THE

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EDINBURGH NEW PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

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Remarks on the Climate and Physical Characters of the Lake District of Westmoreland, &c. By JOHN DAVY, M.D., F.R.S. Lond. and Edin., Inspector-General of Army Hospitals.

IT has been well said, that the staple of the Lake District is its beauty,—beauty depending on a happy combination of the various natural elements by which the feeling is produced in the mind, and which are so well detailed, and vividly brought to the mind's eye, by the Great Poet of the district, the honoured and lamented Wordsworth :—

> "Clouds, mists, streams, watery rocks and emerald turf,
> Bare hills and valleys full of caverns, rocks,
> And audible seclusions, dashing lakes,
> Echoes and water-falls and pointed crags,
> That into music touch the passing wind."

Beautiful as this region is now, if we look back—tracing as well as we can its history, as engraven on its rocks, and hardly less distinctly displayed in its beds of gravel and drift, lodged in its valleys and on the sides of its hills—we may fairly infer that it has not been always so ; on the contrary, that there was a time when it was the scene of violence and deformity every way horrid. I allude to an early period, to that period when the mountains were formed by an uplifting force acting beneath ; when, it may be well imagined, there were neither lakes, nor rivers, nor woods, nor even verdant meadows ; in brief, a region of bare rock, varied only by breaks in its surface; immense chasms, then constituting its valleys, and immense projections, constituting its hills.

That such must have been the condition of the district in a remote geological period, cannot be doubted, if we reflect that all the rocks which come under the name of secondary, because formed of the material of former rocks disintegrated, and of which this district chiefly consists, must once have been in a horizontal position, and from which they could only have been raised by the force imagined, one acting from beneath, and analogous to that still acting as witnessed in the volcano.

How long the district remained in this its primary state, as raised probably from the depths of the ocean, I am not aware that we have any data for calculating. As the rocks bear marks in their consolidation of the action of fire, or of an indurating temperature, the period probably was of considerable duration. A long lapse of time too, probably was requisite to cool down the surface, so as to render it fit for the support of plants, or even to admit of the condensation of aqueous vapour, and the production of rain.

The condition which followed this of high temperature was, there is strong presumptive evidence, an opposite one, one of great cold, and which may be called its glacial period; when, in place of fiery, it had its frozen Alps, and when every valley was filled with ice; when, in brief, it was a glacier district, and hardly less horrid a desert than in its earlier stage. Indications of this condition we have throughout the country, and in three different ways, all according and corroborating: viz., 1st, in the parallel or nearly parallel markings, such as scratches and grooves on the rocks. These are best seen in situations in which the rocks have recently been laid bare, and in the valleys, and on the lower declivities of the hills. Excellent examples of the kind may be seen at the Windermere railway station, close to the buildings, and also in the inclosure belonging to the adjoining new chapel: 2dly, in the form of the rocks and hillocks rising out of the valleys, and of the terraces extending in many instances through the narrower valleys—the rocks and hillocks rounded, more or less dome-like, and the terraces without abrupt angles or breaks; segments of cylinders, as it were, as much as the former are segments of cones. Good examples of these are extremely common; in Langdale there are instructive instances of the bosom-like rocks and knolls, and in Troutbeck, of the extended, gently-rounded, or sweeping terrace formations: 3dly, in the composition of these knolls and terraces, formed as they are of gravel and worn stones, the worn materials, the detritus of the mountain masses, so arranged, not in a stratified manner, but irregularly, as is witnessed in the moraines of the Alpine valleys, where glaciers are at the present time in actual existence, and by a mighty force wearing down the rocky beds, on which I cannot say they rest, for rest they have none, but move, and that constantly. Examples showing this their composition may be seen almost anywhere, where there has been a recent cutting or excavation in the side of a hill. The depth of the accumulated, ground, comminuted material, is often twenty or thirty feet, or more, conveying to the mind the impression, not only of a mighty force exercised, but also of its having been in operation for a lengthened period; and further, how by its agency the mountains have been lowered, the valleys contracted, and their levels raised.

Of its exact period—either its beginning or termination—more than of the former, I apprehend we have no data for estimating. That it was before the district was inhabited, may be inferred from the circumstance that no relics of man have, that I am aware, been found in these accumulations. It is probable even, that during the glacial period this district was completely a desert, as much so as a frozen region could be; if any conclusion may be drawn from the fact, for so I believe it to be, that no remains either of animals or vegetables have hitherto been met with in any cutting or excavation, of the many which have been made.

How marvellous are these former conditions, compared with the present state and aspect of the district! What the cause or causes of the change have been is matter for conjecture, and this both as regards the agents of change and the time in which it has been effected—whether gradually, from a lowering of the mountains, from the wearing-down glacier action, and alteration of climate in consequence; or rapidly, I may say suddenly, from the breaking down of barriers, the engulfing a portion of continent, the opening of new channels to the ocean, and the admission of the waters of a tropical sea, of the warm Gulf-stream to shores before frozen—the same waters which wash our shores now, as well as the shores of the whole of the north of Europe, and to which they unquestionably in a great measure owe the peculiar mildness of their winter climate. All the circumstances considered, the conclusion most probable seems to be the latter, viz., that the change was sudden, concomitant with a great continental disruption, and the insulation of that fragment of the broken continent which now constitutes our happy island,—or as our Shakspeare has it,—

> "This other Eden, demi-paradise;
> This fortress, built by nature for herself,
> Against infection, and the hand of war;
> This precious stone set in the silver sea,
> Which serves it in the office of a wall,
> Or as a moat defensive to a house,
> Against the envy of less happier lands;
> This blessed plot, this earth, this realm of England."

Whichever hypothesis be adopted, whatever question there may be as to the causes concerned, the effects are of the clearest kind; and, reasoning from them, there cannot be a doubt that there has been, as stated, an icy period and one of glacier action; and changes of surface, such as thus described, of a remarkable kind, the results of this action.

Let us pause for a moment and consider the part which this glacier action has performed in altering the surface, and in imparting a certain grace and beauty to the scenery, as exhibited in the rounded forms of its lower rocks and hillocks, and in the pleasing undulations of the skirting mountain declivities, so well contrasted with the rugged summits, and often jagged outlines of the higher mountain barriers; the one, the former, as if softened down and made lovely for the abode of man; the other, the latter, left in untamed asperities, as if sacred to solitude and designed for contemplative meditation.

The curved, the undulating line, has been fixed on by a great artist as the line of beauty. Hogarth, though born and educated in London, belonged to a Westmoreland family; and if he ever visited these regions, especially the valley of Troutbeck, where a branch of his family resided, he might here and there have acquired the first idea of his hypothesis.

Another remark I would offer as to glacier-action: whilst it has polished our valleys, civilized them as one might say, (reflecting on their original wildness and ruggedness), it has also prepared a soil, a gravelly, porous one, with intermixture of a finer material, a fertile mould—the former collected chiefly in the valleys, the latter on the higher declivities; both of them well adapted for pasture; in brief, constituting this a pastoral region, which it essentially is. And when we reflect on the situation of the two kinds of soil—the poorer, lowest, needing manure to be rendered fertile; the better soil on the hills, less needing manure to be productive—the arrangement seems providential; another of the harmonies and adaptations of such common occurrence in nature. And the more so, if we keep in mind the facility there is in applying manure to the one—the lowland meadows, and the difficulty of conveying it to the other—the upland pastures; and how the two are used, and help out each other, the meadows supplying winter forage, and early spring grass, when there is scarcity of food on the fells, which are then often covered with snow; the fells yielding a tolerably abundant and delicate pasture in the advanced spring, and during the summer and autumn and early winter.

I shall pass on now to the principal feature of the district, that which gives it a name and a distinction, namely, its lakes. These beautiful mirrors of nature—for such they are in perfection, when their surface is unruffled on a calm day, though, to those living by their sides or in their immediate neighbourhood, so common as to excite but little reflection, and still more rarely wonder or admiration—are not less admirable in the economy of nature than what I have already commented on, and especially in connection with the climate of the district.

A large proportion of rain falls in the Lake District, more than in any other part of England; and the quantity increases in approaching the mountains; thus, whilst at Kendal, on the outskirts of the district, the average annual fall is little more than 50 inches, at Bowness it is over 60 inches, at Ambleside over 70, at Grasmere over 80, and in the heart of the mountains, as at Saithwaite in Borrowdale, it is over 100 inches.

In relation to the lakes, this great proportion of rain is a happy circumstance, essential indeed to them ; without it, how different would be their character! Many of them would unquestionably be unwholesome marshes; or unprofitable if not unwholesome; and some of them could hardly be other than collections of salt water, dead seas in miniature. The shallower ones would belong to the first description, the deeper to the second. It is only necessary to consider the circumstances which constitute a marsh, and a salt lake or dead sea, to come to this conclusion. I need not dwell on the essentials of a marsh, a naturally undrained space, neither lake nor dry land, tending to both; after heavy rains becoming the former, after a period of drought the latter, and then, in a hot climate, or in a hot summer in our climate, the source of exhalations. The essentials of the salt lake are, you will anticipate me, a supply of water, an inrunning stream without an outlet, an outflowing stream. The Dead Sea in the Holy Land, and the Great Salt Lake on the American Continent, almost on the shores of which that remarkable sect the Mormons are now making their settlement, are striking examples of the kind. Now as all the outlets of these lakes are at a comparatively high level, were it not for the abundant fall of rain, the influx by feeding streams would exceed the efflux. Saline matter, which exists in all river water, as much so as in the Jordan, the feeder of the Dead Sea, would gradually accumulate, and by accumulation render the imprisoned water dead, that is, unfit for animal life. How changed would the scene or the scenery be were the circumstances of climate different from what they are in relation to rain! Salt lakes, in place of those which we at present possess of pure water, so fitted for all the beneficent purposes of the pure element, would be, perhaps, the least deformity and disadvantage; a greater would lie in the aridity and sterility consequent on a small supply of rain. Of this we may form an imperfect idea from our experience of what happens when we have a drought, as occasionally occurs in spring, of a month's or six weeks' duration, when vegetation is arrested,—the springs fail,—the rivers and lochs are almost dried up,—the flocks are pinched for food,—often suffering fatally in consequence,—and even the beauty of the face of nature is lost or impaired in its changed complexion from the cheerful healthy green, to the sickly and sad brown. Further, the large amount of rain with which this district is blessed (and I say blessed on account of the benefits resulting from it) is not limited to the mere feeding of the lakes or streams, and the making them living waters, and the charm and glory of the district; it extends to the climate, and forms an important part of it. Let it be remembered that every drop of rain, in the act of becoming a drop,—that is, in the act of passing from the state of aqueous vapour to the liquid state as in the rain drop,—emits heat, and some notion may be formed of the effects of our rains in rendering our atmosphere mild. Besides which mitigating influence of rain, there are others,—not less important. One tending to purify the air,—to wash it of its impurities; the other to fertilize the earth,—by carrying down from the atmosphere those very impurities;—unwholesome to animal life,—beneficial to vegetable life. Of the former, we have proof, even to demonstration, in the pellicles, or filmy coverings of soot which are often to be seen on the surface of the mountain tarns and of the larger lakes after gentle rain, following a misty state of atmosphere. I call the matter soot, because I have found, on careful examination, that it has all the properties of ordinary soot; and, I have no doubt, has been wafted from the manufacturing districts of the adjoining counties, where the air for miles is often obscured by smoke. Of the fertilizing effects of rains, there cannot be doubt. Such an effect the soot brought down by them will have; and the same effect is produced by the ingredients of rain water, those which a refined chemistry has detected,—especially carbonic acid and carbonate of ammonia,—two of the most powerful of the aeriform fertilizers—by which mainly indeed, with the inorganic elements derived from the soil, all the mountain pastures are fed (I say fed, vegetables requiring food as well as animals), and all our woods are supported and maintained in their growth. Not only has rain a mitigating effect on the climate in the act of forming and falling, but also when collected in lakes and flowing in streams, and rising in springs. Equally in summer and winter their tendency—the tendency of springs, streams and lakes, is to equalize the atmospheric temperature,—to prevent undue heat or excessive cold, in the same manner as the ocean itself; in the summer season absorbing heat,—taking it from the atmosphere; in the winter, emitting warmth,—imparting it to the atmosphere. On the approach of winter, a striking proof of the latter is afforded in the steam or condensed vapour, which is so often seen rising from the lakes and rivers, from their comparatively warm water, into the colder incumbent air,—an appearance by which the course of the rivers may often be tracked. For this equalizing office, as to temperature, water above all fluids is best adapted, inasmuch as its capacity for heat exceeds that of any other fluid; no fluid absorbing so much heat, whether in passing from ice into water, or from water into steam, and no fluid losing its heat and cooling so slowly. Even in the act of freezing, its equalizing or mitigating tendency is exercised,—every particle of water in the act of congelation is, in the passing from the liquid to the solid state, acquiring a diminished capacity for heat, and consequently disengaging heat.

Wonderful are the adjustments and compensations of Nature; and in no instance is it more beautifully exemplified than in the properties of water and the part it performs in the wide economy of Nature. Two of its properties, in addition to those already noticed, are especially worthy of attention, as concerned in this economy; on its being densest, or of greatest specific gravity at the temperature of 40°, so that whether its temperature rises or falls, it becomes lighter, and consequently remains at or ascends to the surface; the other, a further increase of lightness, or diminution of specific gravity, on its consolidating or freezing. Owing to the first property, lakes are secure from freezing till the whole mass of their waters is reduced to the temperature of 40°. Owing to the second property, congelation, when it occurs, always takes place at their surface, and the floating ice serves to the water beneath, like the glass of the windows to our rooms, to check any reduction of temperature, and to retain warmth. In consequence of this beneficial provision, even in the severest winters, the lakes of moderate depth have only a small portion of their water converted into ice,—the greater part of it remaining fluid of the temperature 40°, or but little below that, and fit to sustain in health fish and their other inhabitants. In the instances of the deeper lakes, such as Windermere and Coniston Water, owing to these properties, the effects are more strongly marked; ice is rarely seen on their surface, and never excepting in winters of unusual severity, and then only partially and where they are shallowest, and thus fitting them, I may remark, to be the winter refuge of water-fowl, especially of the migratory kind—by which they are so much frequented.

Moreover, the streams flowing out of the lakes, even when the latter are frozen, being of the temperature above mentioned, little below 40°, are equally fitted for sustaining life as the deep water of the lakes, and especially for becoming the spawning places and nurseries of some of our most valuable fish.

Next to the lakes, if not equal to them, the most distinctive feature of the Lake District is its mountains, constituting the Highlands of England. On their picturesque effect, whether in their aerial distances for beauty, or on near approach for grandeur and sublimity, with all the accidents connected with them, of light and shade, of mist and cloud, and others of Nature's elements, whether in motion or repose, I need not dwell.

Passing by, then, what is picturesque and poetical in these mountains, I shall venture briefly to advert to their physical influences, as affecting the character of the country and its climate.

First, they may be considered as the main cause of the ample supply of water, in the form of rain, which conduces to make this a Lake District, they acting as refrigeratories, condensing the moisture wafted by the winds, and chiefly from the sea; and next, in their elevation, regarding their original uplifting, thereby occasioning depressions—hollows for the reception of the abundant rain,—in other words, the lake basins; so that these mountains and lakes are joined in fellowship most intimate and essential, in origin as well as in function and use. Moreover, whilst by their higher elevations the mountains act as the producers of rain, by their lower declivities they promote warmth by radiation from their surface, and by affording shelter to the valleys. It is these declivities, at a moderate height, which have the preference, and I believe justly, as sites for dwellings by persons best acquainted with the district and its climate. In such situations there is more of sunshine than in the valleys; there is less of mist and fog,—less hoar frost; less heavy dews; a drier, and even a warmer air, and a more wholesome atmosphere.

Of the climate of the district as compared with that of England generally, I think favourably. Were I to give a character of the climate generally, I would say that it is marked by moderate mildness and equability of temperature, and moderate dryness of atmosphere, and more than ordinary salubrity, partly owing to the physical peculiarities which I have noticed, and partly to proximity to the sea, and to the valleys and inhabited parts of the country generally being but little raised above the level of the sea; thus, Windermere is only 140 feet above that level, and Ambleside, in its lowest parts, only a few feet more, and in its highest only 100 more.

It might be supposed that, where so much rain falls, the number of rainy days would be great, that the quantity of snow would be excessive, and that the air commonly would be loaded with moisture. But happily neither is the case. It would appear from accurately-recorded observations that the number of rainy days—that is, days in which during the twenty-four hours some rain has fallen, as determined by the rain-gauge, is actually less than in places in England where the amount of rain is inferior in quantity. I shall quote in proof a statement made by a gentleman of Kendal, of well-known accuracy as an observer. In his summary of meteorological observations made in Kendal in 1853, specially adverting to this point, he remarks,—"Notwithstanding the large amount of rain in the town, the number of rainy days in several parts of the kingdom where the quantity of rain was very much less greatly exceeds that of ours. For instance, whilst we had 150 wet days in 1853, at Doncaster they had 223, a greater number than ours by 73, or nearly half as many more, their quantity of rain being 31·21 inches. At Falmouth they had 203 rainy days, or 53 more than we had, though the quantity of rain was the same as ours within half an inch. At York they had 174 wet days, their quantity of rain last year being only 22·33. At Low Bridge House, Selside, six and a half miles north of Kendal, whilst their quantity of rain greatly exceeds that of Kendal, being 57·984, or nearly 18½ inches more than ours, they had but 125 wet days." Thus far I have quoted from Mr Marshall. I may add, in continuation and corroboration, that at Ambleside, where, for the past year, the quantity of rain has exceeded that at Kendal by 26·81 inches, the amount having been 66·27 inches, the number of rainy days has been less, viz., as 146 to 150, four less.

The important fact that there is no necessary relation between the total fall of rain in any given time, as the yearly period, and the number of showers, or of rainy days, may seem paradoxical at first, but not so if duly reflected on, and taking into account that commonly where most rain falls the rain-drops are largest—the showers are heaviest.

In London, and in the midland counties, a fall of 1 inch of rain in the twenty-four hours is unusual, whilst here, I speak more particularly of Ambleside, a fall of 2 inches in that time is not unfrequent, and even more; this last year, a drier year than usual, as much as 4·45 inches fell in the time specified; this was in November.

Heavy showers, whilst they wash, also clear the atmosphere, and have the like effect on our roads and on all naked surfaces. During heavy rains how turbid are the swollen streams, and how soon after the cessation of rain do they subside and acquire their ordinary clearness and purity. Clay, which is a compound, or, rather admixture, of the finer particles of disintegrated rocks, of such as are carried off by floods, and which render them turbid, is almost unknown in the district; *i.e.* a clay soil, a clay accumulated: and hence in part the drier roads, drying rapidly after heavy rains, and hence also in part the drier atmosphere. By a happy provision of nature, clay, which is retentive of moisture, and well adapted for cereal crops, is conveyed from the mountain districts where there is most rain, and where in consequence the climate is better fitted for pasture, to the lowlands and plains where the supply of rain is less, its retention in the soil more needed, and the soil as well as the climate is best adapted for the crops least suitable to the mountain regions. The adaptation is not confined to plants; surely it extends to animals, and even to man, though in the latter it may be materially modified and altered by habits, education, and occupations of life. Bœotian and Attic were terms of old distinction of country and men. Like distinctions might be made in modern times, but these I shall not insist on. Our great poet, the poet of nature, loved to be in the open air; there, was his study; I have heard him say, that he chose this country for his permanent home, not so much for its romantic scenery, as for the cleanness and dryness of its roads.

The proportionally small quantity of snow that falls is remarkable; it is rare that it amounts to an obstruction. Since the mail-coach has passed through the district, now for a period of many years, I have been assured by an aged person of accuracy, that it has been stopped by accumulated snow only twice. Seldom are the valleys under snow more than twenty-four hours at a time, and rarely is the depth of snow more than a few inches. However this may be explained, and the explanation does not appear to me obvious or easy, rather a problem for solution, it is a happy circumstance for the district. Had we snow in the same proportion as we have rain,—an inch of rain being equivalent to about four inches of snow,—direful, I cannot but think, would be the consequences; the valleys, almost every winter, at least in their gorges, could hardly escape, from the drifting of snow, from being blocked up and rendered impassable; even the climate might be affected, the winter protracted into spring, and an almost glacial period renewed.

In what I have stated respecting the Lake District, I may be charged perhaps with having pronounced its eulogy. It may be so, and I believe it deserving of eulogy. That the climate is not perfect, or the district all that could be wished, I need not say. Were either so, they would be an exception to all the climates, and all the regions of our globe; perfection in nowise belonging to anything earthly. Were I asked which are the greatest defects and drawbacks of the climate, I should say, but with some hesitation, the strong winds, not unfrequently almost hurricanes, to which it is subject, and the vicissitudes of its day and night temperature—the thermometer exposed at night, laid on the grass, with a clear and calm atmosphere, often even in summer falling to or below the freezing point, from the effect of radiation. I notice these qualities of climate, I say, with hesitation, as defects or drawbacks, because they are not without advantages; the atmospheric storms purifying the air, or the reduction of temperature by radiation insuring cool nights in summer—a blessing which only those who have lived in a tropical climate, or who have passed a summer in the south of Europe, can, I believe, duly appreciate. The high winds, moreover—the gales—whilst they promote the salubrity of the climate, are not without effect on our woods; they are great clearers of excess of wood and levellers of decayed trees; a circumstance, with our shallow gravelly soil, whilst unfavourable to timber of maximum growth, such as the deeper soils of tame districts can boast of (their chief ornament), is at least favourable to the growth of young trees, and that in most picturesque situations, amongst rocks and on rocks, and through them, with the cultivation of coppice periodically felled, to that youthful cheerful aspect of scenery which is one of the distinctive features of the district.

Knowledge, it has been said, is power—is it not also taste? This, I think, we are sure of, that the more we know—the more the mind is expanded—the more we have to admire, and the more numerous are the sources of pure and innocent pleasure that are opened to us; and as regards common things, the more uncommon they appear, that is, the more we see in them to excite our wonder and to administer to our gratification. The remark applies to the Lake District. He who would derive from it most delight, must come prepared and educated, as it were, if he would escape disappointment. An ancient orator has said, "How many things does the painter observe, which we do not see!" the same may be said of the student of nature generally. How much does he see which the ignorant never witness: the more exact his knowledge, the more he observes,—the varieties of rocks, even their forms—the varieties of plants, their several localities—are all matters of interest to him. Even the passing clouds, the falling waters, in their course and effects, to him are not without interest. He enters on such a scene as this our district, as on a Great Exhibition of Nature's works, not to gaze in apathy like the ignorant clown, but to observe intelligently, and observing, to learn and be delighted; witnessing, in all he sees, records of the past and of progress, the fine adaptation of means to ends, a perfect harmony of parts, and how every part is indicative equally of design, of wisdom, and of goodness.

On the Post-tertiary and Quaternary Formations of Switzerland. By A. Morlot. (With a Plate.)

The rivers and lakes of Switzerland show distinct traces of having once stood at a higher level. Terraces of regularly stratified and well-rounded shingle, identical with that which they now drift, follow them wherever circumstances have been favourable for their formation and preservation. The Lake of Geneva, for example, is encircled by a zone of three such terraces, at the heights of about 50, 100, and 150 feet above the present level of the water, which stands 1230 feet above the sea.* They do not exist along the shore, where the action of the waves, far from depositing any sediment, only eats and cuts away; but they appear at the mouths of all the watercourses, which carry sufficient shingle with them. In the neighbourhood of Aarau, three such levels, at the same heights of about 50, 100, and 150 feet, have been noted by Dr Tschogge. The formation is not limited to the low country

* The measures are all given in English feet.

between the Jura and the Alps, but it follows the principal water-courses far into the interior of the mountains,—the Rhine, for example, being bordered by such terraces as far as Camischollas above Disentis, 4400 feet above the level of the sea. The same appearances have been observed everywhere in and around the Eastern Alps. Here the formation has been traced from the vicinity of the sea at Gorz, all along the principal rivers, and to a certain distance along their tributaries, far inland, into the very heart of the Alps, to a height of from 3000 to 4000 feet above the level of the sea; the upper limit of the terraces, where they disappear in the side valleys, rising gradually with the bed of the principal valley. On the outskirts of the Alps—at Gratz, for example—where the Mur flows at 1140 feet above the level of the sea, that limit is found in the side valleys at about 2000 feet; while sixty miles further up the course of the Mur, in the neighbourhood of Leoben, in Upper Styria, where the rive stands about 500 feet higher than at Gratz, the extreme limit of the terraces attains about 2500 feet in the more remote side valleys, converging there with the actual level of the water-courses. In those side valleys, the last distinct diluvial terraces measure only from 10 to 20 feet above the present level of the running water, whilst in the main valley the terraces attain 200 feet in certain places,—the circumstances particularly favourable for their mightiest expansion being the confluence of two principal water-courses. On the contrary, where the valley is uniformly embanked by mountain ridges, unbroken by side ravines, the terraces very usually disappear entirely, to reappear with the next affluent.

Fossils are naturally of rare occurrence in such deposits of coarse shingle, but still they are not altogether wanting. At Morges, on the Lake of Geneva, for example, a fine molar of the mammoth has been found imbedded in the middle terrace of 100 feet; and in strata of finer sediment intervening with the gravel of the lower terrace of 50 feet fresh-water shells of species still living in the neighbourhood have been discovered. What has been said is enough to render it thoroughly evident, that the diluvial formation, or *diluvial drift* (*alluvion ancienne* of the French authors), in question, has been formed by the actual system of rivers, when their bed was at a higher level, in consequence of the continent standing lower by several hundred feet. If the continent were to be uniformly upheaved once more, the rivers would scoop out a deeper channel in their modern deposits, which would then project in the shape of terraces, just as is the case with diluvial drift. It is also evident that the formation of such perfectly regular deposits absolutely excludes the presence of any glacier on the same spot and at the same time; so that it is hereby proved that, during the diluvial period, the Alpine domain was generally free from ice, up to a height of at least from 3000 to 4000, and even to 4400 feet, above the present level of the sea. That it must have been free of ice much further up appears most probable, when we consider that the water-courses could not have acquired the same torrential character which they have at present, as proved by the identity of their deposits, immediately upon issuing from the glaciers. Now, it has been set down by the geologists of Switzerland, that the formation of the diluvial drift in question was anterior to the glacial period, for the superposition of erratic deposits upon the diluvium had been distinctly recognised. At Geneva, for example, the erratic is seen lying near 50 feet thick on the diluvium of the middle terrace of 100 feet above the level of the lake. But besides this being in contradiction of what had been made out in the north of Europe, where the glacial grooves and furrows are covered by the diluvial drift, there presented itself a difficulty of a more direct bearing,—the shingle of the diluvial terraces of such localities as Morges, Yverdon, Soleure, and even so far into the valleys of the Jura as the erratic boulders penetrate, was found to be chiefly Alpine, and derived in particular from the Valais,—that is, from the upper course of the Rhone. But how could it have got over the depression of the Lake of Geneva, still measuring a depth of 900 feet? Any current, any diluvial action, the grandest of all the *grandes débâcles*, or the mightiest wave of translation, would infallibly have filled up the lake before casting up on its *opposite* shore, and spreading over the hills as far as Soleure, and into the very heart of the Jura, such quantities of Alpine shingle. The only way of explaining the transport of those materials was by the agency of the glaciers. But then the glacial period must have been posterior to the formation of the diluvium! On the other hand, it had been shown by Mr Blanchet that the large glacier of the Rhone, after having covered a large track of western Switzerland, but before subsiding into its present limits, had remained stationary during a period of some length, filling up the basin of the Lake of Geneva, but not extending much beyond it, or reaching considerably farther than Geneva. At the same time, but by a different method, Mr Guyot was led to establish the same two stages of glaciation, as he has shown in a most able paper on the distribution of the species of rocks in the erratic basin of the Rhone.

Such was the state of the question when Robert Chambers made out the existence of two glacial periods in Scotland, distinguishing a first, of general, mighty glaciation, and a second of more limited, local glaciation,—a result confirmed by Mr Ramsay's observations in Wales.* It was not difficult to point out the corresponding phenomena in Switzerland; but still the second period—that of local glaciation—might have been considered, in Switzerland at least, as being merely a prolonged

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* The author here barely does justice to the merits of Professor Ramsay. The facts we believe to be as follows:—Mr R. Chambers was impressed with the idea of a general glaciation in Scotland during his tour through Sweden and Norway in 1849; and at the Edinburgh meeting of the British Association in 1850 (see *Ed. Phil. Jour., Oct.* 1850, p. 330), he presented an array of facts which he held to be unaccountable on any other supposition. Professor Ramsay, in March 1851, read a paper before the Geological Society, explaining phenomena of the superficial accumulations and surface markings of North Wales, which gave a similar view as applicable to that country, and, looking to other facts, led to the conclusion that there was a second glacier period "on a smaller scale." The laborious paper of Mr Chambers, read to the Royal Society of Edinburgh in December 1852, and printed soon after in this Journal, illustrated the author's original view, and confirmed Mr Ramsay's theory of a second period, of which, in the interval, Mr Chambers had found many proofs in Scotland and in the Lake District of the north of England. It may be remarked, that, while Mr Ramsay considers the first set of glacial phenomena as arguing a deep immersion, Mr Chambers theorizes on a possible sub-aerial glacier, and his views on this point have since received a remarkable support in the account given by Professor Rink of continental glaciers in Greenland.

intermediate stage between the era of general glaciation and the present order of things.

It was then that the writer of this paper discovered in the beautiful neighbourhood of Clarens, celebrated by the greatest of modern poets, a singularly distinct example of the superposition of well-defined diluvial drift upon a pure glacial deposit. The spot, which is easily found, lies 400 paces below the stone bridge of Tavel, on the torrent of Clarens, two miles east of Vevey. The superincumbent diluvium, identical with the present drift of the torrent, is from 7 to 9 feet thick, and forms part of the terrace of 100 feet above the lake, upon which, on the opposite side of the water, stands the lovely little burying-ground of Clarens, where many a poor foreign invalid has found his last resting-place. The glacial deposit beneath those 7 feet of diluvium is to be seen full 40 feet thick, and resting upon the miocene molasse. It is composed of a compact blue clay, containing worn and scratched Alpine boulders, and without trace of stratification constituting genuine *Till.* The same superposition of diluvial drift upon an older glacial deposit has since been observed by M. Ischer in the neighbourhood of Berne. Here then we have plain and positive proofs of a glacier having swept over the country *before* the diluvial period. *During* the diluvial period the glacier had entirely disappeared, as has been shown, whilst *after* the diluvial period the glaciers returned, leaving on the diluvial terraces abundant deposits.

It follows, from what has been said of the presence of erratic materials in the diluvial drift, that the first glacial period was that of the greatest spread of the glaciers. It was then that the glacier issuing from the Valais covered with its immense delta of ice the whole country from Soleure far to the south of Geneva, pushing deep into such valleys of the Jura as open to the east, and well-nigh topping over the chain into France; for on the flanks of the Chasseron near Guerdon, right opposite the opening of the lower Valais, it reached the prodigious height of 4730 feet above the level of the sea. This, however, was its point of culmination, whence its limit is to be seen sinking both ways, reaching the plain beyond Soleure, but still standing 2870 feet above the sea at

Fort de l'Ecluse beyond Geneva, where it was swollen by its powerful tributary of the Arve, descending from Mont Blanc.

The other principal hydrographic basins of Switzerland, such as those of the Aar, Reuss, Limmat, and Rhine, were occupied each by glaciers of dimensions proportionate to their respective domains of alimentation; the glacier of the Rhine, for instance, reaching even into the very basin of the Danube. The smaller valleys of the Alps, such as those of the Sarine, Simmen, Thur, had also their streams of ice; but they can only be considered as inconsiderable affluents. The Jura, which is now free from everlasting snow, except in some caverns and clefts in the rocks, had also its own glaciers. That the southern valleys of the Doire, Tore, Tessin, and Adda, discharged mighty glaciers into the plain of Lombardy, is satisfactorily established by observation, but these regions have not yet been so thoroughly investigated as the northern.

In fact, during the first glacial period, the greater part of Switzerland was overwhelmed by ice, the highest ridges and peaks only protruding above it, enough however to furnish the materials for the numerous angular alpine boulders spread along the Jura, and over the low country. The absence of angular erratics of that period, remarked by R. Chambers in Scotland, shows that there *terra firma* was almost entirely masked by the ice. A similar remark has been made by M. Collomb with respect to the Vosges, which present nothing like the precipitous heights of the Alps.

A curious island in the Alpine sea of ice was formed in the domain of the molasse by the hilly region of the Napf, 4620 feet above the sea, which stood too far out of the reach of the frozen streams, issuing from the great Alpine valleys, being separated from the central chain by a mighty and continuous wall of limestone. A cut across the country from Zurich to Berne, brings to view the singular contrast between the erratic domain of the Reuss and the Aar, so richly strewn with Alpine detritus, and hence so fertile; and the region of the Napf, where the bare, naked molasse sandstone peeps out everywhere from under its thin covering of bad soil.

That first period of general glaciation does not appear to have been of very long duration, for its boulders, although extensively scattered over the country, have not been observed heaped up in large masses, so as to form real moraines. This is particularly striking along the Jura, where the limit of the erratic domain of the Rhone is accurately defined, and yet where there is by no means a great accumulation of detritus, forming anything like a moraine. The moraines of Switzerland appear to belong to the second glacial period, as is indeed proved in many cases by their superposition to the diluvial drift.

The second glacial period, on the contrary, must have lasted very long, for its moraines are numerous, well-defined, and very often stupendous, but they do not reach as far as the traces of the first glaciation, indicating a lesser expansion of the ice. At this second period the glacier of the Rhone, for example, merely filled up the basin of the lake Leman, without reaching over the molassic heights inclosing it along its northern shore, and without extending much beyond Geneva. In the neighbourhood of Vevey, the first glacier must have swept over the mountain of Folly (5771 feet), which is strikingly well rounded, whilst the second glacier only reached to Lalliaz d'Avant (3212 feet), that is, 2559 feet lower, as is distinctly marked by its own particular deposit, of which we shall speak when treating of the glacial diluvium.

Not only must the second glacier have remained for a very long time within limits, but it must also have taken a great length of time to disappear, and have retreated by stages, for it has left a series of moraines in the intervening distance, between its extreme limit and the present glaciers, marking as many intermediate stations, where it must have halted each time for a considerable number of years, if not of centuries. These intermediate moraines are particularly well marked in the erratic domain of the Linth, where they have been studied by Mr A. Escher. They may be traced up to the very margin of the present glaciers, showing that the change of climate from that of the second glacial period to that enjoyed by Switzerland at the present moment, has been slow and gradual.

The researches of R. Chambers have shown, that in Scotland the first period of general glaciation has produced a deposit of compact blue clay, unstratified, and mixed with rounded and scratched boulders; whilst to the second period, that of local glaciation, is to be ascribed the formation of a light brown loamy deposit, with rounded and angular erratic blocks. The same law holds good in Switzerland, but with exceptions which furnish the key to its explanation. In the neighbourhood of Vevey and Lausanne, for example, where the ice of the first glacier lay several thousand feet thick, the erratic clay of that first period is all blue and compact, while the deposit of the second glacial period is light brown, more loose, and much more friable. But in the neighbourhood of Soleure, where no glacier of the second period reached, the erratic clay and loam, although belonging to the first glacier, is exclusively light brown, blue clay having nowhere been observed. But then we stand there on the extreme boundary of the first glacier, where the ice was not above 200 or 300 feet thick, and where the circumstances were analogous to those under which the brown deposits of the second glacier were formed, that is, access of the outward air. For the mineral composition of the brown and the blue clay is the same, the mass being in both cases the produce of the trituration of the same rocks, only the protoxide of iron has been converted into hydrate of peroxide in the brown clay by the oxidizing influence of the atmosphere.

A peculiar formation of some magnitude and of a singular character has to be pointed out here, as belonging to the second glacial period. The second glacier of the Rhone, to take the best known, occupying for a great length of time the depression at the bottom of which lies now the lake of Geneva, dammed up the side valleys opening upon it, and which, being at their origin below the domain of eternal snow, had no glaciers of their own. The water courses flowing in these valleys thus formed pools and lakes along the glacier, just as happens at the present day. In such places deposits are formed under the combined action of ice and water, and the result is irregularly stratified masses of shingle, mixed with erratic detritus and with boulders large and small, angular, and rounded and scratched. On the very edge of the glacier, the deposit is most irregular, scarcely showing traces of stratification, but the further from the glacier, the more does the action of water become evident in a regular stratification. This peculiar sort of formation has been called by M. de Charpentier, *glacial alluvium*, when belonging to the modern glaciers, and *glacial diluvium*, when referable to the glacial period.

After what has been said of the second glacier of the Rhone, we cannot be surprised at finding the basin of the Lake of Geneva encircled by a zone of such *glacial diluvium*, forming one more or less regular line of terraces, hardly less distinct than the diluvial terraces, although not quite so regular, standing high above the bottom of the valley, and inclining in a marked manner toward Geneva,—a line particularly interesting, as tracing out, in the plainest possible manner, the limits of the second glacier of the Rhone. A terrace belonging to that line can be distinctly perceived near Bex; the little village of Arveyes stands upon it, 2664 feet above the Rhone, or 4002 feet above the level of the sea. The valley of Ormont, opening at Aigle, shows no such deposit, having necessarily had no glacier of its own, as its origin is even now commanded by the glacier of the Diablerets; but between Vevey and Villeneuve a terrace is distinctly seen, both at Avant, above Montreux, and on the way to the baths of Lalliaz, above Clarens, at a level about 800 feet lower than at Bex, although still at about 2000 feet above the lake.

Part of the town of Lausanne stands upon a considerable deposit of this class, presenting a wild confusion of erratic detritus, with huge angular boulders, and rounded shingle, irregularly stratified,—light-brown sandy loam being abundant. This spot may be considered as one of the finest examples of a simultaneous glacial and aqueous deposit,—a real lateral moraine, and yet partially stratified.

But nowhere does this glacial diluvium acquire such a vast range as above Rolle, forming there a table-land at its greatest width of about three miles, cut off by the Jura, where the village of Biere lies. Its outer angle or border, fronting the lake, is marked by the *Signal de Bougy*, famous for its panoramic view. The height of that table-land may be estimated at an average of 1100 feet above the lake; and the thickness of the deposit, although not actually measured, must be 200 or 300 feet at least, to judge from the deep ravines by which it is intersected.

It forcibly strikes the mind that this glacial diluvium must have taken an immense time for its gradual accumulation, confirming what we have already said about the long duration of the second glacial period. The glacial diluvium, not to be mistaken for the diluvial drift (*alluvion ancienne*), from which it differs virtually both in composition and structure as well as in its level, has been compared by Mr Martins to the *Oesars* of Sweden, of which he distinctly says that they were produced by the conjoined action of the glacier and of water, whilst M. Desor has as distinctly established the superposition of these Swedish *Oesars* upon the diluvial drift, resting, in its turn, on polished and grooved rocks of the first glacial period. Human remains, said to have been found under certain *Oesars*, would unquestionably show that they belong to the modern period; but according to the observations of M. Durocher and M. Martins, there are in Sweden two sorts of deposits, of essentially different nature, which are comprised under the common denomination of *Oesar*,—the one composed of coarser and more regularly stratified detritus, and containing scratched boulders and sometimes shells of Arctic species, and the other more sandy, following the coast-like lunes, and containing Baltic species. The former corresponds very well with our glacial diluvium; whilst the latter—to which, according to M. Desor, belongs the well-known case of the antique cabin found in cutting the Soedertelje canal, near Stockholm—would be modern. On the other hand, it must not be forgotten that the present companions of man, and in particular all his now domesticated species, existed already at the diluvial period, and that there are facts, although they are certainly not very numerous, tending to ascribe a much higher antiquity to the human race than is generally admitted. Of this, illustrations are to be found,—in the human remains discovered in the south of France, in strata covered by the produce of a volcanic eruption, which, on the other side of the mountain, has covered the same sort of strata containing bones of the mammoth; in the flint arrow-head found in a grave in Sweden by M. Nilsson, and appearing to have been sharpened, after having acquired a white crust, like that of the natural chalk flints; and in the association of human remains with those of extinct species in the caverns of Belgium and of Brazil.

It is worthy of remark, that no real and well-defined glacial diluvium, in the shape of terraces, has yet been observed as referable to the first glacier, and its absence may be considered as a confirmation of what has been said regarding the comparatively short duration of the first glacial period.

Summing up what has been said, we come to establish the following subdivisions of the post-tertiary, or the quaternary age, in Switzerland, observing, that an intermediate deposit between the till of the first glacial period and the tertiary series, such as is found on the coast of Norfolk, has not yet been observed in Switzerland:—

1. *First glacial period.*—The greater part of the country covered by ice; the glacier of the Rhone, for example, occupying the immense extent represented by the map given by M. de Charpentier in his famous *Essai sur les Glaciers* (1841). Scotland seems to have been entirely overwhelmed by ice at that time. The same was the case with the Vosges in France, where M. Collomb has found, on the very summits of the chain, erratic boulders, but rounded, and having a very peculiar look of antiquity, easily understood now. But the mightiest, a real giant of its kind, was the great Scandinavian glacier, which stretched over the vast lowlands of northern Europe, as it was reserved to the genius of M. de Charpentier to unfold. Formation of the *Till*, or compact blue clay, without stratification, and with rounded and scratched boulders, when far enough from the extremity of the glacier, and under a sufficient pressure of ice. The period does not seem to have been very long, so as to have given rise to the formation of terminal moraines of any importance. No fossils. Height of the continent at that time unknown, speaking only with reference to Switzerland.

2. *Diluvial period.*—The glaciers have disappeared, even in all the principal valleys of the Alps to a height of at least from 3000 to 4000 feet above the present level of the sea. The rivers flow at a higher level than at present, because the whole continent stands somewhat lower, at least as far as it

concerns the hydrographic basins of the Rhine, Danube, Po, and Rhone. Period of long duration, as is shown by the corresponding deposits, at least as long as the modern period, consequently of more than 60,000 years, according to Lyell. The mammoth (*Elephas primigenus*) inhabits Switzerland, land and freshwater shells of recent species live in the same sites as at present. Rare deposits of bituminous wood of existing species. Drift terraces and raised sea-beaches in Scotland, in the north and south of Europe, and indeed over almost all the world. In the valley of the Mississippi, for example, the authors of the splendid Smithsonian volume on its antiquities, point out the regular occurrence of three diluvial terraces, together with a fourth lowest, of modern or alluvial formation, exactly as in Switzerland.

3. *Second glacial period.*—The glaciers fill the principal valleys of the Alps, and issuing forth into the open country, take possession of the depressions lying before them, and so well marked by the presence of lakes, such as that of Geneva, encircling them with girdles of stupendous moraines. The glacier of the Rhone, for instance, did not reach above the heights bordering the lake Leman, standing at Vevey full 2500 feet lower than the first glacier, and at Rolle 900 feet lower than at Vevey, so that it could not extend much beyond Geneva. In the appropriate localities formation of considerable *glacial diluvium* by the co-operation of the glacier, and of the water-courses it dammed up, producing a curious mixture of erratic detritus with aqueous drift. Front moraine of the Aar glacier, in the shape of a splendid and mighty semicircular rampart at Berne. Formation of vast deposits of light brown loam, and of the *Loess* of the valley of the Rhone, Rhine, and Danube, distinctly resting on the well-defined diluvial drift of those valleys, and being only the finer sediment, which is found of the same nature, but coarser and mixed with boulders, nearer the Alps, for example at Lausanne, Geneva, Oeningen near Schaffhausen, and Vienna. Fossils, particularly in the Loess; the mammoth, cavern-bear, reindeer, and in general the vertebrata still living in the country, including our now domesticated species, as appears from M. Pictet's investigation of the fossils found in the glacial deposit

at Mattegnin near Geneva. Mollusks not rare, almost exclusively land-shells of existing species, but showing that they met at Bâle (863 feet above the sea) with a climate such as is now congenial for them in the Alpine zone of from 4000 to 6000 feet above the present level of the sea. Height of the continent unknown. If the Loess is a river deposit, the continent could hardly be higher than it is now. *Oesars* of the north. Period of long duration. If in Scotland, according to R. Chambers, the moraines of the second glaciers are inconsiderable, may it not be owing to the scarcity in that country of such precipitous heights commanding the glaciers, as occur abundantly in the Alps?

4. *Modern Period.*—The glaciers having retreated slowly, and by stages, to their present limits, and the continent having been somewhat raised above its level at the diluvial period, the water-courses scoop out a deeper channel, leaving the remnant of their diluvial drift as projecting terraces, rising very often like steps one above the other. These steps are generally three in number in Switzerland, as well as in the eastern Alps, but where circumstances were particularly favourable for their preservation, smaller intermediate terraces are to be seen between the lowest and the middle of the three principal. The presence of those terraces shows, that the upheaving action has not been uniform, but has experienced periods of interruption and repose, during which the continent remained stationary as long as was necessary for the formation of each step, three such principal stations being marked out. It must be pointed out, however, that both the two superior of the three principal terraces or steps must have been shaped out before the second glacial period, as deposits of the latter are to be seen resting upon them. How it stands with the lowest terrace cannot yet be exactly said, satisfactory observations of this sort requiring exceptionally favourable local circumstances, which are naturally of rare occurrence.

Such are the inductions from facts lying before us, plain, well-defined, and intelligible. But the mind cannot rest satisfied; it would fain know, not only that such events have taken place, but also *why*, and in particular, how such an enormous growth of the glaciers was brought about.

Much has been said on the subject, and explanations have even been sought for in the nature of the sun's atmosphere, and in different temperatures of the celestial spaces travelled through by our solar system; nay, a French geologist has even seen in the glacial period the influence of a formerly warmer climate. But let us frankly confess, that science is as yet by no means prepared to answer the question, and to furnish anything like a satisfactory solution of the great problem. So much, however, is already gained, as to show that the climate was not necessarily widely different from what it is now. Prof. James Forbes has pointed out how the glacier de la Brenva (Mont Blanc) swelled, its lower extremity rising full 300 feet, during five years that the mean yearly temperature observed at Geneva was less than $\frac{1}{3}$° F. lower than usual, and Mr Martins has shown that a diminution of the mean temperature of 5·7° F. (4° C.) and very likely of only 2·8° F. (2° C.) would be sufficient to bring back the glaciers of Mont Blanc down to Geneva. It is also well known, that in the southern hemisphere there is to be seen actually a state of things bearing much analogy to what excites our wonder as having taken place in the same latitude north during the glacial period, and which, according to Mr Hopkins, is to be considered as more normal than the present climate of Europe. Then also does the circumstance pointed out both in Sweden by M. Durocher, and in Switzerland by M. Agassiz, of the upper erratic limit converging with the present upper limit of the glaciers, where they pass into the *névé*, prove, that during the glacial period, at least during the second, the snow-line, or the level of the origin of glacier ice, was about the same as it is now-a-days. Consequently, the climate could not be extremely different from what it is at present, nor the elevation of the country above the sea much greater than it is now, unless, indeed, we suppose, what appears at least very conjectural, a compensating influence of both causes acting simultaneously, but in opposite ways.

The impression produced by such considerations leads us to seek in less extraordinary circumstances a mode of accounting for the glacial climate. Mr Hopkins, for instance, has dwelt on the influence of different configurations of land and sea on the climatal state of particular portions of the earth's surface. With reference to Switzerland, Mr A. Escher has called attention to the great effect which the warm south wind of the Sahara, the *Foehn* of the Swiss, has in melting the snow on the Alps. This is so prominent, that if Central Africa were to be submerged, as may very well have been the case during the glacial period, it is by no means impossible that the glaciers might again overwhelm our country. Then, again, looking to the north, we see that a subsidence of a few hundred feet would suffice to submerge the extensive lowlands of the north of Europe and Asia, so that the north wind, which now brings us cold, but clear and sunny weather, would in that event spread damp and chilly mists over the whole country, and produce just the sort of weather suitable for a powerful increase of the glaciers.

Even without going either north or south, we find within our own country a startling indication of the possible cause of glacial phenomena. Our learned meteorologist, M. Denzler, in studying the question of the snow-line, with respect to the level at which the snow begins to be permanent during each season, has found, that if we take the lowest mean height observed for each of the twelve months during a period of twenty-nine years, and set those monthly means together in their proper order, we form an artificial yearly snow-line, such as is usual in Lapland. But the real occurrence at distant intervals, of such an artificial year, as well as that of a more frequent series of less cold years, is a matter which can be calculated by the theory of probabilities.

On the other hand, it must be kept in view, that, plausible as the above speculations may appear, they in no way tend to explain the repetition of the glacial phenomena in North America; and indeed, when we consider this and the ancient marks of ice in Patagonia, as well as the traces of a former greater extension of the glaciers in the Himalaya, we are forcibly restrained from asking for an explanation in exclusively local circumstances. Wild as it may have appeared when first started, the idea of general and periodical eras of refrigeration for our planet, connected perhaps with some cosmic agency, may eventually prove correct. At any rate, the glacial event is now proved to have taken place twice, and it may therefore be regarded as a periodical phenomenon of nature.*

Explanation of Plate I.

Diluvial Drift upon Glacial Till at Clarens.

T. The diluvial terrace, perfectly regular and well-defined, but very narrow, abutting against the hills of molasse, which rise behind it, and running parallel with the modern bed of the torrent. Although only 50 feet higher than the torrent, its lower extremity keeps fully 100 feet above the lake. The torrent extends its delta and raises its bed at the same time, tending thus to bury by degrees its diluvial strata, of which the terrace in question forms part.

D. The diluvial drift of the terrace, from 7 to 9 feet thick, formed of coarse, well-formed shingle, identical with the modern deposit *L*, and unstratified. The power of a water-course is marked by the inclination of its bed and the coarseness of its drift. These two factors being here identical for the diluvium and the present torrent, it follows that the diluvial torrent was of the same nature and power as the modern torrent.

G. Glacial *till*, compact blue clay, unstratified, containing rounded fragments of limestone, distinctly scratched, together with a few crystalline rocks from the Valais. Lying 40 feet thick upon the molasse *in situ* at *M*.

B. Huge block of molasse, smoothed, and showing distinct glacial striæ at *S*.

L. Small terrace, 4 or 5 feet high; modern deposit of the torrent, which has somewhat deepened its channel, because it has been dammed and narrowed.

R. Present bed of the torrent when swollen.

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* The present paper has been transmitted by the author in its English dress. As it is a matter of general interest, a copy of the manuscript has been sent to M. Guyot at Cambridge (U. States). That the same subdivision of the post-tertiary or quaternary formation holds good for America, and that there are to be found in that continent the same traces of two glacial periods, and of an intervening non-glacial diluvial or drift-period, follows from the researches of M. Rogers. These, however, the author is acquainted with only by very brief extracts, so that he could not refer to them more extensively, as would have been desirable.

Evidences of Downward Movements east of the Malvern Range. By W. S. Symonds, F.G.S.

That the Malvern ridge was once a molten mass, deep down in the interior of the planet, and that, previous to its upheaval, it became hardened into syenite, is well known to most geologists. There is also no doubt, from the discovery by Miss Phillips of the conglomerate that bears her name, that the waves of a period as distant as the Upper Caradoc, dashed against the Plutonic rock, and rolled and intermingled together pebbles and chips of syenite with the animal remains of mollusca and corals that lived and flourished in the seas of that remote history of the planet's surface.

Professor Phillips some years since pointed out that the principal upheaval, which caused the elevation of the Malvern ridge, and with it the whole of the great Silurian and Devonian region of Herefordshire, Wales and the south of Ireland, occurred between the carboniferous and triassic systems. The discovery by his sister, just alluded to, also established the fact that in times long antecedent to the post-carboniferous elevation, a mass of syenite had been protruded through the surface on the line of the Malvern ridge, which was acted upon and denuded by the waves, and that, in short, the syenite of the Malverns occupied, to a certain degree, its present position, during the epoch of the Upper Caradoc.

The object of this communication is to describe phenomena exhibited by the *edges* of the stratified deposits east of the Malverns, near their contact with the Plutonic range.

In a paper published by the late Mr Hugh Strickland in the Philosophical Magazine for November 1851, he says, "If we could strip off the thick mantle of New red sandstone which conceals the eastern side of this axis, we should probably find the strata from the Caradoc sandstone up to the coal-measures more or less upturned at their edges." The correctness of this supposition is established by the discovery of vertical beds of the Caradoc transition group, containing trilobites and shells, resting against the syenite, at the base of the Gullet Pass.

The Permian system intervenes between the carboniferous group of rocks and the triassic; and it was during this epoch that the principal elevation of the Plutonic mass in question is generally supposed to have occurred.

The rock known as "Haffield conglomerate," in the Malvern district, was formerly ranked as the lowest member of the New red series; it is now believed by Professors Phillips and Ramsay, and Mr Jukes, to belong to the Permian epoch. Professor Ramsay believes it to be the representative of a glacial period; a most interesting question, as bearing on that remarkable fact in geologic history, viz., the extinction of palæozoic forms of life during this period. There is one question, however, we should like to have answered, and that is, how Professor Ramsay reconciles his Permian glacial theory with the tropical forms of the Permian flora?

The Haffield conglomerate dips to the south-east at angles varying from 13° to 28°.

The beds that succeed the Haffield conglomerate are a thick, red, sandy group, known as the "Newent" sandstone of Professor Phillips. The Professor mentions, that "at a point near North Hill, in the great quarry of syenite, the red sandstone was cut through," "dipping 45° to the northward." During the excavations for the foundation of the Messrs Burrow's new house, near the Bellevue Hotel at Great Malvern, this red sandstone was exposed in a splendid section, showing distinctly the angle of slope. The dip is 41° to the south-east.

We quite agree with Professor Phillips that this sandstone which rests at an angle of 41° against the syenite of the Malvern ridge, is the equivalent of the "Newent" sandstone, dipping under the Keuper group. The question is, what is this "Newent" sandstone? is it a Permian rock, or a representative of the Bunter beds of Cheshire and of Annandale? In the May Hill district, it rests immediately on the Carboniferous deposits!

We call especial attention to the fact, that if the "Newent" sandstone be a TRIASSIC rock ,and acquired its present highly inclined position solely by the *upward* movement of the syenitic axis, the elevation of the Plutonic ridge must have continued to a great extent after the commencement of the triassic epoch! A dip of 41° is an evidence of no insignificant elevation, if due to that alone.

In sinking the shaft and driving the tunnel on the Worcester, Malvern and Hereford railroad, the Keuper shales and sandstones have been well exhibited, as also their position as regards the syenite. The tunnel is about 400 yards to the north of the "Admiral Benbow" at Malvern Wells. The Keuper slabs are in some instances ripple-marked, and contain the characteristic shell "*Posidonomya minuta.*" They dip from the syenite at an angle of 54°.

That elevating movements took place along the line of the Malvern dislocation after the period of the lias and even of the oolitic system, is certain; but these upward movements do not altogether account to us satisfactorily for the phenomena exhibited by the EDGES of the stratified deposits east of the syenite.

The amount of dip displayed by the beds of the "Newent" sandstone and the Keuper marls in contact with the syenite, is greater than can be attributed solely to elevatory forces, when you compare that high inclination with their *loss of dip* at a very short distance from the Plutonic rock. Within half a mile of the range the Keuper sandstones show a dip of but 10°, the Newent sandstone of 15°.

We suspect, then, that in working out the geology of lines of dislocation, we are apt to forget that there may be a downcast as well as an upcast side, and that depression went on contemporaneously with elevation along these ancient lines of fault.

We believe it was Professor Harkness who first formed the idea that the Bunter beds of Annandale show signs of *depression*, and that he attributes the high dip of some of those beds to the sinking of the vale.

He assimilates this depression to that which would occur on drawing off the water of a frozen lake or pond, and the consequent sinking of the ice. To us this theory accounts more satisfactorily than any other for the high angle of dip displayed by the edges of the mesozoic strata east of the Malverns, and their loss of dip at a short distance from the syenitic axis. If elevation was the sole cause of their displacement, the dip would be more regular; while the downward movement, acting with the upward, has effected those faults, contortions, and breaks, everywhere so puzzling in the Malvern district.

Notice of an Accurate and Easily applied Method of Ascertaining the Direction of the Wind, by Observing the Reflected Image of the Clouds. By THOMAS STEVENSON, F.R.S.E., Civil Engineer.

In making some experiments, in which it was necessary to know accurately the direction of the wind, I was much annoyed by the insufficiency of vanes and all ordinary methods employed for that purpose. The under currents of air are so numerous and conflicting, more especially in towns, where the houses are lofty, that I have seen it proclaimed to be due east at one end of a street, while at the other it seemed with equal certainty to be coming in a westerly direction.

In this dilemma it occurred to me that a more accurate conclusion might be arrived at, by observing the direction of the drifting clouds when reflected in a mirror. It is now nearly three years since I adopted this plan, and as I have found it convenient and useful, and am not aware that it has been employed by others, I take this opportunity of introducing it to the notice of those who may have experienced similar difficulties with myself.

At first I used a common mirror, placed horizontally so as to have the sky reflected in it, and having fixed upon a cloud, I watched its progress in the mirror, taking care to keep the eye steadily in one position, and carefully marking the track of the cloud upon the glass with a pencil of soap. When this was done it was easy, by placing a compass on the mirror, to ascertain the direction of the wind from that of the cloud's path traced on the glass. A more convenient and portable instrument has since been constructed for me, consisting of an ordinary compass having a silvered disc in the centre of its covering glass of such a size as to allow the points of the needle and the graduated circle of the compass to be seen beyond it. The glass has cross lines cut upon it, passing through the centre, and drawn so as to correspond with the cardinal points marked on the divided circle. The whole compass can be made to revolve in the horizontal plane, upon a point projecting from the bottom of the outer case. When the cloud which is to be observed has been selected, as near the zenith of the observer as possible, the compass should be gradually turned round until one of the lines upon the glass remains coincident with one well-defined edge of the cloud as it passes across the field of view. The angle indicated by the magnetic needle being then read off, the azimuthal bearing of the cloud's track from the magnetic north is at once ascertained.

The convenience of this instrument might be increased by having an eye-piece attached to it, capable of being fixed in such a manner as to point to the intersection of the cross lines in the centre of the circle, so that the eye may be kept steadily in the same direction. By means of an apparatus on the principle of a camera obscura, the direction of the wind could be easily ascertained by observing the compass bearing of the cloud's track. And in the absence of better instruments, the reflection by a mirror ought certainly in all cases to be preferred to the indications of vanes whose action must always be vitiated more or less by friction, and perhaps by other causes, besides being liable to be acted upon by currents which have been distorted from their true direction by obstructions due to houses, trees, and the configuration of the earth's surface. The changes of wind and weather so characteristic of our climate, might, perhaps, be more certainly or more speedily predicted by comparing the motions of the clouds in the higher regions of the atmosphere, with those nearer the earth's surface, than from information derived from other sources. I lately observed a change of wind apparent in the direction of the high clouds for two days before the currents near the earth's surface were affected, although they ultimately assumed the same direction.

EDINBURGH, *April* 11, 1855.

Remarks on the Natural History of Electric Fishes, with the description of a new species of Malapterurus from the old Calabar River, West Africa. By ANDREW MURRAY. (Plate II.)

The electrical properties possessed by certain fishes have been at all times an interesting topic of inquiry; and as of late years the subject has been pursued, in connection with its relations to Physiology, with so much success as to have engaged general attention, our readers will perhaps not be indisposed to see a resumé of what is now known on the subject.

No land animals have hitherto been ascertained to possess the power of giving electrical shocks,* but amongst fishes several species are known to possess this property. Those possessing it are not limited in their habitat to any particular medium—sea water, fresh water, and brackish water, all contribute their species. Nor is the property confined to any particular tribe or family of fishes. The only absolute requisite in their outward form seems to be that they shall be free from scales. Every electric fish yet discovered has a smooth body. They also appear to be all mud or ground fishes, living in or close to the mud or sand at the bottom of the water.

The species which has been longest and best known is the *Raia torpedo*, or electric ray. It has much the appearance of a skate, but has been properly constituted a separate genus, first under the name of *Torpedo*, and latterly under that of *Narcine*, taken from the word ναρκη, which was the name given to it by Aristotle.

The electric organs are placed on each side of the head and gills, reaching to the semicircular cartilage of each great fin, and extending to the transverse cartilage which divides the

* Some insects and mollusca have been said to communicate sensible shocks, but this has not been confirmed, and appears very questionable as far as regards insects.

thorax from the abdomen, and within these limits they occupy the whole space between the skin of the upper and the under surface. These organs are composed of hexagonal or pentagonal columns, arranged vertically between the upper and under side like the cells of a honey-comb. They are supplied with a profuse ramification of large nerves proceeding from the eighth and fifth pair, but principally from the former.

The electric properties of the *Torpedo* were first fully investigated in 1773 by Mr Walsh, a scientific gentleman of eminence and of some position, being a member of Parliament. His interest in the matter having been aroused, he took up his abode for some time at La Rochelle, for the purpose of being able to make his experiments upon freshly-caught fish, the *Torpedo* being common on that part of the shores of France, while it is rare on the shores of Britain. He made many careful experiments, which were published at the time in the Philosophical Transactions, along with admirable figures and anatomical details, by the celebrated John Hunter; and he satisfactorily proved that the electricity evolved by the fish was in all respects similar to electricity obtained in the usual manner from electrical apparatus. He discovered that the upper and under surfaces of the animal were in different states of electricity, and this circumstance enabled him to direct the shocks of the fish through a circuit of several persons, all feeling them, one touching his lower surface and the other his upper. When the *Torpedo* was isolated, it gave several isolated persons forty or fifty successive shocks in the space of a minute and a half. He did not succeed in obtaining a spark, and we are not aware that any one has yet done so from the *Torpedo*, although it has since been obtained by an ingenious process from the *Gymnotus*. Mr Walsh found the effect produced by the *Torpedo* to be about four times as strong when the fish was out of the water as when touched in the water, and Pennant mentions that the *Torpedo* buries itself superficially in the sand by flinging it up by quick flapping of all the extremities; and adds, it is in this situation that the *Torpedo* gives his most "forcible shock, which throws down the astonished passenger who inadvertently treads upon him."

The *Torpedo* grows to considerable size, and is often above 80 lbs. in weight. A fish 18 inches long and 12 inches across may be considered a large specimen. Its benumbing properties are undoubtedly given to it as a weapon of offence and defence, although Mr Walsh says, that "notwithstanding the familiarity in which I may be said to have lived with them for nearly a month, I never detected them in the immediate exercise of their electric faculties against other fish confined with them in the same water, either in the circumstance of attacking their prey or defending themselves from annoyance ; and yet that they possessed such a power, and exercised it in a state of liberty, could not be doubted." Dr Davy kept some young *Torpedos* alive for five months, and during all that period they ate nothing, although supplied with small fishes both dead and alive, and yet they increased in strength and electric energy. The observations which have been since made upon other electric fishes, however, sufficiently prove the accuracy of Mr Walsh's assumption.

Several other species of *Narcine* are known, and all of them possess the electric property. There is a species described by Bertholet in his work on Fishes, under the name of *Torpedo galvanii*, which seems to be the same as one figured by Willoughby in his *Ichthyographia*, and probably the same as *T. trepidans*, described by Valenciennes in Webb and Bertholet's splendid work on the Canary Islands. The Rev. Mr Lowe of Madeira described a species found at Madeira under the name of *Torpedo hebetans ;* and another, found both there and in the Canary Isles, was described by Valenciennes as *T. marmorata*. Henlé has described four other species in his work, "*Ueber Narcine*," viz., *N. brasiliensis* from Brazil, *N. indicus* from East Indies, *N. timlei* and *N. capensis* from the Cape of Good Hope. And Müller and Henlé have established a new genus, *Astrape*, for the reception of *N. capensis* and *dipterygia*, which have only one back fin. Sir John Richardson also has described a species from Van Diemen's Land, under the name of *N. tasmaniensis*.

The rays and skates proper have themselves been of late years the subject of consideration with reference to electrical organs. In 1844, Dr Stark of Edinburgh first made known the existence of an organ in the tail of the common skate, which he considered to be of an electrical nature. Professor Goodsir followed up Dr Stark's discoveries, and gave an additional and minute account of the organ in question. The papers by Dr Stark and Professor Goodsir were read to the Royal Society of Edinburgh; but although the discoveries were new, and the subject of importance and interest in a physiological point of view, that body did not publish them in its Transactions, but contented itself with inserting a short summary of the contents of the papers in the record of their Proceedings published by them annually. In 1847 (nearly three years after), M. Robin of Paris published in the "*Annales des Sciences*" a full account of the singular structure referred to, but without making any allusion to Dr Stark and Professor Goodsir's discoveries, so that we have no means of knowing whether M. Robin had himself rediscovered the organ in question, or merely worked out the subject from the hint received from the Royal Society's notice of Dr Stark and Professor Goodsir's papers. The organ is composed of a series of cells of a polygonal and irregular form; and, so far as the structure can be judged of from its appearance, both as seen by the naked eye and under the microscope, is of the same nature as the electric organ in other fishes. It lies buried among the muscles in the tail of the common skate and rays, commencing in the midst of the muscles on each side of the tail, at about a third of its length from the root, and running down to the tip, gradually occupying more of the space of the tail, till at the tip it has usurped the place of the muscles, and almost entirely dispossessed them. Its form is that of a cylindrical tube, surrounded by a nervous covering, and it is supplied by nerves from the spinal column. Strange to say, it still remains to be satisfactorily ascertained, by direct experiment on the living animal, whether this organ is possessed of electrical power or not; and, stranger still, if it really has such a power, that the fishermen have never observed nor spoken of it. Not that experiments have not been made by different observers on the living or half-living animal, but that such experiments have not yet satisfactorily settled the question. On the one hand, Dr Stark considered he had detected electrical effects on grasping the tail at the proper part; on the other, Professor Müller, of Berlin, states that he had tried the experiment with the galvanometer, and that it gave not the slightest indication of electricity. But as has been suggested to me by Professor Goodsir, it is quite possible that at one period of the year (the spawning season, for instance, when the vital energy is at its highest state of development), the electric power may be stronger than at another; and a careful observation of living specimens, kept in an aquarium, prepared on the principles which are now enabling naturalists to make observations on sea animals which were heretofore impracticable, will doubtless not only enable us to ascertain whether the organ is electrical or not, but also what part it plays in the economy of the fish. In our present state of doubt upon a point which can be so easily practically settled, it would of course be absurd to enter into an argument in favour of, or against the organ being endowed with electric powers; but the various stories which books on Natural History contain regarding the venomous properties of the spike of the sting ray, may possibly turn out to have some relevancy to this subject—and another circumstance not to be lost sight of is this, that while Dr Stark found the organ always present (though of varying sizes), in the tail of every species of true ray which he examined, both Professor Goodsir and M. Robin ascertained it to be wanting in the tail of the *Torpedo*, which they carefully examined for the express purpose of ascertaining whether, like the organ in the ray, it had not been overlooked in previous dissections; a result which might *a priori* be looked for, supposing the organ to be electrical.

The next fish bearing an electrical reputation is a species of *Rhinobatis* from Brazil. This genus was formerly included among the rays, but has properly been separated from them. It forms the intermediate link between the sharks and the rays, and might almost be taken for a hybrid between the rays and the angel shark, having the body of the one and the tail of the other. This fish, although stated to be electrical, has, however, not yet been proved to be so.

We now turn to the *Gymnotus electricus* or electrical eel, a species little inferior in celebrity to the *Torpedo*. The observations of Walsh, Cavendish, Galvani, and others upon the *Torpedo* in 1773, having given an impulse to investigation on the subject, the announcement shortly afterwards made of a new electric fish being found in the rivers of Guiana was speedily followed by specimens being brought to this country; and experiments as complete and careful as those of Mr Walsh were made and published by Mr Williamson and Mr Garden, and in like manner most excellent figures and dissections were published by Hunter. Humboldt, Fahlberg, and Guisan have further elucidated the subject, and the two latter philosophers succeeded in obtaining the electrical spark from the fish, which previous observers had failed to do. Since that time more recent observations on the subject have been made by Faraday, and published by him in 1844, in his "Experimental researches in Electricity."

The *Gymnotus* is common to all the small rivers which flow into the Oronoco in English, French, or Dutch Guiana, and is usually procured from Surinam. The reader doubtless recalls to his recollection the graphic account given by Humboldt of the mode in which it is used by the Indians in that country to capture wild horses. It reaches the length of five or six feet or even more, but the half of this size is the more common dimension. Although it appears in form to be a long fish, yet so far as the vital organs of the fish are concerned, it is properly speaking a very short one, the whole of its *viscera* being packed close to the head, and its *anus* placed only a couple of inches behind the mouth. The whole of the rest of the body may be said to be devoted to the electrical apparatus. The upper part of the rest of the body is occupied with the muscles, back-bone, swimming-bladder, &c.; below these, occupying two-thirds of the diameter of the body, lies the electrical apparatus, which is composed of four parts, two on each side of the body, one above the other.

More experiments have been made upon the *Gymnotus* than on any other electric fish, it being better able to bear confinement, and giving, from that or other causes, more powerful electric phenomena. A *Gymnotus* has been kept for several months in captivity, whereas Dr Davy was not able to keep a *Torpedo* alive more than 12 or 15 days. We must refer our readers to Faraday's experimental researches for a detail of the experiments made by him on a *Gymnotus*, which had been bought by the proprietors of the gallery in Adelaide Street, London, and liberally lent by them to the Doctor for the purpose of experimenting on. From it he obtained every proof of the identity of its power with common electricity. The galvanometer was deflected, a magnet was made, a spark was obtained, and perhaps a wire heated, (though the experiment requires confirmation), besides the more common phenomena of the shock and the circuit. Faraday concluded that a single medium discharge of the fish is equal to the electricity of a Leyden battery of 15 jars, containing 3500 square inches of glass coated on both sides, charged to its highest degree.

Faraday observed the *Gymnotus* exercise its electrical powers for the purpose of preying upon other fish. He says, "a live fish about 5 inches in length, caught not half a minute before, was dropt into the tub. The *Gymnotus* instantly turned round in such a manner as to form a coil inclosing the fish—the latter representing a diameter across it; a shock was passed, and there in an instant was the fish struck motionless as if by lightning in the midst of the waters. Its side floated to the light. The *Gymnotus* made a turn or two to look for his prey, which, having found, he bolted, and then went searching about for more. The coiling of the *Gymnotus* round its prey had in this case every appearance of being intentional on its part to increase the force of the shock, and the action is evidently exceedingly well suited for that purpose, being in full accordance with the well-known law in discharge of currents in masses in conducting matter; and though the fish may not always put this artifice in practice, it is very probable he is aware of its advantage, and may resort to it in cases of need." It is said, however, that the

Gymnotus eats very few of the fishes which it kills by its discharge. Faraday's experiments also settled another point, namely, that it is not necessary to touch the fish to receive a shock. For instance, several individuals put their hands in the water in the tub at different distances from the fish, and another individual stirred it up with a glass rod. The fish gave a shock, and all the experimenters felt it—those whose hands were nearest to the fish most strongly, and those farthest from it most feebly. This experiment shows, in a striking point of view, the beauty of the relation between the power in question, and the element in which the fish lives. If the power were to be exercised in the air, it could only be made use of on actual contact, but the conducting powers of water render this unnecessary, and the shock travelling through the water all around, extends its effects in more than proportion to the size of the fish attacked; for though the *Gymnotus* may exert only an equal power, a large fish has passing through its body those currents of electricity which, in the case of a smaller one, would have been conveyed harmlessly past by the water at its side. Faraday suggests that it is not impossible that the fish may have the power of throwing each of its electric organs separately into action, and so to a certain degree direct the shock, that is, it may be able to cause the electric current to emanate from one side, and at the same time bring the other side of its body into such a condition that it shall be a non-conductor in that direction; but, he adds, that he thinks the appearances and results are such as to forbid the supposition that the fish has any control over the direction of the currents after they have entered the fluid which circulates around it.

There is another species of *Gymnotus*, *G. fasciatus*, found in Guiana, but it is not electrical, and although in the position of its fins, and somewhat of its outward form, it corresponds with the *G. electricus*, and has therefore been placed alongside of it, there is little doubt that when it is examined, its structure will be found to differ from the true *Gymnotus*, and that it must be placed in another genus. The possession of an apparatus which makes such an alteration in the whole nature and position of the interior organs, ought surely to be sufficient to constitute a genus of itself.

Another electric fish, with somewhat of an eel-like form, said to come from India, was for some time classified with the *Gymnotus*—under the name of *G. indicus*, but has been removed from it, as having no affinity with that genus, but more nearly approaching to the *Trichiuri*, and is now known as *Trichiurus electricus*. There would appear, however, to be great doubt whether any such fish does really exist; for Valenciennes, in his great work, mentions that on going back to the sources from which each author has taken his information, he discovered that the characters and properties attributed to this fish only repose upon a bad figure by Nieuhof, and upon a transposition of some part of his text. The description which is given by no means corresponds with the figure, and its electrical properties depend upon the following sentence:—"It lives in the deepest rocky caverns where it gets tolerably fat, and is wholesome food. Those who take it are affected with a tremour and sometimes a sleep, either from the afflatus or contagion, which however soon go off." Supposing these last words indicate a true electric virtue, the rest of the description applies better to the *Silurus* (*Malapterurus*) *electricus* than to the *Trichiurus*, and as no specimens since that described by Nieuhof have been found, it must only stand among electric fishes, or among fishes at all, with a point of doubt.

Another electric fish, which also stands upon solitary authority, is the *Tetrodon electricus*. Shortly after Mr Walsh and Mr Williamson's researches upon the *Torpedo* and *Gymnotus* had drawn the attention of the public generally to the subject, a young officer in the 98th Regiment, Lieutenant W. Paterson, sent an account of an electric fish which he met with at the Island of Johanna, one of the Comoro Islands, to Sir Joseph Banks, who communicated it along with a very imperfect drawing to the Royal Society of London. It was of the genus *Tetrodon*, and about 7 inches long, and ornamented with bright and gaudy colours. Lieutenant Paterson found several of these electrical fishes in hollows in the coral rocks. He says, "I caught two of them. In attempting to take one of them in my hand, it gave me so severe an electric shock that I was obliged to quit my hold. I however secured them both, and carried them to the camp which was about two miles distant. Upon my arrival there, one of them was found to be dead, and the other in a very weak state, which made me anxious to prove by the evidence of others that it possessed the powers of electricity, while it was yet alive. I had it put into a tub of water, and desired the surgeon of the regiment to lay hold of it with his hands—upon doing which he received an evident electrical shock. Afterwards the adjutant touched it with his finger upon the back, and felt a very slight shock, but sufficiently strong to ascertain the fact." Mr Paterson concludes by stating that he gives this mention of the fish, only as a direction to others who may afterwards visit that island to look for and examine more fully that fish and its electric organs. We believe that no one has since acted upon this suggestion, or if they have, that they have not found the fish. No specimen exists in the British Museum, and the authors who have included this species in their works have merely reproduced the meagre description furnished by Mr Paterson, without giving any other authority for it, or notice of its capture by any one else.

Another *Tetrodon*—*Tetrodon lineatus*, has the property of imparting a pungent pain like the sting of nettles, which is said to be occasioned by the minute spines on its abdomen. It is also considered poisonous if used as food; and Osbec, in speaking of individuals of this species found at Japan, says, the venom which it contains is so powerful that the animal occasions death in two hours to those who feed upon it. Accordingly, he adds, "The soldiers of that eastern country, and all those of the inhabitants over whom they can exercise an exact surveillance, have received a rigorous prohibition against eating it"—a prohibition which, in the circumstances, one would scarcely have thought necessary.

We next come to the electrical fishes of the genus *Malapterurus*. The family of fishes to which it belongs (the *Silu-*

ridæ) is not without interest, and as there is a general family resemblance in their forms and habits, we may mention one or two circumstances relating to the best-known species, the *Silurus glanis*, which is the only one of the family found in Europe. They are smooth-skinned fishes, with a number of long thin barbules or filaments around the mouth. The *Silurus glanis* is the largest fresh-water fish found in the rivers of Europe, with the exception of the sturgeon, and reaches not rarely to the size of 5 or 6 feet in length. It is not found in England nor in the eastern rivers of Europe,—is found very rarely in one or two of the lakes of Switzerland,—but is common in Hungary, Russia, and some parts of Asia,—and is found in the brackish water at the mouths of rivers, as well as in the fresh water of the rivers, and of the lakes from which they issue. It is reckoned good food, and is sold in the different markets of Europe and Asia. As a great rarity and peculiar dainty, a specimen 3 feet long, got in one of the lakes of Switzerland, was served up to King Charles X. at Strasburg, when he passed through that city in 1828. It is very impatient of thunder and storms, rushing out of the mud to the surface of the water, and agitating itself violently during their continuance. It is only during storms that it is caught in the nets of fishermen, the nets at other times passing over it while it lies buried in the mud. It is recorded by Baldner that he got one of the length of a foot in 1569, and kept it in a fish-pond till 1620, when a storm killed it. It has therefore relations to electricity, but of an opposite nature to those of the *Malapterurus*; but it is at least curious to find the old proverb equally applicable to fish as to men, that what is one man's food (or means of getting food), is another man's poison. There seems, moreover, room for some philosophic inquiry into the nervous structure of the *Silurus glanis*, which may possibly throw light on more than the mere sensitiveness of this fish to electrical commotions in the atmosphere. Baldner's fish, in the fifty-one years he kept it, had increased to the size of 5 feet, but much larger examples have been taken, and it is reported that they have been found in the Pregel 16 feet in length. Being a mud fish, it thrives best in such slow flowing rivers as the Danube, Elbe, Pregel, &c. It lies at the bottom of the water, buried in the mud, and the barbules which surround its mouth floating about, enable it to recognise the approach of, and seize upon, any prey that passes it. It is very voracious. The Bohemians have a proverb, "Every fish has another for prey; the Wels (*Silurus*) has them all." It destroys many aquatic birds, and we are assured that it does not spare the human species. On the 3d of July 1700, a peasant took one near Thorn, that had an infant entire in its stomach. They talk in Hungary of children and young girls devoured on going to draw water; and they even relate that on the frontiers of Turkey, a poor fisherman one day took one that had in its stomach the body of a woman, her purse full of gold, and a ring. This must have been one of the 16-feet ones, of whose existence we doubt, as all men may; we would place such exaggerations along with Gesner's well-known story of the pike 19 feet long, and 267 years old.

But these are digressions. The *Silurus* of which we have to speak, is the *Silurus* of the Nile (*Malapterurus electricus*), called Raasch, or thunder-fish by the Arabs. It is found in the Nile in considerable abundance. It has barbules like the rest of the Siluri, and has its smooth, scaleless skin diversified with irregularly-shaped spots, and its usual length is from 8 to 14 inches. It was first well figured and described by Geoffroy St Hilaire in the great work on Egypt, published under the sanction of Napoleon. It has subsequently been more carefully dissected and described by Rudolphi, and more recently by Pacini, who has gone microscopically to work, and has given figures of sections of the electrical organs enlarged, so as to show their primary structure. Different from the other electrical fishes of which we have spoken, this organ assumes the shape of a thick aponeurotic skin surrounding the whole body almost to the tail. The course followed by its electricity differs from that of the *Gymnotus* as well as the *Torpedo*. As already mentioned, the current in the *Torpedo* flows from the upper side of the body to the under. In the *Gymnotus* it flows from the head to the tail; but in the *Malapterurus* it flows equally from the organ in every direction.

The consequence of this would appear to be that unless nature made some provision to meet it, the animal would give itself a shock every time it puts its electric force into operation, and Pacini thinks he has discovered in the necessity of some counteracting influence to such a result the reason of a layer or skin of fatty matter being placed between the electric organs and the body. Rudolphi thought this under-layer or skin was one of the parts of the electric organ, his idea being that it was composed of two plates in different electrical states, as in the plates of a galvanic battery; but Pacini's idea that this under-skin is an isolating medium placed to protect the animal from the force of its own thunder, is attractive from its ingenuity, whether it ultimately proves correct or not.

This species is said to be found in the Senegal and Gambia as well as in the Nile, and also probably in the river Sofala. It is first recorded by Purchas as having been taken in the Gambia by Richard Jobson. He relates that "in the Gambia, they draw in the net, among other fishes one which had the body broad like a bream, but of greater thickness—that one of the sailors having wanted to take it, he cried out that he had lost the use of his hands and arms—another sailor who touched it with his foot felt a numbness in his leg." There is no doubt that there are electric fishes found in these rivers, but we should much question their being the same with the *Malapterurus* of the Nile. The animals of Egypt and those of the west of Africa are, for the most part, all different; and Valenciennes states that the electric *Silurus* of Senegal has its spots more marked and often less cloudy than those of the individuals caught in the Nile. The identity of the Sofala species is also spoken of with doubt; and a species which has lately been received from Old Calabar, and is described at the end of this paper under the name of *M. Beninsis*, is also distinct from the Nile species. Taking all these things together, we see that there are at least two species of electric Malapterurus peculiar to Africa, and it is not improbable that there may be more.

This closes the list of known species of these wonderfully endowed animals. We do, as the reader sees, know something of their habits and powers, of their outward appearance and internal anatomy; but when we try to penetrate farther, and to trace backwards to its source the cause of the effect which we see, we are obliged to confess that it is "knowledge too wonderful for us, and to which we cannot attain." True it is, that conjectures have been made, and it would not be like human nature if we had not a theory for it. The theory, so far as it goes, which physiologists have now generally on the subject, is this. It is known that an electric current passes through the frame of all plants and animals, not always in the same direction, being apt to be diverted by the particular arrangement of the muscles and tendons, but always existing. In the frog, for instance, it passes constantly from its extremities to its head. In most animals it continually proceeds from the interior to the surface of each muscle (and is hence known as the "muscular current,)" this current being particularly intense in the muscles and nerves. Now, the nerves receive from the brain or its continuations (how we cannot tell) an influence which sets the electric fluid in themselves and the muscles in action, and it in turn stimulates them to contraction and motion. Some have supposed that this nervous influence and electricity are identical. This, however, is not so. Prof. Matteucci's experiments all go to prove that the two forces are not identical, but are correlated, each being able to generate the other; so that while by the influence of the nervous system on one class of organs, sensible contraction is produced, in like manner by its influence on another class of organs, electricity is generated. The generation of electricity in the electric organs of fishes would appear to be developed in the same way as in other muscular tissue. Although these organs differ in their structure and form from ordinary muscular tissue, still there appears little doubt that a similar tissue enters into their composition. But the difference of the structure seems to be such, that instead of constantly flowing off as in ordinary muscular tissue, the electricity is accumulated and retained as in a galvanic pile (its prisms and diaphragms and cells acting as the elements of the pile), and given off in the same way. But all such theories only go a certain length, and after we have gone back and back, we are stopped at last, and are obliged to confess that we are unable to explain farther; and if we could go farther, and explain the process which stopped us, we should only get a little way, and again be stopped, and obliged humbly to sum up with the acknowledgement that these things are so, because the Creator has so fashioned them.

The new species of Malapterurus above referred to, was found near Creek Town, in the muddy, brackish water of the river Old Calabar. Creek Town lies about 30 miles up that river, which empties itself into the Bight of Benin within a short distance from the Delta of the Niger, in lat. $5\frac{1}{2}°$ north, and long. 8° west. It is to the industry and scientific exertions of the Rev. Hope M. Waddell, that we owe the knowledge of this interesting species. The United Presbyterian Church of Scotland has a mission established on this spot, and Mr Waddell and the other missionaries, have in an enlightened spirit, been combining the prosecution of their proper christianising and educating duties, with an attentive examination of the Natural History of the country in all its departments.* These gentlemen have repeatedly favoured me by forming, and transmitting considerable collections of insects and other objects of Natural History; and in the last consignment which I received from Mr Waddell, there were four small electric fishes, which I was gratified to find were

* If the United Presbyterian Church continues to be as fortunate as it has been, in securing able and intelligent missionaries at their stations on this coast, we have the prospect ere long of knowing something of the Natural History of the interior of this most interesting and wholly unknown country. The way in which they propose to extend their missions is as follows:—After a station has secured a firm footing they mean to push forward another, thirty miles into the interior, from which in its turn, after it has secured its footing, another outpost will be advanced thirty miles further, and so on. We shall then look with intense interest for the memorials of the Natural History collected at these outposts. As it is, the amount of new species received from Old Calabar is perfectly surprising; many of them possessing an interest of very striking character, particularly in connection with the subject of geographical distribution.

undescribed species of *Malapterurus*. None of them exceeded four inches in length, although Mr Waddell mentions that they grow to be as large as a herring. They seem to have been powerfully endowed with the electric faculty ; in this respect differing from the Nile species, which has its electrical power weak in comparison with that of the *Gymnotus;* while this new species would appear to surpass it in force (particularly when size is taken into consideration), a small specimen about two inches in length having given Mr Waddell a shock which reached to his shoulder. They seem to bear captivity well, for Mr Waddell kept one of them for six weeks in a tumbler of water, and it gave severe shocks daily.

The following is the description of this species—

The fish is short and rounded, and looked at from above tapers from the head to the tail. The head is depressed, and the tail compressed. The height of the body at the ventrals is a seventh of the whole body (caudal fin included), and it is very little higher behind the pectorals. Its breadth at the ventrals is one and three quarters of the height. Its breadth behind the pectorals is very little short of its height there. The whole fish is enveloped in a soft, loose, flaccid skin, which under a lens is seen to be covered with minute papillæ, particularly on the head, while towards the tail they pass into a kind of reticulation, giving the appearance of a tomentose substance wetted, with the hairs flattened down by the wet. The head, measured to the posterior end of the operculum, is about a sixth part of the length of the whole fish. It is nearly as broad as it is long, and is nearly twice as broad as it is high. Both its upper and under surface are nearly flat, the upper sloping slightly down to the mouth. Seen from above, the form of the head approaches in form to a very obtuse semicircle. The mouth scarcely extends down the sides. The eye is small, and situated a little nearer the front of the operculum than the mouth. Its diameter is about a seventh or eighth of the length of the head, and there is about five and a half diameters between the eyes. The lips are fleshy, and the lower is a little more advanced than the upper. The four orifices of the nostrils have membranous and tubular edges which close the orifices, so that they are not easily seen.* The anterior pair is closer together than the posterior. There are a number of small pores upon the head, surrounded by pale edges, which are more perceptible than the nostrils. These

* In life these organs are probably more easily seen, and will assume (particularly the anterior pair) the form of small nipples, of which their flaccid state, when preserved in spirits, has deprived those in my possession.

are doubtless for supplying the surface with mucilaginous slime. There is one immediately behind each eye, one a little further back, another somewhat below the eye, and another more to the front of the eye, but not so low down ; one at the inner anterior corner of each anterior nostril, two immediately behind each of these nostrils, and one at a short distance on the outer side of it ; one at the outer side of each posterior nostril, and a smaller one at its inner corner ; two are placed transversely close together on the middle of the head, and there are two more distant from each other, placed farther back ; there is one behind each maxillary barbule, two close together in the centre of the under lip, one on the outer side of each inferior barbule, and one further back on the under jaw. Those around the nostrils and mouth, and under the eyes, are most observable, particularly the former. The base of the maxillary barbule is exterior and anterior to the back nostrils. The barbules are long and fine, and before their termination become as fine or finer than any hair. When laid backwards, the maxillary barbule reaches beyond the posterior end of the operculum. The external mandibular barbule about equals it in length, but the internal is shorter. The teeth form a broad velvety band in each jaw, broadest in the middle of the front. The teeth are all curved backwards, and are packed very close together in crowded masses. There are no teeth on the palate, but some very small hard looking tubercules can be seen by the aid of a lens. The gill openings are small and oblique, and about half the size of the mouth. The pectoral fin is small and elongate, and attached about the middle of the gill opening. In length it is about an eleventh of the whole fish. It has eight rays, of which the first is frail and without branches, and does not extend up half of the fin. The second and third rays are longest and nearly equal, the second being a very little longer. The ventrals are a fifth shorter than the pectorals, originate a little behind the middle of the fish, are placed near each other, and have six rays, the first without branches, and the second longest. The anal fin commences nearly at the last third of the fish, and occupies about a tenth parth of the whole fish. It has eight rays.* The first of these is very small, and not readily recognisable. The fin is as deep as it is long ; and the fourth and fifth rays are the longest. Between the anal and caudal fin is a space of half the length of the former. The adipose fin begins nearly opposite the middle of the anal fin, and leaves a very small space between its termination and the caudal fin. The latter is somewhat rounded—has seventeen rays, of which the outer ones are not

* There is, perhaps, a ninth ray. There is an abortive appearance at the commencement of the fin which may be a ray, but I have been unable to see any trace of joints in it, and not being willing to sacrifice the specimen to ascertain whether it continues under the skin, I cannot speak positively.

branched, and not half the length of the rest. The formula of the rays of the fins is as follows:

D 0 P 8 V 6 A 8 C 17

The lateral line is narrow and delicate, a very little raised, and runs from the upper end of the gill opening to the tail.

The colour is dark-gray above, and pale whitish beneath. A very few small black spots* are scattered irregularly along its sides. Towards the anal fin, the dark colour extends down the sides, so as to leave scarcely any pale under side at that fin, but a broadish white stripe extends through this dark colouring quite round the fish from the latter part of the anal to nearly the caudal fin. The part of the tail between this white stripe and the caudal fin, and also the commencement of that fin, are very dark; a similar broad white band then runs across the middle of the caudal fin, and it terminates in a gray colour, somewhat lighter than the base of the fin, so that there appear two white transverse bands surrounding the fish at its latter part, one a little before the caudal fin, the other across the middle of that fin.

Dimensions of one of the largest specimens received.

	Inch.	Lines.
Length from intermaxillary symphysis to extremity of caudal fin	3	8
... ... to end of adipose fin	3	0
... ... to beginning ...	2	6
... ... to end of anal fin	2	9¼
... ... to beginning ...	2	4½
... ... to anus	2	1¼
... ... to anterior edge of gill-opening	0	8½
... ... to posterior	0	5½
... ... to anterior margin of orbit	0	4
Diameter of orbit	0	1
Length of pectorals	0	4¼
... ventrals	0	3½
... anal	0	4¾
... space between anal and caudal	0	3
... caudal rays	0	7½
... longest rays of anal	0	5
Height of body at ventrals	0	6
Circumference of body at ventrals	1	4

From the above it will be seen that the principal differences between the *Malapterurus electricus* and this species are the following: The former is a larger fish, reaching 14 and even

* None, in the specimens I have, exceed the size of the eye.

21 inches in length, while the ordinary dimensions of this would appear to be about four inches, although it may sometimes reach six or eight. The formula of the number of rays in the fins of the two fishes also differ. The number in the ventrals and caudal are the same, but the Nile fish has nine in the pectoral and twelve in the anal, while in this fish there are respectively only eight and eight. In the *M. electricus* the upper jaw slightly projects over the under. In this species the reverse is the case, the lower jaw projecting decidedly (though not very far) in advance of the upper. The barbule on the upper jaw of *M. electricus* is a third shorter than the head; *Beninensis* has it longer than the head. In the former the gill-opening terminates at the lower edge of the pectoral fin, in the latter the pectoral fin is attached at the middle of the gill-opening, and its lower edge does not nearly reach the base of the gill-opening. It will also have been seen that there are some differences in the relative proportion of the different parts of the two fishes, and there are also some other differences in the form of some parts of the fishes, (such as the operculum), which are not so readily embodied in words, but the differences which will most easily enable them to be distinguished at a glance are the markings, if these shall be found to be constant. The spots on *M. electricus* are much larger and more numerous than on this species, and it entirely wants the white bands across the tail, and across the caudal fin, which have been above described. I do not know whether these markings are constant in the older fishes, but as in all the four specimens I received, they were uniform and decided, I assume in the meantime that they are so.

