gurlt assert that the surgery of the Salernitian school was not a continuation of Arabian surgery and that the surgeons of Salerno were not influenced by the Arabian commentators. Yet he cites Roger's writings in evidence, and declares that such authorities as are quoted come directly from the Greek, while a good portion of the work rests on the writer's own experiences.

Contrary to popular belief, surgery at this time was not an unlearned profession, for there were many surgeons connected with the early universities. The degradation of the surgeon comes later in the middle ages. The greatest surgical teacher of the early thirteenth century was Roger, who wrote about 1180. His work was annotated by his pupil Roland, and the work of both edited later by the Four Masters. Gurlt says of the latter:

> This volume constitutes one of the most important sources for the history of surgery in the later Middle Ages, and makes it very clear that these writers drew their opinions from a very rich experience.

Their diagnosis of fractures of the skull is quite modern, subdural hemorrhage is described, and the technique is given for a decompression operation for depressed fractures, the old writers saying:

> In elevating the cranium, be solicitous lest you infect the dura mater.

Suturing with silk, and drainage, are recommended for scalp wounds, and the prognosis of infected wounds is considered at length. The surgeon was told that he must keep his hands clean and that he must especially avoid not only menstruating women, but all women, if he would operate successfully.

Bruno da Longoburgo, Theodoric, Hugo of Lucca, and William of Salicet are a famous group of North Italian surgeons of this period. Mondino, the author of the first book on dissection, Lanfranc, who taught at Paris, and, in the words of Pagel, "gave that primacy to French surgery which it maintained all the centuries down to the nineteenth," as well as de Mondeville and Guy de Chauliac, belong to the early fourteenth century.

Hugo of Lucca and his son Theodoric used opium and mandragora to produce anesthesia, and also used a mixture to be inhaled from a sponge, the composition of which is not definitely known. Fifteen great universities arose in Italy from the tenth to the fourteenth centuries, and in all of these surgery was taught. Bruno was the first of the Italian surgeons to quote Arabian as well as Greek authorities. He worked at the universities of Vicenza, Padua and Verona. His "Chirurgia Magna" was completed at Padua in 1252. He insisted that surgery was largely handwork, and must therefore be learned from practical experience and observation. He sums up three important offices of surgery as: "to bring together separated parts, to separate those abnormally united and to extirpate what is superfluous." He discusses wounds, healing by first and second intention, indications for suturing and for drainage. He advised against the use of water in wounds, especially the water in camps and battlefields. Wounds of the intestine he directed to be cleansed with warm wine and closed with fine silk sutures.

Hugh of Lucca was city physician to Bologna, and his writings were edited by his son Theodoric. Theodoric studied medicine, entered the Dominican order at the age of 23, but continued to practise surgery in Bologna, devoting his fees to charity. At 50 he was made a bishop. In his text-book, finished about 1226, he says:

All wounds should be treated only with wine and bandaging.

He emphasized the importance of diet in assisting in wound repair, warned against the wounding of nerves, and suggests bringing ends of cut nerves in proximity to favor repair. It is surprising to find these old surgeons writing of union by first intention, and insisting on cleanliness and antiseptic dressings, such as strong wine. With regard to their treatment of wounds, Professor Allbutt, of Oxford, undoubtedly our greatest English authority on the history of medicine, writes as follows:

They washed the wounds with wine, scrupulously removing every foreign particle; then they brought the edges together, not allowing wine nor anything else to remain within—dry adhesive surfaces were their desire. Nature, they said, produces the means of union in a viscous exudation, or natural balm, as it was afterwards called by Pare and Wurtz. In older wounds they did their best to secure union by cleansing, desiccation and refreshing of the edges. Upon the outer surface they laid lint steeped in wine. Powders they regarded as too desiccating, for powder shuts in decomposing matters; wine, after washing, purifying and drying the raw surface, evaporates.

Theodoric was six centuries in advance of his time when he wrote:

For it is not necessary, as Roger and Roland have written, and as many of their disciples teach, and as *all modern surgeons profess,* that pus should be generated in wounds. No error can be greater than this. Such a practise is indeed to hinder nature, to prolong the disease, and to prevent the conglutination and consolidation of the wound.

Theodoric, like our present-day surgeons, was proud of his small and beautiful scars produced without using salves "Pulcherrias cicatrices sine unguento aliquo inducebat," while poultices, oils and powders on wounds, he said, incarcerated foul material, "saniem incarcerare," evidence enough that this writer knew not only the art, but also the fundamental principles of good surgery.

William of Salicet passed his early life at Bologna, and later was municipal and hospital physician to Verona. Being himself both a physician and a surgeon, he believed that these two branches of medicine should not be separated. In his book he quotes previous authorities less than his predecessors, and he condemns the abuse of the cautery popularized by Arabian writings, and advocates the use of the knife. He describes operations for the relief of hydrocephalus, various eye conditions, nasal polypi and tumors of the mouth. He relates the history of a tumor, probably an epulis, larger than a hen's egg, which he removed from the gums of the upper jaw, and says that he performed the operation in four steps, the last being the resection of a portion of the jaw bone. He did not hesitate to operate on cystic goiter, but he describes the large veins encountered in certain types of goiter and he warns against hemorrhage from them.

Lanfranc practised at Milan until his banishment about 1290. He then practised at Lyons, and later taught at Paris, where he attracted great numbers of students by his fame as a teacher and an operator. He completed his "Chirurgia Magna" in 1296. Ten years later he died, but meanwhile he had transferred the center of the surgical world from Italy to France. Lanfranc was probably the first surgeon to absolutely distinguish between nerve and tendon, and he was the first to advocate and practise nerve suture.

Henry de Mondeville, or Henricus, was a Norman, little known until modern times. The first printed edition of his book was edited by Professor Pagel, in Berlin, in 1892. Mondeville was a scholar and a traveler. Born in France, he studied under Theodoric in Italy, and later at Montpellier and Paris. He afterwards lectured in both of these universities. He was a very busy man—a teacher, a consultant and one of the physicians to King Philip le Bel. We see in him the not unfamiliar picture of the famous surgeon trying to make time for his writing. He died before he was forty of some lung disease—probably tuberculosis. He sketched the earlier chapters of his work on his sick bed, but wrote the practical portion at length in the last chapter so that his students might profit by his experience. He was a shining example of the wide culture and erudition of the university-trained surgeon of his day, quoting, as he did, not only from the Latin, Greek and Arabian authorities on medicine, but also from Cato, Diogenes, Horace, Ovid, Plato, Seneca and other classics not popularly known until the Renaissance. Mondeville used a large magnet to extract portions of iron from tissues, and invented an instrument for extracting barbed arrows from the flesh. He wrote intelligently on the nursing problem, and spoke of the difficulties to the surgeon when wives nursed their husbands. A chapter on the history of surgery is a novel feature of his book. He was one of the first, if not the very first, to use illustrations in teaching anatomy.

Yperman, who was sent by the town of his name in Belgium to Paris in order to learn surgery, fulfilled his mission, and returning to his native town, practised and wrote two books on surgery in Flemish. John Ardern, an Englishman, studied at Montpellier, and, returning to England, practised and wrote on surgery. The "Practica" is a comprehensive work by this English surgeon, containing many case histories. He was a skillful operator, especially famed as a proctologist, and was the first surgeon to collect careful statistics of his cases. His book is illustrated, and he writes on what we now recognize as appendicitis under the title "Against Colic and the Iliac Passion." Ardern was the first great English surgeon.

We are inclined to deny to the middle ages anything approaching our tolerance of thought in the domain of education. The idea of coeducation, and women in the learned professions, would seem to be essentially modern. Coeducation was tried in the middle ages and found wanting, and women taught in the medieval universities, and were eminent as physicians, gynecologists and obstetricians. Salerno admitted women to the study of medicine, and women's diseases were taught entirely by women teachers. The most famous of these was Trotula, said to have been the wife of one of the professors. She wrote two books, the most important one being called "Trotula's Wonderful Book of Experience in the Diseases of Women, Before, During and After Labor, with All Other Details Likewise Relating to Labor." Prenatal care, nursing and the care of mother and child during the puerperium are considered. In the chapter on the perineum a description is given of a complete tear, together with directions for a radical cure in which sutures with silk thread are employed. This author writes:

> The woman is then placed in bed with the feet elevated, and must remain in that position even for eating and drinking and all the necessaries of life, for eight or nine days. During this period, also, there should be even no bathing, and care must be taken to avoid everything that might cause coughing, and all indigestible material.

All students of obstetrics might read with profit her directions for care of the perineum during labor. She says:

> In order to avoid the aforesaid danger, care should be taken . . . somewhat as follows: a cloth should be folded somewhat in oblong shape and placed on the anus, so that, during every effort for the expulsion of the child, that should be pressed firmly in order that there may not be any solution of the continuity of tissue.

Her works were printed at Strassburg in 1544, and in Leipsig as late as 1778. Nicaise, Chauliac's biographer, says:

> Women continued to practise medicine in Italy for centuries, and the names of some who attained great renown have been preserved to us. Their works are still quoted from in the fifteenth century. . . .

Chauliac criticized women surgeons of his day for being too timid in taking chances, and refusing to operate on dangerous cases. There were at least seven women professors at Salerno who wrote works that have survived. One of these, Mercuriade, was a surgeon, and wrote "On the Cure of Wounds." Another one, Abella, wrote "On the Nature of Seminal Fluid" and "Black Bile." Rebecca Guarna wrote on "Fevers," "The Urine" and "The Embryo."

The last great name in medieval surgery is Guy de Chauliac, that brilliant man who, both chronologically and in virtue of his methods, may be looked upon as the father of modern surgery, if indeed that distinction may be conferred upon any one individual. Born in southern France late in the thirteenth century, he was educated at Montpellier, and then journeyed down to Bologna in Italy, to do post-graduate work in surgery, finally finishing his studies in Paris. One of his teachers at Montpelier was Bernard Gordon, author of "Lillium Medicinæ," and a fellow student was John of Gaddesden, the first English Royal Physician, who is mentioned by Chaucer in his "Doctor of Physic." Guy did not like John's Book, "Rosæ Angliæ" because it lacked originality and clung to authority unsupported by experience. At Bologna he studied under Bertruccius, and he relates how "very often" to quote his exact words, his master dissected dead bodies in four lessons. His attitude toward anatomical study is shown by his expression, "The surgeon ignorant of anatomy carves the human body as a blind man carves wood." He practised first in his native province, later in Lyons, and finally was physician and chamberlain to three successive popes at Avignon. He occupied the latter part of his life with writing his "Chirurgia Magna," his "Solatium senectutis," he called it. Nicaise emphasizes the freshness and originality of Guy's viewpoint, and quotes him concerning the surgeons of his own and preceding generations as follows:

> One thing is especially a source of annoyance to me, in what these surgeons have written, and it is that they follow one another like so many cranes. For one always says what the other says. I do not know whether it is from fear or from love that they do not deign to listen except to such things as they have been accustomed to, and as have been proven by authorities. They have to my mind understood very badly Aristotle's second book of metaphysics when he shows that these two things, fear and love, are the greatest obstacles on the road to the knowledge of the truth. Let them give up such friendships and such fears.

For while Socrates or Plato may be a friend, truth is a greater friend.

> . . . Let them follow the doctrine of Galen which is entirely made up of experience and reason, and in which one investigates things and despises words.

In writing on surgery of the brain he records the loss of brain substance with recovery, and notes the recovery, under expectant treatment, of many patients with suspected fracture of the skull. His study of the surgical anatomy of the ribs and diaphragm as applied in opening the thorax, shows sound surgical sense. In wounds of the intestines he gives an unfavorable prognosis unless the abdomen be quickly opened and the wounds sewed up. He describes his sutures and his special needle-holder, like any modern surgeon. In his chapter on amputations he writes on the use of opium, morel, hyoscyamus, mandragora, ivy, hemlock and lettuce to abolish pain during operations, and also refers to inhalation anesthesia, from a sponge soaked in various sleep-producing drugs. Taxis and reduction in hernia were developed by him, and he invented several trusses. Many operations for hernia, he wrote, benefited the surgeon more than the patient. In strangulation he insisted upon immediate operation. He describes six hernia operations, and criticizes all of them, easily enough, since all of the operations at this time included removal of the testicle. He alludes to the use of gold wire, a forerunner of the silver wire of our day. His inventions for the reduction of fractures and dislocations were far in advance of his day and many of these cases were cared for in hospitals. Virchow has told us of the excellence of the hospitals in the thirteenth century, and of the good care given to the patients. How Chauliac and later generations of surgeons came to accept the doctrine of the formation of laudable pus in wound healing, when at this period surgical cleanliness, the use of antiseptic wine dressings, and the possibility of natural union by viscous exudate were written on and discussed, is difficult to understand. But even in Chauliac's time, surgery was becoming more and more divorced from medicine, and the surgeons were ceasing to be students.

Chauliac was a genius living in an age of remarkable achievement. Dante's "Divine Comedy" and Petrarch's sonnets were written in his lifetime. Boccaccio and Chaucer were of his day. Giotto was painting wonderful pictures, the great cathedrals were building and the universities were flourishing, and as Professor Huxley said in his rectorial address at Aberdeen, in 1847, "probably *educating* in the real sense of the word better than we do now." Portal in his "History of Anatomy and Surgery" says:

> Finally, it may be averred that Guy de Chauliac said nearly everything which modern surgeons say, and that his work is of infinite price, but unfortunately too little read, too little pondered.

This obviously extravagant praise is not discounted by Albutt who writes:

> This great work [the ''Chirurgia Magna''] I have studied carefully and not without prejudice: yet I can not wonder that Fallopius compared the author to Hippocrates or that John Friend called him the Prince of Surgeons. It is rich, aphoristic, orderly and precise.

Decadence in surgery began after Chauliac's death. His successors seemed to think that they had little more to learn, and boasted, as each generation does, of their progress. Wars and political disturbances also came to distract men's minds, and study and achievement ebbed away from the standard set by Guy and his immediate predecessors, until the great flood tide of knowledge that came with the Renaissance.

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CIVILIZATION AS A SELECTIVE AGENCY

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WRITERS of recent years appear to agree that there has been little or no improvement of civilized man through selection. Since the dawn of history, it is recognized that many selective forces, some favorable, some deleterious, have acted on the human breed; but it is denied that any constant and effective agency which would bring about a marked advance in moral and intellectual quality has been in operation. August Weismann expressed himself on this score clearly, though with scientific reserve. He said:[1]

> But as a mere suggestion, without any pretense to exactness, I will state that the people of "antiquity," viz., the ancient civilized nations of the Mediterranean, had already, at the very dawn of their history, attained the highest level of intellectual development. If any further growth has occurred since in European states, it certainly has been so imperceptibly small that it could cause no sensible difference in the susceptibility of the human soul to music. The times which produced such legislators as Moses and Solon, poets like Homer and Sophocles, philosophers and men of science like Aristotle, Plato and Archimedes—times which created the Egyptian temples and pyramids and the statues of the Greek gods, most undoubtedly display the achievements of the human intellect at its best. And an age which produced the gentle and forgiving Christian philosophy shows us that, as regards character and feeling, the human mind had attained the highest development.

This view has come, indeed, to be orthodox. Except among thinkers who still cling to the Lamarckian doctrine, it is generally accepted. It is taken over without reservation in many books on social theory.[2] According to this principle our inheritance is primitive inheritance. The growth of the social heritage, rather than changes in the racial heritage, has wrought civilization for us and bridged the gap between aboriginal Teuton and modern German. Mankind may have progressed, certainly has altered, but for cause we must look to "those contrivances which enable human beings to advance independently of heredity."[3]

Among writers of authority possibly no one has given more emphasis to this conception that Alfred Russel Wallace, codiscoverer with Darwin of natural selection. In his latest book[4] Wallace reiterates the conclusion:

1 "Thoughts Upon the Musical Sense in Animals and Man."

2 For example, see Simon N. Patten, "The New Basis of Civilization," p. 169.

3 D. G. Ritchie, "Darwinism and Politics," p. 101.

4 "Social Environment and Moral Progress," p. 102.

that the higher intellectual and moral nature of man has been approximately stationary during the whole period of human history, and that the cause of the phenomenon has been the absence of any selective agency adequate to increase it.

Somewhat earlier than this Wallace asked:[5]

Looking back at the course of our history from the Saxon invasion to the end of the nineteenth century, what single cause can we allege for an advance in intellect and moral nature? What selective agency of "survival value" has ever been at work to preserve the wise and good and to eliminate the bad? And it must have been a very powerful agency, acting in a very systematic manner, even to neutralize the effect of the powerful deteriorating agencies above referred to.

And again:

there is no good evidence of any considerable improvement in man's average intellectual and moral status during the whole period of human history.

At one point in this essay, as a matter of fact, Wallace goes so far as to say, after discussing the ways in which the human breed was brutalized by the withdrawal of the more refined natures to monasteries and nunneries, and the destruction of radicals and students during the witchcraft mania and by the inquisition, that:

we are to-day, in all probability, mentally and morally inferior to our semi-barbaric ancestors.

Must we accept this view as final? Are we sure that a denial of selection during historic times, strongly supported as it is, expresses the whole truth? In the first place, it certainly runs counter to the wide-spread belief that men are to-day inherently more humane, kindlier in character and action, than they were in antiquity. Attention is often called to the growth of altruism, especially during the past century. It is maintained that suffering will not be endured, either among men or animals, as in former times; that cruel punishments have been abolished; that brutal sports, once popular, now only disgust and repel. Further evidence of increasing altruism is offered in the development of social legislation, and in the multiplication of charitable and educational enterprises. And it must be admitted that the twentieth century, with its vast philanthropies, its soft-heartedness, verging so often even to sentimentality, and its insistence on the ideal of service, belongs to a different world from the hard life of the Greek and Latin city states, which seem, sometimes, in their unthinkable indifference to human pain and the rights of the weaker, to be prototypes of nothing modern except the Camorra and the Mafia.

This notion that the human breed is now, in civilized societies, kinder, gentler, more tractable, is not merely a popular idea. One phase of it has been remarked upon by that keen observer, Walter Bagehot.[6]

[5] "Evolution and Character," *Fortnightly Review*, Vol. 89, 1908, pp. 1–24.

[6] "Physics and Politics," p. 25.

> They both (Aristotle and Plato)—unlike as they are—hold with Zenophon—so unlike both—that man is the "hardest of all animals to govern." . . . We reckon, as the basis of our culture, upon an amount of order, of tacit obedience, of prescriptive governability, which those philosophers hoped to get as a principal result of their culture.

Bagehot, of course, had no difficulty in explaining this increase in social amenability which he believed he observed. He had accepted the idea that acquired characters are inherited; and he thought that our modern orderliness and sympathy would be attained "when the soft minds and strong passions of youthful nations are fixed and guided by hard transmitted instincts." But if we rule out this agency, and adhere to the position of Weismann, now generally acknowledged as correct, we must forego this easy explanation and seek some other reason than the transmission of acquired characters for the world's increasing moral stability.

There remain two possible views to be taken of the fact that the moral complexions of the ancient world and the modern are so different. First, we may accept the orthodox dictum, and maintain that any apparent changes are due to the increased weight, so to speak, of the race's moral heritage—to strengthened social controls and the ascendency of new ethical types; or secondly, we may postulate a change in man's innate moral nature, accompanying and reenforcing the influence of the augmented social heritage. We shall be justified in pursuing the second, and bolder, course only if we can discern some selective agency adequate to effect the change.

It is here suggested that such a selective agency can be discerned as operative, an agency at once powerful, comprehensive and continuous. We may denominate it the *elimination of the anti-social*—that is, the constant cutting off of those elements in society which do not fit in with the requirements of orderly civilized life. The forms that this process has taken—a number of which we shall examine shortly—have been many and diverse; but the result has been unified and focused.

Settled community life creates an environment of its own, imposing new requirements of "fitness." A heavy survival value comes to attach to tractability, so that non-conformity, in greater or less degree, leads to extinction or failure to beget offspring. The church and the state cut off the anti-social person by capital punishment, imprisonment and banishment; while the anti-social individual eliminates himself by suicide, by choice of a dangerous occupation, by withdrawal to the world's frontiers, by exposing himself to vice and racial poisons. Those who tend to survive and perpetuate themselves, on the other hand, are those whose moral natures make the restraints of sedentary communal life less irksome.

It would not be possible—nor is it necessary to our present purpose

—to draw a sharp line between the social and the anti-social. That psychology of individual differences which might enable us to grade men and women into distinct ethical types is still in process of creation. Yet in a broad empirical way it is easy to distinguish the moral qualities favorable to communal life. The complete social person is marked, fundamentally, by industry, self-control, kindliness, perseverance and the ability to subordinate present pleasure to future welfare. Anti-social persons embody the opposite characteristics—shiftlessness, violence, brutality, predatory tendencies, viciousness and impatience at restraint. Of course these qualities, social and anti-social, combine in all sorts of mixtures in all sorts of persons. But the principle is clear. As nature's standards of fitness become progressively more civil the social qualities stand a better and better chance, in contrast with their opposites, of perpetuation.

One reason thinkers have overlooked the existence and operation of this selective factor has been a too great preoccupation with the question of intellectual and moral *improvement.* This, as we shall note later, has led to wrong inferences from the data. The problem, in fact, is not one of advance, but one of change. Another source of error has been a confinement of attention to group selection, leading to excessive emphasis of the importance of military success, and neglect of internal selective processes in semi-military communities.

It has long been recognized, of course, that before the emergence of civilizations along the Nile and the Euphrates the race had been subjected to discipline for hundreds of thousands of years. Men lived in groups where tribal custom was supreme. The necessity of prolonged care during infancy had sifted out the gentler mothers and fathers. The clans, moreover, waged incessant war among themselves; and fighting strength and pugnacity being equal, the clan most solidly cemented by fellow feeling succeeded in the conflict with less adhesive clans. Social solidarity, crystallized and preserved in the "cake of custom," stood at a survival premium. Therefore at the beginning of civilization selection had already picked out and conserved a certain minimum of tractability.

Was this rôle of selection dropped with the passing of the predatory pastoral stage and the setting up of orderly communal life? Has the capital of cooperative spirit, acquired before the pyramids, sufficed for all subsequent elaborations? Is not the truth rather that, although the mode of eliminating the anti-social elements has altered, the process has been continuous? Men began to be graded into classes, into occupations and castes. Up to that time man's nature had been clan-hewn. Thereafter selection worked on the individuals within the group, sifting them out in their extensive variety.

II

We may now examine a number of the ways in which this form of socialized selection has worked. Here we shall not try to proceed chronologically, or attempt to strike a quantitative balance between this and other selective forces operating within historic times. Yet by a sketchy enumeration of the factors we may, possibly, suggest how stringent and unrelenting has been the elimination of the anti-social.

In the first place, obviously, the state itself is constantly trying to grind out of society its elements of friction. To-day murderers are executed, and lesser criminals separated from their families and imprisoned; but the penal regulations of the present are charity itself compared with the harsh punishments of the past. For centuries a gallows decorated every cross-roads in Europe, and malefactors, great and petty, were ruthlessly weeded out. Even a hundred years ago in England there were two hundred and twenty-three crimes punishable by death. Throughout the stressful past persons who preferred theft to industry, who scorned constituted authority, who were heedless of the rights and pains of others, were—when caught—swiftly annihilated. Mutilations, shortening life, were so common that the highways were frequently crowded with maimed beggars. Despite the chaos of medieval times life was hazardous for the predatory—at least for the predatory poor.

Again: for many centuries rebellions have been suppressed with bloody finality. Although quickness to rebel, boldness to defy, do not necessarily mark a man as anti-social, yet meekness and a bending to authority, like forbearance, are bound up temperamentally with a kindly disposition and brotherly love. It must be further remembered that the persecutions of the church in all ages have cut off the recalcitrant along with the liberal. Although there has been loss in originality, there has been gain in pliancy. Some of the martyrs were more anarchists than saints. Finally, under the head of legally enforced conformity stands the fact that practically all the civilized race has passed, at one time or another, under a régime of slavery or serfdom. Captives have often come to form, after a few generations, the bulk of the population of the conquering nation. The slave is seldom free to propagate, or, frequently, to live, against the will of his master; so that the descendants of slaves and serfs are bred from the most docile and most industrious of the first generations. Slavery as an institution has vanished, but its effects on human reproduction have been far reaching; for thus man aided directly in his own domestication.

We next consider those various modes of elimination which may be grouped under the term voluntary withdrawal. Suicide during early life effectually abolishes an anti-social strain. The person who has lost the will to live is one who, speaking in the large, has found the conditions of civilized existence unbearable. Suicide as a selective agency is not negligible. The present annual rate for European countries runs above one hundred per million of living; and every day in the year there is a self-murder in the Prussian schools.

Occupational and geographical withdrawal, furthermore, is more significant than withdrawal from life. The hardy, callous, near-savage type of man has ever been employed to do the rough and dangerous work of civilization. From this obdurate material has, in all stages of industrial development, been drawn the sailors, the miners, the range-riders, the pioneers. The bonds of civilized life moreover, are an irritation to many strong and reckless spirits. Such cut loose; for so long as people live together in a net of social interrelations, some overactive elements will break through to the freer life of adventure. Hazardous occupations and adventurous callings have offered opportunity for segregation and voluntary exile. Who, from the first, have been our explorers, our soldiers of fortune, our gold-seekers? Of what stuff are the lads who, in all times, have "run away to sea" or "gone West"? Surely not those who were succeeding best in their trades, not the young men of peaceful ambitions, not those enamored of family life. In somewhat the same class are those restless or slothful souls who take to "the open road." The number of professional tramps in this country is about two hundred thousand. Their occupation is to avoid work: they are anti-social.

It is plain that those who withdraw socially or geographically from their kind contribute less than their normal share to the blood of prosperity. Combat and danger bring death to a considerable proportion. The rest are outside the pale of regular family life. In trading posts, in mining towns, along the frontiers, males are largely in excess; and they are relatively barren. The influence of this selective factor, coupled with the results of military selection, can hardly be over-emphasized. From the loins of the "stay-at-homes" come succeeding generations. The prophecy has been fulfilled; the meek have inherited the earth.

It may be worth while to notice more particularly the effects of military selection, especially because the peace advocates have recently, in their attempt to make out a strong case against war at this point, quite effectively muddled the subject. Possibly the persistence of the military organization, involving the continuous recruiting of a professional military class, alongside of the waxing industrial organization, is the most conspicuous fact in history. Selectively, the question to be asked is: what sorts of men have perished in war? Who marched away? The one patent answer is: not those who were the most peaceably inclined. The factors are, of course, complex; but military selection has drained, on the whole, neither the best nor the worst of the racial stock, but has been an outlet for the intractable members of society. Wild, ungovernable boys, hoodlums in the making, men with the blood-lust still strong in them—such have joined the army and entered the navy through the centuries. The great mercenary forces, recruited so long throughout Europe, did not deprive civilization of men in whom the social virtues were strongly marked. The professional military class has always absorbed—and utilized to advantage, indeed—the men that in the freedom of a purely commercial régime would have been so much explosive material.

This is not to deny, it is admitted, that war has often resulted in retrogression through unfavorable selection. But the peace advocates reveal the one-sidedness of their argument by a too frequent appeal to examples of revolution and internal rebellion, like the French Revolution and the Civil War in the United States, where members of the superior and ruling classes were lopped off, or where enormous masses of enthusiastic volunteers were enlisted from the citizenship. If war had committed such ravages in the human stock as these pacificists maintain, it might be supposed that there would have been a decline in the fighting force of civilized men. But the very opposite is true. Modern men are braver and steadier, make better soldiers, than did the men of antiquity.[7] The reason is that the same moral qualities which have been selected through the elimination of the anti-social, are, in part, the virtues which make the best armies—such virtues as obedience, the habit of discipline, self-control and steadfastness. And, curiously enough, in the breeding out of the opposite qualities, the predatory disposition, irresponsibility and refractoriness, the unbroken existence of the military organization has played its part.

Another prominent factor in socialized selection comes under the head of vice and racial poisons. No argument is required to prove that persons who indulge in sexual excesses, in drunkenness, in drug habits, in debauchery of any kind, are anti-social, lacking the moral stamina which would make them, say, self-supporting individuals contributing their share to the social income. Our point is that vice, in the degree of indulgence, is also eliminative. Sexual excesses, for example, sap energy, weaken resistance to disease, and predispose to early death. The more licentious a man or woman, the greater are his or her chances of contracting a venereal disease. Gonorrhea and syphilis, where they do not kill, tend to sterilize. Consequently those who can not, through lack of self-control or excessive lust, conform to social and ethical standards of purity, cripple themselves in reproductive power. Prostitutes, a big population in every country, every age, bear few, if any, children.

[7] "Physics and Politics," p. 47.

Alcohol and the other narcotics produce much the same results. On the question as to what extent drunkenness is due to flabby moral fiber, there has been dispute. Archdall Reid declares[8] that alcohol taken to excess is an "agent of elimination at once selective and very stringent. It weeds out great numbers of individuals of a particular type—those most susceptible to its charm." This authority thinks moral resistance to alcoholic temptation of small consequence; men, he says, "indulge in it in proportion to their desires." On this point there is naturally much dissent, but there is no need that we enter the controversy. Certain men are swamped by alcohol and other men left. In so far as the moral factor determines the incidence of this selective force, we have elimination of the anti-social.

Finally we may note one more agency which works for the increase of social tractability. The various factors we have mentioned so far have been mainly phases of lethal selection; now we turn for a moment to sexual and reproductive selection. In every generation there are persons who are debarred or abstain from wedlock. Among the men who enter matrimony a certain proportion desert their wives or are divorced. There is, further, a wide-spread practise, rapidly growing in our day, of placing voluntary restraints on child-bearing.

Now persons who do not mate with the opposite sex, or mated, refuse to have children, are sometimes those whose social sympathies are feeble. The domestic virtues are the social virtues par excellence. We could never breed a race of misogamists, nor are we in any danger of populating the earth with a race of women militant against men. Along with many other results we perhaps have here some elimination of the anti-social. But we do not care to stress this point. The motives which lead to voluntary childlessness are numerous and mixed, and the final influence on the racial inheritance seems most disastrous, since it substantially results in a continuous sterilization of the better stocks. All things considered, this is the gravest difficulty that the eugenists have to face.

III

The foregoing hasty summary of the more important factors which have conferred survival value on altruism and tractability has, it is hoped, given some appearance of solidity to the contention that there has been a steady elimination of the anti-social throughout historic times. It is not argued that we have here an explanation of all the moral differences between the civilizations of antiquity and of the present. The increments of knowledge, the growth of cohesive social and political institutions and the betterment of economic conditions, have all played a part in knitting the moral fabric of the world of

8 "The Principles of Heredity," p. 195.

to-day. Nevertheless, the centuries spent in purging the primitive from the race have contributed to the result. Undoubtedly, too, this agency will continue to operate in the future, although with what modifications it is hard to predict.

Patently it is impossible to weigh statistically the effect of the many criss-cross forces which have molded nations, or to reconstruct with accuracy the historical process. Both the men who perished and the men who survived are now gone beyond recall. It might be suggested that we could make a "control test" by analyzing the mental characters of contemporary savages, who are often said to be close replicas of our own barbarian ancestors. We might, provided we had the psychological method at hand, make enough mental tests to define a type-barbarian. In similar wise we might be able to define a civilized type. Then by comparing the two we could determine what were the inherent moral differences between them. But there are unsurmountable difficulties in this procedure. We have not the psychological method as yet to work with, and after the work had been accomplished we could not be sure that the savages whose natures had been charted were in truth identical with the ancients from whom civilized men are sprung. We should, moreover, become entangled in the questions of racial differences—why, for example, some savage peoples, like the Papuans, the Aleuts and the Dyaks, are so amiable, while other savages, such as the North American Indians and the Gonds, are bloodthirsty; or why the ancient Egyptians were apparently less cruel than the ancient Assyrians. In our discussion of selective agencies attention has been directed chiefly to the development of the Aryan peoples.

One test of a logical nature is available. If we grant the validity of socialized selection we find an immediate explanation of the paradox which has puzzled former commentators on the dissimilarities of the classic and modern cultures. We can now understand why it is that there has been an enormous increase of kindliness, of steadiness, of "prescriptive governability," despite the fact that early civilizations were quite as prolific of eminent men of the highest intellectual and moral caliber.

As we said earlier, confusion has been wrought by looking for moral improvement where there has been only moral change. A growth in human meekness may very naturally have been accompanied by a decline in a certain splendid turbulent virility possessed by our ancestors. When this selective instrument made men more sympathetic, it may also have made them less daring. David Starr Jordan remarks:[9]

> If France, through wine, has grown temperate, she has grown tame. ''New Mirabeaus,'' Carlyle tells us, ''one hears not of; the wild kindred has gone out with this, its greatest.''

9 ''The Human Harvest,'' p. 69.

To get altruism we have sacrificed the higher, intenser type of energy; and the cowboy, the soldier and the haughty aristocrat typify the passing virtues of the race. There is a great deal of pregnant meaning in the assertion of William James that the world is evolving into a middle-class paradise.[10]

> An irremediable flatness is coming over the world. Bourgeoisie and mediocrity, church socials and teachers' conventions, are taking the place of the old heights and depths and romantic chiaroscuro. . . . The higher heroisms and the rare old flavors are passing out of life.

Along with this probable decline in energy and intensity, it must be remembered that the elimination of the anti-social has never conferred survival value on originality, on intellectual independence, on path-breaking initiative, or on genius. In fact the very agencies which conserved sociability were the ones which cut down inventive capacity. No force has been at work to increase the racial store of eloquence, poetic imagination, of musical and mathematical ability; so that, while there has been a progressive selection of the fundamental moral qualities, there has perhaps at the same time been a deterioration in the esthetic endowment.

It is plain, then, why individuals of the noblest intellectual and moral qualities appeared as often in early civilizations as among the millions we spawn to-day—why, as James Bryce phrases it,[11] those rare combinations of gifts which produce poetry and philosophy of the first order "are revealed no more frequently in a great European nation now than they were in a Semitic tribe or a tiny Greek city twenty-five or thirty centuries ago." Nothing which the human mind exhibits at present has been added by nature since the dawn of history. The esthetic and intellectual powers were then in as full, if not fuller, bloom, as now, being, as Weismann points out, by-products of the human mind, which had been "so highly developed in all directions." [12] The average man in those times was, we may safely assume, more brutal and flightier than the average man of to-day, but he probably possessed a larger store of native ability, more of sheer mental energy.[13] Selection, through the elimination of the anti-social, has whittled us down, so to speak, to fit our civil environment, cutting away our intellectual strength and our moral weakness with the same strokes.

This is the reason that it is unsafe to argue from the exceptional man to the average man. The exceptional man, in the nature of the case, exhibits a combination of the higher ethical and intellectual traits.

10 "Talks to Students on Some of Life's Ideals."

11 "American Commonwealth," Vol. 11, p. 768.

12 Lecture on "Heredity."

13 This is quite in accord with Galton's calculation that the average ability of the Athenian race was nearly two of the mental grades higher than that of present-day Englishmen. "Hereditary Genius," p. 330.

In him the native harshness of the race is disguised. Alfred Russel Wallace, because of the clarity of his reasoning, betrays the precise manner in which one falls into the mistake of supposing great men to be a racial barometer. He declares:[14]

> Tolstoy can hardly be ranked as higher than Buddha, or Ruskin than Confucius, and as we can not suppose the amount of variation of human faculty about a mean to be very different now from what it was in that remote era, we must conclude that equality in the highest implies equality in the mean, and that human nature on the whole has not advanced during the last three thousand years.

Wallace did not realize that in some particulars the highest may seemingly, at the distance of thirty centuries, belie the mean.

Selection has had an almost infinite variety of human material to work on—all sorts of combinations between intellectual powers and moral excellencies. What selection has apparently done, through those agencies we have denominated the elimination of the anti-social, is to knock apart the two sets of endowments, and to recombine them in ways which give us, speaking broadly, a general average of greater moral stability linked with lesser innate talent. Civilization, in bending human nature to its wheel, has softened it and at the same time crushed out some of its virgin vigor.

[14] Essay on "Evolution and Character."

EPHEMERAL LABOR MOVEMENTS, 1866–1889

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THE history of labor organizations (1866–1889) is a record of ebb and flow, agitation, organization and disintegration. It is, indeed, a strange blend of unionism and politics, of individualism and socialism, of strikes, greenbackism and cooperation, of prosperity, panics and concentration of industry. This quarter of a century is preeminently one of preparation; in it are laid the economic and psychological foundations upon which have been built, in a large measure, the trade-union organizations of to-day. Movements, ephemeral and incohoate, but grand in conception, hasten nervously across the stage. At intervals during the period writers in the numerous labor papers declare that now is a time of transition and that organization at this particular moment will be unusually fruitful of good results. The workers, distrustful and individualistic but harassed by the fear of monopoly, the competition of unskilled labor, the introduction of machinery and lower wages, cohere for a brief period under the pressure of extraordinary conditions or the influence of enthusiastic leaders, only to repel each other as their financial skies appear to clear. But, by the end of the period, the labor organization had become one of the permanent institutions of the nation.

When the civil war ended labor organizations of the trade-union type were multiplying and waxing stronger. The return of the soldiers to peaceful pursuits, the continued influx of immigrants from the old world, and the growing power of industrial combinations, all contributed to arouse the wage earners of the nation to activity. The years 1866 and 1867, probably represent the period of maximum activity during the era immediately following the surrender at Appomattox. In 1864, an unsuccessful attempt had been made to organize a national federation of trade unions. Two years later the National Labor Union was organized at a National Labor Congress held in Baltimore. This was the first successful national federation of trade unions formed since the National Trades' Union disappeared in 1837. In 1865, a state federation of trade unions was organized in New York—The Workingmen's Assembly. This continued until merged in 1897 with the state organization affiliated with the American Federation of Labor. Its chief purpose seems to have been to influence legislation. "The distinctive features of the organization are Protective, Benovelent and Secret."[1] In the early years of the Assembly, nearly all of the affiliated

[1] Proceedings of Fifth Annual Session, January, 1869.

bodies were protective, many benevolent, and at least two were secret—The Supreme Mechanical Order of the Sun and the Knights of St. Crispin. In 1869, the assembly favored the establishment of cooperative enterprises; but little progress was reported for the year 1868. At the close of that year there were at least six cooperative foundries in the state.

The Workingmen's Union of New York City and vicinity, "reorganized in 1864 and incorporated in 1866," was a city central labor union. All representatives sent to this central body were required to be "practical" workingmen actually working at their trade. The objects of the union were to unite the strength of different organizations in the city, to foster a friendly feeling between workingmen, to discuss and modify proposed legislation, to adjust difficulties between labor and capital—accepting the "axiom, That the interests of labor and capital should be identical,"—to discountenance strikes except when "they become absolutely necessary." Evidently class consciousness was not as yet highly developed among the organized workingmen of our largest city.[2] A very interesting preamble to the constitution of The Stair Builders' Mutually Protective and Benevolent Union of New York City offers further evidence. The Stair Builders deplored the concentration of wealth in the hands of the few. They asserted in italics that the "interests of the employee and the employer are identical." But they also declared "the independent and irresponsible action of individual employers ignores the claims and rights of employees, casts upon the field of labor incompetent workmen, lowers the dignity of the mechanic, and degrades labor." Through union action they hoped to advance the interests of labor and to secure their just reward.[3]

In 1868, at least twelve national and international trade unions were in existence: International Union of Bricklayers, Plasterers' International Union, Carpenters' National Union, National Typographical Union, Moulders' International Union, International Union of Machinists and Blacksmiths, Coach Makers' International Union, Ship-carpenters and Caulkers' International Union, Brotherhood of Locomotive Engineers, Glass-Bottle Blowers' Association, Cigar Makers' International Union, Knights of St. Crispin. The Daughters of St. Crispin was organized in 1869; and was the only women's trade union having a national organization. One authority states that more than thirty national trade unions were in existence during the decade, 1863–1873.[4]

The President of the New York State Workingmen's Assembly reported a membership of 280 organizations in January, 1868, and 305

[2] Laws, Rules and Regulations, issued 1867.