I have not felt myself competent to make an examination of the anatomy of this fish, but Mr Goodsir, Professor of Anatomy in the University of Edinburgh, has kindly undertaken to do so, and his report will give every information on that head, as well as supply any deficiencies in the observations I have above made.

On a Deposit containing Sub-fossil Diatomaceæ, in Dumfriesshire. By Robert Harkness, Professor of Geology, Queen's College, Cork.

While examining the boulder deposits which occur on the northern shore of the Solway Frith, last summer, my attention was directed to a locality about a mile west of the mouth of the river Annan, where there is an interesting association of indurated gravel beds, silt deposits, and peat-bog, overlaid by the vegetable soil of the district. The boulder gravel, which here is the lowest deposit exposed, consists of the ordinary Silurian sandstone, mixed with the carboniferous grits, and a few fragments of the Bunter sandstone of the neighbourhood. It had a hardened nature, and in this respect bore considerable affinity to many conglomerates. The larger blocks entering into its composition presented none of the striæ which manifest themselves on the boulders occurring in the clays, in which substance they may be seen occupying the more level country which lies on the east side of the river Annan.

Above this bed of indurated boulder gravel there is seen the silty deposit, already alluded to, which consists of beds of fine drab-coloured sandy clay, having vegetable remains scattered through the mass. These vegetable remains, when in such a condition that they can be recognised, are, for the most part, fragments of Equiseta.

The contents of this silty deposit are, however, not confined to such organisms as ordinary swampy vegetation. On submitting portions of the silt to microscopic examination this substance is found to afford many species of Diatomaceæ, associated together in an interesting manner.

Professor Gregory, who was kind enough to examine for me the contents of this deposit, states, that the following forms of Diatoms occur therein:—*Epithemia Hyndmanni*, *Cymbella Scotica*, *C. maculata*, *Coscinodiscus radiatus*, *Cyclotella operculata*, *C. Kützingiana*, *Campylodiscus cribrosus ?*, *Tryblionella acuminata*, *T. punctata*, *T. marginata*, *Surirella minuta*, *S. nobilis* (or, *biseriata ?*), *Navicula didyma*, *N. ovalis*, *N. rhomboides γ* (Gregory), *N. varians* (Gregory), *Pinnularia major*, *P. viridis*, *P. acuta*, *P. tenuis* (Gregory), *Gomphonema tenellum*, *Doryphora amphiceros* (fine), *Synedra radians*, *Nitzschia* sp. ?, *Grammatophora marina*, *Melosira sulcata*, *M. distans*, *Fragilaria virescens*, *Odontidium mesodon*, *Meridion circulare*, *Achnanthidium lanceolatum*. This association of marine and fresh-water forms indicates the occurrence of conditions of an estuary nature, and leads to the inference that the circumstance under which the silt was deposited approached to that which now prevails at the mouths of rivers. This silty deposit is not confined to the spot where it was first noticed. The subsoil, which extends through almost the whole of the estate of Newbie, has the same character, and may also be seen in spots on the opposite side of the river Annan, showing that the character of the coast has undergone considerable changes since the pleistocene period, as we have deposits of an estuary nature considerably above the present level of the highest tides.

In cases where we have a change in the relative level of the land and sea, if only to a slight extent, such as is shown by the occurrence of the silt of Newbie, with marine and fresh-water forms of Diatomaceæ, there is, in many instances, no reason for concluding that elevating forces have acted in the production of this relative change.

The formation of sandbanks across the mouths of estuaries ; and inland seas, having forms such as those in the Solway Frith, would produce effects altering and modifying the relation between the height of land and water. These sandbanks, acting as barriers to the free flow of the tide, would cause many districts, having a swampy character, to become dry land ; and by such change produce results, having to some extent characters, such as usually originate from the operation of elevating forces. The production of the extensive sandbank Robin Rigg, which forms a barrier to the entrance into the Solway Frith, would effect considerable changes on the relative level of the coast ; and the modifications which this bank is subject to would also have their influence in preventing or facilitating the free flow of the tide, and consequently altering the relative level of the tidal mark. Effects of this nature are sufficient to account for the occurrence of the silty deposit in the neighbourhood of Annan, without having reference to the operation of elevating causes.

The occurrence of marine forms of Diatoms in silt, puts us in possession of another element, by means of which we are enabled to ascertain the changes which have taken place in the physical geography of the earth. It furnishes us with a means applicable in many instances where other and more perfect organisms have disappeared, the siliceous skeletons of these minute bodies being capable of resisting that agent by means of which the solid coverings of molluscs are dissolved. Many of the raised sea-beaches, now affording no shells, will probably be found to contain Diatoms, which will tell of the conditions under which these raised sea-beaches were originally deposited, and provide us with information concerning the circumstances which operated in the production of strata of this nature.

The Dyeing Properties of Lichens. By W. Lauder Lindsay, M.D., Perth.

In the fifty-seventh volume of this Journal (October 1854), I published the results of a series of experiments on the evolution of red, purple, and other colouring matters from British and foreign lichens, with a view to direct public attention specially to the two following facts, viz., First—that, in our own country, many native lichens, which grow more or less abundantly, might, with advantage and economy, be substituted for the somewhat expensive and scarce foreign Roccellas and other dye-lichens usually employed in the manufacture of orchil, cudbear and litmus; and, secondly—that, in our colonies, and foreign countries to which we have access, species valuable as dye-lichens probably grow in abundance,—might be collected and transported—easily and cheaply—and thus become important and lucrative articles of commerce. My present purpose is to explain more fully the grounds for this opinion, and to indicate somewhat in detail the facility and economy with which such lichens may be collected, preserved and rendered subservient to our arts and manufactures. The information which I have to offer is, however, more suggestive than positive: my object shall have been answered by fairly bringing the subject under the notice of the following classes of persons or scientific bodies, to whom I must leave its practical or economical application, viz., Firstly, — chemists, orchil, cudbear and litmus manufacturers, importers and exporters of orchella weeds and other dye-lichens, dyers, &c: secondly, scientific societies, such as the Royal, Geographical and Botanical, and the Society of Arts;—public boards, such as the East India, Army and Admiralty Boards; industrial exhibitions, such as the Sydenham Crystal Palace and Paris Exhibition: scientific and exploring expeditions, &c.: and, thirdly, colonists, emigrants, travellers, officers of our commercial and royal navy, and of the army, and East India Company; residents abroad, and in our own Highlands and Islands, &c. This is pre-eminently an age of discovery and enterprise in scientific matters; the strongest tendency everywhere exhibits itself to multiply the natural resources of our native country and its colonies,—to turn to practical account, for the improvement of our arts and manufactures, their hitherto valueless vegetable products. The efforts at present being made to introduce the fibre of the common nettle, thistle, and other native weeds, in the manufacture of textile fabrics and paper, as substitutes for flax, is only one limited example of this utilitarian tendency. Believing that this desire requires only to be led into suitable channels, my object is to submit to scientific and commercial enterprise, the importance of this particular field of inquiry, and the richness of the fruits it promises. The fact that manufacturers or importers might find it economical or remunerative to be supplied with substitutes for the Roccellas, which are fast becoming scarce, and consequently expensive, is the most limited view we can take of the advantages of such an investigation. Indirectly a multiplied trade in dye-lichens might scatter the seeds of civilization, and place the means of a comfortable subsistence at the command of the miserable inhabitants of many a barren island or coast, at present far removed from the great centres of social advancement; for the dye-lichens will probably be found luxuriant where no other vegetation can thrive, frequently attaining their highest degree of perfection on the most bleak rocky coasts, or on elevated mountain ranges. It is probable that many rocky isles in the broad Pacific and Atlantic,—many hundred miles of desolate sea-coast and vast extents of mountain districts in Africa, America, Asia, and Australasia, which at present yield no products to commerce, and are too barren to support higher vegetation, might furnish an unlimited supply of lichens useful in dyeing. The vast continent of India and neighbouring countries and islands, for instance, already promise valuable results in this respect. In the Indian collection of raw vegetable products exhibited in the London Crystal Palace of 1851, several specimens of "Orchella weeds" from India, Ceylon, Socotra, &c., were shown; and an explanatory note appended to some from the vicinity of Aden in Arabia, stated most suggestively "*Abundant, but unknown as an article of commerce.*" Specimens of *Roccella fuciformis* were there exhibited from Ceylon, estimated as worth £380 per ton, and *Parmelia perlata* at £190 to £225; other dye-lichens exhibited in the same collection, are referred to in Table II. But the whole world may be said to be an open field; in every clime, in every soil, at almost every elevation, and in all seasons, tinctorial species grow, and even luxuriate. In Northern Europe, in Scandinavia, and even in our own Highlands and Islands, many such species are abundant, and might surely be collected at a rate so cheap as to render it remunerative for the manufacturer to employ our destitute Highlanders in gathering them. Moreover, in connection with the development of the economical applications of lichens, it is not unimportant to bear in mind that many species contain such an amount of starchy matter as to become, or to furnish excellent articles of food; many are used as fodder for cattle, some are eaten in Iceland and arctic countries, and one, at least, is frequently used in the making of jellies in this country. I need only here allude, in confirmation of this statement, to the *Cetraria islandica*, or "Iceland moss" of our shops; the *Gyrophora* or "*tripe de roche*" of the arctic regions, whereby the lives of many intrepid travellers have been preserved; the *Lecanora esculenta*, a kind of manna, peculiar to the steppes of Tartary, and the *Cladonia rangiferina*, or familiar "Reindeer moss" of Lapland. On the mountains of Scotland, Ireland, and Wales, species of Lecanora, Gyrophora, Umbilicaria, and Isidium, capable of yielding fine qualities of orchil, cudbear, and litmus, are more or less abundant. While the cudbear manufacture flourished in Leith and Glasgow, the Lecanora tartarea, from which it was prepared, was collected to a great extent in our Western Highlands and Islands, but with the transference of this manufacture into the hands of English orchil makers, this source of remunerative employment to our poor Highlanders suddenly ceased, and this lichen is now chiefly or wholly imported from Norway and Sweden for the London market. The value of this lichen in Scotland is said to have averaged £10 per ton. Hooker states that, at Fort Augustus in 1807, a person could gain 14s. per week by collecting it, estimating its market price at 3s. 4d. per stone of 22 lbs. Pennant records it as an article of commerce about Taymouth in Perthshire. Miss Roberts mentions its having been collected in North Wales at 1½d. per lb. for the London market; and it appears also to have been largely gathered in Derbyshire, the price there given to the collector, who could gather twenty to thirty lbs. per day, being 1d. per lb. The re-introduction of this trade or means of employment might be a great boon to the Highlanders, who have, within the last few years, been deprived of another source of remunerative labour and comfortable sustenance,—the collection of "kelp" or "sea-wrack" on our rocky and stormy western coasts,—and whom dire necessity now compels to transfer their energies to foreign lands.

With the first class of persons above alluded to rests the determination of the utility or value of the various proposed substitutes for the Roccellas, and of the fixity or permanence of the dyes prepared therefrom. It is for the chemist, manufacturer, and dyer, to discover means of preventing decolorization or change by the sun or atmospheric oxygen—of increasing brilliancy—of modifying colour—of imparting bloom or permanence—of ascertaining the particular fabrics for which the various dyes have the greatest affinity, &c.; for it must be borne in mind that the lichen dyes are essentially fugitive, and very susceptible of chemical changes under the influence of light, heat, &c. I freely admit the numerous sources of fallacy in experiments on the small scale; they have no claim to conclusiveness or perfection, and can only yield approximative results. On the large scale alone can the practical utility or applicability of the dye lichens, or their products, be tested; the manufacturer can do this at a considerable expense of time and trouble; the chemist can easily ascertain by analysis the kind and amount of colorific principles capable of metamorphosis, by the process of manufacture, into the desired coloured substances. It is an interesting field of inquiry for the chemist to discover to what extent the same or similar colorific principles exist in the genera Roccella, Lecanora, Umbilicaria, Gyrophora, Isidium, Parmelia, Variolaria, Evernia, Ramalina, and others, some of whose species are used, or proposed to be used, as dye lichens; his results may sometimes differ from those of the experimenter either on the large or small scale, though theoretically they ought to agree with those of both. For instance, *Umbilicaria pustulata*, which yielded me a dye equal in beauty to that of the Roccellas or Lecanoras, is said by chemists to contain only $\frac{1}{12}$th of the colorific materials of Roccella Montagnei. Again, Stenhouse* mentions that several years ago a large variety of *Roccella tinctoria* was imported from the Cape, but was found almost valueless by the London orchil manufacturers. Analysis discovered it to contain comparatively little of the crystalline principle, which, by yielding a red reaction with ammonia, is the basis of the purple colour of orchil, and to possess, instead, another crystalline substance, whereon ammonia had no action. Here chemical analysis and the practical experience of the manufacturer accurately coincided.

Scientific societies and public bodies have much in their power by urging upon their members or officers in foreign countries the importance of directing attention to subjects apparently so insignificant. The example of the Royal Society's code of Instructions and Suggestions to the Officers of the last Antarctic Expedition, wherein rough experiments on lichens, by means of maceration in dilute aqua ammoniæ, were recommended, is one worthy of being followed by similar societies, whose objects, in any form, embrace the development of the natural resources of the vegetable kingdom. In

* Philosoph. Trans. 1848.

endeavouring to open up to British commerce new fields of enterprise—in multiplying the natural resources of our country—in applying discoveries in science to the improvement of our arts and manufactures, much real good has doubtless been effected by the Industrial Exhibitions or Museums recently instituted in this and other countries:—they are to be accepted as the exponents of the public mind and its tendencies. They are valuable not so much directly by the variety and value of the products of nature and art which they exhibit or illustrate, as indirectly by the stimulus or impetus which they give to science, art, and commerce throughout the world; they are beneficial, perhaps more by exposing our deficiencies, than by displaying our excellencies or superiorities. The tables hereto appended were in no small degree based on information obtained at the London exposition of 1851.

The opportunities enjoyed by our colonists and emigrants, by travellers and all whose avocations or tastes lead them to visit foreign shores, or the more remote coasts and districts of our own country, of contributing materially to this branch of economic botany, are very apparent.* At a comparatively trifling expenditure of time or money, and without any botanical or chemical skill, by the steps immediately to be detailed, lichens may either be experimented on in their place of growth, or they may be collected and transported for examination to this country. These steps may be shortly reviewed under the following heads:—I. Mode of Collection; II. Mode of transport; and, III. Mode of testing the colorific value, or of evolving the colouring matters.

I. No plants are more easy of collection; they may be gathered at all seasons, and require simply to be dried before being packed for transport. Most of the dye-lichens grow on rocks from which they may be scraped by any suitable instrument. Should time and opportunity permit, it is advisable to wash the lichens so as to cleanse from earthy and other impurities previous to being dried; but this can equally well

* For an enumeration of some of the chief desiderata, *vide* the Transactions of the Phytological Club of the Pharmaceutical Society, in the *Pharmaceutical Journal*, July 1853.

be done in this country.* The following points are worthy of special attention by the collector :—

Firstly, That crustaceous, dwarf, pale-coloured species, growing on rocks, and especially on sea-coasts, are most likely to yield red and purple dyes; while, on the other hand, the largest, most handsome, foliaceous or herbaceous species are least likely. The species which yield, or which are likely to yield, dyes similar to orchil, cudbear, or litmus, are enumerated in the following Tables, and in those published in former numbers of this Journal.

Secondly, That the colour of the thallus is no indication of colorific power, inasmuch as the colouring matter on which it depends, exists ready formed in the cells of the cortical layer; while the *red* or *purple* colouring matters in question (in reference to which throughout this paper, I must be understood as writing, omitting practically all mention of the *brown*, *yellow*, or *green* dyes, which many species furnish), are the result of chemical action on crystalline colorific principles which were previously quite devoid of colour. Short of actual experiment, therefore, it may be held impossible to predicate the colorific value of any new or unknown species.

Thirdly, That alterations in physical characters, chemical composition, and consequently dyeing properties, are very liable to be produced by modifications in the following external circumstances :—

a. Degree of moisture.
b. „ heat.
c. „ exposure to light and air.
d. Climate.
e. Elevation above the sea.
f. Proximity to or remoteness from sea.
g. Habitat: nature of basis of support.
h. Age.
i. Seasons and atmospheric vicissitudes, &c.

Hence it not unfrequently follows, that species possessing the same general or special characters may vary greatly in the

* The various steps of the processes of collection, transport, manufacture and dyeing with their rationale, are more fully detailed in a series of papers read to the Botanical Society of Edinburgh, and published in the *Phytologist* for April and July 1853, and other cotemporary journals.

kind or amount of colorific materials which they yield. This fact has already been illustrated by the example of the variety of *Roccella tinctoria*, which was found worthless by the London orchil manufacturers as formerly mentioned.

II. For facility of transport, lichens may be simply dried and packed, or they may first be reduced to powder, whereby they occupy much less bulk, and cost much less for freight. But, as Stenhouse very truly points out, in a most instructive paper already alluded to, the cost of transport may form a considerable deduction from the commercial value ; hence he recommends, where the collector has the necessary opportunity or convenience, that the lichens should be pulverized or cut into small pieces—macerated with a little quicklime in water, and the resulting solution of the colorific principles precipitated by excess of hydrochloric or acetic acid—the gelatinous precipitate being collected and dried for export. "Almost the whole colouring matter in a lichen could thus be easily extracted at a comparatively small expense, and the value of the dried extract, amounting to more than £1000 a ton, would abundantly defray the expense from even the most distant inland localities, such as the Andes or Himalayas."

III. After due consideration and experience of the various modes which have been described or suggested for the purpose of developing the lichen dyes, the only plan which I can recommend as of easy and universal applicability, and as uniformly trustworthy in its results, is to macerate the powdered lichen in a somewhat weak ammoniacal solution for periods varying from several days to several weeks,—the metamorphosis being facilitated by the application of a moderate heat, and the free exposure of the whole mass to the air. The process can be carried on conveniently in phials, boxes, or jars of any kind ; and, if no other form of ammoniacal liquor be at hand, putrid urine, or the washings of the dung of animals, can always be easily obtained. The above is the basis of the manufacture of orchil, cudbear, and litmus, and of the domestic dyes prepared by the peasantry of various countries from lichens,—however much it may be otherwise modified. The form of ammoniacal liquor used by the peasantry of Scotland and other countries, and also by manufacturers, till within the last few years, was putrid urine. Not many years ago, the "lit-pig" (or vessel in which putrid urine was kept) was a familiar article—especially in certain districts, *e.g.*, in Aberdeenshire, in the cottages of all our peasantry—who dyed their stockings, night-caps, and other home-made garments, with pigments prepared from the "crotals" or "crottles" (a generic name applied in Scotland to the whole race of dye-lichens). Manufacturers recognised different qualities of urine as more or less useful in eliminating these colouring matters; its value seemed to bear a close relation to the amount of urea it contained, and consequently of carbonate of ammonia it was capable of generating; hence I have been informed that some English manufacturers, who continue to use this form of ammoniacal solution, have learned by experience to avoid urine from beer-drinkers, which is excessive in quantity but frequently deficient in urea and solids, while it is superabundant in water. The process of metamorphosis by means of the ammonia contained in stale urine is, apart from its essentially disgusting nature, a somewhat tedious one; hence various more elegant forms of ammoniacal solution have recently been introduced into our manufactories, especially the waste liquor of gas-works. But some orchil makers, believing that urine is efficient, not merely on account of the ammonia it contains, or, finding by experience that it is superior to any other form of ammoniacal liquor hitherto introduced, continue to use it exclusively. The most convenient form on the small scale is the dilute aqua ammoniæ of our druggists' shops. The red or purple tint is sometimes more rapidly evolved by boiling a small portion of the powdered lichen in a test tube in a little water or alcohol, and adding a few drops of ammonia when cool. Should no ammoniacal liquor be at hand, maceration in lime-water or the milk of lime is the next best substitute. Treated in this way, *Roccella tinctoria* yielded a distinct red colour to the liquid in ten minutes, and other dye-lichens in a proportionally longer time. I cannot here enter farther on the subject of the tests of colorific power, nor on the methods of developing the lichen dyes on the large or small scale; neither can I at all trench upon the chemistry of the lichen-colouring matters. For information on these points I beg to refer to a series of papers laid before the

Botanical Society of Edinburgh in 1852 and 1853,* and to the works, a list of which I have appended to the present article.

As intimately bearing on this subject, I have endeavoured to exhibit concisely in the following tables the lichens which are, or have been, chiefly used,—on the one hand, by the manufacturer, in the preparation of orchil, cudbear, and litmus,—and, on the other hand, by the peasantry of various countries, especially of the Scottish Highlands and Islands, Norway, and Sweden, in the preparation of their home-made simple dyes. It may not be inadvisable, moreover, to make a few additional remarks on the pigments respectively called *orchil*, *cudbear*, and *litmus*, which we may accept as the type of the red or purple colouring matters of lichens.

The synonymy or nomenclature of these dyes has not only given rise to great confusion as to their nature, origin, and uses, but leads to the idea that they are three distinct substances, having a separate composition, source, and economical application. For all ordinary or practical purposes we may look upon these as essentially the same colouring matter, differing slightly in tint, consistence, or applicability to certain fabrics according to modifications in the process of manufacture. We may practically regard *orchil* as the English, *cudbear* as the Scotch, and *litmus* as the Dutch name for one and the same substance; the first being usually manufactured in the form of a liquid of a beautiful reddish or purple colour, the second chiefly in that of a powder of a lake or red colour, and the third in that of small parallelopipeds or cakes of a blue colour. The latter form differs in the greatest degree from the others in colour and consistence. Its colour depends essentially on the addition of some alkali, such as the carbonates of potash, soda, or lime, and sometimes—as an adulteration—of indigo; and its consistence on the presence of thickening agents, such as gypsum, starch, chalk, or various siliceous and argillaceous matters. It would undoubtedly be much more convenient to classify these dyes, and, indeed, all the various red and purple colouring matters of the lichens, under *one* general term; and

* Especially those read 10th February and 12th May 1853, and published in the Society's monthly report in the *Phytologist*, Annals of Nat. History, &c

until chemistry furnish us with a suitable scientific name, founded on community of chemical character or composition, the old and familiar term *orchil* is probably the most comprehensive and appropriate we can find. The chief grounds on which I base this proposed nomenclative amalgamation,—this opinion of the essential unity of the dyes in question,—are, *inter alia*, the following:—

I. In relation to the chemistry of these colouring matters, and of the colorific principles by whose metamorphoses they are produced, Kane states, as the result of his investigations several years ago:—"There exist in the lichens which yield purple colours at least two groups [of colorific substances], characterized by different active principles, but ultimately generating, by their decomposition, the *same* coloured substances; the *orchil* from these various lichens being, for the purposes of the arts, *identical*, and containing in reality the same substance—*orceine*." The chemical character, however, of this purple colouring matter is not persistent; its chemical constituents are in a constant state of change; hence they differ in composition at various stages of the manufacture of the dye, corresponding to variations in colour. The red or purple tint, as usually exhibited in our common orchil, appears to be the ultimate or most permanent stage. The blue colour is exhibited at an intermediate stage, and, while it is very beautiful, it is also very delicate and fugacious, passing rapidly and readily into red on exposure to the air, and on contact with the weakest acids, &c. For instance, blue orchils, on being spread on paper or otherwise exposed to the air, almost immediately lose their beautiful blue colour and bloom, assuming instead a distinctly red tint. This blue tint can only be preserved by the addition of such alkalies as I have mentioned above in speaking of litmus. In most of the dye-lichens, the chemical changes involved in the conversion of the colourless colorific principles into coloured compounds, are of a somewhat complex character; but, in general terms, they appear to consist essentially in their oxidation, either directly or by intermediate steps, into a substance called orceine [or some substance chemically analogous] which is probably the basis of the beautiful purple or red colour. Some [of the older chemical] authors describe the same dye, prepared from the same plant, under different names, according to the colour and stage of manufacture, designating it *orchil* when the *red* tint predominates, and *litmus* when the *blue*.

II. Orchil, cudbear, and litmus, are now manufactured in England by the *same* manufacturer, either from the

a. Same species of dye lichen, or from

b. A considerable variety of species, by varying the process of manufacture; or, in other words, manufacturers can prepare either

a. The *same* dye, which may be red, purple, or blue, and in the form of a fluid, paste, powder or cake, from *different* species; or,

b. *Different* dyes, having distinctive or peculiar characters, from the *same* or from different species, according to very slight variations in the mode of treatment. —[*Vide* Appendix to Table II.]

Moreover, the physical characters of the dyes prepared from the roccellas, lecanoras, and other dye lichens usually employed in the manufacture of these three colouring matters, on the small scale, are identical or indistinguishable.

III. In regard to *litmus*:—Gélis, many years ago, made a series of experiments with a view to determine whether any or all of the dye-lichens used in the manufacture of orchil and cudbear were not equally serviceable for the preparation of litmus, with an affirmative result; and Pereira mentions that it may be variously made from Roccella tinctoria, R. fuciformis, Lecanora parella, Isidium corallinum, Variolaria orcina, or from any lichens capable of yielding orchil or cudbear. The latter distinguished authority was also informed by an orchil-maker that he was in the habit of manufacturing litmus from pipe-clay, starch, soda, and common orchil liquor. I have frequently convinced myself that the most delicate test papers can be equally well made from common orchil to which an alkali has been added. Different species appear to be used in different countries in the preparation of litmus. In Holland Lecanora tartarea is chiefly used; in Sweden, Scotland, and other countries, the peasantry use this lichen abundantly to furnish a red or crimson dye. In France, Lecanora parella, Variolaria orcina, dealbata, and aspergilla, Urceolaria scruposa, and other species are those principally employed.—[*Vide* Appendix to Table II.]

In conclusion, or by way of resumé, I shall briefly sum up the chief grounds on which I beg to direct public and scientific attention to the claims or importance of this limited but interesting branch of economic botany—

I. Experiment on the small scale shows that many native and foreign lichens,—which are at present unknown in commerce, and are unapplied to our arts and manufactures,—furnish the same [or similar] dyes, as those species which are usually employed in the manufacture of orchil, cudbear, and litmus.

II. Many of these species grow abundantly, or reach their acmé of perfection, in cold climates; several are plentiful on the mountains of Scotland, Ireland, and Wales, where they could be collected cheaply and easily; all can be gathered and transported with little or no skill or labour.

III. Whereas in the manufacture of orchil, Roccella tinctoria,—and in that of cudbear and litmus, Lecanora tartarea were the species formerly chiefly used in this or other countries, now British manufacturers have introduced many other dye-lichens, either as substitutes or adulterations.

IV. Some of these were formerly collected to a considerable extent in different districts of this country for the Glasgow and London markets, *e.g.* Lecanora tartarea, the so-called "cudbear" lichen.

V. Many species are, or have been, used to furnish dyes by the natives or peasantry in almost all parts of the world. In evidence whereof I need only refer to the "crotals" of Scotland, the "stane-raws" or "stone-rags" of England, Ireland, and Wales, the "korkalett" and "scrottyie" of Shetland, the "bœttelet," the "sten-mossa," "alaforel–laf," "bjork-laf" &c., of Sweden and Norway, the "Perelle d'Auvergne" of France, the "chulcheleera" of India, the "caranja and Jaffna mass" of Ceylon, and the Usnea barbata in South America; and, for general information thereanent, to Table I. There is a probability that dye-lichens continue to be used in some parts of our Highlands and Islands, where they were formerly employed to a great extent, from the fact that in a collection of the vegetable products of Scotland, at the Exhibition of 1851, yarns dyed by the following "crotals" were exhibited:

	Isidium corallinum,	[white crottle or crotal].
	Lecanora parella,	[light „].
	Sticta pulmonacea,	[crottle].
	Parmelia physodes,	[dark „].
	„ omphalodes,	[black „].
Besides	„ parietina, &c.	

VI. The dye-lichens thus used by manufacturers or by the peasantry are the very species which are proved [as a general rule], by experiments on the small scale, to be richest in colouring matters:—hence, by analogy, the probability that other species, which experiment has also determined to be more or less rich in colouring matters, may be found a useful addition to the present list of dye-lichens used in British manufacture.

VII. In support of the opinion that many new dye-lichens might thus be rendered subservient to our arts and manufactures, we have the testimony of orchil makers and dyers themselves, as given in the Great Exhibition of 1851.—[*Vide* Appendix to Table II.]

VIII. Chemical analysis has shown that colorific principles, similar to, or identical with, those, the product of whose metamorphosis is the basis of the beautiful colours of orchil, cudbear, and litmus, pervade species belonging to several different genera, which are both widely distributed over the world, and more or less plentiful in this country.

IX. Lichens are the most extensively distributed members of the vegetable kingdom; several species are cosmopolitan. The geographical diffusion of the dye-lichens,—even the most valued varieties,—is very extensive. For instance, Roccella fuciformis and tinctoria occur equally in Europe,—on the shores of Corsica and Sardinia, and on various parts of the Mediterranean coast,—in Africa, on the Mogadore coast on the north, on various members of the Azores group of islands on the west, Angola and the Cape on the south, and in Mozambique, Madagascar, and the Mauritius on the east; in Asia, on the coasts of Ceylon, India, and Arabia; in America, on the coasts of Chili, Peru and Brazil, as well as in Australia, New Zealand, the Falkland Islands, and other comparatively unexplored continents and islands of the southern hemisphere. Botanical travellers have found that there is comparatively little difference between European species of lichens, and those of North and South America, India, and New Holland. Brown remarked the strong similarity in regard to New Holland species; Humboldt in regard to South American; and of Royle's collection of Himalayan lichens, Don pronounced almost every one identical with European species. Hence the strong probability, in addition to the other facts above mentioned, that our colonies and other foreign countries to which we have access, may become extensive and valuable fields for the produce and export of dye-lichens.

As the literature of this department of economic botany is somewhat meagre, scattered, and difficult of access, I beg to subjoin, for the information of those who may find interest or profit in following out this subject, a list of works and papers, especially on the chemistry of the lichen-colouring matters, which is in a most unsatisfactory condition at present, standing much in need of immediate reform.* Few or none of our

* Stenhouse (of London) on the Colorific Principles of Orchil, &c.
Philosoph. Transac. London, 1848.
Lond., Edinb., and Dub. Philos. Mag., 1848.
Proceed. of Philos. Soc. of Glasgow, 1848-9.
L'Institut, 1849.

public museums or industrial exhibitions contain collections of dy-lichens, the dyes therefrom prepared, or the fabrics dyed with the latter. The nucleus of such a collection, which is one

Chemical Gazette, 1849.
Annal. de Chimie et de Pharm. lxx., 218.
Kane. Contributions to the Chemical History of Orchil and Litmus.
Philos. Transact. Lond., 1840.
Schunck. On the Colorific Principles of Orchil, &c.
Journ. de Pharm. et de Chimie, 1845 and 1847.
Lond., Edin., and Dub. Phil. Mag., 1844–1848.
Philos. Transact.
Laurent. Journ. de Pharm. et de Chimie, 1848.
Laur. et Gerhardt. On the Colorific Principles of Orchil, &c.
Journ. de Chimie et de Physique, 3d series, v. 24.
Lond., Edin., and Dub. Philos. Mag., 1848.
Comptes rendus, Aug. 1848.
Westring (of Copenhagen). Experiments on the Dyeing Properties of Scandinavian Lichens.
Annales de Chimie, vols. xii., xv., xvi., and xvii.
Crell's Annals, 1796–7–9.
Trans. of the Acad. of Stockholm, 1791, 2, 9.
Edin. Encyclopædia, art. *Lichens.*
Memoirs of Acad. of Sciences of Lyons, 1786, containing excellent reports on the economic applications of the lichens, viz. by
Amoreux. "Recherches et experiences sur les divers lichens dont on peut faire usage en médicine et dans les arts."
Hoffmann. Enumeratio Lichenum, &c.
Willemet. Lichénographie économique.
Pereira. Materia Medica, vol. ii.
Ure's Dictionary of Arts, &c., article *Archil,* &c.
Parnell's Applied Chemistry, art. *Dyeing.*
Encyclopædia, Edinburgh, art. *Lichens and Dyeing.*
Penny, art. *Lichens,* &c.
Britannica, do.
Mulder's Vegetable and Animal Chemistry.
Thomson's Organic Chemistry—Vegetables.
Gregory's Organic Chemistry.
Lightfoot's Flora Scotica.
Withering's British Botany, vol. iv.
Annals of Nat. Hist. Sept. 1839. Instructions of Royal Society to the last Antarctic Expedition.
Liebig and Kopp's Annalen, 1847–8–9 (on Colorific Principles).
Sowerby's English Botany.
Amœnitates academicæ of Linnæus.
Plantæ tinctoriæ by Jörnlin, vol. v., &c.
Transact. of Botan. Society of Edin., vol. i., part ii.
Edmonstone on the Native Dyes of the Shetland Islands.

eminently deserving the attention of the directors of such national institutions or museums as the new Industrial Museum for Scotland, the Sydenham Crystal Palace, the Paris Exposition, &c., is to be found in the Museum of Economic Botany, Royal Botanic Garden, Edinburgh.

Francheville. Roy. Acad. of Sciences, Berlin, 1767.
On Ancient and Modern Dyes.

Hellot. L'Art de la Teinture des Laines.

Bancroft. Philosophy of Permanent Colours, 2d edition, 1813.

Leuch. Traité complet des Matieres tinctoriales.

Martin. History of Western Islands.

Berthollet on Dyeing.

Nicholson's Journ. of Nat. Philos., Chemistry and the Arts, 1799 (Litmus).

Schlossberger. Pharm. Journ., vol. viii., 1848.

Abbé Nollet. Mém. de l'Acad. des Sciences, 1742. (Litmus).

Watt. Philos. Transact., Lond. 1784. (Litmus).

Rochleder, Heldt, Herberger, Dumas, Schnedermann, Heeren, Robiquet (among recent chemists), and Fourcroy, Vauquelin, Chevreul, Berzelius, Desfosses, &c. (among the older), have also written on the chemistry of the lichen colouring matters, especially of litmus and orchil.

TABLE.

Showing the chief Dye-Lichens applied by the peasantry of various countries to the Dyeing of Stockings, Yarns, Woollen Stuffs, &c.

Botanical Name.	Local, Vernacular, or Common Name.	Country in which indigenous and applied to Dyeing.	Colour of Dye.	Habitat.	Remarks.
*Roccella tinctoria,	Orseille, Fr.	South of France		Maritime rocks	The genus *Roccella* is practically a foreign one, attaining its highest degree of development in warm or tropical climates.
*Lecanora tartarea,	Crotal, crottle, Corkur, corcir, Korkir } Scotch Highlands	Scotland, Western Highlands and Islands		Alpine rocks	During the prosperity of the *Cudbear* manufacture in Leith and Glasgow, this lichen was an article of export from the Western Highlands and Islands, where it sold at 1d. per lb.
	Korkalett, Shetland	Shetland			
	Orn-mässa, Bœttelet, or Byttelet } Sweden	Sweden and Norway			
*L. parella,	Light crottle	Scotland		Rocks and trees	Formerly celebrated in the South of France under the name of "Perelle d'Auvergne," and used in the making of a dye called "Orseille d'Auvergne."
	Crab's eye Lichen	France			
		England			
L. hæmatomma,	Bloody spotted lecanora	Scotland ?	I. Shades of *Red*, *Purple*, *Orange*.	Rocks	
— atra,	Black lecanora	— ?		Rocks and trees	
*Umbilicaria pustulata,	Blistered umbilicaria	Norway and Sweden		Rocks	Also yields a black paint [Withering].
*Isidium corallinum,	White crottle	Scotland		Rocks	The genus *Isidium* might furnish several valuable dye-lichens to the manufacturer.
I. Westringii,	Westring's isidium	Norway and Sweden		—	
*Urceolaria calcarea,	{ Corkir, West. Islands Limestone urceolaria	{ Scotland, W. Islands, Shetland, Wales		Limestone rocks	The same remark may be made in regard to the genus *Urceolaria*. Both genera are comparatively abundant in Alpine or hilly districts.
*U. scruposa,	Rock urceolaria	England ?		Rocks	
U. cinerea,	Greyish urceolaria	— ?		Flinty rocks	
Parmelia saxatilis,	{ Crottle, stane-raw Staney-raw } Scotland	Scotland, W. Highlands and Islands		Rocks and stones	In winter the Swedish peasantry wear home-made garments dyed purple by this lichen. By the Shetlanders it is usually collected in August, when it is considered richest in colouring matter.
	Scrottyie, Shetland	Shetland			
	Sten-laf, Sten-mossa } Sweden and Norway	Scandinavia			

TABLE I.—(*continued*).

Botanical Name.	Local, Vernacular, or Common Name.	Country in which indigenous and applied to Dyeing.	Colour of Dye.	Habitat.	Remarks.
P. omphalodes,	Black crottle, Cork, corker, Crostil or crostal } Scotch Highlands; Arcell, Ireland; Kenkerig, Wales; Alaforel-laf, Sweden	Scotland, Highlands and Islands; Ireland; Wales; Scandinavia	I. Shades of *Red, Purple, Orange.*	Rocks, especially Alpine	One of the most extensively used dye-lichens. It yields a dark brown dye readily to boiling water, and it is easily fixed to yarns by simple mordants. It is stated to yield a red, crimson or purple dye. This I am inclined to doubt.
P. caperata,	Stone-crottle; Arcell	North of Ireland; Isle of Man		Trees	Said to dye yarn brown, orange, and lemon-yellow.
P. conspersa,	Sprinkled parmelia	England ?		Rocks	
P. encausta,	Grizzly parmelia	— ?		Rocks	
*Evernia prunastri,	{ Ragged hoary lichen; Stag's horn lichen	Scotland		Trees	E. prunastri yielded me very promising results.
Ramalina scopulorum,	Ivory-like ramalina	— ?		Maritime rocks	Lightfoot had a high opinion of it as a red dye, and mentions it as a rival of the roccellas.
*R. farinacea,	Mealy ramalina	England ?		Trees	
*Borrera ashneh,	"Chulcheleera"	India			
Solorina crocea,	Saffron yellow solorina	Scotland ?		Mountain summits	The colouring matter is ready formed and abundant in the thallus.
Nephroma parilis,	Chocolate-coloured nephroma	— ?		Stones	Said by Withering to dye blue.
Sticta pulmonacea,	[as under]			Trees	
Lecidea sanguinaria,	Red-fruited lecidea	Scotland ?		Rocks	Also yields a lake [Withering].
Cornicularia aculeata var. spadicea, [Lichen hispidus]	Brown, prickly Cornicularia	Canary Islands		Highland mountains	This genus I found very poor in colorific materials. I am very doubtful as to the identity of the species or genus.
Usnea barbata,	Bearded usnea	Pennsylvania and South America		Old trees	Bertram states it is used to dye yarn orange in Pennsylvania. The Usnea yielded me dirty pale greenish-yellow or reddish-brown colours.
U. florida,	Flowering usnea	England ?		—	
— plicata,	Plaited usnea	— ?		—	
Cetraria islandica,	"Iceland moss" of British commerce	Iceland	II. Shades of *Brown.*	Heaths and hills	This useful lichen readily yields a good brown to boiling water; but this dye appears only to have been made available by the Icelanders.
Parmelia physodes,	Dark crottle, Scotland; Bjork-laf, Sweden	Scotland; Scandinavia		Rocks and trees	
P. omphalodes,	[as above]				Withering asserts that it yields a purple dye paler, but more permanent than orchil; which is prepared in Iceland by steeping in stale lye, adding a little salt, and making it up into balls with lime.

Sticta pulmonacea,	Oak-lung, Lung-wort, Aikraw, Hazel-raw } Scotland	Scotland, England, North of Ireland	II. Shades of *Brown.*	Trees	S. pulmonacea is said to dye wool orange, and to have been used by the Herefordshire peasantry to dye stockings brown. Some species yield beautiful saffron or gamboge coloured dyes [*e. g.* S. flava, crocata, aurata.]
	Oak-rag, Hazel-rag, Hazel-crottle } England and Ireland	Scandinavia			
	Rags, Herefordshire				
S. scrobiculata,	Aik-raw, Scotland	Scotland		Trees	
	Oak-rag, England	England			
Gyrophora deusta,	Scorched-looking gyrophora	Scandinavia		Rocks	G. deusta was stated by Linnæus to furnish a paint called "Tousch," much used in Sweden.
G. cylindrica,	Cylindrical gyrophora	Iceland		Rocks	These two species of the "Tripe de roche" family of the Arctic regions yielded me very poor greenish-brown tints.
Alectoria jubata,	{ Horse hair lichen, Rock hair	England ?		Fir-trees	Yielded me only a dirty pale greenish brown.
Parmelia parietina,	Common yellow wall lichen	Scotland	III. Shades of *Yellow and Green.*	{ Trees, Rocks, Walls, Palings	Johnston mentions, about Wooler the children use it at Easter to dye their Pasque eggs. Much used by old women in Sweden to dye woollen stuffs.
	Wäg-mässa, Wag-laf } Sweden	England, Scandinavia			
Cetraria juniperina,	En-mossa, Sweden	—		Trees	Swedish peasantry use it to dye their home-spun woollen garments.
Borrera flavicans,	Yellow borrera	Germany ?		Trees	{ Both yield a very beautiful gamboge-yellow.
Evernia vulpina,	Wolfs-bane evernia	Scandinavia		—	
Lecanora candelaria,	Ljus-mässa, Sweden	Scandinavia		Trees	"Candle-dyeing"—so-called from being, or having been used by the Swedes to dye the candles employed in their religious ceremonies.
Lecidea atro-virens, var. geographica	Map-lichen	— ?		Rocks	
Lepraria chlorina,	Brimstone-coloured lepraria	— ?		—	
L. Iolithus,	Viol-mässa, Sweden	Scandinavia		Stones	Gives to stones the appearance of being covered with blood stains, which have been the origin of many a legend.

Explanation of TABLE I.

1. The colouring matters of most of the lichens which yield *red* or *purple* dyes are produced by the joint action of atmospheric oxygen, water, and ammonia on colourless colorific principles,—probably identical with, or similar in chemical composition to, *orcine*. This metamorphosis is effected, as a general rule, by the maceration of the powdered lichen in putrid urine, or some other form of ammoniacal liquor, the mixture being freely exposed to the air for periods varying from several days to several months.

2. The colouring matter of most of those species which yield *brown*, *yellow*, or *green* dyes, exists ready formed in the cells of the cortical layer of, and gives the predominant tint to, the thallus. This is uniformly separate from, and independent of, the colouring matter of the cells of the subjacent or gonidic layer of the lichen-thallus, which depends on the familiar substance chlorophyll.

3.*Denotes those species in which experiment has corroborated their utility, or which are used by manufacturers in this or other countries in the preparation of orchil, cudbear, or litmus.

4. Though formerly used to a great extent in the highlands and islands, in Shetland, and in many parts of the lowlands of Scotland—in Wales, and in many of the English counties, and especially the more northerly, mountainous, and remote from the great centres of commerce or manufacture—few, if any, of these lichens are now probably used in this country, unless in the more inaccessible districts, which preserve, to a great extent, unchanged by the progress of civilization, their primitive customs. This change in the customs of our peasantry is probably due to the facts that, on the one hand, recent improvements in travelling and transit, consequent on the invention of the steam-engine, bring all our great markets within easy access, or enable all corners of our country to be readily supplied with their produce; and, on the other hand, that the application of recent discoveries in science to our textile manufactures, enables the merchant to offer printed woollen, cotton, and linen goods, at such a price as to obviate the necessity of weaving or dyeing home-made fabrics. In Sweden and Norway, however, and in other countries, where the peasantry, from a deficiency in such facilities or advantages, maintain, in great measure, their primitive customs, they are still probably much used. Some species are, or have been, used to a great extent, *e.g.*, *Lecanora tartarea*, *Parmelia saxatilis*, *P. omphalodes*, and *Sticta pulmonacea:* others only to a very limited degree, *e. g.*, *Lepraria chlorina*, *Lecidea geographica*, *Lecanora atra*, and *Alectoria jubata*.

5. The term "*Crotal*," or "*Crottle*," so frequently used above, is a generic term among the Scotch peasantry, for the dye-lichens in general: The equivalent term or synonyme, but used in a much more limited sense, in the Scotch lowlands, appears to be "*Raw*" (e. g., *Hazel-raw*, *Aik-raw*); and in England, "*Rags*" (e. g , *Hazel-rags*, *Oak-rags*). The terms *Arcill*, *Argal*, *Orchal*, *Corker*, *Corcar*, *&c.*, have been applied, by different authors, to different native dye-lichens, and not unfrequently to the same lichens, *e.g.*, *Parmelia omphalodes*, *Sticta pulmonacea*, and *Sticta scrobiculata;* hence great confusion as to the nomenclature, both of the dye-lichens and the pigments prepared therefrom.

6. The chief *Mordants* used in the fixation of these dyes appear to be alum, common salt, nitre, and carbonate of potash (salt of tartar).

TABLE II.

Showing the chief Dye-Lichens used in this and other countries in the preparation of Orchil, Cudbear, and Litmus.

Botanical Name.	Export, trade, or common name.	Geographical source or country whence exported.	Habitat.	Remarks.
Roccella fuciformis,	Angola orchella weed Madagascar ... Lima [small, flat] ...	Angola, South Africa Madagascar Lima, South America Ceylon Madeira	Maritime rocks	In the Great Exhibition of 1851 orchella weeds were also exhibited, or referred to, from the following localities:—
R. fuciformis var. linearis,		— [Dezertas]	—	Europe,— Spain, Portugal, Sicily.
R. tinctoria,	Canary orchella weed Cape de Verde ... Lima [large, round] ...	Canary Islands Cape de Verde Islands Azores Madeira Lima and Valparaiso, South America Mogadore, North Africa Corsica and Sardinia	—	Asia,— India, Indian Archipelago, Arabia, Socotra, Ceylon. Africa,— Mozambique, St Thomas' Island, Cape Rock, Teneriffe and neighbouring islands and coast.
R. tinctoria var. hypomecha,		Cape, South Africa	—	America,— Falkland Islands, coast of Chili, and Peru.
R. Montagnei,	Cape orchella weed	—	Rocks, Cape Trunks of the mango-trees, India	Australasia,— New Zealand, New South Wales.
R. pygmæa,		Algeria, North Africa	Trees	
R. flaccida,		Mauritius	Maritime rocks	*R. fuciformis* is said to be abundant in Sumatra. India and the Indian Archipelago, as a field of export, remain to be opened up.
R. dichotoma,		— and Cape	—	
R. phycopsis,			—	Other species and varieties are also probably used.
Lecanora tartarea,	White moss of Sweden Swedish moss Tartareous moss	Norway and Sweden	Alpine rocks	Is said to have been imported also from Sicily [Smith], and to have been largely collected in Westmoreland, Cumberland, and Derbyshire for the London market.

TABLE II.—(*continued*).

Botanical Name.	Export, trade, or common name.	Geographical source or country whence exported.	Habitat.	Remarks.
L. parella,	Perelle d'Auvergne	France, Switzerland	Rocks and trees	*L. parella* was collected for the manufacture of "Orseille d'Auvergne" chiefly in the districts of Auvergne and Limousin, its entrepots being St Flour and Limoges.
Umbilicaria pustulata,	Pustulatous moss	Norway	Alpine rocks	
Parmelia perlata,	Canary rock moss	Canary Islands, Ceylon	Trees	
Gyrophora murina,	{ Velvet moss Norway rock moss	Norway and Sweden	Alpine rocks	The genus Gyrophora contains several good tinctorial species, but others are remarkably deficient in colouring matter [*e.g.* G. cylindrica].
Variolaria dealbata,	Perelle d'Auvergne	Auvergne, France	Hard rocks	
— orcina,	—	—		
— lactea,		France	Rocks	Exhibition of 1851—collection of dye-lichens.
— aspergilla,		—	Trees	Said by Guibourt to be used in Litmus.
Alectoria sarmentosa,	Jaffna moss	Ceylon	Trees [on mountains]	The tinctorial species of the genera Alectoria and Usnea are exceptional.
Usnea florida,	Caranja moss	Ceylon	Trees	
— barbata,			—	
Isidium corallinum,	White crottle	Norway and Sweden	Alpine rocks	Exhibition of 1851—collection of dye-lichens.
Evernia prunastri,			Trees	I. Westringii might probably become a valuable article of export from Sweden and Norway.
Ramalina farinacea,		Ceylon	Trees, hedges, &c.	
— fastigiata,			—	I. corallinum has probably been introduced as an intermixture of, or substitute for, Lecanora tartarea.
— calicaris,			—	Exhibition of 1851—collections of dye-lichens.
Urceolaria calcarea,		Norway	Calcareous rocks	Has probably been introduced chiefly as an intermixture, or adulteration of *Lecanora tartarea*.
— scruposa,			Rocks and stones	Said by Guibourt to be used in Litmus.

Explanation of TABLE II.

1. In addition to the above, the following lichens were stated, in some collections of dye-lichens and lichen-dyes, shown by British manufacturers at the Great Exhibition, to be used, viz.:—

   Parmelia physodes.
   — omphalodes—(stated by Turner to be used in the manufacture of cudbear ?)
   Sticta pulmonacea.
   Usnea hirta.
   — plicata.
   Cladonia rangiferina: and Guibourt states, that
   Lecidea geographica, and } were used in the manufacture of litmus [?].
   — sulphurea, }

   These statements have probably been founded in error, and therefore have not been incorporated in the table. I have even doubts as to the applicability or usefulness of several of the species last named therein.

2. The table shows the gradual increase in the number of substitutes for the *Roccellæ*. A few years ago *Roccella tinctoria* was almost solely used in the manufacture of orchil, and *Lecanora tartarea* in that of cudbear and litmus: now, from the majority of the above species, any or all of these dyes can be prepared by varying the mode of manufacture. Several of these were for the first time published as efficient substitutes for the Roccellæ at the Exhibition of 1851.
3. The above list comprises the chief, though probably not the whole, dye-lichens used by British manufacturers in the preparation of the red or purple dye, called variously orchil, cudbear, and litmus. Other species of the same genera have yielded equally fine dyes on the small scale, and might, advantageously to the manufacturer or importer, be added to the list.
4. Some manufacturers prepare all three dyes from the same species—by slightly varying the process, especially in regard to the period of maceration, degree of exposure to atmospheric oxygen, and the subsequent addition of alkalis to convert the red into a blue colour, and of substances to impart consistence. For instance, an English orchil maker exhibited at the Exhibition of 1851 eight qualities or kinds of orchil liquor, and two qualities of cudbear, all prepared from *Roccella Montagnei*,—the dyes so prepared being capable of imparting the finest shades of crimson, violet, blue, and chocolate colour to woollen, silk, cotton, and mixed fabrics, leather, &c., and also of yielding stone blue and lake pigments.
5. Other English manufacturers, again, use a variety of species in the preparation of the same dye, orchil;—or indiscriminately in the preparation of orchil, cudbear, and litmus. The two latter dyes are now, to a great extent, prepared by the English orchil maker; the cudbear manufacture has disappeared from Scotland, where it formerly chiefly flourished. From these three dyes *lakes* are now manufactured to a considerable extent.

   One exhibitor at the Exhibition of 1851 used the following species:—

Roccella tinctoria.	Ramalina farinacea.	Lecanora tartarea.
— fuciformis.	Parmelia perlata.	Umbilicaria pustulata.
	Gyrophora murina.	

   Another used:—

Roccella tinctoria.	Lecanora tartarea.
— corallina [Isidium corallinum ?]	Variolaria lactea.
	— dealbata.

A third used:—

Roccella Montagnei.
— tinctoria.
— fuciformis.
Parmelia perlata.
Umbilicaria pustulata.

And the same exhibitor (a London manufacturer) states his belief, that species of the following genera might also be employed with advantage to the orchil maker.

1. Lecanora.	5. Parmelia.	9. Sticta.	12. Solorina.
2. Gyrophora.	6. Evernia.	10. Usnea.	13. Cenomyce.
3. Isidium.	7. Variolaria.	11. Alectoria.	14. Lepraria.
4. Urceolaria.	8. Ramalina.		

These genera are likely to furnish valuable dye-species in the order in which I have arranged them. Experiment has demonstrated the value of the first eight on the list; with regard to the utility of the last six I am doubtful. Sticta and Solorina yielded me good brown and reddish-brown dyes; but from none did I obtain the same red or purple colouring matters which the other genera on the list are capable of yielding.

6. The general mode of treatment for the development from the dye-lichens of orchil, cudbear, or litmus, consists of the following steps:—(I am here guided by the valuable evidence of English manufacturers, as given along with their collections of specimens of these lichens and dyes, in the Exhibition of 1851.)

   1. Careful washing, drying, and cleansing, to separate earthy and other impurities.
   2. Pulverization into a coarse or fine pulp with water.
   3. Regulated addition of ammoniacal liquor of a certain strength, and derived from various sources (*e.g.*, putrid urine, gas liquor, &c.)
   4. Frequent stirring of the fermenting mass, so as to ensure full exposure of every part thereof to the action of atmospheric oxygen.
   5. Addition of alkalis in some cases (*e. g.*, potash or soda), to heighten or modify colour; and of chalk, gypsum, and other substances, to impart consistence.

   These are the essentials of the process; but various accessories are sometimes employed, *e. g.*, the application of continued, moderate, and carefully regulated heat during the process of fermentation.

   One manufacturer states the process tersely as follows:—The lichens are steeped in an ammoniacal solution, so that the *orcine* they contain may, by combination with atmospheric oxygen, water, and ammonia, develope colouring matters. How far this statement is scientifically correct, I leave it for chemists to decide.

7. The commercial or "trade" designation of the dye-lichens depends upon the thallus being erect or pendulous, cylindrical or shrubby, on the one hand; and flat, crustaceous, or foliaceous, and closely adhering by its whole surface to the basis of support, on the other; species having a thallus of the former character being termed "weeds," (*e. g.*, the Roccellæ); and of the latter "mosses" (*e. g.*, Lecanora and Parmelia). The "weeds" chiefly used in the preparation of orchil (the Roccellæ), are popularly called "Orchella weeds," and are somewhat specifically arranged in commerce, according to their geographical sources (*e. g.*, "Angola," "Lima," "Cape," or "Canary orchella weeds)." The "mosses" are more irregularly designated,—the specific name in some being due to their geographical source (*e. g.*, "Canary Rock Moss"): in others to their physical characters (*e. g.*, "Tartareous moss," "Pustulatous moss)."

8. The species which have no trade or commercial name, have been recently introduced as dye-lichens, and are not imported in such quantity as to have acquired a familiar designation.

Observations on the Trap Dykes in the sea shore between the Bays of Brodick and Lamlash, in Arran. By JAMES NAPIER, F.C.S.* (Plate III.)

During last summer I spent a few weeks at Strathwellan in Arran; and occasionally wandering along the sea shore, between that place and Invercloy, I was struck by the large number of trap dykes cutting through the sandstone in a direction at right angles to the sea-line. On consideration of this phenomenon, it occurred to me that if such dykes continued round the coast to Lamlash Bay, and still at right angles to the sea line, they must in all probability have proceeded from a common centre, lying somewhere between the two bays. In order to put this idea to the test of observation, I started from Invercloy, and walked along the shore to Lamlash, measuring and marking down the position of every dyke I passed, and the result completely confirmed my anticipation that they proceeded from one, or possibly from several centres. The ground examined was the narrow strip of sandstone rock lying between the sea shore and the soil. The dykes passing through it are easily distinguished, but I was unable to trace them to any great distance as they are soon lost under the soil. Some parts of the beach are strewn with trap boulders, concealing the sandstone, but whether they cover transverse dykes could not be ascertained. Between Clachland Point and Lamlash the ground is so completely covered with gravel and boulders that only those dykes which rise above the surface can be seen, and these only are represented in the map which accompanies this paper. It is to be observed also that as I started from Invercloy at low water, and spent four hours in reaching Clachland Point, the tide had risen nearly to the full before my arrival, and as the greater part of the sandstone is covered at high water, the number of dykes counted in the latter part of the walk may not exactly correspond with that which would have been observed at ebb tide, as some of them split into two or more branches, and according to the extent

* Read before the Natural History Society of Glasgow.

to which they are covered by water, the branches may be counted as separate dykes or as part of one.

The number of dykes I counted between Invercloy and Clachland Point was fifty-four, exclusive of those which run parallel with the coast, and connect together those which radiate from the centre. They vary in breadth from one to a hundred feet, making a total breadth of about 727 feet.

The general phenomena along the shore indicate that the whole surface and rock round the central trap hills between the two bays has been completely shattered; and were it not covered by the soil, I believe the dykes would be seen to form a net work, resembling a spider's web, or the fractures in a pane of glass, radiating from a centre, being close to each other, and numerous near the centre, and with a few stretching out for a greater distance, so that from a large trap centre, some of these cracks or dykes may run out for many miles.

The accompanying map of the district with the dykes marked along the sea shore, may serve to give some idea of the appearance, and the reader may conceive their continuation, either to or from the centre.

In connection with the general feature of these dykes, and before examining the matter in detail, I may refer to a phenomenon I have often observed, and which may serve to throw some light on the mode in which they are produced. In copper smelting works, the slag or scoriæ, which has a composition and structure closely allied to that of some sort of trap, is drawn or skimmed from the furnace into large sand beds forming a mass of melted matter of several hundredweight; and as it cools a crust is formed on the surface, under which the mass often remains fluid from ten to twenty minutes, according to its fusibility and the degree of heat to which it has been subjected. It often happens that after the crust is formed, an additional quantity of slag skimmed from the furnace finds its way under that already partially solidified, in which case the crust is either raised up as a whole, or breaks and allows the fused matter to flow up through the main rupture. Cracks are formed in different directions, through which the fused matter also flows; and if it be very fluid it simply covers the surface, but if less fluid it rises up through the main fracture like a cauliflower, forming a miniature trap hill with its radiating dykes. When a second and third addition is made to the liquid scoriæ, the crust may be seen breaking up in different places and different directions, but the previous fractures being weakest yield first; and when the scoriæ are of different qualities, the lightest and least fusible remain on the surface, and form the highest portion of the pressed-up matter.

These phenomena are suggestive of the general characters and probable cause of the trap hills and dykes of the district under review, which I will now describe in detail.

The most casual observer of these dykes is immediately struck with the great difference in the extent to which they have been abraded by the action of the sea. Some are worn a great way under the level of the sandstone beach; others are on a level with it; while others, again, form high and jagged ridges, projecting a considerable height above the surrounding rock. From some experiments made several years ago on the decay of trap boulders, I found that certain varieties of that rock are rapidly changed by the action of water, lime and magnesia being dissolved out, the iron converted into a peroxide, and a crust formed on their surface, which is brittle and easily abraded. This at first sight appeared to afford a sufficient explanation of the rapid wear and decay of some of these dykes within the water-mark, for some of those most deeply hollowed at the beach form quite a ridge along the fields where they are not exposed to the action of the sea; but after a more close examination, I found there were other causes effecting the destruction of the dyke, which may be rendered intelligible by reference to another common metallurgic phenomenon. When iron or any other substance is cast in metal moulds, so that the heat is rapidly conducted from the casting (*chilled*), the iron sets to a considerable depth in a crystalline or columnar form, the crystals or columns lying parallel to the direction of the radiating heat, one end being directed towards the mould, the other to the centre of the casting, making the iron hard upon the surface, but very brittle from the tendency of the crystals to separate. In casting slag in iron moulds the same thing takes place, and the mass when struck will break into columnar pieces.

In most of the small trap dykes I observed a similar appearance, indicating that the rocks forming the side walls of the dyke had rapidly cooled the fused matter ; hence the trap lying in horizontal columns, the water easily gets between them, and the chemical action I have described takes place, loosening and separating each column or piece, which the sea washes away from its bed, and thus the dyke is rapidly disintegrated.

Not less remarkable is the great variety in the mineralogical characters of the trap forming these dykes, all apparently proceeding from a common centre. Greenstone, basaltic, and felspathic traps, may be seen within a few yards of each other, and some running in directions in which they must either intersect or coalesce. This extreme difference naturally suggests the question, whether these different dykes really proceed from one central upheaval or several, and whether these took place simultaneously or at distant intervals of time.

To give a satisfactory answer to these questions would require a more full investigation than I had time and opportunity of making, but the felspathic trap being so distinct from the others, I sought for a special centre near to the place where the two large and prominent felspathic dykes, Nos. 38 and 48 on the map, would intersect each other. And near that point I found an open quarry being wrought for road metal, and composed of the same kind of felspar as the dykes. Whether the part of the hill on which this quarry was situated, be the central upheaval from which these dykes proceeded, or merely a continuation of the two, after joining each other, I will not venture to decide, although I incline to the former opinion. The other varieties of trap I did not attempt to trace to special centres, because the difference in their chemical properties is not so great as to prevent their existing in the same series of dykes, or even in the same dyke at different distances from the centre. The whole of the hills between the bays of Brodick and Lamlash are composed of trap, but it appears to me that they have not been elevated simultaneously, although the differences in time between one upheaval and another may not have been great ;

and I found this opinion upon the differences in composition, and rates of fusibility of the trap of which they are composed. It is not my intention to enter upon a detailed chemical investigation of this point, but I may mention one or two general principles which bear upon these phenomena.

Quartz or silica, and alumina, are infusible alone by any known degree of heat, but if any of these substances, when submitted to a high heat, be brought into contact with lime, magnesia, oxide of iron, potash, soda, or almost any other metallic oxide, they combine and form a fusible compound, but the quantities of these oxides required to combine and form fusible compounds, are definite with a definite degree of heat. If, for example, we take 100 parts silica or alumina, or mixtures of these, and 16 parts of some other oxide, say lime, the mixture would require a most intense heat for its fusion : if there were 32 parts of lime or other oxides, a much less heat would suffice, but still equal to the highest heat of a blast furnace; but if there were 64 parts of lime or other oxides to 100 silica or alumina, a still much lower degree of heat would effect complete fusion. It will therefore be evident that if these separate mixtures were subjected to the same degree of heat, they would be differently affected, for when the first of these mixtures was in a state of partial fusion, the last would be as fluid as oil in summer. These supposed proportions are near the reality of some of the different dykes I have been referring to, and the subjoined comparison of the ratio subsisting between the silica and alumina, and the other oxides will serve to show, that in order to study the origin and history of trap rocks or dykes, they should be studied more in reference to these qualities than has hitherto been customary.

	Pitch Stone.	Felspar.	Basaltic.	Green Stone, &c.
Silica and alumina,	100	100	100	100
Other oxides,	21	23	45	70
Specific gravity,	2·3	2·5	3·	2·9

From the principles above stated, and the fact that these different varieties of traps are distinct in their positions *in situ*, it will be evident that these different fusibilities have a great deal to do both with position and structure. Again, the time necessary for each sort of trap to become solid is important, and gives it a peculiar physical structure. Thus, when bodies solidify slowly they generally take a crystalline form even in mass, and hence the basalts and other easily fused traps have evidently set more slowly, and are, therefore, generally crystalline.

So far as I have observed in the locality under consideration, the most difficultly fusible rock holds the highest position in the upheaval, and where they form dykes they are least worn. Although I am of opinion that in this locality these trap dykes are the result of several upheavals, still their different degrees of fusibility is not a decided proof in favour of this view, for were all these traps fused together, the pitch stone and felspar, owing to their low specific gravity, would float upon the surface, so that when the solid crust gave way by internal pressure, the light and easily solidified rocks would be carried up first while the heavier and more liquid would have the greatest tendency to flow through the fissures or cracks proceeding from the main fracture; and thus we may have, as a general law, a trap of a different composition on the high levels from that of the low levels of the same series, and as the latter contain a larger quantity of oxides, they are more easily decomposed, and may be entirely worn away from the rocks over which they may have flowed, leaving nothing but the fissures or dykes visible.

In addition to the facts already stated, it appears to me that the existence of distinct crystalline minerals within these rocks, has not yet secured a satisfactory explanation. A good deal has been said, from time to time, about the formation of different crystalline forms under pressure, such as Augite and Hornblende, &c., but it must be remembered that these minerals are of the same composition as the mass or rock in which they are formed. I refer more particularly to crystallized minerals distinct from the rock itself, but containing one or more of its constituents, such as quartz, felspar, &c., in basalt. To say that these were formed in consequence of the mass solidifying under pressure, is to pay no attention to the circumstances under which they are formed. We frequently find the highest parts of trap hills where the liquid has over-flown, full of these crystals, although it is obvious that the pressure on them when solidifying would be very trifling, and the cooling very rapid. I consider it more likely that these crystals have been formed in the trap before being upheaved, not as the result of pressure but from the gradual withdrawal of heat. The crystals are always composed of one or more constituents of the mass, and so far as I have seen, always of a less fusible character than the rock in which it is imbedded, and from which it has been formed, as well as of lower specific gravity. To illustrate this, I may take a specimen from the top of Dundubh, from which some of the dykes I have referred to come, which is full of quartz crystals. When these are ground with the mass or rock, the silica and alumina are found to stand to the other oxides in the ratio of 100 to 12, while the rock itself, free from the crystals, contains 100 silica and alumina, to 27 of other oxides. It is known that silicates when fused, have the property of dissolving more silica in quantity corresponding to the heat, and many other bodies in the state of fusion have the same property of acting as solvents to others. Now, in the case of the rock referred to, the intense heat may have caused the true silicate to dissolve more silica, and the gradual withdrawal of the heat, before the fluid burst up, lessening the solvent property of the silicate, the quartz would crystallize from the fluid in the same way that salts crystallize from water, and the specific gravity of the crystals being rather less than the fluid, they would not precipitate, but either float or become diffused through the mass.

During this gradual cooling of a fused mass, formed of such a variety of elements, and subjected to different rates of affinity from a gradual decrease of heat, we have but to establish the fact, that crystals of different compounds are formed under such circumstances, to make it probable that not only quartz but felspar and most other crystals found imbedded in trap and other fused rocks have been formed in a state of fusion by the decrease of temperature ; and this opinion derives support from the fact, that the crystals in the rocks so formed are, as far as I have observed, less fusible and lighter than the fluid in which they are formed. I cannot, however, at the present moment enter upon the consideration of this point for which further investigation is requisite. I may observe, however, that the same views may apply to granite, and that its quartz crystals as well as the other constituents may have separated during cooling from a very high temperature and previous to its upheaval, and these constituents of granite would retain for a long time a sufficient amount of plasticity to admit of its being raised to great elevations.

On the Influence of the Lower Vegetable Organisms in the production of Epidemic Diseases. By CHARLES DAUBENY, M.D., F.R.S., Professor of Botany and Chemistry in the University of Oxford.*

The recurrence of Asiatic cholera at such short intervals apart, in countries the most remote from that to which it has been satisfactorily traced as its birthplace, naturally invites the attention of speculators to an inquiry into the hidden cause of this mysterious malady, and that of epidemics in general. Unlike that class of disorders, which are primarily attributable to a decay or derangement of some one of the organs of the living system, or to malformations consequent upon them, epidemics appear to spring from the introduction of an extraneous principle into constitutions which may have been previously exempt from disease; and although to enable the poison to take effect, it would seem requisite, that its intensity should bear some proportion to the strength or vigour of the recipient, still it is probable that there is no frame so robust, no organization so nicely adjusted, as to be proof against the influence of these morbific agents in their highest state of malignity.

Whilst, however, we are compelled to admit, in the case of all prevailing epidemics, the existence of a specific principle capable of diffusion through various channels, either by the touch, by the breath, by the water of the infected localities, or, lastly, by the atmosphere itself, we must also assume that every living being exposed to its influence possesses, inherent in itself, a certain power of resistance; so that it is quite

* Read at the Ashmolean Society of Oxford, 13th November 1854.

conceivable that a weaker degree of the poison may circulate innocuously throughout a whole community, and that even one of somewhat greater intensity may attack only those whose system is already in a state of greater or less disorder, being received with impunity by persons in a perfectly sound condition of health.

These postulates are required to enable us to explain the fact, that scarlet fever, measles, typhus, and other epidemics, seem never to be entirely absent from any large and thickly peopled community, although their ravages are restricted to particular seasons and places; and on the other hand, that a poison as malignant as that of the plague, which, on its first invasion scarcely spares any that it attacks, fails, nevertheless, to sweep away the entire population of the infected district, and has not, indeed, before the present time, exterminated the whole human race.

Simple and obvious as such considerations must appear, they are nevertheless often overlooked by the eager partisans of some one of those theories of cholera which divide the public mind; as must be inferred from its being alleged, as an argument against the notion of infection, that certain individuals have been found to enjoy an exemption from attacks of the disease, notwithstanding their apparent exposure to as powerful a dose of the poison as that by which others had been overpowered. As if it were not evident that Nature must have made some provision to prevent that highest degree of malignity from being commonly attained by any epidemic disorder, which should be capable of overpowering the resistance of the most healthy, and the least susceptible of the individuals exposed to it.

It is this, indeed, which constitutes one mark of distinction between epidemic and endemic diseases; between plague and malaria, for instance; or between the yellow fever and the cholera. The *virus* of the former, admitting that it may be always present in certain countries and climates, as certain considerations would lead us to infer, varies at least in intensity in every conceivable degree, according to circumstances, some of which are at present obscure, although others, as we shall see, are sufficiently obvious; the disease, therefore, is at one time nearly extinct, at others generally prevalent. It also attacks under common circumstances only those who are either infected by previous illness, or predisposed by some temporary derangement brought about by imprudence; nor does it ever prevail throughout a district in so concentrated a form as to indicate its presence, except either in places where the bodies of persons already infected by the disease, their excretions, or their clothes, are present in the neighbourhood; or else where animal and vegetable exuviæ, in a suitable state of decomposition, attract to themselves a larger amount of the noxious matter floating about in the atmosphere, or encourage its reproduction by affording it a suitable *nidus*.

It would no doubt be quite possible, at a time when cholera was raging at Worcester or at Gloucester, to propagate the disease at Malvern, by bringing there a sufficient number of patients labouring under the disease, and by crowding them together in ill-ventilated apartments; or it might be done, even through the creation of a hotbed of infection by means of a due accumulation of animal and vegetable filth.

Without these or other like adjuncts, however, it would hardly seem within the range of probability, that the morbific influence developed amongst the population of the adjacent towns would ever reach such a degree of intensity, as to impart to the atmosphere, up to such an elevation, and to such a distance from the *foci* of contagion, any very injurious quality.

Endemic diseases, on the contrary, under similar circumstances of temperature and humidity, not only exist at all times in particular spots, but exert their influence over every constitution; although, of course, with greater degrees of rapidity or of violence, in proportion to the health and vigour of the recipient. They pervade the whole district indiscriminately; and although they may be aggravated by previous want of attention to cleanliness in the individuals exposed, inasmuch as filth acts as a predisposing cause to all diseases, by lowering the energies of the system, they are themselves entirely independent of any such cause; and even seem to be counteracted, as in the Jews' quarter at Rome, by the concentration of animal effluvia.

These principles, however, even if admitted as just, leave us as much in the dark as ever with respect to the true action of the poison itself.

Does it, for instance, consist in a deterioration of the atmosphere we breathe, or in the addition of some noxious principle to its ordinary constituents ?

Does this noxious principle partake of the nature of a mineral or of an organic poison ? does it, like arsenic, like strychnine, or like prussic acid, act chemically upon the vital organs, and thus destroy them, or render them unfit to fulfil their functions ? does it operate in the manner of a ferment, setting up changes in the fluids of the body which are incompatible with life ? or is it one, which, like certain vegetables or animals, contain within themselves a principle of so noxious a character, that they are capable, when introduced, of setting up a train of morbid actions in the system ?

Some of these conjectures, although gravely entertained, may be rejected without examination. No change in the constitution of the atmosphere has ever been detected by the minutest examination during the most severe epidemics ; nor can the presence in it at these times, of any foreign ingredient, be discovered.

It seems plain, therefore, that no chemical poison can be the cause of the noxious influence ; for such a quantity at least as could materially affect the constitution ought to be appreciable by chemical reagents.

It may also be remarked, that a poison of a chemical nature could hardly be present in the atmosphere without pervading it, or pervade it without being of the nature of a gas. If so, it should operate simultaneously and equally over all parts of the district in which it is present, instead of being confined, as it is found to be, to certain spots.

It is at least certain, therefore, that the poison of cholera must be in a solid condition, and not in that of a liquid or of a gas.

As for the theory of Ferments, which Liebig has pronounced capable of accounting for the spread of epidemics, it must strike us as ingenious and beautiful ; but even if it were admitted to be established on firm principles, we should still be at a loss to explain the fact which is pleaded most strongly in its favour—namely, the non-recurrence of most epidemics in the same individual; without adopting the violent and gratuitous hypothesis, that there is a specific fermentable substance for each of them present in the system, which is destroyed or eliminated during the progress of the disease.

Granting even that the epidemic poison acts after the manner of a ferment, the question still recurs, what is the nature of the ferment itself? and thus we are brought back again to the original subject of inquiry.

Let us then consider, whether it be more probable that the morbific influence be of an inorganic or of an organic nature; and if the latter hypothesis deserve the preference, whether it be of an animal or vegetable origin.

Now, there are many circumstances in the progress of an epidemic disease, which seem inconsistent with the action of an inorganic poison.

In the first place, its operation is capricious and uncertain—lying dormant for a considerable period, and then suddenly starting into activity. Secondly, instead of being destroyed in the process of development, it seems to have the power of indefinite reproduction, or multiplies itself in direct proportion to its previous activity. Lastly, its virulence is dependent upon a number of extraneous conditions, such as climate, soil, humidity, by which no animal poison would seem to be in the slightest degree affected.

We are driven then, by a process of logical exhaustion, to conclude, that the poison which gives rise to these dreaded consequences is of an organic nature. It does not, however, directly follow, that being *organized* these agents should be *living;* and indeed the theory of their acting as ferments is quite compatible with the notion of their existing in that intermediate condition, when, life being removed, the constituents that had been held together through its instrumentality are in the act of resolving themselves into simpler combinations, and passing back into the state of brute matter.

But although the products of animal and vegetable decomposition are unwholesome, and in certain of their stages even pernici us, it would be absurd to suppose that they could in themselves engender an epidemic. Putrid matter, in one particular, and that not an advanced state of decomposition, or I should perhaps rather say, morbific matter generated in certain parts of the body, as in the peritoneum, during the course of disease, if absorbed by the system, produces the greatest derangement of the functions, and even death, but it does not engender cholera or typhus.

We must look farther, then, for the real cause of these diseases, and seem, indeed, scarcely to have any alternative remaining, except that of referring them to the deleterious influence exerted by certain tribes either of animalcules or of vegetables. Both these hypotheses have had their advocates; the former being supported by Kircher, Linnæus, and in later times by Sir Henry Holland, in a very ingenious and elegant essay; the latter, amongst the rest by Dr Mitchell of Philadelphia.

Both hypotheses have the advantage of explaining equally well the migratory character of epidemic diseases—the period of incubation which belongs to them all, definite in almost every case of the same disorder, and yet varying in length according to the nature of the particular malady,—the power of indefinite multiplication which they all possess, by which they are transmitted from one individual to another, with such rapidity,—their limitation to particular districts, positions, streets, houses, or even to one side of the same apartment—their rapid invasion, and equally sudden disappearance.

But it seems contrary to all analogy to imagine any tribe of animalcules to multiply itself with almost equal facility in such opposite climates, as those in which many epidemics, such, for instance, as cholera, have prevailed. Most of these tribes are limited by certain conditions of temperature, soil, and humidity; and if capable of being transferred from one continent to another, thrive at least only in proportion as like meteoric conditions prevail in both.

The same general objections apply, for the most part, equally to plants as to animals. All the higher tribes, at least of the latter, have a local *habitat*, and can only be made to migrate where similar conditions of climate exist. Nor do they for the most part fasten themselves upon living animals, or by their presence disorder their system.

It is a mistake indeed to suppose, that water, because it contains animalcules, or confervæ, is necessarily unwholesome. However repugnant to our feelings it may be to use water containing these foreign bodies, it is only when they are dead and putrid that danger arises from their presence.

A recent traveller in Ceylon, Mr Sullivan, relates, that whilst the vicinity of the rivers is dreaded from the noxious exhalations caused by their overflowing, and their water is considered unwholesome; that of tanks, in which confervæ grow, and animalcules of all kinds swarm, is regarded as innocuous. Now the only tribe of plants, the members of which seem capable of maintaining themselves independently of those obvious differences in temperature and humidity, which so remarkably affect the development of plants in general; the only tribe, moreover, which grows, after the manner of parasites, upon animals whilst alive, is that of the fungi, and to these, therefore, our attention is naturally directed, as promising to supply us with some more plausible explanation of the nature of these morbific influences, than we can seek elsewhere. Let us consider, then, how far the known nature of fungi corresponds with the conditions of our theory.

In the first place, then, many fungi, especially the minuter kinds, and those of the simplest organization, are believed to be ubiquitous; and like man, would seem to live in every climate, from Sierra Leone to St Petersburg, from Asia to America.

Secondly, not only are the poisonous properties of very many of them notorious, but like certain epidemic disorders, are in some cases modified by climate, so that a fungus which is only narcotic in a cold climate, may be a deadly poison in a hot one.

Thirdly, the period of their greatest development is the autumn, the season in which epidemic diseases more generally prevail; although the decomposition of animal and vegetable matter takes place with greater rapidity during the heats of summer.

Yet when, as in Egypt, the period of vegetation coincides with the winter solstice, these epidemic diseases become most frequent in the spring.

Fourthly, the invasion of epidemic diseases is often ushered in by an extraordinary prevalence of certain moulds, not only of the common kinds, but also of others which had not been previously noticed.

Thus, during the first great plague of Rome, in the reign of Romulus, we read in Plutarch that it seemed to rain blood, a portent which, in ages of *barbarism*, has not been unfrequently recorded. Now the red fungus which presents this appearance has been found to be the concomitant of epidemics in more modern times also, as during the continental sweating sickness at Cremona in 1529. Other kinds of mould appeared on garments, on the roofs of houses, on wooden furniture, &c., during the plagues at Naples, Malta, Brussels, and New York.

Hecker, in his History of Epidemics (Sydenham Society), has cited various other instances of the same phenomenon coexisting with some great epidemic, and remarks that blood-spots, as they were called, went for that reason by the name of *signacula*. They were observed in the plague of the sixth century; and during those of 789 and 959, were called *Lepra vestium*. In that of 1500 and 1503, this phenomenon caused great alarm, more especially because it was found that the sign of the cross could be recognised in these blood-spots. One of the first persons who considered the thing at all scientifically was George Agricola, and he, in his History of the Plague that occurred in his day, viz., in the sixteenth century, pronounced the spots to be caused by a lichen. With its occurrence was connected a great failure of the crops which is often consequent upon the abundance of fungi.

From this and other facts, Hecker draws a conclusion, which, though cautious in its expression, corroborates, so far as it goes, that to which I have arrived—namely, in pronouncing it a probable conjecture, that "the sweating sickness which visited England in 1806 was not without connection with the morbid condition of human and animal life in the south and middle of Europe, and may be perhaps regarded as having been the last manifestation of mysterious agencies in the domain of organized beings."

Now fungi of that description, which, in general characters at least, correspond with those which are observed during the prevalence of epidemics, are not unfrequently invested with properties of a highly noxious character.

Thus, bread, cheese, and meat, when affected with mouldiness,—potatoes diseased through the same cause,—the ergot of rye,—and other parsitical fungi which infest living or dead plants, are known to produce most serious disorders.

Perhaps, however, the most striking confirmation of the fungiferous origin of epidemics is afforded by diseases directly traceable to the growth of fungi that occur in the lower tribes of animals, as well as in plants.

Of this kind is the formidable disease called the muscardine, which attacks the silkworm. Not only is the particular fungus, called "*Botrytis bassiana*," always found upon the caterpillar when affected with the above malady; but if the same minute body, generated upon decaying moss, be placed near a healthy silkworm, its spores are seen to attach themselves to the surface of the insect, and gaining in some way or other access to its subcutaneous adipose tissue, convert it to its own use, so that the fatty tissue of the worm becomes metamorphosed into the rootlets of the cryptogamic plant. By degrees the plants penetrate from within to the surface, where they fructify, and whiten it over with their sporules. Thus created, the germs attach themselves to other worms, and a contagious disease of a vegetable origin devastates the whole establishment.

The malady is here distinctly traceable to the introduction of a fungus, which first grew upon a moss, and was thence transferred to an animal; in the potato and the grape diseases, which might be cited as analogous cases, although the morbid condition of the plant is constantly associated with the presence of a particular fungus, it is perhaps more a matter of dispute, whether the latter be the cause or only the effect of its invasion.

I confess myself inclined, from analogy, to adopt the former view, as the more probable; although quite prepared to admit, that different plants are capable of offering a degree of resistance, in direct proportion to their respective hardihood and vigour.

But at any rate the argument in favour of the fungiferous theory of epidemics only requires us to show, that these diseases in plants start up suddenly in spots where they do not appear to have been known before; that they are propagated from place to place without much reference to climate or to latitude; and that they then disappear as suddenly as they first manifested themselves.

Like the locusts described by the Prophet Joel, they may be called the large army which God has sent amongst us, and which, when it has effected its purpose, He as rapidly removes.

"We see," says Sir Charles Lyell, "that a scanty number of minute individuals, only to be detected by careful research, and often not detectable at all, are ready, in a few days or weeks, to give birth to myriads; and that when the function, whether it be that of removing impurities, or of executing those other mysterious purposes for which they were designed, is completed, they sink again into nonentity."

In almost every season, especially in autumn, there are some species which in this manner put forth their strength, and then, like Milton's spirits, which thronged before the spacious hall, "reduce to smallest forms their shapes immense."

> So thick the airy crowd
> Swarmed and were straitened; till the signal gave,
> Behold a wonder; they, but now who seemed
> In bigness to surpass earth's giant sons,
> Now less than smallest dwarfs, in narrow room
> Throng numberless. *Paradise Lost*, i. 775.

It is obvious that these remarks apply equally to the rise and decay of epidemics, and that the same simile would be applicable to those, as well as to the appearance and disappearance of fungi; so that we are naturally tempted to inquire whether these latter may not also originate in the same cause.

Fungi also agree with epidemic disorders, in the length of time during which their spores would seem to remain dormant, without losing their vitality. This is evinced in the sudden appearance of certain fungi, where they had not been observed within the memory of man; as in the case of the red mould which infected the food, garments, and houses of the Venetians, in the early part of the present century.*

They are also distinguished for the high temperature, as well as severe cold, they can support. Indeed it would appear, that little short of a heat capable of destroying their organic structure can be relied on to extinguish their vitality.

The same tenacity or power of resisting decomposition is also manifested by the matter, whatever it may be, which imparts to certain fungi the power of affecting the functions of life. The filthy custom reported by Longsdorff† as existing amongst the Kamtschatkans, is founded upon the power which the intoxicating fungus *Amanita muscaria*, of which

* In the year 1819 the inhabitants of Laguaro, a village in the vicinity of Padua, were alarmed at a very ominous appearance, like that of drops of blood, which suddenly manifested itself on the surface of various articles of food. The first feeling of the people was to attribute it to magic, and the priest was accordingly sent for to exorcise the evil spirit, supposed to be the author of so peculiar a phenomenon.

On examination, however, the spots were found to arise from a species of byssus, which attached itself here and there to these substances. It spread like a leprosy over the provisions in the houses adjoining, and even extended to the neighbouring villages. It came on only in particular states of the atmosphere, and vanished when these conditions changed. Warmth and dampness favoured it; and a tendency to putridity, without actual putrescence, in the substances in which it appeared, seemed necessary for its production.

It occurred more or less for several successive years, between 1819 and 1824, when the account was published from which the preceding particulars have been extracted. The substances upon which the red spots appeared were the flesh of warm as well as cold-blooded animals, flour, bread, biscuit, slices of ripe pears, rice, &c. This parasitical substance seemed from its effects on animals to be poisonous. Sette, Mem. Stor. Nat. Venezia, 1824.

Dr Fresesius, in his Beitrage zur Mycologie, Frankfort, 1852, alludes to these red spots, which Ehrenberg attributes to an animalcule (Monas prodigiosa); Montagne to algæ of the genus Palmella, and a late writer in the Gardener's Chronicle, to a fungus allied to that found in yeast (Torula cerevisiæ).

† See Greville, in vol. iv. of Wern. Soc. Trans. "It is not uncommon for confirmed drunkards to preserve their urine, as a precious liquor, against a scarcity of the fungus. This intoxicating property of the urine is capable of being propagated; for every one who partakes of it has his urine similarly affected. Thus with a very few Amanitæ a party of drunkards may keep up their debauch for a week. Dr Langsdorff mentions, that by means of the second person taking the urine of the first, the third that of the second, and so on, the intoxication may be propagated through five individuals."

they partake, possesses, of passing through the system, and being eliminated by the kidneys unimpaired.

Had it been an inorganic principle, we should be less inclined to wonder at its thus escaping decomposition; but for an organic product to pass unchanged through the organism of four or five individuals, and to appear unchanged in the urine of each, could hardly have been anticipated, from the comparatively feeble affinities by which organic products are in general held together. Perhaps, however, the fact of the excretions of insects containing the virtues of the plants on which they feed, as is the case with the honey of bees, presents a certain analogy.

There is also such a difference in the habitudes, localities, and properties of fungi, that we might the more readily conceive epidemics, as distinct from each other in character as cholera, typhus, scarlatina, hooping-cough, and plague, all to spring from one or other of their various tribes.

Every kind of vegetable, indeed, has its distinct fungus, some, as the ergot of rye, possessed of properties which render them noxious to the animals that feed upon them. Thus the mould which fastens upon flour, and infects our bread, is different from that which forms upon our dried conserves, or which communicates a peculiar colour and flavour to our cheese.

Hence, if fungi be the cause of epidemics, we may readily understand why, for the most part, an infectious disease is confined to one species of animal; why, for instance, the murrain of cattle does not attack the human race, or the cholera spread to inferior animals, although, as the same constitution of the atmosphere may be supposed to favour the propagation of one species of fungus as well as of another, it happens, that epizootics often precede the breaking out of epidemics in man; as, indeed, old Homer himself has recorded—

"ουρηας μεν πρωτον επωχετο, και κυνας αργους."

Even in the diseased parts of animals, peculiar fungi are apt to spring up; and one species, if not the cause, is at least the constant accompaniment of scald-head, *Porrigo capitis.*

It is curious, too, that the fungus belonging to one disease is not the same as that which characterises another. The fungus of Porrigo (scald-head) is stated to be distinct from that of Pityriasis, or Dandriff; and Sarcina,* which is now so commonly found ejected from the stomach in water-brash, and existing in the lungs during a state of disease, is likewise a fungus of a peculiar kind.

Even in the intestines and stomachs of certain insects, the microscope has lately detected certain peculiar fungi.†

The diseases engendered by this class of plants are very various, sometimes acting upon the stomach and intestines, and producing symptoms analogous to cholera;‡ sometimes upon the cerebral organs, causing mania, narcotism, or delirium;§ sometimes on the extremities, giving rise to mortification and gangrene.‖

In short, the effects produced by those fungi which are known to us vary in such a degree, that we might be prepared from analogy to expect corresponding differences in those resulting from the more minuter ones to which we ascribe epidemics.

There seems also to be a remarkable difference between the poison of fungi and that of other noxious vegetables, which, if it should be substantiated by further investigations, might serve to reconcile the fungus theory of epidemics here proposed, with that of ferments, which Liebig has advocated.

In almost every other case, it may be observed, the poisonous properties of plants are traceable to some peculiar principle, generally speaking of an alkaline nature. Morphine, strychnine, narcotine, and brucine, present us with familiar examples of this fact.

But none such are recognised in fungi; for although a Frenchman, M. Letellier, some years ago announced, that there is a volatile acrid principle in certain poisonous fungi, and likewise a brown crystallizable solid, called *amanitin*, to

* See Dr Bence Jones, Transactions of the Pathological Society; Dr Bennett, Lectures on Clinical Medicine; and Queckett's Lectures on Histology, &c., p. 21.

† See Microscopic Society's Journal, "On a Flora and Fauna within Living Animals;" extracted from Smithsonian Contributions to Knowledge.

‡ See Christison on Poisons. § Namely, Amanita muscaria.

‖ Namely, the ergot of rye.

which he also ascribed noxious qualities, no chemist of authority appears to have isolated those products, or to have verified the experiments from which his conclusions were deduced.

Judging, therefore, from the present state of our knowledge, it would rather seem, as if poisonous fungi may act as ferments when introduced into the system, and thus set up a series of changes in the vital fluids which are incompatible with life.

This will explain the circumstance, otherwise incomprehensible, why the same fungus which operates as a poison upon one person does not affect another; and why certain nations, as the Russians, either from national want of susceptibility or from habit, use as articles of food several kinds of mushrooms which are rejected by us as poisonous. The analogy of this to the case of epidemics is obvious enough.

They also are equally capricious in their operation, and produce effects entirely incommensurate to the minuteness of the quantity of them imbibed. It is not, indeed, necessary to account for this by supposing them to act as ferments, for the property of reproduction, which we must in any case ascribe to the poisonous principles which give rise to these effects, might account for the malignity of the result proceeding from a cause originally so insignificant; but at any rate, the fact is quite in harmony with the process which takes place during fermentation, where the minutest quantity introduced into a fluid susceptible of change is sufficient to operate upon the entire mass.

Dr Prout, at the time of the first visitation of cholera, had made an observation, which, although not yet confirmed by other independent authority, deserves some attention, from the known caution and accuracy which distinguished the investigations of that eminent philosopher. He found, it appears, the lower strata of the atmosphere of greater specific gravity than usual, over the spots where cholera prevailed.

The fact is not easily reconciled with any hypothesis, but it agrees at least as well with the fungus theory as with the rest, since the extraneous principle, which must be supposed to have thus added to the weight of the air, may just as probably be supposed to consist of the spores of innumerable fungi.

as of any other subtle matter which might have produced the disease.

The peculiar odour also which some persons are sensible of on entering a locality infected with cholera, may possibly be connected with the presence of some principle in the atmosphere by which its specific gravity becomes augmented.

Such, then, are some of the circumstances which seem to lend probability to the fungus theory of epidemics. In adopting it, we are not obliged to suppose the fungi in question to be such as could be detected by actual observation. From their introducing themselves into the most subtle textures of the body, incorporating themselves in the blood, and being taken up by the capillaries, it is probable that their minuteness transcends the utmost power of our instruments, and it is not impossible that they may, on this account, ever escape detection.

The spores indeed of a Lycoperdon of large size, the *Reticularia maxima*, are so numerous, that Fries calculated more than 10,000,000 to be present in a single individual, so that their minuteness and levity may be readily imagined.

Bauer indeed estimated that 7,840,000, not of the sporules, but of the individual plants themselves, belonging to the common smut, the *Uredo segetum*, would be required to cover a square inch, so that no difficulty need be entertained in imagining their ready introduction into the vessels of animals. Fries has even compared their relative magnitude to that of the globules of chyle and of the blood in the human subject, and declares that he has seen sporules, which were two-thirds of the size of the former, and one-third that of the latter. But Dr Mitchell contends that they are still smaller than this; for he remarks, that when blood globules, and the spores of various minute fungi, mixed together, were placed under the field of the microscope, the latter appeared at least ten times smaller.