[3] Constitution and By-laws, printed in 1869.

[4] Andrews, "Report on the Condition of Woman and Child Wage Earners in the United States," Vol. 10: 89.

one year later. The assembly was said to represent 25,000 working people. Five unions in New York City were reported to contain a membership of at least 1,000 persons each. These unions were: Typographical Union, No. 6, 2,300 members; Longshoremen's Society, No. 2, 2,300 members; Bricklayers' Union, No. 2, 1,600 members; Cigar Makers' Union, No. 90, 1,250 members; United Cabinet Makers' Union (German), 1,000 members.[5] In the year 1867, thirty thousand was "not an extravagant estimate of the actual strength of the labor organizations in New York" City. Brooklyn, Jersey City, Newark and the Westchester towns were estimated to contain 20,000 additional union men.[6] At the annual meeting of the Bricklayers' International Union in 1867, it was reported that the national body contained 24 unions in good working order. One year previous, the number was only ten.

As has been indicated, with the return of the soldiers looking for employment, the rising tide of immigration, the greater use of labor saving devices, and the growing strength of corporate organizations, the need of greater solidarity and unanimity of action among the working people was felt sufficiently to enable a national federation to be formed and continued for a few years. Like the pioneer national federation of trade unions organized in the thirties, the National Labor Union was merely an advisory body; it never attained much strength or prestige. William H. Sylvis, one of America's ablest labor leaders, was an important factor in initiating and building up this organization. Mr. Sylvis was elected president of the National Labor Union in 1868.

From its inception political activity seems to have been an important part of the work of the National Labor Union. In fact the chief aim and purpose of the organization was political rather than purely industrial. The first congress, held in 1866 at Baltimore, recommended that steps be taken to form a national labor party "which shall be put in operation as soon as possible."[7] Again, in 1867, it was resolved that the time had arrived when "the industrial classes should cut themselves aloof from party ties and predilections and organize themselves into a National Labor Party." In the first congress much stress was laid upon the necessity of organizing trade unions; but, in 1868, a resolution was adopted stating that "the very existence of the National Labor Union depends upon the immediate organization of an independent labor party."[8] The greenback issue and the opposition to national banks first received official recognition in 1867. Doubtless those two issues were raised at that time because of the depression which

5 Proceedings of the 5th Annual Session (1869).

6 *New York Tribune*, April 30, 1867; also in "The Labor Question," a collection of articles published in 1867.

7 "Documentary History of American Industrial Society," Vol. 9: 137.

8 *Ibid.*, p. 204.

followed the close of the war and because of the demand that the greenbacks be retired. Contraction of the currency was checked by act of congress in 1868.

An influential element within the National Labor Union favored affiliation with the International Workingmen's Association; but it never united with this socialist organization. In 1870, a resolution was adopted in which the National Labor Union "declares its adhesion to the principles of the International Workingmen's Association, and expects at no distant day to affiliate with it."[9] The National Labor Union as an organization can not, however, be said to have been class conscious.[10] Substantiating this statement is the fact that delegates were admitted to the annual meetings from organizations other than those of workingmen. In 1866 delegates from Eight-hour Leagues, Land and Labor Reform Unions and Anti-Monopoly Associations were admitted. At the annual congress in 1870 a representative from a farmers' club was seated. It is also worthy of mention that at this congress a representative of the National Guard of Industry and one from the Colored Teachers' Association of Cincinnati were given seats. Nevertheless, at the congress of 1869, Miss Susan B. Anthony was rejected as the delegate of the Working-women's Protective Association, on the ground that it "was not a *bona fide* labor organization."[11] The credentials of Mrs. Elizabeth Cady Stanton as a representative of the Woman's Suffrage Association were accepted in 1868—because she came from an organization for the "amelioration of the conditions of those who labor for a living."

After the death of President Sylvis in the summer of 1869, only a few days before the annual meeting, the National Labor Union began to show unmistakable signs of weakness. The editor of its official organ, *The Workingman's Advocate*, of Chicago, pointed[12] to the apathy of the workingmen as an alarming sign of the times. The officials were not receiving that essential of all organizations, financial support. On January 29, 1870, appeared an editorial in regard to the union under the caption, "To Be or Not To Be." In March, the president issued an urgent appeal for funds. Since the preceding summer only $448 had been received by the treasurer of the organization from all sources.

The Congress of 1871 decided to divide the political and industrial activities; and it authorized calls for two conventions for 1872—the National Labor Party and the National Labor Union. It was the convention of the former which nominated David Davis for president in 1872. The last Congress of the National Labor Union was held in

9 "Documentary History of American Industrial Society," Vol. 9: 268.

10 See Hillquit, "History of Socialism in the United States," p. 193.

11 "Documentary History of American Industrial Society," Vol. 9: 231. Miss Anthony was seated in 1868.

12 *Workingman's Advocate*, December 11, 1869.

1872. It was of little importance; but steps were taken leading toward the organization of a "National Industrial Congress." Nevertheless, as late as March 24, 1874, *The Workingman's Advocate* still called itself "the official organ of the National Labor Union."

The first National Industrial Congress was held in Cleveland, July 15, 1873. The only labor organization which opposed the movement was the ever-conservative Brotherhood of Locomotive Engineers. The leaders of the new movement proposed to steer clear of politics. No constitution was adopted in 1873. Robert Schilling, of Ohio, was chosen as its president. Some of the resolutions adopted savored somewhat of political activity; and later some opposition developed because of the adoption of these resolutions. But the call for this congress stated definitely that steps would be taken to prevent it from deteriorating into a political party.[13] Evidently the leaders of the Industrial Congress believed that politics had wrecked the National Labor Union; and that a stronger national federation of trade unions was desirable. The second congress was held at Rochester, April 14, 1874. Many of the delegates were men who had been prominent in the National Labor Union. A constitution was adopted and the name Industrial Brotherhood was assumed. The declaration of principles was almost the same as that later adopted by the Knights of Labor.[14] Many of the demands were political rather than purely industrial. Its platform viewed with alarm the aggression of aggregated wealth, which, it was urged, tends toward the degradation of the masses.

Although Mr. Powderly[15] is of the opinion that a third congress was not held, there is evidence that a National Industrial Congress was held at Indianapolis on April 13, 1875.[16] In its declaration of principles, appeared a clause opposing the use of the military power against striking workingmen. *The Workingman's Advocate* became in due time the "official organ of the National Industrial Congress"; and as late as October 13, 1877, it still used this title. Although the Brotherhood or the National Industrial Congress was organized by trade-union men, it was somewhat like the Knights of Labor in principle. Trade unionists objected to the organization of locals under the auspices of the Industrial Brotherhood; and they also were adverse to associating with unskilled labor in an organization. This attitude on the part of the skilled men and the continued industrial depression following the panic of 1873 destroyed the organization.[17] The early death of the Industrial Congress indicates that the National Labor Union was not

13 *Workingman's Advocate,* May 3, 1873.

14 Report of the Industrial Commission, Vol. 17: 3.

15 "Thirty Years of Labor," p. 126.

16 Files of *The Workingman's Advocate,* 1875.

17 Powderly, "Thirty Years of Labor," p. 126.

destroyed solely because it went into politics, but chiefly because the industrial development of the country was not sufficient to weld the workingmen of the nation into a strong and permanent federation. They could see no excellent reasons for paying dues to such an organization—except during a time of stress. The National Labor Union and its successor, the National Industrial Congress, died of financial weakness and the apathy of their members.

In 1876, another attempt was made to form a national federation. A call was issued by an "executive committee" from Pittsburgh, January 5, 1876, "To all Labor Orders, Unions and Associations of the United States." Delegates were asked to be "prepared to take such steps as will place our now scattered forces under one organized movement, for immediate action, to get and to hold, and use the balance of power. . . . The issue is a labor issue, an issue of the right of men to 1876. The social democrats tried in vain to commit it to the policy of organizing a distinct labor party. A substitute plan was adopted which is quite similar to the more recent plan fathered by President Gompers of the American Federation of Labor.

> *Resolved:* That independent political action is extremely hazardous and detrimental to the labor interests; that the workingmen of the country should organize into trades unions and labor leagues to educate the people first,

and endeavor to elect men in both parties favorable to the interests of the wage earners.

The editor of a labor paper complained in 1877:

> All our national organizations for the unification of labor are dead. Labor is divided in a thousand unions and factions.[19]

He declared that employers and employers' associations were bitterly fighting labor and that the next necessary step in the struggle against combinations of capital was a "National Federation of Trades' Unions." During the last years of the seventies, such national unions as the Amalgamated Association of Iron and Steel Workers of the United States, the International Typographical Union, and the Cigar Makers' International Union were agitating the matter of a national federation. In 1881, the President of the Typographical Union wrote in his annual report:

> The subject is of such importance that we can afford to suffer in patience numerous failures if as an ultimate result the mechanics of the United States and Canada can be brought into a closer and common organization for the common good.

There is much evidence indicating that the far-sighted labor leaders of the seventies saw the need of a permanent national federation of trade unions. On November 15, 1881, at Pittsburgh, was formed the Federation of Organized Trades and Labor Unions of the United States

[19] *National Labor Tribune,* April 7, 1877.

and Canada. This organization in 1886 voted to merge with other trade unions and the name, American Federation of Labor, was adopted.

In addition to the trade unions of the period, such as the International Typographical Union and the Cigar Makers' International Union, and the national federations, such as the National Labor Union and the Industrial Congresses, the Knights of Labor and numerous ephemeral labor organizations appeared whose ideal was that of "one big union." Like the Knights of Labor these organizations practically ignored trade lines. Except in the case of a few controlled by the socialists, they were in reality reform associations composed chiefly of wage earners. These ephemeral organizations are interesting chiefly because they throw some light upon the conditions of the period and upon the ideals and demands of the wage earners. The decade of the seventies was especially prolific of ephemeral labor-reform associations.

The National Guard of Industry was organized in 1869. It admitted "all trustworthy persons who earn their bread by the sweat of their brow" and who are friendly to its purposes. The platform of the order was a peculiar hotch-potch of humanitarianism, trade unionism and political reform; it favored the eight-hour day and cooperation, and opposed granting land to corporations.[20] The "early closing movement" is not of recent origin. As early as 1866 or 1867, in New York City, a "Dry Goods Clerks' Early Closing Association" was in existence. The Supreme Mechanical Order of the Sun was established in the early sixties. It was still in existence in 1869, a secret order having an extensive ritual and several degrees.

In 1872, the Christian Labor Union was formed for the purpose of influencing the Church to aid in the establishment of cooperative associations. The Association of United Workers of America, called by Professor Commons the "nationalized International," came into being in 1874, and was apparently merged into the Workingmen's Party two years later. It was a socialist organization. Each member was expected to support only those political movements which aimed directly at the economic emancipation of the wage earners.[21]

The Junior Sons of '76 "do not attribute all our suffering to any single cause, but to a variety of causes." They appealed to all workers to unite "against the growing power of monopolies" by using the ballot. Laboring men should be elected to office. The Junior Sons was a secret organization supposed to be composed exclusively of workingmen. In the spring of 1875, it was stated that in several counties of Pennsylvania the majority of the voters were members of

[20] Pamphlet in New York Public Library.

[21] General Rules, published in 1876.

the order.[22] The Order of American Mechanics admitted only native-born persons.

One of the most unique and most powerful of the ephemeral organizations was the Sovereigns of Industry, established in 1874. It was a secret order which admitted both men and women. According to the preamble of the organization's constitution, it was "an association of the industrial working classes without regard to race, color, nationality or occupation; not founded for the purpose of waging any war of aggression upon any other class, or fostering any antagonism of labor against capital, nor of arraying the poor against the rich, but for mutual assistance in self-improvement and self-protection." The sovereigns repudiated the subsistence theory of wages, and proposed to increase real wages by reducing expenses through cooperation. The ultimate purpose seemed to be the elimination of the wage system. They proposed to "make war on the middleman as the exclusive remedy for the ills of the workers." The sovereigns did not propose to displace any existing labor organization. In the spring of 1875, it was estimated that over 50,000 Pennsylvanians belonged to the order.[23]

The International Labor Union was organized in 1877 with George E. McNeill as president.

> In this hour of the dark distress of labor, we call upon all laborers of whatever nationality, creed or color, skilled or unskilled, trade unionist and those now out of union, to join hands with us and each other to the end that poverty and all its attendant evils shall be abolished forever.

The chief objects of the union are indicative of the important demands of the labor reformers in 1877: reduction of the hours of labor; higher wages; factory, mine and shop inspection; abolition of the contract convict labor and truck system; employers to be held responsible for accidents to employees on account of the neglect of employers; prohibition of child labor: establishment of labor bureaus. Although branches are reported to have existed in seventeen states, the membership was small. The union attained its greatest strength in 1878.[24]

As early as 1866, organized labor began timidly and intermittently to enter the political field. Editor Cameron of *The Workingman's Advocate*, perhaps the leading labor paper of the period and the official organ of the National Labor Union, was nominated as a candidate for a seat in the lower house of the Illinois legislature, by the workingmen of Chicago. The editor of the *National Workman*, the official organ of the federated trades of New York City, wrote (January 5, 1867):

22 *National Labor Tribune*, April 24, 1875.

24 McNeill, "The Labor Movement," pp. 161–162.

23 *National Labor Tribune*, April 24, July 31, October 23, 1875.

The New Year opens with flattering auspices to the cause of labor reform. Many governors of states and members of state legislatures have been elected upon the workingmen's tickets, as friends of the eight-hour system.

The first Congress of the National Labor Union (1866) declared that only candidates favorable to an eight-hour law should be deemed desirable by the workingmen of the country. In 1867, at least three states, New York, Connecticut and Michigan, held workingmen's conventions; and a National Labor Reform Party seems to have been organized. In a platform adopted August 22, 1867, it opposed national banks. The "money monopoly" was held to be "the parent of all monopolies." The issuance of treasury notes was recommended as a preventive of growing inequality in the distribution of wealth. Land monopoly was feared; and as a remedy for insufficient employment, it was urged that workers proceed to the public lands and become actual settlers. The platform contained a clause favoring cooperation; and strikes were deprecated. A demand was made for improved dwellings and tenements for workers.[25] This party undoubtedly died soon after its birth, because William H. Sylvis, upon being elected president of the National Labor Union in 1868, urged the organization of a workingman's party, and the congress voted to organize a "labor reform party."

The leaders of the labor movement in the late sixties often deplored the rottenness which prevailed in partisan politics.

It is a sad day for the people when such rottenness prevails in the Senate; when knavery rules the House; when pampered debility occupies the presidential chair, and cabinets are composed of corrupt politicians or political ingrates. . . . The laboring man of to-day in America whatever he may be theoretically, is practically a *paria* and a slave, at the mercy of corrupt swindlers, under the guise of respectable capitalists.[26]

An address of the National Labor Union, issued in 1870, declared that the whole country was under "the supreme control of bankers, moneyed men and professional politicians." The editor of *The Workingman's Advocate* urged the formation of a "Great Peoples' Party." At this time "money and monopoly" were repeatedly mentioned as menaces to free government.

In 1870, the National Labor Congress voted to take independent political action throughout the country. It was stated that the two old parties would not join hands with labor and would not accept the platform of the National Labor Union. The workers did not rally to the support of the labor candidates. After the election, the editor of *The Workingman's Advocate* declared with some bitterness that the labor-reform candidates had been overwhelmingly defeated—and by the workers themselves. The candidates, it was stated, "were for the most

[25] *Workingman's Advocate*, September 12, 1868.

[26] Letter written by H. H. Day, member of executive committee of the N. L. U., to Senator Henry Wilson, *Workingman's Advocate*, June 19, 1869.

part representative trade unionists." The Congress of 1870 also authorized the appointment of a committee to issue a call for a national convention. It was issued soon after a meeting of the committee, held January 17, 1871.

This call is worthy of brief notice. It confidently asserted that capital was master in the United States. The instrumentalities which gave capital its favorable and dominating position were enumerated under five heads:

1. Banking and moneyed monopolies.
2. Consolidated railways and other traction monopolies.
3. Manufacturing monopolies which crushed the small operators and determined the wages of the workers.
4. Land monopolies—the result of the absorption of the public domain by a few corporations.
5. Commercial and grain monopolies which indulge in speculation.

The first and fourth points were not new or especially significant. The outcry against banks dates back to the time of Jackson or before that era. During the forties and fifties much opposition was manifested against land monopoly.[27] This call was, however, directed specifically against the policy of giving land to railways. But the remaining three points are of more significance; new foes are now feared by the wage earners of the country. Consolidated railways, manufacturing, commercial and grain monopolies are represented as inimical to the interests of the wage earners; and the call favored the regulation or abolishment of corporate monopolies. The editor of *The Workingman's Advocate*[28] asserted that "centralization and labor" are two antagonistic elements.

A labor-reform party was organized in Massachusetts in 1869; and in that year it elected twenty-one representatives to the State Assembly and one state senator. The state ticket polled 13,000 votes. In the following year, Wendell Phillips was nominated for governor. The party advocated the separation of industrial from political questions. Two new and significant demands are found in the platform: the regulation of railway rates and the abolition of the importation of laborers, particularly from China, under contract. In 1871, the resolutions presented by Phillips and adopted by the labor-reform party were tinged with socialism. It was affirmed that labor is the creator of all wealth; the abolition of special privileges was demanded; and it was asserted that the capitalistic system was making the rich richer and the poor poorer.[29]

An attempt was made, in 1872, to put a national ticket in the field.

[27] See article by the writer in *Quarterly Journal of Economics*, February, 1910.

[28] July 15, 1871.

[29] Carlton, "The History and Problems of Organized Labor," p. 61.

David Davis of Illinois was nominated for president and Joel M. Parker of New Jersey for vice-president. Neither of the gentlemen were workingmen. Both withdrew a few weeks later; and no further nominations were made. Two years later, independent reform candidates were nominated in Illinois and, perhaps, elsewhere. In 1875, the editor of *The Workingman's Advocate* was interested in the Greenback Party.

Undoubtedly many members of the National Labor Union who were committed to political action and opposed to the "money monopoly" became members of the Greenback Party. Others who were more radical turned to the Workingmen's Party of the United States. In other words, the small but aggressive class-conscious element within the National Labor Union joined the latter party; and the element which stood for reform affiliated with the Greenback movement. Those who joined the Greenback Party adopted the philosophy of the small proprietor and the skilled artisan; but those who united with the Workingmen's Party and later the Socialist Labor Party, adopted the economic theories of Karl Marx. The Greenbackers did not propose to do away with private ownership of capital; they only desired to prevent the concentration of capital in the hands of a few large capitalists. The Greenbacker was a reactionist rather than a progressive; he wished to prevent the growth of monopoly and large-scale industry. His viewpoint was that of the pre-Civil-War period; he looked backward instead of forward. Consequently, the Greenback movement is much more closely related to anarchism than to socialism.[30]

The American workingman of the generation immediately following the Civil War was still saturated with the philosophy of the frontier or of Jacksonian democracy; he as yet accepted the oft-repeated, and not-frequently contradicted, dictum that each and every wage earner had an excellent opportunity to become a small proprietor or even a captain of industry. As long as this situation obtained, it was not difficult for "pure and simple" trade unionism generated in a period of stress and of rising prices like the last years of the Civil War, to be gradually transmuted into "labor reformism" and "greenbackism." The greatest labor organization of the period under discussion, the Knights of Labor, was primarily a reform association. The ultimate aim of its leaders during its years of growth was some form of a cooperative commonwealth. Its famous preamble was taken almost verbatim from one drawn in 1874 for another organization, by George E. McNeill, the "Apostle of the Eight-hour Movement." But hard times, unemployment, the disappearance of the famous westward-moving frontier line, the rush of immigrants from Southern Europe, the consolidation of capital, and the failure of sundry reform movements were preparing

30 For a statement of the theory of greenbackism, see ''Documentary History of American Industrial Society,'' Vol. 9: 33–43.

the way for the development of permanent trade unions. During the decade of the eighties were organized over one fourth of the national trade unions considered by the Industrial Commission in 1901; but only about one in every six were organized before 1880. Or, less than one half were in existence prior to 1890.

Likewise the socialists were not strong before 1890. The "German period of socialism in the United States" ended about 1876.[31] The International Workingmen's Association formed its first American section in 1871.

> By 1874, the attempts to internationalize the American movement were abandoned, and in that year a nationalized International, the United Workers of America, was attempted.[32]

and several local socialist parties arose. In 1876, several organizations of socialists, including the United Workers, were united to form the Workingmen's Party of the United States. One year later the name was changed to Socialist Labor Party. At first the Socialist Labor Party advised its members not to take part in political campaigns; and, although interested in several local campaigns, epecially in New York City and Chicago, it did not put a presidential candidate in the field until 1892. In 1886, however, the Socialist Labor Party of New York united with the single taxers and certain labor organizations to support Henry George for mayor on the United Labor ticket.[33] The socialists joined, in 1878, with the labor reformers to form the International Labor Union.

Another International Workingmen's Association was organized, in 1881, composed of American workingmen and farmers. It was strongest in the west; but soon disbanded. Two years later, the International Working Peoples' Association was formed. In this organization the anarchists were in control.[34] The local socialist labor party in Chicago, which polled about 12,000 votes in the city election of 1879, and elected three aldermen,[35] was soon broken into factions. One portion supported General Weaver of the Greenback ticket in 1880. Another faction influenced by the teaching of anarchists, began to doubt the wisdom of political action.[36] In recent years, the direct-actionists of the Chicago branch of the Industrial Workers of the World seem to constitute a type of socialists similar to the American Internationalists of the eighties. In each case, the value of political action is depreciated, revolution and direct action are emphasized, and a tendency toward anarchism may be discerned.

The panic of 1873 and the five years of depression following the

[31] Hughan, "The Present Status of Socialism in the United States," p. 34.

[32] "Documentary History of American Industrial Society," Vol. 9: 46.

[33] Hughan, *ibid.*, p. 38.

[34] Ely, "The Labor Movement in America," Ch. 9.

[35] One was also elected in 1878 and again in 1880.

[36] Schilling in Parson's "Life of Albert R. Parsons."

panic forced many unions to disband. It was a period marked by an extraordinary amount of unemployment, unrest and suffering, by reductions of wages, and by strikes and lockouts.[37] In the later years of the period, many secret organizations of workingmen appeared. In the spring of 1874, a writer in a labor paper asserted, doubtless with some exaggeration, that "to-day there is not a Trade or Labor Union in existence but gives the greatest publicity to its aims and objects."[38] It was intimated that opposition on the part of employers would cause secret unions to spring up. One year later, the *National Labor Tribune* contained an editorial entitled, "The Spread of Secret Orders"—meaning labor organizations.[39] Pinkerton, the detective, writing in 1878, asserted that there were scores of secret labor organizations.[40] Labor difficulties culminated with the railway strikes of 1877. These were precipitated by cuts in wages. The year 1879 ushered in a more prosperous period.

The two quotations following represent fairly well the attitude of the discontented wage earners in 1876, the centennial year.

> Symbolize if you can the American laborer of 1876. Show him as he is, without liberty of thought or action, oppressed, cheated, trodden on, vilified by press and public opinion, condemned by the pulpit and the platform, reduced to serfdom by a combination of capitalists and monopolists; bring such a picture among your grand paintings, produce such an image among your statuary, and look on this picture and then on that, and ask what has the public of America accomplished for the cause of humanity.[41]

The chairman of an "Immense Mass Meeting of Workingmen" held at Cooper Institute, June 17, 1876, under the auspices of the Independent Labor Party, declared:

> The lands, the money, the property of the nation have passed into the hands of the few, and the many are idle, homeless and starving.

The agitation and unrest among the workers led to repressive measures on the part of various city officials.

> On the announcement of public meetings of the unemployed, the conscience-pricked communities took alarm and feared that the bringing together of so many heretofore patient sufferers might imperil their lives and property. From the earliest days of the agitation of the question of the relations of labor and capital, free speech had often been restrained and sometimes forbidden. This had been especially true in those smaller towns and manufacturing centers.[42]

In New York City, the city officials revoked a permit to hold a meeting of laboring people in Tompkins Square, and drove out the people who came to attend the meeting. This was frequently referred to as "The Tompkins Square Outrage."

37 Rhodes, "History of the United States," Vol. 7: 52–53.
38 *Iron Moulders' International Journal,* quoted in *The Toiler,* June 27, 1874.
39 April 24, 1875.
40 Pinkerton, "Strikes, Communists, Tramps and Detectives," p. 89.
41 *National Labor Tribune,* April 24, 1875.
42 McNeill, "The Labor Movement," p. 147.

In the soft coal fields, after a strike in 1875 caused by a reduction in wages, two of the strike leaders, John Siney, president of the Miners' Union, and Zingo Parks were arrested for conspiracy. Siney was acquitted; but Parks was sent to the penitentiary.[43] The famous "coal and iron police" was organized at this time. The union among the miners was practically destroyed, and soon the "Molly Maguires" appeared as the natural product of a policy of repression.

The pressure of hard times caused the membership of the International Typographical Union to decrease from 9,797 in 1873 to 4,260 in 1878; and the number of unions in the organization declined from 105 to 60. In 1877, unionism among cigarmakers "was almost extinct." Only 17 unions remained in good standing in the International Union. Outside of New York City, Chicago and Detroit there were only 217 union cigarmakers in the United States and Canada. The strikes of 1877 are said to have acted as an "alarm bell." There were over six times as many unions in 1881 as in 1877; and they were better organized "than in the most flourishing days of the past."[44] Organization among the coal miners was practically destroyed by the period of hard times.

> John Siney died of grief and hunger in 1876, and with him all organization among the men.[45]

The Knights of St. Crispin and the Daughters of St. Crispin also practically disappeared with the panic.

Up to 1875 as a rule, labor leaders opposed the use of the strike except as a last resort. President Siney of the National Miners' Association stated that one of the objects of the association was "to remove as far as possible the cause of all strikes." In 1877, the first great railway strike occurred, and many bitter contests took place in the cigarmaking industry. And after 1877, "strikes multiplied enormously."[46]

The middle years of the decade of the eighties were years of discontent and struggle. The competitive battle was extremely fierce. Many independent industries and proprietors were being ruthlessly crushed in order that industrial "American Beauty roses" might flourish; and in the process the employee inevitably suffered. The employer no longer came in personal touch with his employees; and the old personal relations no longer existed to soften and humanize the treatment of his employees. On the other hand, where the unions were in control, "the methods employed were not always diplomatic, and sometimes they were a bit coarse."[47] This big-stick policy reached its climax in some of the western mining towns the government of which was con-

[43] Simonds, "The Story of Manual Labor in all Ages," p. 661.

[44] *Cigarmakers' Official Journal*, March 10, 1881.

[45] Simonds, "The Story of Manual Labor in all Ages," p. 661.

[46] Swinton, "Striking for Life or Labor's Side of the Labor Question."

[47] Buchanan, "The Story of a Labor Agitator."

trolled by the unions.[48] The dark pictures painted by the labor leaders of the decade should be studied.

Absorbed in the task of getting large dividends, the employer seldom inquired of his superintendent how he managed the business intrusted to his keeping, or how he treated the employees. In thousands of places throughout the United States, as many superintendents, foremen or petty bosses are interested in stores, corner groceries or saloons. In many places the employee is told plainly that he must deal at the store, or get his liquor from the saloon in which his boss has an interest; in others he is given to understand that he must deal in these stores or saloons, or forfeit his situation.[49]

Worse conditions never existed in any industry in this country than those of the Hocking Valley region of Ohio in 1884. Slavery was heaven compared with what the miners of the Hocking Valley had to endure.[50]

A new era was in the making; and the wage earners were being prepared for more definite and firm organization. But it was also a period in which capitalism was becoming strong and immigration was multiplying. The old individualistic ideals were still generally accepted; and were not displaced without much social friction. Strikes were of frequent occurrence and the boycott a popular weapon.

The fall and winter of 1884 will long be remembered by men active in the labor movement at that time as a period of great stress. Strikes and lockouts were prevalent as never before in this country, and labor was often a heavy loser. Capitalism was beginning to look upon the militia as its natural ally, and labor was not sufficiently well organized to make politicians who had charge of the state machinery respect or fear its power.[51]

What is the spectacle presented to our view? Crime reaching a magnitude it never did before; poverty increasing with frightful rapidity; intense and steadily increasing competition with labor in nearly every vocation of industry; an army of idlers crowding upon the workers everywhere; the man who is driven by necessity or want to work or die of starvation is compelled to fight his own fellows or be guarded by the police in the discharge of his duties. A decrepit, homeless humanity, swelling in numbers every day, audible groans of want, woe and misery coming up from every mining, manufacturing and commercial district, and from many agricultural districts throughout the civilized world. Strikes on every hand and general discontent prevailing.[52]

Finally, what would to-day be called "direct action" was advocated, and the Haymarket Square episode followed. The decade of the eighties was an era of capitalistic combination in the form of "pools"; but the spirit of solidarity among the wage earners was still very weak. The "separating influences of shops in one town, theories about general principles, language, nationality, or the division of labor, split the workers on one and the same product into bickering factions."[53]

48 Cherouny, "The Historical Development of the Labor Question," pp. 240–244.

49 Powderly in "Labor: Its Rights and Wrongs" (1886). Also, in *North American Review*, May, 1886.

50 Buchanan, "The Story of a Labor Agitator."

51 *Ibid.*, p. 128.

52 Morgan, "History of the Wheel and Alliance," p. 662 (1889).

53 Cherouny, "The Historical Development of the Labor Question."

The variety of political reform movements, their weakness and lack of harmony are indicative of the bankruptcy of the reform movements of the type then prevailing. *Truth*, "A Journal for the Poor," and a radical paper, declared:

> This journal is not the paid mouthpiece of either Trades' Unions, Knights of Labor, Anti-Monopoly Party, Greenback Party, Socialistic Labor Party, Liberal League, Patrons of Husbandry (Grangers), Farmers' Alliance, Irish Revolutionary Organizations, or any other Nihilistic, Communal or Socialistic organization. But it is the friend of every one of them.[54]

Buchanan speaks of the lack of harmony in the ranks of the labor and reform forces of this period. In 1888, as editor of the *Chicago Enquirer*, he pled for a union among the following movements: "The Union Labor Party, United Labor Party, Progressive Labor Party, American Reform Party, the Grange, the Farmer's Alliance, the Tax Reformers, Anti-Monopolists, Homesteaders, and all other political and politico-economic organizations of bread-winners." [55]

Nevertheless, labor organizations were gaining in strength. The Knights of Labor reached its high water mark in 1886; and the American Federation of Labor increased from less than 50,000 in 1881 to over 200,000 in 1889. In an address sent by the heads of several trade unions to the convention of the Knights of Labor in 1886, it was confidently asserted that "within the past year the national and international trades unions have grown with giant strides." The following statistics of growth during the preceding year were offered:[56]

	Members
International Typographical Union has gained	9,642
Cigarmakers' International Union has gained	7,101
Brotherhood of Carpenters and Joiners has gained	13,464
International Union of Bricklayers and Masons has gained.	9,578
National Bakers' Union has gained	7,564
Furniture Workers' Union has gained	6,633
Amalgamated Iron and Steel Workers has gained	8,230
Iron Molders' Union has gained	12,400
Granite Cutters' Union has gained	3,622
Custom Tailors have gained	2,541
Coal Miners have gained	36,000

Labor was sloughing off its reformism and returning to the "pure and simple" type of trade unionism. Its was evidently becoming more difficult to lead the wage earners into the camp of the reformers.

During the period under consideration, employers' associations hostile to organized labor were by no means unknown. In July, 1872, "The Employers' Central Executive Committee" of New York City sent out a *questionnaire* containing eleven questions. The committee desired "to avail itself of the wisdom and experience of Thinkers and Em-

[54] September 15, 1883, Vol. 7.

[55] "Story of a Labor Agitator," p. 429.

[56] "Labor: Its Rights and Wrongs" (1886).

ployers," and hoped to be able to solve the difficulties arising because of combinations of workingmen. The prevention of strikes seemed to be one important problem. The seventh question asked whether unionists had given trouble and whether it would be easy to displace them. The eight read: "What Restrictions are imposed upon you as an Employer by Combinations of workmen assuming to regulate the pay or other conditions of Labor?" Another circular letter emanating from the same source requested employers to meet personally with the executive committee. This committee "are in session every day from 10 o'clock A.M. to 10 o'clock P.M."[57] There is reason to believe that this employers' association was not a weak organization. In a speech given at a mass meeting held in New York City in June, 1876, a member of the "executive committee of the Independent Labor Party" said:

> Less than five years ago we had over 79,000 organized men in the city; but 200 or 300 men gathered together in a hotel on Fifth Ave., combined against you by using the government, by going to Albany, to Washington, and to the Board of Aldermen. They have destroyed the Trade Union system, and reduced the workmen of the city to a condition of beggary and starvation.

The employers' associations of the seventies and eighties used many of the weapons which similar bodies of a more recent date have frequently used—blacklist, detectives, coal and iron police, the labor spy, promotion of labor leaders in order to weaken the union, discharge of union men, and the like.[58]

In conclusion, the chief peculiarities of the labor movements of the quarter of a century, 1866–1889, may be briefly summarized:

1. Unstable—ebbed and flowed with industrial changes and disputes.

2. Undisciplined—demanded of leaders immediate and strenuous action. Many strikes, usually of short duration.

3. No very definite class consciousness, except in the eighties. The chief demands were of the purely trade-union type—higher wages, shorter hours, better working and living conditions, etc.—for political reform—elimination of money or land monopoly, labor bureaus, etc.—or for cooperation.

4. Time after time leaders asserted that a transition period was just ahead and that especial efforts were needed at that particular time and place.

5. Repeatedly the attention is directed to the concentration of wealth and the growing menace of monopoly power.

6. The labor leaders of the period were muckrakers; they attacked the political rottenness of the time.

7. Immigration of Chinese laborers (coolies) was feared—not only in the west but also in the east.

8. Many persistent, but futile, attempts were made to weld labor into a strong political party.

[57] Circulars in New York Public Library.

[58] McNeill, "The Labor Movement," p. 266.

THE SCIENCE OF EDUCATION[1]

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I WANT you to understand that we have established some fundamental principles in our science: (1) A subject must interest a pupil. (2) A man who trains dogs or seals or bears or other animals makes a close study of their minds. In the same way we must recognize that one boy differs from another, and study the mind of each boy. (3) If a boy is not very receptive of an important subject we must do our best with him and try to settle what is the minimum with which we ought to be satisfied. Only a few subjects ought to be compulsory on all boys. (4) There are two classes of boys unequal as to numbers, (*a*) those fond of, and (*b*) those not capable of abstract reasoning. (5) Another two classes are (*a*) those fond of, and (*b*) those not fond of language study. (6) Every boy may be made to write and read in his own language and he may be made fond of reading. (7) The average boy's reasoning faculties are most surely developed by letting him do things. That is, for example, through his sports, or through wood or metal working, or gardening, or experiments involving weighing and measuring. Through the last of these he learns to compute. A boy of eight learns decimals in an hour if he weighs and measures, whereas by the usual method of teaching he is ignorant of decimals at the age of fourteen. A boy learns whist very quickly if you seat him with three other people at a table with a pack of cards; he would not learn in a month if he had no cards. Would you teach a boy to swim by mere talk? (8) Every boy must get a good deal of personal attention. (9) However good a system may be there can be no good results if the teachers are cheap; cheap teachers are usually stupid and over-worked. Men in charge of schools and colleges never seem to learn this. The market price must be paid for a capable man. (10) Fairly good results may be expected from a good teacher, even when he is compelled to work on a bad system, but really good results can be obtainable only from a good teacher with a good system.

I need not go into details about all these principles, but I should like to dwell presently upon a few of them. At the beginning of this address I spoke of the obstruction to great necessary reform—too much antiquated machinery to "scrap." Most schoolmasters will admit the necessity for reform in the case of the average boy, but they say that parents

[1] From the address of the president of the Educational Science Section of the British Association for the Advancement of Science, Australia, 1914.

are opposed to the reform. Unbelief in education for the average man is so general among the higher classes that I am afraid we shall have no reform unless some great national disaster causes conversion. There is a lesson for England, and, indeed, for all European races, in the recent history of Japan. The old structure of Japan was in many ways beautiful, but it proved to be without physical strength. Its extreme weakness proved its salvation. Even the teachers of ancient classics saw that for strength it was necessary to let scientific method permeate the thought of the whole population. And now, at the end of the first chapter of Japan's modern history, we find a nation which can not only defend itself, but which retains all of its spiritual life which was beautiful. Every unit of the population can not only read and write, but it is fond of reading, and its education did not cease when it left school. It is getting an increased love for natural science, so that it can reason clearly; it is not carried away by charlatans; it retains its individuality. One result of this is that in time of war Japan has scientific armies. Not only are its admirals and generals scientific, but also every officer, every private is scientific. Everything in the whole country is being developed scientifically, and we Europeans, hag-ridden by pedantry in our schools and universities, refuse to learn an easy lesson. At present we do not even ask what is meant by education or what education is necessary if a particular boy is to be fitted for his life's work. In 1902, when I was President of Section G, and in opening a discussion on the teaching of mechanics at Johannesburg in 1905, I gave my views as to the teaching of a young engineer, but they apply also to the teaching of nearly all boys. These views have been commended by experienced engineers and teachers. To understand me it is first necessary to try to cast away prejudices, and this is especially difficult if one has a pecuniary interest in education. The student of almost any other science than education cares for nothing but the truth; even when he has committed himself to a theory and his good name or credit is at stake the rule of the game is perfectly well known and must be adhered to. The student must not neglect fact or pervert fact; he must be quite fair. The student of physical science sees at once whether or not he is playing the game, because the coordinates are few; there are no complexities, such as we find in our own life problems. This also is why the study of physical science is so good in causing boys to reason, for reasoning can only be taught by constant practise on simple matters which one thoroughly comprehends. Consider a boy's views about ordinary affairs. He is downright. A complex thing must be greatly simplified to him. His painting is in black-and-white; there is no delicate shading in his picture. He never sits on the fence; he is never a trimmer. An historical character is awfully good or awfully bad, very clever or very stupid. A boy is, in fact, cocksure about everything. He is incapable of reasoning about complex things. And when we try to teach him to reason about simple things we must be quite sure that they really are simple to him, that he understands them. For example, many educationists say that the study of geometry is just right for a boy. Well, yes, for five per cent. of all boys, boys who can take in abstract ideas. They take to Euclid as a duck takes to water. But for the other ninety-five per cent. geometry is very hurtful, because unless they continually experiment with rulers and compasses they do not understand what the reasoning is about. In ancient times only very old and exceptionally clever men were allowed to study geometry. We now assume that it ought to be an easy study for the average English boy. Generation after generation we stupefy the average English boy with demonstrative geometry, and we call him a duffer so often that he thinks himself a duffer, and even his mother thinks him a duffer, and, indeed, we have done our best with geometry and Latin to make him a duffer. Only for his football and cricket, which teach him to reason a little, he would become a duffer. And yet in my opinion if this average boy were properly taught in school he would prove to be very superior to the boy who is usually called clever. The schoolmaster calls a boy clever because he is exactly like what the schoolmaster himself was when a boy; but I am afraid that I place little value on the schoolmaster's cleverness, whether as a boy or a man. Reasoning can be taught through almost anything that a boy does, but more than all things through his experiments in natural science. Formal lessons on reasoning, on logic, are utterly useless, and I may say that set lessons on almost any subject are utterly useless for the average boy.