Thus, from their extreme lightness, they may be wafted by atmospheric currents in every conceivable direction, and evaporation, electricity, and other meteorological changes may be concerned in their distribution. If, therefore any of these spores, or of the fungi themselves, possessing such extreme minuteness, were gifted with poisonous properties, or were capable, in the manner of a ferment, of exciting morbid actions in the system, their circulation, through the atmosphere of infected places, or their transmission unperceived from individual to individual, might account for the prevalence of an epidemic at a particular time and place. Hence the discredit which has been thrown upon the observations of Messrs Swayne and Britton of Bristol, who, during the former visitation of cholera in 1849, believed that they had discovered certain specific kinds of fungi in the excretions of cholera patients, and in infected places, no wise affects the conclusions, to which we may on theoretical grounds be led, with regard to the fact of fungi of such minuteness as to find admittance into the blood and the capillaries, giving rise to the symptoms of cholera.

The question as regards the latter still remains as before; for it is evident, that the bodies observed by the Bristol surgeons, had they really been peculiar to choleroid patients, could not have been the same with those which our theory suggests.

These researches, as well as the corresponding ones of Dr Budd at Bristol, tend at least to point out the abundance of the lower tribes of organisms in infected localities; nor ought I to pass over the ingenious method they adopted of arresting these minute bodies, when present in the atmosphere, by means of a funnel closed at bottom, and filled with a freezing mixture —a much better contrivance than that more recently put in practice by an anonymous correspondent of the *Times*, who, under the name of *Investigator*, professes to have done the same thing during the late visitation of cholera.

With respect to endemic diseases, to which Dr Mitchell, the most able supporter of the above hypothesis, would extend the same explanation, the difficulties in the way of its application are rather greater, since it is evident, that the germs of disease in this case do not possess the same power of reproduction and of transference from place to place, which must be predicated of those belonging to the class of epidemics.

Whether this difficulty might be got over, by supposing that some fungi are confined to particular localities, and others capable of almost universal distribution, it might occupy too much time at present to discuss. I will only just allude to one circumstance in favour of the application of the fungus theory to the case of endemic diseases, namely, that the apparently capricious manner in which fungi are distributed, or rather, I should say, the apparent preference of certain species for particular places, and their absence from others, may explain the healthiness of countries, where the same conditions of heat, humidity, and decomposing organic matter exist, which are supposed to engender intermittent and remittent fevers in other localities.

Singapore, for instance, is healthy, in spite of the marshes and jungles which surround it.

In the Brazils, where a humid climate coexists with a tropical heat, where the vegetation is most luxuriant, the people uncleanly, and the drainage neglected, endemic diseases are rare, and the principal ravages of this kind experienced are due to fevers lately imported from abroad.

The Cape of Good Hope may owe its exemption to its dry atmosphere, yet the driest parts of Spain during the Peninsular war affected our soldiers with intermittent fever.

Australia is in general noted for its salubrity, and yet it is by no means free from swamps or other supposed characteristics of a malarious climate.

The fungus theory may relieve us in some measure from the difficulty of explaining these cases of anomaly; but it must be confessed, that it would be established on a firmer foundation, if it could be shown, that the more salubrious countries alluded to were actually less propitious to the growth of fungi, than the unhealthy ones.

Dismissing therefore the question concerning endemic diseases, let us confine ourselves to the particular case of the cholera, and see how far its more remarkable phenomena are referable to the development of a particular tribe of minute but noxious fungi.

That cholera is a disease of Asiatic origin; that it was unknown in Europe till about the year 1830;* that its

* The distinct manner in which the cholera has been traced from the East, is a significant fact in the history of epidemics. It removes every doubt which might have been previously entertained as to these diseases having a local origin, of being propagated in some way or other from the source which first gave birth to them.

There can be no doubt, that the same is the case with other epidemics, al-progress thither might be traced from step to step along the great lines of traffic, and nowhere else; that so far from being wafted by the atmosphere, it often travelled exactly in the teeth of the prevailing winds; that when it passed from a continent to an island, it always first lighted upon the coasts, and appeared at sea-ports which were in communication with infected localities abroad, are truths which, I believe, cannot well be disputed.

On the other hand, it seems equally well ascertained, firstly, that whatever may be the amount of danger incurred by the attendants on those smitten with cholera, that danger is not sensibly increased by contact with the sick; secondly, that provided the apartment be well ventilated, and scrupulous care employed in removing all the excretions of the patient, and every other kind of impurity, the atmosphere in that locality will not be more highly charged with the noxious principle than the rest of the adjoining neighbourhood; and, thirdly, as might be inferred from the previous facts, that one or more cholera patients removed to a pure and previously uninfected locality, if due provision be made, by ventilation and cleanliness, against any accumulation of noxious emanations taking place from their bodies, need not infect the atmosphere around them in a degree which can be dangerous to the attendants or to the neighbourhood in general.

Amongst the modes by which the cholera poison is disseminated, one of the most frequent perhaps is the water used for drinking. Pure water, so far as we know, is not capable of receiving or generating the infectious principle of cholera, but *impure* water seems to be one of the readiest means of conveying it into the system. There is a curious illustration of this fact in the comparative exemption from cholera which was enjoyed by the parts of London supplied with pure water, during the epidemic of 1849. It appeared, that whilst in the dis-

though they have existed amongst us so long that their origin is veiled in obscurity; and hence the notion of these diseases starting up spontaneously in consequence of a peculiar state, electrical or otherwise, of the atmosphere, must be abandoned. The latter, no doubt in common with other circumstances peculiar to the infected locality, supply the conditions which are necessary for the development f the malady, but we must in every case suppose the poison itself to be something distinct and independent of them.

trict supplied with water by the Lambeth, Chelsea, and Southwark Companies, the mortality was 123 in 10,000, that in the districts supplied by the New River, East London, and Kent Companies, was 48 ; and in those supplied by the Grand Junction and Middlesex, only 15. Now the Lambeth, Chelsea, and Southwark Companies obtained their water from the Thames, between Battersea and Waterloo Bridge ; the New River, East London, and Kent Companies from the Lea and the Ravensbourne ; the Grand Junction and the West Middlesex both from the Thames, but the former as high up as Kew, the latter at Barnes.

Now mark the proportion of deaths during the late epidemic, in the six weeks prior to October 7th of the present year. It is stated from official returns in the *Medical Times*,* that in the population supplied by the Southwark Company, the mortality was 85 to 10,000 inhabitants ; in those which obtained their water from the Kent Company, only 19 ; whilst in the case of those furnished by the Lambeth Company, where the mortality in 1849 was no less than 123, it now was only 17. But this comparative exemption is accounted for by the circumstance, that, whereas in 1849 this company was supplied from the river at Lambeth itself, it now draws its consumption from the Thames at Thames Ditton. No facts would seem more conclusive than these with respect to the unwholesomeness of water obtained from a river polluted with animal impurities.

It is true that Mr Hassell, in his microscopic examination of the water supplied to London, condemns all the water companies alike, exhibiting in his plates a formidable display of animalcules, derived from every one of them.

But I have already remarked, that the presence of animalcules does not necessarily render water unwholesome ; and with respect to the amount of sewage, or of dead animal matter, there can be no doubt that there must be a great difference between water brought from the Thames near London itself, and from spots several miles higher up.

It may be remarked as a curious fact, that in one of the infected parts of France, which I visited in autumn 1854, the peasants had taken up the idea that the disease was caused by

* October 21.

poison introduced into the wells of the country, just as was supposed, during the great plague of the fifteenth century, described by Hecker, under the name of the Black Death, when so many Jews, and even Christians, were put to cruel deaths, on suspicion of having been guilty of this crime.

On one occasion, I even found that suspicion had fallen upon myself, as having come into the country with this diabolical intention, though, as I was not personally molested, it may be supposed to be confined only to a few of the most ignorant of the peasants.

Every popular delusion, however, has some basis of truth; and it is quite possible, that persons flying from the infected districts of the south may have brought the seeds of cholera into the mountains in which they took refuge, and that the infecting principle may have thus found its way into the wells of the country, and through their medium have disseminated the poison.

It was probably owing to the little watering place of Vals in the Vivarais having been the resort of families from Nismes and Avignon, where cholera was raging, that the same disease broke out last August in that remote village; where it raged with such fury, that in a few days it carried off more than forty persons out of that small population, including the Curé and one of the medical attendants.

These facts, if they militate against the doctrine of contagion in the strict and technical sense of the term, indicate at least, that the disease is propagated through the medium of individuals, and not in some mysterious manner, through the atmosphere, irrespective of human interference.

Those, however, who, in their zeal to dispel the exaggerated fears often entertained of contracting the malady, maintain the non-contagious nature of cholera, have often jumped to the conclusion, that the disease, because, as they think, it cannot be called strictly contagious, is therefore not transmissible, except through the atmosphere.

A *dictum* like this, which is sure to be contradicted by experience, can only damage the authority on which it rests; and it is far better, not only for the interests of truth, but also for the purpose of moderating the excessive fears which an epidemic is liable to occasion, that the real amount of risk arising from the presence of the sick should be fairly defined. Equally illogical is the reasoning often employed, that because the propagation of cholera does not follow the same laws as those which the phenomena of some long-known epidemic, such as smallpox or plague, have rendered us familiar with, and taught us to regard as the type of epidemics in general, therefore the disease itself is to be placed under a totally distinct category, and not to be regarded as being, like these, transmissible by the sick.

It is quite conceivable, that fungi of one kind may be less diffusible, and therefore chiefly transmitted by contact; those of another most dangerous or most abundant when derived from animal filth, or from an infected atmosphere; but no one ought on that account to doubt that the primary source of the poison is to be traced to the human frame, from whence it may be transmitted to the atmosphere, and being absorbed by fomites, may thus undergo a rapid multiplication. Now, if this be the case, although it is reasonable to expect that the most frequent causes of infection should be traceable to the two latter causes; there can be no ground for disputing the possibility of its being occasionally transmitted by human contact, or for refusing credence to the positive testimony that may be offered that such has been the case.

In enabling us, then, to estimate, with somewhat greater precision, the degree of danger which the prevalence of cholera entails upon the neighbourhood, and the real sources from whence the danger proceeds, our fungus theory may, I conceive, be regarded, even by those who refuse to adopt it as a guide, useful, in affording a ready illustration at least of the mode in which the disease is liable to become formidable.

I have already called attention to the fact of the extraordinary rapidity with which certain fungi, when they find the conditions favourable to their development, go on multiplying their cells.

The *Bovista giganteum* in a single night has been known to spring up from a few merely perceptible cells to the size of a large gourd, estimated to contain 4,700,000,000 cells. The spores from a few such plants would overspread the globe, were they not limited by the want of those conditions which are necessary for their growth.

That the pabulum which fungi require is soon exhausted, and cannot be quickly renewed, is evidenced by the phenomena of *fairy rings*, caused by *fungi*, which, like the infectious principle in cholera, exhaust the ground where they had grown, and consequently only extend outwards from the point where they had first established themselves.

As all fungi contain *azote*, their proper pabulum is animal matter in a decomposing condition : hence, although the spores of indigenous fungi must be floating about perpetually in the atmosphere of the places where they abound, they only fasten themselves upon spots where azotized matter exists, and can be prevented from getting a footing wherever the latter is carefully removed. Does not the same hold good with respect to our prevailing epidemics, and especially cholera ; and ought not this consideration to disarm it of much of its terrors, by showing that its propagation is in a great measure under our own control, and may be prevented by a scrupulous care in removing from the neighbourhood of the infected locality all those animal exuviæ which act as a *fomes* of infection, by attracting to themselves the spores of the fungi floating about, and by favouring their multiplication.

The fungus theory may also serve to obviate the force of the objections which are sometimes alleged, and still more frequently, it may be feared, entertained, against the use of sanitary regulations, from the circumstance that the greatest degree of filth may often be allowed to accumulate without producing an epidemic.

If our theory be correct, animal impurities, although they cannot but be more or less injurious to health at all times during the process of their decay, are not themselves the *cause* of epidemics, but only afford a suitable *nidus* to the spores of these fungi, which are conveyed from place to place by human agency, whenever an epidemic disorder happens to be raging. Even then, it does not necessarily follow, that the epidemic will break out exactly in the places most charged with filth ; for the habits of ordinary fungi convince us, that there is something apparently capricious in their distribution, or to speak more philosophically, that some only of the conditions upon which their multiplication depends are at present known, so that their appearance or disappearance can never be with confidence predicted. Hence we may be prepared by analogy to expect, that the disease might declare itself in one part of a city, or even on one side of a building, without any assignable reason, whilst it avoided others which seemed equally obnoxious; and likewise why it should fasten itself upon a particular individual, leaving others, under apparently similar conditions, untouched. Circumstances of this kind might be seized upon by a captious disputant, whose only object was to demolish his opponent's argument, but they can hardly be permitted to influence our decision on a great practical question, which must be determined by a general review of all the phenomena, and proceed upon something less than demonstrative evidence.

It seems sufficient for this purpose to know, that whatever local exemptions may here and there exist, and however unprepared we may be, in the present state of our knowledge, to explain their causes upon the principles laid down, still, that whilst on the one hand, epidemic cholera never breaks out except in spots where human beings are closely congregated, its propagation on the other hand may in general be rendered more or less difficult, in proportion to the care bestowed in removing every kind of decomposing organic matter—all bodies capable of absorbing animal effluvia, such as rags, clothes, dust, &c.—everything, in short, of an azotized nature which can serve as a *nidus* of infection; just as moulds and other fungous growths may be prevented from springing up, by removing all those conditions which experience has shewn to be favourable to their growth. Nor must we forget the remarkable experiment of Faraday, which shows with what facility organic matter will cling to any earthy pulverulent substance with which it comes into contact. Faraday found, that sea-sand carefully washed and heated to redness, if it afterwards was merely touched by the finger, emitted, in consequence, ammonia. Now, azotized organic matter, as we have seen, is the proper *nidus* of those noxious miasmata which are the cause of epidemics. Can we wonder, therefore, that the infection of scarlatina should, in some cases be known to adhere for years to the walls of an apartment which has contained the sick; or that hospital gangrene, as in the Oxford Infirmary some years ago, should be present in a particular ward of an hospital for many months, so as to attack every patient afflicted with sores or wounds that happened to be placed in it.

And here too an analogy with the growth of fungi presents itself. How often is it found, that moulds once engendered in a building will adhere so tenaciously to it, that they can only with the greatest difficulty be eradicated. In bakehouses the flour has been known to become, from this cause, so constantly ropy, that it has been necessary, in some cases, to remove the establishment to a fresh locality.

It has been suggested, with some plausibility, that the leprosy on walls and garments alluded to in Leviticus was a fungous growth, which infected these bodies, and which was found capable of spreading to man and other animals, so as to produce in them contagious disorders.

With these facts before us, whilst both theory and experience point in the same direction to the proper modes of preventing the spread of cholera, is it not surprising that the people of England, after having suffered from two visitations of this epidemic, should not have anticipated the invasion of a third, by adopting universally such sanitary measures, as would remove from their doors, if not the only, at least the most productive causes of infection of which we are cognisant? Would it not have been supposed, for example, that the inhabitants of Oxford, when their attention had been called, as was the case some years ago, to the fact, that a portion of the filth of their city was directed into a part of the river which lay immediately under their most public thoroughfare, and which, during the droughts of summer, was often nearly destitute of water, should have turned the sewage in a different direction, instead of resolving, as was the case, that the accumulated filth of nearly half the town should in future be poured out through the same channel, and be discharged into the same general repository, to offend the sight and smell of every passer-by?

Who can wonder that the result of this procedure has been to render the atmosphere round about Magdalen Bridge tainted and unwholesome during the late summer, to deter visitors from approaching that side of the Botanic Garden which borders upon the river, and to empty the adjacent college of most of its inmates for the greater part of the vacation?

Nor are our parochial clergy, I conceive, altogether exempt from censure on similar grounds. I have been told at least of cases of burials even in the most crowded grave-yards of the city, which have taken place within a recent period; a concession to the prejudices of individuals, which, if there be any truth in the principles I have laid down, can only be admitted at some risk to the general interests of society.

Even granting, however, that these interments were confined to corpses inclosed in lead, and deposited in vaults, the practice, so far as regards the security of the living, seems to me little less objectionable than where the commoner mode of burial is resorted to.

The gaseous products which are exhaled during the ordinary course of putrefaction cannot be confined by any leaden covering; and, indeed, this fact is so notorious, that in order to prevent the bursting of the shell, some undertakers are in the habit of boring holes in it, to allow of the disengagement of the volatile products. Now, as these latter are the sole vehicles of the poison, it would seem better to allow them to be absorbed, as they are disengaged, by the soil of the church-yard, rather than that they should first accumulate in the vault, and then escape by fits through cracks into the open air.

If, therefore, there be any truth in the opinion entertained as to the noxious properties of the gases exhaled during the process of animal putrefaction, if the effluvia which emanate from them are capable of becoming the vehicles of any infectious principle, whether proceeding from fungi or otherwise, which may have been carried to the grave, the practice of burying within towns, or indeed anywhere within a church, ought, I would submit, altogether to be abandoned.

Should the wholesome fear engendered by the awful malady with which we have recently been visited prove the means of putting a stop at once and for ever to a practice which is not only pernicious, but which, if we were not habituated to it by long usage, would be regarded here, as it is in other countries, disgusting and repulsive; should it enforce a more thorough system of drainage, and a more complete removal of noxious impurities; should it induce a greater attention to the comforts of the poor, and to the healthy condition of their dwelling houses—then, indeed, the designs of Providence in inflicting upon us such a scourge will no longer be involved in mystery, since it will be seen, that permanent good, both moral and physical, has resulted from a local and temporary evil; inasmuch as the exertions made to ward off the invasion of a foreign pestilence have not only succeeded in disarming at the same time of their malignity those domestic foes which are always hovering about us, in the shape of typhus and scarlatina; but have likewise promoted in an eminent degree the general well-being of society, by affording to our poorer brethren the means of breathing in their dwellings a purer and a healthier atmosphere, and of cultivating amongst themselves habits of greater cleanliness and propriety.

Contributions to Ornithology by Sir William Jardine, Bart. I. *Professor W. Jameson's Collections from the Eastern Cordillera of Ecuador.*

William Jameson has been many years resident in Quito; indeed it is his adopted residence, and he holds the professorship of Natural History in the university of that city, as well as an official appointment in the administration of the mint. He has allowed few opportunities to escape of attending to the natural productions of the country around Quito and the elevated ranges of the Andes. Botany was his favourite pursuit, and to him the early numbers of Sir William Hooker's *Icones Plantarum* were indebted for many of the new and remarkable species described. Some years since we requested him to give his attention to the ornithology of those regions, and various collections have been at different times received, collected chiefly in the proximity of the snow line. These contained several new and interesting species, most of which have been described and figured in the *Contributions to Ornithology*. The small collection last received was from a lower station, in a direction not so frequently visited, and contains some species yet very rare in the collections of this country, with one or two which are apparently entirely new; and the letters that accompany them contain some short but interesting notes on their habits.

Professor W. Jameson was in the custom of making excursions to Pichincha, and to the lower forest regions; and during the past year he made one or two expeditions of some duration to the latter, chiefly with the view of making up sets of the plants which he had engaged to do for some parties in France, and for the Parisian museum.

One set of these plants has been procured for the Herbarium of the University of Edinburgh, and the following extracts from his correspondence give some account of the expedition on which they were collected. These letters were not written with any view to publication, but they are interesting in connection with the plants, and with the ornithological collections which were made at the same time. The wooded region of the eastern Cordillera is exceedingly rich in some groups of birds, but these, at the same time, are very local, as much so as the plants; and indeed, they are dependent upon the latter, certain species of birds living among and feeding on the flowers, seeds and fruits of certain species of trees or shrubs, and appearing only when the flowers are open or the fruit ripe. This is particularly the case with some species of humming-birds, which flock in crowds to certain trees or plants when in flower. *Thalurania verticeps* is one example; *Oretrochilus Jamesoni* frequents the *Chuquiraga insignis;* and the beautiful *Trochilus Stanleyi* is only seen on the elevated Andes when the brilliant blossoms of the *Sida pichinchensis* are expanded. The extracts from the letters alluded to in regard to the expeditions are as follow:—

QUITO, 19*th April* 1854.

"———————— My intention was to have descended the western slope of Pichincha, through the forest as far as Mindo (3926 feet), but having traversed more than half the distance on foot, through a narrow path, more like a water-course than anything else, I was all at once brought to a stand by a deep pool, which, had I attempted to cross, would have effectually ruined my collection of plants by wetting the paper in which I intended to place them; and as the evening was approaching when I encountered this obstacle, I had no alternative but to construct a temporary shed, covering the roof with the largest leaves I could find. By the time this was finished it was almost dark, and as everything was completely deluged by the rain that had fallen in torrents during the afternoon, I experienced a vast deal of difficulty in lighting a fire. Having passed the night rather uncomfortably, I thought it advisable to return from this point; more particularly as I had previously secured some interesting plants which I had not seen on any former occasion.

"The vegetation, *en route*, is exceedingly interesting. The descent commences at Pichau (12,986 feet). Here the forest trees are principally *Melastomaceæ*, *Osteomeles ferruginea*, *Escallonia myrtilloides*, two species of *Buddlea* and *Solanum*. Of shrubs, *Fuchsia triphylla*, *Valeriana*, and many others; of herbaceous plants, *Gentiana Jamesoni* (its only known habitat); a large stinging *Loasa;* a gigantic *Draba;* several *Calceolariæ; Ranunculus*, two species. There are no epiphytal *Orchideæ*, and the only plant of that family observed was the curious *Altensteinia paleacea*. A little farther down we have *Columellia sericea*, *Eupatorium glutinosum; Loranthus*, two species; *Polylepis*, and several arborescent Compositæ. Two very handsome climbers are occasionally found, the one a *Tacsonia*, and the other *Eccremocarpus longiflorus;* of the former I found a beautiful nondescript species, with a remarkably large flower; and no less than five species of *Fuchsia*."

Quito, 23*d August* 1854.

"————Next to the gratification derived from books, nothing delights me so much as an expedition into these vast forests, and I do most positively assure you that no danger whatever attends these explorations. All is achieved at the expense of a little personal fatigue, from which one recovers after a good night's rest on the bare ground under a temporary shed covered with a few large leaves. There are no human inhabitants in those places, and I therefore take with me three or four Indians loaded with the necessary articles of provisions. We all travel on foot, cutting our way through the forest, and when we find a suitable place, we in less than an hour construct a hut or shed, under which we pass the night. A few of the fronds of the tree-fern placed one above another make a tolerable bed."

QUITO, 22*d November* 1854.

"Your very kind letter of the 31st August arrived in this city during my absence on a long but very agreeable journey, in which I was accompanied by several young friends. Our object was to make an exploration of the forest on the eastern slope of the Cordillera. We advanced as far north as a village named Guaca, where the eastern chain is comparatively low. Four days are required to reach this point, travelling on good horses, and crossing two remarkably deep valleys, at the bottom of which are extensive plantations of sugar-cane. A little beyond the village just named, we turned to the right and ascended the eastern Cordillera, whose elevation might be about 14,000 feet. On the top we found abundance of *Espeletia*, a remarkable plant of the order Compositæ; it does not grow on any of the snowy mountains near Quito, but its place is supplied by another alpine plant no less singular, the *Culcitium rufescens*. Both are thickly clothed with wool, and make a good bed to one who happens to be benighted in these elevated regions. Here we had to send back our horses and proceed on foot, for the descent on the opposite side became all at once so remarkably steep as to seem nearly impracticable, but for a forest of stunted trees (chiefly *Escallonias*), which made it by no means a difficult task. Our progress downward was necessarily slow, but the delay afforded me sufficient time to collect many curious epiphytal *Orchideæ*. It took us about three hours to reach the bottom, probably about as many thousand feet below the point from which we started. I am inclined to think so by meeting with a plantation of *Carica* with ripe fruit, a tree which will scarcely grow above the level of Quito. We slept in a hovel inhabited by a family of Indians and guinea pigs. The latter are used as an article of food.

"This being the last inhabited spot, we had recourse to the compass to direct us, cutting notches in the trees, for the benefit of those of our party who should fall behind. We were in all seventeen. Each day's journey usually terminated about two or three in the afternoon, thus leaving us sufficient time to construct for the night a sort of open shed, covered with the leaves of a species of *Arum*, to exclude the rain. We spent nine days wandering in the forest, and I do assure you, never felt more happy, or enjoyed better health. It is much more agreeable than my actual position at this moment superintending the assaying operations of the mint, and I cannot even finish my narrative without being subjected to interruptions. Altogether I made a good collection of plants, and there are probably some new species."

The ornithological collection received from the last expedition was not extensive; at the same time several of the specimens are interesting from their locality upon the Eastern Cordillera, where the greatest part were obtained.

Buteo erythronotus, King. "The elevated table-lands of the eastern Cordillera." A very beautiful species, remarkable for its seasonal changes. In consequence, it has been subject to a long synonymy, and has been confounded with the *Buteo pterocles* (Temm.), from which, however, it is very easily distinguished by its much shorter wings. The adult bird is entirely gray above, with the under parts white. Previous to assuming that plumage, it has the back and scapulars of a brownish-sienna, in which state it is the *B. tricolor*, D'Orbigny, and the *Haliaëtus erythronotus*, King; while the first or young plumage is entirely dull black, in which state it is the *B. unicolor*, D'Orbigny. This species has a very extensive American range. Specimens are recorded from the Straits of Magellan, Chiloe, Falkland Islands, Bolivia, Chili, Brazil, Mexico, Ecuador, and now from the table-lands of the eastern Cordillera.

Trogon personatus, Gould. "Inhabits the temperate regions between 7000 and 9000 feet above the sea-level. It prefers dark, shady woods, well watered, and subsists on various fruits which abound in such localities. The specimens are prepared at the cost of a great deal of trouble, from the circumstance of the skin being as delicate as moistened paper; and the feathers are so easily detached, that when the bird is fired at with the finest shot, they fly out in all directions. The only way to procure good specimens is by killing them with the blowpipe."

Trogon pavoninus, Spix. "Inhabits the forests on the western slope of the Andes, 6000 feet above the Pacific."

Rupicola peruviana. "*Cuchi-pischo* of the Indians, meaning '*Hog-bird*,' from its note resembling somewhat the grunting of a pig, by which its proximity is easily ascertained. All that I could observe respecting their habits is, that they go in pairs, and when disturbed they are almost incessantly in motion, flying from one tree to another, and not remaining on the same tree for more than two or three seconds. They inhabit the dense forests towards the base of the Andes, both on the eastern and western slopes. On the western side, or that fronting the Pacific, they do not ascend above 4000 feet."

It is in these forests also, that we have several species of Euphonia and the beautiful genus Calliste, which have of late years been described as new, and which are still of considerable rarity, *Calliste phœnicotis, lunulata, ruficervix*, &c. were sent.

Euphonia nigricollis was obtained in the valley of Chillo, 1500 feet below the level of Quito. Its food consists of the seeds of various species of *Solanum, Physalis*, &c.

Upon the eastern Cordillera, visited in the last excursions, several species of true *Tanagra*, that beautiful group of which *T. episcopalis* and its allies are typical, and which will include *T. dubusia, flavinucha*, &c., were collected. *T. lunulata*, D'Orbig., is not uncommon here. A single specimen of a species still very rare in collections, the locality of which is given widely, as "Peru," was also received, *T. sumptuosa* (*Tachyphonus sumptuosus*, Lafresn.), and there is a skin of another fine species allied to those, having the colouring and markings of the last, which appears entirely new.

Tanagara notabilis, Jard. N. S.

Above, yellowish-green; head, cheeks, sides of the neck and chin, black; on the occiput a triangular spot of orange-yellow; remiges, greater wing-covers and tail, black; great wing-covers broadly edged with blue. *Below*, rich orange-yellow. Length 7·4. Wing 3·7.

Hab. Eastern Cordillera Ecuador, W. Jameson.

Another Tanagrine bird of a different form, which appears equally new, was also received from the same locality. It is of considerable interest as combining the form of *Saltator* with the colouring and markings of *Arremon*, and clearly indicates that the former genus should form part of the Tanagers. The bill exhibits a slight undulation on the edges of the mandible, representing the Tooth in *Lanio*. By some, these combinations would be sufficient on which to found a new generic name; we prefer, however, retaining it as a *Saltator*.

Saltator arremonops, Jard. N. S.

Above, brownish-sienna; head, cheeks and neck, black; along the centre of the crown and over each eye, a broad streak of gray, extending to the nape; wings and tail brownish-black. *Below*, chin black, throat and breast sienna, shading to brown on flanks and under tail-covers; middle of the belly and the vent gray. Bill and legs black. Length 7. Wing 3.

Hab. Eastern Cordillera Ecuador, W. Jameson.

Grallaria ruficapilla, Lafresn.

Triothorus unibrunnea (Linnornis unibrunnea), Lafresn. easily distinguished from the Bogota bird. "Inhabits the temperate regions, and has a note equal to that of the nightingale."

Anabates flamulatus, Eyton, previously known from Bogota, and *Caprimulgus bifasciatus*, also extend their range to these localities.

Outlines of the Science of Energetics. By WILLIAM JOHN MACQUORN RANKINE, Civil Engineer, F.R.SS. London and Edinburgh, &c.*

1. *What constitutes a Physical Theory.*

An essential distinction exists between two stages in the process of advancing our knowledge of the laws of physical phenomena; the first stage consists in observing the relations of phenomena, whether of such as occur in the ordinary course of nature, or of such as are artificially produced in experimental investigations, and in expressing the relations so observed by propositions called formal laws. The second stage consists in reducing the formal laws of an entire class of phenomena to the form of a science; that is to say, in discovering the most simple system of principles, from which all the formal laws of the class of phenomena can be deduced as consequences.

Such a system of principles, with its consequences methodically deduced, constitutes the PHYSICAL THEORY of a class of phenomena.

A physical theory, like an abstract science, consists of definitions and axioms as first principles, and of propositions, their consequences; but with these differences:—first, That in an abstract science, a definition assigns a name to a class of notions derived originally from observation, but not necessarily corresponding to any existing objects or real phenomena, and an axiom states a mutual relation amongst such notions, or the names denoting them; while in a physical science, a definition states properties common to a class of existing objects, or real phenomena, and a physical axiom states a general law as to the relations of phenomena; and, secondly,—That in an abstract science, the propositions first discovered are the most simple; whilst in a physical theory, the propositions first discovered are in general numerous and complex, being formal laws, the immediate results of observation and experiment, from which the definitions and axioms are subsequently arrived at by a process of reasoning differing from that whereby one

* Read to the Philosophical Society of Glasgow, 2d May 1855.

proposition is deduced from another in an abstract science, partly in being more complex and difficult, and partly in being to a certain extent *tentative*, that is to say, involving the trial of conjectural principles, and their acceptance or rejection according as their consequences are found to agree or disagree with the formal laws deduced immediately from observation and experiment.

2. *The Abstractive Method of forming a Physical Theory, distinguished from the Hypothetical Method.*

Two methods of framing a physical theory may be distinguished, characterized chiefly by the manner in which classes of phenomena are defined. They may be termed respectively the ABSTRACTIVE and the HYPOTHETICAL methods.

According to the ABSTRACTIVE method, a class of objects or phenomena is defined by describing, or otherwise making to be understood, and assigning a name or symbol to, that assemblage of properties which is common to all the objects or phenomena composing the class, as perceived by the senses, without introducing anything hypothetical.

According to the HYPOTHETICAL method, a class of objects or phenomena is defined according to a conjectural conception of their nature, as being constituted in a manner not apparent to the senses, by a modification of some other class of objects or phenomena whose laws are already known. Should the consequences of such a hypothetical definition be found to be in accordance with the results of observation and experiment, it serves as the means of deducing the laws of one class of objects or phenomena from those of another.

The conjectural conceptions involved in the hypothetical method may be distinguished into two classes, according as they are adopted as a probable representation of a state things which may really exist, though imperceptible to the senses, or merely as a convenient means of expressing the laws of phenomena; two kinds of hypotheses, of which the former may be called *objective*, and the latter *subjective*. As examples of objective hypotheses may be taken, that of vibrations or oscillations in the theory of light, and that of atoms in chemistry; as an example of a subjective hypothesis, that of magnetic fluids.

3. *The Science of Mechanics considered as an illustration of the Abstractive Method.*

The principles of the science of mechanics, the only example yet existing of a complete physical theory, are altogether formed from the data of experience by the abstractive method. The class of *objects* to which the science of mechanics relates, —viz.,—material bodies,—are defined by means of those sensible properties which they all possess, viz., the property of occupying space, and that of resisting change of motion. The two classes of *phenomena* to which the science of mechanics relates are distinguished by two words, *motion* and *force; motion* being a word denoting that which is common to the fall of heavy bodies, the flow of streams, the tides, the winds, the vibrations of sonorous bodies, the revolutions of the stars, and generally to all phenomena involving change of the portions of space occupied by bodies; and *force*, a word denoting that which is common to the mutual attractions and repulsions of bodies, distant or near, and of the parts of bodies, the mutual pressure or stress of bodies in contact, and of the parts of bodies, the muscular exertions of animals, and, generally, to all phenomena tending to produce or to prevent motion.

The laws of the composition and resolution of motions, and of the composition and resolution of forces, are expressed by propositions which are the consequences of the definitions of motion and force respectively. The laws of the relations between motion and force are the consequences of certain axioms, being the most simple and general expressions for all that has been ascertained by experience respecting those relations.

4. *Mechanical Hypotheses in various Branches of Physics.*

The fact that the theory of motions and motive forces is the only complete physical theory, has naturally led to the adoption of *mechanical hypotheses* in the theories of other branches of physics; that is to say, hypothetical definitions, in which classes of phenomena are defined conjecturally as being constituted by some kind of motion or motive force not obvious to the senses (called *molecular* motion or force) as when light and radiant heat as defined as consisting in molecular vibrations, thermometric heat, in molecular vortices, and the rigidity of solids, in molecular attractions and repulsions.

The hypothetical motions and forces are sometimes ascribed to *hypothetical bodies*, such as the luminiferous aether ; sometimes to *hypothetical parts*, whereof tangible bodies are conjecturally defined to consist, such as atoms, atomic nuclei with elastic atmospheres, and the like.

A mechanical hypothesis is held to have fulfilled its object, when, by applying the known axioms of mechanics to the hypothetical motions and forces, results are obtained agreeing with the observed laws of the classes of phenomena under consideration, and when, by the aid of such a hypothesis, phenomena previously unobserved are predicted, and laws anticipated, it attains a high degree of probability.

A mechanical hypothesis is the better, the more extensive the range of phenomena whose laws it serves to deduce from the axioms of mechanics; and the perfection of such a hypothesis would be, if it could, by means of one connected system of suppositions, be made to form a basis for all branches of molecular physics.

5. *Advantages and Disadvantages of Hypothetical Theories.*

It is well known that certain hypothetical theories, such as the wave theory of light, have proved extremely useful, by reducing the laws of a various and complicated class of phenomena to a few simple principles, and by anticipating laws afterwards verified by observation.

Such are the results to be expected from well-framed hypotheses in every branch of physics, when used with judgment, and especially with that caution which arises from the consideration, that even those hypotheses whose consequences are most fully confirmed by experiment, never can by any amount of evidence attain that degree of certainty which belongs to observed facts.

Of mechanical hypotheses in particular, it is to be observed, that their tendency is to combine all branches of physics into one system, by making the axioms of mechanics the first principles of the laws of all phenomena; an object for the attainment of which an earnest wish was expressed by Newton.*

In the mechanical theories of elasticity, light, heat, and electricity, considerable progress has been made towards that end.

The neglect of the caution already referred to, however, has caused some hypotheses to assume, in the minds of the public generally, as well as in those of many scientific men, that authority which belongs to facts alone, and a tendency has consequently often evinced itself to explain away, or set aside, facts inconsistent with these hypotheses, which facts, rightly appreciated, would have formed the basis of true theories; thus the fact of the production of heat by friction, the basis of the true theory of heat, was long neglected, because inconsistent with the hypothesis of caloric; and the fact of the production of cold by electric currents, at certain metallic junctions, the key (as Professor William Thomson recently showed) to the true theory of the phenomena of thermo-electricity, was, from inconsistency with prevalent assumptions respecting the so-called "electric fluid," by some regarded as a thing to be explained away, and by others as a delusion.

Such are the evils which arise from the misuse of hypothesis.

6. *Advantages of an Extension of the Abstractive Method of framing Theories.*

Besides the perfecting of Mechanical Hypotheses, another and an entirely distinct method presents itself for combining the physical sciences into one system; and that is by an *extension of the* ABSTRACTIVE PROCESS in framing Theories.

The abstractive method has already been partially applied, and with success, to special branches of molecular physics, such as heat, electricity, and magnetism. We are now to consider in what manner it is to be applied to physics generally, considered as one science.

Instead of supposing the various classes of physical phenomena to be constituted in an occult way of modifications of

* Utinam cætera naturæ phænomena ex principiis mechanicis eodem argumentandi genere derivare liceret.—(*Phil. Nat. Prin. Math.; Præf.*)

motion and force, let us distinguish the properties which those classes possess in common with each other, and so define more extensive classes denoted by suitable terms. For axioms, to express the laws of those more extensive classes of phenomena, let us frame propositions comprehending as particular cases, the laws of the particular classes of phenomena comprehended under the more extensive classes. So shall we arrive at a body of principles, applicable to physical phenomena in general, and which being framed by induction from facts alone, will be free from the uncertainty which must always attach even to those mechanical hypotheses whose consequences are most fully confirmed by experiment.

This extension of the abstractive process is not proposed in order to supersede the hypothetical method of theorizing; for in almost every branch of molecular physics it may be held, that a hypothetical theory is necessary as a preliminary step to reduce the expression of the phenomena to simplicity and order, before it is possible to make any progress in framing an abstractive theory.

7. *Nature of the Science of Energetics.*

Energy, or the capacity to effect changes, is the common characteristic of the various states of matter to which the several branches of physics relate; if, then, there be general laws respecting energy, such laws must be applicable, *mutatis mutandis*, to every branch of physics, and must express a body of principles as to physical phenomena in general.

In a paper read to the Philosophical Society of Glasgow on the 5th of January 1853, a first attempt was made to investigate such principles, by defining *actual energy* and *potential energy*, and by demonstrating a general law of the mutual transformations of those kinds of energy, of which one particular case is a previously known law of the mechanical action of heat in elastic bodies, and another, a subsequently demonstrated law which forms the basis of Professor William Thomson's theory of thermo-electricity.

The object of the present paper is, to present in a more systematic form, both these and some other principles, forming part of a science whose subjects are, material bodies and physical phenomena in general, and which it is proposed to call the SCIENCE OF ENERGETICS.

8. *Definitions of certain Terms.*

The peculiar terms which will be used in treating of the Science of Energetics are purely abstract; that is to say, they are not the names of any particular object, nor of any particular phenomena, nor of any particular notions of the mind, but are names of very comprehensive *classes* of objects and phenomena. About such classes it is impossible to think or to reason, except by the aid of examples or of symbols. General terms are symbols employed for this purpose.

SUBSTANCE.

The term "substance" will be applied to all bodies, parts of bodies, and systems of bodies. The parts of a substance may be spoken of as distinct substances, and a system of substances related to each other may be spoken of as one complex substance. Strictly speaking, the term should be "*material substance*," but it is easily borne in mind, that in this essay none but material substances are referred to.

PROPERTY.

The term "*property*" will be restricted to *invariable* properties; whether such as always belong to all material substances, or such as constitute the invariable distinctions between one kind of substance and another.

MASS.

Mass means "*quantity of substance*." Masses of one kind of substance may be compared together by ascertaining the numbers of equal parts which they contain; masses of substances of different kinds are compared by means to be afterwards referred to.

ACCIDENT.

The term "*accident*" will be applied to every variable state of substances, whether consisting in a co dition of each part of a substance, how small soever, (which may be called an *absolute accident*), or in a physical relation between parts of substances, (which may be called a *relative accident*). Accidents, to be the subject of scientific inquiry, must be capable of being measured and expressed by means of quantities. The quantity, even of an absolute accident, can only be expressed by means of a mentally-conceived relation.

The whole condition or state of a substance, so far as it is variable, is a *complex accident;* the independent quantities which are at once *necessary* and *sufficient* to express completely this complex accident, are *independent accidents*. To express the same complex accident, different systems of independent accidents may be employed; but the number of independent accidents in each system will be the same.

Examples.—The variable thermic condition of an elastic fluid is a *complex accident*, capable of being completely expressed by *two independent accidents*, which may be any two out of these three quantities—the *temperature*, the *density*, the *pressure*—or any two independent functions of these quantities.

The condition of strain at a point in an elastic solid, is a *complex accident*, capable of being completely expressed by *six independent accidents*, which may be the three elongations of the dimensions, and the three distortions of the faces of a molecule originally cubical, or the lengths and directions of the axes of the ellipsoidal figure assumed by a molecule originally spherical; or any six independent functions of either of those systems of quantities.

The distinction of accidents into absolute and relative is to a certain extent arbitrary; thus, the figure and dimensions of a molecule may be regarded as absolute accidents, when it is considered as a whole, or as relative accidents, when it is considered as made up of parts. Most kinds of accidents are necessarily relative, but some kinds can only be considered as relative accidents when some hypothesis is adopted as to the occult condition of the substances which they affect, as when heat is ascribed hypothetically to molecular motions; and such suppositions are excluded from the present inquiry.

Accidents may be said to be *homogeneous* when the quantities expressing them are capable of being put together, so that the result of the combination of the different accidents shall be expressed by one quantity. The number of heterogeneous kinds of accidents is evidently indefinite.

EFFORT, OR ACTIVE ACCIDENT.

The term "*effort*" will be applied to every cause which varies, or tends to vary, an accident. This term, therefore, comprehends not merely *forces* or *pressures*, to which it is usually applied, but all causes of variation in the condition of substances.

Efforts may be homogeneous or heterogeneous.

Homogeneous efforts are compared by balancing them against each other.

An effort, being a condition of the parts of a substance, or a relation between substances, is itself an accident, and may be distinguished as an "*active accident*."

With reference to a given limited substance, *internal efforts* are those which consist in actions amongst its parts; *external efforts* those which consist in actions between the given substance and other substances.

PASSIVE ACCIDENT.

The condition which an effort tends to vary may be called a "*passive accident*," and when the word "accident" is not otherwise qualified, "passive accident" may be understood.

RADICAL ACCIDENT.

If there be a quantity such that it expresses at once the magnitude of the passive accident caused by a given effort, and the magnitude of the active accident or effort itself, let the condition denoted by that quantity be called a "*radical accident*."

[The velocity of a given mass is an example of a radical accident, for it is itself a passive accident, and also the measure of the kind of effort called accelerative force, which acting for unity of time, is capable of producing that passive accident.]

[The strength of an electric current is also a radical accident.]

EFFORT AS A MEASURE OF MASS.

Masses, whether homogeneous or heterogeneous, may be compared by means of the efforts required to produce in them variations of some particular accident. The accident conventionally employed for this purpose is *velocity*.

WORK.

"*Work*" is the variation of an accident by an effort, and is a term comprehending all phenomena in which physical change takes place. *Quantity of work* is measured by the product of the variation of the passive accident by the magnitude of the effort, when this is constant; or by the integral of the effort with respect to the passive accident, when the effort is variable.

Let x denote a passive accident,

X an effort tending to vary it.

W the work performed in increasing x from x_0 to x_1, then,

$$(1.)\quad \begin{cases} W=\int_{x_0}^{x_1} X\,dx, \text{ and} \\ W=X\,(x_1-x_0) \text{ if X is constant.} \end{cases}$$

Work is represented geometrically by the area of a curve, whereof the abscissa represents the passive accident, and the ordinate, the effort.

ENERGY, ACTUAL AND POTENTIAL.

The term "*energy*" comprehends every state of a substance which constitutes a capacity for performing work. *Quantities of energy* are measured by the quantities of work which they constitute the means of performing.

"*Actual energy*" comprehends those kinds of capacity for performing work which consist in particular states of each part of a substance, how small soever; that is, in an *absolute accident*, such as heat, light, electric current, *vis-viva*. Actual energy is essentially positive.

"*Potential energy*" comprehends those kinds of capacity for performing work which consist in relations between substances, or parts of substances; that is, in *relative accidents*. To constitute potential energy there must be a *passive accident* capable of variation, and an *effort* tending to produce such variation; the integral of this effort, with respect to the *possible variation* of the passive accident, is *potential energy*, which differs in work from this—that in work the change *has been effected*, which, in potential energy, is *capable of being effected.*

Let x denote an accident, x_1 its actual value; X, an effort tending to vary it; x_0, the value to which the effort tends to bring the accident; then

$$\int_{x_1}^{x_0} \mathrm{X}dx = \mathrm{U}, \text{ denotes potential energy.}$$

Examples of potential energy are, the chemical affinity of uncombined elements; the energy of gravitation, of magnetism, of electrical attraction and repulsion, of electromotive force, of that part of elasticity which arises from actions between the parts of a body, and generally, of all mutual actions of bodies, and parts of bodies.

Potential energy may be positive or negative, according as the effort in question is of the same sign with the variation of the passive accident, or of the opposite sign; that is, according as X is of the same sign with dx, or of the opposite sign.

It is to be observed, that the states of substances comprehended under the term *actual energy*, may possess the characteristics of potential energy also; that is to say, may be accompanied by a tendency or effort to vary relative accidents; as heat, in an elastic fluid, is accompanied by a tendency to expand; that is, an effort to increase the volume of the receptacle containing the fluid.

The states to which the term, *potential energy*, is specially applied, are those which are solely due to mutual actions.

To put a substance into a state of energy, or to increase its energy, is obviously a *kind of work.*

9. *First Axiom.*

ALL KINDS OF WORK AND ENERGY ARE HOMOGENEOUS.

This axiom means, that *any kind of energy may be made the means of performing any kind of work.* It is a fact arrived at by induction from experiment and observation, and its establishment is more especially due to the experiments of Mr Joule.

This axiom leads, in many respects, to the same consequences with the hypothesis that all those kinds of energy which are not sensibly the results of motion and motive force are the results of occult modifications of motion and motive force.

But the axiom differs from the hypothesis in this, that the axiom is simply the generalized allegation of the facts proved by experience, while the hypothesis involves conjectures as to objects and phenomena which never can be subjected to observation.

It is the truth of this axiom which renders a science of energetics possible.

The efforts and passive accidents to which the branches of physics relate are varied and heterogeneous; but they are all connected with *energy*, a uniform species of quantity, which pervades every branch of physics.

This axiom is also equivalent to saying, that *energy is transformable and transferable* (an allegation which, in the previous paper referred to, was included in the definition of energy); for, to *transform energy*, means to employ energy depending on accidents of one kind, in putting a substance into a state of energy depending on accidents of another kind; and to *transfer energy*, means to employ the energy of one substance in putting another substance into a state of energy, both of which are kinds of work, and may, according to the axiom, be performed by means of any kind of energy.

10. *Second Axiom.*

THE TOTAL ENERGY OF A SUBSTANCE CANNOT BE ALTERED BY THE MUTUAL ACTIONS OF ITS PARTS.

Of the truth of this axiom there can be no doubt; but some difference of opinion may exist as to the evidence on which it rests. There is ample experimental evidence from which it might be proved; but independently of such evidence, there is the argument, that the law expressed by this axiom is essential to the stability of the universe, such as it exists.

The special application of this law to mechanics is expressed in two ways, which are virtually equivalent to each other; the principle of *vis-viva*, and that of the equality of action and reaction. The latter principle is demonstrated by Newton, from considerations connected with the stability of the universe (*Principia*, Scholium to the Laws of Motion); for he shows, that but for the equality of action and reaction, the earth, with a continually accelerated velocity, would fly away through infinite space.

It follows, from the Second Axiom, that *all work consists in the transfer and transformation of energy alone;* for otherwise the total amount of energy would be altered. Also, that the energy of a substance can be varied by *external efforts alone.*

11. *External Potential Equilibrium.*

The entire condition of a substance, so far as it is variable, as explained in article 8th, under the head of *accident,* is a complex accident, which may be expressed in various ways by means of different systems of quantities denoting independent accidents; but the number of independent accidents in each system must be the same.

The quantity of work required to produce any change in the condition of the substance, that is to say, the potential energy received by it from without, during that change, may in like manner be expressed in different ways by the sums of different systems of integrals of external efforts, each integrated with respect to the independent accident which it tends to augment; but the number of integrals in each system, and the number of efforts, like the number of independent accidents, must be the same; and so also must the sums of the integrals, each sum representing the same quantity of work in a different way.

The different systems of efforts which correspond to different systems of independent accidents, each expressing the same complex accident, may be called *equivalent systems of efforts;* and the finding of a system of efforts equivalent to another may be called conversion of efforts.*

* The conversion of efforts in Physics, is connected with the theory of linear transformations in Algebra.

When the law of variation of potential energy, by a change of condition of a substance, is known, the system of external efforts corresponding to any system of independent accidents is found by means of this principle:

Each effort is equal to the rate of variation of the potential energy with respect to the independent accident which that effort tends to vary; or symbolically,

$$\text{(2.)} \qquad X = \frac{dU}{dx}.$$

External Potential Equilibrium *of a substance takes place, when the external effort to vary each of the independent accidents is null;* that is to say, *when the rate of variation of the potential energy of the substance with the variation of each independent accident is null.*

For a given substance, there are as many conditions of equilibrium, of the form

$$\text{(3.)} \qquad \frac{dU}{dx} = 0,$$

as there are independent accidents in the expression of its condition.

The special application of this law to motion and motive force constitutes the *principle* of *virtual velocities*, from which the whole science of statics is deducible.

12. *Internal Potential Equilibrium.*

The internal potential equilibrium of a substance consists in the equilibrium of each of its parts, considered separately; that is to say, in the nullity of the rate of variation of the potential energy of each part with respect to each of the independent accidents on which the condition of such part depends.

Examples of particular cases of this principle are, the laws of the equilibrium of elastic solids, and of the distribution of statical electricity.

13. *Third Axiom.*

THE EFFORT TO PERFORM WORK OF A GIVEN KIND, CAUSED BY A GIVEN QUANTITY OF ACTUAL ENERGY, IS THE SUM OF THE EFFORTS CAUSED BY THE PARTS OF THAT QUANTITY.

A law equivalent to this axiom, under the name of the

"General Law of the Transformation of Energy," formed the principal subject of the previous paper already referred to.

This axiom appears to be a consequence of the definition of actual energy, as a capacity for performing work possessed by each part of a substance independently of its relations to other parts, rather than an independent proposition.

Its applicability to natural phenomena arises from the fact, that there are states of substances corresponding to the definition of actual energy.

The mode of applying this third axiom is as follows:—

Let a homogeneous substance possess a quantity Q, of a particular kind of actual energy, uniformly distributed, and let it be required to determine the amount of the effort arising from the actual energy, which tends to perform a particular kind of work W, by the variation of a particular passive accident x.

The total effort to perform this kind of work is represented by the rate of its increase relatively to the passive accident, viz.,—

$$X = \frac{dW}{dx}$$

Divide the quantity of actual energy Q into an indefinite number of indefinitely small parts δQ; the portion of the effort X due to each of those parts will be

$$\delta Q \frac{dX}{dQ}$$

and adding these partial efforts together, the effort caused by the whole quantity of actual energy will be

$$\text{(4.)} \qquad Q \frac{dX}{dQ} = Q \frac{d^2 W}{dQ\, dx}$$

If this be equal to the *effective effort* X, then that effort is simply proportional to, and wholly caused by, the actual energy Q. This is the case of the pressure of a perfect gas, and the centrifugal force of a moving body.

If the effort caused by the actual energy differs from the effective effort, their difference represents, when the former is the less, an additional effort

$$(5.)\quad \begin{cases} \left(1 - Q\frac{d}{dQ}\right) X, \\ \text{and when the former is the greater, a counter-effort} \\ \left(Q\frac{d}{dQ} - 1\right) X, \end{cases}$$

due to some other cause or causes.

14. *Rate of Transformation; Metamorphic Function.*

The effort to augment a given accident x, caused by actual energy of a given kind Q, may also be called the "*Rate of Transformation*" of the given kind of actual energy with increase of the given accident; for the limit of the amount of actual energy which disappears in performing work by an indefinitely small augmentation dx, of the accident, is

$$(6.)\qquad dH = Q\frac{dX}{aQ}dx$$
$$= Q\frac{d^2W}{dQ\,dx}dx = Qd\frac{dW}{dQ}$$

The *last* form of the above expression is obviously applicable when the work W is the result of the variation of any number of independent accidents, each by the corresponding effort. For example, let x, y, z, &c., be any number of independent accidents, and X, Y, Z, &c., the efforts to augment them; so that

$$dW = Xdx + Ydy + Zdz + \&c.$$

Then

$$(7.)\qquad dH = Q\left\{\frac{dX}{dQ}dx + \frac{dY}{dQ}dy + \frac{dZ}{dQ}dz + \&c.\right\}$$
$$= Q\,d\,\frac{dW}{dQ} \text{ as before.}$$

The function of actual energy, efforts, and passive accidents denoted by

$$(8.)\qquad \frac{dW}{dQ} = \int\frac{dH}{Q} = F,$$

whose variation, multiplied by the actual energy, gives the amount of actual energy transformed in performing the work dW, may be called the "METAMORPHIC FUNCTION" of the kind of actual energy Q relatively to the kind of work W.

When this metamorphic function is known for a given homogeneous substance, the quantity H of actual energy of the kind Q transformed to the kind of work W, during a given operation, is found by taking the integral

$$(9.) \qquad H = \int Q \, d F.$$

The transformation of actual energy into work by the variation of passive accidents is a *reversible operation;* that is to say, if the passive accidents be made to vary to an equal extent in an opposite direction, potential energy will be exerted upon the substance, and transformed into actual energy: a case represented by the expression (9.) becoming negative.

The metamorphic function of heat relatively to expansive power, was first employed in a paper on the Economy of Heat in Expansive Machines, read to the Royal Society of Edinburgh in April 1851 (Trans. Roy. Soc. Edin., vol. xxi.)

The metamorphic function of heat relatively to electricity was employed by Professor William Thomson, in a paper on Thermo-Electricity, read to the Royal Society of Edinburgh in May 1854 (Trans. Roy. Soc. Edin., vol. xxi.), and was the means of anticipating some most remarkable laws, afterwards confirmed by experiment.

15. *Equilibrium of Actual Energy; Metabatic Function.*

It is known by experiment, that a state of actual energy is directly transferable; that is to say, the actual energy of a particular kind (such as heat), in one substance, may be diminished, the sole work performed being an equal augmentation of the same kind of actual energy in another substance.

Equilibrium of actual energy of a particular kind Q between substances A and B, takes place, when the tendency of A to transfer this kind of energy to B is equal to the tendency of B to transfer the same kind of energy to A.

Laws respecting the equilibrium of particular kinds of actual energy have been ascertained by experiment, and in some cases anticipated by means of mechanical hypotheses, according to which, all actual energy consists in the *vis-viva* of motion.

The following law will now be proved, respecting the equilibrium of actual energy of all possible kinds.

Theorem.—IF EQUILIBRIUM OF ACTUAL ENERGY OF A GIVEN KIND TAKE PLACE BETWEEN A GIVEN PAIR OF SUBSTANCES, POSSESSING RESPECTIVELY QUANTITIES OF ACTUAL ENERGY OF THAT KIND IN A GIVEN RATIO, THEN THAT EQUILIBRIUM WILL SUBSIST FOR EVERY PAIR OF QUANTITIES OF ACTUAL ENERGY BEARING TO EACH OTHER THE SAME RATIO.

Demonstration.—The tendency of one substance to transfer actual energy of the kind Q to another, must depend on some sort of effort, whose nature and laws may be known or unknown. Let Y_A be this effort for the substance A, Y_B, the corresponding effort for the substance B. Then a condition of equilibrium of actual energy is

$$(10.) \qquad Y_A = Y_B.$$

The effort Y may or may not be proportionate to the actual energy Q, multiplied by a quantity independent of Q.

Case first.—If it is so proportional, let

$$Y = \frac{1}{K} Q,$$

K being independent of Q; then the condition of equilibrium becomes

$$\frac{1}{K_A} Q_A = \frac{1}{K_B} Q_B, \text{ or}$$

$$\frac{Q_B}{Q_A} = \frac{K_B}{K_A},$$

a ratio independent of the absolute amounts of actual energy.

Case Second.—If the effort Y is not simply proportional to the actual energy Q, the portion of it caused by that actual energy, according to the principle of article 13, deduced from the third axiom, is, for each substance,

$$Q \frac{dY}{dQ}$$

and a second condition of equilibrium of actual energy is furnished by the equation

$$(11.) \qquad Q_A \frac{dY}{dQ_A} = Q_B \frac{dY_B}{dQ_B}$$

In order that this condition may be fulfilled simultaneously with the condition (10.) it is necessary that

$$\frac{dQ_A}{Q_A} = \frac{dQ_B}{Q_B}$$

that is to say, that the ratio of the quantities of actual energy in the two substances should be independent of those quantities themselves; a condition expressed, as before by

(11.) $$\frac{Q_B}{Q_A} = \frac{K_B}{K_A}$$

Q. E. D.

This ratio is a quantity to be ascertained by experiment, and may be called the ratio of the SPECIFIC ACTUAL ENERGIES of the substances A and B, for the kind of energy under consideration.

The function

(12.) $$\frac{Q_A}{K_A} = \frac{Q_B}{K_B} = \theta$$

whose identity for the two substances expresses the condition of equilibrium of the actual energy Q between them, may be called the "METABATIC FUNCTION" for that kind of energy.

In the science of thermo-dynamics, the metabatic function is *absolute temperature;* and the factor K is *real specific heat.* The theorem stated above, when applied to heat, amounts to this: *that the real specific heat of a substance is independent of its temperature.*

16. *Use of the Metabatic Function:—Transformation of Energy in an aggregate.*

From the mutual proportionality of the actual energy Q, and the metabatic function θ, it follows that the operations

$$Q\frac{d}{dQ}, \theta\frac{d}{d\theta}$$

are equivalent; and that the latter may be substituted for the former in all the equations expressing the laws of the transformation of energy. We have therefore

(13.) $$Q\frac{dX}{dQ} = \theta\frac{dX}{d\theta} = \theta\frac{d^2W}{d\theta dx}$$

for the effort to transform actual energy of the kind Q into work of the kind W, when expressed in terms of the metabatic function; and

(14.) $$dH = \theta\, d\frac{dW}{d\theta}$$

for the limit of the indefinitely small transformation produced by an indefinitely small variation of the accidents on which the kind of work W depends.

There is also a form of *metamorphic function*.

(15.) $$\varphi = \frac{dW}{d\theta} = \int \frac{dH}{\theta} = KF$$

suited for employment along with the metabatic function, in order to find, by the integration

(16.) $$H = \int \theta \, d\varphi$$

the quantity of actual energy of a given kind Q transformed to the kind of work W during any finite variation of accidents.

The advantage of the above expressions is, that they are applicable, not merely to a homogeneous substance, but to any *heterogeneous substance or aggregate*, which is internally in a state of equilibrium of actual and potential energy; for throughout all the parts of an aggregate in that condition, the metabatic function θ is the same, and each of the efforts X, &c., is the same, and consequently the metamorphic function φ is the same.

"*Carnôt's function*" in thermo-dynamics is proportional to the reciprocal of the metabatic function of heat.

17. *Efficiency of Engines.*

An engine is a contrivance for transforming energy by means of the periodical repetition of a cycle of variations of the accidents of a substance.

The *efficiency* of an engine is the proportion which the energy permanently transformed to a useful form by it bears to the whole energy communicated to the working substance,

In a *perfect engine* the cycle of variations is this:—

I. The metabatic function is increased, say from θ_0 to θ_1.

II. The metamorphic function is increased by the amount $\Delta \phi$.

III. The metabatic function is diminished from θ_1 back to θ_0.

IV. The metamorphic function is diminished by the amount $\Delta \phi$.

During the second operation, the energy received by the working substance, and transformed from the actual to the potential form is $\theta_1 \Delta \phi$. During the fourth operation energy is transformed back, to the amount $\theta_0 \Delta \phi$. So that the energy permanently transformed during each cycle is $(\theta_1 - \theta_0) \Delta \varphi$; and the efficiency of the engine $\frac{\theta_1 - \theta_0}{\theta_1}$.

18. *Diffusion of Actual Energy; Irreversible or Frictional Operations.*

There is a tendency in every substance or system of substances, to the *equable diffusion* of actual energy; that is to say, to its transfer between the parts of the substance or system, until the value of the *metabatic function* becomes uniform.

This process is *not directly reversible;* that is to say, there is no such operation as a direct concentration of actual energy through a tendency of the metabatic function to become unequal in different parts of a substance or system.

Hence arises the impossibility of using the energy re-converted to the actual form at the lower limit of the metabatic function in an engine.

There is an analogy in respect of this property of *irreversibility*, between the diffusion of one kind of actual energy, and certain irreversible transformations of one kind of actual energy to another, called by Professor William Thomson, "Frictional phenomena," viz., the production of heat by rubbing and agitation, and by electric currents in a homogeneous substance at a uniform temperature.

In fact, a conjecture may be hazarded, that immediate diffusion of the actual energy produced in frictional phenomena, is the circumstance which renders them irreversible; for, suppose a small part of a substance to have its actual energy increased by the exertion of some kind of work upon it; then, if the increase of actual energy so produced be immediately diffused amongst other parts, so as to restore the uniformity of the metabatic function, the whole process will be irreversible. This speculation, however, is, for the present, partly hypothetical; and, therefore does not, strictly speaking, form part of the science of energetics.

19. *Measurement of Time.*

The general relations between energy and time must form an important branch of the science of energetics; but for the present, all that I am prepared to state on this subject is the following DEFINITION OF EQUAL TIMES:—

Equal times are the times in which equal quantities of the same kind of work are performed by equal and similar substances, under wholly similar circumstances.

20. *Concluding Remarks.*

It is to be observed, that the preceding articles are not the results of a new and hitherto untried speculation, but are the generalized expression of a method of reasoning which has already been applied with success to special branches of physics.

In this brief essay, it has not been attempted to do more than to give an outline of some of the more obvious principles of the science of energetics, or the abstract theory of physical phenomena in general; a science to which the maxim, true of all science, is specially applicable—that its subjects are boundless, and that they never can, by human labours, be exhausted, nor the science brought to perfection.

On the Chemical Composition of Mineral Charcoal. By THOS. H. ROWNEY, Ph.D., F.C.S., Assistant in the College Laboratory, Glasgow.

Although coal and its allied minerals have formed the subject of much careful investigation, but little attention has been paid to the soft fibrous matter which occurs in it in thin layers, and has been commonly described under the name of mineral charcoal. Indeed, with the exception of a few cursory notices of the existence of such a substance, little was known regarding it until the publication of Professor Harkness's paper in the January number of this Journal. The absence of all information as to its chemical constitution induced me to undertake a few analyses of such specimens as were easily obtained, and those I have hitherto examined have been from the Scotch coal-fields; but it is my intention when opportunity offers to extend the inquiry to that obtained from other districts. Before entering upon the details of my own experiments, I may mention in a few words the principal facts I have been able to find in the works of previous observers.

Professor Bischoff in his Chemical and Physical Geology describes it under the name of fibrous anthracite, and states that "it accompanies all the true coal of the older formations in beds of from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in thickness; it shows under the microscope the well preserved structure of the araucarias. Besides these, calamites occur in the state of fibrous anthracite, but the other stems very rarely." Mr Queckett, in his paper on the Torbanehill Mineral, read before the Microscopical Society, and published in their Transactions, also mentions this substance in the following terms:—" Many blocks of coal have a fine dull black powder on two of their outer surfaces, which will make the fingers very black; this I call the charcoal layer, and in it will be found fragments of woody tissue of cells and even of vessels. My investigations lead me to believe that this layer is derived from plants which existed at the same time as the coal-wood, but were not capable of being converted into true coal, but having been subjected to a great heat, their remains are left as a species of charcoal."

Professor Harkness states that he has observed mineral charcoal in the coals of the tertiary and oolitic formations, and also in the true coal measures, and that in the latter there exists both a fibrous and granular variety. Both these varieties I have distinctly recognised in all the coals I have examined, and the latter especially is found sometimes as a light powder, at others in the form of a cindery substance, that peels off the coal in flakes which are readily reduced to powder. From his microscopical examination of mineral charcoal, Professor Harkness is of opinion that the two varieties are derived from different plants; the granular, which consists of cellular tissue, he refers to the sigillarias; whilst the fibrous charcoal, from the markings upon the walls of the cells, he considers to be derived from the calamites or allied plants.

I shall not attempt at present to enter upon the nature and origin of this substance, my object in this communication being to show that its chemical constitution is entirely different from the coal in which it occurs, and that it is scarcely entitled to the name of mineral charcoal. Mineral charcoal is found abundantly in most coals, sometimes in the form of layers of considerable extent, and sometimes only in small patches. It is also found in cannel coal, but not in very great quantity. When ignited in a platinum crucible it burns pretty readily, but it contains very little volatile matter. The ash left after ignition varies considerably even in the same specimen, some portions of it being highly ferruginous, and others consisting principally of carbonate and sulphate of lime.

I found it very difficult to obtain accurate results by the usual method of combustion with chromate of lead, and thereford adopted that of burning it in a stream of oxygen from a gas holder, which enabled me also to determine the amount of ash in each quantity experimented upon. In obtaining the charcoal for analysis care was taken to prevent any coal from being mixed with it, and only those portions were taken which came away freely from the coal. Before being submitted to analysis it was finely powdered and dried at 100° C.

The charcoal from the undermentioned coals was analysed, and the following results obtained,—

Fibrous Charcoal from the common household coals of the Glasgow coal-fields, as used in the Laboratory.

I.	·1385	grammes of	substance gave
	·4215	...	carbonic acid,
	·0415	...	water, and
	·0085	...	ash.
II.	·1218	grammes of	substance gave
	·3705	...	carbonic acid,
	·0370	...	water, and
	·0073	...	ash.

III. ·4185 grammes of substance gave ·0032 grammes of nitrogen.

IV. ·6830 grammes of substance lost by gentle ignition ·0800 grammes.

	I.	II.
Carbon, . .	82·99	82·96
Hydrogen, .	3·32	3·37
Nitrogen, . .	·75	·75
Oxygen, . ·	6·76	6·93
Ash, . .	6·18	5·99
	100·00	100·00

The volatile matter, driven off at a low red heat, was 11·71, per cent.

Deducting the ash the carbon was equal to 88·68
... ... hydrogen ... 3·57

Granular Charcoal from the Stonelaws coals.

I.	·1600	grammes of substance gave	
	·4275	...	carbonic acid
	·0330	...	water, and
	·0305	...	ash.
II.	·1570	grammes of substance gave	
	·4180	...	carbonic acid,
	·0340	...	water, and
	·0300	...	ash.

	I.	II.
Carbon,	72·87	72·61
Hydrogen,	2·29	2·40
Nitrogen, Oxygen,	5·78	5·89
Ash,	19·06	19·10
	100·00	100·00

Deducting the ash, the Carbon is equal to 89·89
Hydrogen ... 2·89

·4410 grammes of substance gently heated lost ·0310 grammes, equal to 7·03 per cent. of volatile matter.

Fibrous Charcoal from Ayrshire coal.

I.	·1162	grammes of substance gave	
	·3140	...	carbonic acid,
	·0310	...	water, and
	·0180	...	ash.
II.	·1385	grammes of substance gave	
	·3715	...	carbonic acid,
	·0365	...	water, and
	·0212	...	ash.

	I.	II.
Carbon,	73·69	73·15
Hydrogen,	2·96	2·92
Nitrogen, Oxygen,	7·87	8·63
Ash,	15·48	15·30
	100·00	100·00

Deducting the ash the Carbon is equal to 86·78
Hydrogen ... 3·48

·5315 grammes of substance gently heated lost ·0775 grammes, equal to 14·58 per cent. of volatile matter.

An analysis of the coal from which this charcoal was obtained yielded the following results:—

Carbon, . .	76·08
Hydrogen, . .	5·31
Nitrogen, . .	2·09
Sulphur, . .	1·23
Oxygen, . .	13·33
Ash, . . .	1·96
	100·00
Coke, . .	69·77
Volatile matter, .	30·23
	100·00

Fibrous Charcoal from the Elgin splint coal, Fifeshire.

I. ·1910 grammes of substance gave
·5225 ... carbonic acid,
·0475 ... water, and
·0280 ... ash.

II. ·1990 grammes of substance gave
·5460 ... carbonic acid,
·0490 ... water, and
·0300 ... ash.

	I.	II.
Carbon,	74·60	74·83
Hydrogen,	2·76	2·73
Nitrogen, Oxygen,	7·98	7·37
Ash,	14·66	15·07
	100·00	100·00

Deducting the ash the Carbon is equal to 87·30
Hydrogen ... 3·23

Fibrous Charcoal from the 5-feet seam Elgin coal, Fifeshire.

I. { ·1815 grammes of substance gave
·5410 ... carbonic acid and
·0615 ... water.

II. { ·1837 grammes of substance gave
·5460 ... carbonic acid and
·0650 ... water.

	I.	II.
Carbon,	81·29	81·06
Hydrogen,	3·76	3·93
Nitrogen, Oxygen, Ash, }	14·95	15·01
	100·00	100·00

The coals from which these two charcoals were obtained had the following composition :—

	Splint Coal.	5-feet Seam.
Carbon,	80·63	80·93
Hydrogen,	5·16	5·21
Sulphur,	·84	·63
Nitrogen,	1·33	1·57
Oxgen,	10·61	10·91
Ash,	1·43	·75
	100·00	100·00

I was unable to determine the ash in the last specimen of mineral charcoal in consequence of the great scintillation which took place during the combustion, whereby portions of the ash were carried out of the platinum boat and lost. Analyses to ascertain the amount of nitrogen were made in four of the charcoals, but in one only was any appreciable quantity found; in the others merely a trace of this element existed. I did not determine the amount of sulphur contained in the mineral charcoal, as the large quantity of sulphate of lime present in the ash would have deprived the determination of all value.

At first sight there is apparently a considerable difference in the composition of these charcoals, but on more minute examination it appears that the variable quantity of inorganic matter in the several specimens, is the cause of the difference; so that when it is deducted from the analysis there is nearer approach to a similarity in composition. Between mineral charcoal, however, and coal, the difference is very great, especially when we compare it with the coals in which it is found, of which I have given a few analyses ; the inorganic matter in the one being under 2, whilst in the other it varies from 6 to nearly 20 per cent. The carbon in most cases is rather less than that found in coal, whilst the hydrogen is little more than half as much ; the nitrogen also, except in one case, has nearly disappeared. The principal difference between the mineral charcoal and anthracite is in the inorganic matter, as will be seen from the following analyses of some anthracites :—

	Pennsylvania.	Welsh.	Calton Hill, Edinburgh.	Lamure, Isère Department.
Carbon,	90·45	90·58	91·23	89·77
Hydrogen,	2·43	3·60	2·91	1·67
Nitrogen,			·59	·36
Sulphur,	2·45	4·10	2·96	3·63
Oxygen,			1·26	
Ash,	4·76	1·72	1.05	4·57
	100·00	100·00	100·00	100·00

Deducting the ash, the carbon and the hydrogen in the above analyses are equal to

	Pennsylvania.	Welsh.	Cálton Hill.	Lamure.
Carbon,	94·88	92·16	92·19	94·07
Hydrogen,	2·52	3·66	2·94	1·75

From the little difference in composition and properties of these two substances, the name Fibrous Anthracite, given to the latter by Professor Bischoff, appears more appropriate than that of Mineral Charcoal. Professor Harkness is of opinion that the two varieties of the charcoal are derived from different plants; but the analyses just given do not show any very conspicuous difference in their composition, and on examining the ash of both varieties by the microscope, I have come to the conclusion that both have been derived from the same plant.

The ash requires to be digested with nitro-hydrochloric acid, to free it from iron and other impurities ; and after washing it thoroughly, and placing it under the microscope, its structure may be seen distinctly. The fibrous charcoal contains three distinct kinds of tissue ; 1st, Rounded cells ; 2d, Oval cells; and 3d, Long tubes, pointed or rounded at the ends; sometimes two or more of these tubes may be found adhering together. All these kinds of tissue are marked with dots. The granular charcoal shows similar tubes, but very much broken-up; portions, however, may be found which show the same structure as that found in the fibrous variety.

This examination was made in the laboratory of Dr Anderson, whom I have to thank for the use of his laboratory and apparatus.

REVIEWS AND NOTICES OF BOOKS.

Life of Thomas Young, M.D., F.R.S., &c. By GEORGE PEACOCK, D.D., Dean of Ely. London: 1855.

Miscellaneous Works of the late Thomas Young, M.D., &c. Edited by GEORGE PEACOCK, D.D., and JOHN LEITCH. 3 vols. London: 1855.

The most effectual tribute to the memory of a scientific man is, in these days, a republication of his scattered writings. It is the lot of few to compose massive works which themselves constitute a claim to immortality. The discoveries of Natural Philosophy, and of the Inductive Sciences generally, are often conveyed in a few pages of printed matter, consigned for facility and earliness of publication to the pages of a periodical or to the Transactions of learned societies. The grand discovery by Oersted of Electro-Magnetism was announced in a loose tract of a few pages; the work which has given to Mr Brown his chief title to the character of the first botanist of his age was published as an appendix to the Narrative of an Exploring Expedition; and Mr Adams' Theory of Uranus and Neptune first appeared in a volume of the Nautical Almanac.

No author more urgently required an editor for the conservation and due appreciation of his posthumous fame than Dr Thomas Young. Accustomed to pursue his profoundly original researches in Physics, Languages, and Archæology, in the order in which circumstances brought them under his notice, or gave a handle to their prosecution, he was not scrupulous as to the medium of their promulgation. A popular lecture, a syllabus, a medical treatise, or the pages of a magazine or review, were all in turn enriched with the spoils of his overmastering intellect; and finally, when the late editor of the *Encyclopædia Britannica*, Mr Macvey Napier, with sagacious foresight, invited him to contribute to that work, Young found in its ample pages a fitting storehouse for arranging the treasures of his truly encyclopædical mind, and an opportunity of allaying that thirst for labour which haunted him throughout life as a passion.

To collect into one body the most important of these widely scattered materials was therefore, in the case of Dr Young, a peculiarly needful preliminary to a due appreciation of his vast talents, and was rendered still more necessary by a circumstance to which we have not yet adverted, namely, that a vast majority of his writings were *anonymously* published; and though the *incognito* was never solicitously preserved, it is easy to understand that this peculiarity, combined with the real difficulty of most of his investigations, prevented him from gaining a wide notoriety, and even rendered it difficult for his admirers to refer to his writings, or even occasionally to be aware of the existence of some of them.

Dean Peacock, moved by the commendable solicitations of Mrs Young, has at length executed his task in a manner which appears to us to be both conscientious and satisfactory. The selection of Young's Miscellaneous Writings extends to three closely-printed octavo volumes, containing no less than 1848 pages, and they embrace almost everything which requires preservation; whilst the "Life," in one volume, is a plain and perspicuous history of his wonderful career, including a just and discriminating estimate of the eminent position which he is entitled to hold at once in the scientific and literary world. This rare combination of talent in two departments usually rigorously separated, with the singular felicity of being not only a zealous cultivator of, but a prominent discoverer in each, places Young in a position apart from all his contemporaries. When to this we add that he united the dazzling precocity of boyhood to the maturity of success as a man;—that his industry throughout his entire life, and his learned appreciation of the works of others, must have rendered him a public benefactor, wholly independent of the diviner gift of consummate genius;—and that his private life was marked by the wise moderation of his wishes, by the harmonious appreciation of the claims of family and kindred, and by the unostentatious sincerity of a Christian profession,—we have said enough to show that Thomas Young was indeed one of the rarest characters which the annals of Biography offer to our admiration.

He was born at Milverton in Somersetshire, 13th June 1773. As we have already hinted, he was nothing short of a prodigy in boyhood. That indomitably active spirit must at once show the energies which were to be unceasingly exercised throughout the entire course of a life long enough for his fame, though too short for the wishes of his friends. His education, first and last, was somewhat irregular and desultory. The country schools where he obtained the elements of learning appear to have offered but ordinary advantages. At two years of age he read with fluency; between five and six his powers of memory had already become conspicuous by the facility with which he recited poetry; between his tenth and fourteenth year he had not only mastered the usual topics of school study, but acquired some knowledge of Mathematics from the works of Walkinghame and Ewing; of Optics and Natural Philosophy from Benjamin Martin; and of Chemistry from Priestley. But more singular than this, he had learnt some smattering of Italian and French, and betook himself with seriousness to Oriental literature, having in 1786 purchased Montanus's Hebrew Bible for five shillings. He had thus already read through Buxtorf's Compendium and Taylor's Tract at the end of his Concordance; and before he left Compton school he had succeeded in getting through six chapters of the Hebrew Bible. An ingenious saddler at Minehead first put a quadrant into the hands of the future philosopher, who, with no farther assistance than Martin's books, proceeded to construct a microscope.

Young's uncle, Dr Brocklesby, a London physician, in good practice and well connected, was his most efficient patron and adviser; and one cannot read without much interest the sensible letters addressed by him to "dear Tommy," containing a salutary admixture of advice and encouragement. Through him, no doubt, the medical profession was suggested to the mind of Young, and was finally embraced after a somewhat desultory course of study in London, at Edinburgh, at Göttingen, and at Cambridge. The interval between his leaving school and commencing attendance upon medical lectures in London at the age of nineteen, was devoted to a rigorous course of private study, in which the Greek language held probably the most conspicuous place. He acquired, almost alone, a facility in the use of that language, and a degree of accurate scholarship, such as very few solitary students can boast of. Insomuch, that in 1791, when he was nineteen years of age, he records in his journal, "several conversations on subjects of Greek criticism with Porson, Baker, Burney, and Lawrence, which show that he was already prepared to enter the lists with those distinguished scholars, and to contend with them on not very unequal terms." He also formed an intimate acquaintance with Burke and Wyndham, who were friends of Dr Brocklesby, and the former of whom especially took a warm interest in the future career of Young.

The winters of 1792–3 and 1793–4 he spent in London, attending the lectures of Baillie and John Hunter, and of the teachers at St Bartholemew's Hospital; and now his first really original contribution to science was made. A disquisition on the Adaptation of the Eye to distinct Vision at different distances was presented to the Royal Society in May 1793, of which body he was elected a Fellow on the 19th June 1794, six days after he attained his majority. This subject, intimately connected at once with his profession and with Optics (already one of his favourite studies) was peculiarly adapted to his taste and genius, and he afterwards returned to it repeatedly. His theory—that the spontaneous adjustment of focus is produced by the muscularity of the lens modifying its form—after being first claimed by John Hunter as his own, was abandoned for a time, even by its author, on the faith of some experiments by Sir E. Home; but Young resumed it in 1800, and we have no reason to believe that he again altered his opinion.

Dr Young spent the following winter (1794–5) at the University of Edinburgh. Of his residence there a tolerably full account is given by Dr Peacock in the third chapter of his work; from which, on account of its interest to the readers of this Journal, we will make some extracts.

"He arrived at Edinburgh on the 20th October, and established himself in lodgings in St James's Square. His reputation, which had preceded him, and the various letters of introduction with which he was furnished, opened to him the best society of the place. Amongst the students were many with whom he had been previously acquainted in London, when attending the medical lectures: Bostock, afterwards a physician in London, and a physiologist of some eminence, with whom he long maintained a very animated correspondence; Bancroft, a man of considerable attainments, with whom he lived in habits of great intimacy: he was the son of the author (amongst other works) of a treatise entitled "Experimental Researches on the Philosophy of Permanent Colours," which Young made the subject of a favourable critique in the *Quarterly*; Turner, who was afterwards a distinguished physician at Liverpool; Gibbes of Bath, and many others. . . . .

"The Edinburgh school of medicine enjoyed at that time a very high character. Gregory, who held the first rank in it, was one of a family singularly distinguished in the history of the sciences, which has given, during the last two centuries, nearly twenty professors to our universities. He was a superior classical scholar, and his well-known treatise, entitled *Conspectus Medicinæ Theoreticæ*, is remarkable for the purity and ease of its Latinity. His opinions on medical questions were entitled to consideration, as much from his great practical experience as from the arguments with which they were supported. Dr Duncan, the Professor of the Institutes of Medicine, is very favourably noticed by Young. Dr Black, one of the most illustrious of the founders of the science, was Professor of Chemistry; and though he had at one time been celebrated for his skill in addressing a class and conducting his experiments, he was now old and infirm, and before the end of the session his duties were discharged by a deputy—Dr Rotheram. Monro, the son of the founder of the Anatomical School in the University, the author of a celebrated work on the Bones and the Nerves, was Professor of Anatomy, an office which he filled for forty years, at first conjointly with his father, but latterly with his son, who still survives him, though he has for some years retired from the University. He was generally considered as the greatest of the Monros, and the last of the great physicians who united, like the late Dr Baillie, a profound knowledge of anatomy with that of medicine. He was engaged in many controversies on anatomical subjects, frequently involving claims to priority of discovery. The Clinical Lectures were given by Dr Home. The names of other occasional lecturers are mentioned by Dr Young, particularly that of John Bell, the eminent surgeon, whose demonstrations in Anatomy appeared to him to be of first-rate excellence. In writing to his uncle, he says,—

"'I believe North and Baker are prejudiced against Edinburgh; with respect to the study of Physic, it appears to me beyond comparison preferable to Oxford or Cambridge, and in other respects little inferior. For Anatomy, I am very glad that I am done with it, for I should never learn it of Monro. I think him far inferior as a lecturer to Baillie. I expect much from Gregory's Practice, and something from Black and the Clinical Lectures: these are given by Home, who has some merit, with something ridiculous in his manner.'

"On another occasion, much later in the session, he says,—

"'I have not time for many scientific pursuits, besides the lectures which I closely attend. Some little information on Chemistry I derive from Black's copious course—hardly anything from Monro—something considerable in the Medical line from Gregory and Duncan.'

"It is probable that Dr Young, though generally very candid in his judgments, was somewhat prejudiced against Monro, whom he accuses of a disposition to appropriate the discoveries of other authors as his own." —(*Life*, p. 50–53.)

It was not to be supposed that in a single session Young could have found time to attend other lectures than those most nearly connected with his profession; but his character for Greek scholarship had preceded him, and in Professor Dalzell and Dr Gregory he found men able and desirous to appreciate a pre-eminence so uncommon in Scotland. From Dalzell he received, says our biographer, the most flattering attentions during the whole time of his residence, which Young returned by material aid in the editorial work of the second volume of the *Analecta Hellenica*, with which the Professor was then engaged. This assistance was gratefully and gracefully acknowledged, and Dalzell pronounced a Greek epigram by Young, which he printed in that work, to be conceived in a true classical spirit. Dr Robison (Professor of Natural Philosophy) is not mentioned as amongst his acquaintances; but it is hardly to be doubted (notwithstanding Robison's ill health) that he was more or less known to him. Many of Young's writings bear strongly the impress of Robison's sagacious manner of regarding matters of practical science. In Edinburgh he also studied Spanish and German, practised on the flute, and was not an unfrequent attender at the theatre. We have not yet mentioned that Young was by parentage and education a Quaker. It seems to have been at Edinburgh that he first began to detach himself from the usages of that society, and incurred thereby some admonitions from his friend Mr Cruickshanks. But though he entered into some amusements common to persons of his age, and into general society, we are expressly assured by his biographer that his morals incurred thereby not the slightest blemish;—*whatever he thought to be right, he resolutely practised.* This, first and last, was his undeviating principle of action.

We cannot enter upon his residences at Göttingen and Cambridge, which occupied the next four years of his life. His abode in Germany appears to have been devoted more to general accomplishments, to society, and to the acquisition of familiarity with the language and customs of the country, than to profound or methodical study. During a journey through the Hartz he appears to have made the acquaintance of Mr (afterwards Sir John) Leslie, who was then travelling with Mr Wedgewood. His residence at Cambridge (commenced at twenty-three years of age) was undertaken solely as a passport to the advantages of London medical practice; and his residence there appears to have been almost confined to the stated periods rigorously required for that purpose. He arrived far too late, and with too extensive and matured a knowledge of science and classical literature, to submit to the drudgery of an undergraduate course, and was looked on accordingly with something of the jealousy which his introduction by the master to the tutors of his college (Emmanuel) was calculated to inspire;—"I have brought you," he said, "a pupil qualified to read lectures to his tutors." Accordingly, the information which Dean Peacock has been able to glean on a subject naturally so interesting to him as Young's residence at Cambridge is not so full or so satisfactory as might have been wished. Yet those tranquil and most important years of his life (1796–99), divided between London and Cambridge, were doubtless spent in close application, probably to the more difficult parts of Mathematics and Natural Philosophy, and in them he unquestionably laid the foundations of that wonderful store of scientific erudition which he afterwards displayed, whilst, at the same time, the first ideas of his great Optical Theory were at that time probably also developing themselves in his mind.

Young left Cambridge in 1800, Dr Brocklesby having already been some years dead, and having by his will placed him in a position in some measure independent. London became henceforth his permanent residence, and the career of a physician his stated employment. Dean Peacock has devoted Chapter VIII. of his work to Dr Young's character as a physician and medical author. We gather that his practice was never large, and at length rather diminished than increased. Yet few persons have brought greater talents to the exercise of a profession, or have sacrificed more to its conventional requirements. For a great many years he published his important literary labours anonymously, with a view to meet the popular prejudice against a medical man who devotes any large share of his attention to non-professional pursuits. His practice is stated by his biographer to have been straightforward and judicious, and to have been attended in his hospital cases with more than average success. It is difficult indeed to believe that, if medicine be a science capable of inductive treatment, it should not have yielded some of its practical secrets to one so successful in other, and the most various of human studies, and who united to sagacious talent such an amazing amount of patient research. His treatise on Consumption, and his Introduction to Medical Literature, are his principal professional writings.

Within a year after Dr Young had settled in London, and before he had adopted the rule of professional self-denial just referred to, he was appointed Professor of Natural Philosophy in the Royal Institution, then newly founded. He held the situation for but two sessions. "By his own confession," says his biographer, "he was not adapted for a popular lecturer. His style was too compressed and laconic, and he had not sufficient knowledge of the intellectual habits of other men to address himself prominently to those points of a subject where their difficulties were likely to occur. If indeed these Lectures were delivered nearly in the form in which they are printed, they must have been generally unintelligible even to well prepared persons, notwithstanding all the assistance which models, drawings, and diagrams could afford." These Lectures were in fact only of use,—in any proportion to the labour and skill exhausted in their preparation,—when they were published together with a supplementary volume of important and original matter, including a *Catalogue of References* to works and memoirs in every department of Physics and the Arts, arranged with a degree of method and accuracy which has never been equalled. The Lectures only have been reprinted in the neat octavo edition which appeared some years ago under the superintendence of Professor Kelland. Their form being the same with that of the edition of the Miscellaneous Works which now accompanies the Life, the whole forms a valuable compendium of Dr Young's writings. Most of the original papers which formed part of the second volume of the Lectures, as originally published (some of which had appeared in the Philosophical Transactions), are now reprinted by Dr Peacock, but the *Catalogue of References* remains in the state it was left by the author. "Its republication," says the Dean, "with the addition of the works and memoirs which have appeared during the last half century, would confer an invaluable boon upon scientific students."

We must now briefly refer to the two great monuments of Dr Young's career, his Optical and Hieroglyphical discoveries. The germs of the former are to be found in three papers connected with the Theory of Light and Colours, communicated to the Royal Society of London in 1801, 1802, and 1803. These papers, which are to be found in the volumes which we are analyzing, have commonly been regarded as difficult and obscure, and indeed must probably have appeared so to a student of science of those days. But with the familiarity which we have now acquired with the notion of undulations, they seem scarcely liable to that charge. The phraseology used by Dr Young was in this, as in most other cases where he describes physical phenomena, and physical (not mathematical) reasoning connected with them, unmistakably correct and definite. The very earliest notice of the doctrine of the interference of light regarded as the explanation of certain phenomena in Optics, was given in Nicholson's Journal for 1801. A passage from Dr Young's reply to the severe and unjustifiable attack on his theory by the Edinburgh reviewers gives the exact date :—

"It was in May 1801 that I discovered, by reflecting on the beautiful experiments of Newton, a law which appears to me to account for a greater variety of interesting phenomena than any other optical principle that has yet been made known. I shall endeavour to explain this law by a comparison : Suppose a number of equal waves of water to move upon the surface of a stagnant lake with a certain constant velocity, and to enter a narrow channel leading out of the lake ; suppose, then, another similar cause to have excited another equal series of waves, which arrive at the same channel with the same velocity, and at the same time, with the first. Neither series of waves will destroy the other, but their effects will be combined ; if they enter the channel in such a manner that the elevations of one series coincide with those of the other, they must together produce a series of greater joint elevations ; but if the elevations of one series are so situated as to correspond to the depressions of the other, they must exactly fill up those depressions, and the surface of the water must remain smooth ; at least I can discover no alternative, either from theory or from experiment. Now, I maintain that similar effects take place whenever two portions of light are thus mixed ; and this I call the general law of the interference of light."—(*Life*, p. 142–3.)

The Theory of Undulations had been not only broached by Huygens, but applied with skill and success to the solution of many optical problems. Dr Young's first applications of it were to the explanation of the phenomena of diffraction, as observed by Grimaldi and Newton, and in other cases devised by himself. Even here Dr Hooke had made an advance in the same direction, and his explanation of Newton's rings by an hypothesis of waves, though long overlooked, is now well known. Young's researches were laid before the world publicly, and in his own name, in three papers, mentioned above, which are reprinted in the first volume of the Miscellaneous Works.

"One of the first and most satisfactory applications," says Dr Peacock, "which Young made of his Theory, was to the Colours of Striated Surfaces ; a class of phenomena which Newton had left altogether unnoticed, and which were not explicable by any recognised theory of light which had previously been proposed. When two or more scratches forming concave-cylindrical or other polished surfaces capable of reflecting light in all directions* are drawn extremely near each other, the light issuing in all directions from a luminous source may be reflected from points in those surfaces in directions so nearly coincident as to meet and interfere at the eye, after describing paths which differ in length by one half or by a whole of the undulation which is appropriate to the coloured light, if homogeneous, or to some one of its constituents if white light be employed. The appropriate colour in one case will be destroyed by interference, and corroborated in the other; and if we take into account a series of such points on each surface in lines very near to each other, the combined effect of such interferences will become sensible to the eye, and lead to the production of colour, or to a flash of darkness or light."

It is quite impossible in this brief analysis to give any idea of the masterly and comprehensive manner in which Dr Young applied, in these early memoirs, the fertile principles of his admirable theory. The results are there stated by him in lucid and precise language. Yet the reception of them was not flattering. With the exception of a violent attack in the Edinburgh Review, written, as is well known, by Lord Brougham, they excited scarcely the smallest notice, and if they made a single convert (in this country), they did not at least raise up an advocate. The greatest theory of the day fell to the ground without one echo. The *resumé* of the subject in Young's "Lectures" did not excite more notice, which is hardly surprising, as the nature of that work scarcely admitted of the needful explanatory detail. Some important things could be found only hinted at in the Plates to that work, or in the Explanation of those Plates. Yet Young never for a moment swerved from his own conviction, or let slip an opportunity of supporting his views by the results of new experiments; although it may be admitted that he was more remarkable for the ability with which he interpreted the experiments of others, than for devising new ones of his own; a peculiarity which sometimes arises from intenseness of conviction in a highly logical mind superseding the desire for multiplicity of evidence.

The first extraneous impulse which his theory received was from the hand of a foreigner. Fresnel, a young French engineer, at least a dozen years after Young had first published them, fell independently on some of his experiments and conclusions, along with others of his own. It is perfectly certain that Fresnel knew nothing of what Young had done, a circumstance in the relations of science of the two countries hardly uncommon *now*, certainly not surprising

* We have been in the habit of rather considering the action of the scratches as *negative*, or as being interruptions in the continuity of a smooth and reflective surface, while the untouched interstitial portions of the plate act as centres of undulation of the luminiferous impressions which interfere in the manner stated by Dr Peacock. The furrows in steel or a mother-of-pearl plate in fact perform the same part for reflected light as the opaque wires or threads of Fraunhofer's gratings do when the light is transmitted.

then, when the two nations were engaged in a hot and prolonged war, and when the English language and literature was very little known or appreciated in France. Fortunately for Fresnel he had for a friend and counsellor perhaps the only man in Paris who could have set him right in this matter. Arago was well acquainted with Young's work and his Theory, and had apparently espoused the latter warmly. The two friends had the opportunity soon after (in 1816) of visiting Young in England, and that meeting had no doubt an important influence in stimulating the progress of the Undulatory Theory, which was destined still for many years to be left exclusively in the hands of those friendly rivals. The wonderful phenomena of the Double Refraction and Polarization of Light, which had already for years occupied Young, with reference to their possible explanation upon his theory, now almost absorbed the attention of philosophical opticians. Young had previously advanced one step beyond Huygens in representing the former, and had moreover deduced in some important cases the colours produced by crystals in polarized light from the general principle of interference. But the key to all these complications had not yet been thought of. How light could be a motion in a medium, and yet two motions or rays could be propagated at once in the very same molecules, but with different velocities, was the question. The idea of *transverse vibration*, or waves like those on the surface of a lake, or tremors like those of a vibrating cord, whose rapidity might vary with the plane in which the cord was set to vibrate, was the idea which separately struck Young and Fresnel. In the first volume of the *Miscellaneous Works* before us, are several important and hitherto unpublished letters, illustrating this interesting crisis of discovery, particularly that from Young to Arago, dated 12th January 1817, which contains the following most interesting passage:—

"I have been reflecting upon the possibility of giving an imperfect explanation of the affection of light which constitutes polarization, without departing from the genuine doctrine of undulation. It is a principle in this theory that all undulations are simply propagated through homogeneous mediums in concentric spherical surfaces like the undulations of sound, consisting simply in the direct and retrograde motions of the particles in the direction of the radius, with their concomitant condensation and rarefactions. And yet it is possible to explain in this theory a transverse vibration propagated also in the direction of radius, and with equal velocity, the motions of the particles being in a certain constant direction with respect to that radius, and this is a *polarization*." —(*Miscell. Works*, i., 383.)

In the same year, 1817, Young wrote his very original, but often obscure article Chromatics, for the *Encyclopædia Britannica*, in which he enlarges his explanation of this and other points in Optics. Fresnel, in the mean time, encouraged in his researches by the support of Arago, and the friendly confidence of Young, appears to have arrived independently at a nearly similar conclusion as to the nature of polarized light; though, withheld by the difficulty of clearly imagining and expressing the mechanical conditions of a transverse vibration, he wanted confidence to publish it. His own account of it is as follows:—"Mr Young, more bold in his conjectures, and less confiding in the views of geometers, published it before me, though, perhaps, he thought it after me." From this time Young and Fresnel lived in the most friendly relations to one another, and in their correspondence, a great part of which is preserved in these volumes, freely canvassed their respective views, and the claims of each to the establishment of this great physical theory. In Fresnel's letters we observe some signs of irritability, arising from his fatal disease. In Young's, some inevitable shadows of regret, that a theory which he had for so many of the best years of his life maintained against all the world, and which had been consigned to such undeserved neglect, especially by his own countrymen, should at length rise into notice mainly through the ability of his disciple and successor. Fresnel's Memoirs received one of the highest distinctions which the Royal Society of London can confer—the Rumford medal—in 1827; whilst Young, who had communicated, almost 30 years before, to the same Society the discoveries which formed the basis of future progress, never received any considerable testimony of the intelligent approval of his countrymen. Like Fresnel, however, better understood abroad than by his associates, he was elected one of the eight foreign members of the Institute, the highest distinction to which a scientific man can aspire. But all these distinctions and friendly rivalries were soon to have an end. Fresnel died almost as soon as he had received the testimonials of British sympathy; and Young, though at that time apparently in good health, survived him only two years.

One reason why to Fresnel was in some degree left the undivided credit of pursuing into their farther consequences the beautiful mechanical principles imagined by Young was, that the latter had his attention diverted about that time to another and very different, but not less laborious investigation. This was the interpretation of Egyptian hieroglyphics.

We have seen, that in early life Young cultivated with minute labour the study of Greek, and had acquired a command of that difficult language excessively rare even amongst those who have enjoyed opportunities which in his case were wholly wanting;—that he had a decided turn for Oriental literature;—and that the exhaustive and analytic turn of his mind secured his attention to the general theory of language. His exquisite penmanship, and appreciation of form, also contributed to enable him to compare with facility written characters, and to hit upon cases of essential identity amongst them. The principal charge of editing Young's hieroglyphical writings has been given to Mr John Leitch; and in the third volume of the *Miscellaneous Works* we find republished his principal detached writings (mostly anonymous) on philological subjects; together with a large correspondence with some of the most distinguished scholars of the day, tending to establish Young's priority as to the most essential steps in the process of hieroglyphical interpretation. This was the more necessary from the anxiety with which the claims of our countryman to this notable discovery have been contested by Bunsen and Arago, in favour of Champollion, whose conduct throughout seems so clearly proved by the evidence here adduced to have been disingenuous, that a distinct vindication of Dr Young was peculiarly necessary. Young himself was more alive to his own pretensions, and the injustice and partiality with which they had been received, than in the case of any other of his discoveries. His anxiety on this subject at last induced him to abandon the anonymous method of publication, which he had so long and so uniformly adopted out of regard to the supposed requirements of his profession; and he grounded this change of conduct as much on the claims of the British nation to the glory of the discovery as on his own just rights. As witness the following passage from the preface to his "Discoveries in Hieroglyphical Literature," (1823).

"If, indeed, I have not hitherto wholly withheld from the public the results of my inquiries, it has not been from the love of authorship only, nor from an impatience of being the sole possessor of a secret treasure; but because I was desirous of securing, at least for my country, what is justly considered as a desirable acquisition to every country, the reputation of having enlarged the boundaries of human knowledge, and of having contributed to extend the dominion of the mind of man over time, and space, and neglect, and obscurity. *Corona in* SACRIS CERTAMINIBUS *non victori datur, sed* PATRIA *ab eo coronari pronuntiatur.* And whatever vanity or enthusiasm there might be in this sentiment, it was at least sincere and unaffected. In the mean time, my Egyptian investigations had been as laborious as they had been persevering; and like many other pursuits in which I have been engaged, they had been so little enlivened by any fortunate coincidences, or unexpected facilities, that having to adopt a motto for the signatures of some anonymous communications, I had chosen the words, FORTUNAM EX ALIIS as appropriate to my own history."

In fact, his numerous articles in the *Encyclopædia Britannica* had for signatures two letters from the preceding motto, constantly varied.

The reader who has acquired a just perception of the noble integrity and SENSE OF JUSTICE by which Young was constantly animated, will need little proof beyond his own distinct averments (repeated in his articles, and especially in his private correspondence), that the priority on all great and fundamental points of interpretation rested with himself, and not with Champollion. The fairness with which he constantly treated that clever rival and disingenuous ally, is evident from the testimony he always bears to the value of his researches, and to his own feeling of gratification, that he himself (Young) should leave the subject of his predilection in the hands of a younger man so capable of carrying it to perfection. And these expressions are not mere complimentary phrases put forth in his publications, but are interwoven with the familiar letters in which he at the same time stoutly maintains his own literary rights.

The defence of Dr Young's claims has been taken up, not only by Mr Leitch, but by Dean Peacock, who has devoted a very interesting chapter of the "Life" to a condensed account of this memorable discovery, and the controversy which ensued upon it.

Dr Young's memorable attempt to decipher the inscription of the celebrated Rosetta Stone, dates from November 1814. That inscription, as is well known, consists of three co-ordinate parts, or translations : one in proper Hieroglyphics, one in Ancient Egyptian, or *enchorial* characters (equally undeciphered), and the last in Greek. The first and last are incomplete. A most interesting account of his process of comparison of these documents was given by Young himself (*Miscell. Works*, iii. 129, &c.). Though far from exact or complete, it was the foundation of all his subsequent discoveries, which were steadily pursued with a degree of labour and method which could only be guessed at, until Dr Peacock had given us an account (*Life*, pp. 279, 280) of the manuscripts, which still remain in proof of them. In 1816, Dr Young printed some letters on the progress of his system of interpretation, and in 1818, wrote the very remarkable dissertation, "Egypt," which appeared in the Supplement to the Encyclopædia Britannica in the following year. It was only in 1821 that the younger Champollion published at Grenoble a work on Egyptian literature, which, having been carefully suppressed, is now little known, and which is equally remarkable for the suppression of what he *had* borrowed from his predecessors, and for the proofs it contains of his ignorance or want of appreciation of Dr Young's principles of interpretation, which he (Champollion) afterwards claimed as exclusively his own.

Dr Peacock very correctly refers to this suppression of his memoir as an unjustifiable act, when it tended to compromise the rights of priority of others. He afterwards narrates, as follows, Champollion's further proceedings :—

"We have already seen, that, in 1821, Champollion denied altogether the existence of an alphabetic element amongst the hieroglyphics. But in the following year, we find him adopting the whole of Young's principles, and applying them with one modification only. Like him, he refers to the expedient resorted to in the Chinese language for the phonetic expression of foreign appellations; like him, he regards the rings as marks of the phonetic use of the characters which they include, whether of royal or private personages, whether domestic or foreign; like him, he supposes the phonetic power of the symbol to be derived from the initial letter or syllable of the name of the object which it expresses in the Egyptian language; but he differs from him in considering that such phonetic character could express more than a simple letter, or the syllable formed by it when followed by a short vowel; and he only notices, for purposes of criticism, those applications which Young had made of this principle, where the phonetic power of such a symbol was extended to a syllable, like the Coptic name of the Basket, βιρ, in phoneticising the hieroglyphical name of Berenice. It would be difficult to point out, in the history of literature, a more flagrant example of disingenuous suppression of the real facts bearing upon an important discovery, where principles, too peculiar in their character to have occurred independently to two different minds, are adopted without the least acknowledgment, though circumstances proved incontestably that they were neither known nor thought of at a time immediately antecedent to the perusal of the very work in which they were announced and exemplified; where the conclusions in one work were passed over without notice, when they were precisely the same as those which were adopted in the other, but invidiously criticised, where an erroneous or somewhat too extended application of them afforded a handle to lay hold of for the purpose of establishing a claim for entire originality. It was in a very different spirit that his illustrious countryman, Fresnel, with much higher pretensions to independent research and discovery, at once abandoned the claims of priority, when he found that he had been anticipated by Dr Young."—(*Life*, p. 299.)

"It has been too much the custom," adds the Dean, in another place (p. 288), "with writers on hieroglyphical discoveries, to estimate their value, less by a reference to the state of knowledge at the time they were made, than by a much more advanced state of its progress; to compare, in fact, the views of Champollion in 1824 and 1830, or of Lespius and Birch at a much later period, with those of Young in 1819, instead of duly considering the influence which the investigations and speculations of an earlier, thus unfairly weighed against those of a later age, have had upon the establishment of more correct, because more natural conclusions. It is this spirit of injustice which can hardly fail to be observed, whenever Champollion, or Bunsen, who has usually followed in his footsteps, have had occasion to notice or criticise the labours of Dr Young."

Of the historical injustice of which Arago and Chevalier Bunsen have been guilty towards Dr Young, both the editors of the volumes before us have spoken with manly frankness. Few persons wholly disinterested have ever put much faith in the decisions of Arago on questions of priority, particularly if national or personal claims were concerned Dr Peacock deals gently with him in the following passage:—

"It was not the only instance in which the passion of this powerful and eloquent writer, for signalising what he considered the great epochs in discoveries in various departments of science, has led him to erroneous and unjust decisions, when their progress has been more indebted to continuous and patient labour, guided by just principles of reasoning and philosophy, than to any sudden outbreak of genius, which has superseded the rules which ordinary men must be compelled to submit to."—(*Life*, p. 344.)

The adverse testimony of Bunsen will go farther with English and German readers. That he "learned from Champollion the first rudiments of hieroglyphic lore at the foot of the obelisks of Rome," will not be accepted as the justification of a partial decision. The scattered and anonymous mode of publication adopted by Young is a better excuse. By the present collection of his works, this excuse has ceased; and Chevalier Bunsen will, we think, feel himself compelled, by the evidence they contain, to reconsider his judgment.

We regret that our limits prevent us from entering at all into the vast amount and variety of original scientific research contained in these memorials of Dr Young. They are equally worthy of consideration by the student and the historian of science. We conscientiously believe that no writer on science, except Newton, has ever left so large a mass of well-compacted results of hard thinking and acute induction as to natural laws, with so very inconsiderable an admixture of error, as Thomas Young.

Insecta Maderensia. By T. VERNON WOLLASTON. London: J. Van Voorst, 1854. 4to.

Nature never repeats herself. A fossil species appears scantily for the first time in some particular stratum,—it becomes more plentiful in the strata immediately above it,—would there appear to reach the maximum development of its numbers, and as we ascend in our examination of the strata we see it becoming scarcer and scarcer, and thinning out till it gradually disappears, never to revive. And this is quite in accordance with what we see around us. Even in the continuation of species Nature seems to abhor repetition. Of all the myriads of the human race which have been born since the world began, we do not suppose there have been two individuals exactly and in all respects identical in form; and although the difference in the lower animals is less obvious to us, it is not less true that it exists. If this is the case even in the individual units of a species, how much more certainly may we rest assured that no repetition will take place in the creation of a species or a genus.

It is as a corollary to this position, that the doctrine of *specific centres*—that is, the existence of certain geographical points from which the individuals of each species have been diffused—may be taken, indeed necessarily follows.

Professor Edward Forbes, in his admirable Memoir "on the Geological Relations of the existing Fauna and Flora of the British Isles," published in 1846 in the Memoirs of the Geological Survey of Great Britain, advanced a step farther. Taking the doctrine of specific centres for granted, he deduced the following position from it, viz., "The specific identity, to any extent, of the flora and fauna of one area with another, depends on both areas forming or having formed part of the same specific centre, or on their having derived their animal and vegetable population by transmission through migration over continuous or closely contiguous land, aided, in cases of alpine floras, by transportation on floating masses of ice." In other words, that whenever in any country we find a species of plant or animal which is identical with the species of another country, these two countries must at some time have been continuous, unless we can account for the presence of the species by migration or introduction. This position has all the qualities of a truly philosophic theory. Its application is simple, broad, and universal,—the presence of one species (however minute) unaccounted for, is as good as the presence of a thousand; and the theory has found favour with the scientific world from the first. Not that it has not had its opponents, and that many startling and not yet accounted for instances have been brought forward in opposition to it; but the more it has been examined, and the more that facts have been looked at with reference to its truth (illuminated by its own light, as it were), the more it has been found to be consistent with truth.

This proposition was brought forward by Professor Forbes in illustration and support of his speculation, that the groups of Atlantic Isles were at one time connected with the Mediterranean district of Europe and Africa, and also with the west of Ireland. The speculation not being directly connected with the subject he was discussing, the Professor has not gone minutely into the evidence in support of it, contenting himself with briefly summing up (in a note) the results drawn from the flora of these countries. Mr Wollaston's work gives us additional reliable information, and we shall look at the inquiry a little more in detail.

To begin with the Botany, the evidence adduced by Professor Forbes for the connection of the west of Ireland with Spain and Portugal, was the existence in it of species peculiar to it and these countries, particularly Asturia, such as *Arabis ciliata* and *Pinguicula grandiflora*, and other forms, whose occurrence there could neither be accounted for by any existing distribution of marine currents, nor by dissemination through the air, the plants in question not having seeds adapted for such a mode of transmission, while if they had, they would not have been confined to the spot in question.

With regard to the Atlantic groups of Islands (Azores, Madera, Canary Isles, and Cape de Verde Isles), with which we have more particularly to do, their floras are all closely related to those of the nearest mainland, and are also to some extent mutually related, through endemic plants, to each other.

The Rev. R. T. Lowe, in his "Memoirs on the Ferns, Flowering Plants, and Land Shells of Madera and Porto Santo," thus speaks of the flora of Madera. "The general character of the vegetation of Madera is in correspondence with the equivocal geographical position of the island. It is that of a type intermediate between the forms of the south of Europe, bordering on the Mediterranean basin (more particularly on the African or southern side), and those of the Canary Islands. Comparing it with the vegetation of more Northern Europe, the most striking features are the presence by naturalization, in the lower or maritime regions, of tropical forms, such as the banana, prickly pear, date palm, rose apple, &c., and the almost utter absence in the higher parts of the island of the alpine. Comparing it again with the vegetation of more tropical Africa, we have, higher up the country, forests of laurels, heath, and whortle berry (*Vaccinium padifolium* Sm), in the place of Adansoniæ and palms; grassy mountains instead of those sandy plains, whose only plants are a few wretched *Zygophylla* or *Mesembryanthema;* brooms and myrtles feathering the hills, or the precipitous sides of the ravines, in exchange for the lonely bushes of the tamarisk, *Capparis*, *Acacia*, or *Mimosa*, which sprinkle the arid wastes and rocky defiles of the Mauritanian or Arabian deserts; whilst a few shrubby *Euphorbiæ*, *Semperviva*, and *Seda*, but scantily represent those vast succulent tribes of *Euphorbiaceæ*, *Crassulaceæ, and Asclepiadaceæ*, of more Southern Africa."

The connection between the Azores and Madera seems much greater than between Madera and the Canary Isles. "Out of 596 species of flowering plants inhabiting Madera and Porto Santo 108 are endemic; out of the 108, 28 are common to Madera and the Azores. In the Flora Azorica of Seubert 400 (flowering and flowerless) plants are enumerated, of which 50 are stated to be endemic and peculiar to the Azores, 34 extra European, including 23 common to the Azores and Madera, or the Canaries, and 316 European." "Speaking in round numbers, we may say that four-fifths of all the species now wild in the Azores, are wild also in Europe; of the remaining one-fifth, nearly the whole numbers are peculiar to the Azores or the Archipelago of the Atlantic Islands, which includes also Madera and the Canaries. Some have migrated (?) to the Azores from the continents of Africa and America."* But

* Professor Forbes's Memoir.

of the Canaries, Mr Lowe says, "If Madera has imparted some of her peculiar plants to the Canaries, she has received scarcely one from them. In other words, to some indigenous Maderan plants occurring in the Canary Islands, there is added a multitude of characteristic and peculiar species not found in Madera." We shall presently see this still more strongly exhibited in the insects of these Isles.

Before leaving their Botany, however, we must notice an interesting circumstance mentioned by Mr Lowe, regarding the Island of Porto Santo, one of the Maderan group, which lies to the north-east of Madera, and nearer to the Mediterranean districts. He says the neighbouring isle of Porto Santo approaches still more in the character of its vegetation to the southern borders of the Mediterranean basin than to Madera itself. But its present condition in this respect is one of much deterioration, and it is probable, both from the traces that actually remain, as well as from the obscure and apocryphal annals on such points of Portuguese physico-topographic literature, that its former original state of vegetation assimilated still more closely, as to truly indigenous plants, than it now at first sight seems to do with the present condition of Madera.

Next to plants, insects are the creatures most likely to furnish us with evidence of the original state of created life in any country; and our information regarding their distribution in two of these island groups and the neighbouring continents, is now pretty full. The entomology of Europe and the north of Africa, it is unnecessary to say, is well known. Mr Wollaston's work (so far as relates to the order to which his published volume is confined, the Coleoptera) leaves nothing to be desired for Madera; and Messrs Webb and Bertholet's great work on the Canary Isles, although the entomology in it, is not to be compared to Mr Wollaston's, either for extent of investigation or careful description, gives us a very fair amount of knowledge regarding the insects of these islands. Remain the Azores and the Cape de Verde Islands, of which our entomological information is still very imperfect. From these sources we see, first, as regards the Coleoptera, that Mr Wollaston has recorded 482 species as found in Madera—of which 281, or more than one half are peculiar to Madera and the Maderan group. The remaining 201 are composed partly of insects generally distributed over Europe, but for the most part inhabiting the district known as the Mediterranean province, viz., the south of Europe and north of Africa, and Mr Wollaston points to Sicily, as showing more affinity to the insect fauna of Madera than any other single country. He also notices some slight collective assimilation with what we observe in the south-western extremity of our own country, and of Ireland, nearly all the species which are common to Madera and the British Isles, being found in those particular regions; and he specially draws attention to one species almost identical with the *Mesites Tardii*, Curt., which is peculiar to the west of Ireland, and south-west of England. Whether it is specifically distinct or not, we cannot form an opinion for ourselves, not having seen the new species, *M. Maderensis*, Woll.; but judging from Mr Wollaston's description, we should say with him that it was, but still so near as almost to pass for a variety modified by climate, locality, or food,—(the food of the Irish species, being the holly, and that of Maderan species, the laurel).

We do not find that the insects of Porto Santo (like the flora mentioned by Mr Lowe) show a greater preponderance of Mediterranean forms in that island than in Madera. It has a slight proportion (about a sixth) more than its share—but that proportion does not necessarily prove even that amount of preponderance. Mr Wollaston acknowledges that Porto Santo (although carefully examined) was not so thoroughly investigated as Madera proper, nor at all seasons of the year.

The most striking part of the entomological fauna of the Maderan group, however, is undoubtedly its endemic species. The very large proportion of such species is of itself striking, and their character is not less so. It has been observed that when endemic species are found in an isolated spot, not very distant from an extensive country, these species are found to bear what may be called a relationship or family likeness to the species of the greater country. The Gallapago Islands is an example of this. "Most of the organic productions," says Darwin, "are aboriginal creatures found nowhere else—there is even a difference between the inhabitants of the different islands, yet all show a marked relationship with those of America, though separated from that continent by an open space of ocean between 500 and 600 miles in width. The Archipelago is a little world itself, or rather a satellite attached to America, whence it has derived a few stray colonists, and has received the general character of its indigenous productions." The Atlantic groups furnish us with another instance of the same thing. The endemic species both of the Azores and Madera, have more affinity to those of Spain and Portugal, Sicily, and the Mediterranean provinces generally, than to those of any other country. It is as if the creative power acted according to the same law over a wide area.

The existence of certain species peculiar to one island, and not common to the whole group, is a fact observed by Mr Wollaston in the Maderan group, equally as by Mr Darwin in the Gallapagoes.

We have not the means of estimating what amount of insects endemic to the Atlantic groups, are common both to the Azores and the Maderan group. Judging from the flora we should expect that there would be several. As to the Canaries, so far as we have been able to discover, there would appear to be not a single instance of a species endemic to Madera being found in the Canary Isles, or of a species endemic to the Canaries being found in Madera. We were not prepared for this; we did expect to find a few common to both. When we first took Mr Wollaston's work into our hands, and turning it over for the new species, found not a single one followed by the letters *Br.*, marking that the species had been described by M. Brullé, who executed the entomological part of Webb and Bertholet's work, we thought that Mr Wollaston had surely overlooked or confounded some of the species; and it was only after we had gone carefully over both works, and compared every new species in both groups with each other, that we were compelled to come to the conclusion that Mr Wollaston was right, and that *none* of the endemic species of either island are to be found in the other. In saying so, we do not overlook such species as *Calosoma Maderæ* Fab., which is undoubtedly found in both groups. But we do not consider it to be a distinct species, but merely a variety of *C. Indagator*, Fab. Neither do we overlook such species as *Olisthopus Maderensis* of Wollaston, which he seems to think may turn out to be *O. glabratus*, Br.; but as the only ground for his hesitation is that Brullé's description is short and perhaps defective, and does not negative some salient points in the character of the species, we readily confirm his judgment, and adopt the species as distinct. Abstracting these and such like, we do not find a single endemic species of either group of isles common to both.

Another very interesting point to be noticed in relation to these species, is the number of new generic forms found in Madera, as contrasted with the Canaries. Mr Wollaston constitutes no less than 41 new genera; and although in one or two instances, to which we shall presently revert, we think he has established them on insufficient grounds, there still remain between 30 and 40 undoubtedly new genera, to which no exception can be taken; whereas in the Canaries, M. Brullé has not found a single type of a really new genus, unless it be of two species of *Silpha*, which might be constituted into a sub-genus akin to *Phosphuga*.

As to the distribution of species found in the Canaries, M. Brullé remarks, that it is with Algeria, Spain, the south of France, and Greece, that these isles have most relationship; although they have also some connection with Egypt and Senegal; and like Madera and the Azores, possess a number of the more northern species found in Britain and the greatest part of Europe. We also find one or two American forms, such as *Trogosita Pini*, Br. The total number of species of Coleoptera recorded by Brullé is 181, of which 70 are new, the largest proportion of which are *Heteromera*. And perhaps here is the place to give a glance at the proportions in which the particular families of Coleoptera are found in these groups of islands. Mr Wollaston dwells with interest upon the almost total absence of some of the principal families in Madera. He says, "not so much as a solitary witness of the *Cicindelidæ*, *Buprestidæ*, or *Pselaphidæ*, has hitherto been brought to light; whilst the great genera, *Carabus*, *Nebria*, *Silpha*, *Necrophorus*, *Cetonia*, *Telephorus*, *Tentyria*, *Pimelia*, *Acis*, *Asida*, and *Otiorhynchus*, are altogether wanting. The vast race of Thalerophagous *lamellicornes*, as also the immense department of the *Elateridæ*, are represented apparently by but a single form; as are also the *Silphidæ*, *Telephoridæ*, *Tentyriadæ*, and the *Œdemeridæ*." The numbers of the *Hydradephaga* and *Longicornes* are also in unusually small proportion. The causes for such distributions is an interesting topic, upon which, if we had space, we should like to enlarge. We think we could show reasons for many of the anomalies in the distribution of insects in countries of different habit and climate;—as, for instance, in a country where the vegetation is excessively rapid, that there should be fewer carnivorous insects to keep the number of vegetable feeders within bounds;—in a country where a carcase, if left to itself, would dissolve into liquids and aerial products in the short space of a day or two, there should be no *Necrophori*, or burying beetles;—and, as Mr Wollaston shows, in regard to the scarcity of water-beetles in Madera, that there it is sufficiently accounted for by the rapid nature of the rivers, which are liable to sudden inundations from the mountains, and to deposit their contents in positions distant from their banks, or to pour in ceaseless torrents over the perpendicular faces of the rocks.

The following comparison with the Canary species, however, goes to show that the absence of several of the genera or families in Madera is probably not owing to any special cause, but is merely accidental.

Genera.	Madera.	Canary Isles.
Cicindela, . . .	0	1
Carabus, . . .	0	3
Nebria, . . .	0	1
Silpha, . . .	0	2
Necrophorus, . . .	0	0
Cetonia, . . .	0	1
Telephorus, . . .	0	0
Tentyria, . . .	0	3
Pimelia, . . .	0	8
Hegeter, . . .	1	12
Asida, . . .	0	0
Otiorhynchus,* . .	0	3

* The *Otiorhynchi* in Madera are represented by *Laparocerus* and its congeners.

FAMILIES.	Madera.	Canary Isles.
Elateridæ, . . .	1	0
Hydrocantharidæ,* . .	0	1

* Of all the Coleoptera, the *Hydrocantharidæ*, or water-beetles give the rudest challenge to Professor E. Forbes's theory. They are more widely and extensively distributed than any other tribe. Many of them bear testimony to the ancient junction of lands as to whose former continuity there can be little doubt, such as North America and Siberia, Mexico and the West Indies, Madagascar and the south of Africa. Others, however, if their presence is to be held unaccounted for by introduction or migration, would infer the junction of Madagascar and the East Indies and Philippine Islands; the junction of China and Australia with these islands, and even their junction with Peru. We may adduce one or two examples of this; the general correctness of which may be relied on, as they are in a great measure taken from the published catalogues of the contents of the British Museum, (works which are of the greatest value to the scientific naturalist). For instance,—

1. Both in North America and Siberia, Asia and North of Europe, there are to be found *Dytiscus Ooligbukii* (Kirby); *Hydaticus zonatus* (Hoppe); *Ilybius 4-maculatus* (Aubé); *Agabus tristis*, (Aubé); *A. femoralis* (Payk.); *A. congener* (Payk.); *Gyrinus marinus* (Gyll.).

2. In Mexico, South of North America, West Indies, and Brazil, are found *Cybister lævigatus* (Oliv.); *Acilius incisus* (Aubé); *Colymbetes calidus* (Fab.); *Copelatus posticatus* (Fab.); *Hydrocanthus nigrinus* (Aubé); *Laccophilus proximus* (Say).

3. North and South Africa and Madagascar and the Isle of France are united by the following:—*Gyrinus abdominalis* (Aubé), Turkey, Cape of Good Hope; *Cybister africanus* (Lap.), Sicily, Sardinia, North Africa, South Africa; *C. senegalensis* (Aubé), Senegal, South Africa, Madagascar, Isle of France; *Hydaticus sobrinus* (Aubé), Madagascar, Isle of France; *Hydaticus bivittatus* (Lap.), Isle of France, Madagascar, Senegal; *Copelatus pulchellus* (Klug,), Senegal, Isle of France; *Hydrocanthus guttula* (Aubé), Isle of France, Madagascar; *Hyphidrus impressus* (Klug.), Madagascar, Bourbon, Isle of France; *Dineutes premorsus* (Fab.), Bourbon, Isle of France; *Dineutes aereus* (Klug.), Nubia, Congo, and Cape de Verde Islands; *Orectochielus costatus* (Aubé), South Africa, Madagascar.

4. Again, we find these African lands and dependencies united to the East Indies and Philippine Islands, &c., by the following, viz.:—*Cybister tripunctatus* (Oliv.), Isle of France, East Indies, Java; *Eunectes griseus* (Fab.), nearly cosmopolitan—Europe, Egypt, Algeria, Senegal, East Indies; *Hydaticus Fabricii* (M'Leay), Senegal, Cape of Good Hope, Madagascar, East Indies, and Philippine Islands; *Hydaticus vittatus* (Fab.), East Indies, Java, Hong-Kong, &c.; *Laccophilus posticus* (Aubé), Isle of France, Philippine Islands; *Orectocheilus specularis* (Aubé), Sierra Leone, Guinea, East Indies; *Dineutes micans* (Fab.), Guinea, East Indies; *D. subspinosus* (Klug.), Arabia, Nubia, Senegal, Madagascar, Isle of France, East Indies.

5. A farther connection can be established between these eastern lands and Australia and New Zealand, and even Peru. Thus, *Gyrinus striatus* (Fab.), South of Europe, Barbary, Canary Isles, Madagascar, Bourbon, Australia; *Dineutes australis* (Fab.), Hong-Kong, Philippine Islands, Australia; *Gyrinus ellipticus* (Brullé), Isle of France, Peru, Chili, Brazil. And,

6. *Colymbetes notatus* (Fab.), is found both in Europe (Britain) and New Zealand.

These are startling connections, but the consideration of two points will, we think, go far to satisfy us that they are not inconsistent with Professor Forbes's theory. The first is, that from their constitution, and the medium in which they live, the water-beetles are better adapted to bear extremes of climate than other insects, and that thence they might extend their range through climates which would prove barriers to other species, and can bear differences of temperature which would destroy others. Hence we may infer that the water-beetles are the most ancient insect creations now existing on the face

Of the *Orthoptera*, Brullé notices twenty-four species already known, and thirteen new; of *Hemiptera*, twenty-nine known and eight new; of *Neuroptera*, ten known and three new; of *Hymenoptera*, exclusive of the Ichneumons and Chalcidites, thirty-two known and the same number new; of *Lepidoptera*, he records about forty, mostly already known in Europe, except four of Egypt and Senegal, one new *Polyommatus* and several nocturnal *Lepidoptera*; of *Diptera*, sixty known and forty new. Those known are, for the most part, rather from Europe (particularly Portugal) than from Senegal.

We have, unfortunately, not the means as yet of giving similar information regarding these orders in the other groups of islands.

As regards the mammalia, the species are chiefly, if not all introduced. In the birds, however, we find the same condition of things prevailing as in the plants and insects. There are some species endemic to the islands, but the greater number are also natives of the Mediterranean province.

As to the mollusca, very similar geographical relations prevail with them. According to D'Orbigny, out of one hundred and ninety-six species found at the Canaries, nearly the half belong to the Mediterranean—about a tenth to the pelagic animals of the Equatorial high seas—about an eighth to the west coasts of Africa, and a third are peculiar to the Canaries themselves.

From an enumeration, with descriptions of the land mollusca of Madera, published in 1851, by the Rev. R. T. Lowe, we find out of seventy-one species found by him, forty-four were new. That of these seventy-one, no less than sixty belong to the genus *Helix* alone (including its sub-genera), while in Great Britain there are only about forty-five species. With this extraordinary excess of numbers in regard to the terrestrial mollusca in favour of Madera, the only fresh-water species found by Mr Lowe were *Ancylus fluviatilis*, *Drap.*, and *Linnœa minuta*, *Drap.* Speaking of the distribution of the twenty-seven known species, Mr Lowe remarks, " Did we possess any exact knowledge of the species indigenous to the northern parts of Africa, it may be thought that a chain might be traced, as in the plants from the Canaries through Madera to that region; and thence by the south of France and Europe generally to Great Britain and the North. It is, however, unfavourable to this hypothesis, and in itself very remarkable, that an extensive collection of *Helices* from the Canaries, contributed by Mr Webb, teaches that Madera has at least as little connec-

of the earth. The other consideration is, that although, perhaps, at first sight a water-beetle may not seem a very probable insect to be introduced by man, still, in point of fact, there are few classes of insects more likely to have their range extended in this way. A ship fills its water-casks at a stream or well in one country;—if they are not exhausted by the time it reaches its destination in another, the old water is started out, and the casks again filled, so that, supposing a few larvæ or eggs of water-insects to get into the barrels when being filled, they may be introduced as colonists into any quarter of the globe.

tion in this respect with the Canaries as with the south of Europe, and stands, as it were, isolated in great measure with respect to both." The Canary Islands have actually more species in common with the south of Europe than Madera has, and Madera has not more than five or six at most in common with the Canaries.

Of the *Echinodermata*, there are forty-two species at the Canaries, of which seventeen are proper to the Mediterranean, eleven proper to the Mediterranean and to the shores of France on the Atlantic Ocean, and fourteen special to the Canaries and the coasts of Africa.

Of the *Foraminifera*, D'Orbigny records forty-three species in the Canaries; of these thirty-three are proper to the Canaries; seven inhabit also the coasts of France and the Mediterranean. D'Orbigny supposes these may have been transported by the winds or by the keels of ships, but we are not altogether disposed to get rid of the difficulty in such a summary way, the rather that when we look at the next group, the fishes of these islands, we find a similar anomaly, which we cannot get rid of in the same way. M. Valenciennes says, "The ichthyology of the Canary Isles offers several kinds of interest to general zoology. That Archipelago, situated at the entrance of the great basin of the Atlantic upon the coast of Africa seems rather to connect by the fishes which it nourishes, the coasts of the American continent to the basin of the Mediterranean than to the coast of Africa. It is not only then, on account of the number of new species that it is interesting, but because the *mixture of American forms with those of the Mediterranean* will throw fresh light over the question of the distribution of species over the globe. The *Priacanthus*, the *Beryx*, the *Pimelepterus*, the great *Caranxes* (horse mackerel), the mackerels all of American forms are found at the Canaries, and the resemblance of several species is so much more remarkable that it takes place in fishes which cannot be reckoned among the wandering species. The *Pimelepterus incisor* is one of the best examples to cite." He further observes, that there does not appear to be so many American species at Madera as at the Canaries; and he adds,—"The resemblance between the ichthyology of these islands and St Helena and Ascension Island, again offer another interesting consideration. It shows that the fishes are much more removed from the coasts of the two great continents bathed by the Atlantic, than one would have supposed. In fine, as we do not find at the Cape of Good Hope the American species which reach to the Canaries, and that notwithstanding we observe there a sufficiently great number of Mediterranean species, one would be induced to think that in the distribution of species of fishes, the configuration and the nature of the coast have more influence upon the life of those animals, than the degree of heat due to the latitude of the countries."

We confess, we should rather be disposed to seek for an explanation of the problem in an alteration of the geographical features of those parts of the globe, and some of the recent zoological discoveries on the west coast of Africa, and particularly in the Bight of Benin, give force to a view which the peculiarities of the Canaries first suggested to us. On that coast, a number of American forms have lately been discovered,—a long-tailed Hystrix (the porcupines of South America being the only long-tailed porcupines previously known), and a number of species of insects from Old Calabar, lately received, prove to be of South American forms, and one longicorn at least (*Mallodon Maxillosus*, Fab.), seems identical with the South American species. It is also to be observed, that many marine plants and animals are common both to the coasts of South America, and South Africa. The range of such species, as laid down in Johnston's Physical Atlas, seems to be from the Cape of Good Hope up to the Canary Isles. Let us see if any other arrangement of the land and water of that part of the globe would account for such facts. Professor Edward Forbes carried his speculation as to the connection of Ireland and the Mediterranean district with the Atlantic groups, to the extent of supposing a great continent filling up the bed of the Atlantic, till it reached the great bank of gulf-weed. As his speculation is very ingenious, and will serve as a step towards the explanation of the problem which has stopped us, we shall make no apology for quoting his remarks :—" My own belief is," he says, " that a great miocene land, bearing the peculiar flora and fauna of the type now known as Mediterranean, extended far into the Atlantic, past the Azores; and that in all probability, the great semicircular belt of gulf-weed ranging between the 15th and 45th degrees of north latitude, and constant in its place, marks the position of the coast-line of that ancient land, and had its parentage on its solid bounds ;" and, with relation to this, he quotes the following passage from *Harvey's Manual of British Algæ*,—" Authors who have written on this *Fucus* (the gulf-weed), have much disputed, both respecting its origin, and whether it continues to grow while floating about. Nothing at all bearing on the former question has yet been discovered ; for though species of *Sargassum* abound along the shores of tropical countries, none exactly corresponds with *S. bacciferum*. That the *ancestors* of the present bank, have originally migrated from some fixed station, is probable ; but further than probability we can say nothing. That it continues to flourish and grow in its present situation is most certain. Whoever has picked it up at sea, and examined it with any common attention, must have perceived, not only that the plants were in vigorous life, but that new fronds were continually pushing out from the old, the limit being most clearly defined by the *colour*, which, in the old frond is foxy-brown ; in the young shoots, pale transparent olive. But how is it propagated, for it never produces fructification? It appears to me that it is by breakage. The old frond which is exceedingly brittle, is broken by accident, and the branches continuing to live, push out young shoots from all sides. Many minute pieces that I have examined, were as vigorous as those of larger size but they were certainly not seedlings, and appeared to me to be broken branches, all having a piece of *old frond*, from which the young shoots sprung. As the plant increases in size, it takes something of globular figure, from the branches issuing in all directions, as from a centre. On our own shores we have two species, analogous to *S. bacciferum* in their mode of growth, namely *Fucus Mackayi*, and the variety *B. sub-ecostatus* of *Fucus vesiculosus* (*F. balticus* Ag.). Neither of these has ever yet been found attached, though they often occur in immense strata; the one on the muddy sea-shore, the other in salt marshes, in which situations respectively, they continue to grow and flourish; and it is remarkable, that neither has ever yet been found in fructification, in which respect also they strikingly coincide with *S. bacciferum*. And if it be hereafter shown that *F. Mackayi* is merely *F. nodosus*, altered by growing under peculiar circumstances, may it not be inferred that *Sargassum bacciferum*—which differs about as much from *Sargassum vulgare*, as *Fucus Mackayi* does from *Fucus nodosus*—is merely a pelagic variety of that variable plant." Professor Forbes adds,—"My friend and colleague, Dr Joseph Hooker, who has had great opportunities of studying the gulf-weed, believes with Dr Harvey, that the *Sargassum bacciferum* is an abnormal condition of *Sargassum vulgare*. Now, as the latter is essentially a coast-line plant, growing on rocks, with a very limited vertical range, I propose to account for its abnormal condition as *Sargassum bacciferum* in the gulf-weed bank, on the supposition of the *submergence of the ancient line of coast on which it originated*." "The fact that there is a well-marked belt of miocene coast-line in North America (as shown by Mr Lyell), and that the mollusca of that belt, as I have convinced myself from personal examination, indicate a representative, not identical fauna in that region, proves that during the miocene period, there was an Atlantic gulf separating the new world from the old, and favours the notion that the coast-line of a post-miocene European land would be somewhere in the central Atlantic, about the position of the great Fucus bank. The probability of the ancient existence of such a land, is further borne out by the fact, that the floras of the groups of islands between the gulf-weed bank, and the main land of the old world, are all members of *one* flora, itself a member of the *Mediterranean type*, and only peculiar in as much as certain endemic species are present, many of which are common to the Azores, Madera, and the Canaries."

Following out this line of thought, let us suppose the north-eastern coast of South America advanced to meet this ancient European miocene land, so near as to have only a sea of moderate extent and of no great depth between them.* This will be quite in accordance with the traces of coast left by the gulf-weed; for, besides the great bed to which Professor Forbes refers, there is another smaller bed in front of the south-east of the Mexican Gulf or north-west of South America, and a connection is traced between the two beds all across that portion of the Atlantic.† Such an arrangement would still give us the Atlantic north of the 45th degree of north latitude, stretching across from the great gulf-weed bank to North America, but south of that the two continents of the old and new world, not actually joined together, but approached so near, and connected perhaps so closely by islands and with so shallow a sea, as to allow the same marine plants and animals to find their way to either side, but still at such a distance as not to allow a commixture of the land animals or flora—leaving the resemblance or *representation*, in the few when it is found, to be accounted for by the relationship arising from proximity at the time of creation,—an influence which would cease to act when the proximity in question ceased to exist. But it seems to be one of the laws of this planet, that whenever a depression or a rise in one part of its crust takes place, a corresponding converse rise or fall must take place in some other part. It is not an empty ball which can collapse. If, therefore, we suppose such a great mass of land to have been of a higher level than now exists, we must admit a corresponding lowering somewhere else, and this is just what we want to complete our theory—we want some other passage between the Mediterranean and the seas of the Cape of Good Hope to allow the Mediterranean fishes which are found there to make their way to it. A very trifling depression of the African continent would place the Saharan deserts and the great plains in the south of Africa under water, and there might be an uninterrupted passage from the Mediterranean to the Cape by seas and straits of which we do not dream.

But the general considerations suggested by Mr Wollaston's work have led us away from the work itself, and the manner in which it has been executed, and we should not like to close our remarks without bearing testimony to its excellence. The book, so far as outward finish goes, bears more resemblance to the admirable works which are brought out by ourselves, and more especially by our neighbours, under the sanction and at the cost of government. It is obviously the work of a man of gentlemanly tastes and instincts—the paper, the typography, the plates, and

* We here speak only of the north-eastern coast of South America. There are geological reasons against supposing such an approximation of the coasts further south, as where the great plains of the Pampas, &c., are found.

† Johnston's Physical Atlas.

the general style, all speak of a man who likes to have "every thing handsome about him;" and it is no slight praise to say, that the composition and scientific part is on an equal footing with its external appearance. The descriptions of species are most carefully and clearly drawn up, and the notes and observations upon them are calculated to make the subject as interesting as descriptions of insects can well be. Besides, by not confining his descriptions to new species, but embodying descriptions of all the species found in Madera, he fully adapts his work for the use of whoever wishes to take up the study of Maderan insects—in fact, gives in one volume all that the resident in Madera requires to know on the subject; so that the invalid who resorts to entomology as an occupation for the hours that hang heavy on his hand, may follow out his pursuit with all the advantages which a large and valuable entomological library could otherwise alone have given him. And what is of great advantage to beginners, he may attempt to make out his species with almost the certainty of finding them described in this work; for Mr Wollaston's industry and talents as a collector (even though we were not otherwise aware of them), pierce through every page of the book. But while we acknowledge its merits so fully, we do not mean to say that there is nothing in which we do not differ from him. The point which is most open to criticism in a work of this kind is, of course, the new species and genera constituted by the author. Now, we must admit that, so far as we have had an opportunity of examining specimens in nature of Mr Wollaston's species, they appear to be sound, and he seems to have avoided the vice into which too many of our English entomologists have fallen, viz., becoming species-makers. But we are not quite so well satisfied with all his new genera. Most of them, we admit, are well cut, and possess forms and characters distinctly entitling them to a place as genera, but some of them appear questionable. We think there are two great rules which should never be lost sight of in characterizing genera. The first is, that a species is not necessarily to be made a new genus, merely because there is no genus, as already constituted, which will admit it. In many instances the new species may differ only on some unessential point, which, although forming part of the described characters of the old genus, may be struck out without injuring the individuality of the genus, and in such a case the old genus should be widened to receive the new species, instead of constituting it a new genus itself. The second, which must be taken along with the first, is, that characters which may be of essential generic importance in one family, may be of merely secondary importance in another. There is ample proof in this work that Mr Wollaston was quite alive to the importance of these rules, but we do not think he has acted upon them with sufficient determination. For instance, we think he he has broken the first of them in creating the genus *Thalassophilus*, which is clearly an *Æpus*. In like manner

Crypta might be widened to receive *Cryptomorpha; Mycetæa* to receive *Microchondrus;* and, perhaps, *Dorcadion* to receive *Deucalion*, although of this we have more doubt;—*Boromorphus* appears to us to be not distinct from *Boros;* and we have no hesitation in saying that *Somatium* should be placed in *Hypocyptus; Mecognathus* in *Sunius;* and *Metopsia* in *Phœobium.* We think he has overlooked the second rule in making a new genus for his species of *Melyrosoma*, which should have found a place under *Melyris; Cyphocelis* and *Atlantis* appears to us both to belong to *Laparocerus;* and *Anemophilus* and *Scoliocerus*, and perhaps also *Lichenophagus* should belong to *Omias.* We think *Lichenophagus* is better entitled to a place as a genus than either of the other two, although Mr Wollaston himself, while he entertains no doubt about *Anemophilus* and *Seoliocerus*, treats it with doubt, and only erects it into a provisional genus; and lastly, we think he has disregarded both rules deliberately and with his eyes open, in not modifying *Clypeaster* to receive *Arthrolips, Corylophus* to receive *Glæosoma;* and *Agathidium* to receive *Stagonomorpha.*

We have not space to go over the characters of these genera, and point out on what grounds we differ in opinion from Mr Wollaston regarding them; and if we had, we do not know, that this is the proper place for it. We merely indicate the points on which we do differ from him; and we wish our readers to take this along with them, viz., that we have formed our opinion, not like Mr Wollaston, from a prolonged and careful microscopic examination of the species themselves, but merely from a perusal of his description, and from the plates, as we have not been fortunate enough to see more than a few of them in nature.

The arrangement is another topic, on which men may easily differ, and yet in which, as Mr Mantalini says, "we may both be right and neither wrong." We shall therefore not enter into a discussion as to that adopted by Mr Wollaston, farther than to say that in a great deal we cordially agree with him, and where we differ, we admit that there is much to be said in support of the view he has adopted.

We cannot close without expressing our admiration of the figures and dissections which have been executed by Mr Westwood. He is one of the few scientific artists we have, to whom we can point as on a par with our continental neighbours.

In a word, the whole work is one from which we have derived the liveliest gratification, and which British naturalists may contemplate with satisfaction, as being a credit to their country.

Experimental Researches in Electricity. By MICHAEL FARADAY, D.C.L., F.R.S., &c. Vol. III. London: 1855.

The volume under notice contains the record of ten years' work by the great Electrician whose name it bears. The first paper, containing the nineteenth series of his electrical researches, (the preceding eighteen of which were published in the two former volumes,) is dated November 1845, the last February 1855. The contents are republications, chiefly from the Philosophical Transactions of 1846-1852, but in addition, from the Proceedings of the Royal Institution, and the pages of the London and Edinburgh Philosophical Magazine. They amount altogether to 580 closely-printed octavo pages, and discuss *seriatim* some of the most interesting but difficult problems of Physical Science. The nature of matter, of force, of polarity; the conditions of electrical and magnetic action; the connection subsisting between the great material agencies, heat, light, electricity, magnetism, gravity, and the like, are either formally or incidentally discussed in the light of profound and original views. The remarkable discoveries which have rewarded the genius and patience of the author, during the last decade, such as the magnetisation of light, and the illumination of magnetic lines of force; the magnetic condition of all matter, including the unexpected and fertile observation, that as the earth has its pre-eminently magnetic constituent, iron, so the air has its magnetic constituent, oxygen, the arrangement of substances as magnetic under the heads of *paramagnetic*, or ferromagnetic, like iron, nickel, and cobalt, and *diamagnetic* like phosphorus and the majority of remaining substances; the distribution of the lines of magnetic force within a magnet and through space, the diamagnetic conditions of flame and gases; the connection between electrical induction, conduction and insulation; and many not less important observations, speculations, and conclusions, are announced for the first time, or expounded with fuller illustration and confirmation in this volume.

To analyse or to criticise it, is not our present intention. In truth only men of like genius and training with Faraday, and habituated to similar researches, can judge of its merits and demerits, and they will justly make treatises similar to his, the vehicles of their judgments.

It is within our province, however, to refer to three aspects of the work, which are worth a moment's notice.

1stly, It reproduces in one continuous series, those researches (xix to xxix), which must otherwise be consulted in various volumes of the Philosophical Transactions. It contains also the more popular expositions of many of these researches, which the author gave as occasional lectures at the Royal Institution, and which as his own abstract and summary of conclusions, would have a special value, even if they did not (as they always do) contain new matter, and additionally lucid explanations of abstruse speculations. The volume further embodies various papers from the Philosophical Magazine, which either discuss questions of great interest as collateral to the main subjects of the researches, or explain more fully such of the conclusions in these as had been misapprehended, or reply to objections raised to them. The entire work is thus one which no electrician can dispense with.

Secondly, To younger men devoted to Physical Science, this volume, like its predecessors, may be held up as one of the noblest examples which the records of knowledge afford, of the spirit in which physical researches should be prosecuted and proclaimed.

Faraday combines to a rare extent great boldness in speculating, with great caution in concluding. His patience and perseverance as a worker are as remarkable as his originality as a thinker, and his skill as an expositor; and with an ingenuity in devising experiments, and a manipulative skill and dexterity in performing them, never we believe surpassed, he combines an accuracy and fidelity in working, such as brilliant experimenters and dexterous manipulators often fail to exhibit. Half-truths with him are hateful things, and he grudges neither thought, nor time, nor labour, not to speak of expense, provided they will bring him certainty of knowledge, even though it be but the certainty of nescience. His aim is ever a decided Yes or a decided No; or the attainment of the certainty that the problem is one which man cannot answer either way. These qualities cannot fail to impress every thoughtful reader of the book, which is fitted to render a moral as well as intellectual service to all who study it. We have risen from its perusal with increased perception of the truthfulness, modesty, impartiality, and unjealous, unenvious spirit of its author. The cheerful acknowledgment of the labours of others, the patient study of all reasonable objections to his own most cherished views, the frank confession of change of opinion, where that has occurred, the lowly estimate of himself, and the lofty, nay solemn estimate of the dignity of his vocation as an unfolder of the works of God, make us love as much as we honour our great Electrician, and should prompt our younger men to imitate his spirit, which they may all do, as well as rival him in his discoveries, in which they may be less successful.

Thirdly, These hasty observers of whirling tables, and so-called spirit rappings, and all the host of half-trained amateurs who have imperfectly mastered the alphabet of electricity, should study a page or two of this volume, before intruding on the precious time of Faraday with ill-considered questions. He has been driven to make public complaint of the unreasonable demands thus made upon him, and that he is entitled to do so, those will most fully acknowledge, who can best follow the discussions of this profound book, and who also know how willing its author is to assist the studies of the unlearned, and how much he delights in rendering his attractive science a source of instruction and amusement even to children. Let those who decide upon the import of the most startling and unexpected physical phenomenon, after one or two hastily devised and imperfect experiments read (to take one example), the account of days, nay weeks, spent by our author in deciding the apparently simple, but in reality, very difficult question, "Can a Magnet exist with only a

North or only a South Pole; or must it have two Poles?" and till they have observed in the same spirit, and made certain that their supposed phenomenon has an actual existence, and that they have a distinct and *answerable* question to put, be slow to take such a man as Faraday from labours by which all his brethren are gainers.

The Natural History Review: A Quarterly Journal, including the Transactions of the Belfast Natural History and Philosophical Society, Cork Cuvierian Society, Dublin Natural History Society, Dublin University Zoological Association, and the Literary and Scientific Institution of Kilkenny, as authorised by the councils of these Societies for the Sessions 1853–4. Vol. I. Dublin: 1854. 8vo.

This is a work of a character different from other periodicals devoted to Natural History. It consists of reviews of works relating to Natural History, including notices of serial publications, and, in addition, gives the proceedings of Irish societies.

The plan is a good one. There are ample materials for an annual volume, noticing, analysing and reviewing works of zoology and botany, with geology, the travels of naturalists, &c.; but we think it should be confined to works published in Great Britain and Ireland, and thereby give a complete view of what has been done at home in each year. Commencing at 1855, it might form the sequel to the Bibliographia of the Ray Society, and where it was not necessary to review, the correct title of the work, papers, or memoir, could be recorded. As an Irish work the proceedings of Irish societies might be given; but if all British also were to be included, or even a part of them attempted, the materials to be properly reported would more than fill the volume, and the space allotted for a partial notice only would be better occupied by working up the Natural History publications.

Prodromus Faunæ Zeylanicæ; being contributions to the Zoology of Ceylon. By E. F Kelaart, M.D. Edin., F.L.S., &c. Vol. I. Ceylon: 1852. Vol. II., Part I. Colombo: 1854. 8vo.

The Fauna of a country is a catalogue of its animal productions, and is useful and interesting in proportion to the information conveyed in regard to the habits and distribution of its animals. Insular Fauna are peculiarly interesting, as they often contain species entirely local, and not yet discovered upon the adjacent continents.

The first volume of the Fauna of Ceylon was published so long since as 1852, and contains the "Natural History of Newera Ellia," "Description of Ceylon Mammalia," "Catalogue of Ceylon Birds," "Description of Ceylon Reptiles," and an "Appendix by the late Dr Gardner on the Flora of Ceylon." The volume is the work of Dr Kelaart, an officer residing there, and employing his leisure time in these researches; and although it is the "prodomus" only of a more extended work, a view of the Zoology of the island is given which will be very useful to residents or visitors who may desire information.

Volume II., Part I., a reprint from the "Journal of the Asiatic Journal of Ceylon," is published within the last year, and contains the commencement of a more detailed account of the birds and reptiles, the result of the joint labours of Dr Kelaart and Mr Edgar Layard. And "in order to keep the Ceylon student of natural history up to other departments of zoology, in addition to those the authors are more particularly engaged in," an appendix is added, giving the results of the labours of European zoologists, where they relate to the natural history of the island. That joined to the present part contains a notice of the *Viverridæ*, by J. E. Gray, and the characters of new land shells collected by E. Layard—*Streptaxis*, *Helix*, *Vitrina*, *Achatina*, *Bulimus*, *Pupa*, *cataulus*, and *Cyclophorus*.

Remarks on some Fossil Impressions in the Sandstone rocks of Connecticut River. By JOHN C. WARREN, M.D. Boston, U.S. 1854. 8vo.

This little work of fifty-four pages, already in part printed in the Proceedings of the Boston Society of Natural History, is with some additions now intended as a systematic Synopsis, and a Summary of the discovery of Footprints and other impressions observed upon the surfaces of the rocks in America.

In America, as well as in this country, the attention of geologists to the impressions of footprints and other markings, has been comparatively recent, and it is only a few years since, that, from the accumulation of materials and the importance beginning to be attached to the subject, the terms *Ichnolithology* and *Ichnology* were applied to it. Next to the actual fossilized portion of an animal, the undeniable footprint is the nearest proof of its presence at some period or other. It tells us clearly that a creature had existed, and, perhaps, gives more information, if well marked and defined, than small or detached fragments of the skeleton itself. Dr Hitchcock is deservedly the great American authority in this branch of geology, and he has worked it out with wonderful perseverance and assiduity. Of this Dr Warren bears ample testimony; and we are glad to see that younger men are now taking it up, and that the observations, from being more extended, are being brought to bear more generally in the history of ancient life. In the present work the aid of photography has been brought to assist, and it is the first time we have seen it so applied. The photographic illustration gives an excellent idea of the slab from which it is taken, with this exception, that having been reduced from one of large dimensions the size is not conveyed to us, but we have no doubt of the art being admirably adapted for such illustrations.

PROCEEDINGS OF SOCIETIES.

Royal Society of Edinburgh.

Monday, 2d April 1855. Dr Christison, V.P., in the Chair.

The following Communications were read:—

1. *Account of Experiments to ascertain the amount of Prof. Wm. Thomson's "Solar Refraction."* By Prof. C. Piazzi Smyth.

After alluding to the excessive difficulty of ascertaining the presence and nature of a resisting medium in space, by planetary or cometary perturbations, the author reminded the meeting of the statements made in those rooms last year, that one of the consequences to which the dynamical theory of heat had led him, was the necessity of the existence of a medium filling space; that such medium was but an extension of our own atmosphere, and must experience a condensation in the neighbourhood of the sun; and that there must consequently arise a certain refraction of any heavenly body seen through such medium.

Impressed, therefore, with the importance of endeavouring to get by these means some further light in regard to the long-vexed question of the resisting medium, Professor Smyth had instituted, during the last summer, a series of observations on stars in the neighbourhood of the sun. Atmospheric difficulties had, however, prevented much being done; and in the whole history of the observatory, but one group of observations available for the purpose in view had been found. This, on being subjected to special calculation, has given two results, both confirmatory, and indicating an amount of solar refraction of $0^s{\cdot}04$ in right ascension, at a distance of 12 minutes of time from the sun.

2. *On the Extent to which the Theory of Vision requires us to regard the Eye as a Camera Obscura.* By Dr George Wilson.

The object of this communication was to combat the current theory of vision, as exercised by vertebrate animals, in so far as it teaches that the light which reaches the retina from without, thereafter passes through that membrane, and is absorbed by the pigment of the choroid behind it.

The author, after enumerating the arguments adduced in favour of this view, proceeded to state that a mass of evidence, daily accumulating, had established, beyond question, the certainty that light is reflected from the anterior layers of the retina and from the choroid, and so abundantly, that oculists take daily advantage of the fact to examine, by means of this light, the deeper internal structures of the eye.

This organ, accordingly, cannot be regarded otherwise than in a limited sense as a camera obscura, and the arguments in favour of the opposite belief were shown to furnish no substantial support of the current opinion. Thus, the eyes of albino *animals* were found to exercise vision perfectly, although destitute of *pigmentum nigrum ;* and the presence of the *tapetum lucidum*, which acts like a concave metallic reflector in the eyes of many creatures, was shown to furnish no obstacle to sight, which, on the other hand, it rendered more acute when light was feeble. The supposed cross reflection of light within the eye was also shown to be a phenomenon which could rarely occur so as to disturb vision.

The author finally urged that the reflection of light from the bottom of the eye served important ends, especially in the lower animals. Those ends he held to be—

1. The return from the choroid of light through the retina, so as to double the impression on the latter.

2. The reflection of light on external objects, which was best seen in creatures whose eyes are provided with *tapeta lucida*, and acted alike as an assistance to them in finding their food, and in the case of carnivorous nocturnal and marine animals, to their prey in escaping from them.

In the human subject it was contended that, in very faint light, reflection from the bottom of the eye would assist vision, and that the known delicacy of visual perception, which characterized those who had been long imprisoned in damp chambers or dungeons, afforded an example of such assistance. The author also insisted on the fact, that, as the reflected light is always coloured, so as in the human eye to be bright red, yellowish-red, or brownish-red, and in different eyes to a different degree; and as we add from our eyes coloured light to every object we gaze at, no two persons see the same colour alike, or will exactly agree in matching tints. The existence and importance of such a chromatic personal equation was dwelt on at some length.

3. *Researches on the Amides of the Fatty Acids.* By Dr Thomas H. Rowney, Assistant to Dr Anderson, University of Glasgow.

The author in this paper gives the details of an examination of the compounds obtained by the action of ammonia on some of the oils and fats. The method employed was to mix one volume of the oil, two volumes of alcohol, and four volumes of strong ammonia, in a stoppered bottle, and place it in a moderately warm situation, the stopper being tied down. After a time, varying with the oil employed, a whitish solid matter is formed, which increases in amount as the oil diminishes, until at length the whole becomes nearly solid. The mass is collected on a cloth filter, washed with a little water, and squeezed, and the residue dissolved in warm alcohol; the crystals deposited on cooling are washed first with dilute spirit, then water, and again expressed, and this is repeated till a resinous matter, which adheres obstinately to the product, is removed.

The amides thus formed, when pure, are white, and permanent in the air, but if any of the resin be present they soon become yellow and resinous. The quantity obtained from different oils varied much, the drying oils yielding less of the amides and more resin than the fat oils. Of the oils examined by the author, linseed, poppy, and croton oil, yield margaramide, almond and seal oils oleamide, castor oil ricinolamide, and almond and castor oil, after solidification by nitrous acid, give elaidamide and palmamide, which two latter compounds are isomeric with oleamide and ricinolamide.

The melting point of these amides were found as follows:—

Margaramide, ...	103° C.	(60° C. Boullay.)
Palmamide and Elaidamide, .	94° C.	
Oleamide, ...	82° C.	

The author considers the melting points ascribed to ricinolamide (66° C.) and isocetamide (67° C.), by Boullay, are below the truth.

The researches of the author are not yet completed, and the results of experiments now in progress will be given on a future occasion.

Monday, 16th April 1855. Right Rev. Bishop Terrot, V.P., in the Chair.

The following Communications were read:—

1. *Notice of some new Forms of British Fresh-Water Diatomaceæ.* By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

The author stated that he had examined, more or less minutely, nearly 300 fresh-water gatherings, and that he had found in these very nearly all the known British species, besides a number not yet described.

The new forms were described in three sections.

I. Species figured by foreign authors, but new to Britain.

1. Eunotia tridentula.
2. Navicula follis (Trochus?) Ehr.
3. „ dubia, Kütz.
4. „ Bacillum, Ehr.
5. Pinnularia megaloptera, Ehr.
6. „ dactylus, Ehr.
7. „ nodosa, Kütz.
8. „ pygmæa, Ehr.
9. Stauroneis Legumen, Kütz.
10. Stauroneis ventricosa, Ehr.
11. Cocconema cornutum, Ehr.
12. Gomphonema subtile, Ehr.
13. Melosira distans, Ehr.
14. Navicula amphigomphus, Ehr., and
15. „ dilatata, Ehr., possibly varieties of Navicula dubia, not figured by the author.

II. New Species, observed by others nearly about the same time as by the author, and named by the Rev. Professor Smith, but still MS. species.

16. Navicula apiculata, Sm.
17. „ rostrata, Sm.
18. „ scutelloides, Sm.
19. Mastogloia Grevillii, Grev.
20. Pinnularia hemiptera, Sm. (not figured.)
21. Navicula sufflata, Sm. (Auvergne. Found in Britain by the author. Not figured.)

III. Species now first described and figured.

22. Cymbella (?) sinuata, W. G.
23. „ turgida, W. G.
24. „ obtusa, W. G.
25. „ Pisciculus, W. G.
26. „ Arcus, W. G.
27. Navicula cocconeiformis, W. G.
28. „ lacustris, W. G., do. β.
29. „ lepida, W. G., do. β.
30. „ bacillaris, W. G.
31. „ incurva, W. G.
32. „ longiceps, W. G.
33. Pinnularia gracillima, W. G. (vaciva, Sm.)
34. Pinnularia linearis, W. G.
35. „ biceps, W. G.
36. „ digitoradiata, W. G.
37. „ Elginensis, W. G.
38. „ globiceps, W. G.
39. Stauroneis obliqua, W. G.
40. „ dubia, W. G.
41. „ ? ovalis, W. G.
42. Surirella tenera, W. G.
43. Gomphonema insigne, W. G.
44. „ ventricosum, W. G.
45. „ Sarcophagus, W. G.
46. „ æquale, W.G.

The author concluded by making some observations on the distribution of fresh-water diatoms, and showed by various examples that it is often quite easy to determine the characters of a species, if these be well marked, even when it occurs sparingly or scattered, and that when a form is once noticed, we are pretty sure to find it soon after in greater abundance. To show the value of minute search, he stated that although most of the above new species occurred in several gatherings, yet, in point of fact, nearly the whole of them had been observed in a detailed exploration of only four gatherings, those, namely, from Elgin, Elchies, Lochleven, and Duddingston Loch.

2. *On Glacial Phenomena in Peebles and Selkirk Shires.* By Robert Chambers, Esq., F.R.S.E., &c.

In this short paper, the author presented facts, from which he thought himself entitled to infer that the Silurian mountain tract of southern Scotland falls entirely into his views regarding ancient glacial operations in the country generally, as expounded in a paper read to the Royal Society of Edinburgh in December 1852, and published in the *Edinburgh New Philosophical Journal* for April 1853. He showed that the compact boulder clay, which he regards as the detritus of the early and general *glaciation* of the country, exists in the valleys of this district, and in passes amongst the hills, up to those of Glenlude and Tweedshaws, which are respectively 1152 and 1352 feet above the mean level of the sea. Striated boulders from Glenlude and Tweedshaws were brought before the Society. The rounded form of the hills, and the horizontal *mouldings* or *flutings* which are seen along the faces of many of them, he considers as other memorials of the operations in question. The nature of the rocks is unfavourable for the preservation of smoothed or striated surfaces; but Mr Chambers had found one such on the border of St Mary's Loch, in Selkirkshire, 800 feet above the sea. On the assumption that the hills had been shorn and rounded by moving ice, it appeared from the high inclination of the strata, as exhibited in a copy of Professor Nicol's section of the district, that the amount of denudation fully equalled the remarkable examples adduced by Professor Ramsay in regard to South Wales and the Mendip Hills. Finally, Mr Chambers described an example of the later and limited operations of ordinary glaciers in the elevated moor of Loch Skene, a tarn formed and retained by a moraine.

3. *Preliminary Notice on the Decompositions of the Platinum Salts of the Organic Alkalies.* By Thomas Anderson, M.D., Regius Professor of Chemistry in the University of Glasgow.

This paper was a preliminary notice of an investigation which has occupied the author for some time past, and which, though still too incomplete for publication in full, is sufficiently advanced to render obvious the general character of the results, although, from the extensive and elaborate nature of the inquiry, a very considerable time must elapse before it is complete in all the requisite details.

It has been known for some years that the platinum salts of the organic alkalies are decomposed when boiled with excess of bichloride of platinum; and with narcotine, the only one as yet examined, the action is a true process of oxidation, yielding results similar to those obtained by treating the base with peroxide of manganese or nitric acid. The present investigation refers to the pure platinum salts, which undergo an entirely different decomposition, the nature of which is materially dependent on the stability of the base. Having observed that the decomposition was more precise and definite when the less decomposable bases were employed, and apparently calculated to afford the key to the more complex changes, which occur in other cases, the author has hitherto directed his attention more particularly to pyridine and picoline, which are so remarkable for their stability, and especially for the obstinacy with which they resist the action of oxidizing agents.

When the platinum salt of pyridine, carefully freed from excess of bichloride of platinum, is dissolved in hot water, and the solution kept steadily boiling for some hours, a fine sulphur-yellow crystalline powder begins to appear. After five or six days' continuous boiling the whole of the platinum salt is converted into this substance, but if the powder be filtered off before the change is complete, the mother liquid on cooling gives a deposit of fine golden-yellow scales resembling iodide of lead.

The yellow powder is insoluble in water and acids, and is decomposed by potash slowly in the cold, more rapidly on boiling, with the evolution of pyridine. It is the salt of a platinum base, analogous to platinamine, to which I give the name of platinopyridine. Its analysis gave—

	Expt.	Calculation.		
Carbon, ...	24·30	24·12	C_{10}	60·
Hydrogen, ...	2·14	2·01	H_5	5·
Nitrogen, ...	...	5·65	N	14·
Chlorine, ...	28·56	28·54	Cl_2	71·
Platinum, ...	39·60	39·68	Pt	98·7
		100·00		248·7

It is therefore a bihydrochlorate of platinopyridine, with the formula $C_{10} H_3 Pt N + 2H Cl$, and the decomposition which yields it consists simply in the expulsion of an equivalent of hydrochloric acid, as represented by the equation

$$C_{10} H_5 N, H Cl Pt Cl_2 = C_{10} H_3 Pt N + 2 H Cl + H Cl.$$

The equivalent of hydrochloric acid escapes with extreme slowness, but the change may be much facilitated by the addition of a sufficient quantity of pyridine to combine with it, although an excess must be carefully avoided, as it produces a different decomposition, to be afterwards described.

Platinopyridine cannot be separated from the bihydrochlorate by alkalies, but when boiled with salts of silver, the corresponding salts of the base are obtained. The decomposition, however, is very slowly effected, and certain changes occur which the author is not yet in a condition satisfactorily to explain. When the hydrochlorate is boiled with two equivalents of sulphate of silver, it gradually loses its colour, and the yellow solution produced contains the sulphate of platinopyridine, which is extremely soluble in water, and dries up into a gummy mass on evaporation. Considerable difficulties were encountered in obtaining the salts of platinopyridine in a state fitted for analysis, and the only one which has given satisfactory results is the chromate, which is obtained on adding bichromate of potass to the sulphate, in the form of a fine orange-red precipitate, having the formula, $C_{10} H_3 Pt N HO CrO_3$.

When the bihydrochlorate of platinopyridine is boiled with two equivalents of sulphate or nitrate of silver for a shorter time than is requisite for its complete decomposition, and the chloride of silver collected on a filter, washed and treated with ammonia, it leaves behind a yellow crystalline matter, generally in small quantity. This substance is insoluble, or nearly so, in water, but dissolves in boiling nitric acid, from which it is deposited, on cooling, in beautiful shining plates. It contains chlorine, but its constitution is not yet satisfactorily determined.

The golden-yellow scales produced when the ebullition of the platinum salt of pyridine is stopped before the change into platinopyridine is complete, have a very singular constitution, the analysis giving—

	Expt.	Calculation.		
Carbon, . . .	22·70	23·47	C_{20}	120·
Hydrogen, . .	2·30	2·06	H_{11}	11·
Nitrogen, . . .	...	5·26	N_2	28·
Chlorine, . . .	32·75	33·24	Cl_5	177·5
Platinum, . . .	36·61	36·97	Pt_2	197·4
		100·00		533·9

and its formula is—

$$C_{10} H_5 N H Cl Pt Cl_2 + C_{15} H_3 Pt N 2H Cl,$$

representing it as a double compound of the original platinum salt and the bihydrochlorate of platinopyridine. The author reserves the explanation of its constitution until the paper is published in full.

When the platinum salt of pyridine is boiled with an *excess* of pyridine, the fluid becomes extremely dark-coloured, and on evaporation to dryness in the water-bath and addition of water, a dark solution is obtained, and acrystalline residue left, which is very sparingly soluble in water, more so in boiling alcohol, and is deposited on cooling in small needle-shaped crystals. Its composition was found to be—

	Expt.	Calculation.		
Carbon, . .	28·31	28·14	C_{10}	60·
Hydrogen, . .	2·48	2·34	H_5	5·
Nitrogen, . .	...	6·58	N	14·
Chlorine, . .	16·69	16·65	Cl	35·5
Platinum, . .	45·83	46·29	Pl	98·7
		100·00		213·2

This corresponds with the formula $C_{10} H_4 Pt N + HCl$, which is that of a hydrochlorate of platosopyridine corresponding to the hydrochlorate of platosamine. By treatment with nitrate and sulphate of silver the salts of these acids are produced.

The picoline platinum salt decomposes very slowly, but after eight or ten days' boiling a platinopicoline is produced. If a little picoline be added to the solution, the change is complete in a few hours. The bihydrochlorate is insoluble in water, and the double compound containing that substance in combination with the original salt, and of which the formula is—

$$C_{12} H_7 N H Cl Pt Cl_2 + C_{12} H_5 Pt N 2H Cl,$$

crystallizes in grains, and is much less soluble than the corresponding pyridine compound. The properties of these substances will be afterwards fully described.

The platinochloride of ethylopyridine is very slowly decomposed by boiling, but eventually a substance is deposited which as yet has given only discordant results. A small quantity of pyridine appears to promote the decomposition, but the most remarkable effect is produced by the addition of ammonia. The solution in this case is completely decolorized by a few minutes' boiling, and it then gives a white precipitate on the addition of carbonate of ammonia. The substance so obtained is very sparingly soluble in water, and almost insoluble in alcohol. Analysis showed it to be Raewski's carbonate, the sesquihydrochlorocarbonate of diplatinamine. The action of ammonia is readily explained by the equation

$$C_{14} H_9 N HCl + Pt Cl_2 + 2HN_2 = N_2 H_4 Pt HCl + C_{14} H_9 N HCl.$$

The salt, $N_2 H_4$ Pt HCl, was separated from the fluid and examined; it appears to be identical with the substance obtained by Gerhardt by the action of ammonia on the platinochloride of ammonium.*

The details of these, and other decompositions, the author reserves to a future time; contenting himself with stating that most of the platinum salts examined are decomposed by sufficiently protracted ebullition, although some are extremely stable.

The platinum salt of ethylamine is scarcely changed when boiled alone, but in presence of excess of base, a substance is produced, sometimes in yellow, and at other times in purple crystals, which become yellow at 212°. It appears to be the hydrochlorate of platosethylamine.

The aniline compound is very easily decomposed, but the products do not appear to be definite.

The narcotine compound dissolves in a considerable quantity of hot water, and on boiling the solution at first remains unchanged; after some hours, however, it acquires a brown colour, and, a few minutes' longer boiling, a black precipitate, containing the whole of the platinum, but combined with some organic matter, is deposited. The filtered fluid, on addition of ammonia, gives a precipitate resembling narcotine, but whether it is that base, or a product of decomposition, is not yet determined.

The brucine compound is very sparingly soluble, but if boiled with water is at length decomposed, with the production of a black powder; on filtering a red solution is obtained, which deposits a yellow platinum salt on cooling. It is possible, however, that this may be merely a portion of the original salt, for as soon as the undissolved portion had become black the solution was filtered.

The author reserves for a future paper the consideration of the inferences to be drawn from this investigation, remarking that it is likely to modify to some extent certain of the views now entertained regarding the constitution of the bases. In the third part of his investigation of the products of the destructive distillation of animal substances, he has shown that pyridine and picoline, by taking up a single atom of the alcohol radicals, are converted into fixed bases, so that according to the ordinarily received opinion, they are nitryl bases in which the whole of the hydrogen is replaced by these different radicals. The production of the platinum bases, however, shows that they do still contain replaceable hydrogen, so that either the formation of a fixed base by the addition of one equivalent of a radical does not prove that they are nitryl bases, or the received opinion regarding the constitution of the platinum bases must undergo some modification.

It is clear that at present we cannot attempt any explanation of these apparently anomalous results; but the author is now engaged examining the decompositions of the platinum salts of amide and nitryl bases containing known radicals, which will probably lead to their correct explanation.

4. *On the Volatile Bases produced by Destructive Distillation of Cinchonine.* By C. Greville Williams, Assistant to Dr Anderson, University of Glasgow.

In this paper the author shows that cinchonine by distillation with potash, undergoes a very complex decomposition, and that instead of yielding one base, as has hitherto been supposed, it gives at least seven.

The mode of research at first adopted was to convert the basic liquid into platinum salt, and separate the bases by fractional crystallization.

* Comptes Rendus des Travaux Chimiques, 1849, p. 113.

The experiments made in this manner indicated that several substances were present, but it was evident that to decide the question, a very large amount of material would be required; the author therefore subjected 100 ounces of cinchonine to distillation with potash, and thus obtained sufficient of the basic oil to enable him to effect twelve complete fractionations, involving at least 240 distillations.

Runge's pyrrol was present in the crude bases, and was removed by protracted boiling of the acid solution.

The bases were produced free from water by digestion with potash; the following fractions were then analysed.

Fraction boiling at 310° *F.* The basic liquid on analysis gave numbers exactly agreeing with the formula C^{14} H^{9} N, which is that of lutidine, a base which has as yet only been twice observed before, it having been discovered in Dippel's animal oil by Dr Anderson, and found soon after in shale naphtha by the author of the present paper. Pyridine and picoline were also found by fractionally crystallizing the platinum salts obtained about this point in the earlier distillations, but the quantity present was extremely small.

Fraction boiling between 350° *and* 360° *F.* This fraction was found to consist of collidine, a platinum salt giving on combustion numbers agreeing closely with the theoretical values. Collidine was also found in fractions boiling as high as 380° to 390°.

Fraction boiling between 410° *and* 420° *F.* Five analyses of platinum salts obtained at this point indicated the base present to possess the formula, C^{18} H^{7} N, being that of the chinoline of Gerhardt. The author proposes in a future paper to compare chinoline with the leukoline of Hofmann, with a view of determining the question of their being identical, or merely isomeric. Chinoline forms by far the greater portion of the basic liquid.

Fraction boiling between 510° *and* 520° *F.* This was found to consist of a new base, which the author terms Lepidine, the formula of which, derived from analyses of the double salt with bichloride of platinum, the hydrochlorate, nitrate, bichromate, and also the hydriodate of the amyl compound, is C^{20} H^{9} N, the experimental numbers in each case agreeing closely with those required by theory.

The author states his belief that several bases said to be the sole products of certain reactions, as well as some natural ones, will be found to be mixtures; he also gives the results of some experiments proving pyrrol to be produced by destructive distillation of many nitrogeneous bodies, and concludes with the following table of the substances analysed by him in the course of the investigation,—

Platinum salt of pyridine,	C^{10} H^{5}N, H Cl, Pt Cl^{2}
,, ,, picoline,	C^{12} H^{7} N, H Cl, Pt Cl^{2}
Lutidine,	C^{14} H^{9}N.
Platinum salt of lutidine,	C^{14} H^{9}N, H Cl, Pt Cl^{2}
,, ,, methyllutidine,	C^{16} H^{11}N, H Cl. Pt Cl^{2}
,, ,, collidine,	C^{16} H^{11}N, H Cl, Pt Cl^{2}
,, ,, chinoline,	C^{16} H^{7}N, H Cl, Pt Cl^{2}
Lepidine,	C^{20} H^{9}N,
Platinum salt of lepidine,	C^{20} H^{9}N, H Cl, Pt Cl^{2}
Hydrochlorate of lepidine,	C^{20} H^{9}N, HCl.
Nitrate of lepidine,	C^{20} H^{9}N, NO^{5}, HO.
Bichromate of lepidine,	C^{20} H^{9}N, 2 Cr O^{3}, HO
Hydriodate of amyllepidine,	C^{30} H^{19} N, HI.

Monday, 30th April. The Very Rev. Principal LEE, V.P., in the Chair.

The following communications were read :—

1. *Remarks on the Coal Plant termed Stigmaria.* By the Rev. Dr FLEMING.

The author, after noticing the proofs of Stigmaria being the root of Sigillaria, called attention to the external organs, known formerly as the leaves, and more recently as the rootlets of the former. He stated that in the many examples of stigmaria which he had examined, he had never observed these rootlets articulated to the stem by anything resembling a ball-and-socket joint, considering the appearance which had led to this notion as due to shrinkage and state of preservation.

The views of Dr Hooker as given in his valuable paper on Stigmaria in the "Memoirs of the Geological Survey," vol. ii., p. 437, were next considered. This acute observer, from an examination of a particular specimen, concluded that these rootlets, *within* the body of the stem, form obconical or flaggon-shaped bases, the summits of which are on a level with the mouths of the cavities in which they are contained.

In the two specimens which Dr Fleming exhibited from the Boghead parrot coal, it clearly appeared that the rootlets communicated directly with the body or trunk, which in this case had been filled from within, with the pulpy matter of the coal, and had thus entered the tubular rootlets which extended for some distance into the argillaceous matter on the outside. Hence he inferred that the flaggon-shaped bodies noticed by Dr Hooker were the lower portions of the rootlets, not in the inside, but on the *outside* of the stigmaria.

Dr Fleming next exhibited examples of the different *quantities* of coal produced by stigmaria, sigillaria, favularia, calamite, sternbergia, and lepidodendron, observing that as these plants, can furnish coal-making materials *separately*, and as their remains exist in coal, it cannot be denied that, in the *aggregate*, they would be equally productive, nor, with these facts in view, could it be maintained that coal can only be formed from fir or allied woods.

The author then proceeded to observe, that in ordinary household coals, such as caking, cherry, or splint, each bed is stratified, and the strata are separated at their *partings* by patches of fibrous anthracite, as if formed from broken portions of woody matter. These partings indicate a recurring intermittency of action, probably arising from *season changes* during the accumulation of vegetable matter in a form analogous to peat. The parrot coals, on the other hand, by the absence of stratification (being merely laminated or slaty parallel with the plane of stratificaton of the neighbouring sedimentary rocks), indicate a more decidedly simultaneous origin, and appear to have been in the state of disintegrated vegetable matter, mixed more or less with earthy mud, and distributed like the beds of sandstone and clays. That these coals were originally clays into which bituminous matter was injected, will not be countenanced by any one acquainted with their structural character, contents, and relative position. There is no bitumen in the Boghead parrot, nor any substance analogous to what has been termed ozokerite from Binny Quarry, to which Dr Bennett has referred. The last substance, indeed, melts at a heat considerably below that of boiling water.

The pulpy condition of the original material of the parrot coals must have been favourable for the molecular changes usually termed metamorphic, which may have so far modified the forms and structures of the vegetable tissues as to give them a segregrated or concretionary character.

The author concluded by remarking that the Boghead parrot could not be considered as a new *mineral species*, for it is neither chemically, optically, nor mechanically homogeneous, as demonstrated in the papers of Professors Bennett and Balfour in the last part of the Society's Transactions.

2. *On Errors caused by Imperfect Inversion of the Magnet in Observations of Magnetic Declination.* By William Swan, Esq.

The direction of the magnetic meridian, as indicated by that of a freely suspended magnetized needle, will generally be erroneous, unless the magnetic axis of the needle is parallel to its axis of figure; and hence, in order to obtain an accurate value of the magnetic declination, it becomes necessary to take the mean of two observations of the needle, first suspended on its usual position, and next inverted. If, however, the inversion of the needle is not accomplished with perfect accuracy, the correction, for want of parallelism between the magnetic axis of the needle and its axis of figure will not be complete; and the value of the magnetic declination obtained from the mean of two observations of the needle, first in its usual position, and then inverted, will be affected with a residual error due to an imperfect inversion of the needle. The present investigation refers chiefly to that form of declinometer magnet, in which the magnet is converted into a collimator by attaching to it a lens and cross fibres, or a divided glass scale, in the principal focus of the lens.

It is shown that the errors due to imperfect inversion may be computed, provided the magnet is observed, not only in its usual position, and then inverted,—that is, turned 180° round its axis,—but also when turned round 90° and 270°.

Putting δ for the correct reading, for the magnetic meridian on the limb of the theodolite used in observing the magnet; δ_1, δ_2, δ_3, δ_4, for the readings, when the magnet is turned through 0°, 90°, 270°, 360°, respectively, and ι for the correction to be applied to the value of the magnetic declination got from the mean of the readings in the direct and inverted positions of the magnet.

$$\delta = \tfrac{1}{2}(\delta_1 - \delta_3) - \iota.$$

The value of ι in seconds of arc may then be computed with sufficient accuracy by the following formulæ—

$$\tan\beta = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\frac{1}{2}(\delta_4 - \delta_2)},$$

$$\sin\alpha = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\beta} = \frac{\sin\frac{1}{2}(\delta_2 - \delta_4)}{\cos\beta},$$

$$\iota_1 = \frac{\sin\alpha\cos\frac{1}{2}(\beta_1 + \beta_3)\sin\frac{1}{2}(\beta_1 - \beta_3)}{\sin 1''\sin\psi\cos\frac{1}{2},(\delta_1 - \delta_3)}$$

$$\iota_2 = \frac{\sin\alpha\cos\frac{1}{2},(\psi_1 + \psi_3)\sin\frac{1}{2}(\psi_1 - \psi_3)}{\sin 1''\sin\psi_1\sin\psi_3\cos\frac{1}{2}(\delta_1 - \delta_3)}$$

$$\iota = \iota_1 + \iota_2;$$

Where $\beta_1 = \beta + \gamma_1$; $\beta_3 = \beta + \gamma_3$;

γ_1, γ_2, ψ_1, ψ_3 and ψ, being angles found by actual observation.

3. *On the Accuracy attainable by means of Multiplied Observations.* By Edward Sang.

In this paper the author remarks that, on opening any astronomical work of the present day, we are at first startled by, and then familiarized with, the excessive precision of the numbers set down. In our Nautical Almanac, for example, although referring to a period three or four years subsequent to the date of publication, the declinations of the stars and planets are set down to tenths of a second of arc, and their right ascensions to hundredths of a second of time.

Similarly in tables of the geographical positions of observatories, we find the latitude and longitude often given to the same degrees of precision; an accuracy which would affect to discriminate between the latitudes of the two ends, or the longitudes of the two sides of a dining-table.

Yet it is very much to be doubted if any astronomical instrument exist, which, by a single observation, is capable of giving the altitude of a star, or the longitude of a place, true to the nearest second; and it is also very much to be questioned, whether any ear, however practised, have acquired such delicacy of perception as to note the instant of an expected occurrence true to the nearest tenth of a second.

Now, astronomers draw the most important conclusions from the measurements of minute quantities. Thus, the absolute distances of the sun and planets are determined from the measurement of an angle of 8 or 9 seconds, and which is set down as being accurately $8''\cdot5776$, the unimaginable precision of the last figure being obtained by Professor Encke from observations made in 1761, 1769.

The linear velocity of light, again, is computed from observations on an angle of some $40''$; our knowledge of the relative masses of the planets is founded on the measurement of minute disturbances, and our wide guess at the distance of the fixed stars relies on the perception of a single second of annual parallax, and a heap of uncertainties of precession, nutation, and proper motion.

The common method of determining any quantity to an extreme degree of precision, is to measure that quantity very often, and then to take the arithmetical mean of the multitude of discordant results, it being understood that some principle of compensation exists which renders the mean more trustworthy than any of the actual observations from which it has been obtained.

But the author shows that in reality there are two perfectly distinct cases; those where a known law of compensation exists; and those in which the separate observations and their errors are independent of each other.

Thus, when we repeat the measurements of an angle upon different parts of a circle, we are certain that, however erroneous the division may be, the entire circumference is 360, and that, therefore an error of defect in one part, implies one of excess in another part of the limb. Again, if we read at three or five places equidistant from each other, we know that that part of the inaccuracy which arises from the eccentricity of the fittings is eliminated. Or if we take an altitude face East and then face West, we know that the two errors arising from a misplacement of the zero compensate for each other. But in all those cases where the compensating principle exists, a result from which any of the compensating quantities is excluded, cannot be considered as that of a complete observation: thus an altitude face East, without its complementary altitude face West, could not be used to found upon; and those only in which the compensating principle has had full scope can be admitted to be observations.

The other case, the author illustrates by Santini's observations, made for the purpose of determining the latitude of Padua, which consisted in observing the instant when several stars of various declinations reached a fixed altitude, in making which he depended on the going of his clock and the verticality of the axis of his instrument. From sixteen series of observations he deduces, as the mean 45° 24′ 2·16″ as the latitude of Padua; but when we examine his numbers we find that two of them are 6″·16 below and one 5″ above the mean; and as there existed no particular reason why one set of stars should have been taken rather than another, Santini might have chanced to make only one or other series of observations, and have deduced materially different latitudes; and within the limits of the errors to which the particular class of observations is liable it is difficult to adduce any argument in favour of one rather than the other, in fact, it is a matter of accident which result is arrived at it.

The author comes to the conclusion that the averaging of multiplied observations is a fallacy; if the results agree, the averaging is useless; if they do not agree, their discordances affords evidence that the means employed are insufficient to procure the accuracy aimed at.

Taking into account the various sources of error in the graduation and adjustment of instruments, we can scarcely assume that the declination of any star is known certainly to half a second of arc, or its right ascension to the twentieth second of time; and it appears that the true use of multiplied observation is to guard against blunders in reading off, and to indicate the degree of confidence which is to be placed in our results. A quantitative statement in any branch of physical science should give, along with the numerical result, the limit or probability of error, and conclusions drawn from such numbers ought to be made with the probabilities of error full in view. Increased exactitude is only to be obtained by improvements in the means of observing.

Royal Physical Society.

Wednesday 28th March. Professor Fleming, President, in the Chair.

1. *Of Some Circular Mounds, covered with a Metallic Slag, which occur on the Sloping Sides of the Gneiss Hills, Parish of Birnie, Morayshire.* By William Rhind, Esq. (A specimen of the slag was exhibited.)

Several deposits of this metallic matter occur in circular, somewhat elevated, mounds, about four feet in diameter, lying upon the moss-soil of the moors, both in this locality and in some of the moorland slopes of the country to the westward, the vague traditions of the county being that they are the remains of iron-works, used by the armies that had in former times passed over the country. A discussion ensued, in which Professor Fleming, Mr Alexander Rose, and others, took part, on the probable cause of the formation of this metallic matter,—whether it was accumulated by fires occurring in the moors, or by solution, and subsequent deposition from water. Similar slags were exhibited by Professor Fleming from Maryculter, Aberdeenshire. An accurate analysis of the mineral was recommended, and a report to be given in to the Society at its next meeting.

2. *Contributions to the Hydrology of the British Islands,* By William Rhind, Esq.

In collecting materials for the Hydrology of the British Isles, in connection with Mr Keith Johnston, for the second edition of his Physical Atlas, the author had obtained, from published and unpublished sources, upwards of one hundred records of rain stations and temperature. These amounts were marked down in their respective positions on the map of Britain, and this map was coloured with light and dark shades according as the amount of rain-fall was small or large in the locality. The map he exhibited showed, in the first place, what had been already done, and what parts of the country yet remained to be filled up by observation and registration. A considerable portion of the surface of Britain and Ireland was observed to be dotted with figures, but a large part of Wales and the north-west coast of Scotland were deficient. If we take three waving lines along the map of Great Britain we shall meet with three gradations of rain-fall. The line along the east coast, and penetrating some way into the interior, marks out the region of least deposition. On the whole eastern side of England, from Kent and Surrey, and Oxford, north to York, the average annual fall of rain is 23 to 24 inches. From Durham, north into Scotland, the mean fall is 27 inches, though in some localities, as Mid-Lothian and Morayshire, the rain fall is from 24 to 25 inches. The mean annual rain-fall of the whole eastern half of Great Britain is 27 inches. If we take a middle line, which includes the mountain range that traverses England from south to north, and extends through the centre and west of Scotland, we find that here is the greatest amount of deposition. In the mountains of Cumberland and Westmoreland, from 50 to 140 inches of rain fall annually. South of this range throughout England, from 36 to 46 inches are deposited. In Scotland, from the Lowther Hills to the mouth of the Clyde, from 47 to 50 inches. A third line embraces the west coast near the level of the sea. At Land's End, the annual fall is 42 inches, in Exmoor, 56 inches. As we proceed farther north, the mean fall decreases to 38 and 35 inches. Taking the western half of Britain, including the mountain regions, the annual mean of the rain stations is 45·5 inches, but considering that there is a deficiency of data for the elevated regions of Wales and the north-west of Scotland, and a preponderance of coast stations where the fall of rain is moderate, we may suppose that the actual fall for the western half of Britain is at least 5 or 10 inches more than this average; that is, from 50 to 55 inches. We thus see that the mountain regions of Britain, by their superior elevations, compared with the valleys and plains, and by the consequent diminution of their surface temperature, become the condensers of the moisture of the warm and moist southerly winds. From the interesting data of Mr Miller of the Lake district of England, it is also demonstrated that the greatest amount of deposition takes place at an elevation of 1900 feet, and above this, the fall of rain rapidly diminishes.