Milton's poems are greatly praised. Well, I am not going to say a word against the people who talk in public about the most wonderful epic in our language and who never read it; but how many people have read Milton's magnificent prose works? Milton first taught me the true notion of education, that the greatest mistake is in teaching subjects in watertight compartments. It is the idea underlying one of the most instructive books ever written, "Sandford and Merton." When teaching a subject, teach all sorts of other subjects as well. If Mr. Barlow's boys were interested in astronomy he showed them stars and planets through a telescope for a night or two, but he gave them no stupefying course on astronomy. He gave them stars and the solar system just as long as they were interested. He used a globe as well as mere maps in teaching them geography and history, but the soul-destroying idea of a course of study on "the use of the globes" did not commend itself to him. They walked over the fields and took an interest in trees and flowers, but he gave them no stupefying course on botany. When he gave them a lesson on English grammar or literature he taught them at the same time the geography and history and the fairy stories of their country. How can a man give a course on grammar or geography or history or anything else without diverting his talk in an interesting way to other subjects? What is so tremendously important about natural science laboratory work is that a student must be thinking all the time about the same matters, not from one but from ten interesting points of view. He is not merely observing, he is measuring, he is computing, he is reasoning; he has to write out descriptions of what he sees and does, and he thinks then of his spelling and grammar; he has to sketch; he has to read books about what other people have done before him on the same subject, and also for statistics. He learns the value of a bit of work done in a clean honest way, and when he gets some more experience he glows with the feeling that he has really added to the knowledge of the world. He is a discoverer, and he feels the emotion of Cortez! It is marvelous the alteration which has occurred in the mental attitude of the common average boy. Instead of feeling that he is a degraded slave he feels the emotion of his childhood returning to him. He once made the great discovery at the age of six that the back garden was inhabited by fairies and lions and Indians and pirates. He was the Caliph Haroun Alraschid for a while. And now, after a wretched life at Latin and Euclid, a new revelation is vouchsafed to him, and as he gathers years he finds that nature is placidly willing to let him steal her secrets little by little, one by one, secrets that are gradually changing men from the bewilderment and spirit possession of the Middle Ages; so that at length he enters into complete communion with nature and rollicks with her, and quarrels with her, and loves her more and more until he dies. And his reasoning power has been growing all the time, so that more and more he understands complex things, for, after an experimental study of story-books, he probably entered the kingdom of Shakespeare at the age of fourteen. Things requiring memory can be learned only in early life—weights and measures, the multiplication table, languages. He knows games involving spelling. But, over and above all these, he has from infancy repeated all sorts of poetry long before he could enjoy much more of it than the jingle of its rhyme.

Education consists in the development of a man from his earliest day, and does not cease till he dies. Any thoughtful man must see that there is no science so important as that of education, the preparation of children of this generation to be the citizens, the rulers of the country, in the next generation. The whole future of our Empire depends upon the education of the children. By the study of this science we hope to improve teaching so as to make future citizens not only to have more knowledge and more skill, but to make them wiser than the people of the present or the past.

Early training determines what later training ought to be. Let us consider what the early training of a boy ought to be. In his very early days nature has provided that his education shall proceed very rapidly by observation and experiment, and the only teaching needed is through careful nursing and affection. He teaches himself, and he loves to learn. He ought to get toys not too realistic, for he loves to weave romance around his toys, but still things to observe and experiment with. He has most complex problems in physical science when he is only a few weeks old, the solution of which involves much labor, but it is pleasant labor and he is happy. And he will remain sweet-tempered and happy and unspoilt if there is real affection from his teachers. If, however, somebody teases him by playing practical jokes, or if a selfish mother who was unreasonably kind to him yesterday is unreasonably unkind to him to-day, he gets, because of his reasoning power, a sense of injustice. Man, woman, or child with a sense of injustice may be said to be possessed of a devil. During the first six years of a child's life the creation of its power to reason is more wonderful than anything else, and this reasoning power comes altogether by observation and experiment. An affectionate parent easily finds methods of helping nature in this process. The unspoilt boy of six years seems to forget nothing that he hears; he has gathered a most wonderful vocabulary; he knows endless nursery rhymes and simple poetry; he is as active and adventurous as a kitten, and everything he does is cultivating his senses. This is the time when he fills the smallest playground (which to grown-ups seems bare and desolate) with giants and fairies and Indians and pirates, with forests and mountains and rivers and oceans. His imagination is so extraordinary that the most uncouth creation of his own gives him exquisite pleasure. Why do I dwell upon this stage of a boy's development? Because it has been so perfect! Nature has learned to do this to children during perhaps hundreds of thousands of years, and it has been the most important time of a boy's life, the time when, if parents will only give the boy their love and greatly let him alone otherwise, he develops mentally more than during all the rest of his life. Speaking broadly, he has done nothing in all this time except what nature and affection made pleasant to him. I have studied the science of education and practised the art of teaching all my life, and I say that all our failures are due to our neglect of nature's methods, and our schools destroy the good effects which nature has produced.

As a rule I do not like to be told that certain subjects must be compulsory, but surely every child of eleven must have some such qualifications as these: (1) The power to speak and read and write in his own language. (2) To be able to do easy computation. (3) To have an exact knowledge of the simplest principles of natural science from his own observation and experiment. I think that every observer must acknowledge that these powers are possible for almost every boy of eleven. Some of us have for many years been endeavoring to show how the child of six may acquire these powers by the age of eleven if nature's methods—that is, kindergarten methods—are followed. For example, he plays at keeping shop, selling or buying things by weight and measure, and paying or receiving actual money and giving change. He weighs and measures with greater and greater accuracy as he makes experiments in mechanics and heat and chemistry. Every boy is fond of stories, and if treated reasonably is easily induced to learn to read. Reading aloud is easily made a pleasure and a habit, and so the boy learns to speak properly. Any boy whatever will become fond of reading if the people about him are fond of reading: I state this as a fact which I have investigated. A boy who is fond of reading gets later on to know the value of books and the use of books, and he will go on educating himself till he dies. Any attempt at coercion, unless it is the very gentle coercion of a person whom he loves, is fatal; even coaxing is not always good. He assimilates knowledge from everything which he does, and therefore he ought to be induced to do things which not only keep him healthy, but which give him knowledge and teach him to reason. Do you remember how angry Lanfranc of Bec was at the idea that any pupil could be *forced* to learn; he said "it turned men into beasts." I speak to you who love children, who love young people, who know that there is hardly one child in a hundred, even among rather spoilt children, who does not love to do his duty.

Under the best and most loving of teachers a lonely child has enormous disadvantages, but these can generally be remedied. The usual mistake is to send it to a large school. If it is merely a day school there is no great harm. But no child under thirteen ought to be sent to a boarding school unless it is a small school and the master and his wife have a love and sympathy for other people's children. There are such people in the world, God bless them! but they are not numerous. They are so few that we must return to nature as the best of teachers. The time is coming when a child's own father and mother will have much more knowledge and wisdom than they have now, and they will refuse to give up to others the doing of their highest duties. It is at present not sufficiently recognized that the most important duty of the parents is the education of their children. At present, men who are building up fortunes are too busy to think of their children, and so we find that the sons of Lord Chancellors and other successful men have been marrying chorus girls and squandering those very fortunes to which their education was sacrificed. Of course, if parents are uneducated, and therefore selfish or otherwise foolish, any kind of school may be better than home for their doomed children. It is one of the great advantages of poverty that the children go to day schools and they keep in touch with home life. If the day school is really a boarding school as well, it will be found that there is always a differentiation in favor of the boarder, which has a very bad caste effect, just as the "modern-side" boy of any public school suffers in character because he is of a lower caste than the classical-side boy. It is usual to remove a stupid classical-side boy to the modern side, and every boy on the modern side has a sense of injustice. The work of the modern side ought to be much the higher, but it is always badly done because the atmosphere is altogether bad.

It may be said that I am only destructive in my criticism of public schools. I think it will be found that I am also constructive, although I acknowledge that my sketch needs much filling in. Well, can much more be done in an address lasting one hour? I will now try my hand at a little filling in. I have no objection to the existence of classical schools something like the present for boys who are fond of classics. The average boy will not be asked to attend such a school. I feel sure that much greater attention ought to be paid to the teaching of English composition, to English poetry and prose, and to English subjects generally. I also feel sure that much attention ought to be paid to natural science. And surely it can do no good for the classical masters to go on sneering at natural science subjects and calling them "stinks" as they do now.

I want, however, to speak more particularly of a much higher kind of school, which will educate the boy usually called clever and also the boy usually called stupid. As I have already remarked, I think that these names may sometimes be redistributed.

The school is one for boys from eleven to sixteen years of age. It ought in no way to be connected with any classical school. English subjects will predominate, but teaching in Latin and Greek and modern languages and other alternative subjects will be provided, although they will not be forced upon any boy. The masters who teach English ought to know enough Latin and Greek and Celtic and Old English and modern languages to be able to illustrate the derivation of English words through their roots. And they must be well read in English subjects and fond of English literature. They will make the boys fond of reading English, and encourage them to find out what they like best. Some boys will take to history and philosophy, some to poetry and imaginative literature. Every boy ought to get the best chance of developing his faculties. It may be asked—if we can not make the average boy spend or waste twelve hours a week on Latin, what are we to do with him? At all events, now, we keep him doing something, even if it is only marking time. My answer is, you think only of his putting in time; well, then, let him put in his time at work that interests him; any work of that kind must be educative under an intelligent master who can help him in his studies if it induces him to look up information for himself. Thus, when reading travels or history, he will use the globe and raised maps and read geography, and hunt up plans of battlefields. Think of the things that a boy used to be punished for doing, and let him do those things under wise direction. I used to be punished for reading Scott and Cooper. Nowadays prizes are given to boys for their knowledge of Ivanhoe or Quentin Durward. Expand this into a system. A boy who loves to browse over Chambers' English literature ought to be guided in his browsing, and induced to take up something more than selections, and he may easily be induced to get off selections by heart if his teacher does not show his contempt by speaking of such exercises as *Rep.* [repetition].

Let the teacher take a leaf out of our methods of teaching chemistry and physics. It has been shown that twenty-five boys doing work in the laboratory during a lesson of an hour and a half or two hours can be managed by one teacher. Experimental lectures in a lecture room have now been greatly discarded; such lessons as I speak of take place in the laboratory, but reliance is placed particularly upon the personal attention of the teacher being given to each group of students in charge of an investigation, the group not being usually greater than four in number, and often being less than two. These students are sometimes merely verifying or testing a statement made by the teacher or found in a book, but they are often finding out things for themselves. One idea underlying the work is that there ought to be more and more illustrations of simple fundamental principles. It is long before these simple things really become part of a boy's mental machinery; things like the mere definition of *force,* for example. It is, of course, quite different work for the teacher from anything that he used to have to do; for one thing, being much more exhausting. He can not shirk his duties and sit down waiting for students to come to him. When teaching degenerates into mere maintenance of discipline, everything being regarded as right if the pupils are quiet and seem to be diligent, it is necessary to make a radical change, usually a dismissal of the teacher. It used to be that a science master gave an experimental lecture, and afterwards he had a very easy time, letting the students follow a set routine in the laboratory, but this will no longer do; such attendance at lectures and laboratory work means poor mental training.

Now, I would work out a system for English, English composition, English poetry and prose, geography, history and other English subjects, on the lines that we have found so successful in natural science. An enormous change has been effected during the last fifteen years in the teaching of mathematics. The older methods always failed with the average boy or man. The new system, which is sometimes called *practical* mathematics, is based on the idea that students shall work experimentally, just as they do in their natural science. It is found that their eyes and faces are bright, they work hard, and they evidently enjoy their work. We have merely introduced common sense into the teaching; we have approached the student's mind from other points of view than the old academic one, from the only side on which he has ever been taught anything—the side of observation and trial. He weighs and measures. He does experimental geometry and mensuration, and is assisted by abstract reasoning just to the extent which interests him; he makes plans of the school buildings and maps of the district; algebra becomes interesting when in coordination with experiments in mechanics and physics; trigonometry becomes interesting in the actual measurements of heights and distances. The infinitesimal calculus is bound to be a weapon which any boy of fifteen easily gets to understand by actual use when he is dealing with dynamic experiments. In fact, the physical and mathematical laboratories are in one, and the same teacher takes charge of both subjects and teaches them as much as possible together.

Furthermore, in the preparation of an account of an investigation there are practical lessons in English composition; there is sketching, and also more careful drawing with instruments, and the finding of empirical laws, using squared paper. In such a school every subject is being taught through all the other subjects; every boy is doing the work in which he is greatly interested, and no boy is attending merely and putting in time. Furthermore, out of school-time there might be the usual restrictions as to "bounds," but otherwise I would let a boy do pretty much as he pleased. "Prep." at boarding schools and home lessons for boys at day schools are to be quite discredited. I would—it may cost a little more money—allow a boy to work in the workshops or laboratories or library or in his own room or common rooms at anything he pleases in this off-time, and I would give him advice only if he asks for it. If I saw a boy reading a penny dreadful I would not stop him; nor if he were reading Paine's "Age of Reason," or any wretched treatise on psychology or logic. I would in no way discourage a boy from acquiring a greater and greater fondness for reading, knowing that this is the foundation of future happiness and education, and that no harm which he can get from his reading is of the slightest importance in comparison with the importance of our main object. As he grows up he will become less and less fond of the sixpenny magazine. The school can at its best be merely a preparation for the lifelong education of the man. I would not keep the boy at school after sixteen. Let him then go into business, or to a science or technical school, or to the university.

Unfortunately for the present no university will take men without an entrance examination involving other languages than English. This is a great evil, but it is not going to last much longer. In the meantime a competent coach will prepare any student to pass the necessary examinations (say, in Latin and Greek) in three months, even if there is much other work to do. This is not a matter of learning any classics; it is rather the manufacture of some contempt for the classics, a necessary evil for the present. Indeed, for the present, but let us hope not for long, there are many other necessary evils. We have to find competent enthusiastic teachers, we have to persuade governing bodies to pay salaries two or more times as great as at present, we have to make parents see that some mental training and fondness for reading and writing are really of value, and that Tom Sawyerism is only childish.

The importance of primary education is now well recognized. Rich and aristocratic folk know that they are now in the hands of the common people in a democratic country, and it is important to see that the common people shall be made fit to rule and shall have a real sense of fairness and reasonableness. Above all, if they are to be good citizens we must cultivate their common sense. I think that in the schemes and the administration of primary education by the Boards of England and Scotland it is in a good way; but there is one great curse upon it, and the enormous sums of money spent upon it are greatly wasted. The local authorities give to every teacher far too much to do, and they give him only half his proper wages. In a few years the government of our democratic country will be in the hands of the boys now at school. That they should be good citizens full of common sense is more important than any other thing. If they are without fondness for books, and if they can not reason, their votes will be at the command of fraudulent or foolish, or perhaps only selfish or self-deceiving speakers. Our empire was ruled by George the Third, and by God's grace we only lost America and piled up the national debt: but think of an empire ruled by millions of Georges! Teaching the young requires great wisdom and sympathy, and we trust it to people paid half wages, the "otherwise unemployed." In the secondary schools also we find this penny wise pound foolish policy, and it is particularly evil in the great technical schools. A city is proud of its magnificent college of science, first because of its architecture; secondly, because of its equipment in apparatus, perhaps in steam and gas engines and other expensive machinery. And the man in charge of the most important department of that college receives perhaps £250 a year. He ought to get at least £600. That is the market price of a fit man, and without a fit man the whole money and the time of students are being wasted; the thing is really a fraud, a whited sepulcher, and of course the principal is always a classical non-scientific man. Photographs of the building and its laboratories are very fine to look at in guide-books of the city, and the managers of the college get public thanks for their services. I know nearly all the technical and science colleges of Great Britain, and I hardly ever see any of their complacent managers, members of their governing bodies, without wishing that I had some of the powers of the familiars of the old Spanish Inquisition. What right have they to undertake duties which require a knowledge of natural science?

The latest proposal of our callous copiers of the Germans is to make attendance at evening classes compulsory up to the age of seventeen. At present working boys attend evening classes voluntarily, although in many cases they are too tired to learn much. Yet many of them do learn. These boys are almost martyrs. They sacrifice so many of their poor pleasures, and indeed duties, that they certainly deserve success in life. But it is not fair to impose these sacrifices upon boys who are, as apprentices, learning the principles underlying their trade, and who are paid only small wages on the understanding that their masters teach these principles. In 1889 I introduced a bill into the Kensington Parliament compelling employers to provide such instruction during the working hours. Reforms of all kinds proceed with exasperating slowness, but already many employers are carrying out this idea.

In some things we reformers have made way. It is now recognized almost everywhere that examinations ought to be conducted mainly by the teachers of a student. I have often put the matter in this way: Huxley used to teach about forty students in biology; we can not imagine better teaching. But if those students had only wanted to pass the examination of London University it is quite certain that they would have done very much better by attending the class of a cheap crammer. A university consisting of two, three, or more federated colleges is very little better than a mere outside examining body, and this is what London University has always been. I am glad that a change towards something better is now about to take place. A number of separate universities would be better, but in two years or less, probably, the colleges of London will conduct their own intermediate and degree examinations. One result will be that when a man gets his degree he will not shut up his books forever.

I would, however, point out that Old London University, which was a mere examining body, served an exceedingly important purpose. This statement may seem curious coming from a person who has always railed at London University as a mere examining board. I still say that it was never a university at all in the past. But a man reading hard by himself, perhaps far away from a college, could have a severe test applied to his acquirements which encouraged him in his studies when he had no other encouragement, and the test was very rightly a severe test. To do away with its outside examinations altogether, as I believe is the intention of the authorities, will be exceedingly harmful. It would be impertinent in me to make a suggestion as to the distinction which might be made between a degree conferred by his own professors upon a man who has attended regularly a college of repute, and a degree conferred by a mere examining body upon an outside student. For the first, the examination test may be easy. The Oxford and Cambridge pass degree examinations are quite easy, and rightly so, for the real qualification is that an undergraduate shall have lived for three years in the intellectual and cultured life of an Oxford or Cambridge college. In the other case the mere examination is the only test, and it is rightly very severe. The two kinds of degree differ altogether in quality. In a new country of great distances I can imagine many good secondary schools to be established having neither sufficient funds nor sufficient pupils to be qualified as universities. Yet it may be of enormous importance that a few of the older pupils at such schools should as external students be examined for degrees by distant universities, which in such a case, are merely outside examining bodies. I can see the gradual increase in importance of such secondary schools leading to the establishment of something higher—namely, colleges of university rank—and I can see such affiliated colleges becoming universities themselves perhaps after a period in which two or more of them federated themselves as universities. But I say that there ought always to be some examination machinery by which a student who is too poor or who through any other circumstance is unable to attend a university college may be encouraged to study by himself, by having his attainments tested.

In this address I have said nothing about the education of women. I have always advocated higher education for girls, but it is surely wicked to teach girls as if they were boys. Men are concentrative, and they specialize; women observe more and more about many things, and they really have more capacity for acquiring mental power. Until quite recently girls were saved from stupidity, but the high schools are now giving a crammed knowledge of facts and of the opinions of the tribe, so that girls and women are ceasing to think for themselves. The education of men is in a bad way, but that of women is becoming much worse.

I think that in this address I have put forward no idea that I have not already published time after time in the last thirty-five years. I put these views forward again because, after much thought and much experience, I still think them to be correct, and I feel sure that they must prevail. But I must confess that it is only a very hopeful man who can peg away at a thankless task as Dr. Armstrong and I have been doing so long.

THE PROGRESS OF SCIENCE

SCIENCE AND THE WAR

One of the most serious aspects of the war is the diversion from scientific work which it involves. Should the contributions to pure and applied science in the course of the next ten years be reduced to one half, the loss to the world in life and wealth would be far greater than that caused directly by the destruction of war. It may be guessed that in the course of the past hundred years the death-rate has been reduced to one half in the more civilized nations and the annual productien of wealth has been increased by a hundred billion dollars. If a comparable advance would have been made in the next ten years apart from the war and this should be reduced to half as a result of the war, the loss would be so great as to be almost incredible. Thus the death rate in England has been reduced from 23 per thousand to 14 per thousand in the course of fifty years. If by the advances of science and civilization in the course of ten years the death rate would have been reduced to 12 per thousand and as the result of the war the reduction should be only to 11, so that for a period of ten years the death rate is one per thousand larger than it otherwise would have been, the deaths in England chargeable to the war apart from those directly caused by it would be in the neighborhood of 400,000 and in the civilized world of 4,000,000. There would be a corresponding excess of ill-health and disease over what would have been suffered had there been no war.

In like manner it may be calculated that if the increased production of the world's wealth which might have been expected from new applications of science should be decreased to one half by the war for a period of ten years the economic loss would be in the neighborhood of fifty billion dollars. These calculations are, of course, subject to a very large probable error. We may hope that the advance of science will not be checked to the extent of one half for a period of ten years. It has been said that it will be a generation before the nations involved will regain the position they now hold, but it may, on the contrary, be the case that the loss will be far less than is assumed as the basis of these calculations. It depends on the length of the war and on many other conditions of which we are ignorant.

But figures such as these, even though they have but small reliability, may impress on us the magnitude of the value of science for the world and the injury done by an interruption to its progress. A loss of four million lives and of fifty billion dollars from a slackening in scientific work due to the war is greater than the destruction which will be directly caused. While we are helpless in presence of the direct destruction from the war, this is not equally the case with the loss due to the failure in scientific research and the applications of science. We should in this country do what we can to carry forward the work which will be dropped by the disabled nations.

THE DISTRIBUTION OF SCIENTIFIC MEN AMONG THE DIFFERENT NATIONS

Some idea of the relative contributions to science by the different nations may be gathered from the number of scientific men recorded in "Who's Who in Science," an international biographical directory edited by H. H. Stephenson and published here by The Macmillan Company. In this compilation there are recorded 1,678 scientific men from the United

Hermann von Helmholtz, the great German physiologist and physicist, and Frau von Helmholtz are seated in the center, on the left is Professor Hugo Kronecker, of Bern, the distinguished physiologist, whose death has recently occurred. In the center is Mr. Henry Villard; on the right, Dr. T. C. Mendenhall, the American physicist. We owe the photograph, which was taken in Washington in 1893, to Dr. S. J. Meltzer, of the Rockefeller Institute of Medical Research, a student and friend of Kronecker's.

States and 1,472 from Great Britain. These figures indicate that there are more scientific men in the United States than in Great Britain, practically all those from the latter country having been included. The work being an Anglo-American compilation, the numbers are not comparable with those of the continental nations, but there is perhaps no reason why any one of these should have been favored in the selection of names. In so far as this is the case, the numbers of scientific men of some distinction in the different countries are as follows: Germany, 1,280; France, 423; Austria-Hungary, 236; Italy, 215; Switzerland, 214; Holland, 155; Sweden, 109; Russia, 97; Denmark, 94; Belgium, 90; Norway, 88; Portugal, 49; Spain, 41. It thus appears that Germany has three times as many scientific men as France. The population of Germany is considerably larger, but this was not the case at the time the men were born, they being on the average about 50 years of age and practically none of them under forty. The number of men in France over 45 years is only about one million less than in Germany, though there are twice as many children in Germany.

In order to compare the smaller nations with the larger we must take account of their size. The numbers of scientific men for each million of the present populations of the different nations are as follows: Switzerland, 58; Norway, 37; Denmark, 34; Holland, 26; Sweden, 20; Germany, 19; Belgium, 12; France, 11; Portugal, 9; Italy, 6; Austria-Hungary, 5; Spain, 2; Russia 1. In this comparison the smaller nations show to advantage, and this is a factor that should be kept in mind in any redistribution of empire. Switzerland leads all other nations, followed by the Scandinavian countries and Holland. Belgium is before France, and Portugal is close to it. In so far as the production of scientific men is a measure of civilization, Austria-Hungary and Italy fare badly and Russia is far behind all other nations.

A study of the distribution of the more distinguished men of science was contributed to this journal (October, 1908) by Dr. E. C. Pickering, the director of the Harvard College Observatory. Taking the scientific men who were members of at least two foreign academies, they were distributed as follows: Germany, 29, France 12, England 13, the United States 6, Austria 4, Italy, Sweden, Holland, Norway, Denmark and Russia, 3 each. The recognition of scientific eminence is likely to come late in life and these men were mostly old; half of the six distinguished Americans—Agassiz, Hill and Newcomb—have since died. The present distribution of the foreign members of the National Academy of Sciences is as follows: German 18, Great Britain 11, France 4, Holland 4, Russia and Sweden, two each, Austria, Italy, Norway and Switzerland, one each. Here again France does not compare favorably with Germany. Among its four representatives are two distinguished mathematicians, Darboux and Picard, the other two being Deslandres, the astronomer, and Barrois, the paleontologist. They are scarcely the peers of the four Dutch representatives, Kapteyn, Lorenz, de Vries and van der Waals, and are apparently less distinguished than the Germans and the English.

If we select the greatest men from the list compiled by Dr. Pickering or from the foreign membership of the National Academy, it is not easy to find any who can be placed beside Helmholtz or Pasteur, whose portraits happen to be reproduced in this place. It may be an error of perspective that those nearer to us seem smaller. But when Germany names its greatest men it goes back to Goethe and Kant, and the scientific men who have died or have ceased their active work appear to be greater than those who are now filling the chairs in the universities.

This does not mean that present work in science is less important than

Louis Pasteur.

A replica of the bust by Dubois, presented to the American Museum of Natural History for installation in the hall of public health, through the generosity of Dr. Roux, director of the Pasteur Institute in Paris and M. Vallery-Radot, son-in-law of Pasteur.

it was formerly. It may be that in its earlier history, there was more opportunity for striking discoveries. The condition may also be explained by an inversion of the proverb "The forest can not be seen for the trees." There are now so many scientific men doing work of importance that it is impossible to remember even their names. "The trees can not be seen for the forest." Still, if we write the names of the leading scientific men of the last generation, beginning with Darwin in England, Pasteur in France and Helmholtz in Germany, beside those who have recently died or are still living at an advanced age, there seems to be a decline in distinction, and the same holds if this group is compared with scientific men who are now active. It is not easy to decide whether this is appearance or reality.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Morris Longstreth, formerly professor of pathological anatomy at Jefferson Medical College; of Dr. James Ellis Gow, professor of botany in Coe College; of Overton Westfield Price, at one time associate forester of the U. S. Forest Service; of Dr. W. H. Gaskell, university lecturer in physiology at Cambridge University and of Dr. Eugen von Böhm-Bawerk, professor of economics in the University of Vienna, formerly minister of finance, president of the Vienna Academy of Sciences.

An international committee has been formed to establish a foundation in memory of Henry Poincaré. A medal will be struck in his honor, and a fund will be established under the Paris Academy of Sciences to encourage or reward young scholars engaged in work in the directions in which Poincaré led, namely, mathematical analysis, celestial mechanics, mathematical physics and scientific philosophy.

Dr. A. Penck, professor of geography at Berlin; Dr. F. von Luschan, professor of anthropology in the same university, and Dr. J. Walther, professor of geology and paleontology at Halle, are among the German men of science who attended the Australasian meeting of the British Association. It is said that there is some anxiety as to how they shall return home. If press despatches are to be believed, several German astronomers, including Professors Kempff and Ludendorf, who had gone to the Crimea to observe the eclipse of the sun, have been taken prisoners and their scientific instruments confiscated.—Among the German scientific men who have affixed their names to a manifesto renouncing the honors conferred upon them by English universities and other learned institutions are Professors Paul Ehrlich, Emil von Behring, Ernst Haeckel, August Weismann and Wilhelm Wundt.

Sir Ernest Shackleton and the members of his Transantarctic Expedition left London on September 18 for the South Polar regions. The explorers departed in two sections, the portion for the Ross Sea or New Zealand side of the Antarctic leaving in the morning *via* Tilbury for Tasmania, and the Weddell Sea section, including Sir Ernest Shackleton, leaving for South America later in the day. The *Endurance*, the ship of the Weddell Sea party, left Plymouth on August 8. The Ross Sea ship *Aurora* is to leave some Australian port about the beginning of December.

THE

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THE CINCHONA BOTANICAL STATION

By Professor DUNCAN S. JOHNSON

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THE botanical laboratory and garden at Cinchona, in the Blue Mountains of Jamaica, which for the past ten years has been a tropical station of the New York Botanical Garden, is now to be maintained under the auspices of the British Association for the Advancement of Science, with the cooperation of the Jamaican government. The British Association is concerned primarily in making Cinchona available for British investigators, but it is believed that, except when the laboratory is taxed to its capacity by appointees of this association, its privileges will be extended, upon the recommendation of the Jamaican government, to properly accredited American botanists.

The opening of a new chapter in the history of this long-established seat of botanical activity makes this a fitting time to call attention to the work that has been done at this laboratory during the past forty years, and to its peculiar advantages in location as a botanical station. We may also note the evidence for the need of such a laboratory, and the character of its possible service to botanical science. With the general appreciation of the variety of plant material and other advantages to be had at this laboratory, it is believed that Cinchona will be more and more resorted to by investigators working on those botanical problems which can best be studied with organisms living under tropical or subtropical conditions.

The need of a botanical laboratory in the western tropics, which could offer the facilities and give the stimulus afforded to old-world botanists by the Dutch garden at Buitenzorg, in Java, has long been recognized by American botanists. It is true that biological explorers in quest of new forms, or of new evidence concerning the distribution of known forms, have been searching since the days of Hans Sloane (1687) and Humboldt (1799–1804) through many parts of the western tropics. The plant taxonomists of Europe, of the U. S. National Herbarium, of the Columbian Field Museum, and especially of the New York Botanical Garden, have recently made extensive collections in the continental and Antillean portions of the American tropics. But facilities have been lacking for working out the life-histories or the physiology and ecology of tropical and subtropical seaweeds, as this has been done at Naples and Ceylon; the chance has been wanting to select, study and carefully preserve developmental stages of tropical mosses, ferns and seed plants, and to make investigations of the physiology of growth, nutrition and other activities of plants near the equator, as these have been made at Buitenzorg. This sort of opportunity for studying tropical plants where they must be studied—in their tropical surroundings— has seldom been offered to American investigators until within the last decade. The more or less temporary summer laboratories established in the western tropics have been located directly upon the seacoast, primarily with a view to their fitness for zoological work. They have usually proved unattractive to botanists engaged in studies other than those upon marine algae. This has been largely true of the summer laboratories established by the Johns Hopkins University in the Bahamas and Jamaica, by Harvard University in Bermuda and by the Carnegie Institution on the Dry Tortugas. It is evident, therefore, that for many kinds of botanical research a laboratory must be established at a site selected with these in view—in other words, it must be primarily a botanical station.

A serious attempt to arrange for the establishment of an American tropical laboratory was made by certain of the botanists of this country in 1897. The desirability of such a laboratory was pointed out by *The Botanical Gazette,* and a commission composed of D. T. MacDougal, D. H. Campbell, J. M. Coulter and W. G. Farlow was chosen to select a site. This Tropical Laboratory Commission, after profiting by such information and suggestions as they could obtain, and after two of its members, Drs. MacDougal and Campbell, had visited Jamaica in 1897, was inclined to favor that island as the location for the laboratory. During the presence of these two commissioners in Jamaica they were aided by Hon. William Fawcett, late director of Public Gardens and Plantations, William Harris, superintendent of Public Gardens and Plantations and Professor James E. Humphrey, of the Johns Hopkins University, who was at this time in charge of the Johns Hopkins Laboratory, established at Port Antonio. The sad fate of Professor Humphrey and of that promising young zoologist Franklin Story Conant, as victims of the unwonted visitation of yellow fever to Jamaica, undoubtedly checked the enthusiasm of many who had been interested in establishing a tropical laboratory. The anticipated encouragement and cooperation were not given to the commission, and, in consequence, the search for a site and all further work on the project were, for the time, abandoned. The project was not again taken up by American botanists or institutions during the following six years.

In August, 1903, the Jamacian government, having abandoned Cinchona cultivation, decided to lease the Cinchona property. Through the suggestion of the late Lucien M. Underwood and the writer, and by the prompt action of Director N. L. Britton and Dr. D. T. MacDougal, Cinchona was leased by the New York Botanical Garden. It was maintained by the garden as a laboratory, and as a substation for the propagation of tropical plants. The director of the garden also placed the laboratory and other equipment at the disposal of botanical investigators, of whom more than thirty have worked at Cinchona during the past ten years.

In the last decade, it is true, several other botanical laboratories, all of them primarily for experiment-station work, have been organized in the American tropics. Two of these were maintained by commercial organizations in Mexico. Of the other three, two, at Miami, Florida, and Mayaguez, Porto, Rico, are supported by the United States, and a third, at Paramaribo, is maintained by the government of Dutch Guiana. At none of these has much botanical research thus far been carried on, except the economic agricultural work of the regular staff members.

It is thus evident that the interest of American botanists desiring a tropical laboratory has centered about Cinchona for the past two decades. There is good reason to believe that this interest will continue and increase. When, therefore, it was learned that Cinchona, the only station in the western tropics for the study of pure botany, was not to be again leased by the New York Botanical Garden, the Botanical Society of America, meeting in Cleveland, attempted to secure the continuation of the use of the Cinchona station for American botanists. For this purpose a committee was appointed consisting of D. S. Johnson (chairman), N. L. Britton and D. H. Campbell, and an appropriation was made to pay a year's rental, if this should be necessary, while more permanent arrangements were being perfected. Before the committee had had opportunity to act, it learned of the prospect that the Jamaican government would make the privileges of Cinchona available for American investigators. The publication of this account of Cinchona, and its advantages as a botanical station, may serve to indicate the interest of the committee in its work, and its appreciation of the encouragement given to botanical investigators of our country by the Jamaican government.

Location

The Hill Garden, or "Government Cinchona," as it is commonly called by Jamaican planters, is a reservation of many thousand acres, where the cinchona tree, from which Peruvian bark and quinine are obtained, was introduced 45 years ago. Here, and on the neighboring private plantations, it was grown for profit, until the cheaper labor and transportation in the parts of India and Java devoted to this crop greatly lowered the price of the bark.

Lying on a rugged spur stretching southward two miles from the main ridge of the Blue Mountains, the Cinchona reservation extends upward from the cleared slopes at the 4,500-ft. level to the well-wooded peaks 6,100 feet high, in the main range itself. Practically all the Blue Mountan country above the 4,500-foot level is reserved by the government as a water shed, and thus forms an immense area of mountain forest that may be used for floristic exploration and ecological study. At a spot commanding a remarkable prospect, on the shoulder near the south end of the spur, stands the Cinchona residence and laboratories, situated at an altitude of 4,900 feet. The house is the highest dwelling of any pretensions anywhere in the West Indies.

History

The idea of developing a hill garden, or "European garden," as he called it, was conceived by a governor of the colony, Sir Basil Keith, in 1774. He planned especially to introduce the cultivation of European vegetables in the cool, moist hill country. The plan was first realized in 1869, through the energy of a later governor, Sir John Peter Grant, whose primary object was the encouragement of the culture of Peruvian bark, coffee and tea. Here, in the early seventies, scores of acres were cleared and planted with seedlings of several species of *Cinchona*. These were derived from plants brought out of Peru in 1860 by Clements Markham. In 1874 the Jamaican government organized at Cinchona an experiment station, which became the center of botanical work in the island. A director's residence, other dwellings, offices, laboratories, greenhouses, servants' quarters and stables were erected. A beautifully planned garden was developed about these buildings, and planted with hundreds of subtropical and temperate-zone plants.

Here was stationed during the prosperous days of cinchona culture, nearly the whole botanical staff of the Department of Public Gardens and Plantations. For seven years, under Sir Daniel Morris (1879–1886), and eleven years under the Hon. William Fawcett (1886–1897), the staff was engaged in agricultural and in some purely botanical researches. Methods of propagating, cultivating, harvesting and curing cinchona, tea, etc., were studied. At a lower altitude experimental plantations were made of oranges, orris root, forage plants, and fiber plants such as China grass, which showed that these can be grown successfully in the Hills. The staff included a trained English gardener, William Nock, brought over to demonstrate the possibility of cultivating "English" vegetables in these higher parts of the island. This experiment was entirely successful, and in consequence the natives now grow these vegetables, then carry them as head loads for 15 or 20 miles over the mountain trails to the Kingston market. Besides these purely agricultural investigations, important taxonomic studies were made of the flowering plants of this most interesting part of Jamaica by Messrs. William Fawcett and William Harris, of the staff. Diligent search for new forms in the more inaccessible regions was made especially by Mr. Harris, while G. L. Jenman, then superintendent of Castleton Gardens, studied the ferns of this area. Hundreds of species of mosses, ferns and seed plants new to the island, and to science, were found by these workers. *The Flora of Jamaica,* now being published by Fawcett and Rendle from the British Museum, was initiated at Cinchona. Records were also made for twenty years of the temperature and rainfall at several stations in this region, including Blue Mountain Peak, at 7,423 feet elevation.

Some sixteen years ago the staff was removed to new headquarters at Hope Gardens, near Kingston, from which the lowland agriculture, now of most importance to the island, can be more readily studied and aided. For a number of years after the removal of headquarters, the Cinchona Station was not occupied, except occasionally as a summer retreat from the heat of the plains, by the governor, or other island officials, or by visiting botanists. For example, it was used as a base for botanical work by Campbell in 1897, by Harshberger in 1902, and by Underwood, Maxon, Johnson and Shreve in 1903.

The importance of the later history of Cinchona, during its lease by the New York Botanical Garden, has already been suggested. Aside from being used as a propagating station, it has been the base for much purely botanical work by Americans and Englishmen. Researches have come from Cinchona during the past decade by workers from the New York Botanical Garden, the United States National Museum, Columbia, Yale and Johns Hopkins Universities, and Wellesley College. Important studies of the ecological distribution of Blue Mountain plants have been made here by Forrest Shreve, of Johns Hopkins University and of the Carnegie Institution. Developmental and anatomical investigations have been initiated at Cinchona on the Orchidaceae, Piperaceae, Loranthaceae, Filicales and Hepaticeae by investigators from Columbia, Glasgow, Johns Hopkins and Yale Universities. Aside from the investigations accomplished, many botanists have here had their first opportunity of perceiving the intimate dependence of certain types of extreme specialization in plant structure on the accentuation of definite climatic or edaphic conditions. In other words, many have here first seen ferns and seed plants living as epiphytes, and have first appreciated the extreme diversity of habit and complexity of composition attained by the plant life of a primeval forest under tropical conditions.

Cinchona and the Surroundings

The Cinchona Station of to-day consists in the first place of the residence, a bungalow. This, with an adjoining building, can furnish

Residence, Greenhouses and Offices at Cinchona. The laboratories are behind the flowering pampas grass.

Residence, Greenhouses and Office.

living and sleeping accommodations for eight or ten workers. There are two laboratories, each well lighted on two or three sides, that will accommodate the same number of workers, with tables, shelving, some simple glassware and a supply of plant dryers. There are two greenhouses that can be used for keeping experimental material under constant conditions, and which incidentally collect water for two large cisterns that supply the laboratories and house. The clear, absolutely pure water for drinking and cooking is brought on the head of a native carrier from the springs of the Clyde River, 500 feet below Cinchona.

The finely terraced garden about the house and laboratories is maintained in excellent condition. Despite the ravages of the hurricane of 1903, it still contains numerous fine specimens of tropical, subtropical and temperate-zone shrubs and trees. There are the native tree ferns, junipers, *Podocarpus*, orchids, bromeliads and a great *Datura* with

Two Laboratories. Stables in the background.

corollas a foot long, that have been transplanted from the mountains behind Cinchona. There are fine examples of many Himalayan and Cape of Good Hope species. Large trees are here of *Cryptomeria, Cupressus Lawsoniana, Pinus Massoniana,* and two species of *Podocarpus.* The genera *Grevillea, Hakea, Callistemon, Gordonia, Pittosporum* and the beautiful *Acacia* are represented by from one to several species each. There are splendid specimens or clumps of each of a dozen species of *Eucalyptus.* Eight or ten species of subtropical palms are found here, together with *Agaves, Yuccas,* New Zealand flax with leaves

Corner of Garden. *Doryanthes Datura* and native ferns in foreground. Silk oaks and Eucalypti in background.

six feet long, and the huge Amaryllidaceous *Doryanthes*. There are clumps of beautiful *Azaleas*, whole hedges of bamboo, and thickets of two Asiatic raspberries ten feet high. On the terraces near the house are dozens of roses, *Fuchsias* with two-inch trunks, and tangled masses of deliciously scented heliotrope and *Mandevilla*, besides dozens of the more usual garden plants of temperate zones. The laboratories are nearly hidden by great clumps of pampas grass.