In Ireland the greatest amount of rain-fall occurs on the south-west coast, 59 inches falling in the vicinity of its highest range of mountains. In the low lying central plain of Ireland the annual fall is 23 and 24 inches, while on the mountain ranges of the north-east and south-east from 30 to 37 inches fall.

If we divide the year into three periods of four months each, beginning the winter period with November, we shall find that most rain falls in the summer and winter months, and least in spring. This is shown in the following tabular view :—

	Spring.	Summer.	Winter.
	Inches.	Inches.	Inches.
Penzance, Cornwall, ...	12·2	13·5	17·4
Keswick, ...	16·0	24·0	19·9
Glasgow, ...	8·3	9·8	15·5
Gilmourton, Lanarkshire, . .	11·6	17·3	18·8
Glencorse, Pentlands, . . .	10·2	14·3	11·6
London, ...	6·7	9·2	8·9
Boston, ...	7·2	9·4	6·5
York, ...	7·3	10·0	9·9

On the east coast there are during the year 165 days on which rain falls; on the west coast there are 212 days on which rain falls. The greatest depth of rain noted to have fallen in twenty-four hours, is from 1½ to 2½ inches. At Kendal, in 1792, 4½ inches fell. Our longest continued rains usually begin on the south and west of Great Britain, and proceed northwards. This occurs when an easterly and south-west current both prevail in the atmosphere. In these cases it sometimes takes several days before the dry east wind becomes saturated with moisture, and rain begins to fall on the eastern coasts. Hence the popular idea that our greatest rains come from the east, whereas, in reality all the deposited moisture comes with the southerly current, and the cold east wind acts merely as the condensing agent.

3. *On the Discovery of Calcareous Zoophytes in the Boulder Clay of Caithness, N.B.* By Charles W. Peach, Esq., Wick.

Zoophytes have hitherto been discovered in the boulder clay of Caithness, but the author laid before the Society specimens of two species, one found by Mr Dick at Thurso, the other by himself in the scaur in Wick harbour. The former which was much rubbed, proved to be the *Lepralia simplex* of Johnston, the latter the *Lepralia Peachii*, both of which now exist in our seas. The only perceptible difference between the recent and ancient specimens, is, that the latter have thicker walls to their cells, probably as a provision against the Boreal clime and more troubled seas they were denizens of. Besides this addition to the fauna of the boulder clay, he mentioned that its flora has yielded some of those curious calcareous plants, the *Melobesia*. He proposed in a future communication to lay before the Society, the details of a microscopic examination of these plants.

4. Mr A. Murray then read a short notice he had received from Sir W. Jardine *on the Bark-boring Woodpeckers of California.*

5. *Analyses of Table Spar from Mourne Mountains, and Pectolite from Girvan.* By M. Forster Heddle, M.D.

These analyses have already appeared in the Philosophical Magazine.

6. Dr J. A. Smith exhibited an adult male, female, and young male of the Gadwall duck (*Anas strepera*), shot on the Forth, near Kincardine, in the beginning of March; two adult males of the Smew (*Mergus albellus*, Linn), killed near Mountblairey on the River Doveron, in Banffshire, in February and March; and a specimen of the Glaucous Gull, *Larus glaucus*, taken on the Firth of Forth last autumn.

Wednesday 25th April.—ROBERT CHAMBERS, Esq., President, in the Chair.

1. *Remarks on Rain Gauges, with the view of securing Comparable Observations.* By Professor FLEMING.

In this communication, the author remarked that the expensive form in which rain-gauges were usually made, rendered them comparatively rare, but the gauge recommended by himself, and described in this Journal for July 1849, in its most expensive form cost only about £1. He pointed out the objections to rain-gauges of the ordinary construction, and particularly to the error which is introduced by having them elevated above the surface, stating that when so placed their indications are not to be relied on. The author stated as the result of experiment, in accordance with theoretical considerations, that rain-gauges need not exceed three inches in diameter, that the trouble attending them may be limited to emptying them once-a-month, and that the index rod, if divided into tenths of an inch, is sufficient for all practical purposes. The eye with a very little practice can easily read off to one-fourth of a tenth, a difference often greater than the amount of rain falling at the same time within short distances. He mentioned that gauges of the description which he had recommended were being established in different parts of the country. Twelve parish schools in Annandale were furnished with them by Mr Bryson, for his Grace the Duke of Buccleuch, and the results, according to Mr Stewart, Hillside, Lockerby, have been satisfactory. In conclusion, he remarked that trust-worthy observations would not be secured, for generalizations respecting the distribution of rain, until some simple, easily constructed, and inexpensive but accurate form of gauge be adopted, such as he believed his instrument to be; and sunk in a grass plot, as free from the influence of trees, buildings, or local currents of wind as practicable, the grass around the funnel being occasionally trimmed.

2. *On Electrical Fishes; with a description of a new Species of Malapterurus from Old Calabar, received from the Rev. Hope M. Waddell, Missionary there.* By ANDREW MURRAY, Esq., W.S.

See page 35 of the present number of this Journal.

3. Mr Murray exhibited a collection of *Coleoptera*, which he had received from Mr Jameson, Professor of Chemistry at Quito. Among these were *Oxychelia bipustulata*, *Pharæus conspicillatus*, *Semiotus imperialis*, and other known Columbian species, but a great many were new to him, and apparently undescribed.

Mr Murray also exhibited a few *Coleoptera*, taken by his friend Captain Macneil, of the 20th Regiment, in the camp before Sebastopol during the past winter. These included fine specimens of *Hammaticherus heros*, *Cetonia stictica*, and some other species, which, besides their beauty and rarity, possessed an additional interest from the locality and circumstances in which they were collected.

4. *Anatomical details of the new species of Malapterurus.* By Professor GOODSIR.

Professor Goodsir stated, that as he had only received the specimen of *Malapterurus* a day or two before the meeting, it was impossible for him to do more than merely make a few remarks on the subject. He would, however, be glad to give a detailed communication to the Society next session, after he had made a careful dissection of this very interesting fish. The Professor then, after reviewing shortly the results of Pacini's recent examination of the electrical organs of *Torpedo*, *Gymnotus*, and *Malapterurus*, and his own examination of the presumed electrical organ in the tail of the skate, discovered by Dr Stark, and subsequently described by Robin, stated that, so far as his own dissection had proceeded, the structure of the specimen of *Malapterurus*, for which he had been indebted to Mr Murray, corresponded to the description of Pacini, with the exception of the structure of the electrical organs themselves, in which he had hitherto failed in detecting lozenge-shaped plates or octahedral cells, but could make out only a fine fibrous meshwork, permeated by a gelatinous granular substance, as had been previously stated by Geoffroy. The presumed inner electrical organs he found, as Pacini had described, to be merely fibrous membranes, with subjacent fatty deposits.

5. Dr Lowe exhibited some interesting specimens sent home by the Rev. Mr Waddell. Among these was a lizard, evidently belonging to the *Monitor* class of lizards. It was about a foot in length, and beautifully banded and spotted, bearing a close resemblance to the figure given in the ninth volume of Cuvier's Animal Kingdom as *Monitor pulcher* of Leach, but differing from that species by the rings on the tail being continued to the extremity. Two large myriapods,—one, which appeared to be *Julus maximus*, was about seven inches long, having fifty-four rings. It was a male, the very remarkable organs of reproduction being very conspicuous on the sixth ring. The last ring but one was prolonged so as to almost form a tail. On each leg, except on the first three or four pairs and on the last seven or eight, was a remarkable gland-like body, situate on the joint immediately before the claw. These were probably analogous to the bodies observed in the foot of flies, and for the same purpose, viz., to assist in walking. The other Julus was evidently a female, as shown more particularly by the fringes on the sixth ring. This specimen measured no less than nine inches, and had sixty-six scales or rings. Although a difference of sex might account for some variety of appearance, Dr Lowe had no doubt that this specimen belonged to a distinct species. In particular, he pointed out the beautiful sculpture to be observed upon its surface, and the greater length of the antennæ. The penultimate segment also was not in any degree prolonged, and the legs were provided with two instead of one of the gland-like bodies already mentioned. Lastly, Dr Lowe showed two cockroaches of an unusual appearance, and some spiders, the whole of which had been sent by Mr Waddell, and to whom the Society had already been so much indebted for various objects of the highest interest.

6. *Analysis of the Morayshire Slag*, exhibited by William Rhind, Esq., at last Meeting. By M. Forster Heddle, M.D.

The author stated that the extreme brittleness of this substance, the number of vesicular cavities, the pavonine lustre of its fracture, and the separation of minute specks of *metallic* iron, showed that it was indubitably a *slag*. In the qualitative analysis he obtained silica, alumina, lime, oxides of iron and manganese, magnesia, potash, soda, and a trace of phosphoric acid. The quantity of silica is 24·045, of alumina 14·410, of lime 2·184; the proportions of magnesia, potash, and soda being small, he did not determine, and the large excess obtained in the analysis, when the iron was calculated as *peroxide*, showed that a considerable portion of it (about one-third) must have been present in the metallic state; the total quantity calculated as *metal* is 52·370; the manganese he did not separate from the iron, because the quantity was small, and could not in any way affect the decision that the substance was a slag.

Upon the whole, the opinion of Dr Fleming, as stated at last meeting, seemed to be established, that the substance in question was neither an ore of manganese nor a bog iron ore, but a slag arising from the burning of a bed of peat during a dry season, melting a ferruginous soil.

7. *Notice of the Discovery of Fossils in the Limestones of Durness, in the County of Sutherland.* By CHARLES W. PEACH, Esq., Wick, Corresponding Member of the Royal Geographical Society of Cornwall. (The Fossils were exhibited.)

The author, after stating that the limestone beds of West Sutherlandshire had been referred by Mr Hugh Miller to the old red sandstone formation, although the absence of fossils had prevented his asserting this positively, stated that he had been fortunate enough to detect in the limestone of Durness distinct traces of spiral shells, probably Gonatites or Clymeniæ, which exist, though not abundantly, between Balnakiel and the Kyle of Durness. Besides the whorled shells, coral-like markings were very abundant, as well as the pipe-like forms found by Mr Miller in the quartz rocks of Assynt. He found amongst the blocks scattered over the face of the country around Durness, and on the tops of the dykes, several containing these strange forms, and he immediately detected their similarity to those he had found at Goran Haven, Cornwall, in the quartz rocks. The Cornish ones he described in a paper published by the Royal Geological Society of Cornwall, as like the sandy tubes made by the *Sabellaria alveolata*, so abundant on that coast, and occasionally found on all the coasts he was acquainted with. He still saw the resemblance in the Sutherland ones, and it would be a very interesting fact if, besides these "pipes," Trilobites, Orthidæ, &c., should be found in the Assynt quartz, as well as the Cornish.

Mr H. Miller stated at the close of Mr Peach's paper, that he had twice visited the north and west of Sutherland, in order to acquaint himself with the character and relations of the formation in which Mr Peach had been so successful. But though he had examined with some little care the cherty concretions of the limestone of Durness, he had found no such decided organisms as, one at least, of the specimens on the table. The apparent whorls in the rock had attracted his notice; but the region was one in which mistakes had already been made; Macculloch had regarded the white cylinders of Stonechrubie as organic; and the late Mr Hay Cunningham had fallen into what was deemed a similar mistake respecting the supposed tubes of Loch Erribol; and as he could get no such unequivocal organisms as the one on the table, he did not venture to come to any conclusion regarding them. One well-preserved fossil, however, serves to throw light on many obscure ones, and such was the cast specially referred to by Mr Peach, now before the Society. It was evidently that of a whorled shell, though, as its whorls were not on the same plane, neither a *Clymenia* nor a *Goniatite.* It was not, improbable, however, that the other whorled shells on the table belonged to the former genus—a genus of which no fewer than forty-three species had been found in the old red sandstone of other countries. Mr Miller then went on to show the stratigraphical relations of the Durness limestone. It was overlaid, he stated, by a vast deposit of quartz rock, corresponding apparently to the sandstone of Tarbat Ness and Dunnet Head, and underlaid by a coarse-grained red sandstone, the analogue, it would seem, of the Great Conglomerate; while the limestone itself appeared to belong to the same geologic horizon as the flagstones of Caithness and Orkney, and the fish-beds of Cromarty and Ross. No very decisive finding, however, could be based on the organisms yet found; and Mr Miller concluded by remarking, that he trusted Mr Peach would have some farther opportunity furnished him of following up a course of discovery so interesting in itself and on which he had entered with such decided success.

8. Dr John Alex. Smith exhibited two adult specimens of the Water Rail, *Rallus aquaticus*, Penn., captured by his friend Dr John Messer, R.N., on board H.M.S. *Arrogant* in the southern entrance of the British Channel; one on the 12th October 1853, in lat. 49·27, N., long. 8·3 W.; the other on the 13th, in lat. 48·55, N., long. 5·22, W. A remarkable pale-coloured specimen of the Ring-dove, and a curious piebald Mole, caught near Cramond.

Botanical Society of Edinburgh.

12th April 1855.

1. *On Placentation.* By John Cleland, Esq. Communicated by Professor Balfour.

In this paper the author endeavoured to show that in some cases of supposed axile placentation, the ovules were attached to the reflected margin of an inner row of carpels. The paper is published in the Annals of Natural History for May 1855.

2. *Notes on the Flora of the neighbourhood of Castle Taylor, in the County of Galway.* By A. G. More, Esq., Trinity College, Cambridge.

3. *Notes on the Flora of the Bass Rock.* By Professor Balfour.

The following is the list of the plants which have been observed at different times on the rock:—

Phanerogamous Plants.

Ranunculus repens	Leontodon Taraxacum	Narcissus biflorus. In the site of the old garden
Crambe maritima ?	Carduus tenuiflorus	Agrostis canina
Cochlearia officinalis	... lanceolatus	... vulgaris
Silene maritima	... palustris	Holcus lanatus
Lychnis diurna	Hyoscyamus niger	Poa trivialis
Cerastium tetrandrum	Armeria maritima	... pratensis
... semidecandrum	Atriplex rosea	... annua
Lavatera arborea	Beta maritima	Sclerochloa maritima
Geranium molle	Rumex crispus	Dactylis glomerata
Vicia lathyroides	... Acetosa	Festuca ovina
Montia fontana	Urtica dioica	... duriuscula
Sonchus oleraceus	Narcissus Pseudo-narcissus (old garden)	Serrafalcus mollis
Hieracium Pilosella		

Cryptogamous Plants.

Lastrea dilatata	Squamaria murorum	Chondrus crispus
Hypnum, 3 species ?	Prasola orbicularis	... mammillosus
Parmelia parietina	Enteromorpha intestinalis	Rhodymenia palmata
... aquila	Laminaria digitata	Delesseria sanguinea
... saxatilis	... saccharina	Agaricus personatus
Ramalina scopulorum	Alaria esculenta	... amethystinus
Placodium canescens	Callithamnion Rothii	

The total number of species observed amount to—

Phanerogamous, ...	38
Cryptogamous, ...	22
	60

4. *Notice of Plants collected during a Trip to Loch Lomond in July 1854.* By Professor Balfour. With Remarks on the Geological Phenomena observed during the Trip. By James Hector, Esq.

5. *Register of the Flowering of Spring Plants in the Royal Botanic Garden, as compared with the four previous years.* By Mr James M'Nab.

	1855.	1854.	1853.	1852.	1851.
Tussilago alba	March 15	Feb. 14	March 1	Feb. 27	Jan. 26
Symplocarpus fœtidus ...	— 20	March 3	— 16	— 20	Feb. 4
Corylus Avellana ...	— 21	— 10	— 9	Jan. 25	Jan. 16
Narcissus pumilus ...	April 2	— 10	— 21	March 11	March 5
Scilla bifolia, alba ...	— 5	— 13	— 27	— 21	— 8
,, ,, rubra ..	— 6	— 14	— 30	— 28	— 17
Rhododendron atrovirens	— 6	Feb. 18	Feb. 1	Jan. 14	Jan. 2
Daphne Mezereon ...	— 6	— 18	— 1	— 21	— 28
Primula denticulata ...	— 7	— 27	March 25	Feb. 19	Feb. 15
Arabis albida	— 8	— 15	— 15	— 18	— 7
Aubretia grandiflora ...	— 8	— 17	Feb. 1	March 18	March 1
Nordmannia cordifolia ...	— 9	March 1	March 24	— 10	Feb. 20
Dondia Epipactis ...	— 9	— 11	— 25	— 8	Jan. 4
Primula nivalis	— 10	— 4	— 15	Feb. 20	March 16
Scilla bifolia, cærulea ...	— 10	— 15	— 27	March 20	— 6
Pulmonaria angustifolia	— 10	— 19	— 30	— 1	
Symphytum caucasicum	— 10	— 11	— 26	Feb. 2	— 23
Doronicum caucasicum ..	— 11	— 11	— 26		— 25
Draba aizoides	— 11	— 20	April 1	March 26	— 14
Erythronium Dens Canis	— 11	— 10	March 19	— 12	— 1
Anemone Pulsatilla ..	— 11	— 14	April 13	Feb. 21	April 15
Tussilago Farfara ...	— 11		— 4		Feb. 19

Note.—Between 10th March and 12th April, 1854, 65 spring flowering species were recorded, and during the same period this year, only 22 of the species have come into bloom.

Mr Evans stated that the first expanded flowers of the Apricot were observed in the Experimental Garden on 24th March, being about three weeks later than last year.

Lowest Temperatures indicated by the Register Thermometer Fah. kept at the Botanic Garden during March 1855 :—

	deg.		deg.		deg.		deg.
March 1 ...	37	March 9 ...	31	March 17 ...	34	March 25 ...	26
... 2 ...	30	... 10 . .	30	... 18 ...	29	... 26 ...	32
... 3 ...	31	... 11 ...	30	... 19 ...	32	... 27 ...	31
... 4 ...	38	... 12 ...	33	... 20 ...	34	... 28 ...	23
... 5 ...	31	... 13 ...	26	... 21 ...	31	... 29 ...	28
... 6 ...	27	... 14 ...	24	... 22 ...	31	... 30 ...	27
... 7 ...	28	... 15 ...	33	... 23 ...	25	... 31 ...	26
... 8 ...	25	... 16 ...	35	... 24 ...	24		

Average lowest temperature for March 29½°.

10*th May* 1855.

1. *On some New Species of British Fresh-Water Diatomaceæ, with remarks on the Value of certain Specific Characters.* By Professor GREGORY.

After enumerating the various species of Diatomaceæ which were new or rare in Britain, and which he had detected in different gatherings, Professor Gregory remarks :—

Species, among diatoms, are generally distinguished by the following particulars, which are noted in the character attached to the specific name, viz. the form; the structure, where anything remarkable occurs; the length of the individual frustule, within the usual limits; the arrangement and number of the striæ, where these are visible, as well as their nature, whether moniliform or continuous, narrow or broad, close or distant, &c., and frequently the aspect of the median line, if present, and of the nodules at its centre and extremities.

I shall not here enter on the subject of the structure of the frustule, partly because this is rather a generic than a specific character, and partly because little is known of it in reality.

But I propose to direct attention to some points which occur in almost every character of the species, namely, the form or outline, the number of the striæ in a given space, and the aspect of the median line and nodules, because it appears to me that these characters, at all events in some species, are subject to considerable variation, and cannot therefore be safely trusted to as specific characters.

First, as to form or outline. In a large number of species this varies so much that, if we were guided by it, we should make many species out of what certainly is but one, as is shown by the fact, that these forms pass by gentle gradations into each other. This kind of variation occurs in Navicula lacustris, of which three very different forms occur. It is seen also in Navicula elliptica, of which four varieties occur, only three of which are oval, but of different proportions, while the fourth is constricted. Navicula dubia is believed to belong to the same species as N. amphigomphus and N. dilatata, and by some, all three are united to N. firma. It is certain that all four agree in having the side lines, but they all differ in outline. Navicula lepida, one of the new species, exhibits three varieties, differing in form. One is very short and broad, nearly orbicular, while another has straight sides. But the most remarkable example is found in a species which I have elsewhere described, and which has, although very frequent, been most unaccountably overlooked hitherto. I have named it Navicula varians, and I exhibit a proof of a plate, not yet published, in which I have figured a considerable number of the types of form in which it appears, along with many of the intermediate or transition forms which I always find to accompany them. It would require a second plate to show all the marked types, of different outline, observed in this species, and the connecting transition forms. Of all those figured in the plate, not more than three have ever been figured before, and these all as distinct species, namely, Navicula inflata, N. rhyncocephala, and N. scutelloides. But the first and the last of these are only doubtfully placed by me under N. varians. The former may be a distinct species, although the figures seem to show that it also has a tendency to vary. As to the latter, the N. scutelloides of Smith would seem, according to Dr Greville, to be a Cocconeis, not a Navicula.

My reason for uniting nearly the whole of the forms in the plate, and a number of others, in one species, are, first, the similarity in the general aspect, and in the peculiar arrangement of the striæ; secondly, in the gatherings where I find them, all or most of them occur together, with every degree of intermediate form. Yet, if several of those which differ most in form were to be found unmixed with others, they would certainly have been considered—indeed, so far as observed, they have been considered—as distinct species, and some have even been placed in different genera.

It is plain that, in describing this species, we cannot give any form as a specific character. And if our description or our figures are to be of use to observers, we must give at least figures of all the distinctly different types of form, adding that transition forms occur between any one of these types and all the others. The same rule applies to all the species already noticed as varying in form. To these I may add the following—viz., Pinnularia divergens, Navicula rhomboides, Eunotia triodon, E. bigibba, Himantidium bidens, and others.

The next character is that of the number of striæ, which in this country are usually given for 1-1000th of an inch; on the Continent, for 1-100th of a line, or 1-1200th of an inch. In some species, perhaps in many, this character is by no means constant. In Navicula varians, I find that in the smaller individuals, there are often 24 to 26 striæ in 1-1000th of an inch; while in the larger, there are only 14 to 16, and this in individuals of the same type of outline. Smith describes Pinnularia divergens with 11 striæ in 1-1000th inch, while I find it more frequently with from 22 to 26 in 1-1000th inch—the arrangement, which is peculiar, being the same in both.

A very striking example occurs in Navicula elliptica, which, as we have seen, also varies in form. The species, as described by Kutzing, has very coarse striæ, even coarser than appears by any of the figures. But in a variety to which I have directed attention, and which I regarded on this account as a distinct species, till I found a gradual transition to the first-named type, the striæ are so very much finer, being about three times more numerous, that the aspect of the frustule is totally changed. In comparing examples of the extreme types in regard to striation, I took individuals of equal size, and I found in one very coarse striæ; in the other, striæ so fine as not to be easily seen, unless the valve were placed in the most favourable position with reference to the light. I might adduce other examples, but I shall pass on to another character.

This is the appearance of the median line and nodules. In the coarsely striated variety of N. elliptica, there are lines on each side of the median line, forming a double cone, of which the bases meet near the centre. But in the finely striated variety, these lines are parallel to the median line; only bending outwards round the central nodule. This assists in giving a very different aspect to the two forms, which yet are connected by a graduated chain of transition forms.

Time will not allow me to dwell longer on this subject; but I may add, that in the variety β of Navicula lepida, the character and aspect of the median line and nodules is quite different from those in the typical form α. In this case, the striation is also more conspicuous in β than in α.

We have, then, if we consider only the three characters of form or outline, number of striæ, and aspect of median line and nodules, evidence that great variations may occur in any one of them. Nay, in Navicula elliptica and N. lepida, variations occur in all three together. In such cases as these last, it is difficult to define the species by these characters in the usual way, and we have apparently no resource but to state the fact of the tendency to vary in one or more of these points, as one of the specific characters. In Navicula varians, the arrangement of the striæ is always the same, as it is also in Pinnularia divergens, and many others, but in Navicula elliptica even this fails; for the striæ are highly radiate in the coarsely striated form, and nearly parallel in that with finer striæ.

In all such cases, the definition should be accompanied by accurate figures, showing the way in which the species vary, and in regard to outline, as already remarked, giving all the marked types of form between which the transition forms will naturally find their place.

As to size, in some cases enormous variations occur, as may be seen in the plate of N. varians, even in the same type of form; also in N. elliptica, Eunotia triodon, Pinnularia divergens, and many others. If Pinnularia megaloptera be referred to P. lata, we have a variation in length from about 20-10,000ths of an inch to nearly 80.

The distribution of Diatoms over the world is one of the most remarkable points about their history. Not only do we find, if we examine a gathering from any part of the world, that most of the forms are identical with those of our own waters; but in tracing these minute organisms through the later to the earlier sedimentary rocks (and it is said that they occur in the lower Silurian strata, the oldest in which any organic remains occur), we find still the greater number of species to be those of the present day. This part of the subject well merits a close investigation.

Ehrenberg, in his last great work on the distribution of microscopic forms over the earth, both in the present period and in past geological times, has shown that in all soils in which plants grow, Diatoms are present, often in considerable quantity, and in great variety. He ascribes to them a great part in the formation of such soils, and it is probable that by their life and growth they extract much silica from the water in which they live, and transfer it at their death to the soil. The sediment of all rivers contains a considerable amount of Diatoms, as, for example, the mud of the Nile and that of the Ganges, which have formed the great Deltas of Egypt and Bengal.

I propose to lay before the Society, at a future meeting, the results of an examination of some small portions of earth taken from botanical specimens in herbaria from foreign, chiefly tropical, countries. In all of these Diatoms occur, so far as I have examined them, as is also reported by Ehrenberg in the work I have alluded to. If any member of the Society can supply me with such earth from exotic specimens, as in many cases a little earth adheres to them, I shall be very grateful, and they shall be carefully examined, and the results made known at the time referred to. If any plants should arrive from abroad, with earth adhering to them, such earth ought to be carefully preserved for examination. The results of the examination of the specimens of earth given to me by Professor Balfour are in several respects very interesting.

2. *Remarks on Specimens of Megacarpæa polyandra, Bentham.* By Dr Balfour.

Mr Moore having kindly sent from Glasnevin a specimen of the flowers and leaf of this plant, I think that it is of sufficient interest to call for notice at a meeting of the Botanical Society.

The seeds of the plant were sent by Colonel Madden to Dublin, and he gives the subjoined remarks in regard to the plant as seen by him in India:—

Colonel Madden states:—“The following notice of Megacarpæa polyandra (Bentham), extracted from my Road Book, containing merely hurried remarks made on the spot on plants collected, and cursorily examined, at the end of a frequently fatiguing day's journey in a very difficult country, do not pretend to any minute accuracy, and are only calculated to afford a general idea of the plant and of the site and conditions under which it exists. A more scientific description of the plant will be supplied from specimens grown in the Botanic Garden, Glasnevin, Dublin, by Mr D. Moore, the curator, from seeds transmitted by me from Kumaon in 1849, and which, though speedily germinating, and attaining a great size, have only flowered this spring, for the first time in Europe; as Mr Moore thinks, in consequence of the past severe winter, which must closely resemble the extreme rigour of that proper to the locality where the Megacarpæa is indigenous.

"The interest of the plant consists in its possessing a number of stamens, (from 12 to 15), quite abnormal in the order of Cruciferæ, to which it otherwise belongs; and which might seem, taken alone, to place it between that order and Papaveraceæ; but when these extra stamens are viewed as developments of the glands which are present in the Cruciferæ on the disc or torus, between the petals and the ovary and ordinary stamens, the plant may well be referred simply to that order.

"The Genus Megacarpæa was first discovered, I believe, by Fischer, in the salt Steppes and calcareous hills of Turkistan, in the neighbourhood of the Caspian Sea; and by Ledebour in Siberia; and was originally referred to Biscutella. Two species are described by De Candolle, (Prod. I., 183), but so imperfectly, that till further information is obtained, it is impossible to determine whether the plant before us, from the Himalaya, is identical with either of them, especially M. laciniata from the Altai Mountains, or a new species which is to bear the name of M. polyandra.

"Megacarpæa (probably this very species) was next met with by Dr Hugh Falconer in the Highlands of Little Tibet, on the Husora River, an affluent of the Indus, and in the same country by the late Mr J. E. Winterbottom, who described it to me as growing 6 to 8 feet high on the Barzil Pass, upper glen of the Kishenganga River, between Kashmere and Astor; but neither of these botanists was, I believe, so fortunate as to obtain the flowers, which were first seen by Captain R. Strachey in 1848, on a visit to the glacier sources of the Pindar River in Kumaon, up to which date the existence of the plant in the British Himalaya was unknown; nor has it been discovered, so far as I am aware, in any other of our provinces—at least those south of the Sutlej River. Here it occurs in three localities, where the climate resembles or approximates to that of Little Tibet, Turkistan, and the other habitats, viz., extreme cold in winter, and extreme heat and aridity in summer, conditions which have proved favourable to the migration or presence of many other Tibetan and Siberian plants on the dry northern slope of the Himalayan range, where a system of vegetation is established in marked contrast with what prevails on the Indian face, which is annually for three months deluged with rain.*

* A very instructive example of the manner in which plants are distributed in distant regions of similar physical character is afforded by Calligonum Pallasii. This, like the Megacarpæa, abounds in the Caspian province, and equally or much more, in the sandy deserts of Western India, between the Jumna and the Indus rivers. The heat for many months annually is extreme, and one is at first surprised to find a plant flourishing here which is also indigenous to the steppes of the Caspian, where the winter cold is equally extreme. But, as is now well known, the Caspian and its deserts occupy a deep hollow at the western end of a plane descending from the sources of the Oxus and Jaxartes, and as a consequence of this low position on the earth's surface, possess a summer temperature as high as the winter one is low, and perhaps equal to that of the Indian desert above referred to. In the latter, during the months of April, May, and June, when everything else is burnt up, the Calligonum, with its innumerable green leafless twigs, covers the waste of sandhills with a mantle of verdure, yielding a favourite food to the camel, the proper beast of burden of the country. It is known to the people by the name of *Phoke*, and under this designation is first mentioned by Mr Elphinstone in his account of the

"In Kumaon the plant occurs on the open sunny downs, at from 11,500 to 14,000 feet above the sea level, where all arboreous vegetation has ceased. It is well known to the mountaineers by the name of *Roogee*. They eat the pounded root as a condiment; it has like the whole plant a strong permanent odour and flavour, something like horse-radish. The localities in which it grows are—1. Champwa near the Kaphini glacier; 2. Near the Soondurdhoongee glacier, the heads of the Pindar River; and, 3. At Ralim, on one of the spurs of the snowy Panch—Choola Range, which bounds the next great valley to the east. Here the Roogee flowers in May, June, and ripens its fruit in September, October. The root is fusiform, a foot or more in girth at the collar, and from 1 to 2 feet long, forked below; internally of light cellular substance, externally exhibiting very numerous horizontal annular ridges. Several annual stems from 4 to 6 feet high. When young in winter protected by many erect, rectangular, straw-like scales. Radical leaves spreading from 2 to 2½ feet long, the exterior half occupied by 7 or 8 distant, distinct, sub-opposite or alternate pinnæ; petiole dilated at the base; cauline leaves scattered, erect, pinnato-pinnatifid, about a foot long, with 10 to 12 segments linear-lanceolate, acuminate, incised, the lower ones more or less separate, terminal more confluent. Flowers in dense terminal and axillary leafy corymbs, shorter than the leaves; small, white or yellowish white, with a sweet fragrance or strong odour of horse-Radish (according to taste), and much frequented by bees, flies, &c. Peduncles and pedicels villous, the latter long and one-flowered. Sepals 4, oblong, obtuse, coloured, from 1-5th to 1-4th inch long; petals alternate, oval, veined, half the height of the sepals; stamens 12 to 15, hypogynous, erect, as long as the calyx, and disposed in 2 or 4 sets. Ovary one, flat, obcordate, resembling the silicle of Capsella Bursa-Pastoris, with 2 auriculate, 1-seeded cells; stigmas 2 on a very short style. The silicle is about 1¾ inch by 1¼, one of the cells being abortive."

The following is a description of the plant taken from the specimen sent by Mr Moore:—

Megacarpæa polyandra, Benth.—Leaf sent by Mr Moore about a foot long—greatest breadth about 7 inches; deeply pinnatifid—lobes narrowish, tapering at the apex—toothed; upper surface dark green—under surface glaucous, covered with short hairs, many of which are glandular. Similar hairs occur on the petiole, which is thick, with ridges and grooves, flattened on the upper side and rounded below. Flowers in compact racemose clusters, of a yellowish white colour, and having a strongish odour. Sepals whitish, with a yellowish and purplish tinge in some places, rugose, deciduous, broadly obovate, and convex externally. Petals smaller than the sepals—obovate, tapering below—rugose. Stamens varying from 11 to 13, some longer than others, but not apparently in any definite number; filaments thick—broader below. Anthers innate, two-lobed, yellow; green circle of glands round the base of the stamens, attached to a broadish thick receptacle. Ovary transversely elliptical, with a short style and large stigma—two celled. Fruit a silicula, with the replum across its narrow part. Seed brownish, about 1¼ inch in length, and about the same in breadth—winged; the wing nearly a quarter of an inch deep—veined; hilum straight or slightly curved about half an inch long.

3. *Register of the flowering of Spring Plants in the Royal Botanic Garden, as compared with the four previous years; with a register of*

kingdom of Caubul. A species of Ephedra likewise occurs, which is also called by the same name, but the true plant is the Calligonum, and neither Ephedra nor Ascelpias acida (the Soma plant) as some have supposed.

the lowest temperature indicated by the thermometer at the garden during April 1855. By Mr James M'Nab. [Published in the Scottish Gardener for June 1855.]

4. *Remarks on the effects produced by the intense frost of February* 1855 *on the out-door plants in the Royal Dublin Society's Garden, Glasnevin.* By Mr D. Moore. Communicated by Professor Balfour.

5. *On the Disease of Finger-and-Toe in Root Crops.* By Sir John S. Forbes, Bart. Communicated by Professor Balfour.

6. *Note on the origin of the name Chenopodium Bonus Henricus.* By Mr Hardy, Penmanshiel. Communicated by Professor Balfour.

14*th June* 1855.

1. *Remarks on the Calamite and Sternbergia of the Carboniferous Epoch.* By Dr Fleming. Additional Illustrations by Dr Balfour.

The author made some preliminary remarks regarding the study of vegetable palæontology. The specimens, accessible for the illustration of the subject usually occur in a fragmentary form, marcerated, rubbed, squeezed, and without indications of age or conditions of growth, so that the greatest sympathy should be extended to those who attempt to decypher in such circumstances. The investigation of these relics, he next observed, should be preceded by the study of the structure, functions, and distribution of living plants, and hence he viewed with delight the formation of a collection of the remains of *extinct plants* within the walls of the Botanic Garden.

Dr Fleming then exhibited several examples of *Calamites* of different kinds, which he considered as justifying the following conclusions,—1. That many species have the original matter, now forming a thin film of coal, smooth on the outside or not exhibiting externally any traces of joints or longitudinal ribs. 2. From the inside of their woody cylinder, now converted into coal, diaphragms proceeded at regular, but occasionally at irregular intervals, dividing the inside of the hollow stem into a series of chambers. These partitions appear to have possessed a very loose texture towards the centre, but became more dense in substance towards their junction with the stem, and usually leave traces of coaly matter at the sides. The jointed character of the *casts* of the inside, in general all that is noticed by the geologist, is thus referable to the dissepiment, and cannot be regarded as resembling the jointing of a *Calamus*. 3. The inside of the woody cylinder, although smooth on the outside, was grooved longitudinally on the space between the partitions, or on the walls of the chamber, and hence the ribbed surfaces of the *casts*. 4. The stem, unlike stigmaria and lepidodendron, had no woody axis nor dense medullary sheath.

The author next exhibited specimens of *Sternbergia*, displaying, like the *Calamite*, the external cylinder of coal, with a smooth surface, and giving no indication of the internal arrangements. The inside exhibited diaphragms, having the same origin as in the *Calamite*, but less regularly disposed, frequently uniting, and giving to the surface of the cast, not a distinctly jointed, but a transversely crumpled appearance. He concluded by stating, that from the smooth surface and thickness of the coaly matter into which the plant had been converted, joined to its independent or detached condition in the rocks, it could not be regarded as the remains of a discoid pith, but, like the *Calamite*, as a plant which had a hollow stalk, the cavity divided into chambers by transverse partitions, the remains of which give to the *casts* their characteristic appearance.

Professor Balfour exhibited numerous specimens of *Rhizomes* and stems of plants, which seemed to illustrate, in some measure, the appearance presented by such coal plants as *Stigmaria*, *Calamite*, and *Sternbergia*. Dr Balfour agreed with Dr Fleming in his views regarding these plants, and referred particularly to the statements made by Dr Fleming in his paper on *Stigmaria* in the Proceedings of the Royal Society.

2. *On a Deposit containing Sub-fossil Diatomaceæ.* By Professor Harkness. [This paper appears in the present number of this Journal.]

3. *Notice of the time of flowering of certain Trees this season.* By Mr M'Nab.

4. *On the Effects of the past Winter on certain Trees in the neighbourhood of Belfast.* By Professor Dickie.

The following table shows the lowest point to which the thermometer fell during the month of February 1855. It is taken from a register kept at Queen's College, Belfast :—

	Min.		Min.
Feb. 1.	27·0 F.	Feb. 15.	13·0
2.	30·0	16.	19·0
3.	30·0	17.	20·0
4.	33·0	18.	17·0
5.	39·0	19.	21·5
6.	36 6	20.	22·0
7.	37 4	21.	27·0
8.	31·0	22.	27·0
9.	30·0	23.	30·0
10.	29·0	24.	24·4
11.	22·0	25.	34·0
12.	30·0	26.	34·0
13.	23·0	27.	34·0
14.	18·0	28.	37·4

Mean temperature for the month.	32·45
Mean maximum, . . .	37·6
Mean minimum, . . .	27·7
Amount of rain, . . .	1·690

It will be observed that the absolute lowest temperature was on the 15th, viz., 13° F. In 1845, on 5th March, the thermometer in the Botanic Garden indicated 10° F.; lower, therefore, than in 1855. The injury to the plants, however, in 1855, was greater, because in February last a generally low temperature, with east and north-east winds, prevailed during two weeks.

The following list of plants injured or killed in the Belfast garden during last winter has been drawn up by the curator, Mr Ferguson :—

Pinus macrophylla,	much injured,	12	feet high.
... apulcensis,	killed,	8	...
... patula,	much injured,	6	...
... pseudo-strobus,	slightly injured,	7	..
... Devoniana,	much injured,	2½	...
... Russelliana,	browned.		
... palustris,	killed.		

Abies Brunoniana,	killed.	
... Jezoensis,	killed.	
Cepressus funebris,	north side killed.	
... uhdiana,	much injured.	
... elegans,	killed.	
... mexicana,	killed.	
... torulosa,	1 killed, and others much injured.	
... lusitanica,	killed.	
Juniperus macrocarpa,	slightly injured.	
Fitzroya patagonica,	killed,	4 feet high.
Saxegothæa conspicua,	killed,	4 ...
Cephalotaxus Fortuni,	not injured in the least, whereas the larger-leaved variety has suffered much.	
Erica arborea,	killed, 10 feet high.	

For the sake of comparison, it may be interesting to insert here the following report by the late Mr Templeton of Oranmore, respecting the severe winter of 1813–14, as reported in the *Belfast Magazine* for that year:—

"Viburnum Tinus, Cistus ladaniferus, C. creticus, Erica arborea, E. australis, E. mediterranea, Ulex europæus, Prunus Laurocerasus, P. lusitanica, in many places were killed to the ground, or had their young branches destroyed. Edwardsia microphylla and Coronilla glauca, which, trained against a wall, had stood the frost of several winters, are either killed to the ground, or have their branches of two or three years killed. Calycanthus præcox, Pyrus japonica, and Corchorus japonicus, have passed the winter in the open ground. Timber trees suffered greatly, especially the oaks, which were split with great violence. Walnut, ash, and other trees, had their last year's shoots killed. On 29th December the thermometer fell to 7° F."

5. *Remarks on the Dye Lichens.* By Dr Lauder Lindsay. [This paper appears in the present number of this Journal.]

6. *Account of the origin and of the contents of the Museum of Economic Botany attached to the Royal Botanic Garden of Edinburgh.* No. I. By Professor Balfour.

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

The "Académie des Sciences de Paris" have awarded the *Cuvierian Medal* of 1854 to Professor John Müller of Berlin for his researches on the structure and development of the Echinodermata. The Royal Society of London, at their anniversary meeting November 1854, presented the Copley medal to the same distinguished foreigner for his important contributions to comparative anatomy, and particularly for the researches above-mentioned.

Development of the Nematoidea.—In a recent work by MM. Ercolani and L. Vella, it is stated that the embryos of the ovoviviparous Nematoids do not attain complete development where deposited by the parent. The ova of the oviparous nematoids, and the embryos of the ovoviviparous require to leave the position where they were deposited, and live free for a certain time, and to perfect themselves by entering the bodies of animals. The ova of some nematoids remain stationary in the intestinal mucus of the animals in which their parent had deposited them.

The changes in the development of these ova succeed each other with great rapidity so soon as they are placed in water. Some infusoria, referred by Ehrenberg and other naturalists to the genera *Vibrio* and *Auguillula*, are only nematoids in an embryonic state.—(*Rev. et Mag. de Zool.*, 1854.)

Production of the Cysticerus fasciolaris from the Eggs of the Tænia crassicollis—(From a letter of R. Leuckhart of Giessen, to C. Th. von Siebold of Munich.)—" In October of last year when in conjunction with Bischoff, in making some investigations about the Ascaris mystax, I met with a cat affording excellent specimens of the Tænia crassicollis; I immediately resolved to produce a brood of them, if possible, in the form of hydatids. For some years past I have kept a colony of white mice, which occasionally in my researches were more or less used. This colony at that time consisted of twelve. I divided them, and fed one-half of them with the eggs of my Tænia, which I obtained by crushing between the fingers. The juice thus procured I mixed partly in the water, partly in the food (hemp seed and white bread) in different places in the cage of my mice.

Under such circumstances the probability was naturally very great that the mice would convey the Tænia into the intestinal canal. The experiment was thus conducted, but unfortunately among many other investigations, it was for some time forgotten. In February I first opened five of them, and found them all affected with hydatids of about an inch in length. One specimen contained five worms, another three, and so on. The fifth had no hydatids, but exhibited on the outside of the stomach and in the omentum small cysts of clear water of the size of a pin-head, which, on microscopic examination, appeared formed of a bulb of fibres of cellular tissue, and a dense structureless skin, in which was contained a mass of a fatty appearance. Similar little cysts were found also in the other mice, in one specimen even in the serous coat of the liver, so that I have no doubt these are properly entozoa, which have strayed and died, never having arrived at the end of their journey. Indeed, I could not find the embryonal hooks, but they also were wanting in the cysts of the perfect worms.

My experiment is not to be assailed, for the mice were born in my house, never left their cage, got the above-mentioned food and fresh spring water to drink, and so could scarcely by accident have become infected with the brood of the cat's tænia, neither have I ever observed at any period hydatids, except in my mice. Besides, it happens that these mice contained (except one) several hydatids, which seldom occur in those at liberty.—(*Zeitsch. fur Wissenschaf. Zool.*, 1854.)

Gosse on the Systematic position of the Rotifera.—" The hemispherical bulb which is so conspicuous in *Brachionus amphiceros*, lying across the breast, and containing organs which work vigorously against each other, has long been recognised as an organ of manducation; it has been called the gizzard; but the author proposes to distinguish it by the term *mastax*. It is a trilobate muscular sac, with walls varying much in thickness, receiving at the anterior extremity the *buccal tunnel*, and on the dorsal side giving exit to the æsophagus.

Within this sac are placed two geniculate organs (*the mallei*) and a third on which they work (*the incus*). Each *malleus* consists of two parts (the *manubrium* and the *uncus*) united by a hinge joint. The *manubrium* is a piece of irregular form, consisting of carinæ of solid matter, inclosing three areas, which are filled with a mere membranous substance. The *uncus* consists of several slender pieces, more or less parallel, arranged like the teeth of a comb, or like the fingers of a hand.

The *incus* consists of two *rami*, which are articulated by a common base to the extremity of a thin rod (the fulcrum), in such a way that they can open and close by proper muscles. The fingers of each *uncus* rest upon the corresponding *ramus*, to which they are attached by an elastic ligament. The *mallei* are moved to and fro by distinct muscles, which the author describes in detail, and by the action of these they approach and recede alternately; the rami opening and shutting simultaneously, with a movement derived partly from the action of the *mallei*, and partly from their own proper muscles.

All these organs have great solidity and density; and from the action of certain menstrua upon them, appear to be of calcareous origin.

It is with the Insecta that the author seeks to ally these minute creatures; and by a course of argument founded on the peculiarities of structure, the following identifications are maintained:—That the *mastax* is a true MOUTH; that the *mallei* are MANDIBLES; the manubria possibly representing the cheeks into which they are articulated; that the rami of the *incus* are MAXILLÆ; and that the fulcrum represents the cardines soldered together.

While the connection of *Rotifera* with Insecta is maintained through these organs in their highest development, their affinity with *Polyzoa* is suggested by the same organs at the opposite extremity of the scale, since the oval muscular bulbs in *Bowerbankia*, which approach and recede in their action on food seems to represent the quadriglobular masses of *Limnia* and *Rotifer*, further degenerated.

If this affinity be correctly indicated, the interesting fact is apparent, that the *Polyzoa* present the point where the two great parallel divisions *Mollusca* and *Articulata* unite in their course toward the true Polypi.—(*P. H. Gosse, Proc. Roy. Soc. Lond.*, 1855.)

Organ of Hearing in Nautilus umbilicatus.—The organ of hearing which had escaped detection in the specimen of *Nautilus pompilius* dissected by Professor Owen, altered, as it doubtless had been, by long immersion in spirit, was discovered in the example of *Nautilus umbilicatus.* It consists of two spheroidal acoustic capsules placed one on each side, at the union of the supra and sub-œsophageal ganglia, and measuring about one twelfth of an inch in diameter. Each capsule rests internally against the nervous mass, and is received on its outer side into a little depression in the cephalic cartilage. It is enveloped in a kind of fibrous tissue, and filled with a cretaceous pulp, consisting of minute, ecliptical, octoconical particles, presenting under a high power a bright point near each end, varying much in size, and sometimes combined into stellate, cruciform, or other figures. Cilia were not observed within the capsules.—(*John D. Macdonald, R.N., Proc. Roy. Soc. Lond.*, 1855.)

GEOLOGY.

Tunnel through the Malvern Hills—Discovery of Graphite.—One of the results arising from the formation of railways has been the opening up, by cuttings and tunnels, of the various strata through which they pass, and the exposure, in consequence, of some extremely interesting sections. A work of some magnitude is now proceeding in the vicinity of Malvern, no less than that of tunnelling through the base of the Malvern Hills. The junction, on the east side, of the syenite and the red sandstone has been already disclosed, and a mineral has been discovered, either identical with or closely allied to graphite. The following remarks by a correspondent were made last month during an examination of the tunnel:—

"Arrived at the bottom of the shaft, we commenced our observations, and, working eastward, we came to the edge of the syenite, and found a band of gray marl, in a moist and clay-like state, in contact with it, dipping at a high angle. This we very carefully measured, and ascertained by the clinometers the angle to be 54°. Walking on in the same direction, we passed through red marls, mingled occasionally with gray, all dipping eastward, until, at a distance of 45 feet from the syenite, we discovered the first band of Keuper shale. The dip of this we took carefully, and found it 37°. The marls in the neighbourhood of these shales were so highly indurated as to have the appearance of very compact sandstone. Proceeding eastward, we noticed several thin bands of Keuper shale, the dip varying very considerably, some of them being almost horizontal, while the perpendicular, the dip of the highest was 57°. I conclude from this circumstance that they must have been subjected to local disturbance subsequent to the general upheaval. We noticed nothing farther that seemed remarkable on the eastern side, and, having reached the end of the working, we retraced our steps to the shaft, and began our inspection of the interior of the Malvern Hills. I should state that the syenite in immediate contact with the new red seemed very loose and broken up, and at first I was disposed to think this was the result of the grinding process in upheaval; but finding no fragments among the clay and marl, I came to the conclusion that its fragmentary and rotten appearance was produced by the action of water, a considerable quantity of which was held against it by a barrier of clay.

"We journeyed westward, and carefully examined the syenite as we went. Its appearance is varied as at the surface, but we saw no variety of rock differing from the surface or quarried specimens we are familiar with, excepting that the hornblendic syenite is of a much lighter colour, approaching in appearance the chlorite of the Wytch. Associated with this particular variety of rock, at 111 yards west of the shaft, we found the black shining mineral which Professor Phillips pronounces *graphite.* It there appears in a vein about 6 inches wide; a large quantity has been worked out, and now, at 123 yards from the shaft, the vein has a width of nearly 3 feet; it is much mixed up with masses of quartzose and felspathic rock, and is so loose and schist-like that quantities of it may be knocked down with a stick or hammer. The direction it takes is from south-west to north-east, and as it appears to be increasing in mass, we may hope to pass through a considerable quantity, and it may probably improve as we approach the centre. Several springs make their appearance in the tunnel, but they all rise from the bottom."

Age of the Bengal Coal-fields.—In the coal-fields of India numerous remains of fossil plants are found referable to genera which to European geologists are known only to occur in rocks of a more recent date than the true carboniferous epoch. Associated with these are other genera not hitherto found at all in European rocks, but occurring plentifully in this country (India), and also in Australia. Now it is well known to every geologist that the remains of plants alone furnish exceedingly poor evidence on which to base any conclusions with regard to the age of the rock in which they occur. And this being the case, it is important to find, if possible, fossils belonging to the animal kingdom in connection with them. Now, in Australia, associated with beds containing fossil plants specifically identical with those found in the Indian coal-fields, occur other beds rich in animal remains of a well-marked type, which type represents a period (geological) corresponding to the lower carboniferous group of Europe. It was at first supposed that the beds containing the fossil plants occurred above, and formed a distinct group from the shelly beds; but the observation of all the most truthworthy witnesses negatives this. And in Australia, so far as our present evidence goes, it must, I think, be considered that the same fossil plants which in India characterize the coal-yielding beds, occur associated with abundant remains of shells, which must be considered of the carboniferous epoch of European geology. But the question is by no means so easily solved; for passing into Western India, we find associated with identically the same plants as occur with those found in the coal-yielding beds of Bengal, numerous remains of shells, &c., which are undoubtedly representatives of the oolitic period. The evidence here also would seem clear, and the statements of Captain Grant, in his description of Cutch, would lead us to refer the coal-yielding beds of that district containing Ptilophylla, &c., to the oolitic group. Taking, therefore, the analogy of the nearer country, and coupling this with the general analogy of the fossil plants found in these beds, I am disposed to think that we must *provisionally* consider these coal-bearing rocks of Bengal as belonging rather to the Mesozoic period than to the Palæozoic.—(*Mr Oldham, Proc. As. Soc. Bengal*, 1854. —*Journ. As. Soc. Bengal*, No. vi., 1854, p. 619.)

CHEMISTRY.

Researches on Nascent Oxygen. By M. Auguste Houzeau.

M. Houzeau has made the important discovery that nascent oxygen can be produced abundantly by a purely chemical process, and then has properties completely similar to those of ozone. His process consists in placing sulphuric acid in a tubulated balloon, to the neck of which a narrow tube plunging under the water of the pneumatic trough is attached. Peroxide of barium is then thrown in, and the gas immediately disengaged. In some instances it is necessary to raise the temperature to 1[illegible]0° Fahr., but it must not exceed this, for when exposed to a higher temperature the oxygen passes into its ordinary condition.

Nascent oxygen is a transparent gas with a strong odour, which at first is not disagreeable, but becomes unsupportable when it has been smelt for some time. It may be respired if care be taken, but if introduced in large quantity into the system, it produces nausea and vomiting. When heated to 107° it loses all its active properties. In presence of water it oxidises most of the metals, including silver. It peroxidises most metallic protoxides, and converts arsenious into arsenic acid; the alkalies and acids act powerfully upon it. It oxidises ammonia with great rapidity, and if a rod dipped in a solution of that alkali be introduced into the gas, the vessel is instantly filled with white fumes of nitrate of ammonia. It immediately ignites the non-spontaneously inflammable phosphuretted hydrogen; hydrochloric acid in solution in water is instantly decomposed by it, with formation of water and evolution of chlorine. It decomposes iodide of potassium, and bleaches vegetable colours. When passed slowly through a tube containing spongy platinum, asbestos, cotton wool, or other porous substances, it is immediately converted into common oxygen. The author, in concluding his paper, remarks that peroxide of barium is not the only substance containing oxygen in the nascent state, but on the contrary that it exists in that condition in most if not all compounds, and the reason why we do not obtain it from other substances is, that the conditions of our experiment do not permit its evolution in its primitive state, the heat, light, or other means we employ converting the active oxygen into its inert form. *Comptes Rendus*, vol. 40, p. 947.—[The author promises in a future paper to compare his nascent oxygen with Schonbein's ozone. It is to us obvious, however, that they are identical, and the experiments of M. Houzeau must be considered as conclusive evidence in favour of the view taken by Berzelius, that ozone is really an allotropic oxygen; and it is to be regretted that M. Houzeau had not employed that term in place of nascent oxygen, which chemists have been in the habit of using in a somewhat different sense.—*Ed. Phil. Jour.*]

Preparation of the more oxidisable Metals by Electrolysis.—The recent researches of Bunsen have shown that the density of the electro current has a very important influence on its power of producing chemical decomposition. The density of the current is equal to its intensity divided by the surface of the pole at which the decomposition occurs. Hence, if a current be passed through a solution of chloride of chromium we may obtain, according to the diameter of the reducing pole, either hydrogen, sesquioxide of chromium, protoxide of chromium, or the metal itself. Upon this principle Bunsen has arranged an apparatus, by means of which chromium, manganese, and other metals may be readily obtained in the wet way. He employs a decomposition cell, of which the one pole is formed by the inner surface of a charcoal crucible, filled with hydrochloric acid, and kept hot by immersion in the water bath. Within this is placed a small porcelain cell containing the fluid to be decomposed, in the centre of which is a narrow strip of platinum, forming the other pole.

Chromium is obtained by this apparatus in plates of more than fifty square millimetres in size, which are very brittle, and on the side next the platinum have a high metallic lustre. It has completely the appearance of metallic iron, but is more permanent in moist air, and burns when heated, with the production of the sesquioxide. Hydrochloric and dilute sulphuric acid dissolve it with difficulty, with evolution of hydrogen and production of a salt of the protoxide. It is scarcely attacked by nitric acid, even when boiling. Its specific gravity is about 1-7th higher than that determined from the impure metal produced by the old process.

Manganese may be obtained in plates of above 100 square millimetres, which have a fine metallic lustre, and are as easily oxidised as potassium in moist air.

By employing an amalgamated platinum wire, the density of the stream may be still further increased, and even barium and strontium reduced, although the metals cannot thus be obtained pure; but by a modification of the process, and employing the fused chlorides, Bunsen and Matthiesen have succeeded in obtaining several of these metals, for the first time, in a state of purity.

For the preparation of calcium Matthiesen has employed two different methods. One is uncertain, but when successful gives the metal in globules the size of a pea. Two equivalents of chloride of calcium, and one of chloride of strontium are fused in a Hessian crucible. An iron cylinder forming the positive pole is immersed in the fused mass, and with this is placed a porous cell, containing the same mixture filled in to a level from half an inch to an inch above that in the outer crucible, by which means, and with proper regulation of the heat, a solid crust is maintained on the latter. A thin iron wire forms the negative pole, and with six Bunsen's cells, a large amount of calcium may be obtained in less than an hour. A more certain plan is to melt the same mixture in a porcelain crucible, containing a carbon positive pole, and to use a thin harpsichord wire just dipping under the surface of the fluid as a negative pole, on which small globules of the metal soon collect.

Calcium is a light yellow metal, resembling an alloy of silver and gold. Its hardness approaches that of gold, and it is very ductile, and may be hammered into extremely thin plates. Its specific gravity is 1·584. It retains its lustre for some days in dry air, but decomposes water rapidly. Nitric, hydrochloric, and sulphuric acid produce still more violent action. Heated on platinum foil it burns with a bright flash. It also burns with brilliance when heated in chlorine. With water, calcium is negative to potassium and sodium, positive to magnesium.

Strontium—obtained by galvanic decomposition, with a brilliant metallic lustre, and a light brass-yellow colour. It gives a golden yellow streak on the touchstone, which soon passes into a copper colour, owing to superficial oxidation. Its specific gravity is 2·542. It decomposes water very rapidly, and burns with a brilliant white flame in oxygen, chlorine, iodine, and sulphur. It is electro negative to calcium.

Lithium has the colour and lustre of silver, but is rapidly oxidised, and in the air instantly becomes black. It must be preserved under naphtha, and in hermetically sealed tubes. It melts at 356° Fahr., and is the lightest of all known solids or liquids, its specific gravity being 0·5936. It burns brilliantly, and with a white light, in air, oxygen, chlorine, and the vapours of bromine, iodine, and sulphur. It decomposes water in the cold.

The details of these experiments will be found in Bunsen's papers in Poggendorf's Annalen, vol. xci. p. 691, and Comptes Rendus, vol. xl. p. 717. Matthiesen's paper is in the Annalen der Chemie und Pharmacie, for March 1855, and the Chemical Society's Journal for April 1855.

BOTANY.

Contributions to a Knowledge of the Vegetation above the Snow Line. By Adolph Schlagintweit.

The following is a list of the different species of phanerogamous plants, mosses, and lichens, which were found in the year 1851 in particular parts of the Western Alps, far above the mean limit of the snow. These observations connect themselves with our previous remarks on the vegetation of the subnival and nival regions of the Eastern Alps, below the heights of 7000 and 12,000 feet (Untersuchungen über die physicalische Geographie der Alpen, 1850, cap. xxi., 584–596).

As regards the determination of the plants collected, I am indebted to Professor Alex. Braun of Berlin for the mosses and lichens, and to Professor Koch for the phanerogams. It must be observed that the enumeration of the plants in the vicinity of the Vincenthut, as well as the other *individual* localities, cannot lay claim to absolute completeness. But the comparison of the different localities enables us to ascertain with tolerable certainty the sum of the characteristic species.

In the neighbourhood of Monte Rosa the phanerogams attain a very great height. Their growth is favoured by the great absolute height of this mountain group, and by its southern exposure. Isolated phanerogams are here pretty frequently found at the height of 11,000 Parisian feet; while one of these plants (*Cherleria sedoides*) was found at 11,700. In the Central Alps of the Tyrol and the Bernese Oberland individual phanerogamous plants occur between 10,000 and 10,500 feet. In the northern side chain of the Alps, in Switzerland, in Southern Bavaria, and in Austria, the mountains are not generally sufficiently high to permit an accurate determination of the limit; but at all events phanerogams grow at 9000 feet, and perhaps somewhat higher.

On Zugspitze, in the Bavarian limestone Alps, 2954 metres = 9094 Paris feet, on the light upper alpine limestone the following plants were seen:

Draba tomentosa
Saxifraga stenopetala
    androsacea, var. pygmæa
Andræa rupestris
Barbula tortuosa
Didymodon capillaceus
    flexicaulis ? steril.
Hypnum julaceum
    uncinatum

The lichens on the highest point were remarkably little developed. There was only some appearance of a Lecidea and a Verrucaria, which could not be more precisely determined.

In the neighbourhood of Vincenthut on the southern slope of Monte Rosa, Piedmont, between 9500 and 9800 Paris feet, on gneiss, the following plants were observed :—

Achillæa hybrida
Androsace glacialis
Artemisia mutellina
  spicata
Aster alpinus
Cardamine alpina
Cerastium latifolium
Cherleria sedoides
Chrysanthemum alpinum
Erigeron uniflorus
Eritrichium nanum
Gentiana imbricata
  verna
Hutchinsia petræa
Linaria alpina
Oxyria digyna
Potentilla alpestris
Primula Dinyana
Phyteuma pauciflorum
Ranunculus glacialis
Salix herbacea
  reticulata
Saxifraga aïzoides
  bryoides
  biflora
  exarata
  muscoides
  oppositifolia
  retusa
  stellaris
Senecio uniflorus
Silene acaulis
Thlaspi cepeæfolium
  corymbosum
  rotundifolium
Veronica alpina
Agrostis rupestris
Avena subspicata
Carex nigra
Elyna spicata
Festuca Halleri
Festuca ovina γ violacea
Koeleria hirsuta
Luzula spicata
Poa alpina
  laxa
  minor
Bartramia ithyphylla
Bryum turbinatum
Didymodon capillaceus
Grimmia obtusa
Gymnomitrium concinnatum
Gymnostomum rupestre
Hypnum julaceum (Isothecium moniliforme)
Polytrichum septentrionale (P. sexangulare)
Trichostomum latifolium (Desmatodon latifolius)
Weissia crispula
Cetraria cucullata
  islandica
  nivalis
Cladonia gracilis
Cornicularia ochroleuca
Lecidea conglomerata
  geographica
  pulchella
Lepra incana
Parmelia ceratophylla, var. multipuncta
  fahlunensis α vulgaris
  fahlunensis δ lanata
  saxatilis
Peltigera canina, var. minor
Solorina crocea
Stereocaulon alpinum
Thamnalia vermicularis
Umbilicaria polymorpha α cylindrica
  polymorpha ε mesenteriformis

Environs of Monte Rosa. The Pass of St Theodul or Matterjoch, 3353 metres = 10,322 Paris feet.

Androsace glacialis
Eritrichium nanum
Gentiana verna
Linaria alpina
Ranunculus glacialis
Salix herbacea
Saxifraga oppositifolia
Thlaspi cepeæfolium

The Nase, a rocky edge which rises out of the Lys-glacier.
A. Second Peak, 3570 metres = 10,990 Paris feet.

Cherleria sedoides
Chrysanthemum alpinum
Erigeron uniflorus
Eritrichium nanum

Juniperus nana, a single shrub. The highest locality in which this plant was found in the neighbourhood of Monte Rosa.
Primula Dinyana
Ranunculus glacialis
Saxifraga bryoides
oppositifolia
Senecio uniflorus
Poa laxa
Didymodon capillaceus
Jungermannia
Polytrichum alpinum
Racomitrium lanuginosum
Weissia crispula

B. First Peak, 3630 metres = 11,176 Paris feet.

Cherleria sedoides
Chrysanthemum alpinum
Ranunculus glacialis
Saxifraga bryoides
Silene acaulis β exscapa
Poa laxa
Didymodon capillaceus
Weissia crispula
var. atrata
Lecanora flava β chlorophana
Lecanora muralis var. ?
Lecidea conglomerata
geographica
Parmelia stygia var. lanata (Cornicularia lanata)
Solorina crocea
Stereocaulon condensatum
Umbilicaria anthracina
vellea γ spadochroa

On Weisthor, a pass over the highest point of Monte Rosa, 3618 metres = 11,138 Paris feet.

Chrysanthemum alpinum
Eritrichium nanum
Gentiana imbricata
Ranunculus glacialis
Saxifraga muscoides α compacta. (S. acaulis)
ε moschata. (S. moschata)
Senecio uniflorus
Poa alpina
laxa
Racomitrium
Lecidea geographica
Parmelia fahlunensis var. lanata
Umbilicaria polymorpha var.

On Firninsel, on the western slope of Monte Rosa, near the Glacier of Gorne, 3723 metres = 11,462 Paris feet.

Cherleria sedoides
Lecidea conglomerata
Lecidea geographica

It was here that the last trace of phanerogamous plants was observed, on the north-western side of Monte Rosa.

Rocks on the southern slopes of the Vincent Pyramid, 3823·5 metres = 11,770 Paris feet.

Cherleria sedoides. A few small specimens. This is the highest station for phanerogamous plants which has yet been observed on the Alps.
Andræa rupestris
Grimmia
Stereocaulon
Weissia crispula
Lecidea armeniaca
conglomerata
geographica
Umbilicaria vellea α hirsuta
polyphylla α glabra

Peak of Monte-Rosa, 4640 metres = 14,284 Paris feet.

Lecidea conglomerata.
geographica α contigua, β atrovirens.

Besides a Parmelia and an Umbilicaria, which could not be fully determined.

Peak of Mont Blanc, 4810 metres = 14,809 Paris feet. Determined by Schærer from specimens collected by Saussure on Mont Blanc. Linnæa. 1842, Bd. xvi. 66.

Lecidea confluens
Parmelia polytropa

Bernese Alps, Gauli Pass, between the Gauli-glacier and the Unteraar-glacier, 3274 metres = 10,080 Paris feet.

Androsace glacialis	Barbula (Syntrichia) ruralis
Chrysanthemum alpinum	Bryum Ludwigii ?
Gentiana imbricata	Jungermannia
Potentilla grandiflora	Polytrichum septentrionale. (P. sexangulare)
Ranunculus glacialis	Racomitrium fasciculare ?
Saxifraga bryoides	Lecidea geographica
oppositifolia	Umbilicaria polyphylla β flocculosa
Silene acaulis	
Poa laxa	

Rocks on the south-west slope of the Finsteraarhorn, near the right source of the Viescher-glacier, 3350 metres = 10,313 Paris feet.

Chrysanthemum alpinum	Didymodon capillaceus
Draba frigida	Hypnum cupressiforme
Linaria alpina	Cladonia neglecta
Saxifraga bryoides	Lecidea geographica
muscoides α compacta	Lepra incana
Silene acaulis	Parmelia elegans
Poa laxa	fahlunensis var. lanata

Peak of the Ewigschneehorn, near the Gauli Pass, 3400·5 metres = 10,468 Paris feet.

Androsace imbricata	Lecidea geographica
Poa laxa	confervoides
Didymodon capillaceus	Parmelia elegans
Grimmia uncinata ?	Umbilicaria polymorpha β deusta

Peak of the Jungfrau, 4167 metres = 12,828 Paris feet, according to Eschmann.

Lecidea conglomerata	Umbilicaria atro-pruinosa γ reticulata
confluens var. steriza	
Parmelia elegans α miniata	Virginis

Determined by Schærer from specimens collected by Agassiz on the Jungfrau (Linnæa. 1842, Bd. xvi. 66).—(*Archiv fur Naturgeschichte*, xx. Jahr. 1 Bd.)

On Beech-Oil. By Wilhelm E. G. Seemann.

Amongst the various kinds of oil used in Northern Germany, especially the kingdom of Hanover, for culinary purposes or as materials of combustion, that extracted from the nuts of the beech (*Fagus sylvatica*, Linn.) is, on account of its numerous good qualities, deserving of notice. Beech-oil does not play a prominent part in commerce, nor is it likely to do so, owing to the fact that it cannot be procured in large quantities; the country-people who collect the nuts, or cause them to be collected, use the greater part of the oil extracted from them in their own household, and only dispose of the remaining fraction. This is the reason why it is impossible to give even a rough estimate of the quantity annually produced. About Hanover the nuts are gathered towards the end of October or the beginning of November. This is done either by picking up by hand those which have fallen to the ground, or by spreading out large sheets under the trees and beating the branches with poles, so as to cause the nuts to separate from them. The latter process appears, at first sight, the least expensive; but as the good nuts have to be separated from the bad (abortive) ones, it is found on closer examination to be just the contrary. In 1854 about 25 lbs. of nuts sold in Hanover for eighteenpence; 25 lbs. yield about 5 lbs. of oil, 1 lb. selling for about sevenpence. The oil is of a pale yellow colour, and has an extremely agreeable taste. It is often adulterated with walnut-oil; the latter is even sold as beech-oil, and that may account for the difference of opinion entertained respecting the quality of the Beech-oil. The townspeople use it chiefly as salad oil, but the peasantry employ it generally as a substitute for butter, &c., and only when there has been a good harvest of nuts, for burning in their lamps. The husks are, after the oil has been expressed, made into cakes about nine inches square and one and a half inch thick; these are used for combustibles, and not given, as some people imagine, as food to cattle.—(*Hooker's Journal of Botany*, June 1855.)

MINERALOGY.

Composition of Euclase. By M. A. Damour.

Euclase has been already examined by Vauquelin and Berzelius, and shown to be a silicate of alumina aud glucina. Damour has found that it also contains water and fluorine. The mean of four analyses has given

		Oxygen.	
Silica,	41·63	21·61	4
Alumina,	34·07	15·92	3
Glucina,	16·97	10·73	5
Lime,	0·14	...	
Protoxide of iron,	1·03	...	
Protoxide of tin,	0·34	...	
Water,	6·04	5·37	1
Fluorine,	0·38	...	
	100·60		

which gives the formula, $6\,\dot{\text{Be}}\,3\dddot{\text{Al}}\,\dddot{\text{Si}}+3\dot{\text{H}}$. The oxide of iron appears to be an accidental mixture, but the tin and fluorine, Damour considers as essential ingredients, and in that case, euclase must belong to the class of minerals, which like the topaz, tourmaline, &c., have been produced by the action of volatile fluorides and chlorides on the crystalline rocks.—(*Comptes Rendus*, vol. xl., p. 944.)

Svanbergite, a new Swedish Mineral.—Igelström has described under this name a mineral which occurs at Horrsjöberg in the district of Elfdahl in Wermland, in a vein in quartz rock along with cyanite, pyrophyllite, lazulite, mica, and iron pyrites. Its crystalline form is oblique prismatic; colour light red; semi-transparent; cleavage distinct, parallel to the base of the prism; specific gravity, 3·30; hardness, 5. Before the blow-pipe it gives in the flask a very acid water. On charcoal it loses its colour, but melts only when in extremely thin splinters. With soda in the reduction flame, it gives a red liver, which evolves sulphuretted hydrogen when treated with dilute acids. The finely powdered mineral is insoluble in acids, a small quantity is dissolved on boiling, and the white residue remains entirely unattacked. Its composition was found to be—

Sulphuric acid,	17·32
Phosphoric acid,	17·80
Alumina,	37·84
Lime,	6·00
Protoxide of iron,	1·40
Soda,	12·84
Water,	6·80
Chlorine,	traces.

—*Ofversigt of Akademiens, Forhandlingar* 1854, p. 156.

Statistics of the Production of Metals during 1854. By WHITNEY.

Whitney gives the following table of the production of the metals during last year. It appears to be estimated from that of former years, and though probably only an approximation, is of considerable interest.

	Gold. lbs. Troy.	Silver. lbs. Troy.	Mercury. lbs. Avoirdupois.	Tin. tons.	Copper tons.	Zinc. tons.	Lead. tons.	Iron. tons.
Russia, . . .	60,000	58,000	...	...	6,500	4,000	800	200,000
Sweden, . . .	2	3,500	...	...	1,500	40	200	150,000
Norway, . . .	...	17,000	...	...	500	...	...	5,000
Great Britain, .	100	70,000	...	7,000	14,500	1,000	61,000	3,000,000
Belgium, . . .	...	...	...	...	...	16,000	1,000	300,000
Prussia, . . .	...	30,000	...	...	1,500	33,000	8,000	150,000
Harz, ...	6	30,000	...	...	150	10	5,000	...
Saxony, . . .	...	60,000	...	100	50	...	2,000	7,000
Rest of Germany,	...	3,000	...	...	...	...	1,000	100,000
Austria, . . .	5,700	90,000	500,000	50	3,300	1,500	7,000	225,000
Switzerland, . .	...	...	...	...	...	...	...	15,000
France, . . .	...	5,000	...	...	...	...	1,500	600,000
Spain, ...	42	125,000	2,500,000	10	500	...	30,000	40,000
Italy, ...	...	...	...	...	250	...	500	...
Africa, . . .	4,000	...	...	...	600	...	...	...
East Indies and Southern Asia,	25,000	...	...	5,000	3,000	...	...	...
Australia and Oceania, . .	150,000	8,000	...	...	3,500	...	...	...
Chili, ...	3,000	250,000	...	...	14,000	...	...	...
Bolivia, . . .	1,200	130,000	...	...	...	...	...	...
Peru, ...	1,900	30,000	200,000	1,500	...	...	...	...
Ecuador, New Grenada, &c.,	15,000	130,000	...	...	1,500	...	...	...
Brazil, ...	6,000	700	...	...	...	...	...	...
Mexico, . . .	10,000	1,750,000	...	...	...	...	...	...
Cuba, ...	...	...	...	...	2,000	...	...	...
United States, .	200,000	22,000	1,000,000	...	3,500	5,000	15,000	1,000,000
Totals,	481,950	2,695,200	4,200,000	13,660	56,900	60,550	133,000	5,817,000

Statistics of the production of the Metals in Russia during 1852.—In the *Mining Journal* of St Petersburg complete statistics of the metal-productions of Russia for the year 1852, are given, from which the following details are extracted.

The quantity of gold obtained from the Government mines was :—

	Puds.*	Lbs.	Sol.	Doli.
Ekaterinburg, ...	34	38	38	60
Bogosslowsk, ...	40	4	30	...
Goroblagodat, ...	10	3	16	...
Slatoust, ...	49	22	63	...
Nertschinsk, ...	72	19	44	32
Altai, ...	37	23	40	...
Total from Government mines,	244	31	9	92
Private mines, ...	1122	39	18	5
Total, .	1367	30	58	1

The quantity of silver containing gold amounted to 1073 puds, 32 lbs. 85 sol. 25 doli, all, with the exception of 17 sols., from Government works.

Of platinum the Government mines yielded only 3 lbs. 30 sol.

The private mines gave 16 puds 19 lbs. 37 sol.

* 1 pud = 40 Russian pounds ; 1 lb. = 96 solotnik ; 1 solotnik = 96 doli.

Of the other metals there were produced :—

	Puds.	Lbs.
Copper, . . .	410,572	19
Lead, . . .	40,315	13
Cast-iron, . .	13,159,759	37
Steel, . . .	78,876	18
Wrought-iron, . .	10,292,692	36
Other metallic products,	2,400,847	13

The production of gold appears to have gradually increased, up to the year 1847, when it reached its maximum, since which time a steady diminution has occurred. The amount obtained from 1823 up to 1848 is given in the following table :—

	Puds.	Lbs.	Sol.	Dol.		Puds.	Lbs.	Sol.	Dol.
1823,	105	6	48	24	1836,	398	...	93	90
1824,	204	20	74	...	1837,	442	20	43	21
1825,	232	18	2	...	1838,	493	13	35	24
1826,	231	6	18	...	1839,	492	39	43	42
1827,	281	30	74	...	1840,	533	39	87	84
1828,	290	32	11	60	1841,	655	12	28	18
1829,	288	8	77	72	1842,	908	13	18	72
1830,	352	32	54	72	1843,	1241	26	54	26
1831,	364	27	60	87	1844,	1276	24	33	83
1832,	384	24	4	45	1845,	1304	14	58	90
1833,	378	22	69	72	1846,	1628	28	12	74
1834,	375	...	18	84	1847,	1741	7	91	76
1835,	385	26	5	24	1848,	1726	35	24	48

—(*Zeitschrift fur Allgemeine Erdkunde*, vol. iv., p. 188.)

METEOROLOGY.

Abstract of the Meteorological Register for 1854, kept at Arbroath, by Alexander Brown, Hon. Mem. of the Lit. and Phil. Soc. St Andrews; and Observer for the British Meteorological Society, London.

Latitude, 56° 34′ N. Longitude, 2° 35′ W. Distance from the Sea, ⅜ths of a mile. Height of the Barometer above the Sea, 50 feet; height of the Thermometer from the ground, 11 feet, and of the Rain-gauge, 3 feet.

The number of "Rainy Days" includes those days on which snow or hail fell.

1854.	Thermometer.							Days Ther. below 32°.	Rain in Inches	Barometer. Corrected for Capillarity, &c. & Reded. to 32°.	
	8½ A.M.	7¾ P.M.	Mean	Mean Max.	Mean Min.	Mean	Spring Water.			8½ A.M.	10 P.M.
Jan......	34°·	35°·2	34°·6	40°·1	29°·1	34°·6	47°·5	18	2·571	29·57	29·57
Feb	35·7	37·9	36·8	43·1	31·4	37·3	47·	16	0·851	29·94	29 94
March...	42·1	42·8	42·4	50 9	35·4	43·1	46·5	7	0·833	30·.3	30·13
April....	45·7	44·2	45·	53·6	36·5	45·	46·5	6	0·215	30·12	30·10
May	50·9	49·6	50·2	59·6	39·6	49·6	47·	5	2·849	29 68	29 69
June.....	56·6	56·3	56·5	62·8	45·6	54·2	48·5	...	2·722	29·81	29·81
July	59·5	59 3	59·4	68·1	49·3	58·7	49·	...	1·559	29·88	29·88
Aug......	58·9	58·1	58·5	67·4	48·5	58·	50 5	...	1·463	29·90	29·90
Sept......	54·7	54·1	54·4	64·7	46·3	55·5	51·	..	1·052	29·98	29 97
Oct.	43 9	44·1	44·	52·1	37·7	44·9	49·5	7	1·986	29·71	29·71
Nov......	38·0	39 1	38·5	44·2	33·7	38·9	49·	15	3·379	29·78	29·75
Dec......	35·6	36·	35·8	42·7	30·7	36·7	47·5	21	1·338	29·55	29·56
Mean ...	46·3	46·4	46·3	54·1	38·6	46·3	48·3	sum 95	sum 20·818	29 83	29 83
Do. 1853	45·4	44·9	45·2	52 8	38·5	45·6	47·7	101	27·602	29·82	29 83

1854.	Hygrometer.		Fair Days.	Rainy Days.	Winds, at 8½ A.M.									
	Mean Dew Point.*	Degree of Humidity, (complete Saturation 1·000.)			N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Total.
Jan......	30°·3	0·882	18	13		1	5	5	3	6	5	4	2	31
Feb......	31·4	·824	20	8	1				1		10	11	5	28
March...	38·5	·866	19	12	2	1	2		3	7	11	2	3	31
April....	37·3	·766	27	3	3	3	4	4	3	1	7	5		30
May.....	43·9	·814	16	15		6	1	7	4	3	6	3	1	31
June.....	50·	·837	13	17	3	3	2	8	1	3	4	5	1	30
July.....	53·8	·838	18	13	1	4	1	7	6	5	1	4	2	31
Aug.....	52·4	·833	22	9	3	3	1	4	4	6	5	2	3	31
Sept.....	50·2	·856	18	12			1	1	7	6	11	4		30
Oct......	39·6	·858	16	15	3			2	2	3	9	9	3	31
Nov.....	33·	·841	15	15	1	2	3	2		3	7	12		30
Dec......	29·9	·819	17	14						8	13	8	2	31
			su	m										
Mean...	40·8	0·836	219	146	17	23	20	40	34	51	89	69	22	365
Do. 1853			213	152	41	35	30	52	42	40	51	52	22	365

Barometer at 8½ A.M. was highest on 4th March, 30·83. Wind, W.
.... was lowest on 29th Nov., 28·54. Wind, W.
Barometer at 10 P.M. was highest on 4th March, 30·73. Wind, W.
.... was lowest on 1st May, 28·82. Wind, W.
Thermometer at 8½ A.M. was highest on 23d & 25th June, 69°. Wind, W.
.... was lowest on 3d Jan., 18°. Wind, N.W.
Thermometer at 7¾ P.M. was highest on 22d July and 27th August, 68°. Wind, S.E. & S.W.
.... was lowest on 3d Jan., 20°. Wind, N.W.
Therm. in night, highest 22d July, 57°; lowest 2d and 4th Jan., 17°.
Therm. in day, highest 27th Aug., 78°; lowest 2d Jan., 29°.
Coldest day, 2d Jan., when average of Ther. was 23° for day and night.
Hottest day, 27th Aug., when aver. of Ther. was 67° for day and night.
Coldest month of the year, January; hottest, July.
Wettest month of the year, November; driest, April.
Mean temperature of the year 46·3 degrees.
Mean temperature of eleven years, 45·625 degrees.

For eight years the average daily temperature at 8½ A.M., at 7¾ P.M., and the mean of the daily extremes, are as follow, viz.:—

	8½ A.M.	7¾ P.M.	Mean of Extremes.
1847	45·6	44·7	45·9
1848	45·1	44·4	45·
1849	45·1	44·4	44·7
1850	45·5	44·9	45·5
1851	45·7	45·4	46·3
1852	46·	45·9	46·2
1853	45·4	44·9	45·6
1854	46·3	46·4	46·3

The average temperature of the six months of chief vegetation—viz., those from April to Sept., inclusive—for seven years, is as follows:—

1848	51·7	1851	52·	1853	53·4
1849	50·2	1852	53·	1854	53·5
1850	51·7				

* The dew-point thus found is obtained from observations of the Wet and Dry Bulb Thermometers, and deduced by Mr Glaisher's Hygrometrical Tables. The observations of the Wet and Dry Bulb Thermometers are made daily at 8½ A.M. The times of observation of the instruments, stated in the Table are Greenwich mean time.

MISCELLANEOUS.

Great Earthquake in Turkey.—(From a letter in the *Times* of 1st March, from Constantinople.)—Yesterday Constantinople was shaken by an earthquake which, had it lasted long, might have been reckoned among the calamities of the human race. At five minutes past three in the afternoon the shock was felt, and it lasted, as nearly as can be computed, about half a minute. The motion was a sharp, rapid, trembling, which caused every pane of glass and every tile on the housetop to rattle; but the violence of the movement was far beyond that which is generally felt in the earthquakes of the coast of Asia Minor. Between three and five o'clock no less than six shocks were counted; two took place between seven and eight o'clock in the evening, and the last that I felt was at a few minutes before midnight. The motion was chiefly felt in the upper rooms of houses, where glasses were thrown off the tables, and persons who were standing were obliged to sit down or to cling for support to some fixed object. The buildings which have been injured are not a few. The British Embassy is one of the most solid edifices in the country; but a stack of its massive chimneys was thrown down, and the large square stones of which the walls are constructed are said to have been displaced in certain parts. Every bell in the palace rang violently, and even in one or two churches the still larger masses of metal resounded dismally. A number of minarets in Stamboul and Pera have been thrown down—whether with any loss of life I have not learnt. After the shock was over there was much commotion in the place. Business was to a great degree suspended, and husbands and brothers hastened home to see if the female part of their families had received any injury from the convulsion or the terror it caused. (From another letter dated 8th March.)—The accounts from Broussa are terrible. Such a long continued convulsion of nature has hardly been heard of in the history of the world. The earthquake had lasted five days, and shocks were of constant occurrence when the last news left. The great shock of the 28th February had destroyed a part of the town, and killed or maimed nearly 300 of the inhabitants. Although the shocks were only felt at Constantinople during two days, they lasted at Broussa during four succeeding days, not without causing serious damage to the already shaken houses. The commencement of the convulsion was preceded by torrents of rain, which lasted more than 24 hours, accompanied by high wind and occasional thunder. At three o'clock the sky became suddenly overcast—a strong smell of sulphur was perceived, and the first shock took place, which, in less than a minute, overthrew mosques, houses, and bazaars, in one vast ruin. Nearly 80 mosques have been so much injured that their speedy fall is expected, while not one in the whole city has escaped some damage. The khans or large buildings, which served either as inns or places for transacting business, are mostly injured, and five of them were completely destroyed, crushing scores of their unfortunate inmates. The bazaars, with their heavy arches, are flat on the ground. The ancient mosque of Davoullon-Monastir, a Greek ecclesiastical edifice, said to be 1200 years old, is unhappily destroyed. Another mosque, the Oulon-Djarmi, a fine building 600 years old, is also a mass of ruins. It was the chief ornament of the city, and the most splendid religious edifice in the days when Broussa was the capital of the young and growing Ottoman Empire. Great destruction has fallen on the silk factories, of which scarcely one has escaped without damage, while the number of women who have lost their lives by the fall has been very large. Large masses of rock were detached from their beds, and came crashing down the sides of Olympus into the neighbourhood of the town. In one place several houses were crushed by one of these avalanches. The old wall and fort were shaken to the ground, and in their fall buried ten or twelve houses and the factory of Hadji Anastasi, a respectable Greek manufacturer, who also lost his life. As the shocks continued during the night the whole population at once quitted the town, and it is now encamped in the neighbourhood—the well-off in tents, the poor under the open heaven, preferring to bear the chill nights of March than to live in hourly dread of destruction within the circuit of their ill-fated city. The shocks which have since taken place have thrown down many buildings which were previously injured, but there is no reason to believe that any fresh edifices have been destroyed. The ravages of the earthquake have not extended over any very great tract of country. There is no news that Kutahia or Angora have suffered.

Another Earthquake at Broussa.—The *Morning Chronicle's* correspondent, dating " Broussa, April 11," writes :—" Yesterday evening, shortly before eight o'clock, two or three violent shocks of earthquake were felt here, and caused universal terror among the inhabitants. Every one called to mind the fearful scenes which had occurred hardly a month since, and was struck with the apprehension of the coming calamity, unhappily only too fully realized. In five minutes from that time every public monument and building in Broussa was a heap of ruins. The city is destroyed—fire having devoured what relics the earthquake had left. Among other noble monuments that have perished is the magnificent mosque of Oulou-Djami, the pride of the city. Two minarets of this edifice were overthrown in the former earthquake, and the cupola cracked. It is now wrecked from top to bottom, leaving nothing but a pile of crumbled stones, amidst which the celebrated *turbés* of the first Sultan are buried. All the other mosques have experienced a like fate. No stone-built house in Broussa has resisted the terrible shocks. Enormous masses of earth and rock were detached from the flanks of the mountain, above the upper streets of the place, and rolled down upon the Jews' quarter, whose destruction they completed. As to the wooden houses, which escaped with less damage from the earthquake, they have been destroyed almost totally by a conflagration. The flames broke forth at many points simultaneously, about nine o'clock. The scene is awful. The Bazaar, and the whole quarter of the city around it, present nothing but heaps of smouldering ashes. The European quarter has suffered least. The population seem paralysed with terror, and are plunged into a state of indescribable stupor. The number of victims it is impossible to reckon. News has arrived that the village of Tikindji, situated about a league from Broussa, has been totally destroyed. Several hamlets and farm-houses in the vicinity are also reported to have been wrecked by the convulsion." On the same day shocks were felt at Constantinople, but without any serious injury to the buildings. The destruction of Broussa has reduced 70,000 people to a state of deep distress.

Professor Reinwardt's Library.—The sale of Professor Reinwardt's library took place by auction in Leyden a few months since. As a general library it was not very valuable; it was almost entirely scientific, rich in botanical works, and possessed some upon zoology of a local character not easily procured. It realized a sum of about 20,000 guilders. The prices given for the books were very unequal.

The following is a short note of the principal incidents in the career of Professor Reinwardt :—

Professor Reinwardt was born at Leitringhausen, in Germany, 3d June 1773. His eldest brother was established as an apothecary in Amsterdam, and, having lost his father early, he came himself to Amsterdam and studied chemistry and botany in the Athenæum of that city. He was also employed in the business of his brother.

In 1801 he obtained a professorship at the university of Hardenvyk. In 1808 or 1809 King Louis Napoleon placed him in the direction of the menagerie or zoological garden at Haarlem, which was not long supported, and in 1810 he obtained the chair of natural history and chemistry in Amsterdam. In 1815 he was appointed to superintend a government measure in the East Indies for regulating agriculture, public education, &c., &c. He there made large collections in every department of natural history, and returned in 1822 to the Netherlands, when he was named professor of botany, natural history and chemistry at Leyden. Reinwardt published no great work, but there are numerous papers and reports on various subjects in the transactions of the Dutch and other scientific societies. He was a good classical scholar, besides possessing an acquaintance with several modern languages. His botanical knowledge was extensive. He was well versed in chemistry, and was a good mineralogist. He died March 6, 1854.

George Louis Duvernoy.—On the 1st of March this year died at Paris George Louis Duvernoy, member of the Institute, knight of the Legion of Honour, professor of comparative anatomy in the Museum of Natural History, and also in the College of France. He was born on the 6th of August 1777, and thus attained the age of more than seventy-seven. Montbeliard (Department de Doubs) was his birth-place, as well as that of his famous teacher and friend George Cuvier, to whom he was related. In 1801 he obtained the degree of doctor in medicine. He made himself early known (1805) by the publication of the three last parts of the Leçons d'Anatomie Comparée, of which Cuvier himself confessed that not only the whole arrangement, but even the contents, were principally the work of Duvernoy. Like Cuvier, Duvernoy belonged also to those French literati, at that time more rare than now, who were acquainted with the German language, and the works published in it. In a more special and practical knowledge of human anatomy he was superior to Cuvier, before whom, however, in originality and universal knowledge he must succumb. He afterwards settled as a physician in Montbeliard, where he lost a beloved wife, just at the time when he was promoted to the degree of doctor in medicine. His residence in that city became almost intolerable, and he took the opportunity of removing to Strasburg, where he had been invited as assistant to Professor Hammer in teaching the natural history of the animal kingdom (1827). By the death of Cuvier (1832) he saw himself disappointed in his expectation of assisting him in the teaching of comparative anatomy. A few years after, however, he was appointed professor of comparative physiology in Paris to the College of France. In 1850, when above seventy years of age, he succeeded De Blainville, who had been nominated, in 1832, in place of Cuvier, to the chair of comparative anatomy at the Museum of of Natural History.

Duvernoy's greatest activity was between the years 1830 and 1853, and it is the more remarkable that, at the advanced period of life to which he attained, his scientific zeal appeared steadily to increase. Without having to thank Duvernoy for great discoveries, he deserves, on account of manifold researches into the anatomy of all classes of animals, to be reckoned among the most deserving savans of our time. We shall content ourselves by simply naming some of his published works. To these, in the first place, belong five parts of the new edition of the Leçons d'Anatomie Comparée from 1835–1846, in which all the organs of animal life are treated of, and of which more than the half has been added as wholly new to the earlier edition of 1805. There was a smaller work, the Atlas of Reptiles (finished 1842), for the splendid edition of the Regné Animal of Cuvier. To the Dictionnaire Universelle d'Histoire Naturelle, edited by D'Orbigny, he gave various contributions, and among them an ample article on ovology.

During his residence at Strasburg he contributed various papers on zoology and comparative anatomy to the Memoires de la Société d'Histoire Naturelle of that city, of which he was one of the most active members, among others, on the Macroscelis of Algiers (1832). In the Annales des Sciences Naturelles we find many contributions from his hands, especially on the Anatomical Signs of Poisonous and Harmless Snakes (tom. xxvi.); on the Organization of Snakes in general (tom. xxx.); on the Peculiarities of the Vascular System in *Chimæra artica;* also on the Liver of the Mammalia. In the Archives du Muséum we lately saw (1853) a copious treatise from his pen, adorned with many figures, on the Fossil Species of Rhinoceros.

Finally, the Mémoires de l'Académie des Sciences contain Investigations on the Shrew Mouse, with figures of the microscopic tissue of the teeth; contributions to the Anatomy of the *Echinodermata* (tom. xx., 1848), and an extended treatise, elucidated with numerous figures, on the very intricate Nervous System of the *Mollusca acephala* (tom. xxiv., 1853).

The simple mention of these works shows sufficiently that Cuvier found an active successor in Duvernoy. Besides comparative osteology, he has elucidated almost all parts of the science with useful and important remarks. In all his scientific works Duvernoy showed a noble modesty, an estimable and amiable character, a devout and finely sensible tone of mind, and a friendliness which no one can easily forget who had the privilege of his personal acquaintance.