Among the flowers of the garden flit many beautiful humming birds, while up from the valleys below float the mellow, plaintive notes of a thrush—the solitaire. The garden at Cinchona, like all the surrounding region, is free from snakes and from troublesome insects. The native negro people of the Hills are courteous and obliging, and, of course, speak English.

The surroundings of Cinchona, beyond the confines of the garden, are equally interesting. Just north of the house a high knob of the spur rises a hundred feet above it. Then, after dropping 200 feet, to a saddle ten yards wide, at St. Helen's Gap, the ridge continues northward, growing wider and higher, to the Blue Mountain range itself. Southward from the house the ridge drops off abruptly, except on the southeast, so that from the terrace one may look off over the Port Royal Mountains to Kingston Harbor and Port Royal, fifteen miles away and nearly a mile below. East and west of Cinchona are the steep-sided valleys, half a mile deep, of the Green and Yallahs Rivers, the lower slopes of which have been largely cleared and planted with coffee or vegetables. These valleys, with their changing lights and shadows, from dawn till twilight, are a constant delight to the dweller at Cinchona. In the early morning they are in deep shadow long after the sun has lighted up the mountain tops around them. A thin veil of cloud floats far down below, and, in the stillness of the morning, the faint roar of the river, coming up from the dimly seen bottom, makes the valley seem miles in depth. All day long the clouds, driven by the northeast trade winds, roll over the Blue Mountains from the cool north side and quickly melt away in the dry air above the warm southern valleys. In the afternoon the sun sets in these valleys at four or five o'clock, and their slopes cool down rapidly. Then bits of the flowing cloud break off and slowly settle down into the valley beneath, to form anew the billowy curtain that screens the valley each night. A sight long to be remembered is such a sea of cloud, reflecting from its top the glow of a sunset, or the brilliant light of the tropical moon.

During the rainy season, or "the seasons," as Jamaicans call it, the clouds become denser south of the mountains. Then Cinchona itself is enveloped in cloud most of the time for days together. I might almost say enveloped in water, for the rain is so heavy that a tumber will fill directly from the skies in three or four hours. An inch an hour may fall for hours together. The spring rainy season, of heavy rains both

Cloud Fragments Settling into Valley.

A Sea of Cloud above a Valley Half a Mile Deep.

day and night, extends over two or three weeks in May or early June. A second one occurs in October. For several weeks preceding each of these rainy seasons there may be dense clouds and occasional showers at midday. From four or five o'clock in the late afternoon, till nine or ten in the morning, the sky above is cloudless. The sun sets in splendor over the western peaks and the moon and stars shine out with a sparkling brilliancy. The clear days after "the seasons" are the most beautiful of all the year. On the mountains 'round about, where all had been dark green and gray before the rains, the foliage now takes on a new brightness, and the scar-like watercourses are now veiled by white cataracts that plunge hundreds of feet down the mountainsides. Beyond the lower mountains of Guava Ridge one can see on, past the foaming surf line, out a hundred miles over the blue Caribbean.

During the late summer, and again in midwinter, the rainfall may average but three or four inches per month, and it may even be fair for weeks together, so that the soil of the hilltops and ridges about Cinchona becomes very dry. The total rainfall for the year at Cinchona is from 100 to 115 inches. North of the mountains, three miles away, there may be 200 inches in a year. The temperature at Cinchona ranges from 48 to 78 degrees, but these extremes are seldom reached. In June, 1906, while New York and Baltimore had temperatures in the upper nineties, the thermometer at Cinchona reached 72 degrees but twice, and then for but an hour or two at a time. At night, on these same days, with temperatures of 52 or 54 degrees, we were ready to enjoy the open fire of juniper logs in the living room of the bungalow.

DUCTLESS GLANDS, INTERNAL SECRETIONS AND HORMONIC EQUILIBRIUM

By FIELDING H. GARRISON, M.D.
WASHINGTON, D. C.

IN the year 1749 there came up to Paris from the Pyrenees a young medical graduate of Montpellier who was destined to become, by reputation, at least, the most distinguished French practitioner of his time. At the age of twenty-three Théophile de Bordeu (1722–76) was already professor of anatomy at Montpellier and inspector of mineral waters at Auch and Pau; at twenty-five he had been elected a corresponding member of the Royal Academy of Sciences, and, except for an empty purse, his Parisian success was assured, not only through his handsome presence, his attractive meridional disposition and his newly acquired fashionable connections, but in part through the influence and reputation of his father, who was one of the best known Montpellier physicians of his time. In order to launch himself it was necessary for young Bordeu to pass the examinations of the Paris Faculty (his Montpellier degree counting for nothing here) and to gain the good will of its members; yet, in spite of these handicaps, he began to loom large in public consideration, when his fortunes took an unexpected turn. Bouvart, a rich and powerful practitioner of the day, became so envious that he pursued Bordeu with venomous hatred, and accused him of stealing jewels from the body of a dead patient.[1] On this charge he actually succeeded in having his name stricken from the list of Parisian physicians, and it was reinstated, after long dispute, and only through powerful influence and by two acts of Parliament. The reason for this savage manifestation of professional jealousy (the charge of theft is said to have been false) was not because the young Béarnais physician possessed any very formidable, overtopping ability, but on account of the ease with which he glided into a fashionable practice and aristocratic consideration. In an age in which the byword was "*Le ridicule tue,*" his morals and his moral life were those of the courtiers of the period, and he seems to have succeeded largely through the good graces of women, one of whom, in fact, raised the money start him in practice. In his early days he had not found the rustic patients of the provinces to his liking and he aimed at a court clientèle with such success that shortly before his death he was called to the bedside of the moribund Louis XV. He himself was found dead in bed on the morn-

[1] Stealing from dead bodies was a favorite imputation against the eighteenth century doctor and is represented in an old water-color sketch of Rowlandson's.

ing of the day before Christmas, 1776, and his old enemy, Bouvart, who seems to have always kept him in mind for judicial hanging, vented his glee in an epigram which, for venom, matches up with what Louis XIV said as the cortège of la Montespan passed by in the driving sleet: *Je n'aurais pas cru qu'il fût mort horizontalement!*"

At the present time, the scientific reputation of Bordeu is of the slenderest kind. He is one of the gods of the old Montpellier faculty. In his relation to the fashionable mineral springs of the Pyrenees—Pau, Barèges, Bagnères—he seems the original, indeed, the archetypal *Badearzt.* He was a good anatomist, a piquant writer on medical history, a promoter of variolation. His view of the brain, the heart and the stomach as "the tripod of life" made its fortune in its day, and he achieved a great reputation by his revival of the complex pulse-lore or *ars sphygmica* of Galen and the Chinese physicians, a phase of eighteenth century medicine which Dr. Weir Mitchell pithily described as "observation gone minutely mad." In the history of medicine these distinctions count for very little. Bordeu, who died on the eve of the Revolution, was doubtless one of the giants before the flood, but, as compared with the great names of those who came *après le deluge*—Bichat, Louis, Laënnec, Bretonneau, Andral, Pinel, such clinical "genius" as he had acquires the ghostly implication conveyed in the original meaning of the term. It has been said that every physician of florid or fashionable reputation has in him something of the charlatan, and there are anecdotes about Bordeu which show that he was no exception to the rule. But there are one or two things which make him an important connecting link between the outmoded, pompous, pedantic French medicine of the old régime and the brilliant and truly scientific output of the Napoleonic period and after. Bordeu appears to have been the first anatomist to employ the term "tissue," and his "Recherches sur le tissu muqueux ou l'organe cellulaire" (1767) immediately suggest the great Bichat, whom he influenced, it is true, but in a most untoward way. By *tissu muqueux,* which he also calls *l'organe cellulaire,* Bordeu means neither cellular structures as Schleiden and Schwann saw them nor protoplasm as Purkinje and Schultze saw it, but simply such vague protoplasmic configurations as were visible through a lower-power microscope. It was his ambition to confirm and uphold the humoral pathology of Hippocrates, and he regarded the three Hippocratic stages of disease, irritation, coction and crisis, as dependent upon the glandular and other secretions. Corresponding with the different organs and secretions, he classified diseases, not according to their clinical or pathological manifestations, but arbitrarily as cachexias, of which he devised a prodigious list, *e, g.,* bilious, mucous, albuminous, fatty, splenic, seminal, urinary, stercoral, perspiratory; with an equally complex classification of the pulse as critical, non-critical, nasal, tracheal, gastric, renal, uterine, seminal, etc. All this undoubtedly influenced Bichat in the fundamental error of his scientific work, viz., the ascription of specific vital property to each classifiable tissue. Bordeu's slender reputation to-day is concentered in a single idea—the doctrine that not only each gland, but each organ of the body, is the workshop of specific substance or secretion which passes into the blood, and that upon these secretions the physiological integration of the body, as a whole, depends. This doctrine is contained in his "Analyse medicinale du sang" (1776), the importance of which has been signalized by the eminent medical historian, Professor Max Neuburger, of Vienna.[2] An examination of this work will hardly realize the expectations which are raised by Professor Neuburger's panegyric. It is a typical example of the purely theoretical reasoning so common in the medical literature of the eighteenth century, in which an intolerable deal of verbiage is spread over the smallest substructure of fact. Cases are frequently cited but they are not true clinical delineations, only gossipy personal anecdotes, not unlike those of Brantôme. A great deal is said about the sexual side of man, and indeed the most interesting part of Bordeu's theory is his observation of the effects of the testicular and ovarian secretions upon the organism. He regarded the sexual secretions as giving "a male (or female) tonality" to the organism, "setting the seal upon the animalism of the individual," and as a special stimulus to the human machine (*novum quoddam impetum faciens*). He described in detail, the secondary sexual changes, not only in eunuchs and capons, but also in spayed animals of the female sex. In connecting all this with specific secretions, discharged, not externally, but into the blood, Bordeu was, as Neuburger rightly contends, very close upon the modern theory of the internal secretions, but, as he made no experiments, his ideas can only be regarded as an interesting phase of eighteenth-century theorizing. Aside from Bordeu's deduction from what he saw, almost any stock-raiser or poultry-fancier might have noted the same facts, and facts of equal moment had been noticed long before his time.

To begin with, one of the oldest therapeutic notions is the idea that such unsavory materials as the viscera or excreta of animals, administered either singly or as a maximum compositum might avail in the treatment of disease. This mode of therapy was a common feature of the Egyptian medical papyri, was known to the Greeks and Romans, made great headway during the dark ages, and reached its height in the seventeenth century. The four London Pharmacopœias of 1618, 1650, 1677 and 1721 abound with such remedies as the bile, blood, bones, brains, claws, eggs, excrement, eyes, fat, feathers, hearts, horns, intestines, marrow, milk, omentum, placenta, rennet, sexual organs, skin, teeth and urine of all manner of animals; also bee-glue, civet, cock's comb, coral, crayfish,

[2] Neuburger, *Wien klin. Wochenschr.*, 1911, XXIV., 1367.

earthworms, pearls, perspiration, saliva of a fasting man, scorpions, raw silk, silkworm's cocoons, moss from the skull of a man who has met a violent death, spermaceti, sponge, spider webs, cast off snake's skin, sea shells, swallows' nests, suet, viper's flesh, wax and woodlice; and along with these went those relics of the old Arabian polypharmacy, the theriacs and mithridates, which consisted of grand mixtures of anything and everything in the way of vegetable simples. In the seventeenth century there were actually "filth-pharmacopœias" (*Dreck-Apotheken*). The only physician of the time who did not attach much importance to these remedies was the one who had the greatest fund of practical sense, Thomas Sydenham. In the pharmacopœias of 1721 and 1746, these nauseating remedies begin to disappear. One year before the latter date, William Heberden, who was probably the greatest English clinician between Sydenham and Bright, published his satirical pamphlet "Antitheriaka" (1745), which was, in effect, a critical onslaught on polypharmacy. Charles Lever tells of a certain individual who was "laughed out of Ireland." Heberden banished the theriacs and mithridates from medicine with the scholar's ironical smile, and with them went the filthier features of the materia medica. As a result of this cool douche of common sense, the Pharmacopœia of 1788 retains but a single animal remedy—woodlice. Yet these things were the crude elements of the present theory of treating certain diseases by means of animal extracts. Before the time of Brown-Séquard, the only animal extracts in our present pharmacopœia were the antispasmodics, musk and castoreum, which used to be described to gaping students, receiving their first instruction in the action of drugs upon the human frame, as derivatives of the preputial gland and follicles of the Tibetan musk deer and the beaver, respectively.

Another set of observations which bears upon our subject is that connected with the universal interest in giants and dwarfs, the acromegalics and achondroplasics of modern pathology. The acromegalic giants go back to the legendary lore of the Nephelim in Genesis (VI. 4), of Og, king of Bashan, the Anakim, Goliath of Gath, the Titans, Antæus, Polyphemus, Fafner and Fasolt, Gog and Magog, down to the huge images of Manchuria, the innumerable reports of excavations of giant skeletal remains and the Irish, Chinese and Russian giants of more recent date. The achondroplasic dwarfs suggest the short-limbed satyrs, the dwarf gods of Egypt (Bes, Phtah and others),[3] the black pygmy races,[4] the court dwarfs and buffoons figured by Velasquez and

[3] For a full account of these, with many illustrations, see the Munich dissertation of Franz Ballod: "Prolegomena zur Geschichte der zwerghaften Götter in Aegypten" (Moscow, 1913).

[4] There are no white races of pygmies, and it is probable that most white dwarfs are myxœdematous or achondroplasic.

other great painters, and the athletic, acrobatic and humoristic dwarfs of our vaudeville shows.

Among the ancient Romans, it was customary to test the increase in the girth of a young woman's neck, in connection with defloration or pregnancy, by measurement with a thread, as indicated in the lines of Catullus:

> Non illam nutrix oriente luce revisens
> Hesterno collum poterit circumdare filo,

but there is no evidence that they associated this cervical enlargement with the thyroid gland. Endemic goiter, however, was so well known in antiquity that Juvenal (XIII., 162) has preserved its commonplace aspects in a single line: "*Quis tumidum guttur miratus in Alpibus*" ("Who wonders at goiter in the Alps?"); and Pliny, in his Natural History (XI. 68), hinted at one theory of its causation when he said that "only men and swine are subject to swellings in the throat, which are mostly caused by the noxious quality of the water they drink." In the sixteenth century Paracelsus found goiter to be endemic in the Salzburg region, again attributed it to metallic and mineral constituents in the water, and noticed that it coexisted with another disease of the same locality, cretinism or myxœdema. While goiter is not a necessary characteristic of idiots (*proprium stultorum*), says Paracelsus, yet it is most commonly found among them (*so trifft es die am meisten*)[5] after which, he wanders off into his usual astrological theories, in which few can follow him. The important point is that in goitrous regions, as Dock says, cretins may have goitrous mothers while the marriage of two cretins is usually sterile,[6] which makes the observation of Paracelsus fit in very well with his main theory of the provenance of idiots (*generatio stultorum*).

In 1614 Felix Plater, another Swiss physician, published an observation which seems truly modern, an autopsy of an infant who had died from enlargement of the thymus gland ("thymus-death").[7]

As we begin to perceive the relation of these varied phenomena to the glands of internal secretion, it will not seem strange that Bordeu, who first stated the modern theory, should have hit upon the sexual gonads as the most obvious illustration, for nearly all these glands are in some way connected with the sexual characteristics of the individual. We may now pass from the stage of hap-hazard observations to that in which certain diseases were closely and accurately described, like objects in natural history, and it is worthwhile to range these in chrono-

[5] Paracelsus, "De generatione stultorum" (in his "Opera," Strassburg, 1603, pt. 2, p. 177.

[6] George Dock on "Cretinism" in Osler's "Modern Medicine," Philadelphia, 1909, VI., 448.

[7] Plater, "Observationum in hominibus affectibus . . .," libri III., Basel, 1614, 172. Cited by Friedleben.

logical order, as illustrating the slow growth of a certain phase of inductive science.

II

On the continent of Europe, the disease "exophthalmic goiter" is variously known as "Basedow's disease," or *morbo di Flajani*, after the two observers who in Germany and Italy are thought to have originally described it. Basedow, a physician of Merseburg, published, in 1840, a description so complete that the Germans regard it as the classical one. The three symptoms which he signalized—swelling of the thyroid gland, protrusion of the eyeball and palpitation of the heart—the Germans sometimes call the "Merseburg triad,"[8] which they also designate by the simple telegraphic epithet "Basedow." Among English-speaking people, exophthalmic goiter is usually known as Graves's disease, after the well-known Irish clinician who printed an accurate account of it in 1835. But more than fifty years before Basedow, Caleb Hillier Parry, an eminent physician of Bath, England, made a notation of all phases of the Merseburg triad, part of which deserves citation, if only on account of its historic interest.

> *Enlargement of the thyroid gland in connection with enlargement or palpitation of the heart.*—The first case of this coincidence which I witnessed was that of Grace B., a married woman, aged thirty-seven, in the month of August, 1786. Six years before this period she caught cold in lying-in, and for a month suffered under a very acute rheumatic fever; subsequently to which she became subject to more or less of palpitation of the heart, very much augmented by bodily exercise, and gradually increasing in force and frequence till my attendance, when it was so vehement, that each systole of the heart shook the whole thorax. Her pulse was 156 in a minute, very full and hard, alike in both wrists, irregular as to strength, and intermitting at least once in six beats. She had no cough, tendency to fainting or blueness of the skin, but had twice or thrice been seized in the night with a sense of constriction and difficulty of breathing, which was attended with a spitting of blood. She described herself also as having frequent and violent stitches of pain about the lower part of the sternum.
>
> About three months after lying-in, while she was suckling her child, a lump of about the size of a walnut was perceived on the right side of her neck. This continued to enlarge till the period of my attendance, when it occupied both sides of her neck, so as to have reached an enormous size, projecting forwards before the margin of the lower jaw. The part swelled was the thyroid gland. The carotid arteries on each side were greatly distended; the eyes were protruded from their sockets, and the countenance exhibited an appearance of agitation and distress, especially on any muscular exertion which I have rarely seen equalled. She suffered no pain in her head, but was frequently affected with giddiness. [After outlining his scheme of treatment, Parry concludes:] From this time no further application was made to me respecting this patient, who probably soon paid her debt to nature.

Between 1786 and 1815, Parry collected eight cases of this malady, which were published after his death, in 1825.[9] He undoubtedly is en-

[8] Basedow, *Wochenschr. f. d. ges. Heilk.*, Berlin, 1840, VI., 197: 220.

[9] Parry, "Collective Writings," London, 1825, II., 111.

titled to the credit of the original and classical account of the disease, although he did not, as the French say, *afficher,* that is advertise, his discovery by attempting to label it.

In 1833, Flajani published his account of the disease, in which he recognized two of the cardinal symptoms, the goiter and the cardiac palpitation. In discussing palpitation of the heart at the Meath Hospital in 1835, Robert Graves, the Dublin clinician, published his classical description of exophthalmic goiter, in which the exophthalmic feature was noted. He records that, in one patient, the beating of the heart could be heard at least four feet from her chest. After the time of Graves and Basedow, many similar observations were collected by clinicians, but it was not until the year 1886 that the condition was attributed to an excessive outpouring of the thyroidal secretion by the German neurologist. Möbius,[10] who at the same time, described a number of related symptom-groups which he regarded as due to qualitative or quantitative changes in the secretion itself ("dysthyroidism"). In connection with the cretins observed by Paracelsus around Salzburg, it is of record that Curling, an English pathologist, first observed that absence of the thyroid body is accompanied by "symmetrical swellings of fat tissue at the sides of the neck, connected with defective cerebral development" (1850). The classical account of this condition is due to Sir William Gull (1873) and it was called myxœdema by William M. Ord, of London, in 1877.

It is a curious fact that the same volume of the journal in which Basedow published his account of exophthalmic goiter contains an observation by Benhard Mohr,[11] a privat docent at Würtzburg, of a remarkable and fatal obesity in an elderly gardener's wife, attended by incipient imbecility (*läppisches und kindisches Benehmen*), loss of memory, general somnolence and scotoma, which, coming to autopsy, revealed a tumor-like degeneration of the pituitary body produced by inmixture and copious effusion of a serous fluid, the discharge of which had induced pressure phenomena in reference to the adjacent parts of the brain. This was the first recorded case of what is now known as pituitary obesity (1840), the "dystrophia adiposo-genitalis" of Fröhlich and Bartels.

In spite of the amount of original clinical delineation already on record in the first half of the nineteenth century, these lesions of the ductless glands attracted little attention. More interest was excited by the appearance, in 1855, of what we must now regard as the principal milestone in the history of the subject, the monograph "On the Constitutional and Local Effects of Disease of the Supra-renal Capsules," a quarto of 43 pages by Thomas Addison, senior physicion to Guy's

[10] Möbius, *Schmidt's Jahrb.*, Leipzig, 1886, CCX., 237.

[11] Mohr, *Wochenschr. f. d. ges. Heilk.*, Berlin, 1840, VI., 565–571.

Hospital, London. In the history of medicine, this work was destined to have an immortality of its own. In the very opening lines of his preface, Addison clearly states, for the first time, the true paths by which, as subsequent experience has proved, the problems of these mysterious glandular structures have been best approached and attacked:

> If Pathology be to disease what Physiology is to health, it appears reasonable to conclude, that in any given structure or organ, the laws of the former will be as fixed and significant as those of the latter; and that the peculiar characters of any structure or organ may be as certainly recognized in the phenomena of disease as in the phenomena of health. When investigating the pathology of the lungs I was led, by the results of inflammation affecting the lung-tissue, to infer, contrary to general belief, that the lining of the air-cells was not identical and continuous with that of the bronchi; and microscopic investigation has since demonstrated in a very striking manner the correctness of that inference—an inference, be it observed, drawn entirely from the indications furnished by pathology. Although pathology, therefore, as a branch of medical science, is necessarily founded on physiology, questions may nevertheless arise regarding the true character of a structure or organ, to which occasionally the pathologist may be able to return a more satisfactory and decisive reply than the physiologist—these two branches of medical knowledge being thus found mutually to advance and illustrate each other. Indeed, as regards the functions of individual organs, the mutual aids of these two branches of knowledge are probably much more nearly balanced than many may be disposed to admit; for in estimating them, we are very apt to forget how large an amount of our present physiological knowledge, respecting the functions of these organs, has been the immediate result of casual observations made on the effects of disease. Most of the important organs of the body, however, are so amenable to direct observation and experiment, that in respect to them the modern physiologist may fairly lay claim to a large preponderance of importance, not only in establishing the solid foundation, but in raising and greatly strengthening the superstructuie of a rational pathology.

Thus did Addison set forth the fact that Nature herself is sometimes the physiologist's best vivisector, even as Billroth and the followers of Marion Sims elucidated the pathology of the abdominal and pelvic viscera by making "autopsies *in vivo*."

On March 15, 1849, Addison read a paper before the South London Medical Society[12] in which he described the symptoms of what is now styled pernicious anæmia, cases in which the whole surface of the body "bear some resemblance to a bad wax figure." Only three of the cases came to autopsy, but "*in all of them was found a diseased condition of the supra-renal capsules.*" Was this a mere coincidence? Addison inquires.

> Making every allowance for the bias and prejudice inseparable from the hope or vanity of an original discovery, he confessed he felt it very difficult to be persuaded that it was so. On the contrary, he could not help entertaining a very strong impression that these hitherto mysterious bodies—the supra-renal capsules—may be either directly or indirectly concerned in sanguification; and that a diseased condition of them, functional or structural, may interfere with

[12] Addison, *London Med. Gaz.*, 1849, XLIII., 517.

the proper elaboration of the body generally, or of the red particles more especially. . . . Indeed, not only had he found the anæmia in question occasionally occurring in connection with purpura, but had observed in cases of the latter disorder certain local symptoms which pointed somewhat significantly to the supra-renal capsules; whilst the bloodless and waxy appearance of certain chlorotic females bore so close a resemblance to the anæmia described, that it was difficult not to suspect the existence of something common to both.

In his monograph of 1855, after referring to "an ill-defined impression" that the suprarenals, in common with the spleen, thymus and thyroid body, "in some way or other minister to the elaboration of the blood," and after a modest reference to the "curious facts" upon which he had "stumbled," Addison proceeds to develop the symptoms of what is now called Addison's disease—anæmia, general langor and debility, feeble heart action, irritable stomach, with a dingy or smoky discoloration of the whole surface of the body, sometimes reaching a deep amber or chestnut brown—and elucidates its pathology in eleven cases, accompanied by striking and life-like colored plates. From these records, it appears that the earliest known case of Addison's disease was reported by his great colleague at Guy's, Richard Bright (of Bright's disease) in 1829. In another, reported by Addison himself, the post-mortem section was furnished "by my distinguished friend Dr. Hodgkin" (of Hodgkin's disease). While developing his subject with the firm hand of the master in descriptive pathology, Addison draws no such striking conclusions in this memoir as we find in his paper of 1849 or as are indicated in the preface to the memoir itself. He does, however, draw attention to the important fact that even malignant disease may exist in both capsules without giving rise to the Addisonian discoloration of the skin. It was this memoir which led Brown-Séquard to reproduce the fatal disease experimentally by excising the suprarenal capsules in animals. The pouring out of the thyroidal and adrenal secretions during surgical shock or under the passion of fear (psychic shock) was emphasized long after by Crile and W. B. Cannon.

There remains one other affection which, on account of its present importance, may be briefly considered before passing to the experimental phases of the subject. The disease of acromegaly or gigantism was, as we have said, regarded as an abnormity from the days of Goliath of Gath up to the time of John Hunter's famous and expensive chase after the skeleton of the Irish giant (1783), but even before this definite cases had been reported, with good accounts of the deformities of the bones and the periodic coma, by Saucerotte (1772) and Noël (1779), and in the nineteenth century by Alibert (1822), Chalk (1857), by Friedreich in the case of the two Hagner brothers (1868), by Lombroso (1868), and by Sir Samuel Wilks, who in 1869 made a striking notation of the disease. The accepted classical account is that of

Charcot's pupil, Pierre Marie, who differentiated the affection from myxœdema, osteitis deformans and leantiasis ossea, gave it its present name and, four years later, correlated it with disease of the pituitary body.[13] Marie's claims to priority are somewhat vitiated by the fact that a lesion of the pituitary body in acromegaly had already been noted by Verga (1864), Brigidi (1877) and more particularly in the superb autopsy made by the late Edwin Klebs in 1884, which is the work of a veteran pathologist. This monograph,[14] based upon a case furnished by Dr. Fritsche, of Glarus, Switzerland, contains two striking views of the patient and a remarkable diagram of the acromegalic skull; the hypertrophy of the pituitary body and the consequent widening of the sella turcica is strongly emphasized. But the opinion of the eminent pathologist is divided between this lesion and a proliferation of the thymus gland, which he found in the same autopsy, and after balancing the claims of the two lesions at length, he winds up by declaring that the cause of the disease must remain obscure. The view of Marie, which connects it directly with a lesion of the pituitary body,[15] has been, with some reservations, the theory accepted up to the present hour. It is interesting to note that, from the time of Galen up to the seventeenth century, the pituitary body was held to be the source of the mucous discharges of the nose. Vesalius, for this reason, called it the "*glans pituitam excipiens*." This idea was overthrown in Conrad Victor Schneider's treatise on the membranes of the nose ("Decatarrhis," 1660) and by Richard Lower in 1672. Théophile de Bordeu, in his anatomical researches, states that the ancients thought the office of the pituitary body was to empty its humors through the nostrils, the moderns holding that it sent them to the sinuses of the sella turcica, and there the matter ends with him, although he indulges a few vague conjectures as to the possibility of the passage of the pituitary secretions into the circulation.

(*To be continued*)

13 Marie, *Rev. de méd.*, Paris, 1886, VI., 297–333, and in the graduating dissertation of his pupil, Souza Leite (Paris, 1890).

14 Fritsche and Klebs, "Ein Beitrag zur Pathologie des Riesenwuchses," Leipzig, 1884.

15 For an interesting account of this disease, see "Acromegaly, A Personal Experience" (London, 1912), by Dr. Leonard Portal Mark, a practising physician who has given a graphic and pathetic description of the gradual onset of the distressing malady in his own body. Although his disease was privately diagnosed by most of his clinical associates and he was "spotted" as an acromegalic in a Parisian crowd by Marie himself, Dr. Mark did not begin to realize his condition until he was fifty.

A NEW PHASE OF AN OLD CONFLICT

By LAUNCELOT W. ANDREWS

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WHEN those among us were young, upon whom time has now placed his silver stamp, the intellectual atmosphere was trembling with the noise of a conflict in the clouds. It was called "The Warfare of Science and Religion." The dragon's teeth from which this warfare sprang were sown with the first steps in organizing human society.

The social order is a machine and, like every machine, consists of two functionally distinct elements, the static and the dynamic. In the machine, the static element is the framework which correlates the other parts and maintains stability, while the dynamic part is made up of the moving parts which confer the capacity for change and, hence for work. The static or conservative element in the social order is that body of ethical or moral ideas and traditions which we denominate religion, while the dynamic element is the summation of man's experience with nature, of his knowledge of phenomena, of his technical information, of his objective social history, things which, taken together, we call science.

From the earliest beginnings of science, onward, the scientists have been the pioneers of society and have exhibited the characteristics of pioneers, in their keen interest in the new, in their disregard of the old, in their readiness to risk goods already in hand for better goods dimly seen on the horizon, and their disesteem of tradition. One can easily imagine that if the parts of a machine were conscious the moving members would look upon the stationary stability of the frame with a certain contempt and, resenting its restraint, might even regard it as a thing superfluous, as an obstacle in the way of free movement. This has often been the attitude of men of science.

The religionists, on the other hand, conscious of their conservative function, must regard themselves as the responsible custodians of an inheritance threatened by every change and by every disturbance of the social order, and must, on principle, oppose a new thing until it has proved its value; by which time it is of course no longer new. So we find, the scientist always trying to induce the people to do something they have never done before, while the religionists are urging them to keep out of danger and to return to a model of the past, that is, to imitate the example set by the founders of the several sects.

From this point of view there must always be a conflict between science and religion, but a conflict only in the sense of an action and reaction, a mutual pressure exerted by each upon the other. Religion is the fulcrum and science the lever which together raise mankind.

Recent debate on these matters is marked by a great improvement in tone as contrasted with that prevalent thirty or forty years ago. Not only is the spirit of the controversy altered, but its ground has shifted. Both parties have changed their positions. The religious partisans no longer dispute the verdict of the scientists in scientific things and many scientific men have abandoned the position that "matter holds the promise and potency" of everything in the universe, and now assign this "promise and potency" to energy, regarding matter merely as a symbol of thought.

Now the concept of energy is a good deal more closely related to that of spirit than is the concept of matter, so that it has become easy for the scientific men so to extend the bounds of their own field as to claim all that which was formerly regarded as the exclusive domain of religion. To make this new position clear, I might attempt to give a bird's-eye view of the utterances of several recent scientific writers, to construct a composite picture, so to speak. But to do this briefly would be impossible, so that I have perforce elected a different procedure, namely, to present in outline the views of a single author, selected as highly typical of the modern drift of thought along these lines. The writer chosen for this purpose is Wilhelm Ostwald, formerly, for many years, professor at the University of Leipzig, distinguished as a scientific man and now editor of the *Annalen der Naturphilosophie.*

In what follows, it shall be my aim to lay before you a brief summary of the position taken by Ostwald on the relations of science to religion, in a manner as devoid as possible of any color reflected from my own views. With this object, I shall not break into the presentation by any comment or criticism, and shall follow Ostwald's own phraseology so far as may be compatible with necessary condensations and omissions.

Self-respect and happiness are, in the last analysis, the motives of human conduct in those things that lie beyond mere maintenance of existence. In fact, the greatest happiness which can come to a man in advancing years is to diffuse happiness about him by the production of creative ideas which relieve mankind of heavy burdens and increase the general opportunities for happiness. The creative ideas which bring happiness most directly are, in the first line, those furnished by science, in so much as science lessens or removes many forms of disease and misery which plague or threaten man in consequence of his biological relationships. What no one of the many religions has been able to do has been accomplished, in an ever-increasing degree, in bettering those conditions of life which make for happiness, not alone through the advance of medical knowledge in the treatment of disease, but still more in teaching man how to minimize the causes of disease. The surprising extension of the span of human life, within a few decades, is an index of what has already been attained in this direction.

The fact that any one, to-day, can buy at small cost works of the best thinkers and poets, and excellent reproductions of works of art, is a witness to how much richer, not only our external, but also our inner lives have become, through technical achievements that rest absolutely on scientific progress. So, a fruitful stream, bearing all manner of opportunities for intellectual and esthetic culture, flows among the people.

Yet more deeply does science now influence the spiritual life of man. Self-respect[1] has already been alluded to as holding first place among the conditions that make for happiness. No religion can impart this highest good of mankind, this deep harmony which can withstand all vicissitudes of life. This results from the circumstance that every religion is impelled to construct a fixed and permanent standard for all believers out of the mode of thought of its founder. Now the founder must have been able to raise himself far above the level of his contemporaries in order to become such a founder. But it is no less true that he must have stood on the foundation which his time furnished, otherwise he could have had no profound influence over his own age. Herein lies a necessary limitation.

Again, to science we owe our recognition of the evolution of the human species and of its continued foregoing to higher and higher planes of thought and feeling. This recognition involves the corollary that every religion, in proportion as it becomes older, is brought into ever greater contradiction with the science of the present.

Protestantism is nothing else than a four-century effort to accommodate the content of the christian religion to the time, more fully than was possible with the Romish church. This form of religion succeeded, accordingly, for several hundred years in meeting the needs of the masses, but not so completely those of more advanced religious thinkers. Here again the tendency to become outgrown, which is inherent in every religion, became irresistible, and a sense of the conflict disturbed the conscience, alike of the most spiritually minded and of the multitude.

In contrast with this inevitable, inexpugnable, drift toward senescence of all religions, science shows itself of another character, as being eternally young. Since with her no condition, no cognition, is ever regarded as final or unalterable, and since by her all things are subjected to a ceaseless, conscientious criticism, errors may indeed occur, but they can not become firmly fixed. "Inner self-respect," the unshakable determination to tolerate no internal contradiction, is her life's element and the condition of her existence, hence she must, as against death, defend herself against every attempt to limit the right of criti-

[1] The word ''self respect'' is here used to designate a freedom from all conflict between the thinking and the doing, between ''I will'' and ''I must.''

cism, that is, of scientific investigation of anything whatsoever, under the obligation of absolute sincerity. None will deny that science has not always been conceived in this high sense, but the religions have fallen still further short of their standards, because they have not contained the source of self-betterment, which science possesses in the principle of free criticism.

It is of interest to enquire how it comes that most religions place the paradise or golden age in the past, and teach that man has become worse through sin, while science teaches that savagery, cruelty, bloodthirstiness, murder and cannibalism are greater as we go backward in the history of mankind, and points to the future, not to the past, as the golden age. How does it happen that the opposite view has been so general? The answer is to be found in the attitude of the aged toward the time of their own youth. The old, almost without exception, think that the period when they were young was better, the weather more brilliant, the apples more tasty, the bread their mothers made finer, and the boys more industrious than is the case now. This is not difficult to account for on the ground of the impairment of the keenness of all organs of sense and the enhanced habit of criticism which age brings.

The early writers, who presented views on the topics in question, were naturally old men, for the young have but little inclination for such activities. It comes, then, that the attitude of the aged, tinged as it is by the limitations of age, has very often been accepted as representing a historic fact with regard to the past. Ancient literature is permeated with this myth. The influence of it on the religions of the world has been potent. Admitting that the world has become worse, a necessity is felt to account for the supposed fact by assuming the existence of a personal evil agency, to whom was due the introduction of evil. There is in the religions, accordingly, a marked note of pessimism.

The natural world is entirely filled with cruelty, roughness. It is the theater of the wildest selfishness, in which the balance between the beings who people it is preserved only by their devouring and destroying one another. In it only the battle for existence, so well described by Darwin, rules. Man is the sole being we know in nature which makes himself more and more free from the tyranny of this conflict and provides for existence by peaceable work. He alone seeks to heal the sick and to aid the feeble. The results of the good which he does are not restricted to himself and to the recipient, since, as a result of a known biological law, every time such conduct is practised the easier it becomes, not to the individual only, but to all his descendants. That man is most *man* who most consistently practises love and kindness in a world of egoism.

In early times, when mere existence was so hard a task that progress could scarcely be thought of, religion with its fundamental principle of *stability* was the most advantageous form of culture. Later, when the more primitive substructure of civilization had been secured by the fixative power of religion, conflict arose between the practical requirement of self-preservation, on the one hand, and, on the other, the distinctively human thirst for betterment and progress. Furthermore, those classes or individuals which enjoy special privileges or advantages turn to the church as the preserver of the *status quo*. In fact, the church can so act, but only temporarily, until the disproportion between reward and merit has become so glaring that the unprivileged classes will endure it no longer. Retardation of progress leads to revolution. To that extent the church is as naturally the source of revolutions as science is of peaceful development. The church is unable to prevent progress, but can and does suppress the symptoms of progress. This is tantamount to screwing down the safety valve on a steam engine and hiding the steam gauge.

Recent history affords many instances in Roman catholic lands. It is noteworthy that in the protestant countries of northern Europe, the monarchy remains unthreatened, whereas in most of the catholic lands republics have, by revolutionary methods, supplanted the monarchs, Recently in Norway, as the free choice between monarchy and republic was presented to the people, they chose the former.

The foregoing considerations make clear a certain relation between science and religion. The further we go back in civilization, the more valuable we find religion to be. The further we rise in it, the more does religion retire into the background, giving place to science.

Can religion ever become superfluous?

Ostwald's answer to this query is, that one stratum of the people after another raises itself out of the ocean of religious conceptions, and that the movement toward the superfluity of religions is a gradual one, of which it is impossible to predict the date of completion, inasmuch as considerable portions of the human race are on so low a level of cultural capacity as to make it doubtful whether they will ever reach the highest plane. These will surely have a need for religions and will cherish them. In this sense are to be understood the words of Goethe:

> He who has science and art
> Has religion also,
> He who has neither of these,
> Let him have religion.

All religions maintain that the contents of their scripts and tenets constitute the truth, and that no mere human or mundane knowledge can claim this designation, since it is, at best, artificial and confessedly imperfect. On the other hand, the various religions contradict one another, each claiming for itself absolute truth as its exclusive possession in many and important points. Hence follows the conclusion that the claims of the several religions to the possession of the absolute truth neutralize one another and become invalid.

Again, we must turn to human knowledge, and ask whether *it* can lead us to the truth or near to it. Here we find the picture reversed. Whereas, the religious conceptions claiming the truth for their own, separate in course of time further and further from one another (witness the splitting of the christian church into three great branches, catholic, Roman catholic and protestant, and the further schism into innumerable sects) so, on the other side, the laws and concepts which science accepts as true come, in course of time, ever closer together. The rotation of the earth about the sun, stigmatized as false by the dominant religion, was not on that account abandoned by science as a truth. Historically speaking, science has always maintained its stand, while it has ever been the church which yielded to the decision of science, sometimes after long waiting. The most orthodox priest would not now venture to deny the Copernican theory, and would not be seriously taken by his followers if he did.

It can not be otherwise than that science should gradually supersede the religions, when it comes to investigating the truth, for it lies in the nature of the influence exerted by science on the aspect of life. The religions must drop their old concepts in proportion to the measure in which the spirit of science permeates the people.