At his own request, his earthly remains were carried to Montbeliard, to rest in peace near those of so many whom he had held dear.—Sit illi terra levis!—"*Allgemeine Konst-en Letterbode,*" *No.* 13, 1855).

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PLATE 1.

W H LIZARS LITH. EDINR

Diluvial Drift upon glacial Till at Clarens.

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W. H. LIZARS & TH. EDIN.

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EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

On the Geology of the Dingle Promontory. By Robert Harkness, F.R.S.E., F.G.S., Professor of Geology, Queen's College, Cork. (Plates IV., V.)

The district of country which forms the north-west side of Dingle Bay contains within it the most westerly land in Ireland, and that portion which lies west of Ventry presents to the Atlantic several bold headlands; and along the faces of these we have a fine exposure of the rocks which constitute the solid framework of this part of Ireland.

The stratified deposits which make their appearance in this district, for the most part consist of gray grits, which have a prevailing inclination towards the south, and this southern dip becomes very apparent and very persistent as we approach Slea Head, the promontory which marks the northern entrance into Dingle Bay.

Commencing at a small brook about a mile east from this headland, we have gray grits and conglomerates, which dip south at an angle of 50°, and on the face of some of the grit-beds there are distinct traces of ripple-markings. Beds of the same nature prevail westward to Slea Head, and the same inclination seems to obtain, but the rocks are much fissured and present numerous traces of false bedding; the lines of pebbles in the conglomerate, however, afford sufficient evidence that the prevailing dip is south at the same angle. The pebbles which enter into the composition of the conglomerates along the cliffs here consist of rounded fragments of quartz, which are very abundant; also portions of gray and purple sandstone, and slates, which, like the quartz fragments, have been subjected to the rounding agency. On rounding Slea Head, beds of gray shale occur interstratifying the sandstone and conglomerates, and these also afford a dip of 50° S. On going northward from Slea Head to Coumeenoole the conglomerates become fewer, and the shales more abundant, and in a small cove to the north-west of the village, indurated gray shales are seen abundantly intercalating the sandstones, and here also the inclination is towards the south at 50°. Quartz veins are very common at this spot intersecting the strata at about right angles to its dip. Westward from this small cove, the same shales and sandstones are seen, the former becoming more abundant and assuming a darker colour, which soon becomes purple; and these purple shales having a distinct cleavage present themselves in the form of purple slates with greenish-gray beds running through them, and as such they form Dunmore Head, the most westerly point in Ireland.

These purple slates have the same angle of dip and direction as the sandstones on the south of them, and they constitute the coast until we reach near to Dunquin. But immediately south of this locality they are changed in their colour, having a drab-shade, and in the small coves, where sea-weed is obtained, we have precisely the same arrangement as to dip and direction as occurs to the south. At Dunquin Cove these drab shales are seen lying on purple slates, which latter seem to be of small thickness, and the strata here have the south dip, but the beds have a *curved* form.

North of the Dunquin Cove we have a series of strata coming in from underneath the beds lying south, which are very interesting from the great quantities of fossils contained in them, and also from the characters of these fossils. They consist of Corals, Brachiopods, Lamellibranchiata, Gasteropods, Cephalopods, and Crustaceans of decided Silurian types. The deposits in which they occur consist of yellow soft slates, which seem to have been affected by atmospheric action, and green slates; both these forms of deposits being full of fossils. The area occupied by these beds is but small, and on the north they are rapidly succeeded by purple slates similar to such as occur south of Dunquin. They have, however, the south dip and the curved aspect of the strata which are found immediately south of Dunquin Cove. The purple slates which succeed them on the north have also the southern dip; and as we approach Clogher Head purple grits and sandstones prevail; and these, at the last-named locality, are intersected by porphyry,—a circumstance which was noticed by Mr Jukes, who had a run over these headlands some years ago. These purple grits and sandstones have the prevailing dip, viz., south; and on the north side of Clogher Head purple slates are again seen having the usual inclination, and they are succeeded on the north at the small cove near the village of Clogher by greenish shales which have a dip south at an angle of 45°.

The surfaces of these greenish shales are in some instances covered with branching corals in an imperfect state, which appear to be the Heliolites inordinata, (Londs.). Following the coast from the village of Clogher, in a north-east direction, we have strata of a similar character exposed, and affording the same dips. When we reach Ferriter's Cove the green slates also make their appearance, and here likewise we have the prevailing south inclination. At Ferriter's Cove the green slates abound in fossils to a greater extent than even the beds at Dunquin; they, however, contain the same organic remains, and as the slate is less liable to be acted upon by the weather the fossils are more perfect. Not only the fossils but also the mineral nature of the beds show an intimate connection between the strata exposed immediately north of Dunquin, and those between Clogher Village and Territer's Cove, and here also, as at the former locality, we have evidence of a curving in the deposits.

At that portion of Ferriter's Cove which lies nearest to the village of Ballyoughteragh we have the green slates dipping south 55°, and from this spot the strata are well exposed along the cliffs to Doon Point, having the same inclination. At Doon Point a dike of porphyry cuts through the strata in the direction of their strike, and this is well seen in consequence of its hardness rendering it less liable to be affected by the destructive action of the breakers than the slate rocks with which it is associated, and this porphyry forms the extreme limits of Doon Point. On the north side of Doon Point we lose sight of the green slates which are seen on the southern side of this headland so full of fossils; the deposits on the north side consisting of reddish sandy beds, having the same south dip at 55°. These reddish sandy strata are thin-bedded, and form the south side of the cove immediately north of Doon Point. The north side of this cove consists, for the most part, of gray porphyry, having crystals of white felspar about half-an-inch in length embedded in it. On rounding this porphyritic point we come to a cove called the Slate Cove, a name which well expresses the nature of the rocks which here occur. The strata at Slate Cove are composed of purple and gray slate dipping 55° south, and corresponding in their aspect to the slaty beds which are seen in the headlands south, namely, north side of Clogher Head and at Dunmore Head. Passing on northwards, in the direction of Sybil Head, we have these purple and gray slates succeeded by beds of a more arenaceous character, which are thin-bedded and have a very distinct slaty cleavage. These also afford the same south dip. The direction of the inclination and the cleaved structure of these thin-bedded reddish-purple sandstones is well seen in a rock which forms an abrupt island on the south side of Sybil Head, which is known under the name of Feough. These purplish-red sandstones, as we proceed north to Sybil Head, become less prominent, and at this last locality we have a strong conglomerate coming in, and forming the rugged points of this precipitous headland. This conglomerate is composed of rounded fragments of quartz, syenite, porphyry, and schistoze rocks, and its inclination and direction is indistinct, except where beds having more of the character of a sandstone occur, and then the same south dip is visible. Sybil Head presents a bold precipitous wall to the north, from the top of which, in some spots, a stone would fall without meeting with any impediment until it reached the Atlantic, and at first sight this perpendicular wall would be taken for the dip. It results, however, from cleavage, which has here cut the conglomerates and sandstones into perpendicular masses; the direction of the cleavage being that which usually prevails in the south-west of Ireland, viz., in an east and west course; and in consequence of the Atlantic cutting away the rocks here in the direction of the cleavage, we have a headland with a perpendicular wall on its north side exceeding 500 feet in height.

Going along the headlands in a north-easterly direction we have these conglomerates and sandstones exceedingly well developed. They form the three picturesque headlands known under the name of the Three Sisters; and these, like the Sybil's Head, present the same bold front on their north sides to the Atlantic.

At the north-west side of Smerwick Harbour we again meet with the same beds which are exposed immediately south of the Sybil's Head; these consisting of thin-bedded purplish-red sandstone, which towards the south pass into purple slates, such as are seen at the Slate Cove near Ballyoughteragh. Here, too, we have the same south dip, at about the same angle; and at Port-Lore the porphyry makes its appearance under precisely similar conditions as when it manifests itself at Doon Point on the west. At Boat Cove, a short distance south from Port-Lore, we have greenish-yellow slates coming in, affording the same dip and direction; and here, as at the north side of Ferriter's Cove, they present the curved appearance and agree very nearly with the beds at the latter locality in all their conditions.

South from Boat Cove we have but a small expanse of strata, the coast becoming low and sandy; but in the small interval which occurs between the Boat Cove and the sand shore we find the same greenish-yellow slates, having the same arrangement as regards direction and inclination; and on the faces of these we also meet with the coral which is so abundant near the village of Clogher, and which bears great affinity to the Heliolites inordinata, (Londs.).

The sandy nature of the coast between this and the Black Point precludes any observations being made on the solid strata occurring in this interval; and the country between this and Ferriter's Cove being flat and boggy, also prevents any of the rocks occupying this area being seen; but it is probable that the green slates occupy about the whole of this area to near Black Point. At Black Point we have purple grits coming in, showing the same arrangement in inclination and direction; and these, along with conglomerates, continue to form the coast round the Mark Point to the village of Ballinrannig. The conglomerates are well seen a short distance inland W. of the village of Ballinrannig at a place called Carrigaloughran; and here too they preserve the uniformity of inclination and direction which runs through the whole of the stratified deposits already alluded to. From Carrigaloughran the strike of these conglomerates is westwards; and with the sandstones, with which they are associated, they appear to form the mountains which range in the direction of Clogher Head.

With regard to the strata which make their appearance on the east side of Smerwick harbour, it would seem, judging from the contour of the coast, that from Ballynagall northwards purple slates and conglomerates, such as are seen in the north-west side of Smerwick Harbour, occur, and that about Murrough the same greenish slates as appear at Ferriter's Cove and the Boat Cove form the solid strata. Not having had an opportunity of examining this portion of Smerwick Harbour, I can, however, speak only as to the probable nature of the deposits which here make their appearance.

Having given a description of the deposits which occur on this coast, and also the mode in which they present themselves, we are led to inquire, what is the relation which they bear to each other, and to what series among sedimentary rocks are they referable?

The only observations which I can find concerning the strata which constitute the geology of this district are in Sir Roderick Murchison's *Siluria*, pp. 167 and 168, where it is stated, that "in the district of Dingle, or the western part of Kerry, which I have personally examined, a vast number of fossils (trilobites, mollusks, and corals), have been of late years found, which I have recently inspected, either in the cabinets of Mr Griffiths, or those of the Government surveyors.

"Some of these fossils, particularly from the eastern parts of this promontory, may belong to the same Lower Silurian type which prevails through Wicklow, Kildare, Wexford, and

Waterford. Others, however, including most of the species found in Ferriter's Cove and at Dunquin, are as certainly Upper Silurian fossils, which are well known in England and Wales.

"Among the commonest of these may be mentioned,—*Euomphalus funatus*, *Cardiola interrupta*, *Murchisonia Lloydii*, *Pterinea* (*Avicula*) *retroflexa*, *Orthis lunata*, *O. elegantula*, *Rhynchonella* (*Terebratula*) *Wilsoni*, *R. navicula phacops* (*Asaphus*) *caudatus*, *Encrinurus punctatus*, and a multitude of common Upper Silurian corals.

"It is, therefore, to be hoped that the exact order of that promontory between Dingle and Tralee Bays may soon be unravelled."

Mr Griffith, in his map, lays down the district as Silurian; and as this was done previous to the publication of *Siluria*, he must have long recognised this promontory as appertaining to the Silurians.

That this is the case, so far as the Coves of Dunquin and Ferriter are concerned, there is no reason to doubt, since the fossil evidence is conclusive on the point. The question, therefore, which remains to be determined is, what relation do the Silurians of Dunquin and Ferriter bear to each other, and what connection have they with the strata of purple slates, grits, and conglomerates, with which they are associated?

Looking at the contour of the coast of the most westerly portion of Ireland, as this occurs between Dingle and Tralee Bays, we find three prominent headlands,—Slea Head, with its westerly continuation, Dunmore Head being on the south; Clogher Head near the centre, and Sybil Head on the north. Between these headlands we have two well-marked bays, or rather coves, viz., Dunquin and Ferriter, the headlands and the coves being formed of different mineral substances. The former consist of hard conglomerates, grits, and slates; and the latter of slates of a softer nature which have yielded more readily to the power of the Atlantic, and consequently present us with indentations in the form of small bays.

We have, therefore, three distinct occurrences of grits, conglomerates, and hard purple slates, separated from each other by two areas of soft green slates, of undoubted Silurian age.

The conglomerates, grits, and hard purple slates, whether they occur on the south, in the centre, or on the north side of the district, have the same lithological nature, and the same arrangement as regards dip and direction; and the like remark applies to the two areas occupied by the Silurians. In these two latter areas we have evidence which does not present itself among the conglomerates, grits, and slates, namely, indications in the form of curved strata, leading us to infer that the deposits here are rolled over. And in these two areas we have organic remains of such a character as to show that these deposits have an intimate connection palæontologically.

If therefore we take in connection the lithological structure of the beds here, the curved character of the Silurian strata, and the relationship which exists between the organic remains in the two Silurian areas, we shall be able to arrive at some knowledge concerning the arrangement of these deposits, and the geological age to which they are referable.

The conglomerates, grits, and hard purple slates, which occupy the three headlands appear to be intimately allied to each other, not only in their mineral nature, but also in their geological position, and both near Dunquin and on the side of Ferriter's Cove, we have them with the Silurians conformably underneath them—and then passing over the Silurian areas, we find them again apparently coming out from below these latter. The conformity which exists between all the strata of this coast, shows that a perfect sequence occurs among them; but this sequence is not of such a nature as to support the inference that we have the highest beds on the south, and the lowest on the north, although there is a continuous south dip from Sybil Head to Slea Head. Had such been the case, we should have had a sequence of deposits over this area, giving us about 24,000 feet of perpendicular strata; since we have over a distance of about 6 miles an average dip of 50° south—and moreover we should have the same Upper Silurian fossils occurring in strata removed from each other by the distance of about 12,000 feet of perpendicular depth; acircumstance quite at variance with anything known concerning the thickness of the Upper Silurians.

From the results of my observations on this portion of the coast of Kerry, I am disposed to regard the whole of the strata here as owing their present position to two great rolls, in the lower portion of which Upper Silurian strata are exposed, and are overlaid conformably by a series of slates, grit, and conglomerates, which probably belong to the Devonians.

The section therefore which is exhibited in this portion of the coast consists as follows: commencing at the south, or at Slea Head, highest beds, conglomerates, and gray grits; next gray grits with shales passing downwards into purple slates, these beds constituting the Devonians. Taking the line occupied by these Devonians as $2\frac{1}{4}$ miles along the dip, we should have of these conglomerates, grits, and slates, about 9000 feet in perpendicular thickness.

It is, however, by no means improbable, that about Slea Head, the conglomerates may be doubled upon each other, and in this case, the estimated thickness must be reduced.

The Silurians, which succeed the conglomerates, grits, and purple slates, which I have regarded as Devonian, and which make their appearance conformably underneath the Devonians at Dunquin, are only slightly developed so far as regards thickness, but in them the curved strata are seen which indicate a roll. At a short distance inland from the coast they appear to be overlaid by the slates of the Devonians, and therefore we have at Dunquin only a small patch of the Silurians exposed. In consequence of the roll in the Silurians here, we have the slates of the Devonians succeeding them to the north in a reversed position, and apparently underlying them. As we approach Clogher Head these Devonians put on more of the character of the middle series of the Devonians, assuming a gritty nature; and as this gritty nature is succeeded to the north of this headland by the slaty beds of the lower series of the Devonians, we may infer that about Clogher Head the roll separating the Dunquin Silurians from those at Ferriter's Cove presents some of the higher deposits of the Devonians, the strata here being rolled under.

Near the village of Clogher we have the Silurians coming out from below the purple slates, the lower members of the Devonians precisely as at Dunquin, and having the same degree of conformability. The circumstances which are attendant on the Silurians occupying the area between Clogher Village and

Doon Point, are in all respects like those which accompany the Silurians at Dunquin. And here, too, we have the same evidence of rolling in the form of curved strata. Measuring along the dip from Clogher Village, where the purple slates disappear over the Silurians, to Doon Point,—where, in consequence of the second roll which gives rise to the Silurian area of Ferriter's Cove, we have the same slates apparently passing under the Silurian beds,—the distance is about two-fifths of a mile, and this distance with the prevailing dip 50° south would give us about 1600 feet of perpendicular thickness; but as the strata are here rolled over, this thickness must be reduced one half, and therefore about 800 feet of deposits form the Silurians as they are developed at Ferriter's Cove; and certainly not more are exposed at Dunquin.

North from Doon Point to the Sybil's Head we have the northern portion and lower beds of the Devonians of the second roll exposed, and as already mentioned, these consist, first, of the purple slates of the lower series, succeeded by the grits and conglomerates which constitute the coast from Sybil's Head to the north-west entrance into Smerwick Harbour.

The area occupied by the Silurians, which come out underneath the northern roll, is apparently more extensive than that of the southern one. From Ferriter's Cove it extends eastward to Smerwick Harbour, and from the nature of a portion of the eastern side of this bay it would appear to extend a short distance inland, but it must soon become covered up by the base of the lofty mountains which lie east from Smerwick Harbour, and which are formed of deposits appertaining to the higher beds of the Devonians, as these occur forming the headland of this coast.

From the foregoing remarks it will be perceived, that, so far as the western portion of the county of Kerry is concerned, we have two formations manifested, which are conformable the one to the other, viz., the Devonian and the Silurian.

With regard to the former, this can only be considered as Devonian because it partakes of the lithological character of this formation as it occurs elsewhere in Ireland; but probably future observation may discover among the purple slates fossils which possess a Silurian character. Until such be the case it would appear better to consider the purple slates, with their overlying grits and conglomerates, as Devonian. These conglomerates are succeeded by gray and purple grits of a hard nature, forming the mass of the Devonians in this portion of the county of Kerry, which, in their mineral nature, have a great resemblance to the strata which make up the lofty mountains lying between Glengariff and Killarney.

As concerns the rolling of the strata to which I have attributed the occurrence of the two Silurian patches of the same age, and the thrice-repeated purple slates, grits, and conglomerates, every one who is conversant with the geology of the south-west of Ireland, will be struck with the intimate relation which those rolls in the west of Kerry bear to those which occur among the Devonians of the county of Cork, more particularly those appearing in the northern area of these Devonians, where we have frequently a south dip prevailing over several miles of country across the strike of the beds, the strata being rolled as in the Dingle promontory. And it is only in the lower beds of these rolls that we could expect to find the deposits, on which the Devonians rest, exposed.

Such an exposure does not, so far as I am aware, exist in the interior of Ireland; and it is only on the coast, where the immense force of the Atlantic has for ages been wearing the solid strata that we should most naturally expect to find such low beds exposed, and on the most westerly portion of Ireland, we have the strata manifested under such conditions.

Concerning the fossils which present themselves among the Silurians of Dunquin, and about Ferriter's Cove, and elsewhere in this district, the corals consist of the following forms,—Alveolites fibrosa (Londs.), Favosites multipora (Londs.), F. polymorpha (Gold.), Halysites catenulatus (Linn.), Petraria bina (Londs.), Stromatopora concentrica (Gold.), Heliolites interstincta (Wahl.);—all corals which are met with in the Upper Silurians of England, and some even in the Devonian beds. Besides these, there is a very abundant species, which is found on the yellowish green slates near Clogher Village, and south of the Boat Cove at Smerwick Harbour, which seems to be the Heliolites inordinata (Londs.); but owing to the decomposed state of its surface, which does not show the pores, the species is uncertain. If it should be the form alluded to, it is the only purely Lower Silurian fossil in these beds. And the palæontological evidence, so far as the corals are concerned, justifies the inference of Sir Roderick Murchison, concerning the strata here, that they are Upper Silurian; and the occurrence of some Devonian corals would lead to the conclusion that the beds occupy a high position among the Upper Silurians.

The brachiopods are also of such types as indicate the Upper Silurian age of the lower strata at Dunquin and Ferriter's Cove. Among these occur Lingula cornea (Sow.), Leptœna depressa, L. lævissima (M'Coy), L. concentrica (Port.), L. euglypha (Dalm.), Chonetes striatella (Dalm.), C. sarcinulata (Hapsch.), Orthis elegantula (Dalm.), O. lunata (Sow.), Spirifer crispus (Linn.), S. speciosus (Schloth), Atrypa reticulans (Linn.), Athyris navicula (Sow.), and Rhynchonella Wilsoni (Sow.), forms which point out upper Silurian strata, and some of which even appertain to the Devonian. Concerning Lamellibranchiata, Sanguinolites rotundatus (Sow.), Cardiola interrupta (Sow.), are Upper Silurian species, and along with these are several forms of Pterinea and Avicula, which seem to be alike Upper Silurian. Of the trilobites, Phacops caudatus, and Encrinurus punctatus have a wide range, occurring both in the Upper and Lower Silurians. Therefore they afford nothing definite concerning the geological age of the strata under consideration.

Taking the palæontological evidence as a whole, it distinctly indicates that the strata exposed have a decided Upper Silurian character; and not only so, but the presence of Devonian forms in connection with Upper Silurian types, would support the conclusion that these upper Silurian deposits appertain to a position akin to the Ludlow group, if not to the tilestones.

The connection of the Dunquin and Ferriter's Cove deposits with the Silurians, as these occur elsewhere in Ireland, is remote. The Silurian strata of Wicklow, Wexford, and Waterford, from the characters of the fossils, are decidedly of the Lower Silurian range, and here we have the Devonians resting unconformably upon the slates of the former formation, as may be seen at Mount Misery, near Waterford, where the Silurian slates, upturned, and dipping at an angle of 80° N.N.W., are overlaid by the conglomerate of the Devonians, dipping at 12° in the same direction. So far as the Silurians of the rest of Ireland are concerned, the same difference in age would appear to be manifest between the Silurians and Devonians, when these occur together; and the palæontological evidence generally supports the inference, that the Silurians of Kildare, Galway, Fermanagh, Tyrone, and the rest of Ireland, belong to the Lower series. Under such circumstances, the deposits which occur on the western portion of the promontory of Kerry become very interesting, since that locality is the only one which has yet furnished a position in Ireland containing Upper Silurians; and here, this Upper Silurian character is both exhibited, by the conformability between the Devonians and the Silurians, and also, by the fossil contents of the inferior formation. Other localities in the neighbourhood of Dingle will perhaps be found to afford the same strata in like intimate connection; but when we consider that we have the exposures of Dunquin and Ferriter's Cove, from the results of the abrading action of the Atlantic, we can scarcely expect to find these strata exposed, where such influence is not in operation to wear down the rolls to which the stratified deposits have, in this country, been subject.

*Description of a Malformed Trout, with Preliminary Remarks.** By T. Spencer Cobbold, M.D., Assistant Conservator of the Anatomical Museum, University of Edinburgh. (Plate VI.)

The occurrence of malformation among fishes, though not a matter of daily observation, is by no means unfrequent; and it would seem, from the writings of Pennant, Yarrell, and many other naturalists, that the Salmonidæ are particularly liable to structural abnormity.

In this general statement we do not include under the term "malformation" those slight irregularities of outline, and deviations of aspect, constituting *varieties*, properly so called; at the same time we fully recognize in these somatic changes, however trifling, an extension or arrestment of the same law of development resulting from modifying circumstances. It is important to keep this idea in mind; and its significance is at once apparent, when we consider the innumerable varieties to which trout are liable; thus viewed, too, all morphological differences are seen to be alterations of degree rather than of kind.

Professor Goodsir has placed on record a description of anomalies, affecting the fins of Goldfish, in which he recognises a law of reciprocal redundancy and deterioration;† but the most interesting account of deformed fish we have met with, is contained in the *Philosophical Transactions*, vol. lvii., entitled, "A Letter to Dr William Watson, F.R.S., from the Hon. Daines Barrington, F.R.S., on some particular Fish found in Wales." As this memoir dates so far back as 1767, and is consequently inaccessible to many, we shall briefly indicate some of the more important particulars.

Mr Barrington records, in the first place, the existence of Perch in a pool called Llyn Raithlyn, in the parish of Trawsvynnyd, Merionethshire. In the larger specimens, some of which were nearly two pounds in weight, the deformity was more manifest. He adds, "I have never examined the back-bone of these

* Read at the Glasgow Meeting of the British Association, Sept. 1855.

† The specimens are preserved in the University Anatomical Museum.

fish; they are not only crooked near the tail, and for about one-third of the whole length of the body; there is likewise a very remarkable protuberance on each side, which I have opened with a knife, but did not observe it to differ materially from other parts of the flesh."

This author subsequently ascertained that there were trout, crooked in the same part, stated to be peculiar to the river Eynion in Cardiganshire, which is a small brook emptying itself into the Dovey near Egglwys Vach, and is on the road from Machentleth in Montgomeryshire, to Talypont in Cardiganshire.* These trout are only caught in a small basin, eight or nine feet deep, which the river forms after a fall from the rocks. Mr Barrington dissected one or more; and referring to the vertebral column, says, "this bone differs most apparently from that of a common trout, or any other fish, by its being crooked near the tail. I have therefore no doubt that the back-bone of the perch will turn out to be equally crooked." About half the perch and trout taken from the above-mentioned localities exhibited this irregularity. From Llyn Marchland and Llyn Bochlynd, in Caernarvonshire, similar specimens had heen obtained.

Giraldus Cambrensis states that monocular fish are found in the lakes of Snowdon.† This traveller and observer was archdeacon of Brecknock, and attended Baldwin, archbishop of Canterbury, in a progress through South and North Wales, in the year 1188. Confirmatory of the truth of Giraldus' remarks, it is affirmed, on good authority, that a cyclopic trout had been caught at Lyn y Cyn, Caernarvonshire, the head of which was also thicker than usual.‡

In the river Gabard, in France, there is a pool containing blind pike.§ The Fischau, near Mandorf, in Germany, also contains blind trout.‖ In Dalekarlia, a province of Sweden,

* The names of these places are spelt somewhat differently on maps of recent date.

† *Giraldus Cambrensis*, liber ii., cap. 10.—"Anguillis, truttis, et perchiis, omnes in eo pisces monoculi reperiuntur." ‡ See Memoir, *loc. cit.*

§ *Hist. de l'Acad. des Sciences*, 1748, p. 27. L'observation par M. le Marquis de Montalembert.

‖ "Truttæ *omnes* in flumine Fischau prope Mandorf visu destitutæ dicunter."—*Fr. Ern. Bruckmanni Epistolâ Itinerariâ*, xxxvi., Wolfenb., 1734, p. 10.

near Fahlun, are two small lakes, famous for the singular shape of the perch, which grow to the ordinary size, and are of a good taste, but have all a hump on their back.*

The fish we are about to describe was shewn to the Royal Physical Society of Edinburgh, 22d March 1854. On this occasion, James Wilson, Esq. of Woodville, remarked, that in his rambles among the Scottish lakes he had frequently met with trout possessing a remarkably thickset appearance, and arched back, but he had not examined their internal organization.† The museum of the Zoological Society of London contains a trout with an imperfect development of the upper jaw. This variety occurs in Lochdow, near Pitmain, Inverness-shire, and Mr Yarrel figures it in his History of British Fishes.‡

For the specimen now before the Association I am indebted to Mr Thomas Turnbull,‖ who captured it while fly-fishing in the river Jed, near Jedburgh. He stated, that though for many years familiar with different kinds of trout, he had never met with one of this form. Its chief peculiarity, viewed externally, consists in the preponderant depth of the body, as compared with the length, giving the animal a hump-backed appearance, and causing it in outline to resemble individuals of the Sparidæ or Cyprinidæ, rather than members of its own group. To ascertain the cause of this anomaly, we proceeded to examine the viscera, under the impression that any deviation from the structural arrangement usually observed in Salmonidæ would indicate a hybrid, the visceral morphology at the same time suggesting the kind of fish whence such agency had been derived.

Turning down the integument, and dissecting the great lateral muscular mass from one side, so as to expose some of the ribs and diverging appendages, these parts, and some of the verte-

* "In stagnis Fahlunæ hujus piscis (Percæ) varietas est, quæ spina recurva, et corpore omnino gibbo, frequens reperitur."—Linnæi, *Fauna Suecica*, p. 118.

† For a detailed description of varieties of Salmonidæ, see Sir William Jardine's Account of an Expedition to the north-west of Sutherlandshire, in company with Dr Greville, John Jardine, Esq., P. Selby, Esq., and James Wilson, Esq. The paper is published in the 18th vol. of the *Edin. New Phil. Journal for* 1835.

‡ See also Article ANGLING, *Encyc. Britannica*, 7th Edition.

‖ Fish-salesman, Lothian Street, Edinburgh.

bral segments which had also been laid bare, at once offered an explanation of the longitudinal shortening of the trunk; we had here, in fact, an extreme abrogation of the spinal column, resulting from the coalescence of numerous vertebral "centra," giving rise secondarily to modifications in the surrounding soft parts.

The following is a brief record of the skeletal peculiarities:*—

The vertebral segments, not including the bony elements of the head, which appear natural, are 56 in number.† The first seven, proceeding from before backward, have their bodies or "centra" united into one bone, the multiple parts of which are recognised by grooves at the side, and further indicated by seven corresponding spinous processes above, and as many ribs, with the accompanying styliform appendages, below. A single "centrum" carries the neural and hœmal elements of the eighth and ninth vertebræ.

Thus far the bones do not present any marked change of position, save that which immediately results from their close approximation. There is a little bending forward of the tips of the spinous processes belonging to the five hindmost, but throughout their greater extent they take, as usual, an oblique course backward.

The tenth vertebral quantity is normal, but its neural spine, to which is articulated the first of the interspinous bones, is much curved forward. The eleventh and twelfth are conjoined; their laminæ or "neurapophyses" slope backward, as in the healthily-developed trout, but the corresponding neural spines have a perpendicular direction. The thirteenth segment is quantitively natural, its autogenous parts having a similar disposition to the foregoing. The bodies of the fourteenth and

* In this description, the terms employed by Professor Owen have been introduced, in order to illustrate the proportionate change which each presumed typical element has undergone. The accompanying Plate gives a tolerably accurate view of the anomalies, but the styliform appendages have been omitted, to avoid confusion. The dotted lines explain the number of conjoined "centra" in each osseous mass.

† Probably there is a slight variation consistent with specific identity. Yarrel and Parnell give fifty-six vertebræ to the common trout. In specimens we have examined, fifty-seven and fifty-eight have been counted.

fifteenth vertebræ are united to form a single "centrum." The sixteenth and seventeenth are likewise anchylosed, but more attenuated. The "centra" of the succeeding five segments, viz., the eighteenth, nineteenth, twentieth, twenty-first, and twenty-second, are all developed into a single osseous mass. The neural spines of these, and the preceding six, are all very closely packed together; they support the eleven interspinous bones, and in consequence of a vertical position, have tilted up the latter with their associated fin rays, so as to produce the great dorsal elevation. The ribs curve obliquely forward, and this mal-direction, especially at the upper part of the hœmal arches, applies more or less to all the "pleurapophysial" elements of the spinal series at present described; the small osseous appendages agree in number and relation.

From the twenty-third to the thirty-third vertebra inclusive, the neural and hœmal "apophyses" are attached to a single bone, which is consequently the representative of eleven "centra." The laminæ or "neurapophyses" of the first six segments are directed diagonally forward, the neural spines of all gradually curving backward. The transverse processes or "parapophyses," with the accompanying "pleurapophyses," belonging to nine of the included segments, approach the normal position.

The axes of the thirty-fourth and thirty-fifth divisions of the spinal series, are ossified together. A single "centrum" indicates the union of the bodies of the thirty-sixth, thirty-seventh, thirty-eighth, and thirty-ninth vertebræ, the spinous transverse processes pointing obliquely backward. The fortieth and forty-first vertebral bodies are united. The forty-second is independent. The forty-third and forty-fourth have coalesced. In these latter five instances, the supra and infra-axial developments have recovered much of their natural character.

The twelve remaining segments of the spinal series, from the forty-fifth to the fifty-sixth inclusive, alone present a completely healthy aspect, and a glance at their uniform disposition affords a criterion of the extreme mal-arrangement to which the abdominal vertebræ have been subjected.

Appendix to Paper on the Influence of the Lower Organisms in the production of Epidemic Diseases. By Dr DAUBENY.

Owing to a delay of several months which has taken place in the publication of this Memoir, some of the remarks of a local nature contained in it are less applicable at present than at the time they were originally put forth.

Thus the nuisance complained of towards the conclusion of the Essay has been since, temporarily at least, abated, and, it is hoped, means will be shortly taken for preventing its recurrence ; nor have I heard of any recent cases of intramural interment in Oxford which call for animadversion.

The Memoir having been so long out of the author's hands, no notice could be taken in it of a Charge by the Venerable Archdeacon of London, delivered on the 18th of May last, and since published, the purport of which was to prove, that " intramural burial in England is not injurious to the public health, and that its abolition is injurious to Religion and Morals."

Nevertheless, I think it will be found, that many of the arguments alleged in support of the former position, which places the Archdeacon in opposition, not only to myself, but likewise to the great weight of authority on sanitary questions, have been answered by anticipation in the course of this Memoir.

I shall therefore merely remark, that although it be not pretended that the origin of Cholera can be traced to putrescent animal matter, yet so universal is the belief in the connexion between the two, that no one, if he could help it, would choose to sleep near a churchyard set apart for the interment of the victims of Cholera, at the time the disorder was raging.

I believe, too, that after making due allowance for the efficacy which vegetable mould unquestionably possesses in absorbing, and thereby rendering innocuous, the products of animal decay, every candid mind would admit the real danger which accrues, from the constant temptation the authorities will be under of outstepping the limits of security afforded by the earth of a crowded cemetery, so long as the practice of burying in cities continues to be tolerated.

The archdeacon himself, on the authority of an eminent chemist admits, that the soil of his own churchyard in the parish of St Giles's, Cripplegate, is highly charged with ammonia. Now, this product is at once the evidence and the vehicle of those miasmata which are often generated during life, and disengaged after death, but of which chemistry at present lacks any direct means of determining the presence.

Whatever, therefore, may have been the original motive of the enactment in the old Roman law "Hominem mortuum in urbe neve sepelito, neve urito," the sentiment would be re-echoed in all civilized countries at the present day, not only from prudential motives, but also from the repugnance instinctively felt against bringing the dead amongst the living, except where long habit has reconciled us to the practice.

With respect to the theological part of the question, namely, "that the abolition of intramural interment would be injurious to religion and morals," I will merely remark, that it seems difficult to reconcile such a view with the fact of the entire abandonment of the practice in almost every Christian country, excepting Great Britain.

The archdeacon is eloquent upon the advantages of preserving unbroken the connection between the parish church and the place of burial, and for the sake of this he would be willing to forego the quiet, the seclusion, the accessibility, which are the recommendations of the burial grounds on the Continent, where this connection indeed is severed, but where, on the other hand, at any moment of the day, the parent may visit undisturbed the resting place of his child, or the widow of a husband, and seek that consolation which is denied in the grave-yards of our towns, fenced off as they necessarily are by high walls or iron grating, and only open, perhaps for one day in the week, during the hours of divine service.

On which side the advantages may preponderate I will not take upon myself to pronounce, but the archdeacon must excuse me for reminding him, that if there be any strong feeling of attachment in the country to the parochial system of interment, that feeling may be gratified on easier terms, than by jeopardising for the sake of it the health of the public, through the continuance of the practice of intramural interment.

In Oxford some years ago, at the instigation of, and chiefly by the aid of funds contributed by, the university, the several parishes undertook to create certain new burial-grounds in the neighbourhood, as substitutes for the old and overcrowded ones which had up to that time existed in the midst of the population; and though the scheme did not prove a remunerating one, but turned out more expensive than the establishment of one general cemetery would have been, still it was far better that such an outlay should be incurred, than that the risk should continue of creating a *fomes* of infection in the midst of our town population, by allowing the previous practice of intramural burial to be maintained indefinitely.

On the Cleavage of the Devonians of the South-West of Ireland. By ROBERT HARKNESS, Professor of Geology, and JOHN BLYTH, M.D., Professor of Chemistry, Queen's College, Cork.

The strata which, in the south-west of Ireland, form the Devonian formation, are arranged as a series of hills having, in the county of Cork, long regular ridges, running in nearly an east and west direction. In the county of Kerry they assume elevations greater than any other mountains in Ireland, and lose, to a great extent, the ridge-like appearance which is so manifest in Cork. In both counties the higher portion of the Devonians is succeeded by the overlying carboniferous limestone, and this latter formation presents itself resting conformably in the troughs of the Devonians; these troughs being produced by a succession of rolls, to which these formations have been subjected.

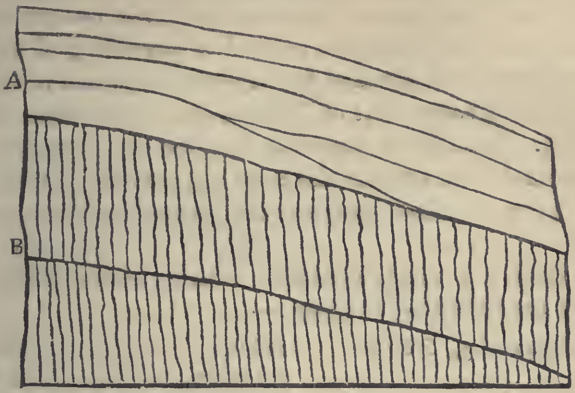
The strike of the Devonian formation partakes of the direction in which the ridges run, being generally east and west; and this strike prevails through the whole of the palæozoic formations of the south-west of Ireland, with a few local exceptions.

As concerns the lithological characters of the Devonians, these, on the whole, have somewhat of the same mineral nature, consisting of reddish-brown strata, of a flaggy aspect, which are locally known under the name of "*Brown stone.*" But besides these flaggy beds, there are seen, in the upper portion of the Devonians, deposits which have a different nature; and with this difference of nature some important features occur in connection with the cleavage, which is seen among these Devonians. The upper beds of this formation have a lighter colour, and are composed of sandstone; and in this light-coloured sandstone, in some localities, *Anodon Jukesii* and *Cyclopteris Hibernicus,* as well as other vegetable remains, have been obtained by the officers of the Geological Survey of Ireland. Sandstones, having to some extent the same lithological characters, make their appearance among the underlying flaggy strata; and when this is the case, the same features, so far as cleavage is concerned, present themselves as those which are seen in the superior light-coloured sandstones.

As regards the cleavage of the Devonians of the county of Cork, this, for the most part, occurs with a dip approaching nearly to the perpendicular; and with a strike in an east and west direction, following the general strike of the strata. On the whole this cleavage is of a coarse nature, and it gives to the reddish-brown beds the flag-like aspect already alluded to, the strata dividing along the cleavage planes into flaggy portions, and not along the laminæ of bedding, which, in most cases, are obliterated by the action of the force to which cleavage owes its origin. The lighter-coloured sandstones which succeed the reddish-brown beds are only slightly affected by cleavage, and in some instances they do not appear to present any traces of this action, but divide along the laminæ of bedding, and on these laminæ are seen the fossils alluded to.

A section affording both the reddish-brown cleaved beds and also the overlying light-coloured sandstone, unaffected by cleavage, may be seen at Rock Terrace quarry, Cork, of which the following is a sketch taken from the east side of the quarry; and similar occurrences may be seen elsewhere in the county of Cork.

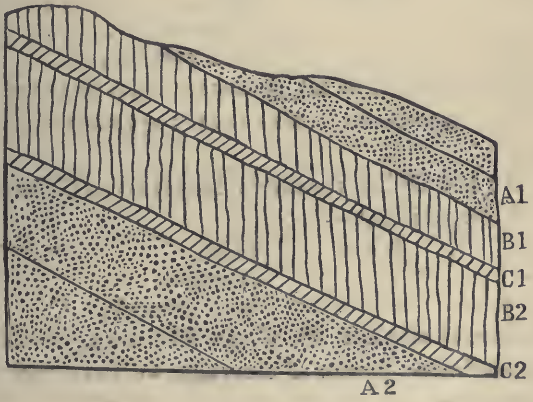
No. 1.



A. Light-coloured sandstone devoid of cleavage. *B.* Brown-stone with cleavage.

The sandstone strata which interstratify the brownish-red beds, having a distinct cleavage, also show that the cleavage is dependent, in a great measure, on the mineral nature of the deposits, as indicated by the two following sections, taken from near Killeen, about three miles north of Cork.

No. 2.



In No. 2, the highest and lowest strata exposed consist of sandstones having a purple colour, between which are four other beds, two of considerable thickness, and having the usual perpendicular flaggy-like cleavage which pervades the Devonians of the south of Ireland. Associated with these are two other beds, which are thin, and in which there are considerable modifications in the cleavage. In these two latter the cleavage is not only more imperfect, but instead of partaking of the perpendicular position common to the cleavage planes in the Devonians of the south-west of Ireland, they are inclined towards the south. In order to ascertain how far the constitution of these several beds affected the cleavage, portions of them were submitted to chemical analyses, and yielded the following results:—

A^1, which is a purple sandstone entirely devoid of cleavage, afforded the following analysis:—

Specific gravity,	2·695	Silica, . .	79·3
		Alumina, . .	4·7
		Iron peroxide, .	5·7

B^1 had the following composition, and in this bed the cleavage was in its normal condition.

Sp. gr., .	2·733	Silica, . .	68·0
		Alumina, . .	13·5
		Iron peroxide, .	12·0

The thin bed C^1, with the cleavage having a south inclination, yielded—

Sp. gr., .	2·678	Silica, . .	76·6
		Alumina . .	12·0
		Iron peroxide, .	9·6

The stratum B^2 is, in the character of its cleavage, like B^1, and in its composition it also nearly approaches the higher deposit.

The thin bed C^2 has considerable affinity to C^1, and has the subjoined composition:—

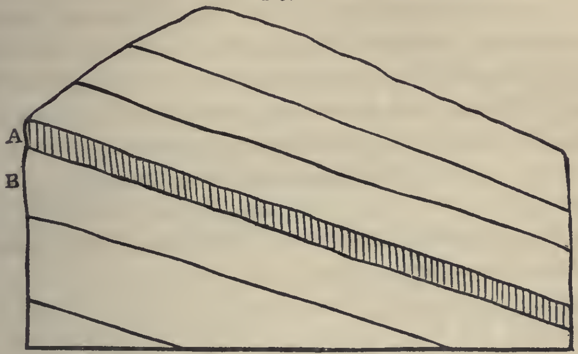
Sp. gr., .	2·630	Silica, . .	76·0
		Alumina, . .	11·7
		Iron peroxide, .	6·1

In the lowest stratum A^2, which, like the upper bed A^1, is a purple sandstone devoid of cleavage, we have the following constituents:—

Sp. gr., .	2·6944	Silica, . .	81·3
		Alumina, . .	7·4
		Iron peroxide, .	6·5

The other section, 3, taken from the same locality, and which consists of a stratum of reddish-brown colour, having quite a slaty character from cleavage, contained between two

No. 3.



A. Cleaved bed. *B.* Sandstone without cleavage.

deposits of sandstone of a similar mineral nature, devoid of cleavage, affords the subjoined analysis.

A, the slaty bed alluded to,

Sp. gr., .	2·7397	Silica, . .	62·0
		Alumina, . .	13·9
		Iron peroxide, .	11·3

And the underlying sandstone, B, had the following composition :—

Sp. gr., .	2·589	Silica, . .	87·0
		Alumina, . .	7·0
		Iron peroxide, ·	2·8

Another specimen obtained from near the same locality, and in which the cleavage was only imperfectly manifested, afforded the following results :—

Sp. gr., .	2·6589	Silica, . .	72·3
		Alumina, . .	10·0
		Iron peroxide, .	9·6

The specimens also contained varying quantities of lime, magnesia, and sulphide of iron. These were not determined, as the object in view was to ascertain the relative proportions of silica, alumina, and iron, in connection with the specific gravity of each specimen.

In connection with cleavage the foregoing analyses give two results. In the one we find that such beds as have the cleavage most developed the specific gravity is the greatest, and the other result is, that in these also we find the greatest amount of alumina.

Their mineral composition is such as to support the conclusion that they were originally beds of a shaly nature, and that in proportion as they lost their shaly nature from a greater abundance of silica, and assumed the characters of sandstone, so they became less subject to the operation of that force to which cleavage owes its origin.

The effect of a difference in the mineral nature of deposits having considerable influence on cleavage is not confined to the south-west of Ireland. It appears to be a universal law operating on this agent, and has been noticed by Professor Sedgwick in his early paper on cleavage in the *Geol. Proc.*, vol. iii., new series; and by Mr Sharpe, who, in his paper on the cleavage of the Alps, gives many instances of the phenomenon of cleavage being modified according to the constitution of the rocks through which this structure passes; and many other geologists have recorded observations of a like character in various parts of the world.

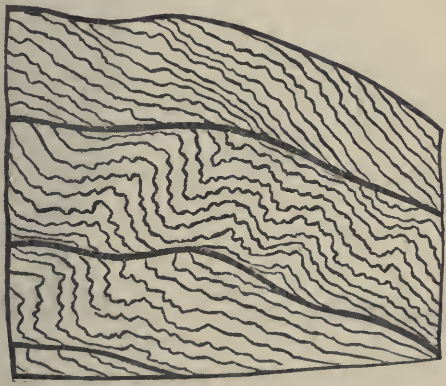
West from the city of Cork, as we approach the most mountainous portion of Ireland, the deposits which form the Devonian formation assume a somewhat different character, and with this we have changes produced on the cleavage. In the more mountainous portion of the country, the strata have an older aspect, and we have thick beds of purple and greenish-gray grits associated with beds of a more argillaceous nature; and in these latter the phenomena of cleavage present themselves under similar circumstances to those which are seen in the neighbourhood of the city of Cork. Here too we have the gritty beds devoid of cleavage, or possessing it only to an imperfect degree, associated with deposits which are well marked with all the features indicating this kind of structure.

The same things prevail also in the county of Kerry, where the east and west strike of cleavage obtains to a large extent. But here we find certain phenomena of a physical character well presented, which do not occur to the same extent in the adjoining county of Cork.

The whole of the county of Kerry, where the Devonians are exposed, furnishes abundant examples of the cleavage which prevails in this formation; but it is in the island of Valentia that we have the best examples of the modifications which this structure has undergone, and also the physical causes to which cleavage appears to be in a great measure attributable.

Here we have, in numerous instances, the mineral nature of the rock modifying cleavage to a greater extent than is seen on the mainland, for besides dipping at various angles according to the constitution of the stratum, the cleavage occurs in the form of complex sigmoid flexures in several of the beds which this island affords. A fine example of this mode of the occurrence of cleavage may be seen at Reengarriv Point, on the west side of the lighthouse, which presents the following appearance.

No. 4.

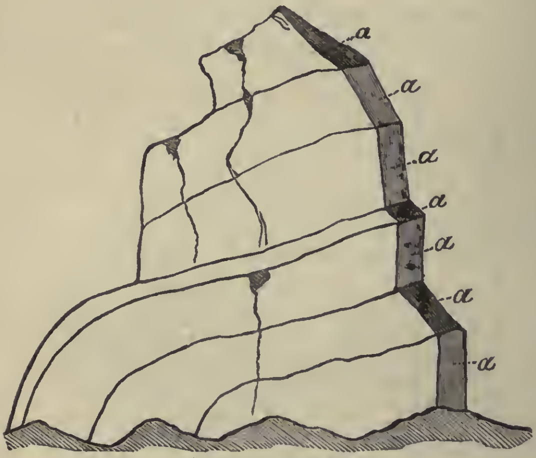


In this complex sigmoid form of the cleavage, it would seem that the several laminæ entering into the composition of each stratum were different in their mineral constitution, and with this difference we have various angles of the dip of cleavage, which, running into each other, give to the strata the contorted forms of cleavage which these afford. It would appear that this is simply owing to the operation of that cause which we have seen modifying the angle of cleavage in section 2 at Killeen, near Cork, the difference being, that in the first case we have the cause operating upon each stratum, while at Reengarriv Point the effect is produced on each lamina.

Many fine examples may be seen in this island of the modifications which the angle of cleavage undergoes in consequence of the varying composition of each stratum, and one in particular may be mentioned which occurs a short distance to the north of Brayhead, the most southerly point in the island.

In this instance we have an isolated rock composed of several strata of different mineral composition, and as the wearing away of this rock is in the direction of the strike of the cleavage-planes we have these planes well exposed, and dipping at different angles in an E.S.E. direction, as shown by the subjoined sketch.

No. 5.



A. Planes of cleavage.

We have other phenomena besides those of flexured and variously inclined cleavage presented to us in connection with this form of structure in this island. The usually obtaining strike of the cleavage in this locality is the same as that of the adjoining mainland of the county of Kerry, being W.S.W. and E.N.E. This is the strike of the cleavage at the slate-quarry of Valentia, where the dip of the cleavage is about 27 S.S.E. in the purple stratum which is wrought for slate, and which is succeeded by a more siliceous stratum having a greenish-gray colour, locally termed "*greenstone*," which, in consequence of its imperfect cleavage, is useless for commercial purposes. These two beds, the purple slate and the greenstone, are so intimately united to each other that the original plane of stratification separating them has been obliterated, and the two beds are found adhering together as though they originally formed portions of the same stratum. Instances of a like character may be observed in many parts of the island, and sometimes a line of stratification may be seen perfect in all respects at one spot; but on tracing it for a short distance it gradually loses its distinct nature, and finally disappears altogether, the beds which it separated becoming united, as is the case with the purple slate and greenstone at the quarry.

Although the prevailing strike of the cleavage in Valentia is W.S.W. and E.N.E., yet there are others which have different directions; and in connection with these several strikes we have an important physical phenomenon, which seems to have an intimate relation with the cause to which this form of structure owes its origin.

On the north side of the island, about Reengarriv and Reenodrolaun Points, the strike of the cleavage planes is nearly east and west, and here we see a series of rolls in the strata having also the same strike, the beds dipping north and south. On the west side of the island, between Culloohead and Brayhead, the strike of the cleavage is N.N.E. and S.S.W., and the dip E.S.E. at various angles, according to the mineral composition of the rocks. Between these two points we have also a series of rolls, well developed, striking in the same direction as the cleavage, and these rolls, together with the cleavage planes and dips, are well seen in the isolated rock already alluded to as occurring north of Brayhead (Fig. 5).

From the S. side of Brayhead the rocks are well exposed to the E. of the village of Clynacartan, and in this interval we have the W.S.W. and E.N.E. strike and S.S.E. dip of cleavage, the prevailing one of this portion of Ireland; and in this interval are several rolls striking in the same direction with the cleavage. In Valentia, therefore, we have three distinct strikes of cleavage, the most predominant one being W.S.W. and E.N.E., another, on the north side, having an E. and W. course, and a third, on the S.W. side, running in a N.N.E. and S.S.W. direction; and these three strikes of cleavage accord with the strikes of the rolls of the strata; and the dip of the angle of cleavage, when it is not perpendicular, has always more or less of the south in it.

No. 6.

Lines of strike of cleavage.

Leaving Valentia for the mainland, we find like circumstances manifested. At Port Magee the same W.S.W. and E.N.E. strike of cleavage obtains, the dip of the cleavage planes being S.S.E.; and here too we find a roll occurring, and striking in the direction with the strike of the cleavage.

South from this, and along the coast of St Finnan's Bay, we have no more evidence of rolls, but a continuous S.S.E. dip of the strata sets in to Ducullahead, and the strike of the cleavage here also agrees with the strike of the strata, the dip of the cleavage being also at various angles S.S.E. when not perpendicular. Along this portion of the coast of the county of Kerry the cleavage is more distinct in some parts than others. Thus between Doon Point and Puffin Sound the cleavage is so distinct that the lines of stratification are imperfectly seen, the rocks wearing away into headlands and bays along the cleavage planes.

Between Puffin Sound and Ducullahead the cleavage is not so perfect, the planes of stratification being easily seen, and the coves and headlands in this interval are formed along the stratification, and not along the cleavage. From the difference in the perfection of the cleavage, as this is seen in this portion of the south of Ireland, it would appear that the occurrence of rolls in the beds is in some way connected with cleavage phenomena.

The origin of cleavage, and the causes which tend to modify the nature of its phenomena, are questions which as yet can hardly be regarded as being satisfactorily answered. The observations of Professor Sedgwick, Messrs Sharpe and Sorby, on these subjects, have done much to make us acquainted with the various phases which cleavage assumes, but as regards the causes to which these are referable these geologists differ; the Woodwardian professor assigning the origin of cleavage to a crystalline re-arrangement of the rocky particles, while the latter gentlemen refer the phenomena of slaty cleavage to mechanical causes, both assuming that pressure has been the force to which cleavage owes its origin.

This latter cause has many circumstances to support it; and among those cited by Mr Sharpe are the distortion and elongation of fossils in the direction of the cleavage planes, and the compression of the more solid fragments, which occur in the form of embedded pebbles in a direction at right angles to the cleavage planes, and an extension in the direction of the inclination of these planes.

Mr Sorby, having called to his aid the microscope, arrives at the same conclusion as Mr Sharpe concerning the cause of slaty cleavage. He finds that when cleaved rocks, in thin sections, are submitted to microscopical examination, they present such an arrangement among their particles, as to lead to the inference that these particles have been subjected to the operation of a force by which they have left their original plane of deposition, and assumed a new one more or less inclined to their original position; the amount of inclination varying in proportion as the direction of the cleavage differs from the stratification. This arrangement of particles Mr Sorby regards as resulting from pressure, which forced the particles to assume a new position at right angles to the planes of pressure, a mode of arrangement which must have taken place under circumstances allowing of some freedom in the motion of the particles composing such rocks as afford slaty cleavage.

Mr R. Were Fox has succeeded, by long-continued galvanic action, in impressing on soft clay a structure having some resemblance to cleavage, but some doubts exist if similar conditions prevail in nature, and also, if the experiments of Mr Fox have any great bearing on the subject of cleavage.

As concerns the cleavage of the south-west of Ireland, there are two distinct phenomena which present themselves in connection with this structural arrangement. The one embraces the various aspects in which the cleavage is seen, as regards the modifications which it undergoes in rocks of different mineral natures; the other includes what may be considered as of a more physical character, the direction of the strike of the cleavage and the causes to which this is referable.

As respects the former, the chemical examinations of the several specimens from the sections near Killeen, in different states of cleavage, associated with rocks devoid of this structure, afford some important deductions. In the two specimens which have the cleavage best developed, we have the greatest specific gravity; and of these two specimens, that which has a slaty cleavage shows also a greater specific gravity than the one with the flaggy cleavage, the former being 2·739, and the latter 2·733. The two thin beds, having an imperfect cleavage with a south dip, have less specific gravity, being 2·678, and 2·630.

In these specimens we have an increase in density attendant on a greater development of the cleavage; and the analyses show also a difference in chemical composition. In the slaty cleavage specimen, having sp. gr. 2·739, we find 62·0 silica; 13·9 alumina; and in the flaggy cleaved specimen, sp. gr. 2·733, we have 68·0 silica, 13·5 alumina. The two beds with the imperfect cleavage, and south inclination of this structure, show a greater amount of silica, and a smaller proportion of alumina; and in the purple sandstones devoid altogether of cleavage, we find this difference prevailing to a still greater extent. From the analyses, it would seem that the relative amount of alumina has much to do with the presence or absence of cleavage in rocks which have been submitted to this agency; and this refers not only to the south-west of Ireland, but also elsewhere, for well-cleaved slates possess a considerable amount of this constituent. The chemical constitution of these cleaved rocks, leads to the inference, that originally they have been shales, and have lost their shaley character, in consequence of the operation of the cause producing cleavage. With regard to the density of shales, these rarely exceed a sp. gr. of 2·6, and we must assume that the greater density of the cleaved rocks is one of the results of the cleavage force.

The originally shaley nature of rocks which are affected with cleavage points out why these have been operated on by the force producing this structure, while others of the nature of sandstone do not show traces of cleavage. In the former we have a description of rock of a somewhat soft nature, and yielding in proportion to the amount of alumina contained in it, while in the other we have a rigid rock incapable of being acted upon by that cause which has changed the original nature of shales.

As regards the phenomena of a more purely physical character, namely, the connection of the strike of the cleavage with other circumstances, observations having relation to these have been made by several geologists. Prof. Sedgwick observes (*Trans. Geol.*, 2d series, vol. 3, page 473), "when the cleavage is well developed in a thick mass of slate rock, the strike of the cleavage is nearly coincident with the strike of the bed."

Prof. Phillips (*Rep. Brit. Assoc.* 1843, page 61) remarks, "the cleavage planes of the slate rocks of North Wales are always parallel to the main direction of the great anticlinal axis."

Mr Darwin (Observations on the Geology of South America, page 163) states, that "the cleavage laminæ range over wide areas, with remarkable uniformity, being parallel to the strike of the main axes of elevation, and generally to the outlines of the coast," and Mr Jukes' observations on the cleavage of Newfoundland lead to the same results. (Excursion in Newfoundland, vol. 2, page 324.)

Mr Sharpe (*Geol. Jour.*, vol. 3, page 88) says "the strike of the cleavage is parallel to the main direction of the axis of elevation, and has no necessary connection with the strike of the beds."

Mr Sorby (*Jameson's Jour.*, vol. lv., p. 146) remarks, "that the strike of the cleavage would usually coincide with the general strike of the beds, and be parallel to the main axis of elevation of the district, as has been found to be so commonly the case."

These several observations tend to the conclusion that between cleavage and axes of strata there is considerable connection; and the examples afforded by the counties of Cork and Kerry fully bear out this inference; but in the latter county they go further; for they not only show that the cleavage planes are parallel to the principal axis of elevation of the district, which has a nearly east and west course, to which course the strike of the cleavage generally accords in the district, but they also show that the strike of the cleavage agrees with the strike of even the minor axis, as seen in the island of Valentia, where we have the cleavage planes following the strikes of the several rolls which here affect the strata. The observations in connection with the cleavage in the county of Kerry do not however stop here; for we find that in districts where the rolls occur, as in Valentia, and near Port Magee in the mainland, the cleavage is best developed and most perfect; while over the areas where we have a continuous SSE. dip *without* rolls, as on the coast of St Finnan's Bay, the cleavage is less perfect. In the former case, it to a great extent obliterates the stratification, the rocks wearing away along their cleavage planes; while in the latter instance the stratification is distinct, and along this the rocks suffer from the destructive action of the Atlantic—a circumstance already alluded to.

There is another feature before mentioned in connection with the cleavage of the rocks in Valentia island which remains to be noticed. This is the perfect union which exists between several strata, the one passing into the other in consequence of the planes of stratification which originally separated them having become obliterated. In cases of this nature, we have generally these occurring in this island most immediately in connection with the well-developed rolls, under conditions where the cleavage manifests itself in its most perfect degree; but even where rolls do not predominate, and the stratification is more distinct, the surfaces of the strata present appearances which show that some change has been produced upon these in consequence of cleavage. These altered surfaces have an aspect which at a distance resembles ripple-markings, but when examined more minutely, and seen in sections, they have a more serrated nature, and the elevations of one bed are received into the depressions of the other, giving a somewhat dove-tailed character to the planes of stratification, which gradually becomes less distinct, and finally disappears, owing to a perfect union of the beds. The strata having a sandstone nature rarely possess these features, being generally distinct; but a stratum having a perfect cleavage, and possessing such an amount of alumina as to give it a slaty appearance, is often found intimately united with a more siliceous rock, as is the case with the slate, and so-called greenstone of Valentia slate quarry.

The various phenomena which the cleavage of the SW. of Ireland presents, afford some important inferences concerning the cause of this form of structure, and support the conclusion that pressure is the force which induces these phenomena.

The strike of the cleavage planes in the direction of the strike of the strata—a circumstance intimately connected with the cause of cleavage, as observed by Professor Sedgwick in N. Wales—shows the relation which exists between the force giving the rocks of the SW. of Ireland their present position, and the causes of the cleavage structure. The long ridges of the Devonians which traverse the south of Ireland are portions of a series of curves, which have flexured this formation in this district to a great extent, and must have given rise to a degree of pressure sufficient to change the internal arrangement of the particles composing these rocks, in cases where any amount of movement among the particles constituting them could take place; and in such rocks as possessed the power of re-arrangement in the greatest degree, we should have the most perfect alteration of the position of the particles resulting from this pressure. Mr Sharp, when speaking of the force producing cleavage, says (*Quart. Journ. Geol.*, vol. v., p. 128), "The direction of the cleavage planes is in direct relation to the movements of elevation of the strata, being everywhere at right angles to the direction of the elevating force; and where the beds have been raised with regularity over a single axis, the cleavage planes appear to be portions of curves of which the width of the area of elevation is the diameter."

It is not only in the long ridges of the Devonians of the S. of Ireland, having a nearly E. and W. strike, that we meet with the connection which exists between the force which has produced these ridges in Valentia, we have it shown to a still greater extent in the agreement of the strike of the cleavage planes with that of the several rolls which affect this island. There is another circumstance which supports the conclusion of the intimate relation of the elevating force and that producing cleavage, which is, that when the inclination of this structure in this country is not perpendicular, it has more or less of a dip, having different degrees of *south* in it according to the direction of the rolls. Where we have a WSW. and ENE. strike of roll, the *inclined* cleavage is always SSE. on both sides of the roll. Where we have a NNE. and SSW. strike of the rolls, the *inclined* cleavage has in all cases a SSE. dip; and where the rolls occur E. and W., the dip of the cleavage rocks when not perpendicular is south.

An examination into the physical geology of this portion of Ireland puts us in possession of an important circumstance, bearing on this general southern dip of the cleavage.

The strata in the counties of Cork and Kerry have not merely been rolled into a series of curves, but these curves have been pushed over in a more or less northerly direction; and to this pushing over of the strata we owe the inverted position of the carboniferous limestones and coal measures, which occur near Kanturk, and also the singular positions in which the Silurian areas occur in the Dingle promontory. The cleaved structure of rocks does not result from the simple rolling of the strata, but from this cause combined with a considerable amount of pressure; and this latter force acting from the south has pushed over the strata in a series of oblique curves to the north, and given to the inclined cleavage its more or less of a southern dip.

The effect of pressure on rocky masses would be more or less modified as the mineral structure of these masses varied, and also in proportion to the amount of pressure exerted. As concerns the latter, we have evidence of this in the perfect cleavage which exists among the rocks of Valentia, where the beds present themselves in an extremely twisted form, showing the operation of great pressure, as compared with the cleavage seen at St Finnan's Bay, where the pressure has not been so great, and where the cleavage is less perfect.

Regarding the differences in the mineral nature of the rock submitted to pressure, and the alteration in structure resulting from this, the analyses of the several strata from near Killeen show that in the case of sandstones little or no change has been produced, while in rocks having more or less of a shaley nature, and possessing some degree of freedom in the motion of the particles composing them, a circumstance which the rigid sandstone did not afford, a re-arrangement of the particles took place to a greater or less degree in proportion to the amount of freedom, and to this re-arrangement we owe the various degrees of cleavage which obtain among the rocks having this structure in the south of Ireland, and, consequently, we have cleaved and uncleaved rocks intimately associated with each other.

The obliteration of the planes of stratification among rocks which have a cleaved structure owes its origin to the same force which has induced this structure, viz. pressure ; for one of the results of pressure among rocks of a shaley nature would be not only to change the originally laminated structure from one parallel to the planes of stratification to one at right angles to the planes of pressure, but, also to force one structure into another in such a manner that the lines of bedding would be destroyed. Mr Sharpe, when alluding to the effects of pressure, says (*Quart. Jour. Geol. Soc.*, vol. v., page 128)—" The compression of the mass in a direction perpendicular to the cleavage has been partially compensated for by its expansion along the dip of the cleavage, in which direction only its expansion was permitted as the elevation of the beds enlarged the area occupied by them. The difference between the amount of compression in one direction, and the expansion in another, is accounted for in the greater density of the rock after compression.

The compression of the rock in one direction and its expansion in another, would obliterate traces of stratification in such rocks as possess a high degree of cleavage, and to this compression also is to be attributed the increased specific gravity, as shown in the two specimens from Killeen having a distinct and perfect cleavage.

Every circumstance attendant on the cleavage of the rocks as this is manifested in the south-west of Ireland tends to support the deductions of Mr Sharpe, (*Quart. Jour. Geol. Soc.*, v. 3, p. 87,) that there has been "a compression in their mass in a direction everywhere perpendicular to the planes of cleavage, and an expansion of their mass along the planes of cleavage, in the direction of a line at right angles to the line of incidence of the planes of bedding and cleavage, or, in other words, in the direction of the dip of the cleavage."

Description of a New Species of Trematode Worm (Fasciola gigantica).* By T. SPENCER COBBOLD, M.D., &c. (Plate VII.)

In a paper "On the Anatomy of the Giraffe," communicated to the Royal Physical Society of Edinburgh, 5th April 1854, and published in the June Number of the Annals of Natural History for the same year, we cursorily alluded to the circumstance of our having detected a species of fluke in the ducts of the liver of the above-mentioned ruminant.

No fewer than forty such individuals were washed out of the gland by means of a syringe; but as the animal had been dead nine days, some of the entozoa had acquired a dark, semiputrid-looking appearance, and it was not expected that the vascular or digestive tubes would be sufficiently fresh to admit of artificial distension. With the view of strengthening the canals, they were immediately placed in strong spirit,

* Read at the Glasgow Meeting of the British Association, Sept. 1855.

by which precaution we succeeded in injecting some of the specimens, though not in so complete or perfect a manner as could be desired.

The trematode worm to which we propose to apply the combined generic and specific title of *Fasciola gigantica*, is possibly confined in its habitat to the situation just indicated, which will account for its having hitherto escaped observation; yet, seeing how close are the structural and physiological affinities connecting the genus Camelopardalis with the Cervidæ, Antilopidæ, and Camelidæ, it is highly probable that certain of the numerous species of these allied families may be infested by the same entozoon. In the case of the common fluke (*Fasciola hepatica*, Linn.), Rudolphi mentions its occurrence in eleven species of Mammalia, six of the animals thus infested being ruminants.

The generic name Fasciola may be objected to, because the term Distoma has been, of late, so universally employed by naturalists in reference to the flukes, &c. We think, with M. Blanchard, there is no good reason for rejecting the original title given by Linnæus, but that it is rather convenient to retain it, in contradistinction to the term Distoma, substituted by Rudolphi, Bremser, Dujardin, and others. M. Blanchard, who has done so much to clear up disputed points concerning the organization of the Planariæ and Trematoda, makes very broad distinguishing characters between the genera Fasciola and Distoma; for example,—in the former genus he includes only those flukes which have the digestive apparatus ramifying or dendritic, as in the case of *Fasciola hepatica*, and as is also seen in the undescribed species now before us. In the genus Distoma, on the other hand, he characterizes the alimentary canal as consisting of an œsophagus dividing into two intestinal tubes which terminate in cœca, and do not present any ramification. The *Distoma lanceolatum* (Mehlis) is instanced as an illustration of this type of structure.

The trematode now before the Association, and which we have designated *Fasciola gigantica*, varies in length from an inch and a half to nearly three inches, most of the specimens being about two inches; their breadth averages three lines, some attaining the third of an inch. The general form of the body is elongated, and rounded at the caudal extremity, in which latter feature it differs very markedly from *F. hepatica*. The larger or more fully developed individuals present slight irregularities or crenations of the lateral margins near the neck; a character, however, by no means constant. The borders are more attenuated than in the common species, and the substance of the body thinner. The anterior extremity is prolonged forward about two lines, and terminates in a sucker half a line in diameter. There is no evident distinction between what has been termed head and neck, but the part to which the latter title is assigned is very prominent on the dorsal surface, from the distended condition of the oviducts and seminal reservoir lying immediately beneath.

The digestive apparatus commences by a short œsophagus proceeding downward from the base of the oval sucker; while in the neck it divides into two slightly diverging trunks which pass on either side of the ventral sucker, again approximate, and are continued to the tail. On their passage down, the two principal trunks lie almost parallel, near the mesial line of the body; they give off eight or ten secondary branches, which proceed to the lateral margins, and end in blind cœca; small twigs also proceed from the main tubes inwards, but they do not extend beyond the middle line, and present very few subdivisions. The ramifying systems of digestive cœca in each lateral segment of the animal, are not absolutely symmetrical, neither is there uniformity in respect of number; they preserve, however, a general resemblance both in the degree of subdivision and in the direction which the secondary trunks assume. The downward direction of the branches, and the angle of divergence resulting from such a disposition of parts form a striking contrast to the arrangement of that system of canals situated nearer the dorsal aspect of the body, and usually regarded as the circulatory apparatus. These vessels are represented in *F. gigantica* by a single median trunk, from which numerous primary branches pass obliquely upward to the sides.

We may here remark, that considerable dispute has arisen among helminthologists, as to the propriety of regarding this series of canals as vascular; some have even expressed doubts as to the presence of any true organs of circulation in the trematode worms, and the distinguished authority Van Beneden holds this opinion. Those who regard the superficial set of tubes in the light of an excretory or secreting gland, ground their view on the circumstance of a supposed caudal opening, through which matters thrown into the median vessel frequently pass. M. Blanchard has shown the aperture in question to result from over-distension of the canal, which readily gives way at this, its weakest point; our own attempts to inject have confirmed this observation.

Accepting M. Blanchard's explanation as correct, we have to state further, in regard to these vessels, that they exhibit less regularity of distribution than obtains in the branching tubes of the alimentary system, and they inosculate freely from one end of the body to the other. Irrespective of these distinguishing marks, there is a disparity of calibre between the two sets of tubes, and all their peculiarities taken together strongly convince us of their true vascular nature.

The external spiral appendages, with the minute orifices of the reproductive organs, occupy the same relative position as in *F. hepatica*, *i. e.*, lying directly in front of the second or great ventral sucker. In reference to these structures—the nervous system and other special parts—it is unnecessary to give additional particulars; their characters resembling in all respects those seen in the typical species, and which are now so fully understood.

Fasciola gigantica, Cobbold.

Corpore compresso, elliptico-lanceolato, tres uncias longo, antrorsum attenuato; ore hausterioque anticis; collo elongato, cylindrico; caudâ rotundatâ; ventriculo dendritico, ramis clausis.

Habitat in hepate Camelopardalis Giraffæ.

Appendix.—In the accompanying Plate, figures have been introduced of two kinds of Cericaria, which were found associated with the above-described trematode. One group of these cysts infested the liver, where they appeared either at the surface, in the form of small, hard, projecting points, or were thinly scattered throughout the substance of the gland.

They were very numerous, and some had undergone calcareous degeneration. The other, a small group, consisted of three semitransparent cysts, imbedded in the cellular aponeurosis surrounding the stylo-glossi and lingualis muscles.

Description of Plate VII.

A. Dorsal aspect of *Fasciola gigantica*, representing, in particular, the vascular system, which has been injected with vermilion. At the lower part, several of the vessels ruptured, producing extravasation.

B. Ventral surface of another specimen of the same species. It illustrates the disposition of the alimentary apparatus, the tubes of which have been filled with artificial ultramarine.

Fig. 1. Cyst from the liver, with shreds of glandular substance adhering. Natural size.

Fig. 2. Cysticercus, or trematode larva removed from the cyst. Enlarged 3 diameters.

Fig. 3. The same, further magnified, showing the head and neck unfolded, and separated from the caudal vesicle.

Fig. 4. Head and neck, exhibiting the oval sucker. Magnified 25 diameters.

Fig. 5. Section of a cyst which has enlarged and undergone calcareous degeneration. The deposits are arranged in irregular concentric laminæ, and the investing sheath is much hypertrophied. Natural size.

Fig. 6. Oval semitransparent cyst from the cellular substance surrounding the muscles at the base of the tongue. This investing capsule is composed of two layers, the outer of condensed areolar tissue, the inner of well-marked epithelium. Natural size.

Fig. 7. Enclosed endocyst, which was separated from the outer envelope by a transparent fluid. Natural size. (See Fig. 14.)

Fig. 8. Embryo or larva removed from the endocyst, and partly unrolled. Natural size.

Fig. 9. Embryo in its coiled state, enlarged to show the cephalic sucker.

Fig. 10. Sectional view of the same. A tube is seen passing towards the caudal extremity, which is in this larva attenuated; it is apparently intestinal, but we did not succeed in tracing its connection with the sucker. A number of markings cross the body transversely, and these correspond with linear depressions or divisions on the integument.

Fig. 11. Slightly magnified view of two ova-like bodies or cells, from the caudal extremity of the embryo. They could be

seen with a pocket lens, and probably are the remnant of germ cells, which, before the cercaria passed into the pupa condition, gave rise to a progeny of embryos, differing from the parent or *nurse* cercaria.

Fig. 12. One of these germ cells, showing the included formative cellules. Magnified 60 diameters.

Fig. 13. Formative cellule, showing the nucleus and nucleolus. Magnified 100 diameters.

Fig. 14. Irregular albuminoid particles, constituting the structure of the endocyst. They adhered closely to each other, and presented no distinct cell wall. Magnified 250 diameters.

Fig. 15. Spherical cells, forming the mass of the parenchymatous substance of the embryo, and exhibiting various nuclei, or granular contents. Magnified 250 diameters.

Astronomical Contradictions and Geological Inferences respecting a Plurality of Worlds.

I. *Astronomical Contradictions.*

There are many persons who have never looked through a telescope, who have never had the *opportunity* of looking through a telescope, and who in all probability may *never* have an opportunity of doing so, but who nevertheless have rested an implicit faith in the revelations of astronomers. In making this assertion we believe that we state the case of a large majority of the reading and educated public. Astronomy lies within the field of the actual observation of but few, and all that can possibly be learned on such a subject by the multitude must depend upon the evidence of those, who, from superior wisdom, superior education, and above all, superior telescopes, claim credit for their statements. "The ring, which, to an intelligent Saturnian spectator, would be so splendid a celestial object," and "therefore is not altogether without its use," is unfortunately a mere matter of CREDIT to hundreds and thousands of intellectual and educated beings, and to whom it is likely to remain nothing else! In the labours of such philosophers as Galileo, Kepler, Newton, De Laplace, the Herschels, Arago, and multitudes of others, men believed that they recognised the spirit of true philosophy; in their books they fancied they beheld sound vehicles of human testimony, while even in their arguments from analogy, they were acquitted of "sporting the plausibilities of unauthorized speculation."

What an annihilation of all our ideas of the innumerable splendours of creation formed on the evidence of these astronomers—what a refutation of astronomical *imagination* do we possess in that remarkable Essay "On the Plurality of Worlds!" This book is a great fact—an era in our age—an enormous error or a great *truth;* there is no *via media* about it. The author is sufficiently plain and straightforward in his hypothesis, and to cast a doubt upon our belief in the existence of intellectual inhabitants of other planetary bodies is his sole aim and object. He evidently fears that man is not disposed to think sufficiently of himself and his destiny, and is likely to forget that he is "an important object in the eyes of the Creator."

Sir David Brewster has answered this Essay in a treatise, entitled "More Worlds than One." This work might have been more carefully written, and rendered more worthy of the subject. Sir David Brewster is a great man, and when he writes or speaks, men read and listen, and seldom read or listen in vain. We regret, therefore, especially, that he had not made himself better acquainted with GEOLOGICAL facts before he attempted to reason upon them.

In order to state the case fairly, we cannot do better than employ the very words of the controversialists, especially as some of the expressions of the Author of the Essay are, to say the least, peculiar, when treating of so important a subject as the creation of the universe, and we have a delicacy ourselves about "winding planets neatly up into balls," and "spoiling them in the making," and comparing them to "possible thistles," which we would gladly avoid by taking refuge in simple extracts.

When the mechanism of the planetary system, and the composition and actual speed of light was discovered and registered, men began to think that astronomy stood upon sound and competent evidence, and without going into the still deeper tangibilities of the science, and the proofs wrought by the aid of the higher mathematics, the astronomer seems to have thought that he was only making a right and a reasonable use of his science, when he brought *analogy* to bear upon his discoveries in the realms of space, and consequently we are not surprised that Sir David Brewster, in his introduction to "More Worlds than One," declares that the doctrine of a plurality of worlds "was maintained by almost all the distinguished astronomers and writers who have flourished since the true figure of the earth was determined. Giordano Bruno of Nola, Kepler, and Tycho, believed in it; and Cardinal Cusa and Bruno." "Sir Isaac Newton likewise adopted it, and Dr Bentley, master of Trinity College, Cambridge," has ably maintained the same doctrine. "In our own day we may number among its supporters the distinguished names of the Marquis De Laplace, Sir William and Sir John Herschel, Dr Chalmers, Isaac Taylor, and M. Arago." "The same just views of the sidereal system, in which no motion is visible, are taken by Dr Whewell, in his Bridgewater Treatise." * "Astronomy," says he, "teaches us that the stars which we see have no immediate relation to our system. The obvious supposition is, that they are of the nature and order of our sun; the minuteness of their apparent magnitude agrees, on this supposition, with the enormous and almost inconceivable distance which, from all the measurements of astronomers, we are led to attribute to them. If, then, these are suns, they may, like our sun, have planets revolving round them, and these may, like our planet, be the seats of vegetable, animal, and rational life; we may thus have in the universe worlds, no one knows how many, no one can guess how varied; but, however many, however varied, they are still so many provinces in the same empire, subject to common rules, governed by a common power." With these great authorities it is hardly necessary to say that Sir D. Brewster entirely agrees; with these great men and great philosophers, he does NOT believe that the Earth is "the oasis in the desert of our system,"—"the largest solid opaque globe in it;" and, "really, the largest planetary body in the Solar System,—its domestic hearth, and the only world in the Universe!" Sir David

* Book III., ch. ii., p. 270.

Brewster has written little in his answer that is *new*, his doctrine is but an old and a general doctrine ; most people thought as he did, until the publication of the Essay, and believed that the mighty worlds that rolled in other spheres were not called merely into existence, and then left untenanted! Right or wrong, with Sir David, we have been taught to look upon this planet but as an insignificant portion of the universe ; that the other planets of the solar system are many of them worlds, more vast and splendid than our own ; and, therefore, inhabited by beings more intellectual, or at least as intellectual as ourselves : right or wrong, we cannot doubt that astronomers and philosophers believed, and taught others to believe, in the theory, that the planets about our sun are inhabited by intelligent beings—possibly that their satellites are inhabited also—and that other supposed suns, known to us as fixed stars, had each their family of planets, also the " homes of life and of intelligence ;" while even the far distant nebulæ are stars or suns, each with their system of globes tenanted by living creatures.

In another place, we enter farther into the detail of the arguments brought forward by Sir David Brewster *in favour* of a Plurality of Worlds ; suffice it to say now, that he considers the Author of the Essay has taken such a view of the subject, as is " calculated to disparage the science of astronomy, and to throw a doubt over the noblest of its truths."

Before we examine the doctrine and theory of the Author of " The Essay," (and which for our purpose we find necessary), we may remark, that he especially deprecates the " odium theologicum,"* and makes a particular request, viz., that " those persons who may have thought that there was too much boldness in some of the author's expressions—as when he speaks of wasted means in the works of creation, of failure in some parts of its plan, of several sketches of which only one has been completed, and the like—will see, on a further consideration of what is said in the essay and dialogue, that nothing is involved in the ' thought thus expressed' but what

* Pref. 3d Edit.

is in full harmony with the spirit of reverence, which prompts their own sentiment." We have no wish to say one word against the piety and reverential feeling of the Author of the Essay; that he has been *unfortunate* in his expressions, there can be no doubt.

This then is the theory, doctrine, and belief of our author.

1*st*, As regards our planet, he endeavours to prove, that the Earth is "the oasis in the desert of our system,"—"the largest opaque globe in it;" and "really, the largest planetary body in the solar system, its domestic hearth, and the only world in the universe."

2*d*, Our satellite, the Moon, "is a mere cinder; a collection of sheets of rigid slag, and inactive craters,"—"cooled down as to its exterior at least, without ever being judged fit or worthy by its Creator of being the seat of life."

3*d*, The satellites or moons of the other planets, Jupiter, Saturn, &c., are equally valuable as regards anything besides the light they yield to their Primary, excepting the moons of Jupiter, which are useful to man for nautical purposes!

4*th*, Mercury, the planet nearest our earth, is much too hot for "any of the conditions which make animal existence conceivable."

5*th*, Venus "is almost as large as the earth; almost as heavy,"—also hot, SO HOT, that "it is hard to say what kind of animals we could place in her, if we were disposed to people her surface; except, perhaps, the microscopic creatures, with siliceous coverings, which, as modern explorers assert, are almost indestructible by heat."

6*th*, Mars "is much smaller than the earth, and has not been judged worthy of the attendance of a satellite." Atmosphere uncertain! force of gravity also small! "In a planet so dense," the animals "may very likely have solid skeletons." "We may easily imagine that those seas are tenanted, like these, by huge aquatic animals of the nature of seals and whales." The land of Mars also may possess animals differing from terrestrial animals, much as "the iguanodon and dinotherium differed from the animals which now live on the earth." Here it may be as well to caution the reader as to what the Author of the Essay would himself separate as *Theory* from *Physical fact.* Thus, the theory of the Author would include the following heads, and which nobody is called upon to believe without proof! That Venus contains no animals but microscopic creatures with siliceous coverings, or the land of Mars nothing beyond "great land and sea saurians," is pure theory. PHYSICAL FACTS, such as the size, distances, and gravity of the planets, should always be carefully separated from the author's opinions, to enable us to judge fairly of this remarkable work! That Venus is "almost as large as our earth, almost as heavy," *is true*, but that she is inhabited only by animalcules, MAY NOT be true.

7th, Of the Planetoids or Asteroids which revolve between Jupiter and Mars, with the exception of Vesta; "they are mere dots, and we do not even know that their form is spherical;" they may be of the nature of meteoric stones,—"mere crude and irregularly crystallized masses of metal and earth," and if so, "bits of planets which have failed in the making, and lost their way, till arrested by the resistance of the earth's atmosphere."

8th, We now turn to the Author's consideration of Jupiter. The density of Jupiter, he informs us, "is not greater than it would be if his entire globe were composed of water." The size of Jupiter is allowed to be 1300 times greater than our earth, the diameter of Jupiter being 87,000 miles, and that of the earth 7926. The moons of this planet are four in number, and the Author of the Essay believes them to be of the same use as our own moon was, "during the myriads of years which elapsed while the earth was tenanted by corals and madrepores, &c." "Light and heat, at his distance, are only one-ninetieth of those at the earth. None but a very low degree of vitality can be sustained under such sluggish influences." We must either suppose that Jupiter has no inhabitants, and is "a mere mass of water, with perhaps a few cinders at the centre, and an envelope of clouds about it;" or "if we are resolved to have a population," they must be "cartilaginous and glutinous masses." "It does not seem likely that the living things can be any thing higher in the scale of being than such boneless, watery, pulpy creatures as I have imagined."

9th, In the three planets superior to Jupiter, viz., Saturn, Uranus, and Neptune, the case, according to the Author of the Essay, appears even stronger "in proportion to their smaller light and heat." "They agree with Jupiter in being of very large size and of very small density," and "the supposition of the probably watery nature and low vitality of their inhabitants must be commended to the consideration of those who contend for inhabitants in those remote regions of the solar system."

10*th*, Next we take the Sun, that vast globe of light, 880,000 miles in diameter, the central lamp of the Solar System. Revolving upon its axis in 25 days, and throwing off its light with the velocity of 192,000 miles in a second, our author tells us that although Sir William Herschel and Arago thought it probable that the Sun is inhabited, he does NOT, and he draws a kind of parallel between a certain madman who murdered a young lady, and was shut up in the Old Bailey, and Sir William Herschel and Arago. They all believed the sun to be inhabited, *ergo* they were all mad! The Author of the Essay, although he thus ridicules the opinions of his brother astronomers, appears to have no doubt that, "so far as we yet know, the Sun is the largest sun among the Stars." The Sun *is* the centre of the Solar System; the size, &c., the author does not question, nor the heat of his luminous atmosphere, nor possibly a solid nucleus of the "slag" order. The heat is certain, for "the water and vapour of the System were driven to the outer parts, or retained there by the central heat of the Sun." "Water and aqueous vapour are driven from the SUN" "as they are driven from wet objects placed near the kitchen fire." "According to our view, water and gases, clouds and vapours, form mainly the planets in the outer part of the solar system, while masses, such as result from off the most solid materials, lie nearer the sun, and are found principally within the orbit of Jupiter." This accounts most satisfactorily for the *squashiness* of Jupiter, and the sal volatile substantiality of Saturn, which "are *still* only huge masses of cloud and vapour, water and air," with "lumps" "of planetary matter at the centre."

We assure our readers that it requires some little patience to fix in our mind the remarkable illustration of our author's constitution of the Solar System, as treated in his essay. It is *rather wordy* (he will forgive this homely expression), and it is *rather* difficult to condense. We would not, however, willingly mistake his opinions and conclusions; and we believe we speak truth, and that Sir David Brewster has done no more, when we say, that, from his description of the Solar System, it is impossible to avoid the conclusion, that he believes, and wishes others to believe, that God has created *useless* worlds, appointing for them their motions with "miraculous precision;" their days, their years, and even their *useless* satellites, without one conceivable reason or idea. The chapters on the "Argument from Design," on the "Unity of the World," and "The Future," are no doubt very grand, very eloquent, and very argumentative; but the upshot of them all, when you have threaded the labyrinth, simply amounts to this, that the whole Universe, with the exception of this earth, is *a void*, as far as life and intelligence are concerned. No man in his senses can believe in astronomy and agree with the Author of the Essay, without also believing (in the words of Sir David Brewster), that (with the exception of this earth) "the sun, with his magnificent attendants, the planets with their faithful satellites, the stars in the binary systems, the Solar System itself, are performing their daily, their annual, and their secular movements, unseen, unheeded, and fulfilling no purpose that human reason can conceive; lamps lighting nothing, fires heating nothing, waters quenching nothing, clouds screening nothing, breezes fanning nothing, and every thing around, mountain and valley, hill and dale, earth and ocean, all *meaning nothing*."

So much for the Solar System. We might indulge in long quotations on the fixed Stars and Binary Systems; we are, however, satisfied with the extinction of our sister planets, and shall merely observe with the author, that stars "ARE STARS," *i. e.*, that Arcturus and Sirius, fixed stars, are probably not suns, and "many may have failed in throwing off a permanent planet;" it is just possible "that the distant stars were sparks or fragments struck off in the formation of the solar system, which are really long since extinct, and survive in appearance only by the light which they at first emitted." At all events, allowing their existence, "whether they are as dense as the sun, or globes a hundred or a thousand times as rare, we have no means of knowing." Under these circumstances, and as they may be only diluted moonshine, we will pass on to the nebulæ.

Nebulæ are "star powder"—"vast masses of incoherent or gaseous matter," a long, long way off—"of immense tenuity"—and "destitute of any regular system of solid moving bodies." All this is SATISFACTORILY explained at great length in the author's seventh chapter. As in the solar system, we have the luminous separated from the non-luminous, and the habitable earth distinguished from the uninhabitable planets; so in the seventh chapter we have a highly luminous elucidation of those "mere confused, indiscriminate, incoherent masses," called nebulæ.

We have not space to enter at any length into Sir D. Brewster's answer to the Essay in his "More Worlds than One." It is probably well known to our readers. Suffice it to state, that whereas the Author of the Essay believes this earth to be "the only world in the universe," Sir David conceives—

1. That it is nothing of the kind, but one world out of *many*, in the "great material scheme planned by its Creator as the residence of moral and intellectual life." Sir David summons to his aid the names of Laplace, the Herschels, and Arago, and with them joins the undeniable support of Newton, Kepler, and Tycho; and although Sir William Herschel and Arago were insane upon the subject of the sun being habitable, yet their sane opinions are of consequence when weighing the arguments of our anonymous author.

2. Sir David doubts the assertion of our author when he says the moon, our satellite, is all cinders, or "sheets of rigid slag," and justly argues, that, if it *were* revealed to us that the moon had no inhabitants, "it would not diminish, in the slightest degree, the probability of Jupiter's being inhabited." "The moon has great functions to perform as the satellite of the earth, even if no living thing breathed upon her surface." Our moon, therefore, must be compared with the MOONS of Jupiter and Saturn, not with a PRIMARY planet. We were

present at the meeting of the British Association at Liverpool (September 1854), and heard convictions expressed that the moon possessed no water, vapour, or air. Sir David tells us simply that "*this is not true*," and that there is an atmosphere in the moon, though her atmosphere does not reach to the tops of the mountains. However, this is of slight consequence as a matter of argument. The moon being "slag," and Jupiter's satellites being "slag," and Saturn's moons being "slag," do not affect their Primary.

May we be allowed a digression? It was when listening to Mr Nasmyth, in the geological section of the British Association at Liverpool (September 1854), and after much reflection upon the works of the Author of the Essay and Sir David Brewster, that we were so vividly struck with the *enormous* difference of opinion even amongst the first astronomers! There was the diagram of Mr Nasmyth, exhibiting the torn, crateriform, and disturbed surface of a portion of our satellite, the ancient lava currents being distinctly visible, and the unabraded pinnacles of what may be granite mountains standing sharply out. Yet we find astronomers quarrelling about her atmosphere,—some admitting an atmosphere, others denying it *in toto!* In one work we read of vast volcanoes and liquid torrents of lava; another tells us that they have long ceased to be active, and that her surface now is everlasting "slag." And certainly the thought did arise, that if with such telescopes, and such magnifying powers brought to bear upon the only planetary body placed sufficiently near us to have the inequalities of its surface rendered distinctly visible, astronomers have yet come to no satisfactory determination even as regards an atmosphere sufficient to support life; if they do not yet know whether the "mare crisium" be fluid or *not;* if one great authority hopes that on her surface "traces of living beings" will yet "be seen with some magnificent telescope which may yet be constructed;" and another tells us she is all "slag;"—if there be such contradiction respecting OUR OWN SATELLITE, it certainly did enter into our mind that it would be more appropriate to settle the astronomical conditions of our own moon before we wound up other Primaries neatly "into balls," and peopled them only with watery monsters and gigantic cuttle-fish. Sir David Brewster and the Author of the Essay both quote at considerable length the great geologist of Scotland, and the poet of all geologists, Hugh Miller. Words of the same author also flashed across our own memory on this occasion,—words not inapplicable to the present subject:—"I know not why it is that moral evil exists in the universe of the All-wise and All-powerful."—"The question—like that satellite, ever attendant upon our planet, which presents both its sides to the sun, but invariably the same side to the earth—hides one of its faces from man, and turns it to but the Eye from which all light emanates."—"We can map and measure every protuberance and hollow which roughens the nether disc of the moon, as, during the shades of night, it looks down upon our path to cheer and enlighten; but what can we know of the other?"

Yes, what *can* we know of the other? was the question that haunted us at Liverpool. A vision came o'er us, and we thought that we beheld the Author of the Essay with a powerful telescope standing upon a distant star, far beneath our southern hemisphere. By his side stood he of the Mighty Hammer, and they gazed upon Victoria-land; even their very words seemed wafted to us through the air:—

H. Pray, Mr Essayist, you who have distinguished nebulæ into lumps, and stars into "shred coils," and planets into "neatly bound-up balls," tell us what you *see* on the disc of that far off planet? and from what you see of the one side, tell us what you *believe* of the other?

E. Man! I behold floating clouds, and ice-bound shores and frozen seas. I see the flames and lava torrents of a volcanic mountain that rises among eternal snows, but I behold no sign of the habitation of man; and man, as constituted here, could not exist on that inhospitable shore. "Continents and floating islands of ice" "chill the fluids of the slimy tribes whom we regard as the only possible inhabitants." Lay aside thy telescope, O Man! such a world is not worthy farther consideration.

"We can map and measure every protuberance and hollow which roughens the nether disc of the moon, as, during the shades of night, it looks down upon our path to cheer and enlighten; *but what can we know of the other?*" seemed to re-echo in our ears, as we left to prepare for Professor Owen's Lecture on ANTHROPOMORPHOUS APES!