When man made his first attempt at comprehension of the chaos of the world, the sum of such thoughts, constituting the germs of that which we now call poetry, science, religion, technology, was all put in one basket. The early bearers of the torch of culture were priests, doctors, rulers, judges, all in one. That was quite possible, since the sum total of intellectual possessions was not very great and might find commodious lodgment in a single head. With growing specialization, some of these functions were of necessity delegated to certain classes. The position of first comer and the prestige of tradition long enabled the priesthood to still reserve to itself the functions of government.

The source of the conflict between science and religion lies in the fact that science takes part in the development of the human species and is, herself, the most distinctive and purest expression of this development, while the religions seek to remain as unchanged as possible, although in doing so they condemn themselves to destruction. In consequence of the illusion which always located the golden age in the past, the priesthood never surmised that their attitude was equivalent to suicide, and emphasized just that which must ultimately make their position untenable. When the contrast between the old, cherished by the priesthood, and the new, which life brings, becomes too obvious, the phenomenon known as a "Reformation" follows, as, for example, the reformation of Judaism by Jesus and of Christendom by Luther and Calvin. The only reason why no similar reformation has occured in protestantism is that science has gained such an influence, even within the church, that the latter has accepted progress as a practical principle. So, protestantism advances along the path where science has led the way—at a variable distance. At present, in the whole protestant church, science is recognized as the court of last resort. The church no longer undertakes to say what shall be valid in science, *i. e.*, what shall be true, but, on the contrary, endeavors to keep its doctrines in harmony with the established results of science, or, at least, seeks to show that no disharmony exists.

The root of the irresistible power of science lies therein, that she is, in fact, in possession of the truth. Certainly not of *all* truth, and still less of the absolute truth: but, all the truth which exists in our world is in the possession of science. This possession can never grow less, but is bound to increase.

What is truth? To this question Ostwald replies: Truth is that which makes possible prediction of the future. If a man says he fell down yesterday while alone, it is impossible to determine the truth of the statement, and his story must forever remain in that uncertain limbo where the distinction between true and false is lacking. If, however, he says: "To-morrow I shall go to Chicago," it is perfectly feasible to test the truth of the affirmation by observing the man on the following day.

The lesson taught by the illustration is a general one. In strictness, truth exists only as regards the future, since only in the future can we exercise trustworthy control. Although as to the past we have many witnesses and traces, nevertheless, our conclusion from them has only the character of a probability, and floats somewhere between truth and falsehood, although at times very near the former. The truth of an allegation with regard to the future can, in general, be positively settled. Moreover, we have no interest in the past as such, since we can not change it for better or worse. We can change the future, and it only. Hence, we call that truth which enables us to have a sure influence on the future. Many cases indeed exist where we wish to know the truth about the past, but such truth interests us only in so far as it enables us to exert a defined influence on the future. Whether snow fell on February 3, 1325, on the spot where my house now stands has for me no importance, because for me nothing depends upon it. But if I had information of the qualities of my ancestors for several generations back, it *would* interest me, for the reason that it would give me knowledge of my own mental and moral make-up and assist my self-culture. Self-culture is, however, equivalent to a regulation of my conduct in the future.

All our fellow-men are able to predict the future more or less, in the measure that they possess science. When the domestic lights a fire in the stove of a winter morning she goes through a series of manipulations, which of themselves produce no heat, on the sure prediction that her labors in carrying coal, chopping kindling and striking a match will result in a warm room. When an ocean steamer is to be built at a cost of $15,000,000, the capitalists risk that sum on the prediction of the engineers that if such and such be done, a steamer of well-defined capacities will be the outcome.

We are already in possession of so great a body of truth that no man can know one-hundredth part of that which mankind as a whole has. On looking over the field of what science has accomplished for the amelioration of human life, we are impelled to ask: "How has science solved such problems and conferred such benefits?" Science is the systematized knowledge of the human race. The science which deserves the name is a knowledge of the future. How do we arrive at this knowledge of the future? The answer is familiar.

Science has at her disposal a great number of so-called "laws," that is, knowledge of the interdependence of occurrences. If we know that whenever *A* happens, *B* will follow, we have gained two things. If *A* occurs without act of ours, we can predict the coming of *B* and so arrange our lives that *B* will be as advantageous as possible for us, or as little injurious. On the other hand, if we can influence the coming of *A*, we will avoid *A* when *B* is undesirable, or produce *A* in the reverse case. Science, then, works in two ways. By its help we can prepare ourselves for the future or we can prepare the future for ourselves. Neither of these things is done by man exclusively. All living things have the rudiments of the capacity to see into the future, and even to adapt it to their needs, as, for example, in the case of a certain wasp, which buries along with each egg hidden in the soil, a freshly killed insect, so that the larva may find food at hand. Such primitive forms of conduct directed toward the future do not constitute science; in so much as they are not purposive nor conscious. It is necessary merely to allude to these instinctive acts upon which the existence of a species depends, in order to bring clearly to the understanding the vital importance of science to mankind.

In ancient times work was looked upon as highly undesirable. As a heavy punishment for disobedience regarding the tree of knowledge, the primal curse was imposed: In the sweat of thy brow shalt thou earn thy daily bread. Civilized man has arrived at an attitude toward work quite different from this. To him, a life devoid of labor appears empty and shallow. Those who would wish such a life he regards as contemporaries of minor worth. His high aspirations turn, not toward a state free from labor, but, rather to one in which he may enjoy the happiness of choosing the object of his work and its kind.

Even modern conquerors and despots, that is, those collectors and possessors of giant capital, who in our time are the greatest world-power, are infected with the modern need and impulse to work and, however questionable (or unquestionable) their morals may in other respects be, most of them wear themselves out more in acquiring the source of their dominion than the humblest of their dependents, and for the most part do not cease to strain their mental capacities to the limit in this exacting labor, long after they have amassed fortunes far beyond the most exaggerated possible requirements of the individual.

We perceive that for the man of to-day work has become an instinctive need. We find it difficult to understand the biblical presentation of it as a curse. Herein we have an illustration of a phenomenon of moment to living beings which can be summarized thus: In the course of evolution the necessities of life develop into the happiness of life.

Those beings in whom pleasurable sensations attend the tasks necessary to life will carry on these tasks better and more completely than will others, who are brought to labor only by force of necessity. Hence, in the competition for existence, or in the course of adaptation, such beings are at an advantage, in comparison with the discontented, and have a better chance to transmit their characteristics. Thereby is established a progressive confirmation and intensification of this vitalizing tendency, which gradually becomes a fixed peculiarity of the species. The case is similar with regard to the taking of food. Eating and drinking came to be ranked among the chief ceremonials of men, as a result of uncertainties and irregularities in the food supply. In highly civilized environments the custom survived, along with the sentiments that prompted it, as a consequence of the law of biological inertia, for long generations after the conditions which created it had passed away. Thus, we still punctuate our festivities of various kinds with banquets, during which the festive spirit usually reaches a maximum. Again, the decisive function for the continued existence of a species, reproduction, is safeguarded by a strong development of the corresponding emotions. The mode of life and the character of most of the higher animals undergo marked changes at the time of mating, and we see such animals instinctively make the greatest sacrifices for the preservation of their young. If we ask how it is with man in this regard, we have only to consider the content of art. Ninety per cent. of all poetry relates to love, and the personal experiences of most individuals further go to show that the emotions aroused in connection therewith and the feelings of happiness and misery are keener than any other emotions that affect mankind. In this, some men have a different experience, or express themselves doubtfully. These are the *creative geniuses.* They often declare that in hours of greatest productivity they have a sense of profound or even of inexpressible happiness.

Labor, being a necessity imposed on life, has developed till it has become one of the joys of life. The completeness of this change of feeling varies with the stage of culture of the particular group. Desire for work has become instinctive, more especially among those peoples who have longest been subjected to the urgent necessity to labor. It is, accordingly, largely a matter of climate; and we find that, in general, the instinct to work diminishes from high latitudes to the tropics. This aspect of work appears as a substantially modern conception. In order to appreciate the full significance of the point of view, it will be helpful to turn our attention for a while to an entirely different field; that of physical science. There, the idea of work (and of its correlate, energy) has begun to play a rôle so prominent as to be in fact the center and point of departure of our apprehension of life and of the universe.

In the narrowest physical sense, "work" is exclusively mechanical work, such as that required to move an object. Such work is performed when a locomotive pulls a train or when a man lifts a load. In these cases the work is made up of two factors, first, power or force; second, path or distance. The science of physics teaches us that the work is equal to the power (or force) multiplied by the path (or distance), because the product has the peculiarity that it is equally influenced by a change in either component. If either the force or the distance be doubled, the work will also be doubled. In virtue of measuring work in this precise manner, a very important law of nature is arrived at, called the law of the conservation of work, or energy. The essence of the law is, that by no means is it possible to obtain work out of nothing, but only to obtain one kind of work out of another kind of work, under the limitation that the total work obtained can never be greater than that used to start with.

According to a familiar anecdote, Archimedes declared that if he had a lever long enough and a place to rest it on, he could move the world. He figured that he could increase the force of his effort indefinitely by indefinitely increasing the length of the lever. Every laborer who uses a crow-bar has experimental knowledge of the effect, which, at first glance, seems incompatible with the conservation law. The apparent discrepancy vanishes when we remember that the short arm of the lever moves less than the actuating hand, so that just in proportion as we increase the force do we diminish the distance through which the force is applied; the work done at the short end of the lever remaining the same as that performed by the hand at the long end. Hence, while Archimedes might indeed move the world as he imagined, yet the distance through which it moved would be so infinitesimal as to transcend observation.

In a word, we may say that work is not creatable. We must be content with that which is in the world accessible to us. Still, our whole existence depends on work, in the broader sense. Whenever anything whatever happens, work is consumed, to be transformed into that which distinguishes the new from the old condition. The significance of work, then, is this; it is the bottom principle of everything that happens. In a universe in which there were no work, nothing would happen. *Work alone conquers death.*

When Faust, saturated with the pseudo-science of scholasticism, cries out in despair:

> Geheimnissvol am lichten Tag
> Laesst sich Natur des Schleiers nicht berauben;
> Und was sie Dir nicht offenbaren mag,
> Das zwingst du ihr nicht ab mit Hebeln und mit Schrauben.
>
> (Nature, secretive in the bright day,
> Suffers no man to snatch her veil aside;
> And what she does not care to tell thee,
> Thou canst not force from her by rack nor screw.)

His utterance, in the light of natural knowledge, shows itself to be false. Nature tells man all he asks; only he must have learned to question her intelligently. How can he learn to do that? There is but one answer, through science. Not in ancient parchments, but in the fresh well of experience shall we find the knowledge that we need, which is fruitful and a sure guide.

We have seen that work can not be produced from nothing. But how does it stand with the reverse proposition? Can work be annihilated? The fact is, of course, familiar that in mechanisms of every sort there are seeming losses of work, or of "power" as we sometimes incorrectly call it. This is true, doubtless, but not the whole truth. It is all we knew of the truth till an original thinker, Robert Mayer by name, came upon the scene early in the forties of the last century, who was not satisfied with this meager information. The young physician, on the occasion of a journey by sea to the tropics, was assured by an old ship's officer that the sea-water is always warmer after a severe storm than it was before. This suggestion was enough to arouse in the mind of Mayer a series of questions. Might not the heat be produced by the large amount of work which had been done in raising the waves which had disappeared? The thought looked like an absurdity to the scientific men of the day, but, luckily, there were none of these for Mayer to question, as his ship lay off the coast of Java, and he followed out the line of thought, undisturbed by prejudices. In the steam-engine work is undoubtedly produced. Whence comes it? May not the work it does spring directly from the heat which it must receive in order to run? Work gives heat when it vanishes and, conversely, heat generates work in the engine. Are, then, heat and work things which can be transformed into one another, like two chemical compounds, or are they merely different forms of one and the same thing?

Filled with these reflections and with the conviction that he had attained a deep insight into the nature of things, Mayer returned home, communicated his ideas to friends, and sought to convince them. The mathematicians among them were so affected by the faulty form in which Mayer put his theory, that they would not listen and paid him no attention, even after he had corrected the error. The professors proved no more amenable. One of them remarked, sarcastically, that if that were so, a bottle of water violently shaken ought to become warmer. Mayer, undeterred by the sarcasm, tried the experiment, the result of which is now so familiar to us as to seem almost axiomatic.

We see clearly that in doing mechanical work the *losses* of work, due to friction, result in heat. In a word, friction is a means of converting work into heat, just as a steam engine is a means of converting heat into work. Incomplete machines are those that transmute part of the work into heat, and the smaller this part is, the more perfect we call the machine.

Heat is, however, not the only thing into which work may be converted. It may reappear in the form of electricity, or of light, or of chemical change. All these things, out of which work may arise or into which it may be changed, we now call energy. While the law of the conservation of work has only a limited and ideal application, that of the conservation of energy is a natural law of universal application, without any limitation or exception. If we call those amounts of energy equal which arise from one another, we can, as the result of all experience, express the conservation law in the following terms:

Within a closed system, through whose walls no energy can pass in or go out, the total amount of energy remains the same, regardless of what happens inside the system.

In what light are we to consider this energy? Is it an actuality or a mere figment of thought? The reply can scarcely be doubtful. That which can not be created by any power in the universe, which maintains itself unaltered in amount in spite of all the unnumbered and protean changes to which it is subjected through all the ages, must be the most real thing we can conceive of. All efforts of the adherents of the older view to discredit the reality of energy have been fruitless, so that it is now thought of not merely as a formal thing, but as an essential entity, as a commodity which can be measured, stored, bought and sold. When you have the storage battery of your electric car charged up, and pay for it, what are you getting for your money? The battery is not heavier by the smallest fraction of an ounce. You have not purchased a figment of the mind, nor any mere abstraction, but an absolutely real thing, so many units of energy. You may think of it perhaps as electricity, but this is erroneous, since the charged battery contains its energy in chemical, not in electrical form.

Energy is more than *a* reality. It is *the* reality. No phenomenon, no effect, is anything but a (more or less transitory) manifestation of energy and, as such, is subject to the energy law.

Only ideal machines convert one form of energy exclusively into one other, desired, form. A plant is a machine that uses the rays of the sun directly for building up its body, a thing man can not do; but it is not a perfect machine, since it does not convert all the solar energy it receives to its own uses. From the human standpoint, a plant is a machine for storing up energy of solar radiation in the form of food for man. We have the data for comparing the energy available to the plant with that stored up. The result of the comparison is striking. The plant stores up, in fact, less than one-hundredth part of the energy it receives. The relation between the total energy received by a machine and that which it utilizes we call the figure of merit of the machine. This technical expression is but an extension of a colloquial figure of speech: thus, we call an electric generator "good" if it converts 97 per cent. of energy received into electric current, and "bad" if it only converts 85 per cent. *In the final summing up, the moral concept of "good" and "bad" must unavoidably rest on the same basis, inasmuch as all things that happen are but energy manifestations.*

Every change in the form of energy is accompanied by a dissipation of part of it in the form of heat. This loss may be compared with the material losses, in the way of saw-dust, chips, etc., which accompany the work of carpenter or stone cutter. We may look on the heat dissipated by machines as an undesirable by-product. Actual machines fall far short of ideal ones in their figure of merit, that is in their efficiency, but those made by human hands are relatively much less wasteful of energy than those furnished by nature.

The inefficiency of our practical mechanisms, compared with their theoretical efficiency, is a measure of our stupidity or unskillfulness. In this respect improvement is constantly taking place. All technology is devoted to the conversion of crude energy into forms useful to man. The "figure of merit" in the transformation is a gauge of our culture in this field. Let us consider what is the scope, upward, of technology in the sense referred to. We have not yet quite got rid of the ancient view of *work*, and hence of technical operations, as being something *low*. It is interesting to recall that Aristotle held the institution of slavery, on which the civilization of Greece and Rome rested, to be inevitably necessary for all time, since he could not picture to himself how the crude labor of grinding corn, pumping water and the like could be done at all, if not by slaves. Later times have taught us to solve the slave problem by the inanimate agencies of wind, water and coal, which make superfluous the lowest forms of human labor. In this illustration we see to what a high degree technical progress has had a humanizing influence by reducing the amount of de-humanizing work. Without technical advances, we would have to have slaves to-day, and would still be, in the development of social conscience, ages behind what we are. All the ethics and morals ever thought of never could have effected this. We must eat before we can philosophize!

Of yore, figures of men and women in the sweat of their brows, digging, were a symbol of humanity. The symbol of modern mankind is the man who, by switch-board, steering wheel, or dictograph, expends enormous amounts of mental energy with but trifling muscular effort for the attainment of his ends. This elevation of man from the level of the ox to that of a higher being, who controls absolutely amounts of energy thousands of times greater than that represented by the muscles of his body; this is a great ethical gain which we owe exclusively to technology.

We may also find ethical applications of the idea of "figure of merit," or the efficiency relation. Jesus said of Himself that He came to bring peace into the world. Unfortunately, in the outcome, the sword was more prominent than the dove, and the church, as such, did but little for the realization of the idea. However, the perception that warfare involves an immense waste of energy, both in actual war and in armed peace, is a view destined to be of decisive effect.

To be delivered from waste of energy is to be delivered from evil. Take the most abstract of the sciences, philosophy, and the most abstract branch of it, logic. What can *that* have to do with transmutation of energy or with improvement of efficiency? Logic has for its subject the laws of thought, and for its object the avoidance of defective thinking. Let us suppose its object so far attained that only very few individuals are any longer guilty of drawing incorrect conclusions. Who can estimate how colossal is the waste of energy which would be spared if men almost invariably thought correctly, and were accordingly noble and virtuous in their dealings? In that happy state, all those energies now expended for judiciary, for punishment, for police and for government, would be set free to use for higher ends.

Ostwald emphasizes the ethical side of all these considerations and condenses the whole into a principle, called by him the energetic imperative, valid in all phases of our lives, technical, intellectual, ethical; as follows: "*Waste no energy, use it!*"

We know energy in two states or conditions. In one it is free to do work, or to be transmuted. In the other, it is in a dissipated state, like a cup of water poured in the sand, and is not available for use. It we call "bound energy." We are, then, expressing the facts of observation in saying, "any given amount of energy consists of two parts, free and bound."

Now, in every process of any kind, a portion of the free energy becomes bound, but never does any part of the bound energy become free. Everything of which we have knowledge as happening is subject to this law. Hence, the utmost limit of human achievement is, that we should seize a part of this ceaseless river of free energy (mainly from the sun) flowing by us to the sea of dissipation, and divert it to human uses. We can never increase its amount, but by ignorance or maladroitness we may waste or destroy some of that part which is available to man, by facilitating instead of reducing its dissipation. Each of us is, then, made a trustee of that single working capital, that foundation of our collective possibility of living, and his value to mankind is measured by the proportion of total free energy that he takes from the general stream and applies to the benefit of the race. If, however, by carelessness or misuse he allows the free energy which is under his control to become dissipated, he is guilty of a crime against the general welfare which can never be made good; because dissipated energy can never again be converted into free energy. It is the sin against the energetic imperative and has the qualities of unforgivability and irrevocability that have been ascribed to the sin against the Holy Ghost.

The rule of natural law is much more "humane" than that of man-made law, although infraction of the former is indeed punishable, in so much as the life of each individual is rendered more arduous and unpleasant in proportion to his aberration from the natural laws of vital phenomena. But these laws are not something imposed from without. They form part of the very texture of his being. He only needs to see himself rightly, to be impressed, not only with the inevitableness of natural laws, but with their desirability. The law that a straight line is the shortest distance between two points does not trouble us, since we do not have to go that way unless we prefer it. But we have every ground for satisfaction that we know this law and have since early childhood learned its practical application, for this knowledge enables us to reach our destination by the shortest path and so puts us in a position to act in harmony with the energetic imperative and to visit our friends without undue waste of energy!

Ostwald states that he learned not to force himself to work when he did not feel inclined toward it, and so accomplished much more in the end, because there was no waste of energy in overcoming the resistance of disinclination; and argues that the aim of our practical social ideals should be, so to arrange *all* labor as to conduct it in like manner. This would conduce to the greatest happiness of the greatest number, and all would be working to the greatest advantage, since working voluntarily.

The energetic imperative requires, in fact, that we should remove out of our lives and those of our fellow men every compulsion, every opposition to individual preference so far as is compatible in any way with living together.

To the scientific man, natural laws are not commands, but guide-posts, whose purpose and use is to show him the way to a truer and fuller life and to inner content; and he can not fail to desire to see the social order conform to this type so far as possible.

The ethics of the New Testament is generally and rightly thought to attain its climax in the injunction: "Love thy neighbor as thyself." One is nevertheless compelled to ask whether *love* can, in fact, be the subject of a command or an injunction. *Love,* is it not the freest and most personal thing there is? The natural philosopher must recognize the existence of an incompatibility here and change the content of this conception as science has changed the concept of law. A natural law is not a prescript, but a transcript, a simple statement of how things actually are. So, in the ethics of science, the doctrine of the conduct of man toward man must have, not the character of a juridical law, but of a natural one, one which shall inform us, which shall instruct us, as men among men, how we can live a peaceable, efficient and happy life. And if, perchance, on this path we meet love, it will come to us not as a thing prescribed, but as an incident and as the most natural, inevitable thing in the world. The road that leads from an insight to a sentiment is often long, but education helps, self-education in case of the more competent; for the rest, education of the children's school type. But by opening our eyes we can find love already present without either command or education. First of all, self-love, in every living being. Not by the most exacting ethics will self-love be objected to, so long as each individual is isolated from the others. But under these conditions there can be no ethics, in the widest sense. When the life lines of two beings cross one another, conflict begins. It is the conflict for existence, in which there is no ethical content whatever. On the contrary, it is the direct source of that which we call evil in the world. Simultaneously therewith good also begins to appear.

Deep is the riddle that comes with life, for with life comes the function of reproduction, so that through the activity of each individual a second enters the field, which is to the first a competitor and an enemy. To ensure perpetuation of the species, each being of the species must, through its offspring, contribute to the keenness of the competition which he himself must contend against. A strange situation!

Further, the functions involved in the perpetuation of the kind are bound up with a complex of instincts and feelings that exceed in power all others, even the love of life. In the simplest organism, consisting of a single cell, reproduction takes place by division of the cell. There are now two beings where there was one before, but it is impossible to say which is parent and which the offspring. If they were self-conscious, we may well imagine that they would learn only by experience that they had become two. Something of this sentiment of identity is to be seen in the feelings of the mother toward the young, in the higher animals and in man. The most elementary form of love is that of the mother toward the child, and it is a direct development from self-love. The cat-mother who defends her kitten with her life, later shows toward it an increasingly unfriendly attitude. With decreasing dependence of the young life there is a diminution of parental love. Among gregarious animals that find an advantage in living in groups, the affectionate relation lasts much longer, but the change finally comes.

Here the sources of love lie open before us. Parental love is an elementary phenomenon, resulting in the passing of the instinct of self-preservation from the individual to the species. From the same source arises sexual love and also the bond between members of a family, which makes each ready for a measure of self-sacrifice for the protection of the others. From the family to the tribe, from the tribe to the race, from the race to mankind, the same process extends and develops, and this development is equipollent to and largely identical with the growth of ethics.

The energetic imperative enters again here. If we ask why a family or a group of animals or, specially, of men, hang together, the answer is that it is to their mutual advantage, because it brings in numerous ways an economy of energy in the securing of shelter, food and defense. As soon as the group is formed, the conduct of each member must adapt itself to the requirements of the group. Those whose behavior is most beneficial to the group are highly esteemed and their demeanor becomes a pattern for others. Those who have not modified their individualistic instincts to harmonize with the standards of the group are treated worse, or may even be punished or turned adrift. Often one member of pronounced individualistic instincts appears, who combines therewith great abilities and personal force. He may subordinate the others and compel them to serve his personal interests. The condition thus created, if it continues long enough, gives rise to an ethics in which obedience to the ruler appears as the greatest virtue, and opposition to his will as the most heinous offense. Out of this condition, according to our author, grows the type of morals presented by the higher religions and summed up in the injunction, love God above all and thy neighbor as thy self. This is the moral system of an oppressed folk, who give to Cæsar what is Cæsar's and who contrast their joyless lives on earth with the higher existence hoped for early in the future, for which they seek to prepare by the exercise of love toward those who are to be their fellows for all eternity. Ostwald lays stress upon the point that the foundation of this morality has been shaken by the fact that the kingdom of Heaven, expected so soon, has not as yet put in an appearance.

The demands of the present will, however, not be denied, and under their pressure a new, unacknowledged morality has arisen, containing the living elements of the old, adapted to the changed environment of to-day.

As for love, it is an instinct which has grown to be a moral necessity—a social compulsion that has been so fully absorbed into the individual consciousness as to assume the character of love. Rephrasing the old injunction, to meet modern needs, we find the new form of the ethical ideal to be:

> Love thy neighbor in proportion to his social worth.
> Love thy people and mankind more than thyself.

The crux and point of departure of Ostwald's ethical views, as may be perceived from the foregoing exposition, is to be found in the tacit assumption that the activities of mind are but variants of energy, in the sense in which this term is used in physics. It is, then, strictly comparable with the phenomena of electricity, of heat, of matter in motion, and must be intertransmutable with them, as they are with one another. If the assumption is valid; the principles of thermodynamics are applicable in the domain of Mind and Ostwald's philosophical edifice rests on a solid foundation. If it is not valid, his entire line of argument is reduced to a reasoning by analogy.

Let us then ask, whether the deductions from experience that we call "laws of thermodynamics" are such as to necessarily include *all* forms of energy or only those which we have learned to measure, as chemical, electrical, mechanical or thermal energy. The latter we can, and do, quantitatively determine. When a phenomenon involving them occurs, we can measure the exact number of units of each energy-form present both before and after the phenomenon and, by doing so, we know that the sum of these units previous to the phenomenon is equal to the sum of the units after, although the relative amounts of the different kinds may have greatly changed. This is the essence and substance of the positive knowledge from which the theory of thermodynamics has, by logical methods, been deduced.

If we use the term "energy" for powers that are not quantitatively determinable, that we can not measure in so and so many heat units, we should make it clear to ourselves that we are applying it to something that may, or may not, be identical with the "energy" known to physics. Its identity remains to be demonstrated.

At present, it is difficult to conceive by what experiments the "energy" represented by any logical process or by an emotion of love, hate or fear, could be measured in units of heat or electricity. It is, in fact, so difficult as to arouse a strong suspicion that intellectual and emotional manifestations of mind are something else than forms of physical energy. But, whether or no this suspicion corresponds to a "truth," it is certain that no one has yet affirmatively shown that such phenomena are subject to thermodynamical laws and, until this *is* shown, the reasoning of Ostwald, highly interesting and suggestive as it is, can not be held to be without logical flaw.

THE NORMAL CHILD: ITS PHYSICAL GROWTH AND MENTAL DEVELOPMENT

By Professor BIRD T. BALDWIN
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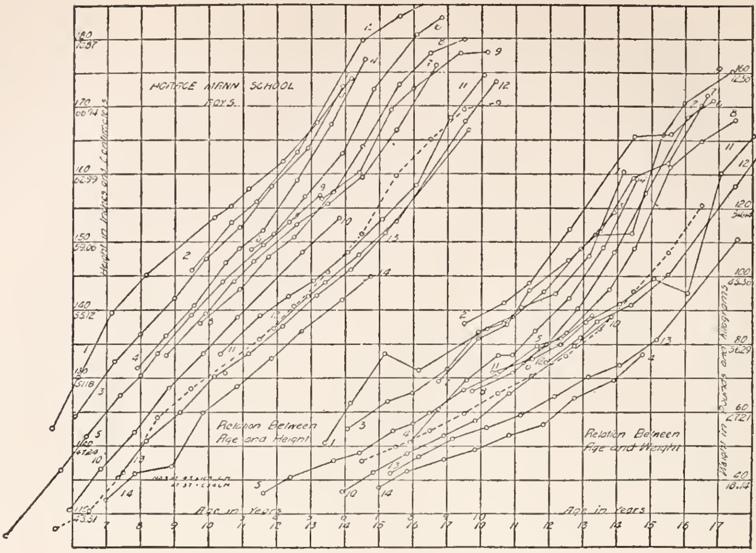
FOR purposes of psycho-educational analysis it should be recognized that a child has five parallel or interrelated ages: a *chronological age* in years, months and days, denotive of the temporal span of life; a *physiological age* denotive of stages of physical growth and maturity; a *mental age* denotive of the ripening of certain instincts, capacities and mental traits; a *pedagogical age* denotive of the rate and position in school progress; and a *moral age* denotive of fairly well-defined nodes of development in moral judgment and religious awakenings. In a normal child these ages balance each other.

This paper presents the results of a study of the physical growth (physiological age) and the pedagogical age (school standing) of a group of boys and girls from six to eighteen years of age when observed consecutively. The chief value of the study lies in the fact that it is the first attempt to follow for any considerable length of time the same group of individuals through the elementary and high schools, either in physical growth, school standing or the relation of the two.

The scope of the investigation includes, first, a series of norms based on the height, weight and age distributions: the average and average deviations of individual yearly and half-yearly increments of growth in height, weight and lung capacity; and individual curves in height, weight and lung capacity with health notes, and weight, height and vital indices. The second part of the paper deals with the school standing of the same individuals in marks, grades and ages; the third with the relation or correlation of physical growth to mental development as shown in school progress. The data comprise 43,840 measurements on approximately 1,000 boys and 1,000 girls, and 21,683 final quarterly term marks for 135 of these same boys and girls from the Horace Mann School at Teachers' College, New York, the University of Chicago Elementary and High Schools and the Francis W. Parker School in Chicago.

That these boys and girls form a select group and that school-medical inspection, directed play and physical training are important educational agencies are shown by the fact that on the average these children are taller, heavier and have better lung capacity than any other group in a series of 112 groups extending from Quetelet's first study in 1836 to 1914, and comprising over one million individuals.



HEIGHT AND WEIGHT CURVES. BOYS.

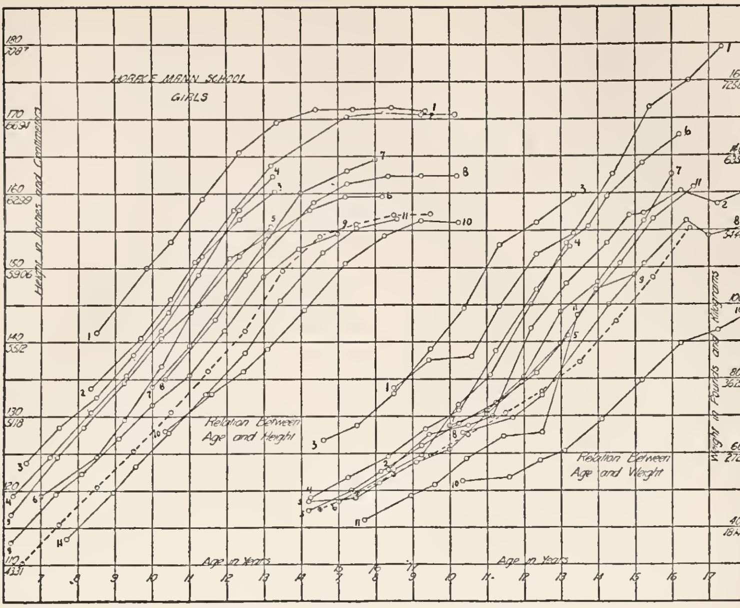
The base line divisions represent periods of one year; the vertical divisions represent 5 centimeters in height and 10 pounds in weight. The degree of pitch of the line shows the relative amounts of increase of absolute increments for the same individual. The broken line shows Boas's norm.

In reply to the question how tall or how heavy is the normal child within this group, and how much lung capacity has this child, the distribution tables give the following medians in inches, pounds and cubic centimeters, respectively.

	8 yrs.	10 yrs.	12 yrs.	14 yrs.	16 yrs.
Height: Boys	50.3	53.5	57.1	60.9	65.7
Girls	49.2	53.0	*57.4*	*61.8*	62.9
Weight: Boys	57.2	67.2	76.8	96.1	111.8
Girls	51.3	65.5	75.4	*102.6*	108.8
Lung capacity: Boys	85.6	110 6	134.0	162 5	212.6
Girls	81.8	100.9	128.9	150.2	176.2

For the boys and girls below the median or normal height, the period for accelerated growth in height, weight and lung capacity is later than for those above and the growth continues longer. This is true of the schools individually and collectively for yearly and half yearly increments, and for the per cent. of gain over the initial measurements. In conclusion the nodes of acceleration or cessation are different for tall children and heavy children than for short and light children.

In answer to the question, "What relation does the growth of any one age or period have to subsequent ones?" it can be said that the per cent. of gain from year to year shows that each child remains practically

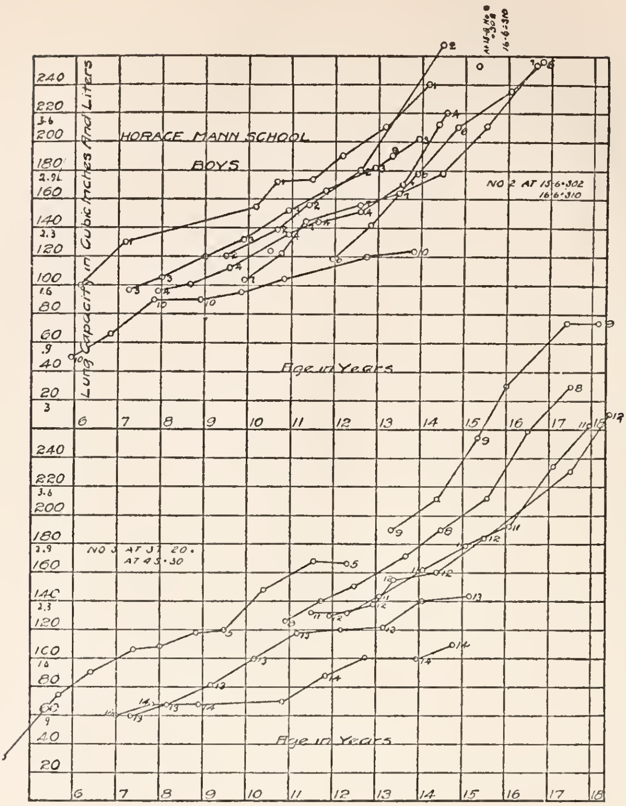


HEIGHT AND WEIGHT CURVES. GIRLS.

within its percentile group. Aside from the height and weight curves in 1890 for Dr. Weiner's four boys, no long series of curves have been available in scientific literature. Taking at random 170 individuals and plotting their curves for height, weight and lung capacity, we have 510 such curves for comparison.

In carrying out comparisons graphically among forms so dissimilar in absolute size as those of height, body weight and lung capacity, it was thought best to use the following units. In the height and weight curves the same base line division of 20 millimeters equals 12 months in age, while for the ordinates or vertical lines 40 millimeters equal 20 centimeters in height and 10 millimeters represent 20 pounds in weight. In the lung capacity charts a base line division of 15 millimeters is used for 12 months in age, and in the vertical or ordinates 10 millimeters represent 20 cubic inches in lung capacity. The original charts have been reduced in size and the millimeter lines taken out. The black lines represent distances of 20 millimeters on the height and weight charts and 15 and 10 millimeters on the lung capacity charts. The same Arabic numerals in a chart refer to the same individual.

Short children do not become tall, neither do tall children become short, under normal conditions. The per cent. of increase in height increments over the initial heights for a given chronological age from 6 to 18 is so comparatively uniform for each normal individual that the growth curves enable us to prophesy with considerable accuracy how tall a child of normal growth should be at any subsequent age within the



LUNG CAPACITY CURVES. BOYS.

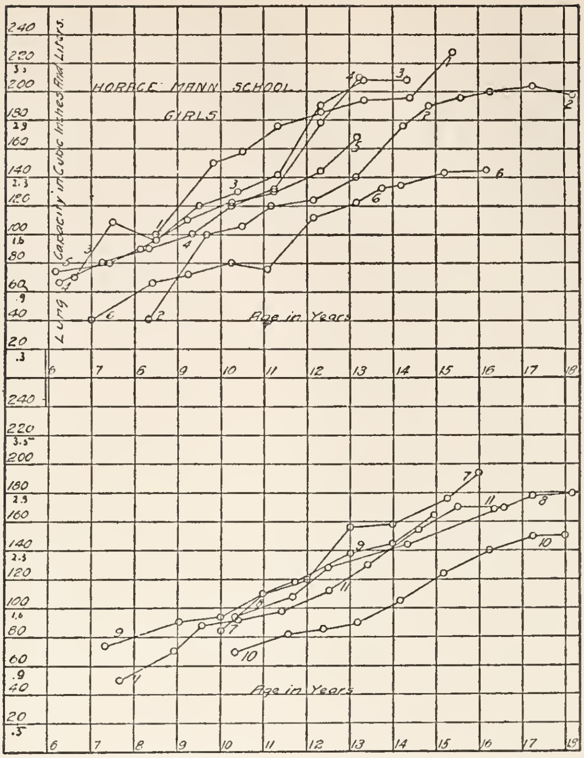
The base line divisions represent periods of one year; the vertical divisions represent 20 cubic inches in lung capacity. The degree of pitch of the line shows the relative amounts of increase of absolute increments for the same individual.

interim, provided his relation to any given median or norm be known.

The second significant point to notice is the relative shifting of the period of adolescent acceleration from 12½ for the tallest boy (No. 2) to 16 years for a short boy. For the tallest girl maximum height was attained at 14½ and for the shortest girl at 17 years, 3 months.

A period of marked retardation before adolescence is usually marked by a period of rapid acceleration during adolescence. If the increment of growth before adolescence is uniform, this uniformity tends to persist throughout adolescence. Where there is unusually rapid growth from 7 to the beginning of adolescence, there is frequently a decrease during adolescence. Marked arrests with these children usually occur during adolescence and persist throughout the period.

As a rule the weight and height are relatively proportionate to each other. Aside from irregular periodic fluctuations in height, each child retains relatively its position throughout childhood in regard to weight.



Lung Capacity Curves. Girls.

One of the most useful and practical indices of growth is the weight-height coefficient, which expresses the comparative solidity or robustness of the individual, and therefore, other things being equal, his general nutrition.

The lowest ratio in this group of boys is .15 at six years, and the highest .40 at 17½ years of age. There is little or no apparent difference, as a rule, between the tall boys and the short boys, except that the acceleration begins earlier for tall individuals. For example, if we take 0.23 as representing a given physiological stage of development, it will be noted that the time shifts chronologically in a fairly uniform manner between 7 and 8 years of age with No. 1, to 14½ years for No. 14.

It will be noted in the boys' lung capacity curves that No. 9 in the first chart, who is relatively heavier than the others for his height, also has more lung capacity. This is significant since the other boys hold approximately their relative places for height, weight and lung capacity.

The boys have greater lung capacity than the girls, on an average, for all periods except at about 13 and 13½ years of age. The development in lung capacity for girls about comes to a standstill or decreases after 15 years of age; for boys the period is some time after 17 or 18. Marked arrests in height and weight are uniformly accompanied by arrest in growth of lung capacity. The boys and girls above and below median height differ in their periods of accelerated growth in lung capacity in a manner similar to the differences in height and weight.

In general it may be stated that there is more marked relationship between disease or physical defects and growth in weight than growth in height. Diseases seem to inhibit growth more during the late period of childhood than earlier. Accelerated growth and resistance to disease go hand in hand. The inception and removal of adenoid growth materially affect physical development.

Selecting the individual growth curves of the girls whose physiological changes have been recorded day by day during the periods of maturation, it is evident that the taller girls mature early.

Height and weight, therefore, offer excellent objective criteria for teachers and parents for determining the advent of menstruation as a factor in pubescent development and the onsct of maturity. If the girl is tall, healthy and well nourished, this physical stage may be reached as early as 11 years in a normal girl; if tall, but underweight, it may be delayed; if very short and markedly light, it may be delayed until 16 years of age.

These conditions have wide educational application both in physical training and school work. They emphasize the fact that the smaller child should be treated as a younger individual, who has not the physical development and the accompanying mental disturbances and experiences which would seem to be indicated by her chronological age in years, and which, too often, has been used as a basis of classification, training and social activities.

It must bc recognized, since we are investigating the school standing or pedagogical age, and since promotions are based on marks, school records must be taken at their face value, because they represent school practise and because they offer tangible criteria of the efficiency of the individual and of the school.

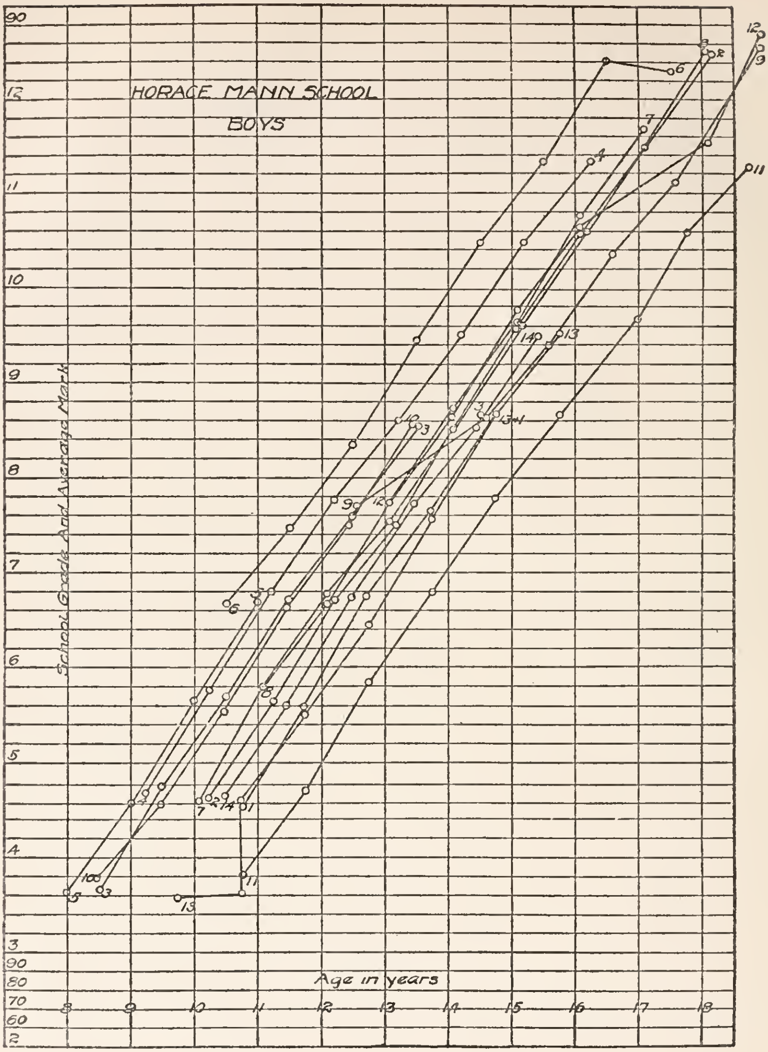
If we accept progress through school when measured by marks, age and grade distribution in highly specialized schools, as criteria of mental development or at least indicative of nodes of mental maturation, we have in this section of our discussion 135 individual pedagogical curves based on 21,682 final term marks in the common school subjects, music and deportment. The average school mark for the Horace Mann boys is 81.9 per cent., for the girls 85.9 per cent., for the Francis W. Parker boys it is 77.7 per cent., and for the girls, 80.9 per cent.

Some of the main facts are: Girls maintain a higher school standing than boys; there are also more repeaters among the boys; and fewer cases of skipping a grade. In the fourth and fifth grades the boys and girls are approximately the same age, but in the last year in high school the boys are older on the average.

Expressing these tables in school standing in graphic form where 20 millimeters in the horizontal equals one year in age and 30 millimeters in the vertical equals one school grade, the two variables, age and school grade, may be expressed in the form of a continuous line. A third variable, or the average mark for each grade, may also be expressed, assuming the first 6 millimeters in the vertical within a grade to represent a standing between 50 and 60 per cent., the second 6 millimeters, between 60 and 70 per cent.; the third, between 70 and 80 per cent.; the fourth, between 80 and 90 per cent.; and the fifth, between 90 and 100 per cent. Thus it will be noted in the chart that the uppermost curve represents the most precocious child and the lowest curve the most retarded from standpoint of age and grade. No. 6 is the most precocious from the standpoint of age until he reaches 16½ years, and No. 11 the most retarded throughout his school life. On the contrary, comparing the average marks within the grade, No. 11 has higher marks than No. 6, as may be seen by noting the height of the circles in each grade.

Pupils who are relatively poor in the first few grades are relatively poor in the upper grades; that is, poor marks in the early school course are indicative of low standing throughout the school course. Boys and girls of normal school age or under maintain a better school standing, both as to grades and marks, than those over age for grade. The age of entrance after six or seven years determines the age for completing the elementary and high school. With very few exceptions these children progress through the elementary school at the rate of one grade per year, regardless of the chronological age at entrance.

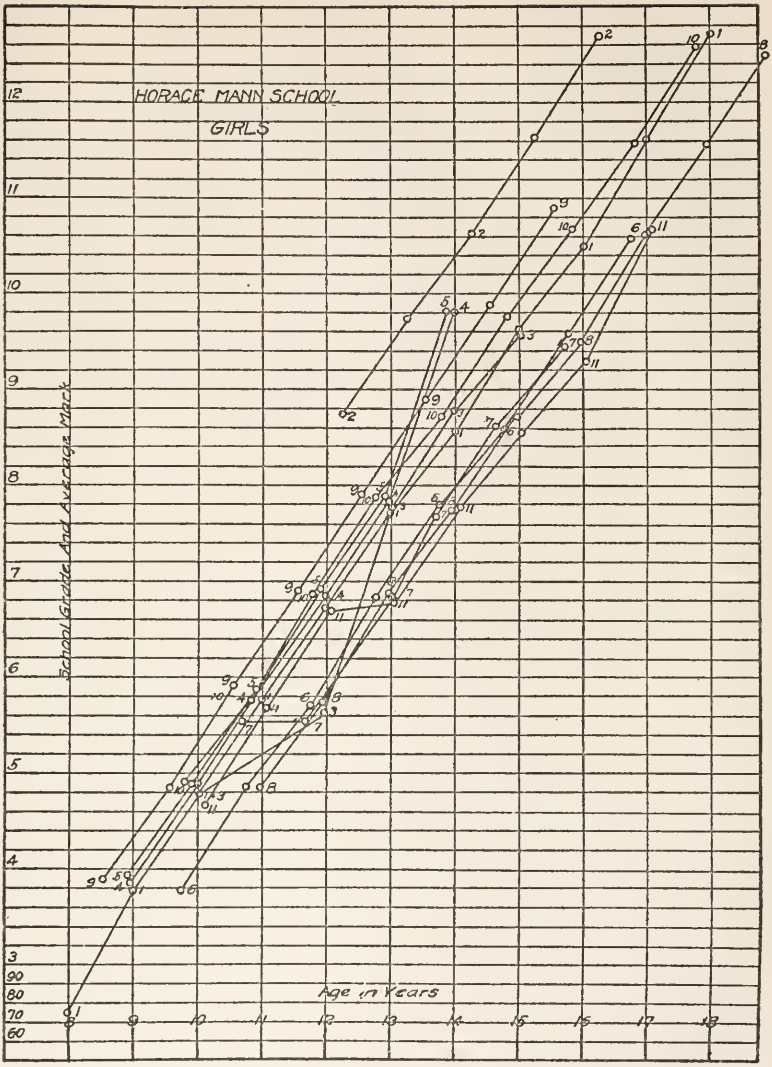
What is the relationship between these two? Accepting the pedagogical age as a fair equivalent of mental development, the first noteworthy fact of general significance is that among these children those of normal school age or younger maintain a better school standing both as to grade and mark than those age for grade. These are the physiologically accelerated or normal pupils. Those above median weight complete the last grade of the elementary school at 12 years, 9⅚ months of age with an average of 84.35, and those below average or of retarded physiological development complete the elementary school work at 13 years, 7$\frac{4}{12}$ months of age with an average of 81.72 per cent. Checking the individuals whose curves have been plotted for age, height, weight, lung capacity, school grade and school mark, and giving the results graphically, it may be seen that the majority of children above median height are in or above normal grade and above the average in marks. Of those below median height the majority of children are below or in normal grade and below average mark.



School Standing Curves. Boys.

The base line divisions represent one year in age, while five of the vertical divisions equal one school grade. The average mark for each grade may be determined by assuming that the first division of the grade represents a standing between 50 and 60 per cent., 2d between 60 and 70 per cent., 3d between 70 and 80 per cent., 4th between 80 and 90 per cent. and 5th between 90 and 100 per cent. The degree of pitch of the line shows the relative amounts of increase of absolute increments for the same individual.

The main educational corollaries which logically follow from this study would require that our school systems, public and private, be graded on the *physiological age and the accompanying stage of mental maturity* of boys and girls in place of the chronological age, as is now



SCHOOL STANDING CURVES. GIRLS.

done. This would require that tall healthy children of accelerated physiological age be encouraged to proceed through school as rapidly as possible within the limits of thoroughness, and that the small light children of retarded physiological development be kept below or in the normal grade doing supplementary work, *since these short light pupils are immature in mental development, although in many instances precocious in brightness.* It also follows from the study that rapid healthy growth favors good mental development, and therefore the healthy growing child should have plenty of physical and mental exercise.

COMMON FACTORS IN MENTAL HEALTH AND ILLNESS

By Dr. F. LYMAN WELLS

McLEAN HOSPITAL

Denn sie hatte,—wie die meisten Menschen,—nur die Wahl zwischen Tobsucht und Ergebenheit.—*Simplicissimus,* 18, 661.

I AM asked to deal in these remarks with variations in different human traits which are produced by pathological conditions. For example, although in health John's eyesight is sometimes better or worse than at others, yet John's eyesight is so consistently better than James's that we speak of John as having better eyesight than James. But John's eyesight might become much worse as the result of a central lesion, and, if it remained fairly stationary at its new level, John would have much worse eyesight than James as the result of the pathological condition, and a new individual difference would be produced. The psychoses of which we shall speak, however, do not act in altogether this way. The differences associated with them are not sufficiently stable at any one level to make it just to say, *e. g.,* that a *general paralytic* has on the average one half the memory capacity of the normal. We can therefore speak of the kind, direction and limits of such changes, but not of their amount as representative of any clinical group.

It is one of the gentle ironies of scientific history that the concept of individual differences should have originated with one of its least significant functions. One must needs be the assistant of a pre-Galtonian astronomer to suffer for his simple reaction time. This fact, together with the necessary technical complications, has not encouraged the accumulation of pathological data on the "personal equation." The most important determinations are those of Diefendorf and Dodge, on the reaction time of the eye-movements. They found lengthened time in all the psychoses tested, slightest in the *manic-depressive excitements* and in *dementia præcox,* most marked, as would be expected, in *manic-depressive depression.* The angular velocity of eye-movements was found by these authors to be somewhat more rapid than normal in *dementia præcox, general paralysis,* and slightly also in *manic-depressive excitement,* while the slowest movements were seen in the *depressions* and in *epilepsy.* The generally quick movements of manic cases and the slowness of depressed ones are a clinical commonplace.

The rapidity with which some small movements can be repeated has a special neurological meaning, and many observations have been made with the psychoses. The rate is probably a little faster than the normal in *manic* cases, but if anything more fatigable. It is much slower in the *depressed* phase of the psychosis, and increases somewhat as it is kept up, and the retardation is partially overcome by the continued work. E. K. Strong has recently followed this and other functions through different clinical stages of the disorder. Nothing particular has appeared in the other psychoses, save that in terminal cases of *dementia præcox* a disorganization of control is sometimes seen, similar to what appears, and would be expected, in coarse nervous lesions. W. G. Smith found a rate averaging a little above the normal in *epileptic* cases, owing to a notable persistence of speed.

The most psychologically interesting observation of choice reactions is that of Franz, in which the psychomotor retardation produces a longer simple than choice reaction time, owing, apparently, to a greater overcoming of retardation in the more complex process. A similar finding is reported by Marie and Vaschide.

The tremors of the "steadiness test" play no part in mental pathology outside of the coarse nervous lesions. Defectiveness in the speech movements, where it is a real defect and not a mannerism, is usually also produced in this way. For the same considerations as apply with the eye-movements, accurate registration should enhance their diagnostic significance. Something of the sort has already been reported by Scripture in reference to *epilepsy.*

A number of fairly definite motor phenomena of the psychoses ought to be mentioned, though they have not been brought under experimental control. Retention of the limbs in positions where placed is most common in *dementia præcox* states, but is also seen in extremely retarded cases of the *manic-depressive* type, where it has been psychologically interpreted as an extreme ideomotor perseveration. Closely allied to this is the type of motor disorder in *dementia præcox* known as "waxy," or *flexibilitas cerea,* in which the limbs are movable from one position to another like those of a wax figure. On the other hand, the resistiveness may be of the spring type, the member strongly resisting displacement, and at once returning to its original position. Extreme motor stupor combined with mental alertness is also met with in this psychosis; while the stereotypy and mannerisms of normal life are often tremendously exaggerated in it.

There is a good deal of ground for suspicion that these phenomena are far from motor in the sense that they originate at the same levels with tremors or reflexes. Thus in some cases the resistance to pressure is begun in anticipation of the pressure, and, if, for example, a finger nearly but not quite touching the forehead be slowly drawn away, the patient, resisting the suggested pressure, may bend forward until equilibrium is lost. There is more likely an ideational element in such phenomena, and like their counterparts that we shall see among the higher mental processes, they are obscurely purposeful. So also are the impulsive acts of *dementia præcox* as compared with those of *general paralysis.*

The psychology of feeling is one in which the standpoint of individual differences has played very little part. The field is both tempting and difficult, and there has been the least progress in proportion to the experimental work done in mood and emotional reaction. Common observation shows that there are true individual differences, and for the adaptation to life, these differences are of paramount significance.

In many of the psychoses, the mood and emotional reactions are markedly and fundamentally altered. Heightened emotional sensitiveness, or lability of mood, is especially characteristic of *exophthalmic goiter* or *Graves' disease.* The source of intoxication here being internal secretion, it is a noteworthy illustration of the interdependence between mental activity and various extraneural processes. Functional atrophy of the thyroid gland is accompanied by a converse picture showing dulness and stupor, and with generally opposite symptoms, both physical and mental, to *Graves' disease.*

Still other psychoses are characterized by feelings of exaggerated well-being. The *manic excitement* shows a typically active exhilaration, often with no apparent diminution of intellect, manifesting itself as we should expect to see it manifested in an exaggeratedly happy normal person, with dancing, singing, jibing, half-jocular overestimations of one's powers and the like. Another phase of the *manic-depressive psychosis* shows a sort of mute transport, or silent ecstasy, in which it is very difficult to get at the mental content at all; it is termed the *manic stupor.* The most genuinely beatific state of mind that is maintained in terrestrial relations is probably seen in *general paralysis;* a state of easy-going, beaming euphoria, which the patient himself has no words to describe, but which finds some expression in grandiose but feeble delusions, scarcely if at all reacted to, as that he possesses countless millions, is king of the world, the super-god. It is interesting to note that this unitary disease process is associated with a great variety of mental pictures, sometimes with melancholic symptoms instead of the euphoria.

Simple, persistent depression of spirits is not a normal mental reaction to any external cause, but it is a most common reaction of the psychoses, where it is classified with the *depressed* phase of the *manic-depressive* group. This is the correlate of the *manic* condition above mentioned, sometimes alternating with it; though alone, it represents much the more benign process of the two. As in exhilaration, a number of delusions may arise secondarily to the emotional condition, which here favors depressive or persecutory interpretations of the events about one. These ideas are generally superficial and changeable; there is quite another origin for more fixed and elaborated delusions, as we shall see.

As in normal life we notice that some people are quiet when they are depressed, and others agitated, so here we have very agitated as well as retarded or even stuporous melancholias; the latter especially in younger people. All forms tend towards suicide, and as the condition is not necessarily accompanied by any of the features popularly associated with mental derangement, it happens that many, perhaps the great majority of suicides are allowed to occur in this way.

The underlying mood regularly influences the emotional reaction to the environment. So while we contemplate with gladness the signs of returning spring, the melancholia is more depressed by them. It is also a law of normal emotion that a mental process with strong emotional reaction tends to endow with similar emotional value any mental process with which it stands in close association. Thus if we witness a very harrowing accident on a certain street, it is not pleasant for us to pass down that street next time—we may even pass down another street, though it is no safer to do so—and what is most important, the unpleasantness of passing down this street can exist whether the memory of the accident comes into consciousness or not. Such transfers of emotional reaction are worse than useless in life, and the personality much subject to them soon ceases to be "normal." In psychopathology it has long been observed that incoordinate emotional reaction—the "intrapsychic ataxia" of Stransky—particularly characterizes the mental pictures of certain neuroses and of *dementia præcox.* The psychogenic origin of these "ataxias" in normal life is clear enough, and in these disorders it can be traced sufficiently well to make it improbable that any new process is involved. The connection is often bizarre, especially in *dementia præcox.*

Although it is far from the most difficult of psychopathological questions, but little knowledge exists on the subject of the speed of the higher mental processes beyond that afforded by clinical observation. Many of its basic problems are scarcely touched. Thus we do not know whether mental time in *manic excitement* is quicker than normal, and if it is, at what level of the nervous system the difference lies. The elementary process of addition has been found to be somewhat more rapid, at least at first, in *manic* than in normal individuals, but how far this is gained at a sacrifice of accuracy, or whether staying power would be as good as normal, does not appear. There is no question however, of a specific slowing in the case of the corresponding *depressed phase* of the psychosis. We have spoken of it before at the motor level, and it can pervade the entire mental system. Clinically it is here known as "thinking difficulty," and is shown by general delay or loss in responses that require mental effort. It may simulate a memory defect. The normal range of about 2:1 in such processes is thus indefinitely extended.

In other mental diseases these questions scarcely apply. Thus we do not speak of a characteristic psychomotor retardation or acceleration in *general paralysis, arteriosclerosis,* or *dementia præcox.* Only in the case of immediate drug intoxication has a stimulating effect been attributed to such poisons as alcohol, morphine and cocaine. Experimentally, the effect of alcohol seems to be to remove inhibitions, so that there is greater freedom of motor response. Many premature and false reactions occur. Morphine and cocaine are too dangerous for experiment, though both may be taken with the idea of temporarily stimulating the mental powers. The former does appear to bring about a certain facilitation of the thought processes, its effects being in some ways opposite to those of alcohol.

The range of normal variation is so great that few abnormalities in the association experiment can be attributed to pathological conditions except with knowledge of the subject's normal reaction. The rather stable character of the association type through normal life makes its fluctuations through the psychoses of considerable significance; but the individual differences there are of very doubtful interpretation. It is scarcely evident that there are features of themselves characteristic for different psychoses except in *dementia præcox,* where irrelevancies, neologisms and stereotypies are frequent in the presence of good appreciation of the experiment. "Narrowing of mental horizon," according to Kent and Rosanoff, is prominent in grave neural disorders such as *epilepsy* or *general paralysis.* Nothing approaching specific alterations has been observed in other psychoses. It is certain that normal performance is not incompatible with severe *manic-depressive* states; and the marked tendency to unusual associations—the prime feature of the psychoses in general—occurs also in personalities that are distinctly better than the normal average.

There is no clinical entity among the psychoses in which memory is improved, though the hysterical *hyperamnesias* furnish particular instances of it, as the corresponding *amnesias* do of memory gaps. Memory defect is a special characteristic of mental disease accompanying the coarser brain lesions, as *general paralysis, arteriosclerosis,* or *senile dementia.* It is most prominent in the last named, and also more especially associated with recent experiences. The loss in *general paralysis* is rather generalized over the entire memory field, and in *arteriosclerosis* it tends to be "patchy," so to speak, losing and retaining here and there, though not with systematic amnesia in the hysterical sense. The most prodigious memory defects are seen in a psychosis of usually alcoholic origin, the *Korsakoff syndrome,* where, in spite of good understanding, all impressions are immediately lost; indefinite practise does not suffice to learn what a normal person gets with one or two repetitions. Memory seems essentially unaffected in *dementia præcox* and in the *manic-depressive psychoses,* though it may be masked by confusion, apathy or stupor. These factors are mainly responsible for the poorer performance in memory tests that most other pathological cases show.

Various attempts have been made to experiment with the suggestibility of mental life, as by measuring the extent to which judgments could be influenced by suggestion. Scott's ingenious experiments showed that this could be different in different functions, so that we might not speak of general suggestibility any more than we should speak of general sensory acuity. But as an acute sense of sight would be much more important for our behavior than an acute sense of smell, a relatively great importance doubtless attaches to suggestibility in the higher levels of conduct, though the level of human activity where suggestibility really counts be not represented in experiments on the simpler sensory and motor processes. In a sense, the distractible *manic* case might be called over-suggestible because he catches up the examiner's interjected phrases and weaves them into his talk, or is easily diverted from one thing to another. But it is in the *hysterical* and in some *dementia præcox mechanisms* that suggestibility is increased to the point of giving real control over conduct. The Lata of the East Indies, and the Jumpers of the lumber camps are the most conspicuous examples of the former. Here we see an automatic, positive response to the idea suggested. In *dementia præcox* this occurs, but is not so very common. The striking feature of heightened suggestibility in *dementia præcox* is that it is negative to the suggestion. Not only may the individual be "blocked," as we say, making no response whatever, but so far as possible the opposite response may be made. It represents the extreme of the "contrariness" that is met with in normal life. It even may become possible to direct the individual's actions through asking the opposite of what one wishes; but the negativism is strictly to the idea conveyed. These cases know what they are about, and when it is clear that the thing wished is the opposite of the thing suggested, it is no longer obtained in this way. Bleuler has given a unified formulation of how this symptom is related to the underlying psychosis to which latter I shall subsequently allude.

Individual differences occur in a number of mental processes more involved than the above, which are but slightly subject to experiment. There is no reason to suppose any specific alteration of sense imagery as a result of mental disease. But those hyperfunctionings of it that we call hallucinations are quite different in various mental disorders. There is a delirious type of hallucination produced by poisons, like alcohol, morphine and cocaine, generally visual, and not especially systematized. It has rather the appearance of a selective action of the drug upon particular nervous elements. The hallucinations of *delirium tremens* are typical of this. Epilepsy is said to favor hallucinations of blood, fire, and catastrophe; cocaine, images of a microscopic character. Detailed analyses are apt to be unsatisfactory, owing to the unclear condition of the patient; when the alcoholic reads from or describes in detail the picture on a blank page, he confabulates rather than hallucinates. A number of curious clinical observations, such as illusory completion of lost fields in hemianopsia, doubled hallucinations to prisms or pressure, made greater or smaller by opera-glasses, hallucinations in one eye or ear only, need be no more than mentioned.

Hallucinations are reported in all the major psychoses, but for the understanding of the clinical picture, they, and the delusional ideas which supplement them, play the most important rôle in those types of mental disorder which have been termed *biogenetic;* that is, where the personality *as such* fails to meet the normal mental demands of the environment, and reacts to it along certain fairly definite pathological lines. These types of reaction may be for us summed up in the *manic-depressive* and *dementia præcox* groups. A most significant development in the conception of these conditions is that their basic hallucinations and the delusions, whether or not involved with them, are the expressions, not of the selective action of some fortuitous intoxication, but of *instinct trends,* detached from, or not controlled by, the main personality, and lived out through fantasy. Both Tuttle from the pathological and Cattell from the normal side have indicated how ideas can develop into hallucinations through abnormal reaction to them. These hallucinations and delusions are thus absolutely continuous with normal imagery and imagination, and the minor satisfactions which these latter supply to the normal individual are here magnified to take the place of reality, in response to coercive instincts and desires for whose adjustment reality must be escaped. Are some patients beset by unrecognized erotic longings? The voices horrify them with accusations of immorality. Is there some obscure maladaptation in the patient's marriage? The response may be a tragic imagination of the partner's death. The husband who visits his wife is then not her husband, but an impostor. Or there may be a fancied alteration of personality, as when under similar circumstances a young man calls himself at different times "Harry Thaw," "Clarence Richeson," the "king of the fairies."

Following Cattell's formulation of those higher mental qualities not directly measurable, we should say that defects, particularly of *judgment,* lead to the most serious consequences in *general paralysis, arteriosclerosis,* and sometimes in *manic excitement. Refinement* deteriorates especially in *dementia præcox* and in *general paralysis,* being, however, curiously preserved in cerebral syphilis; also comparatively well in the depressions. The preservation of *clearness* as opposed to clouding of consciousness is especially noteworthy in *dementia præcox,* confusion is most prominent in infective, exhaustive and toxic conditions. Many cases of *dementia præcox* have all the *originality* of Alice's White Knight; and the *catatonic* with his floor-polisher surpasses in *perseverance.* The most striking abnomalies with *Aussage* experiments would probably be met in the *Korsakoff* psychosis.

It is obvious that, in any social sense, *leadership* and independent *efficiency* are practically wiped out in the mental diseases we have discussed. The fact that as a group they must be removed from society sufficiently attests this, though in many cases a diminished capacity for work under direction is preserved. But to this rule there are important exceptions, which fall into three classes. In spite of real suffering from neurosis or psychosis, special aptitudes enable some persons to maintain themselves independently, and even to perform valuable service in a highly organized society. Most neurologists number such individuals among their patients. In a second group of cases there is a clearer connection between the greater efficiency and the immediate symptoms of the psychosis. There are two types of these. Mild cases of *manic excitement* derive therefrom an energy which, if only the judgment be enough preserved, enables them to do tremendous amounts of work, bear troubles, and carry off situations that would be impossible to them in their normal states. I have often quoted a case of alternating excitements and depressions who used his excitements to earn enough money to tide over his depressions in private hospitals. This *hypomanic* state may be constitutional, giving energy and capacity far surpassing that of normal men, but complicated with pathological features. The personality of Alexander the Great, with its stupendous accomplishment, its egotism and its excesses, is a distinct historical example. The other of these types of effectiveness results through *paranoic* rather than *manic* traits. *Paranoia* carries with it a faith, singleness of purpose, persistence and self-confidence greatly in advance of normal personality, but these regularly attach to ideas whose working out throws that individual permanently out of adjustment with the social order. But if the ideas are such as to arouse social response, great leaders are produced. In the religious sphere it is evident that strong personalities may found systems of belief which, not to mention the occasional amassing of worldly goods, attract many followers, and are genuine moral forces, with no other support than their autistic convictions and indomitable zeal. The inspiring power of such characters in secular history is fitly represented by Joan of Arc.

Lastly, we may take up the question of the general cohesion in the different elements of the personality. As one may gather from the late

Professor Pierce's thoughtful contribution to the Garman Commemorative Volume, the extreme cases of splitting that attract so much forensic attention under the names of double or alternating personality, are psychologically continuous with divisions of personality that are quite usual and normal. We sometimes think of *systematic amnesia* as the criterion of a real alternation of personality. The lives of many normal persons, however, are so ordered that they at various times make a total change of environment to another to which they are equally accustomed, but with practically no associative links between them. In such cases the abandoned mode of life may be lost sight of with truly hysterical completeness, and its most common passages require distinct effort for recall. The differences between these normal alternations of personality and those of hysteria are simply that the latter are more independent of environmental change, less subject to voluntary control, and in that the associations from the other personality or association system are more difficult of recall, they are more complete alternations. The pathological condition simply brings about the fuller working out of a tendency that in some degree is common to all of us, though never quantitatively measured.

The same is true of those splittings of personality where we do not have two or more associative systems alternating, but running side by side, and contending for expression in action; as in some reported hysterical automatisms, where the patient is said to write answers to one set of questions, and answer another by mouth. It has been remarked that all of us are a little hysterical, and it is again true that all of us are a little *schizophrenic*. Every one carries about with him numerous systems of likes and dislikes, attractions and counter-attractions, impulses and counter-impulses. Some of these favor the social adaptations of the personality, and others are in truly Mephistophelian opposition to it. The discipline of the former and the control of the latter are the balance of the personality. The lack of these qualities, with the conspicuous preservation of other mental functions, gives us some of the most striking features of *dementia præcox*. Here we observe that certain egocentric, sometimes formulated as autoerotic, tendencies, that all persons have in some degree, acquired a markedly independent organization, and crush the objective, social instincts of normal personality; covering it with hallucinatory insult, picturing to the mind's eye offensive scenes, preventing the personality from doing as it would, forcing it to think and do things which are hateful. The acutest mental suffering that occurs seems to ensue when the main personality attempts the unequal contest against them; sentiment can paint a lurid picture of its tortures in the death-grip of the destroying "complex." But as a rule these trends gain the mastery without the struggle; and we see simply the general failure of reaction to external things that gives us the apparent apathy of these cases.

It is quite probable, too, that there is a mere disintegration of the personality without its destruction by an organized trend; such a one is certainly impossible to demonstrate in many cases.

Here, too, it is easier to observe than to measure, and there is no telling now if the degree of personal integration for very complicated reactions will ever be brought under experimental control; for the lower psychomotor levels of reaction, however, there is considerably better hope.

I will quote two instances of the way in which this disintegration of personality is spoken of by the cases themselves. It is not often clearly expressed, *dementia præcox* cases being commonly inaccessible. First in the case of a young woman of twenty-five, with nothing very definite appearing in the previous history. At various times in the psychosis she makes such utterances as these:

> My mind seems to be in layers like strata in geology. . . . Something seems to push my mind into channels I don't want it to be in. . . . I don't know why I think of these things. I seem to be bound to find out a lot of things I am not interested in, as if some one was teasing me. It makes me feel frightened, as if I was changing to something else. It is like the difference between a good and a bad person. All at once I seem to wish somebody would die. I don't mean it, of course, but I can't keep it down. . . . If I could gather up a good will it would be all right. Instead these vague ideas seem to be wandering all around as if you were going through a sort of labyrinth. . . . I can't say anything I want to. It is like going through a river where there are a lot of weeds and they get in your way and you can't get through. . . . I seem to be imagining a lot of things. I can't get my mind together. . . . I seem all of a sudden to sink right down into deep thoughts as though I were covered up in a snow-bank. Whether it is a loss of the train of thought or of the spirit I don't know—it seemed as if my mind had been crushed back and I had lost control. . . . I try to use my mind but there is no thought there; it is empty. Somebody takes my mind away every two seconds. . . . If they want something to experiment on let them take a rabbit. I want my intellect.

And a young man of about thirty, of *shut-in personality,* and of somewhat coarser mental fiber than the previous case, expresses himself in this way, with more delusional coloring, the disconnected fragments of his own personality being rationalized as "spirits."

> My life is apparently in the hands of others the way I am now situated. . . . It seems as though the air about me were made thicker; it is condensed about me so that it gives the spirits some support, foundation, to act and carry on. . . . It is a peculiar trick for strangers to use other strangers in that light. . . . I feel as if I was supporting this column of spirit realm, as you might say, and I was wondering whether if hundreds of other spirits came into it if I could stand the tension. . . . The more persons that enter, the greater the tension, and in the last analysis I don't like any such existence. I am a human being the same as any one else, and I want my freedom and independence. . . . The spirits show themselves through voices, forms and various practises; they are very clever about some of their practises and cover them up. Any spirit that enters this realm can gauge the clearness and distinctness of the form—they can make them-

selves plain or just give you a faint idea of what they are doing, but you or any one else can imagine that they would be practises of sexual intercourse; of the spirits having intercourse with each other. It seems to me right now that this room is all filled with miles and miles of them all doing anything they can think of. . . . Now I am sort of carrying the load, as you might say, and any one who uses this (spirit) realm ought to be fair enough to keep out of my sight; I don't want to see all this business. Another thing, these people are total strangers to me, and if this business is going to keep me from engaging in remunerative employment there is going to be some remuneration, because I'm not running a free lunch counter!

We have reviewed the major exaggerations and distortions of personal traits which characterize the psychoses—individual differences due to pathological conditions. But there has been mentioned a group of disorders, the *biogenetic,* that arise upon constitutional incapacity for mental adaptation to life, and in this aspect do the psychoses represent pathological conditions due to individual differences. Here we see individuals, who, though in early years presenting no such abnormalities as would bring them into the group of *feeble-minded,* and adapting themselves at least passably well to the situations of childhood, yet, when they meet situations of a certain character in later life, are not able to cope with them as normal individuals, but are precipitated into psychosis.

The fact that these situations are common ones in every-day experience has been held to refute the supposition that they could be the precipitating factor in psychosis. Thus, if a girl, such as I have in mind, develops a brief, *dementia-præcox*-like episode on the death of an old lover, this would not be an occasion for the psychosis, because thousands of people live through the situation with no abnormal reaction. But this fairly obvious reasoning that the shock could not occasion the psychosis has to yield before the very obvious fact that it does. The truth is rather that in these individuals certain particular shocks would tend to be followed by psychotic reactions, and this girl developed her psychosis because, as further observation indicated, the death of that old lover *meant* to her something very different from what the corresponding event means to the average person.

Just what mental events will in any given individual be of the character to precipitate a psychosis is a psychogenetic matter, and varies as people's life-histories do. But that they have the property of precipitating one at all, and what kind of psychosis they will precipitate, depends on individual differences of constitution.

The most definite conception has been reached in regard to those mental constitutions on which *dementia præcox* reactions develop. It has been found by Adolf Meyer, August Hoch, and others who have repeated their observations, that individuals who develop these psychoses tend to be distinguished by a combination of traits which they sum up as the *shut-in personality*. In the time at my disposal the conception can not be fully discussed. The characteristic picture, however, is one of repression, seclusiveness, secretiveness, failure of normal "participation in cares, pleasures and pursuits" of others, self-centered stubbornness as contrasted with aggressive persistence, special oddities of conduct, the so-called "in-growing conscience," strong religious or mystical trends, with relative emphasis of passive virtues. A concrete example is described in the following words:

As a child he was precocious but in school had to study hard. He lacked confidence, was pessimistic, brooding and egotistical in disposition. He preferred reading to athletic sports, and gave religious scruples as a reason for not attending the theater. He did not use alcohol, tobacco, tea or coffee, and it was also noted that he did not care to associate with the opposite sex. At the age of 17 he began work as a clerk and was steady, honest and exact. . . .

The *manic-depressive* group shows a larger number of cases where abnormal traits are not seen before the psychosis, and the *shut-in* traits are nearly absent. But as an elementary point here it is brought out in some recent figures of Hoch's that persons who develop *manic-depressive* psychoses have also shown special tendency to exaggerated emotional reactions in their normal lives. These may be of either a euphoric or a depressive nature; when they are euphoric the individuals are more likely to have *manic* attacks, when they are depressive to have *depressive* attacks; and the melancholic personalities, manic ones. The apparent influence of the personality on the form of the attack diminishes to zero as the difference between the cheerfulness and depression of spirits in health becomes less marked.

In *dementia præcox* the psychotic mode of adjustment is regularly adhered to; in other words, the psychosis is not recoverable. The *manic-depressive* states, whose picture is as a whole much less detached from reality, represent rather a temporary mode of adjustment; that is, the psychosis is recoverable. The *manic-depressive psychosis* makes for any port in a storm; *dementia præcox* scuttles the ship.

Both conditions, however, with *paranoia*, and in a more circumscribed way the neuroses, show definite and *systematic* effort of adaptation to the patient's life-circumstances. The final understanding of these cases is given in the questions, "*Why did you have to have this thing?*" what made this adjustment a necessary one for the patient? and what needs must now be met in a more normal way, what particular danger points must be guarded, what false views of life corrected?

It is now apparent, I hope, that the mental criterion of psychosis is essentially one of mental maladjustment to the surroundings, and often it is the only criterion, mental or physical. The individual differences that distinguish psychotic and normal personalities are not so much differences in motor power, sensory acuity, affectivity or intellect, but depend on the way in which this complex enables the individual to make appropriate reactions to his environment. An individual becomes psychotic when he fails to behave with a certain more or less arbitrary degree of appropriateness. Where the mental malfunctioning follows a sufficiently definite line, we may formulate a definite psychotic entity, as the manic-depressive or the hysterical states. The experimental side of the dynamic psychopathology is therefore distinct from the academic psychology in that it is essentially grounded in the measurement of the reaction's *adequacy* or *fitness*. It involves a fundamental recasting of psychological methods, more along the lines of comparative psychology, whose details have only begun to be worked out.

These things shall enable us to observe certain mechanisms of adaptation, from which we must learn about the individual's fundamental adaptability. There are very few adaptations which *every* individual must make, but life places very many persons in situations which *they* can not meet. Some can not meet them within themselves; they react with the "flight into the psychosis." Some can not meet them as members of society; they react along criminal lines. Others can do neither, and they have led us into the absurdness of a dividing line of responsibility for action where not the shadow of a line exists. We have seen how continuous all normal human traits are with the pathological. The value of all attempts at controlling the actions of men, as with automobiles or waterfalls, depends upon taking account of the mechanical principles upon which they act. A chief legislator of my native state lately remarked, "Men do not make laws, they discover them." The problems of the jurist, even more than those of the psychiatrist, are failures of mental adaptation; and as we discover its laws we shall discover the best laws to regulate human conduct for both the happiness of the individual and the order of society.

GERMAN MILITARISM AND ITS INFLUENCE UPON THE INDUSTRIES

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MILITARISM in its true sense is the defense of home and family which has been forced upon the continental nations for the reason that they live in such propinquity to one another. Germany, for instance, is surrounded on all sides by potential enemies. Its frontiers are contiguous to Austria, Russia, France, Swtizerland, Belgium, Holland, Denmark, and it is separated by narrow bodies of water from Sweden, Norway and England. What such surroundings mean is evident in our own case. We have only two neighbors, Canada and Mexico, and with each of them we have had wars and frequent disputes, such as the Alaskan boundary question, the scaling and fishing controversies, etc. Inasmuch as our comparative isolation has not saved us from trouble, it is most remarkable that Germany, bordering on ten countries, has had so few wars.

German militarism is the application of arts and science as well as the most perfect organization and administration to the defense of the hearth. The prominent features of German militarism are conscription and the standing army.

Conscription has made the defense of house and family everybody's business and not the affair of a few hired men. It has caused the uprising of this wonderfully united nation as one man during this war, and it is the reason for the boundless self-sacrifice of the people—men, women and children—who all feel that everything must be given up for the fatherland and that individual wants and necessities, worries and pain do not count until victory and peace have been achieved.

The standing army has been pronounced by an American author to be the greatest democratic university of the world. Conscription and compulsory military service combine to make it the army of the German people, and not that of the Emperor, and therefore, German militarism is not the militarism of the Kaiser but of the German nation. Every one from the highest to the lowest is proud to be a member of the army and to be able to contribute to the defense of home and family. Here men of all types of education, the university man and the artist, mix with the laborer and the farmer. During the period of service they learn order and discipline. They are taught the value of punctuality, of exactness, of cleanliness and of obedience. They become aware of the fact that the individual is only a cog in the wheel of the big machinery. The few illiterate recruits from the most easterly parts of the country receive instruction in reading and writing; those recruits who have neglected to develop their bodies owing to lack of exercise improve in physique during their time of service, and in this respect the time spent in the army is of as much benefit as membership in an athletic club. The lessons learned are not forgotten by the soldier after his return to civil life, and order, discipline and the necessity of physical exercise become indelibly impressed on his mind.

It thus follows that the workingman who has had the advantage of a training in the standing army must be of especial value in the industries. An artisan who is cleanly, orderly, punctual, exact and disciplined, cannot fail to be an invaluable acquisition to a factory of any kind, and undoubtedly the success of the German industries in every branch of human endeavor is due to this class of well-trained laborers. This is a well-recognized fact in Germany, and similar views were expressed as early as 1893 by Dr. Caro, one of the greatest technical chemists of all times, who, in his classical description of the development of the German coaltar industry, published in the *Berichte der Berliner Chemischen Gesellschaft,* ascribed German superiority to the character of the workingmen who had served in the army.