3. With regard to the other moons or satellites of the solar system, we find Sir David declaring, that every "satellite in the solar system *must have an atmosphere*." Jupiter is attended by four moons, or satellites, the average size of which is larger than our own. Saturn is accompanied by eight satellites, as well as his rings. Uranus has eight moons, and Neptune is accompanied "with one, or probably two satellites." All these satellites, Sir David believes to be "gorgeous appendages, for the use, doubtless, of living beings:" the Author of the Essay, of course, believes them to be "slag," and tells us that "we may be content not to know how;" "they tend to the advantage of the brute inhabitants of the waters."

4, 5, 6. Of Mercury, Venus, and Mars, all of which the Author of the Essay considers too hot, or too dense for the circumstances of animal life, we find Sir David saying:—"In Mars, Venus, and Mercury, the length of the day is almost exactly twenty-four hours, the same as that of the Earth; and in many other points, the analogy with our globe is very striking. Continents and oceans, and green savannahs, have been observed upon Mars; and the snow of his polar regions has been seen to disappear with the heat of summer." "We actually see the clouds floating in the atmosphere of Mars; and in Venus, astronomers have even observed the morning and evening twilight. These atmospheres are doubtless the means of tempering the great heat which Venus and Mercury receive from the sun." The reader cannot fail to be struck with the *difference of opinion* here manifested.

7. The Planetoids, or Asteroids, the "dots" and "shreds" of the author, are considered by Dr Olbers and Sir D. Brewster to be the fragments of a planet that has burst.

8, 9. We regret that we cannot give at greater length, extracts from the fourth chapter of "More Worlds than One," on the analogy between the earth and the other planets. The difference of opinion between our two authors is so decided, that it is difficult to express, and no one that has not attentively studied both works can form, an idea of the dire incongruity! Let Sir David speak for himself. In reference to the position of the planets, Jupiter may be regarded as "the middle planet, and is otherwise highly distinguished." "With respect to the number of moons or satellites—the only uses of which, that we know, is to give light to the planet, and produce tides in its seas,—the earth has the lowest number, all the planets exterior to it having a larger number." The satellites of Jupiter afford him perpetual moonlight. The *trade winds* of Jupiter have left their streaks, or belts. "Why does the sun give it days, and nights, and years? Why do its moons throw their silver light upon its continents and seas? Why do its equatorial breezes blow perpetually over its plains?" The questions of temperature and density are discussed at full length, and we are not prepared to say that the Author of the Essay is right, and Sir David is wrong. The force of gravity upon Jupiter is entered into, as also that of Saturn, Uranus, and Neptune; and Sir David declares, "that human beings, like ourselves, would experience no inconvenience from the greater or less force of gravity on those planets!" while, as to the heat of the sun, he tells us, "that in so far as vision and local temperature are concerned, the light of the sun may, in these planets, be as brilliant, and the temperature of the seasons as genial as they are upon our earth."

10. The sun, in the opinion of the Author of the Essay, the evidence of insanity in Dr Elliot, Sir William Herschel, and Arago, is, we are informed in "More Worlds than One," the mainspring of the great planetary chronometers, without which they would stop and rush into destructive collision. It is the lamp which yields them the light, without which life would perish. It is the furnace which supplies the fuel, without which organic nature would be destroyed." Created for such noble purposes, we are led by no analogy to assign to it an additional function.

But, judging from the creations of the material world, which have "various and apparently contradictory purposes to answer,"—"as the masses of ironstone in our earth" answering the two purposes of supporting its framework and supplying "man with tools of civilization,"—Sir David argues, "that though the sun and the satellites are primarily intended for the great purposes which they so obviously subserve, it is not unreasonable to suppose that they may also be the seats of life and intelligence." From the discoveries of Sir William Herschel and Arago (*insani ambo*), " we approach the question of the habitability of the sun with the certain knowledge that the sun is not a red-hot globe, but that its nucleus is a solid opaque mass, receiving very little light and heat from its luminous atmosphere."

The light reflected by the opaque body of the sun is only " 7 rays out of 1000," consequently this solid nucleus is not so affected by its luminous atmosphere, as to prevent its being inhabited ; in consequence too of other analogical considerations, Sir William Herschel declares, " we need not hesitate to admit that, THE SUN IS RICHLY STORED WITH INHABITANTS."

Of single stars " we are led to believe with Huygens," says Sir David, " that the fixed stars, 3000 in number, as seen by the naked eye, and about one hundred millions as seen by the telescope, are the suns of other sytems, whose planets are invisible, from their distance."

" To suppose them without planets, and to be merely globes of light and heat, would be contrary to analogy as well as to reason. We know that there is one star (our sun) in the universe surrounded by planets, and one of these planets inhabited ; and when we see another single star equal, if not greater in brilliancy, we are entitled to regard it as a centre of a system, and that system with at least one inhabited planet."

" The star *á Centauri*, which is the nearest to our system, has been found to be about two and a half times brighter than our sun, and the star Sirius, the brightest in the heavens, has been found to be four times brighter than *á* Centauri, but the distance of Sirius is four times greater than that of *á* Centauri, and therefore the intrinsic brightness of Sirius is sixty-three times greater than that of our sun. A luminary like this, so resplendent in brightness, and so gigantic, doubtless, in its magnitude, was surely not planted in space to shed its light and its heat upon nothing."

When we compare the 10th chapter of " More Worlds than

One," upon "Single Stars and Binary Systems," with the 8th chapter of the Essay on "The Fixed Stars," we are, indeed, inclined to agree with Falstaff as to the way in which some persons on this planet of our own are given to MIS-STATEMENTS. It is impossible to read these chapters without coming to the determination that either Sir David, Copernicus, Galileo, and Kepler, are mistaken, or the Author of the Essay is. Sir David tells us that the STARS are SUNS, and we are "compelled to draw the conclusion, that wherever there is a sun, a gigantic sphere, shining by its own light, and either fixed or moveable in space, there must be a planetary system, and wherever there is a planetary system, there must be life and intelligence." The Author of the Essay comes to the determination, that the stars may after all be nothing but "shred coils," "sparks or fragments struck off in the formation of the solar system, which are really long since extinct," "lumps which have flown from the potter's wheel of the Great Worker;" "the sparks which darted from his awful anvil when the solar system lay incandescent thereon; the curls of vapour which rose from the great cauldron of creation when its elements were separated."

After having entered at some length into the subject of Single Stars, we pass by the Binary System, that is, a system in which one star or sun with its supposed system of planets is supposed to revolve round another star or sun with its system of planets, or "rather round the centre of gravity of both." As these "sparks," according to the author, may have long since become "extinct," we will pass on to the nebulæ.

The 11th chapter of "More Worlds than One" is devoted to the consideration of clusters of stars and nebulæ. We have already seen that the Author of the Essay considers the nebulæ to be "Star Powder," "vast masses of gaseous matter," &c. &c., and that his opponent, from the fact of the gigantic telescope of Lord Rosse having resolved certain nebulæ into distinct stars and clusters of stars, believes that we are entitled to draw the conclusion, that this large class of celestial bodies are clusters of stars at an immense distance from our own system, that each of the stars of which they are composed is the sun or centre of a system of planets, and that these planets are inhabited.

Such is a short statement of the difference of opinion, the "contradictions," which exist among astronomers, regarding the history and organisation of the universe. That the author of the Essay is an astronomer we believe there is no doubt. His hypothesis we have already seen; some of his statements are we understand accepted by astronomers, and others are considered as wholly irreconcileable with the science of Newton and Laplace. If, however, there were "nothing rotten in the state of Denmark," it would be absolutely impossible that such downright contradictions could exist.

Instead of the heavens presenting a glorious spectacle, filled with stately worlds, and occupied by mortal—perhaps immortal—existences, the lights of that firmament are or may be EXTINGUISHED SPARKS that shone and then died out myriads of ages ago! The author fears an "odium theologicum;"—the day for the *argumentum crucis* is gone by! But there is another light in which his volume must be looked at—we have before characterized it as an *enormous mistake* or a *great truth*, and we again repeat our assertion,—If the Essay be TRUE, systems disappear, suns are extinguished; the varied scenes of life and population, believed to be implanted by the Almighty's hand in other planets, are blotted out from the face of the whole broad universe, save on our own planet. The creation is a void; solitude reigns everywhere but here on earth;—all that Chalmers, Newton, Brewster, have written upon this subject are wasted words;—Earth and Earth only is the real object of any worth in the sight of the Almighty, the rest of the visible universe all "slag."

It is not, however, only to Astronomy that the Author of the Essay appeals to prove his position; he devotes his longest chapter (the 6th) to the argument from GEOLOGY, and Sir David Brewster's 3d chapter, in "More Worlds than One," is also devoted to geological considerations.

As upon a question of cotton-weaving and calico-printing, though "cotton-weavers and calico-printers may be very narrow men," the astronomers must permit the geologists to examine their geological statements, and cross-examine our own witnesses. With certain knowledge that we possess respecting the surface of the earth in palæozoic ages, we cannot accept the proposition of the author as all *proven*.

The Author of the Essay is evidently a theorist in geology as well as astronomy, (though we shall willingly bear testimony to the truth of much that he has said on our own science;) and he has forgotten frequently those analogies of nature and observation which every student of God's works should carry in his mind, whatever be the field of his research.

The geologist learns above all things, from the records of his science, never to base positive conclusions on merely negative grounds; for if he does, the chances are that he lives to find himself mistaken! There is a mystery attached to all creation, which neither astronomers nor geologists are ever likely to be able to solve, whether the thing created be simply "slag," the first coral, the first mammal, or the first man,—Creation always will, we apprehend, be to mortal man a "mystery of mysteries." But there are piles upon piles of geologic records and evidence, that, from the first organism which appears upon the surface of our planet to the creation of man, all has been PROGRESS,—an upward march of organization, capacity, and intelligence. The mollusk preceded the fish, the "fish preceded the reptile, the reptile preceded the bird, the bird preceded the mammiferous quadruped and the quadrumana, and the mammiferous quadruped and the quadrumana preceded man."

It is hard, if, while such evidences of a succession of existences and elaboration of design are revealed to us by geology on our own planet, we cannot furnish arguments from analogy for a like arrangement on other planets besides one, and one only. We do not ourselves believe that the attributes of the wonder-working Deity have been lavished upon our earth alone, and we would summon witnesses from Geology, the records of the hoary past, to bear upon this question.

On some new Compounds of Furfurine. By Mr Robert Davidson.

The recent researches of How, Stalshchmidt, Von Planta, and others, have shown that the natural fixed alkaloids, when treated with the iodides of ethyl and methyl, assume a single equivalent of these radicals, and are converted into bases soluble in water, and presenting many of the characters of ammonium bases, although with some discrepancies, which our imperfect knowledge of the fixed bases does not enable us to explain. All our present knowledge of the bases is deduced from the examination of those that are volatile, and the interval by which they are separated from the fixed alkaloids is too great to permit us to apply with certainty to the latter conclusions drawn from the former, and some intermediate point of comparison is wanting which may enable us to trace more minutely their internal constitution. The artificial preparation of furfurine, which seems to throw some light on its constitution, and its general similarity to the natural alkaloids, point to it as a substance likely to afford some information on these points; and I therefore undertook the experiments contained in the following pages, for the purpose of ascertaining its relations to the iodides of ethyl and amyl. At the outset, however, I encountered some difficulty from the imperfect manner in which its salts are described, the hydriodate particularly being entirely unknown; and I was thus induced to examine some of them, and to make a few observations on some other points, which I shall commence by describing.

Salts of Furfurine.

Hydriodate of Furfurine.—This salt is easily obtained by adding powdered furfurine to a moderately-dilute solution of hydriodic acid. The base rapidly dissolves, and, should the solution have the proper degree of concentration, crystals shortly make their appearance, which are purified by solution in boiling water. It may also be formed by mixing strong solutions of iodide of potassium and hydrochlorate of furfurine. It is obtained in fine, colourless, oblique four-sided prisms, which require 55 times their weight of cold water for solution, but are much more soluble on boiling. It is also soluble in alcohol and ether, from which it may be obtained in fine crystals by spontaneous evaporation. It fuses in its water of crystallization at 212°, and after the greater part is expelled, it solidifies into a tough mass, from which the remainder is driven off with difficulty. Its analysis gave—

I.	5·256	grains	dried at 212°, gave
	8·763	...	carbonic acid, and
	1·825	...	water.
	7·582	...	dried at 212°, gave
	4·482	...	iodide of silver.
II.	7·006	...	dried at 212°, gave
	4·143	...	iodide of silver.
III.	9·447	...	gave
	5·613	...	iodide of silver.

	Experiment.			Calculation.		
	I.	II.	III.			
Carbon, .	45·47	...	...	45·44	C_{30}	180
Hydrogen,	3·85	...	...	3·30	H_{13}	13
Nitrogen,	...	...	...	7·07	N_2	28
Oxygen,	...	...	...	12·11	O_6	48
Iodine, .	31·92	31·95	32·00	32·10	I	127·1
				100·00		235·1

The crystallized salt contains in addition two equivalents of water, which it loses at 212°, or *in vacuo* over sulphuric acid,

7·314 grains of the air-dry salt lost at 212°
0·300 ... of water = 4·07 per cent.;

and 4·35 is the calculated number for the formula

$$C_{30} H_{12} N_2 O_6 HI + 2HO.$$

Hydrobromate of Furfurine is obtained by mixing strong solutions of bromide of potassium and hydrochlorate of furfurine. The mixed solutions slowly deposit crystals, which are purified by re-solution in boiling water, from which they separate on cooling in short prisms, soluble in 26 times their weight of cold water. They contain two equivalents of water expelled at 212°—

{ 7·558 grains of hydrobromate dried at 212°, gave
{ 4·048 ... bromide of silver,

corresponding to 22·78; while 22·92 is the calculated result for the formula

$$C_{30}\,H_{12}\,N_2\,O_6\,H\,Br.$$

Bichromate of Furfurine.—This salt is obtained as an orange crystalline precipitate when concentrated solutions of bichromate of potash and hydrochlorate of furfurine are mixed. If the solutions be dilute, it is deposited more slowly, in the form of slender orange needles. The bichromate is very sparingly soluble in cold water, and when boiled with that fluid speedily decomposes. Even in the dry state, at ordinary temperatures, the crystals are apt to acquire a brownish tinge, apparently due to partial decomposition. The air-dry salt gave the following result:—

{ 6·944 grains of bichromate gave
{ 1·417 ... sesquioxide of chromium.

corresponding to 14·08 per cent. of chromium, while 14·12 is that required by the formula

$$C_{30}\,H_{12}\,N_2\,O_6\,HO\,2Cr\,O_3$$

Bisulphate of Furfurine.—By digesting furfurine with excess of sulphuric acid, and concentrating carefully, irregular crystals of the bisulphate are obtained. Under favourable circumstances, they are obtained in the form of rhomboidal plates soluble in less than their own weight of cold water, and melting at 212° into a colourless oily liquid. Owing to its great solubility, it was found impossible to purify it by re-crystallization, and it was simply moistened with a little water, and pressed between folds of blotting paper. A sulphuric acid determination was made, which, though differing so much from the calculated number as to render it unnecessary to give the details, was still sufficiently near to show that the salt was the bisulphate.

The neutral sulphate is obtained in flattened needles resembling sword blades, which are very soluble in water. They were not analysed.

Carbonate of Furfurine.—When a current of carbonic acid is passed through furfurine suspended in water, solution slowly takes place, and on filtering from excess of the alkaloid, and exposing the fluid to the air, silky crystals soon begin to form. These crystals, however, are only furfurine, as was inferred from their general characters, and from the fact that they dissolve in acids without effervescence. It is obvious that a carbonate must have existed in solution, but its instability prevented its being obtained in the solid form.

Sulphuretted hydrogen showed a precisely similar deportment.

Action of Bromine on Furfurine.

A quantity of furfurine was mechanically diffused through water, and an aqueous solution of bromine added as long as the solution became decolorised. Vigorous action took place, and a whitish precipitate was produced, which changed almost instantly into a dark uninviting substance, which appeared to be a feeble acid. Various expedients were resorted to in order to obtain a bromo-furfurine, but without success, the action being always too violent, and resulting in a complex decomposition.

Action of Iodine on Furfurine.

Powdered furfurine was digested at a moderate heat with an alcoholic solution of iodine in a loosely stoppered flask, so as to prevent evaporation of the alcohol. The action went on slowly, and after eighteen hours the solution was evaporated in the water bath, when it left a syrupy mass which in some places showed decided traces of crystallization, and was partly soluble in boiling water, leaving undissolved a resinous substance. The fluid on evaporation gave crystals of considerable size, and rather sparingly soluble in water. They proved to be the hydriodate, and the analyses Nos. I. and II. on a preceding page were from the salt thus obtained. These results point to the conclusion, that the iodine decomposes part of the furfurine combining with an equivalent of hydrogen and forming hydriodic acid, which unites with the portion of the base unacted on; the final products of the reaction being hydriodate of furfurine, and a black resinous product of decomposition.

Action of Iodide of Ethyl upon Furfurine.

Ethylo-Furfurine.—A preliminary experiment having shown that no action took place in the cold, between an alcoholic solution of furfurine and iodide of ethyl, the mixture was transferred to a tube which was sealed and immersed in boiling water. At the end of about three hours, the point of the tube was broken off, the contents poured into a flask, and the excess of iodide of ethyl distilled off. The evaporation was then carried to dryness. On the addition of hot water, the residue readily dissolved, and on cooling deposited hemispherical crystalline tufts. A portion of the mother liquor being decomposed by ammonia, a milky precipitate separated, which on stirring with a glass rod collected into a pale mass having the consistence of syrup. This was found to be but sparingly soluble in water, but freely so in alcohol, both solutions having an alkaline reaction. From these well-marked differences between this substance and furfurine it was inferred to be a new base, a supposition which was confirmed by the analyses about to be given. To obtain it in the pure state, a strong alcoholic solution of the crystallized hydriodate was decomposed by oxide of silver, and the precipitated iodide of silver having been separated by filtration, the filtrate was evaporated at a very gentle heat until it ceased to lose weight.

Analysis of the base yielded the subjoined results, the combustion being made in small glass boats.

I.	4·550	grains	ethylo-furfurine dried at 212°, gave
	11·110	...	carbonic acid, and
	2·134	...	water.
II.	5·113	...	gave
	11·525	...	carbonic acid, and
	2·552	...	water.

	Experiment.		Calculation.		
	I.	II.			
Carbon, .	66·59	66·81	66·88	C_{34}	204
Hydrogen,	5·21	5·54	5·58	H_{17}	17
Nitrogen, .	...	...	9·18	N_2	28
Oxygen, .	...	...	18·36	O_7	56
			100·00		305

It will be seen that these numbers agree with those required by the hydrate of ethylofurfurine, whose composition is expressed by

$$C_{34}\,H_{16}\,N_2\,O_6\,HO.$$

The reaction between the elements of furfurine and iodide of ethyl is shown in the annexed equation.

$$C_{30}\,H_{12}\,N_2\,O_6 + C_4\,H_5\,I = C_{30}\left\{\begin{matrix} H_{11} \\ C_4\,H_5 \end{matrix}\right\}N_2\,O_6,\,HI =$$

$$C_{34}\,H_{16}\,N_2\,O_6,\,HI.$$

The hydrate of ethylofurfurine, when recently precipitated, is a whitish syrupy substance, which, on standing, acquires a darker shade and greater consistence. It is but slightly soluble in water, readily so in alcohol, but from neither menstruum can it be obtained in a crystalline form. The air-dry base does not show the smallest indication of crystalline structure, though left to itself for weeks. Its solution has a bitter taste. Dilute nitric acid oxidises it in the cold, giving off nitrous fumes. When added to a solution of a salt of ammonia, if the temperature be raised to nearly 212°, it displaces the volatile alkali, a property which it possesses in common with furfurine.

Hydriodate of Ethylofurfurine is deposited from a hot aqueous solution as a gummy mass, but in favourable circumstances in crystalline tufts, composed of thin plates grouped together and radiating from a common centre. By spontaneous evaporation, I have obtained several crystals of great beauty and magnitude, modifications of the oblique prismatic system. The hydriodate requires for solution 36 parts of water at ordinary temperatures; but it is much more soluble in alcohol and ether. The crystals do not lose their brilliancy when exposed to the atmosphere for a length of time.

The following are the results of analysis :—

4·857	grains, dried *in vacuo*, gave	
8·575	...	carbonic acid, and
1·980	...	water.
9·900	...	dried *in vacuo*, gave
5·485	...	iodide of silver.

	Experiment.	Calculation.		
Carbon, .	48·15	48·10	C_{34}	204
Hydrogen, .	4·53	4·01	H_{17}	17
Nitrogen, .	...	6·60	N_2	28
Oyygen, .	...	11·32	O_6	48
Iodine, .	29·94	29·97	I	127·1
		100·00		424·1

The formula of the salt dried *in vacuo* is therefore,

$$C_{34}\,H_{16}\,N_2\,O_6,\,HI.$$

When crystallized, it contains in addition two equivalents of water.

{ 13·485 grains at 212° lost
{ ·554 ... water,

equivalent to 4·11 per cent.; the calculated quantity is 4·01.

Chloride of Platinum and Ethylofurfurine.—After precipitating the iodine in a solution of the hydriodate, the excess of silver is thrown down by hydrochloric acid. To the solution evaporated to a moderate bulk an excess of chloride of platinum is added. If this addition be cautiously made, only a very slight immediate precipitate falls, the greater part crystallizing out after several hours. The crystals are collected and washed with water, in which they scarcely dissolve. They are decomposed when boiled with water for some time.

In igniting this salt, it is necessary to apply the heat very gradually, as it decomposes at a low temperature, and swells to many times its bulk.

I. { 7·000 grains, dried at 212°, gave
{ 1·371 ... platinum.

II. { 6·426 grains, dried at 212°, gave
{ 1·260 ... platinum.

III. { 5·285 grains, dried at 212°, gave
{ 1·035 ... platinum.

equivalent to a percentage of

I.	II.	III.
19·56	19·61	19·58

The theoretical amount corresponding to

$$C_{34}\,H_{16}\,N_2\,O_6,\,H\,Cl,\,Pt\,Cl_2$$

is 19·66.

Action of Iodide of Ethyl on Ethylofurfurine.

The preceding experiments having shown that ethylofurfurine does not possess the usual properties of an ammonium base, it seemed desirable to ascertain whether it might not be capable of assimilating another ethyl molecule, which the constitution of furfurine seemed to render not improbable. We have only to recall to mind the fact that furfurine is formed from two equivalents of ammonia, in which the six equivalents of hydrogen may be considered as replaced by three equivalents of a substance having the formula $C_{10}\,H_4\,O_2$, to see that, as far as analogy will entitle us to draw conclusions, we might anticipate that two equivalents of ethyl would be requisite to produce an ammonium base.

The ethylofurfurine employed in making this experiment was prepared by decomposing an aqueous solution of the hydriodate by ammonia. When agitated with a rod, the milky particles which are separated collect at the bottom of the vessel, and the ethylated base is then washed with hot water, and stirred up, so as to allow the solvent to come more freely into contact with its particles. The vessel being cooled by immersion in cold water, the washings may be poured off without permitting the escape of any of the base. This process is repeated until, when tested with a silver salt, no precipitate is produced.

The ethylofurfurine being thus obtained, it was treated with iodide of ethyl, in the manner already employed for furfurine. A salt was obtained in prismatic crystals, which, when analysed, gave the following results:—

5·660 grains gave
3·114 ... iodide of silver,

equivalent to a percentage of 29·73, differing but little from the theoretical quantity in hydriodate of ethylofurfurine.

A platinum salt was also prepared as a confirmation.

{ 4·723 grains platinum salt gave
{ 0·933 ... platinum.

corresponding to a percentage of 19·54, the calculated result for the formula

$$C_{34}\,H_{16}\,N_2\,O_6,\,H\,Cl,\,Pt\,Cl_2$$

being 19·66.

Hence it appears that ethylofurfurine is incapable of uniting with an additional atom of ethyl.

Action of Iodide of Amyl upon Furfurine.

Hydriodate of Amylofurfurine.—A spirituous solution of furfurine placed in a sealed tube, along with excess of iodide of amyl, was exposed to a temperature of 212° for nearly twelve hours. A platinum salt was then prepared and analysed; but the high percentage of platinum left upon ignition showed the presence of a quantity of unchanged furfurine. The tube was therefore resealed and exposed to the same temperature for four days, at the end of which time it was taken out, and the contents transferred to a basin and evaporated to dryness. The gummy residue was purified by solution in boiling water, from which it is deposited on standing in radiated crystals, rather sparingly soluble in water, which are the hydriodate of amylofurfurine, as shown by the subjoined analysis:—

5·922 grains of hydriodate gave		
11·240	...	carbonic acid, and
2·537	...	water.
5·800	...	hydriodate gave
2·934	...	iodide of silver.

	Experiment.	Calculation.		
Carbon,	51·78	51·50	C_{40}	240
Hydrogen,	4·76	4·93	H_{23}	23
Nitrogen,	...	6·00	N_2	28
Oxygen,	...	10·30	O_6	48
Iodine,	27·34	27·27	I	127·1
		100·00		466·1

These numbers agree with the formula C_{40} H_{22} N_2 O_6 HI, and the constitution of the base was farther determined by the analysis of its platinum salt.

Platinochloride of Amylofurfurine is prepared by the successive addition of nitrate of silver, hydrochloric acid, and bichloride of platinum, to a solution of the hydriodate. It falls as a yellow crystalline precipitate, scarcely soluble in water.

I. { 6·982 grains dried at 212°, gave
1·236 ... platinum.

II. { 4·802 grains dried at 212°, gave
0·852 ... platinum.

I.	II.
17·70	17·78

the calculated number is 18·14.

An attempt was also made to obtain a diamylofurfurine, but without success, the salt obtained being only hydriodate of amylofurfurine, as shown by this analysis.

{ 4·821 grains dried at 212°, gave
9·075 ... carbonic acid, and
2·225 ... water.

	Experiment.	Calculation.
Carbon, .	51·34	51·50
Hydrogen, .	5·13	4·93

From the preceding experiments, it would appear that furfurine is capable of taking up only one atom of the alcohol radicals, but the compounds produced have none of the characters of ammonium bases, their insolubility in water and comparatively feeble alkaline properties especially distinguishing them from all the known members of that class, whether produced from the volatile or fixed bases. It is difficult to draw from them any absolute conclusions as to the constitution of furfurine; but the non-production of the diethylo and diamylo-furfurine seem to me to raise the question as to whether the two equivalents of ammonia, from which the furfurine is produced, may not perform different functions in it, one having basic characters, and the other playing an entirely different part. Into this question, however, I shall not attempt to enter, as it could only be answered by an extended investigation of the bases of allied constitution; but I may mention that I am at present engaged with an investigation of amarine, which may possibly throw some light upon it.

The preceding experiments were undertaken at the request of Professor Anderson, and I now seize the opportunity of expressing my thanks to him, not only for his kindness in placing at my disposal suitable apparatus, but also for the advice and assistance with which I was favoured.

Appended are a list of the substances described and analysed in the present paper.

Hydriodate of furfurine, .	$C_{30} H_{12} N_2 O_6$, HI + 2 HO
Hydrobromate of furfurine, .	$C_{30} H_{12} N_2 O_6$, HBr + 2 HO
Bichromate of furfurine, .	$C_{30} H_{12} N_2 O_6$, HO, 2 Cr O_3
Hydrated ethylofurfurine, .	$C_{34} H_{16} N_2 O_6$, HO
Hydriodate of ethylofurfurine,	$C_{34} H_{16} N_2 O_6$, HI + 2 HO
Chloride of platinum and ethylofurfurine, . . .	$C_{34} H_{16} N_2 O_6$, HCl, Pt Cl_2
Hydriodate of amylofurfurine,	$C_{40} H_{22} N_2 O_6$, HI
Platinum salt of amylofurfurine,	$C_{40} H_{22} N_2 O_6$, HCl, Pt Cl_2

On a new Glucoside existing in the Petals of the Wallflower. By Mr JOHN GALLETLY, Assistant to Dr T. Anderson.

A watery infusion of the petals of the wallflower has been occasionally employed for the purpose of detecting the presence of free acids or alkalies in solution, giving with the former a fine rose-red, and with the latter a brilliant green. Although it does not appear to exceed in delicacy the substances usually employed for this purpose, I had occasion to make use of it in some experiments, in which it became necessary to ascertain the effect produced by different colouring matters; and in preparing the infusion I detected the substance which forms the subject of the present notice, and for which I propose the name of cheiranthine, derived from that of the genus to which the wallflower belongs.

When the petals, carefully picked from the flowers, are infused for some time in water at a nearly boiling temperature, they lose the dark marks with which they are covered, and acquire a uniform pale-yellow colour. The infusion has a very pungent smell, due to the presence of a volatile oil containing sulphur, and doubtless identical with that found in other cruciferous plants, and, in addition to the colouring matter and other substances, contains the cheiranthine. The method which I found most advantageous for preparing it consists in covering the petals with boiling water, digesting for some time, filtering off the infusion, and adding to it about a fifth of its bulk of alcohol. The fluid is set aside, and in the course of twenty-four hours crystals begin to make their appearance in it, and go on increasing for some days. The whole of the cheiranthine appears to be extracted by the first infusion, or, at all events, what remains cannot be obtained, as it appears to become uncrystallizable during the evaporation to which the fluid must be subjected. The crystals are separated from the fluid, and purified by solution in boiling alcohol and digestion with animal charcoal.

Cheiranthine does not crystallize well from its watery solution; but from alcohol it is obtained in the form of fine tufts of long silky needles of a light-yellow colour. It is very sparingly soluble in cold water and alcohol, but dissolves readily in both fluids at the boiling temperature. The hot alcoholic solution becomes nearly solid on cooling. It is very slightly soluble both in cold and boiling ether. It is entirely without action on vegetable colours, and its taste, which is not very marked, is slightly bitter and pungent. It contains only carbon, hydrogen, and oxygen, and its analysis, made on the substance dried at 212°, gave,

I.	5·090	grains of substance gave	
	9·750	...	carbonic acid,
	2·635	...	water.
II.	4·865	grains of substance gave	
	9·300	...	carbonic acid,
	2·410	...	water.
III.	5·330	grains of substance gave	
	10·245	...	carbonic acid,
	2·820	...	water.

	I.	II.	III.
Carbon, . .	52·24	52·13	52·42
Hydrogen, . .	5·75	5·50	5·87
Oxygen, . .	42·01	42·37	41·71
	100·00	100·00	100·00

These numbers agree with the formula, $C_{40} H_{20} O_{24}$, as is seen by the following comparison of the experimental mean with the calculation:—

	Mean.	Calculation.		
Carbon, ...	52·26	52·40	C_{40}	240
Hydrogen, . .	5·71	5·67	H_{26}	26
Oxygen, ...	42·03	41·93	O_{24}	192
				458

Cheiranthine dissolves in alkalies in the cold with a deep orange-yellow colour, which disappears on the addition of an acid, and a precipitate slowly forms, which appears to be the unaltered substance. Baryta and lime water, when added to its hot aqueous solution, give gelatinous orange-coloured precipitate, slightly soluble in cold, and rather more so in boiling water; their solutions have a pale-orange colour. Perchloride of iron gives a dirty green, almost black colour. Subacetate of lead gives an orange precipitate.

The aqueous solution of cheiranthine becomes red when treated with chlorine; bromine gives a light-brown precipitate, which dissolves in alcohol, and iodine also appears to exert an influence upon it, the colour of a very dilute tincture of that substance being perceptibly deepened by the addition of cheiranthine. The compounds produced are probably substitution products, but I had not a sufficient quantity of any of them for analysis.

When cheiranthine is boiled with dilute sulphuric acid, a yellow substance precipitates, which is insoluble in water. On removing the acid by means of carbonate of baryta, the fluid is found to have a sweetish taste; and when boiled with sulphate of copper and caustic potash, gave unmistakeable evidence of the presence of sugar. The peculiar odour of saccharine fluids was also distinctly observed during its evaporation. The yellow matter precipitated by sulphuric acid is readily dissolved by a dilute solution of soda.

From these properties, it is obvious that cheiranthine belongs to the group of glucosides, like salicine, phloridzine, &c. To the latter substance it even approximates in constitution, and this similarity extends to the composition of its lead compound. This substance was prepared by adding subacetate of lead to the aqueous solution of cheiranthine, and washing the precipitate, which is orange-yellow, and nearly insoluble in water.

{ 7·73 grains of the lead precipitate gave
{ 4·88 ... oxide of lead.

	Experiment.	Calculation.		
Carbon, . .	...	22·3	C_{40}	240
Hydrogen, . .	...	1·9	H_{20}	20
Oxygen, . .	...	13·4	O_{18}	144
Oxide of lead, .	63 1	62·4	6 PbO	669·42
		100·00		1073·42

The formula is therefore C_{40} H_{20} O_{18}, 6 PbO. The phloridzate of lead also contains six equivalents of oxide of lead; but there is this difference between it and the cheiranthine compound, that in the latter the oxide of lead replaces an equivalent quantity of water, while in the former that base is directly combined with the unchanged phloridzine. The examination of the lead compounds of the glucosides hitherto investigated is far from complete; but it is to be observed, that the silicine compound is formed by replacement of four equivalents of water by oxide of lead, and is therefore analogous to the lead salt of cheiranthine.

The foregoing are the results to be drawn from the experiments hitherto made; but as they are founded on a single lead determination, and as several other formulæ might be deduced from the analysis of the cheiranthine itself, they must be considered as in some degree provisional. The season during which wallflower can be obtained in abundance was nearly over before I commenced this investigation, and the whole of the material I could obtain only sufficed for the observations contained in the preceding pages, which are far from being as complete as I could have wished. It is my intention, however, to return to the subject next summer, when I shall be able to command a larger quantity of wallflower. I propose also to extend my inquiry to some other cruciferous plants which may possibly be found to contain it. I may mention, however, that it does not exist in the field mustard, *Sinapis arvensis*, the only other plant I have yet examined.

This investigation was made in the laboratory of Dr Anderson.

Miscellaneous observations on some Tropical Plants.

By John Davy, M.D., F.R.S., &c.

The following observations, extracted from note-books kept whilst I was in the West Indies, were made in the Island of Barbadoes, between 1845 and 1848. Should any of them lead to further and more exact inquiry, I shall be more than satisfied.

1. *On the Juice of the Star-Apple* (Chrysophyllum Cainito, *Linn.*)

The juice of this luscious fruit has, I have found, the property of coagulating on exposure to the air very like coagulable lymph.

I have a note of one trial only. After dividing the fruit with a knife (the knife was much blackened, chiefly, it would appear, by the cortical part), the inner mucilaginous portion with the seeds was scooped out, well mixed with about an equal bulk of water, and pressed through a coarse linen cloth. What was thus obtained was semifluid (its coagulation had commenced), of a creamy appearance, and uniform consistence. Under the microscope it appeared to be composed chiefly of exceedingly minute granules, the largest not exceeding the $\frac{1}{10,000}$ of an inch in diameter, which were rendered brown by tincture of iodine, with the exception of a very few that were tinged blue. After two hours a pretty firm coagulum had formed with the separation of a transparent fluid, and so great was the contraction as to be equal to about one-third of the diameter of the containing vessel, a circular glass one; and so coherent and firm was the coagulum itself, that it admitted of being lifted out without breaking or change of form. On the following day, the coagulum was found still more contracted, and in all its dimensions. The transparent fluid surrounding the coagulum was sweet. It was not rendered turbid by nitric acid. In a few days it began to ferment, and in a few more it became acid. The contraction of the coagulum continued increasing during several days. After about a fortnight it softened, became pultaceous, and emitted an offensive smell not unlike that of chyme as met with in the cadaver. Under the microscope, as before, it exhibited a granular texture, without the admixture of any fibres.

2. *On the supposed influence of the Papaw* (Carica Papaya, *Linn.*) *on Meat.*

It is commonly believed, both in the East and West Indies, that this tree has the property of rendering tender meat of any kind that is brought near it. In Ceylon the opinion is, that the effect is secured merely by suspending the meat beneath the foliage of the tree during the night. In Barbadoes greater reliance is placed in wrapping the meat in its leaves for a few hours with a portion of the young fruit.

The trials I had made afforded negative results, tending to prove that the effect on the meat was owing to other and incidental circumstances, rather than to any special power possessed by the plant. I shall mention one in illustration.

Of two fowls killed at the same time, one was wrapped in the leaves of the papaw by my cook in the most approved manner, not neglecting the introduction of a piece of the young fruit; the other was similarly treated, substituting the leaves and fruit of the squasse (*Cucurbita Pepo*, Linn.) Both roasted, were found equally tender. Other trials, using the leaves of other plants, gave like results.

The juice of the leaf, to which by some the supposed effect on the meat is attributed, appeared, as well as I could judge, to possess very little activity. It is milky, almost insipid, or only in the slightest degree acrid, and only after many hours promotes fermentation, and that in a very slight degree when added to a solution of sugar in water.

The incidental circumstances alluded to, whether the suspending of the meat under the leaves of a succulent plant exhaling moisture, or the wrapping it in the same, may be sufficient to account for the softening effect on the meat at a temperature such as that of Ceylon or the West Indies, so favourable to rapid change, that change on which tenderness in meat depends, without reference to any occult virtue in the plant.

3. *On the growth of the Bamboo-cane* (Bambusa arundinacea, *Willd.*) *and of the Horse-radish tree* (Moringa pterygosperma).

These plants afford good examples of the powers of vegetation within the tropics in their rapid growth.

I have been assured on good authority that the first, the bamboo, has been known to shoot fourteen inches in the twenty-four hours. I measured one six days successively, one that was about four feet from the stoale from which it sprung; during the first twenty-four hours it increased in height 6·75 inches; during the second, 5·25; during the third, 4·5; during the fifth, the same; during the sixth, 4·5 inches. The growth appeared to be in part terminal, and in part interstitial, the space between the joints in the new shoot having lengthened. These observations were made between the 22d and 29th September, and on a plant in a comparatively poor and dry soil.

A horse-radish tree close to my house, that had sprung from seed, had, in nine months from the sowing of the seed, attained a height of at least twenty-four feet. Its trunk then exceeded in thickness a man's arm, and its branches, proportionally large, were at this time bent from the weight of its pods, some of which were ripe. It had received no culture or manure, and the soil on which it grew was stony, and nowise a fertile one.

I find amongst my notes another instance of the activity of tropical vegetation, in the rapid manner in which plants right themselves on change of position. Thus, in a flower-box in which weeds had taken the place of the flowers, placed on its end at six o'clock in the morning, I found in the short interval of twelve hours—viz., at six in the evening—that they, the weeds, had become bent at right angles to the soil in which they were rooted, so that the upper portion of their stems had recovered their perpendicular position.

The extraordinary productiveness of a tropical climate is by many considered an inestimable advantage, forgetful of the more than counterbalancing evil arising from the astonishing growth of exhausting and often smothering weeds. The poet may sing of the

> "redundant growth
> Of vines and maize, and bower, and brake,
> Which Nature, kind to sloth,
> And scarce solicited by human toil,
> Pours from the riches of the teeming soil;"

but the planter knows to his cost that in no part of the earth's surface is more care and industry required than within the tropics to make agriculture profitable.

4. *The purification of Sugar by Ants.*

If the juice of the sugar-cane—the common syrup as expressed by the mill—be exposed to the air, it gradually evaporates, yielding a light-brown residue, like the ordinary muscovado sugar of the best quality. If not protected, it is presently attacked by ants, and in a short time is, as it were, converted into white crystalline sugar, the ants having refined it by removing the darker portion, probably preferring that part from its containing azotized matter. The negroes, I may remark, prefer brown sugar to white; they say its sweetening power is greater; no doubt its nourishing quality is greater, and therefore as an article of diet deserving of preference. In refining sugar, as in refining salt (coarse bay salt containing a little iodine), an error may be committed in abstracting matter designed by nature for a useful purpose.

5. *Leaf of the Pigeon-Pea Tree* (Cajanus indicus).

The leaf of this tree on its upper surface is covered with a fine down. When incinerated, it yields a large proportion of fixed matter, derived from the soil, consisting chiefly of the vegetable alkali, of phosphate of lime, of carbonate of lime, of magnesia, and silica. The silica is derived from the down. Under the microscope it exhibits the same form as the down, viz., that of spiculæ, in shape not unlike the poison-fang of the serpent, tubular to a certain extent, and slightly curved, from about $\frac{1}{300}$ to $\frac{1}{200}$ of an inch in length, and in width at the base about $\frac{1}{3000}$. The substance of these spiculæ—that is, what remains after incineration—I infer to be silica, from its being infusible before the blow-pipe, and insoluble in the mineral acids.

Were the soil in which the plant grows to be examined, probably after a few years, these spiculæ might be found deprived of their vegetable organic portion, the residual silicious matter preserving their forms, and they might be mistaken for the skeletons of infusoria.

The leaves examined were from a plant growing in a volcanic soil, that of St Kitts, where it is much used as a green-dressing to the cane-fields, and is considered very fertilizing. As its roots penetrate deeply, and the roots of the cane spread near the surface, it seems well adapted to counteract the exhausting influence of the cane.

6. *Peculiarities of the Sweet Potato* (Batatas edulis).

In its raw state this vegetable has a slightly acrid taste; on boiling it becomes sweet. In its sound state it is almost without odour; when it is worm-eaten, it acquires a perfume very like that of the hair-powder formerly in fashion called "The Marshall's," or that of the Vanilla-bean. The water in which it has been boiled has the taste of a weak animal broth.

Besides starch, its principal ingredient, it contains a certain quantity of matter resembling gluten. When the potato is cut, this matter exudes in a liquid milky state, viscid at first, diffusible through water, but soon becoming solid on exposure to the air. Under the microscope, when suspended in water, it appears in the form of granules of about $\frac{1}{20,000}$ of an inch in diameter, which were rendered brown by tincture of iodine.

Probably this matter is concerned in the production of the changes to which the sweet potato is subject, as well as conducing to its highly nutritious quality as an article of diet.

7. *Composition of the Ground-Nut* (Arachis hypogæa, *Linn.*)

This singular nut, becoming now of so much importance in connection with the industry and civilization of the western coast of Africa, not only abounds in oil, to which it owes principally its commercial value, but also contains a considerable quantity of starch—rather an unusual alliance—and in addition a large proportion of albuminous matter. The starch particles are about $\frac{1}{1000}$ of an inch in diameter. In no other instance have I seen so much starch associated with oil.

8. *The Coco-Nut* (Cocos nucifera).

Of all the gifts which bountiful nature has bestowed on the inhabitants of the tropics, this perhaps is the most valuable, and certainly the one most fitting them for a paradisiacal state of idleness. What other fruit is there in which, as in the coco-nut, we find a refreshing beverage contained in a cool limpid state, in a nutritious pulp of the consistence of blanc-mange, and as agreeable to the taste!

In a young nut, the lining pulp of which was thin and almost of gelatinous softness, the quantity of contained fluid exceeded rather half a pint. It was quite clear, as much so as spring water, pleasantly, slightly sweet, of specific gravity 10183. The pulp was rendered brown by the tincture of iodine. No starch particles could be detected in it under the microscope, nor oil globules.

The water of a ripe coco-nut, much less in quantity and nearly transparent, was of the specific gravity 10203. It did not become turbid on boiling, or by the addition of acetic or nitric acid. Sugar, it may be inferred, was its principal ingredient.

The lining pulp was found to consist of 36 per cent. solid matter and of 64 water, as determined by thorough drying. As is well known, it abounded in oil. I could detect in it no starch particles. In composition I believe it to be very like the ripe almond. The emulsion it makes is equal to that of the almond, and is an excellent substitute for milk for tea.

The coco-nut palm, I may add, thrives best by the sea-shore; it thrives even within high-water mark. Viewed in this light, may it not be considered as designed by a kind Providence to yield a drink in situations in which springs of fresh and wholesome water are often not to be found. It is only the traveller in such regions who can justly appreciate its value, and be sufficiently thankful for such a blessing. In Ceylon, the natives are in the habit of putting a portion of salt into the ground when they plant the nut, so convinced are they that salt is required for its successful growth.

9. *Cassava* (Manihot).

Two varieties or species of this plant are cultivated in the West Indies, the so-called bitter and sweet (*Manihot utilissima* and *Janipha*); I say so-called, because neither of them is bitter or sweet, the words probably having been applied by the negroes, who, with a limited vocabulary, are nowise exact in the use of terms. The tuberous roots—the parts used—do not differ in a very marked manner. . That of the first-named has a more decided pungent, acrid taste than that of the second; and from the few comparative trials I have made, appears to contain a larger proportion of glutinous matter and of hydrocyanic acid.

When a section of the root is made, three parts are distinguishable—an epidermis, very thin and tasteless, an inner laminated and fibrous layer, which is easily separated, the principal seat of the hydrocyanic acid and gluten; and innermost, the body or main portion, abounding in starch contained in a cellular structure. On the division of the root, the glutinous matter exudes as a milky fluid, like that from the sweet potato, and with the same microscopic character. Its granules are about $\frac{1}{10,000}$ of an inch in diameter, and they are coloured brown by iodine. The starch particles contained in the substance of the root vary in size from $\frac{1}{5000}$ to about $\frac{1}{800}$ of an inch in diameter.

In the mode of preparing the root as an article of diet, viz., by steeping for a short time in water, grating and pressure, a portion of the glutinous matter is separated, and in the dressing, whether by roasting or baking, the volatile poison, the hydrocyanic acid, is dissipated. To the gluten which remains, probably the highly nutritious quality of the cassava is owing. We learn from Southey's History of the Brazils, that the Dutch "soldiers preferred mandioc to wheat, thinking it a stronger food;" and I have been assured by a gentleman who travelled in the wilds of South America in company with native Indians, that he lived for many days on no other food than cassava bread, undergoing a great deal of fatigue, and found it to agree with him well and support his strength.

10. *Seed of the Cotton Plant* (Gossypium herbaceum).

The cotton plant, once so largely cultivated in the West Indies, offers this advantage, that it succeeds in poor soils; indeed it is said to succeed best in the poorest, and without manure. Another advantage is, that the old, infirm, and young, can be employed in collecting its produce.

The uses of the plant are many. Its cuttings are good for fuel; its seeds contain a good deal of nutritive matter, and are eaten by cattle and sheep, but not, I have been told, by horses, only by ruminating animals, and it is said they are even fatal to hogs; but whether true or not I am ignorant. The plant, as cultivated in Barbadoes, is of three years' duration.

One self-sown in my garden in that island yielded the first year 192 pods; in each pod or capsule there were 20 seeds, together weighing in their dry state 43·3 grains; the lining-wool—the cotton-wool—detached weighed 23·7 grains. The shell or epidermis of the seed is black, thin, hard, and tough. The substance of the seed inclosed is of a light yellow colour, of an oily taste followed by a slightly acrid one. Under the microscope it is found to consist of oil globules, which are abundant, and of a fine granular matter. The seeds are broken (for instance when crushed in a mortar) without much difficulty, and with water on trituration yield a yellow emulsion. Thrown in a filter, the liquid which passes through is turbid and yellowish. It is not apparently altered by boiling; but on the addition of acetic acid flocculi separate, and on cooling subside. Now filtered the fluid is clear and colourless. The precipitate, it may be inferred, is in part at least casein. The larger portion of the washed kernel, that which is retained in the filter with the oil, soon acquires an unpleasant smell; kept a fortnight and then mixed with lime it gave off a distinct odour of ammonia. The oil is of a yellow colour, not volatile, and is fluid at 80° Fahrenheit.

The seed incinerated without the pellicle, after burning,—it burns with much flame,—leaves a coal that is easily reduced to ash, inconsiderable in quantity, composed chiefly of carbonate of potash, phosphate of lime, and magnesia. The same were found in the ash of the epidermis with some silica. Though growing in calcareous marl no carbonate of lime or free lime could be detected in either.

On the Composition of Two Mineral Substances employed as Pigments. By Thomas H. Rowney, Ph.D.

In the course of an examination of some mineral substances employed as pigments, which I have lately made in the laboratory of Dr T. Anderson, I have met with two which, in addition to their practical applications, present considerable scientific interest, their constitution entitling them to be classed as distinct and hitherto unknown mineralogical species.

Indian Red.—The substance named Indian red is imported from the Persian Gulf, but the exact locality in which it is found is unknown, at least I have been unable to obtain any information from the importers. It comes to this country partly in small lumps, and partly as a coarse, hard, and gritty powder. Its colour is deep red, with a shade of purple. Its specific gravity is 3·843.

Before the blowpipe, on platinum wire with borax and with microcosmic salt, it gives a transparent bead, with the usual reaction for iron; when heated by itself on charcoal it is infusible, and after cooling it is attracted by the magnet; mixed with carbonate of soda on charcoal it fuses into a bead, the iron at the same time being reduced, and also attracted by the magnet. By digestion with concentrated hydrochloric acid a small portion is dissolved, and the remainder retains its red colour, and is not further altered by continued application of heat. The portion dissolved consisted of peroxide of iron and alumina, with small quantities of lime, magnesia, sulphuric and carbonic acids. The insoluble portion contained silicic acid, peroxide of iron, and a little alumina and water. The analysis was made by fusing the substance dried at 212° F. with carbonates of potash and soda, and conducting the separation in the usual manner. The results were—

Silicic acid, . .	30·17
Peroxide of iron, . .	56·59
Alumina, . . .	3·79
Lime, . . .	2·65
Magnesia, . . .	1·43
Sulphuric acid, . .	2·28
Carbonic acid, . .	1·73
Water, . . .	1·62
	100·26

Another portion was digested with hydrochloric acid, which dissolved 13·66 per cent. of the mineral. The portion dissolved consisted of—

Peroxide of iron, . .	3·91
Alumina, . . .	2·22
Lime, ...	2·65
Magnesia, . . .	·87
Sulphuric acid, . .	2·28
Carbonic acid, . .	1·73
	13·66

If, now, we deduct these constituents from the results of the total analysis along with the water, and the slight difference in the magnesia, the insoluble portion consists of—

		Oxygen.
Silicic acid, . .	30·17	15·96
Peroxide of iron, .	52·68	16·53
Alumina, . .	1·57	

The oxygen in the acid and bases is here almost exactly in the ratio of 1 : 1, and the insoluble portion is therefore a silicate of the peroxide of iron, represented by the formula $Fe_2\,O_3$, $Si\,O_3$, and corresponding in constitution to the silicate of alumina called xenolite, $Al_2\,O_3$, $Si\,O_3$. Although the silicate of iron of the constitution $Fe_2\,O_3\,Si\,O_3$ has not hitherto been found in the free state, it is known in combination in Wehrlite $(Fe\,O\,Ca\,O)^3\,Si\,O_3 + 3\,(Fe_2\,O_3\,Si\,O_3)$, a mineral analogous in constitution to Wernerite and anorthite, which are aluminous minerals both represented by the formula $(Ca\,O)^3\,Si\,O_3 + 3\,(Al_2\,O_3,\,Si\,O_3)$.

Terra de Sienna is said to be obtained in the neighbourhood of Sienna. It is a brownish-yellow substance, which acquires a fine and rich chestnut colour by ignition, in which state it is used as a paint under the name of burnt sienna. Its fracture is earthy and conchoidal, and it is easily scratched by the nail. Its specific gravity is 3·46. It adheres strongly to the tongue, and absorbs a considerable quantity of water without appearing moist. It gives a transparent bead both with borax and with microcosmic salt with the reaction for iron; with carbonate of soda on charcoal it is reduced and attracted by the magnet, held between platinum forceps and exposed to the reducing flame it is infusible, but is afterwards attracted by the magnet. It is not in the least degree attacked by concentrated hydrochloric acid. It was fused with carbonates of potash and soda, and the various steps of the analysis conducted in the usual way, the iron being determined by means of a standard solution of bichromate of potash.

		Oxygen.	
Silicic acid,	11·14	5·80	1
Alumina,	9·47	4·41	4
Peroxide of iron,	65·35	19·60	
Lime,	·53		
Magnesia,	·03		
Water,	13·00	11·33	2
	99·52		

In this case the oxygen of the silicic acid, the sesquiatomic bases, and the water are in the ratio of 1 ÷ 4 ÷ 2, from which we deduce the formula $4\,(R_2\,O_3)\,Si\,O_3 + 6\,HO$, the calculated numbers for which are—

Silicic acid,	11·04
Alumina and peroxide of iron,	76·09
Water,	12·87
	100·00

The characters and composition of this substance are so distinct from that of all other minerals, that I propose to apply to it the name of hypoxanthite. Although it stands alone among the iron compounds, it may be compared with opaline, allophane, and schrötterite, both of which are hydrated silicates of alumina corresponding in composition with that existing in hypoxanthite, as is seen from the subjoined formulæ—

Hypoxanthite, .	$4\left\{\begin{matrix}Fe_2O_3\\Al_2O_3\end{matrix}\right\}+SiO_3+6HO$
Opaline allophane,	$4(Al_2O_3)+SiO_3+18HO$
Schrötterite, . .	$4(Al_2O_3)+SiO_3+16HO$

Sketch of the Operations executed in the Drainage of the Lake of Haarlem, with its actual state at the present time. By M. Gevers D'Endegeest, President of the Commission for the Drainage of the Lake Haarlem, &c. &c.

In giving the following sketch of the actual state of the drainage of the Lake of Haarlem, I begin with the supposition that those who are interested in it know my work upon this undertaking, of which the first part, with three plates, was published in 1843, and the second, with five plates, in 1853. Both of these have been freely translated into French ;* I shall therefore repeat none of their contents, but only carry it on to the actual period which may almost be considered as the end of the enterprise, since the commission charged with the drainage reckoned upon settling by the end of 1855, the new Polder of the Lake of Haarlem in the new Direction, which the purchasers of the drained lands will choose among themselves.

It is known that the waters proceeding from the lake during its drainage ought to have been discharged by the draining-machines into the canals, ponds and ditches, which together form an intermediate basin between the Polders of all the hydraulic district of the Rhineland and the sea ; and in order that the basin might receive the waters of the lake, it ought at least to have been aided in its ordinary means of overflowing into the sea, by the enlargement of one of the old sluices, and of the principal canal, which terminates at the

* Apply for this work at the Brothers Van Cleef at the Hague, and at M. Frederic Müller at Amsterdam. " Du Dessechment du lac de Harlem, par M. Gevers D'Endegeest," &c.

village of Ratwyk, more especially by the establishment of two steam-engines, the one at Spaarndam, and the other at Mi-chemin.

After the drainage the new Polder continued in the same manner to pour its waters into the basin, which again discharged them into the sea; and it might be thought that the mass of waters being infinitely greater before the drainage, the same machines were no longer necessary. This is an error. In general words, in the course of a year the Polder, it is true, gives much less water, but the machines ought to be sufficiently powerful to exhaust at the same moment the greatest quantity of water that the Polder can receive (whether it be rain-water or infiltrations), even during the worst month of the worst known year; these bad months might return, and without this power the Polder might be flooded during some weeks, and the harvest lost. This is, then, the basis upon which to establish the power of machines for all the drainage. In constructing more or stronger ones, in order to drain more quickly and to destroy them afterwards, would be a useless expense. The same machines which effect the drainage remain for the wants of the Polder, with this difference only that during the drainage they work day and night as much as they are able, but that afterwards they may be used only in the rainy season, to prevent its canals and ditches from overflowing their banks. The result is that the machines which aid the discharge of the water from the basin into the sea remain constantly necessary.

It is, then, very necessary to know the state of the machines after their prolonged work of drainage, the service which they still have to perform, and what may yet be expected of them. Of the wind-mills known and approved of old, there was nothing problematical, but of the steam-engines, of a construction quite new and gigantic, this question is of the highest importance.

1. *Machines for the Drainage of the Basin.*

The table of work of that at Spaarndam until 1st July 1852, the period when the lake was dried, is to be found at page 15 of my second part. The following table is the continuation of the first, but subsequent to the drainage, and it may be admitted that the expense of firing and lubrication have been in the same proportion as that previously stated.

Years.	Working Hours.				Total of the working hours of the wheels, at the calculation of 1 met. in breadth.	Mass of water discharged, at the rate of 5232 cubic metres of water per hour by 1 metre of breadth.	Observations.
	10 Wheels or buckets.	8 Wheels.	6 Wheels.	4 Wheels.			
1852	124	570	737	266	23,726	124,134,432	These numbers apply only to the last six months of 1852.
1853	235	1036	704	163	32,482	169,945,824	
1854	312	686	484	120	25,073	131,181,936	
1855	184	282	128	9	10,210	53,418,720	These numbers apply only to the first four months of 1855.
	855	2574	2053	558		478,680,912	
	Total 6040 hours, or 251 days and sixteen hours.						

The steam-engine of Mi-chemin was only in a state to work after the drainage. It only came into active operation towards the autumn of 1853. The following table gives the details.

Years.	Working Hours.			Total of the working hours of the wheels, at the calculation of 1 met. in breadth.	Mass of water discharged at the rate of 4550 cubic metres of water per hour by 1 metre of breadth.	Observations.
	6 Wheels.	4 Wheels.	2 Wheels.			
1853	428	128½	1	6,168	28,064,400	These cyphers apply only to the last eight months of 1853.
1 4	1147	323	...	16,348	74,383,400	
1855	531½	105½	9	7,258	33,023,900	These cyphers apply only to the first four months of 1855.
	2106½	557	10		135,471,700	
	Total 2673½ hours, or 111 days and 9½ hours.					

Recapitulation.

The steam-engine of Spaarndam has raised in .	6040	hours	478,680,912	cubic metres.
That of Mi-chemin, .	2673½	„	135,471,700	„
	8713½	„	614,152,612	„

I have said how indispensable it is to constantly keep in repair the machines for draining the lake, in order to keep the new Polder from which they raise the waters into the basin of the Rhineland dry. It follows then that the steam-engines of Spaarndam and Mi-chemin are equally necessary, in order to accelerate the discharge of the waters of the basin into the sea. The short space of time elapsed since the drainage proves it already by the fact, that these two have raised from the basin since the lake was drained in July 1852, till the 1st of May 1855, a period of two years and ten months, more than two-thirds of the mass of waters raised from the same basin by the engine at Spaarndam throughout the period of the whole drainage, or during more than six years. This mass of water, in proportion much greater after the drainage than during its progress, proves only this circumstance, that after the drainage the rains have been more abundant. The steam-engine of Mi-chemin leaves nothing to be desired ; it has perfectly answered its purpose. Although only of 100 horse-power, the half of that at Spaarndam, it requires the same attention, and more than half the firing and lubrication. It might at first sight be believed that this engine was useless, since the lake has been drained without its assistance ; this however is not so. The basin of the district, of which previously the lake formed the largest part, has been deprived by the drainage of nearly four-fifths of its ancient extent, and the fifth remaining part ought to receive not only the same quantity of water issuing from all the Polders as before, but also the waters issuing from the new Polder ; in other words, before the drainage, 70,000 hectares of low embankment ground or *Polder* throw their superfluous waters into a basin of 22,700 hectares ; afterwards 88,000 hectares of Polder throw their waters into 5000 hectares of basin.

Fortunately during the drainage, less rainy years and other favourable circumstances have rendered for the time the enlargement of the canal and sluices of Ratwyk with the engine at Spaarndam alone sufficient for the wants of the discharge; but it is certain, that these means will be found insufficient during very rainy seasons accompanied by unfavourable circumstances. So convinced are they of this, that a new law has granted a sum of 200,000 florins for the establishment of a third steam-engine of the same power (100 horse) as that at Mi-chemin, for the sole purpose of discharging the waters of the basin on the opposite side to the one at Spaarndam, upon the river Yssel. These three machines, however, will shortly, according to an agreement formed with the administration of the district called the Rhineland, be in the charge of that administration, which will find the expense of maintenance and work, the cost of which will at least be about 30,000 to 40,000 florins per annum for keeping the lake within its bounds; and the annual return from the reclaimed lands of the new Polder, taken upon the same scale with all the others of the district, may be about 18,000 to 20,000 florins. One must then in the estimate of the expenses of the undertaking only include the cost of the first establishment of the three engines, probably about 200,000 florins for each. There will be no further expenses either for the state or for the new Polder.

The steam-engine of Spaarndam since 1845 has not met with any serious accident, any more than that at Mi-chemin, the work of which dates from 1853. Both of them are in the most satisfactory state, and perfectly answer their intention. Together they raise with their great wheels into the sea, even when it is from 4 to 5 centimetres higher than the level of the basin, as much water as 60 large windmills of the different Polders of the Rhineland could send there; with the one to be constructed upon the Yssel, they will be equivalent to 80 large windmills. They will never prevent in unfavourable seasons the 250 windmills, great and small, of the Polders of the Rhineland from raising, in addition, the waters of the basin; but whilst the mills depend upon the wind, which rarely permits them to work continuously during the twenty-four hours, because it is very often either too strong or too weak; on the contrary these steam-engines work at will night and day, for a whole month without interruption, should it be desirable. This then is their undoubted advantage, an advantage which permits them even entirely to regulate the level of the basin.

The Machines which were used at first for the Drainage of the Lake, and now for the new Polder.

Three engines have been established for the drainage of the lake, each about 400 horse power, and each costing about 500,000 florins; one at the south, another at the north, and the third at the east of the lake. When these three magnificent engines had, during the 39 months the drainage of the lake lasted, raised in 19½ months of constant work 831,839,501 cubic metres of water, and thus rendered the lake dry by the 1st of July 1852, they were able, during a warm and dry summer, to remain stationary until the autumn. The following winter the water rose to 3·69 metres ÷ 0A* of 4·50 metres ÷ 0A, which it had been during the summer. The cause was very natural: the ground, *scarcely* dried, did not absorb a drop of rain-water, and this besides, could not find a sufficient receptacle in the then unfinished canals of the new Polder. The water was again very low in the month of June 1853, and they commenced from that time the sale of the lands, which will be spoken of shortly.

Notwithstanding the exertions of the engines, the water rose again during the following winter of 1853–1854 to almost 4 metres ÷ 0A, but the large canals, the secondary canals and the ditches of the new Polder having been at last completed, a basin for the reception of the rain water having thus been formed, and its passage to the *engines* secured, it was easy to maintain them lower than ever during the summer of 1854.

However, during the last winter (1854–1855) the water rose again in the middle of the Polder, at its lowest part, to a con-

* 0A is the point of commencement for our hydraulic works, corresponding to the level surface of the country.

siderable height, and more than was expected. The cause was, first, the unsatisfactory state of the boilers of the engines; *on the one hand, their unfinished state,* on the other, the want of sufficiently pure and filtered water to supply them, which caused deposits of mud, always very prejudicial. A second cause is the still unfinished state of the ditches intended for the reception of rain water, or rather the want of a sufficient extent of these ditches.

The lands had been divided into lots of 20 hectares. The ditches necessary for forming the divisions were insufficient for receiving the rain water; this was known before, but it had been calculated that each new proprietor would dig many more for the regular improvement of his own lots. Meanwhile, several among them commenced only with small drains, and 4000 hectares not yet sold, and where, in consequence, no purchaser could commence to work, continued to occupy the centre of the Polder. It will, nevertheless, be easy to remedy both of these inconveniences.

The following table shows the work which had been performed by the three draining-machines from the 1st of July 1852, when the lake was drained, to the 1st of May 1855, when the new Polder was perfectly freed from all superfluous water:—

From the 1*st of July* 1852, *when the Lake was drained, until the* 1*st of May* 1855,—

The "*Leeghwater*" has produced 2,132,681 strokes, namely:—

With 11 pumps,	661,552	or with all the eleven pumps working,	661,552	
„ 10 „	951,713		865,194	
„ 9 „	519,416		424,977	
				1,951,723

The "*Lijnden*" 2,356,602 strokes, namely:—

With 8 pumps,	1,005,968	or with all the eight pumps working,	1,005,968	
„ 7 „	1,350,634		1,181,805	
				2,187,773
			Carry forward,	4,139,496

		Brought over,	4,139,496

The "*Craquius*" 2,757,140 strokes, namely:—

With 8 pumps, 1,289,650	or with all the eight pumps working,	1,289,650	
„ 7 „ 1,467,490		1,284,054	
			2,573,704
		Total,	6,713,200

The machines have sustained no serious accident since the unexpected breaking of the fly-wheel of the "Leeghwater." Some of the chains of the pumps have broken; some valves have been deranged; those of the pumps especially are often worn or accidentally damaged; but all this has been repaired as it occurred by the attendant of the machines, and at the work-shop of the "*Leeghwater*." The boilers only require considerable repairs. With these exceptions, the machines are in a perfect condition. The walls and wood-work of the buildings have not given way nor suffered any damage, and the machinery, notwithstanding several years' work, is better than at the beginning, the bad or weak parts having been renewed successively.

There is no reason for thinking that the expenses of work and maintenance will exceed the seven florins per hectare, the payment of which is imposed on the purchasers as long as the commission for the drainage shall direct the undertaking.

Division, Extent and Level of the Polder.

The important works comprised under the name of the *division* of the Polder were in part already finished in 1853. They were terminated in 1854, without presenting the ordinary difficulties of digging in ground scarcely dried; for if it is in general necessary in recently-drained lands frequently to cast out the ditches on account of the ground being muddy and soft, here, on the contrary, they can dig in the layers of solid clay, which often occur on a foundation of sand; and the greater number of the banks of the canals and ditches have remained firm from their commencement. This solidity of the new ground has produced a happy result, for the roads were soon passable. Last summer, all sorts of carriages already traversed the lake everywhere; and the villages on the opposite borders, which for ages had looked at each other without communication, found themselves suddenly neighbours and "*fraternizing*."

The map No. 8, belonging to the second part of my work, gives at the first glance an idea of the division of the new Polder. Each oblong forms a block of 300 hectares, composed of fifteen lots of 20 hectares, of which the length, running from north-west to south-east, is 1000 metres, or the width of the square. Each lot is bounded on one side by a road, and on the other by an accessary canal, suited for the interior navigation of the Polder. The blocks along the borders of the Polder are exceptions to those general rules on account of their slope. The roads and longitudinal canals extend in straight lines of 18,000 to 20,200 metres. When all the canals are brought back to their original size and depth, which will be done this summer at the cost of the undertaking, and when all the ditches dug by it, and those that the purchasers ought necessarily to add in order to improve their lands, shall be finished and in repair at their charge, it appears that the basin of the Polder will suffice for the reception of the rain-waters, and to conduct them to the machines. If experience proves the contrary, the administration of the Polder will order the regular establishment of a greater quantity of ditches. This case is provided for in the conditions of the sale of lands.

The cost of this immense work of division, far from exceeding the estimated amount, already reduced to 1,287,121 fl., has not even reached it, since it only amounts to 1,261,199 fl. See the table at the end of the present sketch.

The Accessary Works.

These have only been increased by two moveable bridges, and by three ferry-boats upon the surrounding canal, with roads of greater or less extent joining to the great roads of the surrounding country. The entrances to the Polder, with those already existing in 1852, thus amount to eleven, of which five are moveable bridges, four large ferries for carriages, and two smaller ones for track horses.

Sale of Lands.

The lands had been formerly estimated at the average value of 200 florins per hectare. This was thirty florins more than the average price obtained twenty-five years ago, in the last great drainage analogous to that of the Lake of Haarlem. However, a society of speculators had in 1852 offered to the government to buy the entire Polder for 300 florins per hectare; but the commission judged the drainage an undertaking too national to abandon its profits to strangers, who besides being unacquainted with the manner of cultivating these new grounds, and with the complications of our hydraulic economy, would not easily have succeeded, and would have caused embarrassments.

It was necessary, according to the commission, to deliver up this new land to the competition of all who might desire to buy a part, whether simple agriculturists, or proprietors in the neighbourhood who wished to enlarge their estates, or capitalists of great neighbouring towns; above all, in a time when capital abounded, and when the rates of the public funds were raised. These circumstances might bring in better prices still than those of the sum offered. The result surpassed the expectation. The first sale of the highest lands along the banks took place on the 16th of August 1853; 784 hectares brought in 575,000 florins, or 733 florins per hectare. A second sale took place in the same month, and the price of 1273 hectares was 742,450 florins, or 583 florins per hectare. A third sale of 514 hectares in the month of October, and a third in the month of November, in the same year, were not so favourable. The remainder no longer obtained the same price, but the average price has nevertheless remained considerable.

Four sales took place consecutively in the months of February, May, September and November 1854. Eight sales had then taken place.

The result of these eight sales is (at the average price of 473 fl.

per hectare)	12,634	hectares sold	for	Fl. 5,973,953
The remainder to sell (if the average price of 473 fl. remains),	4,200	„	for	1,986,600
	32*	„	for	70,000
	16,866			Fl. 8,030,553

This result surpassed all expectation, inasmuch as the grand object of the drainage was rather to put an end to the encroachments of the lake, than to make a lucrative speculation of it.

The subsequent sales were made less frequent, first, with the intention of not wearying the purchasers; and second, in consequence of the bad season of 1854–1855. New delays in the termination of the works of the commission, and new charges upon the Treasury for the costs of administration and of maintenance, have been involuntarily the necessary consequence.

The Cultivation of purchased Lands.

The result which I have just made known is so much the more important, by the indirect benefits which will result from it hereafter. After twenty years, these new grounds will pay a ground-rent tax; such is one of the conditions of the sale. After this tax has existed some years it will be paid also by the houses and buildings, indispensable to the agriculture of the new Polder, and for those villages which will not fail to spring up. The personal taxes of the new inhabitants for doors, windows and chimneys, will form a new revenue for the state. Is it necessary to say that work is procured for many classes by the cultivation of lands so extensive, and by the construction of buildings, which already spring up on every side? They are counted already by dozens; and at this moment, 28 to 30 large farm-steadings, which will cost from 6000 to 10,000 florins each, are in process of con-

* These 32 hectares are reserved in two different places in the centre of the new Polder, in order to build villages there. This ground will be sold for 30 cents. per square metre for building houses there after a given plan, which, after the deduction of ground for streets and squares, will bring in 70,000 fl.

struction. As for the cultivation, eight days after the first sale in 1853, it had commenced everywhere. After each consecutive sale, it has recommenced upon a still larger scale.

Those who can begin in time hasten to profit by the month of August, in order to sow rape ("*Colza*") for the first harvest; those who are not ready before the autumn, sow rye; in the spring, oats; but rape is the seed most suited for these new lands; it covers the ground entirely with its large leaves, smothers the weeds, and if it answers well, does the most good. Many of the fields of the first two sales were valued in 1854 at the rate of 400 to 430 florins per hectare. The grounds of the lake, like those elsewhere of all the reclaimed lands of Holland, as soon as they are dry, are covered spontaneously with a multitude of plants; first, and most generally, by an aquatic plant vulgarly called *Andive sauvage* (*Cineraria palustris*); then of reeds, often (and this has taken place particularly in the Lake of Haarlem) with an innumerable quantity of young willows. Several of the lands sold in 1853 were already covered with all these plants, which were higher than a man: one could only walk there with difficulty, and by placing aside with one's hands the bushy plants which covered it entirely.

The first work in these great lots of 20 hectares is to divide them through all their length by ditches, at first by simple drains, which, successively enlarged, become ditches; then, after having torn up the willows, as opposing too much resistance for the operation which I am about to mention, a heavy plank is rolled over the roots of the noxious, pliant and brittle plants. These are bent, partly broken, and remain fallen; they are then covered with the earth taken out of the ditches and drains, of which the quantity ought to be calculated for this purpose, till it arrives at the thickness of half a centimetre, and the rape is then immediately sown. The weeds, not rising again, become decayed; and when in the spring they ought to push their way through, the rape in full vigour overpowers them, covers the ground entirely, and they die. This first operation, which is called "*noircir le terrain*," because from the bright green which it had been by the spontaneous and vigorous vegetation, it becomes black. This costs, including the ditches and drains, from 70 to 100 florins per hectare.

After the harvest, they work with large wooden shoes on the horses' feet, when the soil is still too soft to permit of their walking without this aid. If they sink, it is often impossible to draw them out; in this case, they leave them on the spot. A second sowing of rape, if the grounds are sufficiently rich, succeeds the first harvest, or sometimes they substitute oats, rye, or wheat. Several of these new lands along the borders produce spontaneously grass, and are then changed into pastures necessary for the number of horses used in the cultivation. One can judge of the agriculture of this undertaking, and of the sums laid out in land labour, in taking into consideration that the 12,643 hectares sold since the month of August 1853, have all produced this year their first or their second harvest. In general the first has been good, and the second promised to be so. There are only two places where some hundreds of hectares have not answered, on account of the deposit of ferruginous particles, which poison the ground and spoil the water. But this phenomenon, known elsewhere, passes away after exposure to the action of the sun and air.

The 4200 hectares still to be sold will be so in the course of this year. Afterwards, the executive commission, ceasing from the labour of sixteen years, will give up to the new administration chosen by the proprietors the new Polder, with the dike and the surrounding canal, the bridges and the ferries, the three draining machines, and their accessaries; the whole will be abandoned by the state to the profit and to the charge of the new Polder.

Pecuniary Results.

The law of 1839 had granted for the drainage,		Fl. 8,000,000
A law of 1843 had increased this sum to		9,916,344
But in this sum was comprised for partial payment of rent,	Fl. 1,390,000	
And also the expenses of borrowing the 8,000,000,	97,000	
		1,487,000
The remainder for the works of the undertaking and accessaries,		8,429,344
Two laws passed in 1854 add to this sum, for expenses of maintenance of drainage of the new Polder, in 1854,		125,000
And for the same object in 1855,		127,000
Carry forward,		Fl. 8,681,344

Brought forward,	Fl. 8,681,344
It was necessary to add for the indispensable improvements of the principal canals of the Polder, damaged during the last winter,	100,000
A very recent law granted also, for the steam-engine upon the Yssel, of which I have spoken before, . . .	200,000
Total of the works, . . .	Fl. 8,981,344

The following table shows the amount of each kind of work.

Table of the Total Expense for the Works of Drainage from 1839 *till* 31*st December* 1855.

Articles.	Objects.		Sums Expended.
I.	Works for the discharge of waters from the Rhineland, namely, the enlargement of the canal of Ratwyck, the improvement of the river Spaarne, the steam-engine of Spaarndam and that of Michemin, . . .	Fl. 1,089,167	
	That upon the Yssel yet to make,	200,000	Fl. 1,289,167
II.	The surrounding canal and the dike, . .		1,988,257
III.	Indemnities for appropriations, . . .		684,514
IV.	Steam-engines for drainage, repairs, firing, and necessary attendance, ...		2,299,523
V.	Works in relation to the navigation, such as roads for towing along the Spaarne and of the surrounding canal, with bridges and boats, and repairs of some accessary canals, ...		133,288
VI.	Military works of defence, instead of those which, in addition to the Lecke as a means of inundation, defended the capital, . . .		275,921
VII.	Works of division of the new Polder,	Fl. 1,161,199	
	Additional supply still necessary in 1855, . . .	100,000	1,261,199
VIII.	Repairs of all the works and machines, . .		363,751
IX.	Personal expenses, police, law, and travelling expenses, offices, taxes, remuneration for appropriated lands belonging to the Polders, staking out, models, specimens, proceedings, &c., .		639,477
X.	Payment of rents, ...		Memorandum
XI.	Unforeseen expenses, ...		46,247
	Total,		Fl. 8,981,344

When one considers the years of unforeseen delays against which the undertaking had at first to struggle, the new delays due to the slow progress of the sales indicated in the present note, and the works of military defence, as well as the establishment of a third steam-engine on the Yssel, not comprised in the first estimate, which was 8,355,000 fl., one can say that this estimate has been very little exceeded, a rare thing in works so vast, and necessarily of so long duration.

Let us see in the end what the ultimate enterprise will cost the treasury.

I have said that the expense of the works has been .		Fl. 8,981,344
From this it is necessary to deduct the amount of expense of guarantee, of which the clear profit has been	Fl. 932,236	
Profits of the leases, of the pastures, and of the fishing, also that of the sum of 7 fl. per hectare of the ground sold in 1853, to pay for the expenses of maintenance and of the drainage of the Polder, of which I have spoken before in 1854, ...	61,647	
Do. do. in 1855, during which year the lands also sold in 1854 will pay 7 fl. per hectare, approximately and in round numbers, . . .	87,461	
		1,081,344
Remainder for the expenses of work at the charge of the state,		7,900,000
The revenue of the sold lands will be, after what has been said, probably		8,000,000
In admitting that this sum may not be obtained,—that there may even be wanting of it Fl. 100,000,—there will always be		7,900,000

The works even on this hypothesis will then have cost the state nothing.

However, the state has had to support the rents or interest of the negotiation of the original 8,000,000 fl.

The capital had already been redeemed in 1854, in consequence of the prosperous state of the treasury. The amount of the rents, up to the moment of the redemption, had been 3,890,000 fl.

For this sum the state will have delivered the centre of the country from an immense lake, always increasing, from an enemy becoming more and more dangerous, and will have acquired for agriculture 18,000 hectares of fertile land, situated in the centre of population and of capital towns, and of which the direct and indirect advantages, indicated above, are as incontestable as permanent.

This conquest, obtained by skill and perseverance over the obstacles of nature and of man, commenced in times of scarcity, continued notwithstanding the troubles of 1848, terminated after sixteen years of labour and of care, is without doubt an honourable satisfaction for the commission, which has directed it without other recompense than the thanks of the public, which the country will not fail to accord to it.

The commission will finish its task at the end of the year 1855, in giving back the new Polder to its own administration, with the exception of finishing the establishment of the steam-engine upon the Yssel, which, if the government does not execute itself, it will demand to have the charge of.

On some of the Basic Constituents of Coal Naphtha. By C. GREVILLE WILLIAMS, Assistant to Dr Anderson, Glasgow University.

There are few bodies of organic origin whose points of difference are more easily defined than the gelatinous tissues of bones, cinchonine, coal, and the bituminous shale of Dorsetshire; but a remarkable similarity is observed in the basic products of their destructive distillation, thus —

GELATINOUS TISSUES.	CINCHONINE.	COAL.	DORSET SHALE.
Pyrrol.*	Pyrrol.†	Pyrrol.††	Pyrrol.§§
Pyridine.*	Pyridine.†	...	Pyridine.¶
Picoline.*	Picoline.†	Picoline.§	Picoline.§§
Lutidine.*	Lutidine.†	...	Lutidine.§§
Collidine.*	Collidine.†	...	Collidine.§§
...	Chinoline.**	Chinoline.††	Parvoline.§§
Aniline.*	Lepidine.†	Aniline.††	

As soon as I had ascertained the nature of the basic products of the action of heat and alkalies on cinchonine, I could not fail to observe these resemblances, and I was anxious to ascertain whether the intervals which are seen to exist in the coal series, could not be filled up. Notwithstanding the numerous researches which have been made upon the substances alluded to, there are many points upon which our information

* Anderson, Trans. Royal Soc., Edin., vol. xvi., part iv.; vol. xx., part ii., and vol. xxi., part i.

** Gerhardt, Revue Scientif., vol. x., p. 186.

† Greville Williams, Trans. Royal Soc., Edin., vol. xxi., part ii.

†† Runge (1834), Poggendorf's Annalen, Band. xxxi., u. xxxii.

§ Anderson, Trans. Royal Soc., Edin., vol. xvi., part ii.

§§ Greville Williams (1854), Quart. Jour. Chem. Soc., Lond.

¶ Greville Williams (1854.), Phil. Mag.

is very scanty. Some of these are under investigation by abler hands, but there are others which I have promised myself to study. Among these may be mentioned the following:— 1. Whether leukol and chinoline are really identical. 2. Whether pyridine, lutidine, and collidine, exist in coal-tar. 3. Whether lepidine or an isomeric base exists among the coal bases. The first and last of these points are now under examination; the second forms the subject-matter of the present paper.

Before detailing the experiments, I should mention, in outline, the facts already elicited in the successive investigations of the coal bases, by Runge, Hofmann, and Anderson. The first chemist indicated the presence of kyanol and leukol (aniline and leukoline), but he did not attempt to ascertain their composition, which was done by Hofmann,* who extracted his bases from the less volatile portion of the distillate from coal-tar; and consequently did not meet with the pyridine series.

Dr Anderson, in examining the fluid, procured by agitating the ordinary naphthas with sulphuric acid in the process of purification, discovered picoline; but the quantity on which he worked was too small to enable him to find the other members of the series which were afterwards discovered by him in Dippel's oil.

During my investigation of the shale bases, I was induced to prepare a small quantity of those from coal, for the sake of comparison. I was not at that time able to procure access to the raw material, but by treating about one gallon of crude coal naphtha in the manner described so often in the papers previously referred to, I procured about one and a half ounces of base, which, fractionated two or three times, gave about half that quantity of fluid, boiling at 270° F. By treatment with nitric acid, to destroy the small quantity of aniline still remaining, and distillation with lime, I obtained the basic liquid in such a state, that when dry, a portion of it distilled over below 240°: it was still, however, far from pure, and the quantity was too small to allow of more than two or three fractionations; nevertheless, a platinum salt was obtained, giving on analysis the following numbers:—

* Annalen der Chemie und Pharmacie, vol. xlvii.

	Experiment.	Theory. Pyridine.	Theory. Picoline.
Carbon, ...	22·1	21·0	24·1
Hydrogen, . . .	2·4	2·1	2·7
Platinum, . . .	34·1	34·6	32·9

It was evidently therefore a salt of pyridine, contaminated by a portion of the next base higher in the series.

Although this result pointed very unmistakably to the presence of bases not generally believed to exist in coal-tar, I should not perhaps have returned for some time to the subject if it had not been, that in consequence of my having ascertained the complex nature of the fluid, which had hitherto been regarded in the light of pure chinoline, a fresh comparison of the latter in a pure state with leukol became necessary ; and possessing, through the kindness of Mr George Miller of Dalmarnock, the means of obtaining any quantity of coal-tar products, I availed myself of Dr Anderson's permission to make use of his laboratory, and proceeded to examine, in the first place, the acid magma, produced by agitation of the crude naphthas with oil of vitriol. Nine gallons of the acid matter yielded (after separation of pyrrol and resins by protracted boiling, &c., as described in the previous papers) three quarts of crude bases, by far the greater portion of which boiled under 369°, although containing a large quantity of aniline. No leukol however appeared to be present. The basic liquid appeared therefore well adapted for determining the presence of pyridine, lutidine, and collidine.

The means of purification adopted were fractional distillation, treatment with nitric acid to remove aniline, and fractional crystallization of platinum salts, according to the methods described in my paper, on the presence of pyridine among the shale bases, previously referred to. After several rectifications a portion was obtained boiling very steadily between 240° and 242° F.; and as 240° was supposed to be the correct boiling point of pyridine, a portion of the fraction was dissolved in hydrochloric acid and chloride of platinum added; fine prismatic crystals of a deep golden tint soon began to form; different preparations and crops obtained by evaporation of mother liquors over sulphuric acid *in vacuo*, gave the annexed results on analysis :—

I.	2·730	grains of	platinochloride of pyridine gave
	·940	...	platinum.
II.	3·225	...	platinochloride of pyridine gave
	1·115	...	platinum.
III.	6·350	...	platinochloride of pyridine gave
	2·175	...	platinum.
IV.	9·158	...	platinochloride of pyridine gave
	7·070	...	carbonic acid and
	1·885	...	water, and
V.	4·100	...	platinochloride of pyridine gave
	1·407	...	platinum.

	I.	II.	III.	IV. & V.	Calculation.		
Carbon,	...	...	...	21·05	21·03	C^{10}	60·
Hydrogen,	...	...	...	2·28	2·10	H^{6}	6·
Nitrogen,	...	...	...	...	4·93	N	14·
Chlorine,	...	...	...	...	37·34	Cl^{3}	106·5
Platinum,	34·43	34·57	34·25	34·32	34·60	Pt	98·7
					100·00		285·2

Although the analysis agrees perfectly with the theoretical numbers, and leaves no doubt of the identity of the base, I was desirous, if possible, of obtaining further proof, because small but perceptible differences are found in certain bases when obtained from different sources, although corresponding perfectly in boiling point, composition, odour, and general characters. For the purpose required, no compound appeared more suitable than the very characteristic substance procured by prolonged boiling of the aqueous solution of the platinum salt of pyridine. When ebullition is continued for several days, the salt becomes converted into an insoluble powder, much resembling in appearance sublimed sulphur, and having, according to Dr Anderson,* an analogous constitution to the bi-hydrochlorate of platinamine of Gerhardt. This view, it will be seen, supposes one equivalent of platinum to supply the place of two equivalents of hydrogen, the formula being—

$$\left.\begin{matrix} C^{10}\ H^{3} \\ Pt \end{matrix}\right\} 2\ H\ Cl.$$

* Proceedings Roy. Soc. Edin., vol. iii.

On boiling the platinum salt of pyridine from coal naphtha for four days, a powder made its appearance, having all the physical properties of the substance sought. A platinum determination was all, therefore, that was considered necessary for its identification.

3·195 grains of bi-hydrochlorate of platino-pyridine gave
1·260 ... platinum,

or, per cent.,

Experiment.	Theory.
39·44	39·68

As the crude coal naphtha from which the raw material for the experiment was obtained had originally been distilled over, in an atmosphere of steam at 212° Fahr., comparatively small quantities of the less volatile bases were present; some little labour was necessary, therefore, before the lutidine could be obtained in a sufficiently pure state for analysis. I was unable to procure the base itself quite free from picoline, as the quantity of material boiling as high as 310° was far too small to allow of the requisite number of fractionations. The portion distilling between 300° and 310°, after four rectifications, gave—

		Theory.
Carbon, ...	77·5	78·5
Hydrogen, . . .	8·6	8·4

But, on converting the rest of the fraction into platinum salt, and fractionally crystallizing *in vacuo*, much nearer results were obtained. Several crops of platinum salt procured in this manner gave, on analysis, the following numbers:—

I.	3·395	grains of	platinochloride of lutidine gave
	1·062	...	platinum.
II.	4·905	...	platinochloride of lutidine gave
	1·530	...	platinum.
III.	3·220	...	platinochloride of lutidine gave
	1·010	...	platinum.
IV.	8·830	...	platinochloride of lutidine, same salt as in experiment II., but re-crystallized, gave
	8·680	...	carbonic acid and
	2·652	...	water, and
V.	4·097	...	platinochloride of lutidine gave
	1·290	...	platinum.

	I.	II.	III.	IV. & V.	Calculation.		
Carbon,	...	...	...	26·81	26·81	C^{14}	84·
Hydrogen,	...	...	...	3·34	3·19	H^{10}	10·
Nitrogen,	...	...	...	...	4·49	N	14·
Chlorine,	...	...	...	...	34·00	Cl^3	106·5
Platinum,	31·28	31·19	31·37	31·49	31·51	Pt	98·7
					100·00		313·2

For convenience of comparison I place side by side the numbers obtained on analysis of platinum salts of lutidine from the various sources from which it has been obtained :—

	Dippel's Oil. Dr Anderson. (*Mean.*)	*Shale Naphtha.* Grev. Williams.	*Cinchonine.* Grev. Williams.	*Coal Naphtha.* Grev. Williams.
Carbon,	26·35	26·14	26·94	26·81
Hydrogen,	3·23	3·16	3·36	3.34
Nitrogen,	...	...	...	...
Chlorine,	...	...	...	...
Platinum,	31·50	31·76	31·14	31·49

The next base (collidine) was present in such very small quantity that a great deal of time was occupied before it could be isolated; probably the three quarts of mixed bases did not contain more than three or four drachms. The amount operated on was much less than this (about three-fourths of a drachm); but with care a platinum salt was nevertheless obtained of considerable purity, for different crops gave on analysis the annexed numbers—

I.	6·855	grains of platinochloride of collidine gave	
	7·390	,,	carbonic acid and
	2·365	,,	water,
II.	3·193	,,	platinochloride of collidine gave
	·960	,,	platinum.
III.	3·908	,,	platinochloride of collidine gave
	1·173	,,	platinum.
IV.	5·080	,,	platinochloride of collidine gave
	1·532	,,	platinum.

	I. & II.	III.	IV.	Calculation.		
Carbon, .	29·40	...	...	29·33	C^{16}	96·
Hydrogen, .	3·83	...	...	3·66	H^{12}	12·
Nitrogen, .	...	...	...	4·31	N	14·
Chlorine, .	...	...	...	32·54	Cl^3	106·5
Platinum, .	30·07	30·02	30·16	30·16	Pt	98·7
				100·00		327·2

I annex the results of analyses of the platinum salt of collidine from all the sources from which that base has been obtained except shale naphtha; for in the latter case I was content with the result of the combustion of the base itself.

	Dippel's Oil. Dr Anderson. (*mean*)	*Cinchonine.* Grev. Williams. (*mean*)	*Coal Naphtha.* Grev. Williams. (*mean*)
Carbon, .	28·88	29·30	29·40
Hydrogen, .	3·60	3·55	3·83
Nitrogen, .	...	...	...
Chlorine, .	...	...	...
Platinum, .	30·08	29·99	30·08

With regard to parvoline, the next base of the series, it was impossible to obtain it in sufficient quantity for analysis without an expenditure of time altogether disproportioned to the importance of the result, and as I was sure of meeting with it in the examination, now in progress, of the bases in the dead oil, I was content to let that part of the inquiry remain for the present.

It is evident, therefore, that coal-tar contains members of at least three classes of homologous bases, namely, the pyridine, aniline, and leukoline series; for there can be no doubt that the latter is only one of a group; indeed if leukol be really identical with chinoline, the fact of its being one of an homologous series is conclusively established by the existence of lepidine ($C^{20} H^{9} N$). Even if leukol is proved to be merely isomeric with chinoline, there is little doubt that it will not be found to exist alone; but this point I hope shortly to decide.

It is singular to observe the similarity which exists between the basic products from coal and cinchonine, the chief, perhaps almost the only, distinction of importance being the absence of aniline in the latter case; but if the nature of the substance decomposable by nitric acid existing in the less volatile fractions of the chinoline base mentioned in the paper before adverted to was properly understood, the parallelism would, perhaps, appear even closer than it does. Some experiments I have made, but which are not yet sufficiently advanced for publication, indicate that toluidine or even still higher members of that class of alkaloids, are present among the basic products of the destructive distillation of certain nitrogenous bodies, and it is very far from improbable that in some cases where aniline is absent its place is supplied by one or more of its homologues. It fact it appears to me extremely doubtful whether aniline is the only member of the group to which it belongs present in coal naphtha; this point is now under study.

In my paper on the volatile bases from shale naphtha, I remarked, that although no evidence of the presence of aniline could be obtained, certain fractions gave with chloride of lime a brilliant green tint, and the apparently characteristic nature of the reaction induced me, perhaps too hastily, to apply to the substance giving the coloration a distinctive appellation. My result was also obtained by Dr Anderson, under circumstances which appeared to preclude the possibility of error, I mean after destruction of the aniline present among the crude Dippel bases, by nitric acid, and recovery of the undecomposed alkaloids by distillation with lime. I have also obtained still more marked reactions of vertidine in operating on the crude bases from coal tar. If a little solution of chloride of lime be added to some of the basic fluid mixed, by agitation, with water, the violet reaction of aniline becomes immediately manifest; but, at the same time, distinct patches of a brilliant emerald green appear upon the surface of the fluid, and, on emptying the basin, adhere to the sides, while the violet-tinted fluid from the aniline has little tendency to remain on the dish. Moreover, if the crude bases are heated with nitric acid until the aniline cannot but have been destroyed, on recovering the bases by distillation with an alkali, the fluid gives the green coloration with chloride of lime very distinctly. These reactions, and some other peculiarities of the volatile alkaloids of the pyridine series, as obtained from different sources, are as yet by no means well understood, but they are being actively studied, and can scarcely fail to yield results of sufficient value to repay examination.