German militarism early recognized the fact that the life and health of the laboring class are an important factor in the resources of the country, and consequently legislation for the protection of industrial workers has been evolved, which has become the pattern for all nations of the world. Even our own country which we think so free from militarism, has benefited by this German legislation, and when Governor Glynn of the state of New York, in becoming a candidate for reelection, reviewed what he had accomplished for the people during his term of office, he considered the Workingmen's Compensation Law as the most important of the measures passed during his incumbency. These compensation laws, together with the old age, accident, sick and death insurance laws, safeguarding and improving the economic conditions of the workers, are directly due to German militarism in its endeavor to husband the strength and earning power of the individual members of the industrial army. Even Lloyd-George, the arch enemy of Germany, copied these legislative measures of German militarism for the benefit of the laborers of England. To this constant care for the individual health and betterment of the working class are also due the establishment all over the Empire of government and provincial homes for convalescents, of homes in which persons suffering from incipient tuberculosis are treated, and of many other institutions with the object in view of promoting the recovery of those stricken with sickness.

These in a general way are the benefits which the industries of the country have derived from German militarism. Specifically, we note its greatest influence in the agricultural conditions of the country, an influence which is perhaps best expressed by the phrase "the balancing of the interests of agriculture and industry."

German militarism soon realized that in time of war the nation cut off from all supplies will have to feed not only its army but also its population. For this reason, special efforts were made to foster agriculture. On general principles, industry and agriculture are sworn enemies. Industry wants cheap food for its workers; agriculture wants high pay for its products—meat and cereals. It is one of the greatest achievements of modern Germany—and this is especially due to Emperor William II.—that these ever clashing interests were reconciled, and that they were made to see that for the common good compromises concerning taxes, duties, etc., must be adopted, under which both industry and agriculture could prosper. Hence, a give-and-take policy resulted, which has accomplished the greatest good for the greatest number, and has elevated agriculture to such a flourishing state that the feeding of the German people to-day is independent of foreign produce—quite different from England, where agriculture was sacrificed at the altar of the industry and where the soil was so outrageously neglected that the nation depends for its food supply almost wholly upon the importation of meat, flour, eggs, cereals, etc.

To bring about this magnificent result in Germany, agriculture was forced to produce as much as the soil could possibly bear, and consequently farming became intense. Cultivation of the soil, the feeding of animals, etc., became a science. Other sciences, especially chemistry and botany, contributed to the culture of plants adapted for the varied conditions of the climate and soil of the empire. Seeds were developed and improved to a marvelous extent. While the sugar beet at the beginning of the last century, when the manufacture of beet sugar was started, contained only about 4 per cent. of sugar, the quality of the seed was gradually so highly improved that they now produce beets with over 22 per cent. of saccharine contents. This seed is exported all over the world from Germany, and during the present war one of our greatest worries is that we may not obtain this excellent material from Germany in time to prepare our next year's crop.

The cultivation of potatoes, which were originally introduced into Germany from the United States, has been brought to such a wonderful stage of development that two distinct classes of potatoes are raised, the one rich in carbohydrates but poor in nitrogenous matter for the fermentation industry, and the other rich in nitrogenous matter for eating purposes. Curiously enough, seed potatoes are now imported *into the United States* from Germany because our farmers allowed this vegetable to degenerate to such a degree that it has substantially lost all value for seeding.

The science of fertilizing achieved the amazing result that Germany's soil, although cultivated for almost two thousand years, is to-day more productive than the virgin soil of the United States and Canada. Deserted farms like those of the New England States and the state of New York are unknown in the Empire. Chemistry is not only educating the farmer in scientific fertilizing but producing the requisite artificial fertilizers, and here again German militarism in its farsightedness has brought about most astonishing revolutions.

Of greatest importance in agriculture are nitrogenous fertilizers, that is, artificial manure which introduces nitrogen into the soil. The chief material for this purpose is nitrate of soda, which, as saltpeter, is imported in large quantities from South America. Unfortunately, this substance is also the sole raw material for the manufacture of nitric acid, and nitric acid is the chief material for the manufacture of all kinds of explosives. The French and English employ picric acid, which is trinitrophenol (lyddite, melinit) and is made by the action of nitric acid on carbolic acid. The Germans are using as their chief explosive trinitrotoluol (tritolyl), which is produced from toluol, a coaltar hydrocarbon, and nitric acid.

German militarism realized that two great dangers might arise from these applications of saltpeter. In time of war the importation of saltpeter might be stopped by the navy of a foreign nation, and it might therefore become impossible to manufacture nitric acid and explosives. The feeding of the nation might be interfered with, inasmuch as the soil could not be properly fertilized, and hence could not produce sufficient food-stuffs. Therefore, it became imperative that the nation must become independent of the importation of saltpeter.

The problem was solved by the utilization of nitrogen from the air, and in this way nitric acid was produced without saltpeter as a starting material. Unfortunately, however, the available processes can be carried out economically only in localities where cheap power is available, which to-day means countries where water power is abundant. Since Germany has hardly any waterfalls, and therefore is very poor in power created in this manner, the plants for the manufacture of nitric acid by utilizing the nitrogen from air were mostly established in Norway—a foreign country. The problem was therefore only half solved. But soon by the direct union of nitrogen and hydrogen, as accomplished by the ingenious synthesis of Haber, an absolutely independent source for nitrogenous fertilizers and nitric acid was created within the German Empire. The raw materials for the Haber synthesis—nitrogen from the atmospheric air and hydrogen from water gas—are obtainable in unlimited quantities in the country. In the Haber synthesis ammonia is first produced which, in the form of the sulphate of ammonium, is as efficient a fertilizing material as saltpeter. This method, however, has the disadvantage that the ammonia must be converted into nitric acid by processes which are not yet completely worked out. Undoubtedly, however, the economical manufacture of nitric acid from ammonia will soon become an accomplished fact, as recent publications seem to indicate that the problem is almost solved. During the present war all the saltpeter in the German Empire has been requisitioned by the government for the manufacture of nitric acid and the production of ammunition, while sulphate of ammonium obtained by the Haber synthesis and that recovered from the by-product of the coking industries takes its place for fertilizing purposes. The output of the existing Haber plant was doubled at the beginning of the war in order to provide sufficient sulphate of ammonium for the coming crops, and it is said that since that time another unit is in course of construction which will definitely secure Germany's requirements for nitrogenous fertilizers.

Another great benefit which, while the war lasts, will accrue to German agriculture from scientific farming is that the large acreage devoted to the cultivation of the sugar beet—usually the most fertile soil—will be *directly* available, without the use of additional fertilizers, for the raising of rye, oats, potatoes, etc. During the war Germany will not be able to export beet sugar which she does at other times on an extremely large scale, and will, therefore, not raise so many sugar beets. Utilizing this fertile soil for cereals, potatoes, etc., means an additional supply of food stuffs for the nation.

The industry for the recovery of the by-products from the coking process, which we already mentioned as a source for sulphate of ammonium, has also been highly developed because German militarism needed some of the resulting coaltar products for the manufacture of explosives. Benzol, toluol, carbolic acid, metacresol and diphenylamine are starting materials used in the manufacture of ammunition. Formerly, most of these substances were imported from England, where they were produced from coaltar obtained in the manufacture of illuminating gas by the distillation of coal, while in most other countries, for example, in the United States, illuminating gas is made from water gas. By developing the coking industry, that is, by suitably and economically heating coal, Germany has made herself independent of England, and now produces all the materials required for explosives and ammunition within her own borders.

Germany is also the only country which has made itself independent of England as far as its consumption of carbolic acid, one of the most important coaltar products, is concerned. This substance, employed both for explosives and as a disinfectant in general hygiene and surgery, is a material of war of the highest value. It was not considered wise nor profitable to remain dependent on foreign sources for such an indispensable article. Soon the ever watchful and resourceful chemist found artificial methods for its manufacture, employing domestic raw materials. To-day several German factories have installed plants to produce carbolic acid by the action of sulphuric acid on benzol and subsequent treatment with alkali. Whenever the price of coaltar carbolic acid rises beyond a point at which synthetic carbolic can be profitably manufactured, these plants are put into operation. They are promptly shut down when the price decreases.

German militarism, by initiating and promoting the everlasting battle between armor plates and armor piercing projectiles, also conferred great benefits on the industry and on mankind in general. We all know that as soon as an improvement in the manufacture of steel was made which allowed the production of armor plate of great resistance, the chemists and engineers evolved a projectile driven by powder, which would pierce such an armor. This fight is still on!

Instead of carbon, which originally was added to iron to produce the iron-alloy called steel, we now use nickel, chromium, tungsten, molybdenum, vanadium, manganese and silicon, which enable us to manufacture refined steel possessing varied properties. Most of these additions in order to give the desired results must be in the state of highest purity. These substances which at first seemed of no use in any other industry were produced primarily to fill the requirements of the manufacturers of cannon, projectiles and armor plate, and the largest maker of these elements in the pure state is the firm of Th. Goldschmidt, located in Essen, where it is able to work in close union with the Krupp Works.

By these modern improvements wonderful materials were placed at the disposal of the industries. The hardness of steel has been so increased that for safety vaults and safes an alloy is made which can neither be drilled nor exploded nor cut by the oxy-hydrogen flame. The chemical industries have been supplied with refined steel which is not attacked by acids, not even by boiling "aqua regia," while other modifications are not affected by hot caustic soda. Some of them are non-magnetic, others are unaffected by atmospheric influences, or exhibit great resistance to electricity, while some possess high tensile strength. They are thus of specific value in the manufacture of automobiles, of steam turbines, of electric appliances, of rails for electric tramways, of dynamos, motors and transformers.

Vanadium steel furnishes our modern tools, which are distinguished by extreme hardness, and here a war on a small scale is going on between structural steel and steel for tools with which to work the former. Every improvement in the hardness of structural steel must of necessity bring about the manufacture of a still harder steel for tools, exactly as in the case of armor plates and armor piercing projectiles.

German militarism has also benefited the industries in a field where its activities could hardly have been expected. We refer to the manufacture of hydrogen and oxygen. Strange to say, these two gases which had never found any industrial application, although known since the birth of chemistry, have lately become of the greatest technical importance and are to-day manufactured on a tremendous scale. Hydrogen is used for military purposes in immense quantities for all lighter-than-air flying machines—the filling of Zeppelin ballonettes, the filling of captive balloons, which have become of such great importance in modern warfare, being constantly employed by the staffs of the armies for observation of the battlefield. By telephone and photography they are in constant communication with headquarters.

The cheap and practical methods which were evolved by the military authorities for the generation of hydrogen are now utilized in one of the industries which has recently become of the highest importance, namely, the manufacture of what is called "hardened oils and fats." By treatment with hydrogen, oils and fats in the liquid state are converted into solid materials, which usually command a higher price for technical purposes, such as the manufacture of soap, etc.; and low class fatty substances, which are not fit to be eaten on account of their appearance or odor may be transformed into valuable food materials. By the economical manufacture of hydrogen, which makes it possible to utilize such inferior goods for alimentation, German militarism again deserves well of the nation. It must also be noted that the cheap production of hydrogen is one of the prominent features in the above mentioned manufacture of sulphate of ammonium according to the Haber process. Thus the manufacture of hydrogen, while originated for military purposes, is helping to feed the nation by providing new edible substances, on the one hand, and a new source for fertilizers, on the other.

The manufacture of oxygen likewise assumed gigantic proportions, after it was found that armor plates could be cut almost like butter by the heat of the flame from a burner fed with a mixture of hydrogen and oxygen, or oxygen and acetylene gas. At present, not only the cutting but also the welding of iron and steel is accomplished by means of such a flame; every machine shop is provided with an oxygen apparatus, and soon every garage will be similarly equipped, as it has been observed that the carbon collected in the cylinders of gas engines for automobiles, etc., can be easily removed by burning it out with the oxygen-flame.

The oxygen problem also plays an important part in the running of submarine boats where it is necessary to provide the crew with oxygen for breathing under particularly difficult circumstances. It is stated that nitrogentetroxide, a gas which can be easily compressed to a liquid, and which, when appropriately heated, decomposes with the liberation of oxygen, has been employed for this purpose with great success. But for the necessity of supplying oxygen to the submarine boats, this substance—until now largely a chemical curiosity—would perhaps never have been thought of for any technical purpose. Undoubtedly many other industries will avail themselves of this new source of oxygen under conditions similar to those on submarines, for example, for diving operations, in mines, for caisson work, etc.

Militarism in the search for new explosives discovered guncotton and thereby started the "nitrocellulose" industry. While guncotton made by the treatment of cotton with nitric acid proved to be an almost uncontrollable explosive, it was soon found that by a less energetic action of nitric acid on cotton, substances could be produced which were practically free from any danger of explosion. These lesser nitrated cotton products became the starting material for the celluloid industry in all its interesting and important branches. Besides furnishing various well-known household articles, billiard balls, etc., and substitutes for ivory and tortoise shell, celluloid became the base for a class of very valuable varnishes. It made amateur photography possible by the substitution of sensitized celluloid films for the breakable and heavy glass plates, and it provided humanity with its greatest agent of amusement and instruction—the moving picture show. But as the lesser nitrated cotton substances in celluloid, like all nitro derivatives, were not yet absolutely free from explosive risk under certain conditions, persistent efforts were made to find safe substitutes for them. Lately these experiments were carried to a successful termination, and acetylcellulose obtained by the action of acetic acid on cotton has replaced the dangerous nitro products, especially in the manufacture of non-inflammable films for moving pictures—a material in which the absence of danger from fire is obviously of the highest importance.

This acetylcellulose is also of distinct value in the manufacture of a varnish which finds its largest application in the construction of flying machines where its particular properties are of signal service. What a brilliant record of achievement in the search of militarism for a new explosive!

Militarism has also solved the problem for the textile industry as to which colors are most conspicuous and which least visible. Exhaustive tests showed that uniforms of a peculiar grayish-green shade rendered the soldier practically invisible in the field. How correct these observations were, was demonstrated at the start of the war when it was reported that the presence of the German troops was not noticed by the enemy at distances greater than two hundred to two hundred and fifty yards.

The most conspicuous color in all kinds of light was found to be red on white or white on red. This fact was made use of by the German advertising men who now paint their posters, etc., mostly in red and white, and also by the municipalities of German cities which are using red and white surfaces for sign-posts in their street. How peculiarly unfortunate for the French soldiers with their red trousers that they could not avail themselves of the result of these tests!

These few instances, which could be multiplied indefinitely, will suffice to demonstrate the correctness of my contention as to the manifold benefits conferred upon industrial development by militarism.

Evidently, therefore, German militarism is not the horrible institution which the English try to make us believe it is. It suits the German people, and it has made Germany one of the most powerful and prosperous nations, and enabled her to compete successfully in commerce and industry with the richest countries in spite of the lack of almost all crude materials, the natural resources consisting only of coal, iron and potash salts. Compare this with our country, which abounds in gold, silver, copper and practically all other metals, besides furnishing cotton and petroleum to the whole world. Yet as the result of wise legislation, incredible thrift and economy, the cooperation of science and technique, and thanks to its militarism, the standing army and general conscription, Germany has reached a most enviable position among all industrial and commercial nations.

German militarism is not the arrogance of a military caste whose intrigues lead to war. To its salient features—compulsory service and the standing army—Germany owes its organized industrialism, which has made possible not only the efficient defense of home and family, but the mighty victories gained by the nation in manufacture, commerce, the arts and sciences. German militarism ultimately means progress along the whole line—law, order and justice.

HOPE FOR THE RUSSIAN PEASANTRY

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IT was in the district of Kineshma on the Volga that I first saw that suggestively pitiful sight, thin-growing grain cut by hand. A toil-worn peasant woman, her head covered with a scarlet kerchief, her body bent, grasped the stalks in one hand and cut them with the sickle held in the other. She seemed the embodiment of that patient acceptance of a hard destiny so characteristic of the Russian peasant. It was evening, and the meager results of the day's work lay heaped up in less than half a hundred bundles lying in a line down the narrow field. The ribbon of stubble, only a few yards wide and hundreds of yards long was one of many that lay parallel and stretched almost as far as the eye could see, separated from each other by shallow ditches or rudely heaped-up earth. There were other strips of light yellow rye, of darker yellow barley, of reddish-brown buckwheat, of green hemp.

Further on lay a second set of narrow strips almost at right angles to the first. Searching the landscape I discovered that except for the low-lying meadows, patches of woods, and the village on the high bank overlooking the river, the surface of the country was divided into innumerable bands all long and very narrow, grouped together evidently according to some principle as yet unknown to me. Later I learned the meaning of these minute divisions and found its roots in the past.

Previous to 1861 the Russian peasants were serfs. Except for those who did duty as household servants, they were bound to land which belonged to their masters. Those thus bound, by far the greater number, spent a part of each week in cultivating the estates to which they belonged, and the remnant in working their own fields upon which they were dependent for bread. When these serfs were liberated each village or group of villages was given a certain amount of land in communal ownership, the price to be paid in forty-nine annual installments called redemption taxes. The community was held responsible by the state for all dues. It could cultivate the fields in common, using what was necessary of the harvest for these payments and dividing the rest among its members; or it could parcel out the fields and demand from each family a part of the total sum due the state proportionate to the value of the land allotted to the family. In the latter case the amount of land given to a family was ordinarily determined by its working strength, by the number of grown sons, for instance, able to help their father till his fields. The essential thing in the eyes of the community was that strict justice should prevail, that the ratio between the value of the land held and the annual payment made by the family should be the same in every case. The *nadiel,* the land acquired by the community when emancipated, was, therefore, divided into units of equal value, one or more of these units being assigned to each family.

There were three principle methods of division and all of these resulted in cutting the land up into minute parcels. It may be interesting, by way of illustration, to consider in detail the method which was followed, for the most part in central Russia. The *nadiel,* leaving out of account pastures and woods which were ordinarily held in common, was first divided into three fields to provide for a rotation of two different kinds of grain and fallow. Each one of these fields was then divided with reference to quality. Areas of good black loam, of sandy, clayey and other kinds of soil were carefully delimited. Each one of these areas was then divided into a fixed number of strips equal to the number of units needed at the time by the community. Each unit contained one strip of every kind of soil in each of the three fields. The number of strips in a unit was comparatively few in lands of uniform quality and many, fifty, eighty, one hundred or even more, in lands that varied much. In any case it was certain that each unit possessed exactly the value of every other unit. Here was justice but at what a price! Land cut up into such bits that it could be tilled only with the simplest implements, endless time lost in going from one parcel to another, sameness of crops necessitated by the fact that all must sow and all must reap at the same time. More often than otherwise the only approach to a strip was across other strips. Once these had been seeded they barred the way. The absence of fences made it impossible to plant anything that would mature after the neighboring fields had been cut. The cattle having been turned into the stubble of these fields would eat the adjoining not yet ripened harvest. And what soil rendered utterly fruitless in boundary lines, the furrow used to separate the strips being sometimes one fourth as wide as the strips themselves.

For long years the Russian *mujik* was slow to grasp these disadvantages. He was used to community life. He liked doing what his neighbors did. Why not all plant rye and buckwheat? Did they not all eat black bread and *kasha?* What better than hemp and flax for the weaving of household stuffs? The fields were a long way off—yes, but it was God's will, and one must be willing to harness the horse to the *teléga* and begin the five mile journey at break of day. And when one grew hungry and thirsty there was the loaf brought along and the keg of water hung on the hooks at the back of the wagon. True the fields were sometimes so far away that it was necessary to spend nights there, but the earth was a good place upon which to sleep, the baby's crib could be suspended from two poles fastened in the ground and the mother and children could help gather the precious kernels. Such sights are not uncommon in Russia to-day and are true to the past in nearly every detail. The Russian peasant accepts with scarcely a murmur what he believes can not be changed. He is not likely even to question circumstances if he has bread enough.

And during the period immediately following the emancipation it would seem that there was for the most part bread enough. There were hungry years even then, when the crops were poor or failed altogether, but they were taken as a matter of course. No one was held to blame. The peasants complained, it is true, at the necessity of paying for the land which they firmly believed had always been theirs, but the pressure of poverty was not yet such as to drive them to seek a remedy.

Time, however, brought changes. Sons and daughters grew up and married. Whether they remained in the home of their parents or built *izbas* for themselves land must be provided for them. How else could they live? But new units could be created only by dividing the fields anew and every parcel was thereby made smaller. Now and then, indeed, the community leased private land, but the rent was a difficult problem. Occasionally, also, alas! it was obliged to lease out some of its own land for money paid in advance and imperatively needed for the annual dues. Ordinarily this was a tract worked in common, not parcelled out into lots, but its alienation decreased none the less the food supply of the village. Thus the time came when the *nadiel* did not yield enough to support those who cultivated it. They were obliged to eke out a livelihood by earning money during the winter. Sometimes a whole village made nails, or carved wooden spoons or painted icons. Often the men sought work away from home. Some of them wandered from place to place, accepting any employment that offered itself, living most meagerly, saving every *kopec* and bringing back with them in the spring perhaps forty rubles apiece, little more than twenty dollars. Some went to the city and became cab-drivers, household servants of one kind or another, porters in railway stations. It often happened that all the men of one village who left home to earn money went to the same city and engaged in the same employment. Those whose services were not required to cultivate the land apportioned to their families frequently stayed throughout the year, sending their earnings back to help pay the dues to the state, comforting themselves in their exile with the thought that in old age they could return to the land and depend upon it for a livelihood. To return to it and share its fruits was certainly their privilege. Every *mujik* family recognizes the right of its own to come back, but the amount to be shared grew ever smaller.

As the years passed and the Russian peasantry increased in numbers by leap and bounds, doubling itself in less than half a century, its lot became constantly worse. The loaf scarcely large enough for four is scanty food for eight. Small wonder that very many of the communities were quite unable to make their annual payments to the state. Others managed to do so only by selling their entire harvest and even their horses and cattle. The misery into which they were plunged may be easily imagined. Nearly every year in some one region or another thousands perished from slow starvation.

The government of Russia has been many times arraigned, and justly, for its apathy in the face of such conditions. Doubtless it did not wholly understand the situation. The country was vast, roads poor, and communication slow and difficult. There was, moreover, a great gulf between the world of officials and the peasants bridged over only by the *zemstva,* councils of the district and province. One circumstance, however, certainly known to the government since it touched its purse, should have prompted an investigation—the ever-increasing inability of the peasants to pay the redemption money. The government did offer some slight relief. In 1881 it lessened the taxes, particularly in the provinces whose arrears were greatest, in 1882 it established the Peasants' Bank, the chief business of which was to assist the *mujik* to buy land from those willing to sell, generally owners of large estates. The activity of this institution, however, was not great during the first thirteen years of its existence. The conditions on which the bank was permitted to lend money were such that the peasants could not for the most part profit by them. Some transference of land to peasants did take place but not enough to better the situation appreciably. The *zemstva* made laudable efforts to spread information concerning rotation of crops and enrichment of soil, but the results were merely palliative. The end of the century found matters even worse than before and in the southern part of Russia the misery and unrest among the peasants assumed a threatening aspect.

The fear of revolution is a powerful stimulus. In this case it led to the creation in 1902 of a special Council of Rural Industry to study the agrarian situation in its various aspects. Some members of this council were placed in every district of every province and there joining to themselves representatives of the gentry and the peasants of the district inquired carefully into conditions in the immediate vicinity. This investigation resulted in a mass of valuable data and some recommendations, which, be it said, those highest in authority did not wholly relish and which were not adopted. Then in 1904 came the Russo-Japanese war, which distracted the attention of the government from home difficulties while it increased the misery of the people and their ire against the state. The result was great and wide-spread peasant disturbances. Private estates were laid waste and the rioters made ready to seize the soil which they firmly believed to be their own. It was imperative that something be done at once.

In these circumstances it is not at all strange that the government should have read the situation as most people in Russia read it. The peasants saw no remedy for their plight but more acres, and the various political parties differed chiefly as to ways and means of providing them with this desideratum. The first *Duma* had advocated the forced expropriation of all crown, church and private lands, and its steadfast adherence to this demand had brought about its dissolution. But while the government disapproved of this method of supplying the need of the peasants, it felt the need to be a real one. It therefore increased the powers and privileges of the Peasants' Bank so that through its medium the poor could add to their holdings on surprisingly easy terms. Appanage lands were offered for sale. Large areas of private estates whose owners had suffered in 1905 and who feared further disturbances were placed on the market. During the five years from 1905 to 1910 inclusive, more than 14,000,000 acres were sold to the people through the agency of the bank. These figures sound large. They are, however, relatively small. Moreover, it must be remembered that in those very districts where the cry for land was loudest there was in the nature of the case least to be had.

Meanwhile, however, the government attacked the agrarian problem from another side. The *ukase* of November, 1906, was meant to induce the peasants to change from communal to private ownership. This had been their privilege on certain conditions according to the laws governing the emancipation but in 1893 the privilege had been made subject to the consent of the *mir,* the village community, because at that time the government did not wish the strength of the *mir* to be impaired. The *ukase* restored the privilege, but whereas in the past the peasant had seldom been able to avail himself of it because he had not the money to buy out his land from the community now he had no need of money since the government cancelled all arrears and all redemption installments payable in the future. Any member of a *mir* could step out whether the *mir* were willing or not, receiving his due amount of land in private ownership. How much the individual received depended upon circumstances. If he had held the same parcels for twenty-four years, in other words, if there had been no redistribution of the *nadiel* during that time, he received these parcels or their equivalent, the assumption being that in that particular community the principle of parcelling out the land was dead. If on the contrary there had been a redistribution of land within the last twenty-four years, the assumption was that this principle was still operative. In that case the withdrawing peasant could claim only as much land as would be allotted him if a redistribution were made at the moment of his withdrawal. He must be allowed, however, to purchase the difference between what he actually held and what he would receive in the event of a redivision.

This law definitely announced the break-up of the *mir,* it looked toward the end of community ownership. It had, in all probability, as its immediate object the formation of a class of small proprietors who would be loyal to the state, moved by gratitude for the property rights granted them and the desire to retain those rights. Even small property owners are in general on the side of law and order and against that anarchy which destroys real wealth. Doubtless, also, the government felt that so long as the peasants held land in community ownership they would act as communities in other matters; and when it came to an expression of grievances it could more easily deal with individuals than groups.

It may be questioned whether the mere transition from communal to private ownership held in itself any salvation for the starving peasantry. If the land remained split up into tiny parcels, it was a matter of little moment whether the title lay with a group or with an individual. About 18 per cent. of the *mujiks* already owned their land in perpetuity. Exact statistics dealing with the subject are lacking, but it would seem that these were for the most part no more prosperous than their communistic neighbors. Some of them had so little land that they were of necessity very poor. Having been offered in 1861 their choice between a certain number of *dessiatines* at a fixed price and one fourth of this amount as a gift they had chosen the latter alternative. Others had bought their shares from the community but received them for the most part in such small parcels that they could not be worked to advantage. Private ownership, therefore, where known, did not always wear an alluring garb. In many places it was wholly unknown. Communal ownership, on the other hand, was an old institution, generally prevalent and deeply ingrained in the people. They saw in it safety for themselves and for their posterity. So long as the village continued to own the soil there was a bit for every man and for his sons and grandsons.

In the light of these considerations it is not strange that the great bulk of peasants were not inclined to take advantage of the new law. There were, however, two classes to whom it appealed. One was captured by the clause which provided that the family whose holding was larger than it would be, were a redistribution made now, might buy, at the price attached to this land in 1861, the difference between what it held and what it would receive in the event of a redistribution. Land having trebled in value during the last half century, such a family would of course profit greatly by a purchase on these terms. The other class was made up of those peasants who held parcels of land as members of a community but who had taken up their abode in some city or industrial center. Such were glad to receive their parcels in private ownership because they could then sell them. Aside from these two classes, there were of course some *mujiks* who seized this opportunity of getting compact farms, which, being their own, they could work as they pleased in a scientific way. These were comparatively few in number. It must be confessed, then, that the *ukase* of November, 1906, did not in itself provide a salvation for the economic difficulties of the people.

A solution was, however, bound up in a way with the working out of the law. Its execution lay with the provincial and district commissions created in 1906 primarily to assist the Peasants' Bank in smoothing the way for those who wished to purchase land. Now the bank had been definitely instructed to sell its land as far as possible in well-rounded pieces which in the hands of individual owners might serve as models to the neighboring communities. The commissions were therefore, while assisting the bank, engaged in the creation of compact farms. Their other activities were along this same line. They were instructed by the government to do everything in their power to persuade the peasants to give up irrational methods of cultivation, particularly the division of the fields into minute parcels.

The *ukase* of 1906 gave these commissions a great opportunity. The law did not state that every peasant who wished to withdraw from the community and receive his share of land in perpetuity must be given that land in a single piece but it permitted and even encouraged this procedure and it was quite natural that the commissions should have striven toward this end in the surveys which they were called upon to make. During the five years from 1907 to 1911 inclusive 503,408 families withdrawing from the community received their land, through the agency of the government surveys, in compact units. This was certainly not a large number, considering the population of Russia—but it was a decided step in the direction of agricultural progress.

The *ukase* of November, 1906, then, although primarily political in its spirit and purpose, resulted in a certain limited economic good. From the very beginning there were some who defended this effort to transform community into private property on the ground that it paved the way for scientific farming. Gradually the emphasis shifted from the question of tenure to the question of husbandry. It was plain to those who studied the subject that the diminution of crops in Russia was due to obsolete and wasteful methods of cultivating the soil. There were whole areas that were exhausted, there were fields that lay so far away from the village that owned them that they could not be tilled, the weed-grown furrows which served as boundary lines between the parcels aggregated a vast territory lost to cultivation. The essential thing was to map out the land anew so that it could be worked in larger tracts and with better methods.

It might have been possible, as some contend, to legislate toward this end without disturbing the *mir*. The separate parcels could have been consolidated into large areas and still have remained communal property. This was done by some villages in central Russia during the last decade. They cultivated these large tracts to advantage, using improved machinery. There is, however, much to be said on the side of those who insist that technical advance in agriculture can be furthered best in connection with private property. This is the assumption on which the law of June 1911 rests. There is in this law definite evidence of the change of emphasis in the land policy of Russia. The government still wishes to encourage the transformation of communal property into private property, but it brings less pressure to bear in this direction. On the other hand, it lays tremendous stress upon uniting the various parcels of land belonging to one owner, whether that owner be an individual or a community. The law makes the most elaborate provision for the settlement of every imaginable difficulty arising from the lack of clear demarcation of boundary lines and the confusion of tenures. There are areas in Russia which wear the aspect of a veritable puzzle—fields of different villages intermingled, church, state and private property enclosed in one piece of communal property, holdings partly communal and partly private and so on almost without end. Out of this chaos the government proposes to bring order—but only upon request. When a family, or a number of families, or a village, or a group of villages forming a community, desire to have their land surveyed and rearranged, they appeal to the district commission whose members represent the central government, the local government and the peasants themselves. This commission appoints one of its number, or a surveyor, to examine the locality in question and to confer with the petitioners as to their wishes. The entire matter having been explained to it, the commission decides whether the project is in harmony with the principles laid down by law to govern all the new land arrangements, and, according to its decision, either refers the project back to the peasants for changes, or orders that it be worked out in detail. When this has been done, those whose lands are concerned are requested to pass upon the plan in its final form. It is their privilege to accept or reject it, but every effort is made by the members of the district commission to overcome objections by persuasion or by practicable modifications. When accepted the plan is sent to the commission of the province. Upon the approval of this commission the work is put under way as soon as surveyors can be spared for it.

The character of the work done by these surveyors depends upon circumstances. A few illustrations will serve to make it clear. When the peasants were emancipated it often happened that a group of villages, being the property of one and the same lord, received their *nadiel* as one community. This land was not a single piece but was made up of many irregular pieces. Certain ones belonged to each village, had been cultivated by it in the days of serfdom. These were rarely continuous and were mixed with the pieces belonging to the other villages of the group. Furthermore the *nadiel* often enclosed in its boundaries lands owned by the state, the church or private individuals. Suppose these villages request what is known in German as *Verkoppelung und Auseinandersetzung*—consolidation by means of exchange of land belonging to each village. It then becomes the task of the government surveyor to measure off the land belonging to the entire community and to give to each village in one piece, if possible, the equivalent of the many parcels belonging to it heretofore. The difficulties of such a task are apparent at first sight. The quality of soil may be anything from very good to very bad. It is necessary to fix a standard and then determine the value of each particular quality with reference to that standard. If the best soil is taken as the standard then it will require let us say $1\frac{1}{8}$ *dessiatines* to equal one *dessiatine* of the best, $1\frac{1}{6}$ *dessiatines* of the next poorest to equal the best and so on down to the worst. The problem attaching itself to the division of the arable land among the villages being solved, there remain the questions of the meadows, the pastures and the woods. Each village will wish to have some grazing ground in its immediate vicinity even though its arable land should be far away. The group of villages may desire to continue to hold the meadows and woods in common. This arrangement was often made in the surveys of several years ago, but the government now distinctly discourages it. When the private lands strewn among the parcels of the community hinders the giving of a compact area to each village, then efforts are made to buy the offending pieces or to exchange them for outlying portions of the community land.

It must be understood that each village, being now provided with the equivalent in one tract of its many parcels, is still at liberty to regard the tract as communal property. It is under no obligation to divide it into individual holdings. But any family in the village may demand that its just share be given it in perpetuity, in which case the matter is either amicably arranged in the village, or is settled by government authorities. It frequently happens that a number of families, alert, ambitious and enterprising, make this request and transport their little homes from the village to their new farms which are then known as *houtors.* Curious it is to see, but not at all uncommon in Russia, four such families whose lands form approximately the four quarters of a square, building their *izbas* in the angles that meet at the center so that a few steps will cover the distance from the door of one house to the next. Even these pioneers dread living alone. The *mujiks* are gregarious. The opportunity for companionship is a prime requisite with them. And, indeed, quite aside from the matter of temperament, a family might well wish to avoid complete isolation during the long weeks when the melting of the snow and the spring rains render the roads impassable.

The government may be called upon to survey the *nadiel* of a single very large village. Take Borma as an example. It owned 6,250 *dessiatines* or approximately 16,625 acres cut up, so that each household tilled eighteen widely scattered parcels. The pasturage was divided anew each year and the ravines were held in common. One hundred and ninety-one families desired to have their holdings given them in private ownership, the rest wished to retain theirs in communal ownership. It was decided to divide the *nadiel,* so that the northern part might be given to those who wished to withdraw from the *mir.* Of the latter class ninety-nine families settled upon the tracts assigned them, ninety-two settled in eight groups upon sites purposely chosen at some distance from each other for villages. This arrangement was made for the benefit of those who felt it necessary for the sake of social intercourse to live in the near vicinity of neighbors yet who wished also to be relatively near their fields. Farms whose owners live in the village are known as *otroubs.* This arrangement is at present very common in Russia. Often it is doubtless an intermediate stage. In the course of time many families living in villages will move to their farms, provided they are able to find good drinking water there or in the near vicinity. The *mujik* does not mind carting his water in barrels over long distances but there is a limit to the time he can spend in this occupation. A single well frequently serves an entire village.

Here is another example of the kind of task the government may be called upon to perform. A village that has worked its *nadiel* in common since the time of the emancipation or that, while holding it in common, has parcelled it out periodically among its families, decides at a meeting of the adult men to go over to private ownership. The proper request is laid before the district commission and the surveys begin. The first question has to do with the roads. In central Russia particularly the old ones are meandering and very broad. Why take the trouble to fill in wagon ruts that have become hopelessly deep when it is possible to drive alongside of them? And when new ruts have been formed these, too, can be left to care for themselves. Thus the old roads lost whatever straightness they may originally have had and stretched to a great width. New ones must be carefully laid out. Next comes the question of water. It is the ideal of the government to persuade each family to live on the tract allotted it and with this end in view the commission frequently offers to assist the *mujik* with the money necessary to transport his old dwelling or to put up a new one, the sum to be paid back in fifteen years without interest, although occasionally in extraordinary circumstances it is an outright gift. Often, however, the absence of water or the expense involved in sinking deep wells makes it necessary for the peasants to live in groups. In this case sites must be selected for these so-called daughter-villages. Then comes the differentiation of the different qualities of land. After that the tracts are laid out, each one as nearly as possible approaching a square, some perhaps entirely of plough land, some combining plough land with pasture and woods. The peasants who are to receive tracts of exactly equal value often draw lots for them. The assignment of other tracts is ordinarily made by mutual agreement.

It is difficult to comprehend what a vast amount of labor is involved in these surveys. In the single year of 1912 nearly 9,000,000 acres passed under the measuring-chain. More than five thousand surveyors are employed and paid by the government. The commissioners in charge of the so-called new land arrangements number seven thousand.

Well laid-out tracts of land are not, however, an end in themselves. They are simply the requisite for scientific farming that will yield the largest returns. The peasants of Russia must be taught how to manage their soil to the best advantage. This instruction is being given them. Agricultural experts have been stationed throughout the country to teach the *mujiks* by counsel and example how to dress and till their fields, what crop to plant. The number of these experts in the employment of both the government and the *zemstva* increased from 2,541 in 1909 to 5,185 in 1911. Many model farms and testing-fields have been established to make plainly evident the concrete results of better agricultural methods. The experimental stations increased from seventy in 1907 to two hundred and ten in 1911. I can speak from personal observation of one in the province of Samara. It is in charge of a gentleman who studied agronomy for two years in the United States and is excellently managed. Much should be said in praise of the work done by the *zemstva*. That at Kineshma is engaged in a great variety of admirable activities all looking toward the welfare of the peasant. I need only mention as àpropos of agricultural progress the placing of stallions where they will help toward breeding finer horses and the furnishing at little more than cost price of excellent seed and farm machinery of every kind practicable and desirable in that part of Russia. Many other *zemstva* are engaged in the same work. Indeed these district and provincial councils were the first to conceive the idea of teaching the peasants how to improve their methods of cultivating the soil. That was twenty years ago, more or less; now the government is co-operating with them and added stimulus and strength have brought corresponding results.

The new land policy of Russia is scarcely known to the world at large. Considering its magnitude and importance very little in the way of a careful exposition of it has been written. Yet it has to do with more than 100,000,000 people and with an area almost equal to the rest of Europe. It endeavors to change in a decade or two the habits, customs, ideas and ideals of centuries. While the reforms of Peter the Great were limited almost entirely to the upper classes, this concerns itself with the masses. It seeks to lift them from poverty into comparative well-being. It is theirs to seize the opportunities offered them. As they do so they will enter upon a new life.

There are those in Russia who point to the many mistakes made by officials and surveyors in the execution of this land reform. It is true that in the beginning the work was pushed so rapidly that it was not always well done. There was a dearth of good surveyors and the government was often obliged to make use of those inadequately prepared. Roads were not always well placed, possibilities of obtaining good drinking water were not everywhere thoroughly investigated and peasants withdrawing from the *mir* were allowed to retain meadow and pasture land in common. The mistakes of the first years are certainly to be deplored, but it must be recognized that they were almost inevitable in so vast an enterprise. Now, however, the various district and provincial commissions have profited by their experiences and are directing operations more wisely. Certainly there is in the higher commission to which they are responsible one man fitted in every possible way to inspire and direct the great undertaking. I refer to Mr. A. A. Koefoed. He was connected for many years with the Peasants' Bank. He traveled widely in Russia studying at first hand the question of land tenure and the prevalent methods of cultivation and has become the most eminent authority on this subject. Moreover, he understands the *mujiks* and knows how to meet them and is heartily desirous of furthering their best interests.

Again there are those who say that this policy of the government will bring only temporary well-being. In less than a century the peasantry will be as badly off as ever. The family provided with land enough to yield it a livelihood now will divide this land among its children and so rapidly do the *mujiks* increase in numbers that it will not be long before their farms will be so small as to throw them back into indigence. This assumes that the children of all those now tilling the soil will also till the soil, a supposition which is scarcely tenable considering the ever-increasing demand for laborers in industry. It would be well, however, to take some precautionary measures against the contingency of redividing the land into small parcels. Denmark has enacted an inheritance law which fixes a minimum size for farms. If Russia were to do the same no peasant could divide his freehold between two heirs unless it were at least twice the size of the minimum. The farm incapable of division could be left to one of the children, this one to make good the shares of the others by money payments, a practise which prevails in Norway and in certain parts of Germany. There is, however, very little occasion to fear that the sizable freeholds of to-day will in the future be divided into minute parcels. Rather it may be confidently expected that the number of small freeholds will steadily decrease. Many peasants have been obliged to mortgage the land which they had in order to purchase more. Some of these will find themselves unable to meet their obligations and will sell or lose that land. This may happen as the result of incompetence, inexperience in the management of private property, poor harvests or other calamities. On the other hand those peasants who are shrewd, thrifty, hardworking, fortunate, will prosper and will add to their *dessiatines*. The march of time, then, bids fair to divide the rural population of Russia into two classes, the one landless, dependent upon wages for a livelihood, the other made up of small, well-to-do landowners.

This probability, not to say certainty, has raised other voices against the new land policy. These maintain that the increase of a landless class, a proletariate, is always a bad thing. It is not proposed to discuss here the general question of the right of each man to a bit of soil large enough to yield him a livelihood. It need only be pointed out that this ideal can not be realized in Russia. Even if every *dessiatine* in that vast country were given to the peasants, in much less than a century the holdings would again be too small. Poverty would once more reign over the people. On the other hand it is possible for the proletariate to be self-respecting, intelligent and prosperous. The opportunity for wage-work is not lacking in Russia. There is to-day a demand for laborers on the large estates which can not be satisfied. Great losses are annually sustained by them because there are not hands to gather in the harvest at the proper time. Factories, too, suffer from the lack of operatives who will keep at their tasks the year around. They are too often dependent upon those who leave their farms in the fall to return to them again in the spring. This demand is steadily growing since manufacturing is greatly on the increase.

Certainly the augmentation of the proletariate is not an unmixed good either for those who constitute the class or for society at large. Work is not always to be had for the asking and returns are often inadequate and uncertain. Then, too, there are the dangers inherent in leaving an environment that has exercised a restraint and set up standards and entering another in which one has at first no fixed place and no social responsibility. In time, however, the new environment will become an old one with a conscience and with rulings of its own. Moreover in the long run much good may be expected from separating the individual from the community and obliging him to stand alone. Unsupported by the props to which he is accustomed he will stumble, he may fall, but when he rises it will be with a new strength all his own.

And what of the other class whose numbers whether through superior intelligence or industry, fortunate circumstances or a combination of all these are able to add substantially to their lands. Certainly it has not yet come into existence as a body conscious of its solidarity, able as a whole to work definitely toward chosen ends. Time and experience and education are necessary for that. But individual well-to-do *mujik* families grow steadily more numerous. I remember in particular one such in the province of Samara. Its past, its present, its future were, so to speak, plainly in view. I drove up the hillside through fields of golden grain, past the tiny orchard not yet old enough to bear fruit, to the brand-new home, each one of the four good-sized rooms fully furnished and so orderly and immaculate as to show conclusively that they were not being used. Scarcely ten feet back stood an old *izba* bearing every evidence that the family lived its life there. The back part of the stove and a low platform served as beds. Sheep-skin coats and long felt boots lay heaped in one corner. Hens walked placidly in and out of the door and the horses and cattle were stabled only a few feet away. Our host displayed his possessions with the greatest pride and pointing significantly to a field adjoining his own said, "It will soon be mine. I am buying it." It is probable that this man will not be content to have his children attend only the parish school. Some one of them may be sent away if only to study how better to till the soil and make it yield larger profits. Here is the new agricultural Russia from which great things may be hoped. These well-to-do farmers, sobered by the possession of property, no longer obliged to labor for bread to the exclusion of everything else, able to educate their children, will rapidly rise to the position of a powerful middle class to whose united voice even autocracy will listen. If this class is able to preserve the remembrance of its kinship with the poor, if it deals as justly with all strata of society as the communes from which it has sprung sought to deal in the distribution of their land the future of Russia is assured.

THE WAR AND THE WEATHER DURING THE FIRST THREE MONTHS OF THE FIGHTING

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WAR and the weather seem, at first sight, to have no relation to one another. Set in motion by human forces apparently far beyond the control of our ordinary physical surroundings, military campaigns seem likely to go on unaffected by such more or less "accidental" conditions as cold or heat; rain or snow; wind or cloud. Yet all through human history, as far back as we can secure accounts of wars and of military campaigns, the weather element stands out as one of the great controls, a control to be reckoned with by every commander, and one which, when powerful enough, has had consequences of far-reaching historical importance. The weather factor in war is not a joke. It is a perfectly serious subject for study on the part of military and naval strategists. It must be taken into account in laying out a campaign or in organizing troops for a battle. To disregard the weather factor in warfare is almost, if not sometimes quite as serious an omission as to forget to provide food, or clothing, or ammunition. The weather has, time and again, turned the scale, for victory or for defeat. Written large in history, as events of the greatest significance, we have the retreat of the Turks from Vienna in 1529, their siege artillery having been left behind in Hungary on account of heavy rains which made the roads impassable, and the besieging army being hampered by inclement weather and by the scarcity of provisions, which were both difficult to secure, and almost impossible to transport. All three of the Spanish Armadas (1588, 1597, 1719) suffered from hostile winds and storms. In 1719 the Spanish fleet was scattered off Cape Finisterre by a violent storm which raged for twelve days. Only two ships succeeded in reaching the coast of Scotland. To take an illustration from our own early history, the closing chapter in the evacuation of Boston by the British would probably have been quite different if a severe storm had not frustrated General Howe's plans. The Americans had begun the fortification of Dorchester Heights during the night of March 4, 1776. The morning of the 5th dawned clear and mild, with a bright sun and a warm southerly wind. General Howe and Admiral Shuldham, realizing that their own positions were insecure as long as the Americans remained on the heights, sent between 2,000 and 3,000 men in transports across the Bay, the plan being to have them land and attack the enemy in the rear. But a violent storm, which began during the afternoon, drove three of the transports ashore on Governor's Island. The rain fell in torrents. There was no abatement of the storm on the following morning (March 6), there being a furious gale from the southeast which caused such a surf on the Dorchester shore that "an attempt to land (on the part of the British) must have proved fatal." The Americans continued to fortify in spite of the storm, and when the weather had improved sufficiently for the British to attack, they realized that the American position was too strong. By night of March 6 the evacuation had been decided on. General Washington wrote on March 14: "A very heavy storm of wind and rain frustrated their design." The terrible winter retreat of Napoleon's Grand Army from Moscow furnishes a tragic but wonderfully vivid illustration of the strength of Russia's two invincible generals, January and February, who, if the scene of the present war should be transferred into Russia during the winter, would again be found fighting on the side of the Czar. We may note, in passing, that the French Revolution was precipitated by a severe winter, and that the "Boxer" outbreak in China, in 1900, was brought on by a scarcity of rain in the preceding autumn, leading to famine and destitution, and driving the people to robbery and pillage.

History is full of examples of individual engagements in which weather played an important, if not actually decisive part. Heavy rains, making the roads muddy and the movements of troops and of guns difficult, had a marked effect upon the plans of the commanding officers in the battle of Waterloo (1815), the battle itself being postponed for this reason. In our own civil war the list of weather controls is a long one. Of one of General Grant's campaigns in Virginia it is reported that the country was densely wooded and the ground swampy—the troops waded in mud above their ankles, horses sank to their bellies and wagons threatened to disappear altogether. The men began to feel that if any one in after years should ask them if they had been through Virginia, they could say, "Yes, in a number of places." Dense fog favored the northern forces in the battle of the Wilderness. Deep mud and impassable roads were, at least in part, responsible for General McClellan's delays, which caused so much anxiety and indignation in Washington. During the fighting around Tientsin in 1900 the situation of the allied troops was very critical, when a torrential rainfall compelled the Chinese to retire. Cold and snows have time and time again been potent factors in warfare. In the last Russo-Turkish war thousands of men died of the cold, and the sufferings of the troops at Plevna were terrible. The siege of Sebastopol furnishes another illustration of the sufferings which a severe winter inevitably produces. In the Russo-Japanese war fighting continued in the severe cold of the Manchurian winter. Frozen rivers or lakes may make it very easy for an army to proceed on its plan of advance, and, on the other hand, the ice may help a pursuing army to follow its retreating enemy without the delay needed for building bridges. In 1780, troops were led on the ice from New Jersey to Staten Island, to attack the British, and provisions were sent across on sleighs. In 1809, the Russians were led to Sweden across the frozen Gulf of Bothnia. Sudden thaws after severe cold are often serious handicaps in a campaign. Roads and fields are suddenly turned from hard ground into deep mud or swamp, and the movement of troops, and especially of guns and supplies, may be stopped. Heat has caused as great suffering as has the cold, but less often, in our latitudes. The sufferings of the French army under General Kléber in Egypt in 1798 are well known to students of history. Officers threw themselves on the sand and gave way to despair.

If we look over the foregoing, and many other cases of weather controls in war, it is easy to see that these examples may be grouped in two classes. In one of these, the particular weather condition or phenomenon was so to speak accidental; it was sudden; unexpected at that special time; and therefore hardly to be guarded against. Cases of this sort are the sudden storms which have so often been decisive factors in military undertakings. In the second class the weather conditions were perfectly normal and natural for the particular region and season in which they occurred, but the army was not prepared for them because of the ignorance, or lack of foresight, or over-confidence, or haste, on the part of the commanding officers. Thus, the terrible disaster which befell the French army in Russia was largely due to Napoleon's own recklessness in rushing unprepared troops into the teeth of a northern winter. Cold and snow contributed towards making a disaster complete which would probably have been a serious one under any meteorological conditions. Again, during the British expedition into Tibet, a few years ago, great difficulty was experienced at the higher altitudes owing to the hardening of the oil in the guns, on account of the cold, and the low boiling point at those great altitudes made it difficult to cook food properly in the absence of special cooking utensils adapted for use at low pressures. These handicaps could have been provided against if proper care had been taken beforehand.

It is clear that weather, although not always, or ultimately, is a factor which must be reckoned with in warfare. It is one of a large number of factors, among which topography, soil, hydrography, vegetation, and so on, must also be included. To know, in advance, the general climate of the war zone; to be prepared for the special weather conditions which are reasonably to be expected at this or that season; to have as accurate a knowledge as possible of the probability of occurrence of severe cold; of sudden thaws; of heavy rains; of great heat; of high winds; of deep snows—this is a very essential element in planning a campaign or in organizing a single engagement. This is to make our knowledge of climate and of weather of immediate practical use, however much we may deplore the occasion which necessitates such use. Heavy rains make roads muddy and often impassable; delay the movements of troops, and of supplies; necessitate the abandonment of heavy guns and of ammunition; flood trenches and camps; cause discomfort and suffering, and bring on illness. Deep snows have many similar effects, but in addition are often accompanied by severe cold. Unless proper clothing, protection and fires can be provided, and often in spite of such precautions, severe cold almost inevitably increases the sufferings of the men, especially of the sick and wounded, causing an increase in the sick and mortality rates; disabling men through frostbites; making them unfit to march or to use their hands; freezing up water supplies, etc. Hot spells necessitate shorter marches, and may disable hundreds of men through sunstroke or heat prostration. Droughts make it difficult to secure water and food; cause dust which hampers the movements of troops, and may make their presence known to the enemy, and interferes with the accuracy of cannon and rifle firing. It does make a difference whether an army marches on dry, hard roads, or through deep and slippery mud; whether it suffers from frozen feet or is warm and comfortable; whether snow is falling or the sky is clear and the sun is shining; whether the wounded on the battlefield are soaked with rain, and beaten by hail, and covered with ice, or can be cared for under favorable conditions. As Sir John French put it, a few years ago: "The darker the night, the more inclement the weather, the more disagreeable the surroundings, the more valuable the training will be, and our young soldiers will gain some glimmering of what they must expect to meet in war."

Picked troops; discipline; a well-organized system of transport; proper clothing—in short, all that goes to make up the most efficient military organization, is of vastly more importance than the weather. But we fail to read history aright if we do not recognize that the weather element is by no means the least important of the many external factors which have affected military campaigns.

The present war gives us an immediate opportunity to study the influence of weather upon military operations. Although the war has lasted but three months, there are already many cases which may be cited in illustration.

During the first six weeks of the war the despatches made practically no mention whatever of the weather. Only incidentally was reference made to the oppressive heat. We may, therefore, conclude that there was nothing in the meteorological conditions in August and early September which had any noticeable effect upon the campaign. The mild and pleasant weather of the European late summer apparently ran its accustomed peaceful course. Suddenly, beginning with mid-September, we come upon constant reference to the difficulties caused by heavy rains. Autumnal rains, usually especially marked in October, are characteristic of the northern coasts of Europe. They come in connection with storms that drift in from the Atlantic Ocean, and pass eastward, across the Channel and the North Sea. It was to be expected that there would be many difficulties on account of the wet weather during the latter part of September and in October. The despatches from the front clearly show that the expected happened. Heavy rains during the long battle of the Aisne caused the rivers to swell; filled the trenches, and often drove the troops out to fight with their bayonets, thus changing the plan of operations. The difficulty, even the impossibility in some cases, of moving the heavy guns through the deep mud, was a serious handicap to both armies. During the general retreat of the Germans from their advanced position in France many guns and much ammunition had to be abandoned. On September 19 a despatch to a London paper said that the heavy rains had flooded such large areas that it was unlikely that the Germans could move their heavy siege guns towards Antwerp, but that these "would probably end in destruction in the mud." Subsequent events, however, proved this prediction a mistaken one. Nevertheless, the bad weather for a time threatened disaster to the Germans in that it delayed the arrival of reinforcements, and of provisions, and helped to demoralize the tired troops. The Allies, also, were prevented from advancing rapidly for similar reasons, and an extra time allowance was necessary in order that the various divisions could reach the ground assigned to them. The flooded rivers made the work of the "heroic engineers a veritable task of Hercules."

During the later fighting along the Franco-Belgian line, and near the Channel coast, the heavy rains continued to cause incessant trouble. "Torrential rains," producing "seas of mud"; "quagmires"; "morasses"; "bogs"—these are the expressions used to describe the condition of the region. Both sides were severely handicapped by the difficulty of moving the heavy artillery and motor trucks, but the Germans seem, on the whole, to have suffered most, with their heavy guns and motor trains. When the roads became impassable, the guns and trucks were driven through the fields, and in many cases became hopelessly stalled. The misty, rainy weather, making observation at a distance almost impossible, led to less artillery action. Autumnal fogs several times afforded a protecting cover which made a sudden assault on the enemy's trenches possible. At times, when the weather was especially stormy, the fighting ceased entirely. We read that "General Rain" helped the Allies. The discomfort of all the troops was very greatly increased because of the growing cold as autumn came on, the cool, damp nights and early mornings proving especially trying. It is interesting to note that the Belgian troops who were interned in Holland after the fall of Antwerp accidentally crossed the Dutch frontier in the dark, rainy night of their march.

These autumn rains were not limited to the Franco-Belgian war zone. In the eastern campaign, in late September, we read that the roads were quagmires and that the German troops who were advancing against the Russians were greatly hampered by the difficulty of moving the heavy guns and armored motor cars. In early October the rain and mud in this district interfered with the movements of both armies, but the Russians had the advantage because their field guns and wagons are especially designed for going through mud and soft ground, as a result of their development in districts where there are few good roads. The German artillery and automobile trucks, on the other hand, built low for service on hard ground, were moved with great difficulty or not at all. Hence the rain and the mud fought on the side of the Russians. The troops of the Czar got more of their artillery into action, and used it sooner. The Germans even found it impossible to protect themselves in the customary roofed-over trenches, because the soil was so saturated with water.

Late in October, in the campaign around Warsaw, heavy rains seem largely to have defeated the German plan of operations. The deficiency in railroads was to be made good by means of long trains of fast motor cars, but the mud was so deep that whole roads are reported to have been blocked with abandoned German transports and guns. In the advance towards Warsaw, the German artillery was so much delayed by the mud that it could not be brought up to strengthen the advance guard. The Russians captured many guns which had been abandoned in the mud. The big Krupp siege guns, which proved so effective in the west, where the roads are good, were a serious handicap in the east. Up to the end of October no important fortress had been taken by bombardment by the Germans in the east. In the west, fortress after fortress fell under the heavy gun fire. In such a region, of lowlands and swamps, winter cold, by freezing the ground, will make campaigning easier.

It is clear from these few illustrations that modern warfare has in no way become independent of the handicaps imposed by rain. Motors instead of horses are used to pull artillery and supply trains, but the guns have become heavier, and deep sticky mud is just as serious an obstacle as it ever was.

The grim specter of winter began to rise above the horizon as far back as the middle of September, and almost every day since then has brought some new evidence of the nearer approach of the cold, and the snow, and the suffering which are sure to come with the shortening days and the lowering sun. Modern wars are intense. They do not come to a dead stop in winter. The armies do not go into winter quarters as they did in the old days. The soldiers in the present war will suffer from the cold; the icy roads will make it difficult for horses to keep their footing; the snow will block roads and delay marching and transportation, just as has happened in the wars of the past under similar weather conditions. Modern methods of transportation are so well-organized that winter storms and cold do not interfere as much as was formerly the case, yet the movements of the heavy guns, the automobiles and the motor trucks of the present-day army are likely to be blocked by deep snows at least as effectively as was once the case when horses were exclusively used.

From Galicia, with its high ground and its exposure northwards, towards the great Russian lowland, came, in mid-September, the first mention of the suffering of troops from the cold. Early in October we read that the soldiers there were marching and camping in the snow. The Russians, well protected by their heavy overcoats, suffered little discomfort, but the Austrians whose winter clothing had been captured by the Russians in Lemberg were less fortunate. Whatever may have been the other reasons for the Russian advance into Austrian Poland, it is clear that this southern route into Austrian and perhaps later into German territory would naturally give the longest open season for the prosecution of the campaign. In the northeast, the Germans seem to have been surprised by the setting in of cold weather in the first half of October, and, not having heavy clothing, they are reported to have suffered severely. The Russians, on the other hand, were well protected, having fur caps covering both their heads and necks and being otherwise well equipped with requisites for a fall and winter campaign. It is not unlikely that the Germans, even if they were distinctly victorious in this zone, would think of penetrating far into Russia, to face, as did Napoleon, the might of Generals January and February. Heavy rains and sleet made speedy movements of troops difficult in early October. Toward the latter part of October snow was interfering with the offensive of the Russian army in Poland, because delaying the movement of their transport. The German and Austrian troops, therefore, retreated less rapidly, and made a more determined resistance. They were, however, themselves greatly hampered by a breakdown of their own supply trains. It is probable that the German activity against Russia in the east has been at least in part due to the desire to gain a distinct advantage before the setting in of the rigorous Russian winter. The capture of Warsaw before winter would have greatly strengthened the German line in East Prussia, would have endangered the Russian frontier in Galicia and would have had a distinct moral effect on the Poles. Further, if a large body of German troops could then be transferred to France, a new campaign against Paris might perhaps be attempted during the milder French winter. The Russians are more accustomed to severe cold than are the men from the west and south of Europe, and will probably prosecute the war with little diminution of energy. The Germans have evidently been preparing for the winter fighting in Poland, for the troops which went to the front early in October were equipped with fur gloves and sheepskin coats.

In the French and Belgian war zone the September rains are noted as having brought lower temperatures, "with a distinct feeling of autumn in the air, especially in the early mornings." This warning chill, with cold winds, seemed to arouse all the commanders to a sudden realization of the unpreparedness of their troops for a winter campaign. The terrors of the winter suddenly loomed up on the horizon of warring Europe. Living outdoors and in trenches is bad enough when the weather is favorable, but the sufferings of the men, especially of the sick and wounded, when the weather is cold are immeasurably greater. The lowered vitality of the wounded leads to many deaths from the cold, even if none of the men are actually frozen to death, as has so often happened in previous winter campaigns in Europe. On all sides we hear of preparations for winter. The German Crown Prince, some weeks ago, telegraphed to the Emperor for winter socks and underclothing for his men. Germany has ordered sheepskin clothing from Rotterdam; fur coats to the number of 150,000, presumably for the use of German officers, have already been delivered, and 2,000,000 sheep and lambskins have been bought for the use of the men. People ordinarily employed in glove-making are now engaged in providing the troops with clothing made from the skins usually taken for gloves. For the German cavalry, special leather leg protectors are being made. The French minister of war some time ago sent a circular to all the prefects, requesting them to obtain as rapidly as possible supplies of woolen underclothes, socks, gloves and blankets for the use of the French soldiers during the winter. England has made special provision for her Indian troops in the way of mufflers and warm underwear; has commandeered large quantities of woolen goods, and is importing from this country at the present time immense numbers of rubber boots and cardigan jackets. The difficulty of digging trenches, and of living in them, is greatly increased when the weather is wet and cold. Under date of October 16, we read that the allied troops are protecting themselves in the trenches with blankets and waterproof sheets, and are guarding against the cold by wearing "sheets of parchment" under their uniforms. Dug-outs are being cut under the sides of the trenches for the men to sleep and take shelter in. These refuges are raised somewhat above the bottom of the trenches, so that they are dry in wet weather. Some of the trenches are now provided with cover overhead, for protection against the weather as well as against the shrapnel fire. In the last week of October snow fell in the Vosges, in considerable amounts, and also at several points along the French frontier. The nights were reported as becoming steadily colder. The French colonial troops, especially those from Africa, were stated to be "benumbed by the cold."

There are many respects in which the weather is of more importance in warfare to-day than it ever was in the past. The use of searchlights and aeroplanes in directing ordnance fire, and the greatly increased mortality caused by modern artillery, make the protection of troops, in trenches or otherwise, of essential importance. A low cloud, a fog, a snowstorm, a heavy rain, may give just the protection needed, and yet not interfere with the free movement of the troops. In this very war, the surrender of Namur was hastened by a heavy fog, which enabled the Germans to plant their siege guns in a good position and without danger to themselves.

It is hardly necessary to point out that in the matter of aeroplanes and airships modern warfare is far more dependent upon weather conditions than it ever was. Since the great war began we have had many illustrations of this fact. It seems to be a fairly well established point that in order to have his reconnaissance of real value the observer in an aeroplane must, unless the weather is unusually clear, come down low enough to be in danger of gun and rifle fire. Fogs and low clouds obscure the surface from an aerial observer. Wind may wholly interfere with his work at a time when his report is most needed. The increasing numbers of London fogs with the coming on of autumn led to great anxiety in London on account of possible Zeppelin attacks. Tests were made at the end of September to ascertain whether searchlights can detect a Zeppelin even through a fog. A warning has been issued by aviation experts to the effect that an attack on London is most likely on a clear calm night. Foggy and misty weather hampered aerial reconnaissance in northeastern France during the October storms. In a despatch dated October 24, from Paris, we read that the aviators who were protecting the region over Paris suffered severely in "terrible hail and snowstorms." The German aviators, it is noted, set out according to schedule, in spite of unfavorable weather. It is not difficult to realize how serious the lack of a daily European weather map must now be to the whole aerial campaign. Germany, in particular, if she plans a Zeppelin raid on England, will find the lack of observations from the British Isles most serious. Possibly some of the secret wireless stations which are reported to have been discovered in Great Britain were used for sending daily weather reports to Germany. So far as the naval side of the war is concerned, there has thus far been little or nothing to note on the meteorological aspects. With the approach of winter, and the increase of stormy weather over the northern seas, we may not unreasonably look for losses due to gales, and thick weather, and fogs, and to suffering from the cold. Rough water and fog make the approach of a submarine difficult or impossible to see, and therefore help the attacking vessel. We note that the weather was "bitterly cold" at the time when the British cruiser *Hawke* was torpedoed, so that the chances of saving the men who were struggling in the water were greatly lessened. Special precautions should be taken to guard against collision, shipwreck and submarine attack, as the winter comes on. The German fleet is doubtless waiting for a winter gale to scatter the British ships. At the end of October a severe storm was raging in the North Sea—a sure sign of the approach of winter—and was making life on board of the smaller vessels, the torpedo boats and submarines, most uncomfortable. Archangel, which evidently served as a very important port for the Allies during the summer, is now frozen, and will remain so until next summer.

Thus, throughout the area of the Great War, the weather from day to day is playing its part in the campaign. Modern military tactics; modern armament; modern methods of all kinds, have not in any way eliminated the weather element as a factor of the greatest importance. The story of the present war does not, thus far, read so very differently from that of the stories of previous wars in the same countries. In 1586, the Spanish, as related by Motley, encountered such terrible rains on the Meuse that they retreated. A previous fall of Namur, in 1692, was largely due to heavy rains which prevented the English from crossing the river and meeting the besieging French army. The English in Flanders in 1708–09 endured great hardships on account of deep snows, which blocked the roads. The cold was intense and the troops, who were short of firewood, suffered severely. The Duke of Marlborough wrote (1708): "Till this frost yields we can neither break ground for our batteries nor open our trenches." The French, in Poland, in 1806–07, found mud 3 feet deep; drenching rains; driving sleet; melting snow and icy streams. In the Franco-Prussian War of 1870–71, over the same historic ground in France, we read of torrential rains; floods; icy roads; muddy fields, and of sufferings on account of cold.

So the story goes on, from age to age, from one war to the next. War and the weather: they are related to-day, as they were in the past, physically, physiologically, psychologically, and as they will be until wars shall cease.

Dropping the Pilot:

Tenniel's cartoon, printed in *Punch* in 1890.

THE PROGRESS OF SCIENCE

WAR AND PUBLIC OPINION

It is difficult to write, speak or think about anything except the war now devasting Europe and the earth. Although social and economic questions can not be treated with the same objectivity as the natural and exact sciences, The Popular Science Monthly has always included them in its scope, the immediate ground of its establishment in 1872 having indeed been the need of a journal in which to publish Herbert Spencer's "Principles of Sociology." That work takes an attitude strongly opposed to militarism and discusses the difficulties of obtaining scientific points of view in sociology owing to national interests and prejudices.

The events of forty-two years have enforced the arguments of Herbert Spencer and to-day their truth is convincingly exhibited, at least in the sight of most of us. But it must be admitted that the two arguments are not on the same scientific plane. When it is claimed that armaments and war are not only inevitable, but may be desirable for a nation and for the world, there is no scientific disproof, only conviction against prejudice or prejudice against conviction, as the case may be.

The extent to which belief may be determined by emotion is demonstrated by the fact that the people of each of the nations now involved hold that they are engaged in a war of defense against the selfish and wanton aggression of their opponents. We have been requested to print a manifesto, addressed "To the Civilized World" by ninety-three leading representatives of German science and art, including Professors von Baer, von Behring, Ehrlich, Fischer, Haeckel, Klein, Nernst, Ostwald, Röntgen, Waldeyer and Wundt. They say:

> *It is not true* that Germany is guilty of having caused this war. Neither the people, the government, nor the "Kaiser" wanted war. Germany did her utmost to prevent it; for this assertion the world has documental proof. . . . *It is not true* that we trespassed in neutral Belgium. . . . *It is not true* that the life and property of a single Belgian citizen was injured by our soldiers without the bitterest self-defence having made it necessary. . . . *It is not true* that our troops treated Louvain brutally. . . . We can not wrest the poisonous weapon—the lie—out of the hands of our enemies. All we can do is to proclaim to all the world, that our enemies are giving false witness against us. You, who know us, who with us have protected the most holy possessions of man, we call to you: Have faith in us! Believe, that we shall carry on this war to the end as a civilized nation, to whom the legacy of a Goethe, a Beethoven and a Kant, is just as sacred as its own hearths and homes. For this we pledge you our names and our honor.

A reply alleging the exact contrary has been signed by one hundred and thirty leading British professors, authors, artists and men of science, including Lord Rayleigh, Sir William Ramsey, Sir William Crookes, Sir William Osler, Sir Ronald Ross, Sir William Turner, Professor Sherrington and Professor Schuster. They say:

> We grieve profoundly that under the baleful influence of a military system and its lawless dreams of conquest she whom we once honored now stands revealed as the common enemy of Europe and of all peoples which respect the laws of nations. We must carry on the war on which we have entered. For us, as for Belgium, it is a war of defense waged for liberty and peace.

The workings of the psychology of the crowd may be illustrated by a minor incident. German scientific men have renounced the honorary degrees conferred on them by British universities, and German scientific men who had attended as invited guests the Australian meeting of the British Association are being held as prisoners of war in England. But at the meeting of the association after the outbreak of war these same scientific men received honorary degrees from a British university with special applause.

When public opinion in regard to war is so subject to emotional control, the way of wisdom is to avoid war and the conditions leading to war, even to the extent of holding that there never is a good war or a bad peace. The only gleam of hope in the present situation is that public sentiment in this country is against war and against the nations which, rightly or wrongly, are supposed to be the aggressors, and that each nation is anxious to disclaim responsibility for the existing chaos. In its inception the war was an affair of militarists and diplomatists, and Germany was unfortunate in combining these two classes in the same clique. All would have been different if there had been a Bismarck to whom the military machine was subordinated; there might have been war between Russia and Germany, but there would have been no European war. Conditions were better in Great Britain, and diplomacy tried to prevent war, but when war came then diplomacy had involved the people in its tricks.

Suddenly out of its stale and drowsy lair, the lair of slaves,
Like lightning it lep't forth half startled at itself,
Its feet upon the ashes and the rags, its hands tight to the throats of kings.

But none of us can see clearly in the storm and in the darkness. It is our helplessness, the horror of it all, the pity of it all, that overwhelm us. The only safe conclusion is that the work of the world for science and for civilization must be maintained. We may well honor the Paris Academy of Sciences for continuing its meetings when the enemy were at the gates of Paris and the government had fled; the scientific men and scholars of Strassburg for opening the sessions of the university at the usual time. And most of all it is our business to carry forward the flickering torch. The fact that the greatest nations of Europe will be prevented, not only this year but for some years to come, from doing their share of scientific work, makes it all the more necessary that the scientific men, the scientific institutions and the scientific journals of this country should maintain and increase their efforts.

CRYSTALS AND X-RAYS

As part of the celebration of the one hundred and fiftieth anniversary of the founding of Brown University a series of meetings and courses of lectures have been arranged. One of the most interesting of these was a series of four lectures by Professor William Henry Bragg, F.R.S., of the University of Leeds, discussing the important work that has recently been done on the phenomena resulting from the passage of X-rays through crystals.

Two years ago an experiment of great beauty and extreme scientific importance was successfully carried out in the physical laboratories at Munich by Friedrich and Knipping, acting on a brilliant suggestion made by Laue, a member of the staff of the university at Zurich. To put it very briefly the experiment consisted in the exposition of the interference effects accompanying the passage of X-rays through crystals, and it proved that X-rays consist of extremely short waves in the ether. It is now clear that X-rays are exactly the same thing as light rays, except that the wave length is roughly ten thousand times smaller. The significance of this discovery can not be compressed into a single sentence because it points in several independent directions.

In the first place, the result is of the greatest importance in connection with the general theories of radiation. The undulatory theory of light has been extraordinarily successful in correlating experimental facts. Towards the end of the last century it seemed as if it had conquered all the great problems of physical optics. More recently it has shown signs of inefficiency. For example, it seems unable to account for the so-called photo-electric phenomena. Incapacity has been still more obvious in connection with the properties of X-rays. At one time it seemed, at least to some, easier to deny the identity of light- and X-rays than to force the orthodox theory to yield an explanation of X-ray effects. When therefore the identity is established by the new experiment, a very interesting position results. The orthodox theory is to be supplemented in some way not yet clear. It will then be, surely, far more effective than it ever has been before. From our new point of view our difficulties are more clearly defined, but, at the same time, we shall probably receive new help to their solution.

In the second place a method of analyzing X-rays has been evolved from the original experiment. The wave lengths of X-rays can now be measured exactly, and other characteristics of X-rays can be expressed in terms of these. Remarkable relations have already been found to exist, for instance, between the wave lengths of the X-rays emitted by various atoms under proper stimulus and the positions of those atoms in the table of Mendelejeff. Much light is thereby thrown upon the meaning of the table, and a limit is set to the number of its vacant places, that is to say of elements not yet discovered.

Again, the new experiments provide a means of investigating the structure of crystals. We are able to determine the arrangement of the atoms in a crystal and to measure the distance from atom to atom. The science of crystallography can be built on a firmer basis than before, for it can now take account of the internal structure of the crystals whereas it has hitherto relied on observations of the external form.

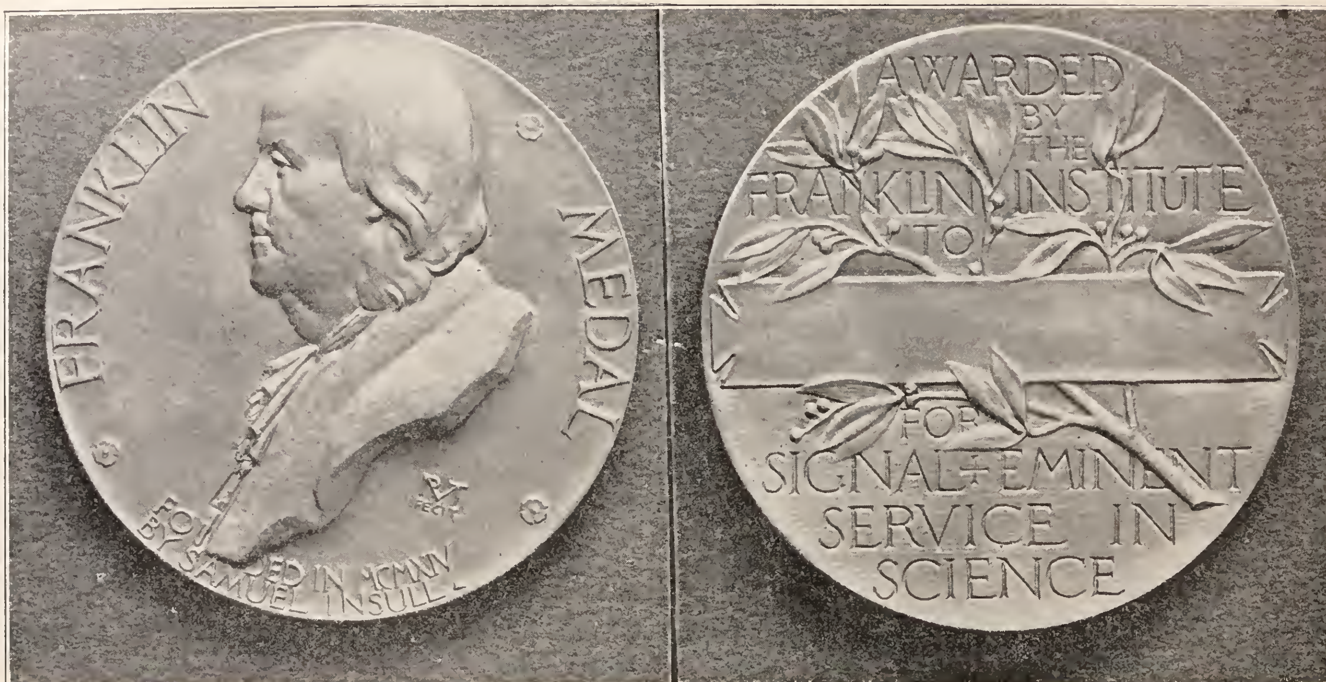
Finally, the motions of the atoms about their average positions are made manifest. Little experimental work has yet been done in this direction, but it does not seem unlikely that we shall presently measure with exactness the extent of the atomic movements which contribute to the heat content of a body.

Professor Bragg's lectures were devoted to an attempt to explain more fully the statements outlined above. In the first lecture the general question was considered. Laue's experiment was described and interpreted and its meaning discussed. The subject of the second was W. L. Bragg's restatement of Laue's theory, together with its important consequence, viz., the X-ray spectrometer and its powers. The third was devoted to the consideration of crystal structure in the light of the new discovery, and the fourth to X-ray spectra, the relation of X-ray properties to wave length, and the thermal movement of the atoms in the crystal.

NATURAL SCENERY FOR MUSEUM EXHIBITS

In connection with the rearranging of the scenic effect of one of the Roosevelt animal groups in the National Museum, actual African plants and grasses are to be filled with plaster and preserved in their natural state to give the animal specimens local color. In the art of modern taxidermy the old system of simply "stuffing" the skins of animals has been done away with, and a standard method of accurate life-size modeling established. Over a carefully made plaster cast of this model the skin is stretched, glued and sewed, so that it is difficult to see how it was accomplished; for the moment it is easy to believe that the animal itself has been preserved intact in some marvelous manner.

For many years past the National Museum has been employing natural scenery—real grass, foliage and soil—in its biologic and ethnographic groups, much as in theatrical effects, to create a natural atmosphere. Now-a-days, museums do not simply mount individual animals on a platform and place them in a case. They are mounted in natural attitudes, and ground work, suitable to both the environment and the posture of the figures, is prepared.



Franklin Medal.

Founded by the Franklin Institute as the result of a gift from Samuel Insull, Esq., of Chicago, to be awarded for eminence in science or the applications of science to industry.

The animals are often arranged in family or social groups that the student or spectator can gleam something more than an impression of how an isolated specimen looks. Physical geography, geology, botany and other studies now enter the field of taxidermy.

In preparing a new setting for the African buffalo group, built in the National Museum about a year ago, the three animals are to be left in their original positions, which indicate alarm, just as they were first discovered by the hunters, but in addition they are to be represented as standing on the edge of an African papyrus swamp. The ground-work of the group will present the effect of the marshland where the buffalo live, the grasses and plants being added, that a complete picture of the African swamp may be effected.

Since nearly all grasses and foliage are subject to decay and shrinkage, with constant loss of original form and color, they, like the skins of the animals, are especially prepared. Few grasses, as a rule, can be dyed or preserved in anything like their natural form, but, fortunately, to this end the papyrus lends itself very well. The plants having thick stems are opened, and the pithy inner removed; they are then bent or curved and secured in the position desired, wired and filled with plaster. When the plaster is set, the plants are painted to represent their colors in life, and grouped together with other grasses to form a setting for the animals.

When the African buffalo group was first assembled, as no African material was yet at hand, it was decided to use temporarily cosmopolitan foliage which was to be found here as well as in Africa. Although the artistic effect proved very satisfactory, the museum officials determined to have this group as technically correct in every detail as the lion, the hartebeest, and the rhinoceros groups already on exhibition, and finally arrangements were made whereby the native African material was obtained. Several cases of papyrus plants and arundo grass were secured from the natural habitat of these buffalo, and the animals, set in their true environment, will soon be placed on exhibition again.

SCIENTIFIC ITEMS

We record with regret the death of Professor August Weismann, the distinguished German zoologist; of Dr. Henry Gannett, geographer of the U. S. Geological Survey; of Bernard Richardson Green, civil engineer and superintendent of the Congressional Library, and of Mr. G. R. Mines, professor of physiology in McGill University, who died while making experiments in his laboratory on the action of the heart, apparently as the result of some failure in the apparatus.

Professors Roentgen, Lenard and Behring have each recently been reported to have repudiated the gold medals conferred on them by scientific associations in Great Britain, and have donated them to the Red Cross or other relief work, and now it is said that the Hanbury medal has likewise been donated for relief work by its recipient, Dr. E. Schmidt, professor of pharmacology at Marburg.

The past and present members of the scientific staff of the Rockefeller Institute for Medical Research gave a dinner at Delmonico's to Dr. Simon Flexner on October 16, in celebration of the tenth anniversary of the opening of the laboratories of the institute under his direction.—At the celebration of the twenty-fifth anniversary of the Johns Hopkins Hospital a portrait of Sir William Osler, by Mr. Sargeant, was presented.

The National Academy of Sciences will hold its autumn meeting at the University of Chicago on December 7, 8 and 9.—The American Association for the Advancement of Science and the national scientific societies affiliated with it will hold their convocation week meetings at the University of Pennsylvania, Philadelphia, during the week beginning on January 3.

INDEX

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