Biographical Sketch of the late George Johnston of Berwick.

It does not often happen that the death of one who has occupied the laborious and unobtrusive position of a country surgeon, calls for notice in a strictly scientific Journal; but it would ill become us to pass unmarked the name of the late Dr Johnston of Berwick, whose death has occurred since the date of our last publication. We could have wished that this duty had fallen to the lot of some one better acquainted with those departments of science which Dr Johnston more especially cultivated; and we can pretend to little more at present than a slight sketch of his life and labours as a naturalist. The former was uneventful, and its history may be summed up in few words. Born in a farm-house at Simprin, in Berwickshire, on the 20th of July 1797, he passed his boyhood at the foot of the Cheviot Hills, at Ilderton, in Northumberland, whither his father had removed. Ilderton and its beautiful neighbourhood always retained a favourite place in his memory. A drawing of its church and vicarage ornamented the mantelpiece of his study; and in his latest work, "The Botany of the Eastern Borders," he commemorates, in his own happy style, after an interval of half a century, the remarkable garden of an old French *emigré* who lived there, and whose "Silver and Golden Rods," "Peonies of monstrous size and beauty," and Narcissuses "such as I have never since seen," served thus early to nourish his taste for flowers. From his father's roof he was sent to school, first at Kelso, and subsequently at Berwick, whence he was advanced to the University of Edinburgh. During his residence in this latter place, he lived in the family of Dr M'Crie, the biographer of Knox, who was also a native of Berwickshire; and his medical studies were superintended by Dr Abercrombie, to whom, after the fashion of his time, he was apprenticed. The advantages which he enjoyed from such intimacies were not wasted, and he often referred to them in after life. He also joined the Royal Medical Society, which has always enumerated among its members the *élite* of the medical students and younger practitioners in this city.

At the period to which we refer (1813–18), there did not exist in Edinburgh those encouragements to the study of natural science which are now to be found. There were, indeed, the valuable lectures of Professor Jameson, "never," as Dr Johnston in after years wrote, "mentioned without a mark of respect from one who had the honour of being his pupil;" but the Botanical Professor did little towards exciting that love of the science which distinguished the pupils of his successor. While a student, Dr Johnston gave some attention to botany, but hardly any to zoology; perhaps it was fortunate that so little stimulus was applied to his inclination for these branches, as he was thus enabled to give more undivided consideration to purely medical subjects. That he was a diligent student we know; that he loved his profession none could doubt who ever met him professionally. But after he settled as a medical practitioner in Berwick, in 1818, scientific pursuits served to fill up the vacant time which every beginner must have; and in those leisure hours was laid the foundation of his fame as a naturalist. His attention was first directed to the botany of the district, and the result was the publication, in 1829, of his "Flora of Berwick-upon-Tweed;" a second volume, containing the Cryptogamia, appearing two years later.

At intervals during the early years of his residence in Berwick he published, in Loudon's Magazine of Natural History, a series of papers entitled, "Illustrations of British Zoology." These referred chiefly to the Mollusca, Annelides, and Zoophytes of Berwick Bay; and the value of his descriptions, the accuracy of which was universally acknowledged, was enhanced by equally accurate delineations from the pencil of Mrs Johnston which accompanied them. To these drawings, indeed, he often ascribed much of the scientific utility of his works; and those alone who have made the attempt themselves, or who have at least carefully watched it in others, can appreciate the patience and care expended in portraying those minute creatures. Regret was more than once expressed that these interesting researches should be lost amidst the transitory articles of a magazine, and accordingly, having resolved to direct his attention to the Zoophytes and Sponges, Dr Johnston accumulated a mass of materials, and in 1838 published his "History of British Zoophytes," followed in 1842 by the "History of British Sponges and Corallines." It would be superfluous to mention the estimation in which these works are held, not only in Britain, but on the Continent and in America; in fact they were at once acknowledged as the standard authorities on the subjects of which they treat, and the Zoophytes reached a second and much enlarged edition in 1847. He at one time planned a similar systematic History of the British Mollusca, but seems at once to have dropped the intention on hearing of the proposed publication of Forbes and Hanley. This however did not interfere with his Introduction to Conchology, published in 1850; a more popular work, written in a pleasing and interesting style, characterized by Mr Kingsley in his Glaucus, as a collection of true fairy tales, but at the same time replete with solid information as to the structure and habits of the mollusca. His last publication, like his first, was botanical, viz., the Botany of the Eastern Borders, published in 1853. This was the first volume of an extended work on the entire natural history of the district which he had long been engaged upon, and a reperusal of its pages only deepens our regret that he had not been spared to complete the work, and to expend upon the animals some of that fund of curious and amusing information which is interwoven with his account of the plants of the Border counties, both in relation to the structure and habits of the objects themselves, and also to the popular superstitions and local names and uses belonging to them.

Besides the works above mentioned, Dr Johnston communicated many detached papers to various scientific journals, especially the Magazine of Zoology and Botany, which he, in conjunction with Sir William Jardine and Mr Selby, originated, and to its successor, the Annals of Natural History, of which he was one of the editors. In the Transactions of the Berwickshire Naturalists' Club, he described the Acarides of that county, and furnished catalogues of its mollusca and fishes. This Club, which has proved the parent of many similar associations, owed its origin to him, and the zeal and activity which have hitherto marked its progress, must be in great part ascribed to his constant superintendence. Its meetings, which are held five times during the summer months, afforded almost his only periods of relaxation, and he was seldom absent from them. Few, indeed, could guess from his published works, under what disadvantages they were composed. Engaged in an extensive and too often ill-requited practice, involving rides or drives to considerable distances in the country, it was difficult to pursue steadily any train of investigation, and frequently, after a hurried visit to the sea-shore, snatched during an hour's leisure, just as some novel form had arrested his attention, or some long-expected discovery had rewarded his patience, he was called away for hours, perhaps for a whole day, and ere his return the frail and delicate structure had perished: for he never forgot that his professional cares were his first duty; and very few of those who experienced his most kind and judicious attentions as a physician, were aware of the scientific labours he pursued at the same time, and which were procuring for him a European reputation; and never did any one pursue science from more pure and unselfish motives. His works were not remunerative; he was most frank and liberal in communicating either information or specimens to any one engaged in similar pursuits, and he was destitute of any paltry jealousy of the reputation of others. To those who knew Dr Johnston,—and his circle of acquaintances was very large,—these statements are superfluous. Many can call to mind the readiness with which he replied to their inquiries on any doubtful point which his superior knowledge enabled him to clear up; and his correspondence in this way was very extensive. Nor was a letter from him a mere dry scientific detail, for oftener it contained some kind advice, or was entwined with some quaint and amusing matter from the antiquarian or poetic stores of his own mind. His letters were indeed a true picture of the man; and a selection from those preserved by his friends would form a peculiarly delightful volume.

With all this work as a physician and a naturalist, he combined a more than usual attention to his duties as a citizen.

Esteemed by his fellow townsmen for the urbanity of his manners, his profuse hospitality, and his general intellectual superiority, he for many years was elected to municipal office. He was thrice mayor and twice sheriff of the town, and took a prominent part in the management of its schools and charitable institutions. He took a warm interest in the Mechanics' Institute, and frequently delivered lectures for its benefit, on which he bestowed much time and preparation. When, to these claims on the public esteem and respect, we add the more private obligations conferred by his valued services as a medical attendant, and remember the extent of his gratuitous attendance on the sick poor, we can understand why his death was so universally lamented; but only they who knew him personally can rightly appreciate his loss. He died on the 30th of July last from the effects of a chronic disease of the brain, which had probably been coming on for some time, although it did not appear serious till within a month of his death.

Dr Johnston was a graduate of the University of Edinburgh, and a Fellow of the Royal College of Surgeons; he was likewise presented with the degree of LL.D. by the University of Aberdeen, and he was an honorary member of many scientific societies. The Ray Society originated in a suggestion of his own, the wisdom of which has been amply borne out by the importance and value of the works published by that association.

A Brief Review of the Present State of Organic Electricity. By John Goodsir, F.R.S., Lond. and Edin., Professor of Anatomy in the University of Edinburgh.

The general Theory of Electricity has rapidly approached a consistent form through the labours of recent physicists, and particularly by the researches of Mr Faraday. The hypotheses of one or of two electric fluids, however modified, have been found tenable only so far as they involve the idea of force. In the phenomena of statical as in those of current electricity, there is constantly pressed upon the observer the necessity of admitting two forces, or two forms or directions of a force, inseparable from one another. And thus "the influence which is present in an electrical condition may best be conceived of as an axis of power having contrary forces, exactly equal in amount, in contrary directions." *

This peculiar form of force manifests itself in different kinds of inorganic matter, under circumstances such as friction, change of temperature, magnetic influence, and chemical action.

It is also manifested in organized beings, not only under circumstances in which they stand related to it as masses of mere matter; but more particularly during the actions performed by their component textures and organs.

Electrical science has been hitherto chiefly prosecuted in the region of inorganic nature; and although Volta opened up a boundless field of discovery in the region of inorganic under the influence of organic electricity, the latter still remains comparatively uncultivated.

In the investigation of electrical force as manifested in organic nature, the peculiar economy of the organized being must be taken into account. Each organized being, although dependent on certain external circumstances as the conditions of its existence, is, nevertheless, a system *per se*. Irrespective of those electrical conditions into which it may

* Faraday, Philosophical Transactions; and Experimental Researches in Electricity.

be thrown, through surrounding bodies, or through the medium in which it lives, it undoubtedly contains more or less numerous sources of electrical disturbance, in the numerous processes and arrangements productive of currents, in the structures which collectively constitute its organization. The organized being may be considered *electrically* as a system of electrical currents, excited by electrical arrangements in the disposition of its fluids, textures, and organs.

So far as has yet been ascertained, these electrical currents, with the exception of those produced by the special batteries in the electrical fishes, are not employed in the economy of the being. They are merely necessary consequences of the organic processes carried on by the different structures; and effect, by their arrangement, the distribution of the resulting electricity, and the maintenance of the general electrical equilibrium of the organic system. The detection and investigation of these organic electrical phenomena are, however, important, not only for general electrical science, but also for the elucidation of the organic processes themselves. Residual phenomena, as such electrical disturbances must generally be considered in physiology, will, when investigated, indicate the probable nature of the actions from which they result.

ELECTRICAL PHENOMENA IN VEGETABLES.

Various observers have proved the existence in plants of arrangements which affect the condenser and galvanometer. The experiments of Pouillet* on electricity developed in, or in connection with, young plants in a state of growth, although valuable, present too many sources of fallacy to be available at present. Donné† was the first to point out the opposite electrical conditions of different parts of vegetables. He found the opposite extremities of certain fruits, and even the juices removed from those parts, to be in different electrical states; and thus opened up a new field of organic electricity, which promises, when more fully investigated, to lead to

* "Sur l'Electricité des fluides élastiques, et sur une des causes de l'Electricité de l'Atmosphère." Ann. de Chim. et de Physique, tom. xxxv. 1827.

† "Recherches sur quelques unes des Propriétés Chimiques des sécrétions et sur les courants électriques qui existent dans les Corps Organizés." Ann. de Chim. et de Physique, tom. lvii. 1834.

important results. The most precise information, however, regarding the effect of different parts of vegetables on the galvanometer are contained in two communications by M. Becquerel in the *Memoirs of the French Academy*,* and in a notice by Professor Wartmann in the *Bibliothèque Universelle de Genève*.† The researches themselves are not yet sufficiently advanced to admit of a satisfactory analysis. Indeed, as M. Becquerel observes, the electrical effects are so complex that it is unsafe to draw any conclusion regarding the part which electricity takes in the organic functions. Hitherto, therefore, in his researches, he has considered electricity rather as an effect, serving to elucidate the study of physiology, than as a primary cause of organic phenomena. Much difficulty exists in determining whether certain currents, indicated by the instrument, are primary or derived; and also in ascertaining how far the observed currents are produced by unavoidable injury of texture, and consequent mixing of fluids, by the insertion of the platina electrodes. The progress of animal electricity had, previously to the labours of Du Bois Reymond,‡ been impeded by similar circumstances; and until the electromotor properties of the component parts of vegetables are in some way separately investigated, as those of muscle and nerve have been by the observer alluded to, no solid progress can be looked for in vegetable electricity.

The general arrangement of the parts of a plant, and the functions they perform, indicate the probable direction of the resulting electrical disturbances. The differences in the constitution of the ascending and descending portions of the axis, and of their different transverse segments, naturally indicate the existence of longitudinal currents; while the structural and functional differences between the central and superficial portions of the axis point to transverse or radiating lines of

* "Recherches sur les causes qui degagent de l'électricité dans les végétaux, et sur les courants végétaux terrestres;" and "Memoire sur les effets électriques obtenus dans les tubercules, les racines, et les fruits, au moyen d'aiguilles de platine." Mem. de l'Acad. des Sciences, tom. xxiii.

† "Note sur les Courants électriques qui existent dans les végétaux." Bibliothèque Universelle de Genève, tom. xv. 1850.

‡ Poggendorff's Annalen, and Untersuchungen über thierische Electricität, 1848.

force. Accordingly, all the observations of Donné, Becquerel, and Wartmann, indicate currents, primary or derived, in the longitudinal and transverse direction, in roots, tubers, stems, leaves, flowers, and fruits.

The electrical reactions of the plant, soil and atmosphere.—The soil is in a constant negative, while the air, when calm and free from clouds, is in a positive, electric condition.

According to the experiments of Pouillet,* plants in the later stages of germination, after they have protruded from the soil, exhibit, by the condenser, an excess of negative electricity. The explanation he gives is, according to Becquerel,† probably correct; that the action of the oxygen of the air on the starch of the seed, during its conversion, gives an excess of positive electricity to the air, and of negative electricity to the plant and soil. The electrical effects observed by M. Pouillet, in this first period of vegetation, correspond with the ordinary electrical conditions of the earth and atmosphere.

But according to M. Becquerel's own observations,‡ the electrical relations of the plant to the soil and air are reversed after germination is completed. If the electrodes of the galvanometer are inserted, the one into the stem or branch, or passed through a number of leaves laid together, but still adherent—the other into the soil—the former will exhibit an excess of negative, the latter of positive electricity, in proportion to the humidity of the soil and the succulence of the plant.

It may, therefore, be presumed that in the act of vegetation, after germination is accomplished, the ascending sap, which communicates by means of the root with the soil, conveys to it continuously the excess of positive electricity which it has acquired during its course upwards in its reactions more particularly with the descending sap; while the latter furnishes to the air, by exhalation, its excess of negative electricity.

Vegetation, threfore, produces electric effects contrary to those which render the air and soil respectively positive and negative.

* Ann. de Chim. et de Physiques, *loc. cit.*

† Mem. de l'Acad. des Sciences, tom. xxiii., p. 60.

‡ Ibid., tom. xxiii., pp. 61, 62.

Longitudinal electrical currents in the Dicotyledonous Plant.—Becquerel states,* that if the electrodes of the galvanometer be inserted transversely into the parenchyma of the bark, the one a certain distance above the other, or if one be inserted between the bark and wood, and the other be passed through a number of leaves, superimposed and still adherent, the needle will indicate a current passing from below upwards† through the parenchyma, the upper electrode indicating positive, the lower negative electricity. M. Becquerel accounts for the relative electrical conditions of the green parenchyma from the leaves downwards, by the removal of oxygen.

But the observations of M. Becquerel on the relative electrical conditions of the plant and soil indicate the existence of a descending current passing from the stem through the roots into the earth, which therefore becomes positive around the plant.

M. Wartmann, in the notice already quoted,‡ states that in the roots, the stem, the branches, the petioles, and peduncles, there exist a central descending current, and a peripheral ascending one, which he denominates axial currents; and that the galvanometer indicates currents from every part of the plant, aerial or subterranean, to the soil, which is thus positive in relation to the plant.

From these observations of Becquerel and Wartmann, little doubt can be entertained that electrical currents exist in the dicotyledonous plant, in the course of the circulation of its sap, but in an opposite direction to it.

* Mem. de l'Acad. des Sciences, tom. xxiii., pp. 55, 56.

† The statement of the *direction* of an electrical current is a conventional form of expression, which ought to convey merely an indication of *the relative positions of its positive and negative extremities*, and consequently of the two polar forces, both of which exist in the current. In the circuit formed by the galvanometer the current which traverses its wire, and which deflects the magnetic needle, is conventionally said to pass from the positive to the negative electrode; while in the electromotor portion of the circuit,—*e. g.* a portion of vegetable structure—the current is said to pass in the opposite direction. But "there is never one current of force, or one fluid only." "In a current, whatever form the discharge may take, or whatever part of the circuit or current is referred to, as much positive force as is there exerted in one direction, so much negative force is there exerted in the other."

‡ Bib. Univ. de Genève, tom. xv., p. 302.

Currents passing from within outwards, and from without inwards in the horizontal section of the Dicotyledonous Plant.—According to Becquerel,* if one electrode be inserted into the pith, in a clean horizontal section of a young poplar, and the other into one of the woody layers, or into the bark, the needle is deflected 5°, 10°, 15°, or more, according to the delicacy of the instrument, the succulence of the tree, or the radial distance of the layer into which the second electrode has been inserted; a current from without inwards is indicated, the electrode in the pith being positive, that in the wood or bark negative.

If the one electrode be inserted close to the outside, and the other be removed from the pith, and be reinserted from place to place outwards, the current will diminish in intensity as the second electrode approaches the cambium. Beyond the cambium the current changes its direction and becomes stronger. The current which now deflects the needle passes along the wire from without inwards, indicating a positive electric condition of the outer part of the parenchyma, and a negative condition of the cambium.

On removing a piece of bark, and applying the electrodes, (which in this experiment should consist of platinum plates) to its opposite surfaces, the current becomes very intense. The piece of bark thus forms a voltaic couple, of which the exterior or parenchymatous side is positive, and the interior, covered by the cambium, negative.

It would appear then that, from the pith to the cambium, the woody layers are less and less positive in relation to the pith; whilst from the cambium to the cuticle, the parenchymatous layers are more positive, or at least comport themselves as such in the production of derived currents. This inversion of the electrical effects corresponds with the relative position of the cellular texture in the bark and wood. In the bark, it is on the exterior; in the wood, in the interior; in both it is positive.

In the notice by M. Wartmann, in the *Bibliothèque Universelle de Genève*,† that observer states that "in uniting by

* *Loc. cit.*, p. 44.

† Bib. Univ. de Genève, tom. xv., p. 301.

the galvanometer the layers of the stem where the liber and cambium touch one another (and where many botanists admit a passage of descending juices), either with the most central parts (the pith or the perfect wood), or with the parts more exterior (the young bark), a lateral current will be found tending from these layers to the neighbouring organs."

It would appear, therefore, that currents pass from the contiguous surfaces of the bark and wood of the dicotyledonous plant outwards towards the cuticle, and inwards to the pith; or at least, arrangements exist in these directions which excite currents in the opposite directions through the galvanometer wire.

Currents in the root and its dependencies.—According to M. Wartmann,* in some roots the central structures and the cortical structures are, as in the stem, positive in relation to the layers by which they touch and are united.

Centrifugal transverse currents would appear to exist in certain roots, which resemble tubers in the quantity of their nutritious deposits. For Becquerel† has found the central part of the carrot, and of the red and white beetroot negative in relation to the exterior.

In the potato, in the tubers of the *Helianthus tuberosus* and *Lathyrus tuberosus* currents radiate from the centre to the cuticle; for the electrode at the centre is negative in relation to the other, the latter indicating a more positive condition the nearer it is placed to the cuticle. Becquerel, who has ascertained these facts, and refers them to the system of transverse currents in the bark, states at the same time that in the tubers of *Tropæolum tuberosum*, and *Ullucus tuberosus*, the currents are reversed, and correspond, therefore, with the transverse system in the wood and pith of the dicotyledonous stem.

It remains to be determined how far the single transverse system of electrical currents in either direction, in certain roots, and in tubers, depends upon the disappearance of the central or peripheral elements of the axis.

* Bib. Univ. de Genève, tom. xv.

† Memoire sur les effets electriques obtenus dans les tubercules, les racines, et les fruits, au moyen d'aiguilles de platine. Mem. de l'Acad. des Sciences, tom. xxiii.

On currents in leaves.—The relations and functions of the leaf indicate the probable direction of the electrical currents which may exist in it.

Becquerel's* observations lead to the conclusion that currents set from the cambium to the parenchyma of the leaf; while at the same time it is negative in relation to the pith and wood of the branch and stem. He states that the leaves comport themselves as the green part of the parenchyma of the bark, that is to say, the sap which circulates in their tissues is negative in relation to the wood, pith, and soil; and positive in relation to the cambium.

M. Wartmann† states that in most leaves the currents proceed from the limb of the leaf to its veins, and to the central parts of its petiole, and of the stem.

This centripetal current attributed to the leaf by Becquerel and Wartmann is evidently referable to the central, or descending axial current of the plant; while the centrifugal current alluded to by the former belongs to the superficial transverse system, or that between the inner and outer aspects of the bark.

The electrical condition of the flower.—From the energetic actions and rapid development of the flower, a considerable amount of electrical disturbance is to be expected in it. Various observers have ascertained the remarkable elevation of temperature which occurs during the development of this part of the plant; and the important chemico-vital actions which take place in it must certainly excite corresponding electrical phenomena.

The only observations in regard to these which have been recorded are by Zantedeschi quoted by Becquerel in his second memoir.‡ The Italian observer found that at the period of flowering in the tulip, jonquil, and anemone, a deflection of the needle to the extent of 3° or 4°, due to a descending current, occurs. He also found in an Azalea, an Amaryllis, a white lily, and in various species of Opuntia, a current passing from

* Recherches sur les causes qui degagent de l'électricité, &c. Mem. de l'Acad. de Sciences, tom. xxiii.

† Bibliothèque Universelle de Genève, tom. xv.

‡ Memoire sur les effects electriques, &c. Mem. de l'Acad. de Sciences, tom. xxiii.

the stamen to the pistil; the one electrode being in contact with the pollen, the other inserted into the stigma.

Electrical condition of the fruit.—The only recorded observations on this subject are by Donné,* in a memoir which may be said to have introduced for the first time the subject of vegetable, as well as certain important departments of animal electricity.

Donné found that when the platinum extremities of the galvanometer wire are plunged into certain fruits, the one at the stalk, the other at the opposite end, the parts exhibit different electrical conditions. In the apple and pear a current would appear to pass from the stalk towards the eye at the opposite end; whilst in the peach and apricot the current passes in the contrary direction. In the apple and pear the fruit is electro-positive at the distal end, electro-negative at the stalk; the contrary being the case in the peach and apricot.

Irrespective of the chemical causes to which these currents are ascribed by Donné and Becquerel, it might be well to determine how far their opposite directions may be referable to morphological differences in the two forms of fruit examined: whether in the monocarpel form, as in the peach, the current be not referable to the centripetal current of the leaf; and whether in the apple form (the fleshy mass of which is not a development of the carpellary leaf, but of the cortical layer of the receptacle, and of the end of the peduncle) it is not due to the same causes which produce the general superficial, or cortical axial current in the plant.

Are the currents which affect the galvanometer derived from currents which actually exist in the plant? or are they produced by the insertion of the electrodes?—M. Becquerel expresses himself very cautiously on this point; and blames certain physicists for entertaining inexact ideas regarding the currents obtained from organized bodies by the galvanometer platinum wires; and for assuming that such currents are necessarily derived from other currents which actually exist in the plant. But M. Becquerel adds,† somewhat inconsistently with his own admissions in other parts of his memoirs,

* Ann. de Chim. et de Physique, tom. lvii.

† Mem. de l'Acad. des Sciences, tom. xxiii.

that nothing at present authorizes an induction of this kind. The effects, he states, appear to be due, at least in most cases, to the reaction of different liquids in contact with the electrodes ; from which results such a disengagement of electricity, as that the liquid which comports itself as an acid in relation to the other sets free positive electricity.

At the same time, M. Becquerel admits that the two necessary conditions for the production of primary currents exist in the plant. The first is, that two liquids capable of acting chemically on one another should be arranged so as to do so gradually and continuously, or that there should be, as M. Becquerel expresses it, "le contact des deux liquides per transition insensible." The other is the intermedium of a conducting texture, or substance to complete the circuit. M. Becquerel, accordingly, both in his memoirs* and in his abridgements in the *Comptes Rendus*,† seems inclined to admit the two axial currents, and the horizontal system in the stem and branches of the dicotyledonous plant. Beyond this he appears, at the date of the publication of his memoirs, to have drawn no more precise conclusion from the facts then observed ; and states that the electrical effects which take place in vegetables are so numerous, that it has only been possible hitherto to observe a limited number of them.

M. Wartmann,‡ while he admits that the electro-chemical action, which results from the tearing of the textures during the insertion of the electrodes, produces at first a considerable deflection of the needle, states, at the same time, that when this action ceases, which it speedily does, there remains a more feeble current which must be due to the normal electrical action of the parts. He states that vegetable currents probably form closed circuits ; that the extremities of the root fibres on the one hand, and the terminations of the leaves on the other, establish a continuity between the ascending peripheral and the descending central current ; while the similarity in the electrical condition of the exterior of the bark,

* Mem. de l'Acad. des Sciences, tom. xxiii.

† Comptes Rendus, tom. xxxi–xxxii.

‡ Bib. Univ. de Genève, tom. xv.

and the interior of the wood, probably depends on the medullary rays.

To what actions and arrangements in the plant are its electrical disturbances and currents due?—From what has already been stated, it must appear that the knowledge hitherto obtained of the relations and circumstances of the electrical disturbances and currents in the plant is not yet sufficiently precise to afford a solution of this question. Before the publication of Du Bois Reymond's researches on the electrical actions of muscle and nerve, and of Pacini on the structure of the batteries in the Torpedo and Gymnotus, electrical excitement in the animal body had not been accurately connected with anatomical structure; and until a definite electrical current in the plant is distinctly referred to a demonstrable structural arrangement, a precise determination of the exciting causes of currents in the latter cannot be expected. We are not, indeed, acquainted with the actual chemical or physical causes of electrical excitement in any animal texture or organ; but we now know the direction and relations of the current, in and to the anatomical structure in certain cases. This is a secure step in the proper direction, and one which has yet to be taken in vegetable electricity.

At present, therefore, it can only be stated generally, that the disturbance of electric equilibrium in the textures and organs of the plant is due to the chemical action which plays so important a part in the organic processes—at its surface, as during transpiration, respiration proper, and the fixation of carbon—and in its interior, during the reaction of its ascending and descending sap, with the substances contained in the cells of its various structures. In the same manner, no precise statement can be made at present regarding the arrangements by means of which electrical currents are produced in the plant. The researches of Becquerel* have proved that a current is produced when two liquids of acid and alkaline reactions respectively, and separated from one another by a porous substance, are connected either by a fluid or solid conductor. It is quite evident that similar physical and chemical

* Recherches sur les circuits electro-chimique simple formé de liquides. Comptes Rendus, tom. xxiv.

conditions for the production of currents exist in innumerable forms in the organization of vegetables. It is, however, impossible in the present phase of the subject to define them with greater precision.

Animal Electricity.—The first discovery in animal electricity was the determination of the electrical character of the shock of the Torpedo by Walsh in 1772. The development of the subject has since been retarded, not only by its own intrinsic difficulty, but also by the greater attractions of those departments of general electricity which were opened up by the labours of Volta. Its history presents three distinct lines of research, that of the special electrical organs of the Fish, commencing with the discovery of Walsh in 1772,* that of the electrical properties of muscle and nerve, starting from the fundamental experiment of Galvani in 1786–94,† and that of the electrical phenomena of membranes and glands, introduced by Donné in 1834‡.

The results which have ultimately been attained in these three directions shall now be briefly examined, but in order to obtain a more comprehensive view, they shall be taken up in the reverse order.

Electric Phenomena in connection with Membrane *and* Gland.—The experiments of Donné are now alluded to only because they were the first which proved electric disturbance in connection with secreting membrane and structure. He found that when the electrodes of the galvanometer were applied respectively to the mucous membrane of the mouth, and to the skin, the needle deviated 15°, 20°, or 30°; the former being negative, the latter positive. In the same manner, when the instrument was applied between the mucous membrane of the stomach and the gall-bladder, or interior of the liver, the needle deviated 30°, 40°, or 50°.

Donné attributed these electric effects to the acid and alkaline properties of the secretions with which the electrodes were respectively in contact. Matteucci,§ again, while ad-

* "Of the Electric Property of the Torpedo." Phil. Trans., 1773.

† "De viribus Electricitatis in Motu Musculari Commentarius." Bologna, 1791.

‡ Ann. de Chim. et de Phys., tom. lvii. 1834.

§ Ann. de Chim. et de Phys., tom. lvi.

mitting the correctness of Donné's experimental results, attributed, as Drs Wollaston* and Thomas Young† had previously done, the difference of the chemical composition of the secretions to the electric force itself. It is evident, therefore, that the ingenious conjectures of Wollaston and Young, and the experiments of Donné and Matteucci, merely indicated a promising field of discovery, and formed a prelude to researches which promised more precise results after the structures experimented upon had been more definitely selected.

The Electric relations of Mucous Membrane.—Mr H. F. Baxter has recorded the results of his experiments on this subject.‡ The principal object Mr Baxter had in view was to determine the relative electric condition of the secretions of the mucous membrane, and of its vessels and blood; fulfilling, therefore, what has already been stated as an apparent condition of success in all such inquiries, viz., experimenting, as far as can be, on distinct textures or organs, and not on their aggregations.

The mucous membrane of the stomachs, and of the small and large intestines of the rabbit, cat, and guinea-pig were selected; and pointed and flattened platinum electrodes applied respectively to the surface of the mucous membrane, and inserted into the vessels. The following were the general results—

1. The inside and outside of the gut were formed into a circuit without effect.

2. One electrode on the mucous membrane, the other inserted into an artery proceeding to the same spot, produced no effect.

3. One electrode on the mucous membrane, the other inserted into a vein proceeding from the same spot, indicated a positive condition of the vein or its contents, by a deviation of the needle to the extent of from 3° to 5°.

4. One electrode on the mucous membrane, the other inserted into a vein emptied of its blood, produced no effect.

* Phil. Mag., vol. xxxiii. On the Agency of Electricity on Animal Secretions.

† Young. Syllabus of Lectures on Medicine.

‡ Phil. Trans., 1848. An Experimental Inquiry, undertaken with a view of ascertaining whether any, or what signs of Current Electricity are manifested during the organic process of secretion, in living animals, &c.

5. One electrode applied to the mucous membrane, the other inserted into a vein *not* proceeding from the same spot, produced no effect.

6. It was not necessary to insert the second electrode into the vein, for the needle was deflected if the second electrode was merely dipped into the blood flowing from the vein.

Having ascertained how far the different solid and fluid substances in contact with the electrodes might interfere with the result, and also in what manner the effects were influenced by the death of the animal, Mr Baxter concluded from his experiments, that—

1. When the electrodes of a galvanometer are brought into communication—one with the mucous membrane of the alimentary canal, the other with the blood flowing from the same part—a deviation of the needle takes place, indicating that the secreted product and the blood are in opposite electric states.

2. The effect occurs during the life of the animal, and ceases after its death.

3. The effect may be considered as arising from the decomposition of the blood,—*i. e.*, from the changes which occur during the formation of the secreted product and venous blood.

4. These changes are effected by the organic actions of the part.

The Electric relations of Gland.—In a second paper,* Mr Baxter records the experiments which he had made to determine the electric relations of the secretions and blood of the liver, kidney, and mammary gland. The facts which his experiments tend to establish are as follow:—

1. During biliary secretion, the *bile* and *venous blood* flowing from the hepatic veins, are in *opposite* electric states.

2. During urinary secretion, the *urine* and *venous blood* flowing from the renal vein, are in *opposite* electric states.

3. During mammary secretion, the *milk*, and the *venous blood* flowing from the mammary veins, are in *opposite* electric states.

* Phil. Trans., 1852. An Experimental Inquiry undertaken with a view of ascertaining whether any, or what signs of current electricity are manifested during the organic process of secretion in living animals, &c.

In these experiments on glandular action, as in those described above on the alimentary mucous membrane, the venous blood was found to be positive, producing a deflection of the needle to the extent of 3°, 4°, 5°, 8°, 10°.

The Electric relations of the Respiratory Mucous Membrane, and the Pulmonic Blood.—Mr Baxter having ascertained that the venous blood flowing from a secreting membrane or gland, is in a positive electric condition, applied one electrode in contact with the mucous membrane of the lung, and the other in contact with the blood flowing from it, *i.e.*, the arterial blood. He thus found the blood of the pulmonary veins, or of the left ventricle, invariably positive, producing a deflection of 2°, 3°, 4°, or 5°. At the same time, he ascertained that when the respiratory mucous membrane and the blood of the right ventricle are connected, a deflection of 2°, 3°, or 4°, occasionally occurred. All his experiments tended to the same conclusion, viz., that the blood of the pulmonary veins is positive; and that when a circuit is formed between the mucous membrane of the lung, and the blood in the left ventricle of the heart, a current is produced.

The Electric Properties of MUSCLE.—Galvani having discovered and investigated the contractions produced by electricity in the muscles of the frog,* afterwards observed similar contractions when two dissimilar metals, in contact with one another, are also brought into contact with the nerve and muscles respectively of the frog's leg.† At first he appears to have conceived the contractions to be due to electricity evolved by the metals; but finally he concluded that it is produced by the animal textures themselves. The researches of Volta verified the original opinion of Galvani, that the metals, *when they are employed*, are the sources of the electricity which produce the muscular contractions;‡ but the discovery of the pile, with its consequences, threw into temporary oblivion the actual evidences of an electromotor property of the animal textures *independently on metals*, which the numerous expe-

* De Viribus Electricitatis, &c.

† De Viribus Electricitatis, &c.

‡ Nuova Memoria dell' Electricita Animale, &c.

riments of Galvani and his supporters had afforded.* Even Humboldt's observations did not prevent the almost total neglect of the subject for a quarter of a century.†

In 1827 Nobili,‡ having applied his improved galvanometer to the fundamental experiment of Galvani, discovered the electric current of the frog. He found that, when the circuit of the nerve and muscles of the leg is closed by the instrument, a deviation of the needle to the extent of 10°, 20°, or 30°, occurs, due to a current which passes in the limb from the toes upwards, and which could be increased by inclosing in the circuit several frogs arranged as a battery. There could no longer be any doubt of the truth of Galvani's later opinion, that electricity is developed in connection with muscle and nerve.

The researches of Matteucci, carried on during a transitionary stage of the subject, and exhibiting occasional obscurity and contradiction, are, nevertheless, valuable, not only from having directed attention generally to electro-physiology, but particularly from having, in regard to muscle, indicated that its electric properties are due to its own texture, and not to the conjoined nerves. He had always, however, experimented with masses, or aggregates of muscle, and had not attempted to ascertain the laws of electric action in the muscular fibre or bundle itself, or in a single isolated muscle.§

These laws have been investigated by Du Bois Reymond, who has ascertained that muscular structure presents two distinct electric conditions,—firstly, during the intervals of contractions, and, secondly, during contraction.

Electric condition of a Muscle during the intervals of contraction.—Galvani conceived the outer surface of a muscle to be charged with negative, the inner with positive electricity. Matteucci had found that in order to produce contractions in the galvanoscopic frog, two parts of its nerve must be brought into contact with *two parts* respectively of the muscle of a

* Dell' uso e dell' attivitá dell' arco conduttore nei contrazione de' muscoli. 1793; and Supplimento al Trattato dell' uso, ec. 1794.

† Versuche ueber die gereizte Muskel-und Nervenfaser, u. s. w., 1797.

‡ Ann. de Chim. et de Phys., 1828.

§ Bib. Univ. de Génève; Ann. de Chim. et de Phys.; Traité des Phénomènes Electro-physiologique.

living animal; and that the experiment uniformly succeeded if the nerve touched the bottom of a wound in the muscle and the margin of the wound at the same time. Du Bois Reymond has ascertained the actual relative electric condition of certain surfaces or aspects of the muscular fibre or muscle.* These aspects he denominates the *longitudinal* and *transverse sections.* These sections, again, may be either *natural* or *artificial.*

The *natural longitudinal section* is as much of the surface of a muscle as is formed by the exposed sides of its superficial fibres.

An artificial longitudinal section is any surface exposed by a section in the direction of the muscular fibres.

The surface or side of a fibre or fasciculus viewed as a cylinder or prism is its *longitudinal section.*

A *natural transverse section* is any part of a muscle formed by the extremities of its fibres, coated by tendon of attachment.

An *artificial transverse section* is a section made at right angles to the fibres.

The natural or artificial extremities of fibres are *transverse sections.*

By employing a very delicate galvanometer, and by certain refined precautions in the arrangement of his experiments, Du Bois Reymond found that the *longitudinal section, natural* or *artificial,* is invariably positive in relation to the *natural* or *artificial transverse section.* The following are the general laws of the *derived* muscular current.

1. If any point of the natural or artificial longitudinal section be put into connection, by means of the galvanometer, with any point of the natural or artificial transverse section, the needle will indicate a current in the wire from the longitudinal to the transverse section.

2. If one point of the natural or artificial transverse section of a muscle is brought into connection with another point of the same or of another similar transverse section, and if the points be unequally distant from the centre of the section con-

* "The Law of the Muscular Current," p. 498, vol. i. of Untersuch. ueber Thier. Electricität.

sidered as the base of a muscular cylinder, a current is indicated passing from the electrode furthest from the centre, and directed to that which is nearest to it.

3. If we now consider the mass of the muscle as a cylinder, and connect a point of the natural or artificial longitudinal section nearer the middle transverse section of the mass, with a point of the natural or artificial longitudinal section more distant from the middle, a current is indicated passing from the nearer to the more distant point.

4. If both connected points of one or of two natural or artificial transverse sections be equally distant from the centre of the surface, no current is indicated. So also in regard to longitudinal sections, points equally distant from the middle produced no current.

These laws are most satisfactorily illustrated in the muscles of rabbits and frogs, but they are essentially the same in man, in representatives of the four vertebrate classes, and in molluscs, crustaceans, and annelids.

The electromotor power, which is exhibited in the muscular current, does not depend upon the areolar texture, the tendons or vessels, &c. of the mass; or on the contact of dissimilar textures with the muscular fibre; for the power is exhibited when the smallest manageable portion, or even a single primary fasiculus is employed. The power evidently resides in the ultimate fibre.

Du Bois Reymond has investigated the arrangement of the electromotor elements on which this power depends. After various experiments, he succeeded in constructing a model consisting of a solid copper cylinder, with its cylindrical surface coated with zinc, and suspended in or surrounded by an electrolytic liquid, which fulfilled by means of the galvanometer all the conditions of the current as derived from the natural sections of an entire muscle. He arranged another model, consisting of a number of similar but smaller cylinders, set in longitudinal series, so that the positive or zinc elements were directed laterally, and the copper or negative in the longitudinal direction. A combination of this kind, immersed in a fluid, exhibited by means of the galvanometer not only the currents of the natural section of an entire muscle, but also the currents of its artificial sections. Du Bois Reymond, therefore, concluded, that the conditions of the muscular current are fulfilled by assuming in the muscular mass the existence of electromotor centres, each of which may be conceived to be a molecule consisting of an equatorial positive zone, and two polar negative zones, these molecules being arranged linearly, so that the polar zones are in the direction of the muscular fibre.

These investigations in no way anticipate the *cause of the electromotor property* of the muscular fibre; they bear only on the laws of its action. They leave very little doubt that the muscular substance during its life, and in the intervals of contraction, is in a state of electric tension; and that there are in it an infinite number of electromotor centres in connection with closed circuits, according to the laws already stated; and which must be infinitely stronger than those derived currents which are procured from a muscle, or a portion of it, by means of the galvanometer.

Du Bois Reymond having observed that the current derived from a longitudinal section and from a *natural transverse section* was generally weaker than that from an artificial transverse section, and that it was even occasionally not obtainable when the electric tension of the muscle was much diminished by cold, found, on further investigation, that it was necessary to admit the existence of a layer of peculiar electromotor elements at the ends of the muscular fibres in contact with the tendon. He denominates this the *parelectronomic* layer, as it produces a current opposed to the general muscular current, and must therefore present its positive elements towards the tendon. For the purpose of including this layer in his general theory, he modifies his conception of the electromotor molecules, and illustrates the entire action by a corresponding change in his model. Instead of the molecules being, as he had denominated them, *peripolar*—possessing an equatorial positive and two polar negative zones, he substitutes for each of such molecules a pair of *dipolar* molecules with their positive poles in contact, and their negative directed away from one another. If, now, the *parelectronomic* layer be conceived as formed of one set only of such dipolar molecules, they must necessarily have their positive poles next the tendinous surface.

This hypothesis not only satisfies the general law of the muscular current, but also affords a reason for the counteracting influence of the natural transverse section, and the facility with which it can be removed by any fluid which corrodes or acts upon the muscular fibre, or by the knife.*

The general Muscular current.—Nobili discovered, by means of the galvanometer, that a current passed from the toes towards the head of the frog. If the animal be deprived of its skin, and bent backwards so that its feet dip into one vessel and its snout into another, the vessels being filled with a saturated solution of common salt, and connected by the electrodes, the needle will indicate a current in the galvanometer wire from the head to the feet. According to Du Bois Reymond, the general current may, by certain precautions, be detected even in the undissected frog, although the circuit is partially closed by the skin. This current is the resultant of the currents of all the individual muscles of the frog; for Du Bois Reymond found, firstly, that in some muscles the currents set from head to feet, in others in the opposite direction; secondly, that the electromotor power of a muscle is directly as its length and thickness; and, thirdly, that if two muscles are opposed to one another in a circuit, the thicker or the longer overcomes the other.

This general muscular current must therefore exist in every animal possessing muscular arrangements, at least in the four vertebrate classes. It does not, however, necessarily assume the same general direction in all.†

Electric condition of a Muscle during contraction.—This condition has not yet been accurately determined. Matteucci observed, that when two prepared frog's limbs are so arranged that the nerve of the one lies across the muscles of the other, muscular contraction of the latter induces contraction of the

* The muscular current is investigated at great length, historically and experimentally, in the second and third chapters of section iii. of Du Bois Reymond's "Untersuchungen."

† The fourth chapter of section iii. in the first part of vol. ii. of the "Untersuchungen," treats "Of the influence of Contraction on the Muscular Current."

former. He concluded therefore, along with Becquerel, that during muscular contraction there is an evolution of electricity. But the galvanometer, even when a pile of contracting limbs is included in the circuit, gives no decided indication of a current. Matteucci, indeed, has latterly denied the evolution of electricity during muscular contraction, and is inclined to attribute the secondary contraction to another cause. Du Bois Reymond concludes from his investigations, that during contraction the ordinary muscular current is much diminished, if indeed it does not altogether disappear.

The contraction produced by a single act of excitement of a striped muscle is momentary. Any change, therefore, of its ordinary electric condition during such a contraction is too brief to be satisfactorily indicated by the needle. But if a muscle be included in the circuit of the galvanometer, and if, as soon as the deflected needle comes to rest under the influence of the ordinary muscular current, the muscle be put into a state of continuous contraction, or tetanus, by means of strychnine, or an interrupted electric current, the needle will pass backwards beyond zero, and oscillate unsteadily on the negative side, till the muscular contractility is exhausted. That this negative deflection is not the result of any influence exerted by the current employed to tetanize the muscles, is shown by the fact that it occurs even when precautions are taken to prevent such an influence; and also by its occurrence when the tetanus is produced by strychnine, and other non-electric means.

If, again, an arrangement be made so as to enable the galvanometer circuit to be closed as soon only as the tetanus has commenced, the needle will be found, during the contraction, only to approach zero more or less, instead of passing to the negative side, indicating therefore a *diminution* of the ordinary muscular current.

That this diminution in the ordinary muscular current is not due to an increased resistance to conduction in the muscle from its contracted condition is proved by placing the two corresponding muscles of the same animal, one before the other in the same galvanometer circuit, but reversed so that their currents are opposed to one another, and then tetanizing one of them, for when this is done the current of the other acquires the ascendant.

The negative deflection in the first form of the experiment is due, therefore, neither to invasion of the galvanometer circuit by the exciting current, nor to a change in the direction of the ordinary current, nor to increased resistance to conduction. It is the result of the counter-current produced at the platinum electrodes of the galvanometer during the passage of the ordinary muscular current; and this counter-current deflects the needle negatively as soon as the ordinary muscular current begins to lose its influence on it, through the annihilating effect of the tetanus. The negative deflection is also in proportion to the intensity of the ordinary current, and is, moreover, increased by the negative effect of the parelectronomic layer, which, according to De Bois Reymond, is not affected by the act of contraction.

The diminution or cessation of the ordinary muscular current has been employed by Du Bois Reymond to explain certain curious experiments which he has latterly made. The general muscular current of the frog sets, as has been stated, from the toes to the head of the animal. Now, if one of the legs of a frog be paralyzed by cutting the sciatic plexus, the feet being then placed in the two conducting vessels for the electrodes of the galvanometer, and the animal tetanized with strychnine, it is evident that the ordinary general current will be diminished in the tetanized limb. Under these circumstances, the galvanometer indicates, not only an increase of the upward current in the paralyzed limb, but a downward current in the tetanized one. On the human subject a corresponding experiment may be made. The forefinger of each hand being dipped into the saline solutions along with the electrodes of the galvanometer, no deflection occurs. But if all the muscles of one arm be strongly and continuously contracted, a current is indicated as passing from the finger to the shoulder in the contracted arm, and in the opposite direction in the relaxed one. It is evident that this current is the result of the diminution of the ordinary general muscular current in the contracted arm, and the substitution for it of the closed circuit of the ordinary current of the opposite arm.*

The Electric Properties of Nerve.—The resemblance between many actions of the nervous system and certain electric phenomena has frequently impressed physiologists; but investigations of this subject have been so generally mixed up with that of the electricity of muscle, as to lead to no precise result. Matteucci had failed in obtaining any indication of electric currents in nerves; but, nevertheless, the singular parallelism between the two powers could not be overlooked; and Faraday has pointed out the importance of such considerations in his statements regarding electro-nervous action and reaction. More recently Du Bois Reymond has admitted that electricity and the nervous force are at least equivalents. He was the first to derive electric currents from the nerves, and has procured many most remarkable results from his researches on the subject.

The Electric condition of a Nerve in the intervals of functional activity.—By employing a very delicate galvanometer, Du Bois Reymond has detected the electric current in nerve, and has determined its laws. They are similar to those of the muscular current, having the same relation to the longitudinal and transverse sections; except that as the nerve presents no natural transverse section, the relative conditions of the longitudinal and transverse sections cannot be detected before the nervous cord has been cut across. If a transverse section is in contact with one electrode, and the outer surface of the nerve with the other, the current passes through the galvanometer wire from the latter to the former. The current has the same relative direction whether the transverse section belong to the peripheral or central extremity of the nerve; and, consequently, when a segment of nerve is doubled in the middle, the current passes from the loop to both sections. The currents derived from the natural longitudinal section, that is, the outer surface of the segment of a nerve, are similar to those derived from the outer aspect of a muscle; and there is reason for believing, that if the small size of the

* The general muscular current and the frog-current are treated of in the first chapter of section iii. of the "Untersuchungen."

transverse section did not present an obstacle, it also would be found to be in the same condition of electric tension as a corresponding surface in a muscle.

It is a remarkable and important fact, that no difference exists in the laws of the electric current in the two classes of cerebro-spinal nerves. The motor and sensory nerves, the dorsal and ventral roots of the spinal nerves, and the nerves of special sense, all present the same electric conditions. It is also remarkable that the spinal marrow and brain afford the same results as the nervous cords. The former has its natural and artificial longitudinal surfaces in a positive electric condition, and its transverse in a negative. In the brain the entire surface covered by the pia mater, whatever complication of form or direction it may assume, being morphologically a longitudinal surface, is electrically positive in relation to artificial sections of the organ.

Du Bois Reymond has discovered a very remarkable condition of a nerve produced by the passage of a continuous electric current through a portion of it. If a continuous current be passed along a portion of a separated segment of nerve, it alters the ordinary electromotor condition of the nerve in such a manner as to increase the force of the ordinary current at that extremity of the segment where they correspond in direction, and to diminish the ordinary current at the other extremity where they are opposed. That a new condition of electric tension is induced by the exciting currents along the entire segment, is proved by the galvanometer, which indicates a current in the direction of the exciting current between points equally distant from the middle of the outer surface of the segment, where no galvanometric indications of the ordinary current can be derived.

From the resemblance which this peculiar condition of a nerve bears to the change which Faraday supposes to take place in a wire along which a current is induced by a neighbouring current, Du Bois Reymond adopts the term applied by the former to the induced change, and denominates the new condition of the nerve the *electrotonic* state.

In the electrotonic state the ordinary electromotor elements are evidently polarized, so as to have all their positive and negative poles turned in opposite directions. Du Bois Reymond conceives that the change may be explained by assuming that the ordinary electromotor elements consist each of two dipolar molecules, with their positive poles in contact, and that in the electrotonic condition, one of the dipolar molecules of each electromotor element turns on itself from 90° to 100°.*

The Electric condition of a Nerve during functional activity.—As Du Bois Reymond was the first to detect the ordinary electric current in nerves, so we owe to him the only information we possess regarding the electric condition of a nerve during functional activity. The question to be determined is the electric condition of a motor nerve while it is engaged in transmitting to a muscle the stimulus which induces contraction, and of a sensory nerve while it is conveying to the sensorium the impression produced at its peripheral extremity. In this investigation it was necessary to produce in the nerve that state of continuous activity which is required for overcoming the inertia of the needle. Such a condition may be procured by mechanical or chemical agents, or by the transmission of interrupted electric currents.

A segment of a nerve having been placed so that its longitudinal and one of its transverse sections are in connection with the electrodes of the galvanometer, if after the needle has come to rest at the angle of deflection produced by the nerve current, the other end of the nerve be burned or crushed, the needle will return towards zero a few degrees.

If the extremity of the nerve of a rheoscopic leg be connected with the galvanometer in a similar manner, and the leg itself be confined in one limb of a glass syphon, into which a boiling solution of salt is passed from the opposite limb, the needle will indicate a similar negative variation.

A frog having been fastened down, its sciatic nerve laid bare, cut across at the lower end, and turned up from the thigh, so as to have its longitudinal and transverse sections applied to the electrodes, the needle will exhibit the usual positive

* The greater part of the first division of vol. ii. of the "Untersuchungen" is occupied with the subject of the nerve-current. The statement of the laws of the nerve-current will be found at p. 262, 263.

deflection. If the animal be now tetanized by strychnine; the needle will return towards zero, and continue to oscillate, approaching zero during each spasm, and receding from it in the intervals of muscular action, that is, while the nerves are not engaged in conveying their stimulus of muscular contraction.

From these experiments it appears, that when a motor or sensory nerve is in a state of functional activity its ordinary electric condition is altered, as it no longer affords the same galvanometric indications, the current derived from it being diminished.

Electricity passed through a nerve excites that condition which in a motor cord induces muscular contraction; and in a sensory, common or special, sensation. In order, therefore, to determine the nature of the change which occurs during the functional phase of a nerve, Du Bois Reymond had recourse to electric excitement.

It has already been stated that a nerve is thrown into what has been called the electrotonic condition as long as a continuous electric current passes through a portion of it. Now, as muscular contraction is induced at the closing and opening of the circuit, and at the movements of variation in the density of the exciting current, and as sensation also occurs most vividly under similar conditions, it was necessary to examine the electrotonic state, as produced by variable or intermitting currents. For, as a variable or alternating electrotonic state promised the greatest resemblance to a state of continuous functional activity, its investigation might be expected to throw some light on the change which takes place in the ordinary electric condition of a nerve when it is thrown into action.

Du Bois Reymond found that the galvanometer as distinctly indicated positive and negative variations in the currents which passed through it, when these currents were derived from the extremities of a segment of nerve which was in an intermitting, as when it was in a continuous, electrotonic state. When, however, the interruptions of the exciting primary current become very frequent, the negative variation of the derived currents becomes more marked, and even the positive variation diminishes. It appeared probable, therefore, that by producing the electrotonic state of the nerve by rapidly alternating currents, the negative condition already indicated might be increased. It was consequently found that if, after the needle had come to rest in the deflection by the ordinary nerve current from either end of the segment, a rapid series of alternating currents be transmitted through a portion of the cord from an induction coil (in which each primary current induces an opposite in the other wire), the needle returns to zero.

These experiments appear to prove, that when a nerve is completely excited or tetanized by electricity, its usual electromotor power is diminished or in abeyance; and as a similar loss of electromotor power also accompanies intense functional excitement from ordinary agents, Du Bois Reymond conceives this negative electric condition to be in some manner related to the motor or sensory functional power of the nerve.*

To what is the polarization of the nerve, when in a state of functional activity, due?—A nerve is thrown by a current of electricity into an electric condition apparently similar to that in which it is during excitation by its normal stimuli. Is its natural action due therefore to electricity? Is its natural electrotonic condition similar to its so-called artificial condition? Is it induced by an electric current? Du Bois Reymond's opinions on this subject are guardedly expressed.† He holds the so-called nervous principle and electricity to be similar or alike. A nerve in action is in an induced electrotonic state; and exhibits a consequent amount of negative variation of its ordinary electric current. The source of the inducing current is not stated; but its direction may be conceived as resulting, during its influence, from the direction and extent of the rotation which occurs in one or the other of the two dipolar molecules, of which the presumed ordinary peripolar electromotor elements consist, and on which the or-

* Chap. vii. of the Second Division of vol. ii. of the "Untersuchungen."

† See p. xv. of the Preface of the "Untersuchungen," in which Du Bois Reymond states that the electricity in muscle and nerve will probably ultimately prove to be not the mere consequence of their organic processes and actions, but the actual source of their activity.

dinary current of the nerve depends. The induced current will be more or less directly centrifugal or centripetal as long as the inducing current or power rotates the peripheral or the central dipolar molecule in each pair of double electromotor elements in the series, round an arc of from 90° to 180°.

The Electric relations of Centrifugal and Centripetal Nerves are identical.—It would appear to be an important result of Du Bois Reymond's electro-physiological researches that motor and sensory nerves exhibit no difference in their electrical relations. The electrotonic condition can be induced in either direction. It may consequently be inferred that a motor nerve is capable of conveying its mere influence in either direction, but effectively only when it terminates in a muscle. On the other hand, a sensory nerve is capable of conveying its impression both ways, but with effect only when it reaches a sentient centre. In so far as the investigation has been carried by employing electricity as the exciting agent, Du Bois Reymond draws the following conclusions from his experiments, "that in both kinds of nervous fibres the innervation advances in both directions with equal facility." *

The Law of the Excitation of Nerves by the Electrical Current.—When a uniform current is transmitted through the nerve of the prepared limb of a frog, the leg contracts only at the closing and opening of the circuit. In order to keep up the contraction, or to produce a tetanic condition of the muscles, the current must be variable or intermittent. The action of a muscle is not, therefore, equivalent to the strength of the electric current which may be transmitted along its nerve, but to the variations in it. The law is thus expressed by Du Bois Reymond, "It is not the absolute value of the density of the current in a motor nerve which corresponds to the contraction of the muscle; but the variation in this value from one moment to another, the excitation being greater the greater and quicker the variations in a given time."† This law is also illustrated by the so-called secondary contractions, which are produced by bringing the nerve of the prepared frog's limb into contact with a muscle during its contraction.

* "Untersuchungen," vol. ii., p. 590.
† "Untersuchungen," vol. i., p. 258.

If the nerve is laid upon a muscle which is in a tetanic condition, however produced, the muscles of the limb become tetanized also. This secondary tetanus is the result of that alternating negative variation which the ordinary muscular current undergoes during continued contraction.

The nerves of sensation, like those of motion, are more particularly affected at the closing and opening of the circuit, and by variations in the current; but they would also appear to be capable of excitement by a constant current.*

The organized being may be considered electrically as presenting a system of electrical currents, excited by arrangements in the system of its fluids, textures, and organs; the two systems representing each other. The electric disturbances and currents in the Microcosm are represented by similar but grander phenomena in the Macrocosm. These phenomena coincide in both cases with the disposition of component parts, and rank with other forms of material force alternately as causes and effects. But the Organized Being is, moreover, subordinated to those indwelling psychical powers and impulses by which it enjoys its prescribed freedom.

THE SPECIAL ELECTRICAL APPARATUS IN CERTAIN FISHES.—The only animals in which undoubted special electromotor organs have been detected are certain fishes, of which the most remarkable are the Torpedo, Gymnotus, and Malapterurus. These animals, by means of peculiarly adapted apparatus, can excite, under the influence of the nervous system, voluntary electric currents of great power in definite directions, but of only momentary continuance.

The general structure of the Electrical Apparatus in the Fish.—The electrical apparatus in the fish consists of three parts—the battery, the nervous centre, and the nerves. The battery may be described, in general terms, as consisting of a very large number of laminæ of vasculo-nucleated texture, largely supplied with centrifugal nerve fibres, which are distributed on one of their surfaces only. These laminæ are so arranged in reference to one another, and to thin intervening

* "Untersuchungen," vol. i., p. 283.

layers of fluid, as to constitute a uniform series in the order, nerve surface—vasculo-nucleated surface—fluid—nerve surface—&c.

The nervous centre consists of a portion of the cerebro-spinal axis developed in relation to the large nervous supply contributed to the battery, and so organized as to be subject to the influence of the will, as well as capable of reflex action.

The nerves are centrifugal, referable apparently to the motor series. They are connected at one extremity to the nervous centre of the apparatus; and are distributed at the other to the nerve surfaces of the laminæ of the battery.

The Electrical Apparatus in Torpedo.—In Torpedo there are two batteries which occupy the two spaces between the pectoral fins, the head, and gills. Each battery consists of a number of hexagonal, pentagonal, or tetragonal prisms, which vary in number from 400 to upwards of 1000, according to the age of the animal. The prisms extend perpendicularly between the dorsal and abdominal integument; and are separated from, and connected with it, by a thin but dense aponeurosis, which at the same time separates them all from, and connects them with one another, by passing inwards in single layers, so as to form a continuous series of prismatic aponeurotic compartments, in the interior of which the prisms are situated. Each prism consists of delicate, horizontal, super-imposed laminæ, separated from one another by thin layers of fluid, so that the arrangement bears a general resemblance to a galvanic pile. It has hitherto been supposed that the laminæ are connected by their margins with the aponeurotic wall which surrounds the prisms; but Pacini has lately shown that the laminæ are attached by their angles only to the corners of their aponeurotic sheaths; and that an entire pile may be removed from its containing cavity, by cutting the four, five, or six series of attachments by which it is fixed.* It is extremely important that the structure of the laminæ should be determined. Valentin states, that each lamina consists of a thin

* Sulla Struttura intima dell' organo elettrico del Gimnoto, e di altri pesci elettrici, 1852.

prolongation of the aponeurotic wall of the pile, covered above and below by an epithelial layer, and affording a matrix for the ultimate divisions of the vessels and nerves, which, he is inclined to believe, are so arranged, that the terminal nervous plexuses are placed towards the upper, the capillaries towards the lower surface.* Savi describes the elementary filaments of the nerves as forming a network by anastomosis in the lamina;† but Rudolph Wagner has shown, that each elementary filament, enveloped in a very thick sheath, divides at once into twelve to twenty-five secondary filaments, which passing towards the laminæ, splitting into two or three ternary filaments, and losing their envelopes and dark contours, disappear in the soft, dotted, nucleated substance of the laminæ, without forming meshes.‡ Pacini has lately made a most important addition to Wagner's description of the laminæ.§ The laminæ, or electrical diaphragms, as Pacini terms them, are attached, as has already been stated, by their angles only. The vessels and nerves enter at these points, but so as to be at first placed on the under surface of the diaphragm, and therefore in the fluid interposed between that surface and the upper surface of the diaphragm below. Passing inwards and ramifying in this fluid, they ultimately pass up to the under surface, and the nerves are distributed *on that surface only*, of the diaphragm to which they belong. Now, as the dorsal surface in Torpedo is positive, and the abdominal surface negative, it follows, as Pacini has indicated, that the upper surface of each electrical diaphragm, consisting only of soft, dotted, nucleated vascular texture, is positive, while the under surface, on which the nerves only ramify, is negative.

Pacini was led to the observation of the position of the nerves in the electrical diaphragms of Torpedo, by the more complex structure which he had previously discovered in the corresponding parts of Gymnotus.

The four nerves distributed to each battery of Torpedo, are

* Electricität der Thiere, in Wagner's Handwörterbuch der Physiologie.

† Matteucci and Savi, Traité des Phenomènes Electro-Physiologiques, 1844.

‡ Annales des Sciences Naturelles, 1847.

§ *Loc. cit.*

branches of the fifth and eighth cerebral pairs; the nervous centre of its electrical apparatus is therefore situated in the medulla oblongata, and consists of a large lobe on each side of its anterior part. Valentin† states that these lobes consist of nucleated cellules so large as to be visible to the naked eye. The anterior or trigeminal electrical nerve is derived from the non-ganglionic portion of the third division of the fifth; the three posterior or vagal electrical nerves pass out along with the branchial divisions of the eighth nerve, but have no connection with the ganglionic masses developed on the branchial nerves. These electrical nerves belong, therefore, to the non-ganglionic series, with central relations similar to those of motor nerves.

Gymnotus possesses four batteries, which extend nearly the whole length of its eel-like body, from behind the pectoral fins to the extremity of the tail; forcing the lateral muscles towards the dorsal, and the comparatively small abdominal viscera, with the anus, towards the cephalic region. The great or dorsal batteries are separated from one another above by the vertebral column, great vessels, displaced lateral muscles, and the air-bladder; below by a mesial aponeurotic septum, along which the nerves pass to the batteries and ventral fin. Laterally these dorsal batteries are intimately connected with the skin; and inferiorly are separated from the ventral, or small batteries, by a thin layer of muscle. The small batteries are, moreover, separated from the skin by the laterally displaced muscles of the ventral fin; but are intimately connected with one another by a thin aponeurosis only. These small batteries are, therefore, peculiar, not only in their close approximation, but also in being enveloped in muscular substance.

The batteries in Gymnotus consist of a number of piles placed horizontally in a direction from head to tail. From this circumstance, as well as from their peculiar structure, they are aptly compared by Rudolphi to galvanic troughs. These troughs are in the form of flattened masses, separated from, but connected with one another by aponeurotic septa, which diverging, extend outwards from the inner to the outer aspect

* Electricitat der Thiere, in Wagner's Handwörterb.

of each battery. It is not easy to determine the exact number of the piles or troughs in a battery, as they vary in number in different parts of it, and are lost as they pass backwards and downwards. From the statements of Mr Hunter* and Valentin,† the number of troughs in the great battery ranges from thirty to sixty; in the lesser from eight to fourteen. Hunter,‡ Rudolphi,§ Knox,‖ Valentin,¶ and all observers previous to Pacini, state, what may be easily verified, that the troughs in Gymnotus consist of numerous perpendicular laminæ, which extend transversely between the aponeurotic septa, with fluid interposed, as in the piles of Torpedo. Pacini's account** of the structure and relations of the electrical laminæ or diaphragms of Gymnotus is much more precise; and elucidates in a remarkable manner a structure hitherto sufficiently obscure. The more important features of Pacini's account may be thus described. Each of the electric diaphragms in Gymnotus, instead of being, as in Torpedo, a single lamina with the nerves distributed on one of its surfaces, consists of two laminæ, with a thin layer of fluid interposed. The posterior of these is a delicate, wide-meshed, fibrous layer, in which alone the nerves ramify; the anterior consists of a thicker layer of the peculiar vascular, dotted, nucleated texture, which forms the laminæ in Torpedo. Both surfaces of the vasculo-cellular layer present an arrangement of prominent, close-set, undulating ridges, with thick, rounded, nucleated margins. The ridges are more fully developed on the anterior than on the posterior surface of the layer, and from the ridges of the latter a number of thread-like prolongations pass backwards through the interposed fluid to the fibro-nervous layer, so as to connect the two layers as one compound lamina. From the measurements and calculations of Pacini, the superficial extent of the anterior surface of the vasculo-nucleated layer is increased by this ridged structure from five to six times, the posterior about twice.

* "An Account of the Gymnotus Electricus," Phil. Trans. 1775.

† *Loc. cit.* ‡ *Loc. cit.*

§ Uber die electrischen Fische in Abhand. der Akad. zu Berlin, 1822.

‖ Edin. Jour. of Science, 1824.

¶ *Loc. cit.* ** *Loc. cit.*

The electromotor series, therefore, in Gymnotus, instead of simple laminæ, as in Torpedo, consist of compound laminæ separated by layers of fluid. There are thus two kinds of fluid in the electro-motor series of Gymnotus—firstly, that between the vasculo-cellular layers and the fibro-nervous, and which must be considered as an element of each compound electric diaphragm; and, secondly, that between any two electric diaphragms, which is the homologue of the fluid layer in Torpedo. As the current in Gymnotus passes from before backwards, Pacini demonstrates the vasculo-cellular layer the positive, and the fibro-nervous layer the negative element of the electromotor couple.

The batteries of Gymnotus are supplied by about 224 pairs of nerves on each side.* These are all derived from the inferior or motor roots of the spinal nerves; none being supplied by the lateral nerve, or combined branch of the fifth and eighth. The spinal cord exhibits no peculiar development, nor indication of the existence in it of a series of electrical nervous centres; but Valentin† has described a great lobe springing from each side of the brain between the peduncle of the cerebellum and the mesocephalon, extending upwards and forwards with its fellow of the opposite side, like an anterior or supplementary cerebellum. These lobes, according to Valentin, exhibit no trace of the large characteristic nucleated cells which exist in the electrical lobes of Torpedo. Whether the electrical lobes in Gymnotus be peculiar developments of the cerebellum, or of the grey matter at the cerebral extremities of the motor columns of the spinal cord, they present a highly interesting arrangement.

The Electrical Apparatus in Malapterurus.—The batteries are two in number, separated, but at the same time intimately connected to one another in the mesial plane along the dorsal and ventral margins of the body, so as to form a continuous layer of a gelatinous consistence closely adherent to the skin, and inclosing as in a sac the entire animal except the head and fins. In the Malapte-

* J. Hunter, Phil. Trans., 1775. Rudolphi, Abhand. der K. Akad. zu Berlin, 1820.

† Wagner's Handwörterb. *loc. cit.*

rurus of the Nile, of which species only dissections have hitherto been published, a subjacent areolar, laminated, fatty layer has been described, as a second and deeper electrical apparatus.* Pacini, however, has shown that this presumed deep electrical structure consists principally of fat, and probably acts as an insulator to protect the fish from its own shocks: the electrical currents being presumed to pass from within outwards—that is, through any point on the surface of the body.† The determination of the intimate structure of the battery of Malapterurus is extremely difficult. Before Pacini, no precise description of it had been attempted. He represents the structure as consisting of octahedral cellules, or alveoli: a form which, in some measure, accords with the presumed direction of the currents through the electromotor mass. Professor Ecker, in a communication contained in Siebold and Kölliker's *Zeitschrift*, states that Dr Bilharz was then engaged in Egypt in the anatomy of the Nilotic species, and that he conceived he had determined the alveoli of the electromotor layer to be lenticular in form, with their surfaces directed forwards and backwards. He would appear to have observed that they are arranged, not in antero-posterior series, but alternately, so as to constitute decussating series, and to afford in certain sections the octahedral form attributed to them by Pacini. He also states, that these lenticular alveoli consist of a fibrous membrane, covered by a very fine layer, on which the nerves are disposed.‡

The presumed deep electrical layer of Malapterurus, which is merely a fatty mass, is supplied by branches of the spinal nerves; but the true electrical organs or batteries are supplied, the one on each side, by a longitudinal nerve, accompanied by an artery and vein, which pass along on their mesial aspects. This nerve was formerly considered to be a branch of the eighth pair; but Pacini§ describes it as derived from the first

* St Hilaire, Annales de Museum, tom. i.; Rudolphi, Abhand. Berl. Akad. 1824; Valenciennes, An. des Sci. Nat., tom. xvi.

† Sopra l'organo elettrico del Siluro elettrico del Nilo, etc. negli Annali delle Sci. Nat. di Bologna, 1846.

‡ Zeitschrift für wissenchaftliche Zoologie. July 1854.

§ Sopra l'organo elettrico del Siluro elettrico del Nilo, 1846.

spinal nerve. Ecker has more recently stated* that, according to Bilharz, " the electrical nerve on each side appears to be a new element intercalated between the third and fourth spinal nerves." From the same communication it appears that Bilharz has found the trunk of the electrical nerve of the Nilotic Malapterurus, to consist not of a bundle of ultimate filaments, but of one such filament only, one-fourth of a line in diameter, surrounded by three fibrous sheaths, so as to present an entire thickness of one line. From this remarkable structure, Ecker has suggested to Bilharz further observations to determine whether the nervous centre of the electrical apparatus in this fish may not be a colossal unipolar nerve cell. From the peculiar structure of the trunk of the nerve, it is also evident that its branches and twigs of distribution must be subdivisions of the original single filament; in this respect resembling the subdivisions of the ultimate filaments in Torpedo, as observed by Wagner.

The presumed Electrical Apparatus of the common Ray.—The electromotor power of this apparatus has not been experimentally determined; but as the structure of the two organs contained in the tail of the animal is strongly corroborative of the opinion entertained by their discoverer, Dr Stark, that they are batteries;† and as the relations of their elements illustrate those of the batteries of Torpedo and Gymnotus, as determined by Pacini, they may be briefly stated. On each side of the tail of the skate (Raia), partly in contact with the skin, but chiefly enveloped in the so-called sacro-lumbalis muscle, is an elongated fusiform mass, which exhibits all the structural characteristics of an electrical battery. The mass consists of a number of longitudinally and somewhat spirally arranged series of discs, the series being separated from and connected with one another by thicker, the discs by thinner layers of areolar texture. The discs are somewhat triangular, quadrangular, or pentangular in form; and are invariably arranged so that their two large surfaces or faces are directed, the one backwards, the other forwards; and their three, four, or five smaller surfaces or margin enter into the formation of

* Siebold and Kölliker's Zeitschrift, Jul. 1854.

† Proceedings of the Royal Society of Edinburgh. Dec. 1844.

the surface of the series to which they belong. Of the two large surfaces, the anterior, or that towards the head of the animal, is smooth and slightly convex; the posterior slightly concave, and presents numerous alveolar depressions of various but graduated sizes, which penetrate two-thirds through the disc, and are separated from one another by corresponding straight or slightly curved partitions, which diminish in size as they pass off from three or four primary ridges, which radiate from near the centre of the surface, and thus separate the alveoli into larger and smaller elliptical or angular groups. The discs consist of jelly-like dotted or granular nucleated substance; the granules being arranged in the form of spheroidal shells around clear spaces, in each of which a nucleus is situated. The ultimate ramifications of the vessels and nerves are situated not *in* but *on* the two large surfaces or faces of the discs; the former on the concave, alveolar, or posterior face; the latter on the convex, smooth, anterior face; and like the vascular and nervous trunks and branches of the organ, lie in the midst of the areolar texture, which forms the greater and lesser laminæ of separation and connection of the constituent series and discs of the battery. The ultimate arterial twigs enter the areolar texture which lines the concave face of each disc; and pass into the alveoli as bundles of looped capillaries; which are continued into similarly arranged venous radicals. A number of ultimate nervous filaments spread from one of its margins through the areolar lamina, which clothes the convex face of each disc, and preserve their double contours, until becoming somewhat narrower, they divide into two or three secondary filaments, which pass into corresponding secondary divisions of neighbouring filaments. The smooth convex surface of each disc is thus covered by an areolar lamina, which contains a net-work of ultimate branching and anastomosing nerve filaments; the secondary or division filaments, which form the boundaries of the meshes of the net-work, having a peculiar festooned or looped and fusiform aspect, with a mass resembling a nucleus in the centre of each.

The organs are supplied by numerous nervous twigs, derived from the ventral or motor roots of the spinal nerves of the corresponding portion of the tail. These are distributed, as already stated, on the anterior faces of the discs, and do not exhibit at their spinal extremities any appreciable central development.*

The successive opinions which have been entertained regarding the action of the Electric Organ.—Walsh concluded that the electricity of the Torpedo is entirely due to the batteries; that their upper and under surfaces are capable, from a state of electric equilibrium, of being instantly thrown *by a mere energy* into a plus and minus state, like that of a charged phial; and that the current results from a conducting medium between their opposite surfaces being supplied naturally or artificially. Galvani originally, Becquerel subsequently, and latterly Matteucci, conceived the batteries to be charged by electricity developed in the brain, or central organ of the apparatus. Rudolphi considered the perpendicular prisms in Torpedo as galvanic piles, the horizontal series in Gymnotus as trough arrangements; but without entering into the details of the comparison. This view of their action does not explain the intermittent and voluntary character of the electric discharges. For, as Valentin has stated, the organs in the fish cannot be complete galvanic batteries, or they would be continually charged, and a current would follow every suitable closure of the circuit. Valentin proposes the following theory of the apparatus. He assumes the structure of the battery to be a series of closed spaces; the series enveloped in thicker, the spaces separated by thinner aponeurotic laminæ; each space being lined by a vascular epithelium, under which the nervous plexuses lie; and filled with fluid. He supposes that there results from the organic or nutritive reactions of the circulating blood, the epithelium, and the contained fluid of each space, a certain amount of electric force, not, however, sufficient to overcome the insulating obstacle opposed to it in the aponeurotic walls: all the spaces in the battery are, therefore, so far only insulated electrical spaces. As soon, however, as the will of the animal determines a flow of nervous force into the spaces, the organic re-

* Robin. sur un appareil qui se trouve sur les poissons du genre des Raies. Ann. des Sci. Nat., 1847.

actions become so much exalted, that the resolved electric force overcomes the insulating power of the laminæ, and a current is produced; the current being confined to the series by their thicker aponeurotic walls.* This theory, although it may account for a sudden increase of electricity in the organ, affords no explanation of its progressive character; the current is not accounted for.

The theory which most satisfactorily combines the anatomico-physiological as well as the electrical phenomena of the apparatus, is that lately propounded by Professor Pacini of Florence.† Having discovered the important anatomical fact, that the nerves are distributed on one surface only of the electrical elements of the battery, while the vessels and nucleated cellular texture occupy the other; he finds in these structural peculiarities the condition which is wanting in Valentin's theory, to explain the progression of the electricity. Pacini refers the electrical batteries in the fish to two forms of structure, and two modes of action; of the first and simplest form the Torpedo affords the type, of the second and more complicated, the Gymnotus. The batteries of Malapterurus are probably referable to the form in Torpedo, those of Raia certainly to that in Gymnotus. In the Torpedo, according to Pacini, the action is analogous to that which takes place in a thermo-electric pile, inasmuch as he conceives it to depend upon a peculiar dynamical difference in the condition of the two surfaces of each diaphragm of this binary type of pile. The nerve surface and the vasculo-cellular surface of the electric diaphragm correspond to the bismuth and copper, or bismuth and antimony elements of a thermo-electric arrangement; the nervous influence in the former taking the place of the heat applied in the latter. There is here assumed, what on other grounds is highly probable, that the electrical and nervous forces are correlative; and here it must be admitted that in Torpedo, as pointed out by John Hunter,‡ the bulk of the nerves in relation to the batteries, is much greater than in Gymnotus, which exemplifies Pacini's

* Electricität der Thiere in Wagner's Handwörterbuch.

† Sulla struttura intima dell' organo elettrico del Gymnoto, e di altri pesci elettrici, 1852.

‡ Phil. Trans., 1773.

second or *ternary type* of animal battery. When the Torpedo, therefore, wills a shock, or when, through the reflex action of its electrical nervous centre, a shock is induced, a sudden and copious nervous influx flows over the under surfaces of its electric diaphragms, the upper surfaces are thrown into an opposite electrical condition, and a current is the consequence.

Pacini refers the structure of the battery in Gymnotus to a ternary type. This type presents a negative element, which consists of the fibrous layer on which the nerves ramify, together with the fluid which it bounds below; a positive element formed by the ridged vasculo-cellular layer, and the conducting inter-diaphragmatic fluid. The vasculo-cellular layer predominating in this ternary type over the nervous, Pacini conceives the electricity to be evolved in the organic actions of the vasculo-cellular layer under the influence of the nerves. In other words, the will of the Gymnotus, or the reflex action of its electrical nervous centre, directs an influence along the nerves of its batteries over the fibro-nervous layer, which suddenly exciting the nutritive or other organic actions of the highly developed vasculo-cellular layer, an electrical disturbance is produced, with an opposite electrical condition of the fibro-nervous and vasculo-cellular layers of the diaphragms, and, consequently, a current through the series. Pacini compares the wide-meshed fibrous layer, on the under surface of which the nerves ramify, to the hollow cylinder of porous clay, which in a Bunsen's or a Grove's galvanic arrangement, separates the negative from the positive elements.

The Batteries of the Fish are independent electromotor structures.—From the observations of Pacini, the terminations of the nerves appear to form important elements in the structure of the battery. On physiological grounds, however, it appears probable that the peculiar texture of the electric diaphragm, is itself the seat of the electromotor power. As an ultimate muscular fibre contracts, although entirely separated from the nerve, it remains to be determined whether an appreciable electric discharge cannot be procured from an isolated element of the battery. If so, it may be presumed that the force which in the form of a contraction is elicited from a muscular fibre by the influence of a motor nerve is replaced by electric force, when the same kind of nerve influences an ultimate element of the electric structure. The laws of the electromotor power of the electric organ cannot be determined by experiments on its entire mass, or on rudely separated portions of it. The parts must be selected and removed on precise anatomical and physiological principles; and as Du Bois Reymond has stated his intention of investigating the electrical organs of the fish, his previous researches show that he will be guided in his proceedings by such considerations.

If the battery is separated from its nervous centre by section of the trunks of all the nerves which supply it, it will still afford discharges if the nerves are irritated; and the different portions of the organ, even the smallest, will do so likewise if the nerves which are distributed to them be similarly treated. Matteucci, who has latterly admitted that the nervous centre is not the source of the electricity in the fish, states, that if even a minute fragment of the battery of the Torpedo is irritated by a spiculum of glass, it will yield a discharge.*

Peculiar Character of the Electricity evolved from the Batteries of the Fish.—The nature of the force evolved from the batteries of the fish is evinced by the shock and spark, by its influence on the galvanometer, its magnetizing and heating powers, and its chemical action. The absolute quantity of electricity which the animal can put in circulation at each effort is enormous. For as it can decompose water, and form magnets, it must greatly exceed the quantity which can be produced by any ordinary electrical machine. It is probable, therefore, that the animal has the power of continuing the evolution for a sensible time; so that its successive discharges rather resemble those of a voltaic arrangement intermitting in its action than those of a Leyden apparatus charged and discharged many times in succession. At the same time the power is one of low intensity, so that a dry skin wards it off, though a moist one conducts it.†

It is remarkable that the electric fishes, although affected

* Traité des Phénomènes Electro-Physiologiques, &c.

† Faraday. Researches in Electricity, vol. i. p. 101.

like other animals by ordinary electric shocks, do not appear to feel the electric discharges which are produced by themselves, or by other individuals of the same species.

The condition of the water which surrounds the Fish at the moment of discharge of the Electric Organs.—At the moment of a discharge in water, the currents between the opposite surfaces of Torpedo, or between the ends of Gymnotus, instead of being confined to a transverse area of limited extent, as when they pass along a wire during a discharge in air, must be diffused through a considerable extent of the water surrounding the fish. The entire current force of the batteries must, in fact, be subdivided into numerous subordinate axes of force arranged in lines which come round the margins of Torpedo from back to belly, and along the sides of Gymnotus from head to tail. There is therefore at the moment of discharge an atmosphere of power around the fish which, in the language employed by Mr Faraday in reference to the magnetic force, may be considered as disposed in sphondyloids determined by the lines, or rather shells, of force. "The magnet, with its surrounding sphondyloid of power, may be considered as analogous in its condition to a voltaic battery immersed in water or any other electrolyte, or to a Gymnotus or Torpedo at the moment when these creatures, at their own will, fill the surrounding fluid with lines of electric force." It is evident, therefore, that another fish placed so that its antero-posterior axis is in the direction of lines of inductive action in the water, will be affected less powerfully by the circulating electric power than if it were placed across these lines. Mr Faraday* found that while the Gymnotus can stun and kill fishes which are in various positions in relation to its own body, it can, moreover, by throwing itself so as to form a coil enclosing the fish, the latter representing a diameter across it, so concentrate its currents of one side as to strike it motionless as if by lightning. The Torpedo would also appear, from the observations of Dr Davy, instinctively to elevate or arrange its margin so as to adjust the direction of its currents to the position of the object through which it wishes to pass them. "Thus," as Mr Faraday observes,

* Phil. Trans., 1839.

"the very conducting power which the water has, that which it gives to the moistened skin of the fish or animal to be struck, the extent of surface by which the fish and water conducting the charge to it are in contact, all conduce to favour and increase the shock upon the doomed animal."

Supplemental Observations on Electric Fishes. By Andrew Murray.

Since writing the description of the *Malapterurus Beninensis*, published in last number of the Journal, I have received the following additional information regarding it from Mr W. C. Thomson, who was stationed for several years at the Creek Town mission station on the river Old Calabar.

Mr Thomson tells me that the electric properties of the fish are made use of by the natives as a cure for their sick children. The fish is put into a dish containing water, and the child made to play with it: or the child is put in a tub or other vessel with water, and one or more of the fish put in beside it. It is interesting to find that a remedy, which has only of recent years come into favour among ourselves, should have been already anticipated by the unlettered savage, who probably has had the remedy handed down to him by tradition from remote generations.

Mr Thomson also mentions an instance of the electric power of the fish which fell under his own notice, and may be worth mentioning. He had a tame heron which had been taken young, and never had had an opportunity of fishing for itself. On one occasion some live fish were brought for it, and among them was a small *Malapterurus*. The bird swallowed it, but had no sooner done so than it gave a great scream, and was thrown violently backwards. It got up again, and soon recovered, but always remembered the circumstance, and would never after touch a *Malapterurus*.

I take this opportunity of remedying an omission in my former paper, of a species of electric fish which should have been included in my list of these species, viz. the *Gymnotus æquilabiatus* of Humboldt, found in the rivers of Guiana.

REVIEWS AND NOTICES OF BOOKS.

Acadian Geology: an Account of the Geological Structure and Mineral Resources of Nova Scotia, and portions of the neighbouring Provinces of British America. By JOHN WILLIAM DAWSON, F.G.S., &c. Edinburgh: Oliver & Boyd. 1855. Sm. 8vo.

Old Stones: Notes of Lectures on the Plutonic, Silurian, and Devonian Rocks in the Neighbourhood of Malvern. By W. S. SYMONDS, F.G.S., &c. Lamb: Malvern. 1855. 12mo.

Whatever tends to the increase of knowledge concerning the mineral structure of any country, is an important addition to the stock of geological information, and serves as a means by which the deductions of this science may be tested, and its details applied to other countries than those where the phenomena of the several divisions of this science were first observed.

As regards the New World, extensive opportunities have been afforded for increasing the amount of geological knowledge, in the form of the government surveys, which have been, and are still in progress in this country, not only under our own government in Canada, but likewise in the United States; and from this latter many valuable and important additions have been made to geology. As respects Nova Scotia and the adjoining districts, including Prince Edward's Island, nothing has been done by the agency of government; but the importance of its mineral wealth has been the means of furnishing us with a very extensive knowledge of its structure and resources. The great development of its coal-fields, and the beautiful manner in which these are exposed along its coasts, have induced many geologists to visit it; and from these circumstances there have also sprung up many local geologists, to whom we owe most of the information we possess concerning those countries. At the head of these stands Mr Dawson, who, in a work just published, and termed "*Acadian Geology*," enters at great detail into the geology and mineral resources of Nova Scotia, Prince Edward's Island, and New Brunswick.

Commencing with the present physical conditions of this area, Mr Dawson describes the changes which are now taking place along the shores and in the interior of this district. As regards the shores, among these we have the portions which are washed by the Bay of Fundy, where, owing to the somewhat triangular form of the bay, the tides rise to 60 feet or more; and rushing onwards with great force along the coast of the United States, carry into the upper portion of this bay a large quantity of muddy matter, which is now being deposited in the Cobequid and Chiegnecto bays, in the form of marshy land; and on the layers of this marshy land we have the records of physical phenomena in the form of rain-drops, and the evidence of animal existences in the form of foot-steps, as shown by Sir Charles Lyell,* pointing out how nearly akin are the conditions which, at the present day, prevail in the Bay of Fundy, to those which obtained in some of the areas of the trias sandstones of Great Britain.

These marshy deposits, of which there are two kinds, viz. the red marsh and the blue marsh, in some localities are found covering submarine forests, the roots and stumps of the trees of which are seen occupying the soil on which they originally grew; and as these trees are of such a nature as to require a rather dry habitat for their growth and development, it would appear that some portions of Nova Scotia have been subjected to downward movements; and to these downward movements, according to Mr Dawson, we owe the present position of the submarine forests below beds of marshy character.

The two silty deposits, the red and the blue marsh, differ greatly in their value as agricultural soils. The former yields a rich productive soil, containing a large amount of soluble salts, available for plants; the latter, although it affords a much greater quantity of organic matter in the form of decayed vegetables, is injurious to the growth of plants, from containing sulphate of iron, the product of decomposed iron pyrites, which abound in this description of marsh.

In Nova Scotia alone, along portions of the Bay of Fundy, no less than 36,382 acres of the marshy products had been embanked up to the year 1851; and these marshes, in the production of cheese and butter, are, according to Mr Dawson, "unsurpassed, and perhaps unequalled by those of any other part of North America."

In other descriptions of alluvial deposits, Nova Scotia does not seem to be very prolific. The offspring of rivers and lakes being but partial, and the bogs, although they appear very numerous in the rocky districts of the Atlantic coasts, are marked by no features which give to them any peculiar interest.

The deposits which are of an age anterior to the modern alluvial beds, and to which the term *boulder formation* has been applied, are more extensive than those which are now resulting from causes in operation over this area. We have in Nova Scotia extensive deposits of unstratified clay filled with boulders, having all the characters of the drift of England and Scotland, and pointing out the existence over this country of those causes to which we owe the transport of large blocks of rock, and their dispersion through

* Quart. Journ. Geol. Soc., vol. 71.

the clay. The general route of these rocky masses has been from the north-east, with local exceptions: a course similar to that of the erratic blocks of North America in general; and Sir Charles Lyell, in a recent lecture at the Royal Institution, has shown this to be the direction which masses of rocks, forming certain trains of erratic blocks occurring in the western borders of Massachusetts, have taken. The force by which these blocks have been transported is still in operation, to a slight extent, on the shores of Nova Scotia; for here, during winter, masses of ice may be seen floating about, and bearing their rocky burdens until the atmospheric influence causes their deposition among the mud, and thus forming, even in our own time, deposits having great affinity to the more ancient boulder clays.

In this portion of the New World there are seen, resting upon the unstratified clays, deposits of stratified gravel and sand; and in this circumstance there is a considerable affinity between the deposits of Nova Scotia and those of some parts of Great Britain and Ireland, as in the case of the "*kaims*" of Scotland, and the "*eskars*" of Ireland. In external features, these beds of stratified gravel also have much of the aspect of similar deposits in the United Kingdom; for they "occur in mounds and long ridges, sometimes extending for miles over the country."

The nature of these sand and gravel beds leads to the conclusion that they resulted from the action of shallow water and currents; and Mr Dawson infers, from the occurrence in them of large blocks, that the influence of ice was also exerted in furnishing in part the materials which make up these sand and gravel mounds and ridges. In this superficial gravel, the bones of the Mastodon have been found in Cape Breton; a circumstance which agrees with the osseous remains which have been obtained from similar deposits in the United States.

The solid strata which enter into the composition of Nova Scotia, New Brunswick, and Prince Edward's Island, consist of sandstone, either triassic or permian; carboniferous rocks; strata which have not yet been determined, but which Mr Dawson is disposed to regard as Devonian, and metamorphic rocks. With these strata are associated traps of various characters, and plutonic masses.

Concerning the first of these, the red sandstone, this, in Nova Scotia, is only developed to a small extent, occurring along the shores of Cobequid Bay, and running also in the form of a narrow strip from the south-west side of the Minas Basin to the head of St Mary's Bay. In Prince Edward's Island the red sandstone has a much more extensive range, for it appears to constitute the whole of this island. This "new red sandstone," that being the name applied to it by Mr Dawson, is seen in Nova Scotia to rest unconformably both upon the older rocks, and also upon the lower portion of the carboniferous series. In its mineral nature it appears to have an intimate relation to the Bunter sandstone of Great Britain; and with it are associated, in many places, masses of augitic traps, principally in the form of amygdaloids, in the cavities of which are contained abundance of zeolitic minerals, and others which are common to this form of igneous matter.

During the deposition of these sandstones in Nova Scotia, voltanic forces were in active operation, and resulting from them is the large area of trap which fringes the south-eastern side of the Bay of Fundy, extending from Cape Blomidon on the north-east, to Briar Island on the south-west.

The strata which form Prince Edward's Island are, in their lithological natures, similar to those which form the new reds of Nova Scotia, consisting of sandy particles united by a calcareous cement. "In some places the calcareous matter has been in sufficient abundance to form bands of impure limestone, usually thin and arenaceous." On the south of the island there are seen some beds of a different nature, which consist of "brown and grey sandstones and shales, not unlike some of the upper parts of the coal-formation of Nova Scotia, and containing a few fossil plants;" these appear to be the oldest strata in the island. Mr Dawson remarks, that "these beds must belong either to the very newest portions of the coal formation, which in some particulars they closely resemble, or to the lower part of the new red sandstone; and in either case the sandstones of the greater part of Prince Edward's Island will be new red. Unfortunately I could not observe whether the latter were superimposed conformably or unconformably on the lower beds; and the fossils are hardly sufficiently well characterized to indicate to which epoch they belong." The fossil plants which occur in these grey sandstones, are for the most part trees; and these retain sufficient of their original structure to permit of a microscopical examination, and a determination of their tissues. The internal structure of these trees points out their coniferous nature, and the hexagonal discs which mark the walls of the cell refer them to Witham's genus *Pinites*. From the fineness of the tissue of these trees, as seen in transverse section, also from the discs on the sides of the cells occurring only in two rows, Mr Dawson is disposed to regard these plants as appertaining to the higher portion of the coal measures, or even to the permians. Such a conclusion is, however, based upon too slight distinctions, since the lower coal measures of Great Britain have furnished species of this genus very nearly allied to the Prince Edward's Island trees, and even, in some species, the discs on one cell will be only two-rowed, while in the adjoining cell they will appear arranged in three or even more rows.

From the red sandstone itself, on the north side of the island, we have fossil remains of an important character in a zoological point of view; but unfortunately these are not of such a nature as to lead to much information concerning the age of the red sandstone of Prince Edward's Island. This fossil consists of a portion of the jaw of a reptile; and as this form has hitherto been found only in this island, it is inapplicable as a means of comparison with other countries, although in some respects allied to the earliest saurians of the permians. On the whole, it would appear that the evidence on which to refer this red sandstone to the permians,—a disposition which Mr Dawson to some extent manifests, is very slight; and perhaps it would be more advisable, at present, to regard it as the equivalent of the Connecticut beds, and place it among the trias.

The series of strata which are best developed, and which occupy the largest area in Nova Scotia, are those which appertain to the carboniferous formation; and in this country we have as fine an exposure of these strata exhibited as can be seen anywhere.

Mr Dawson divides this formation, as it occurs in Nova Scotia, into the upper or newer coal measures, having a thickness of 3000 feet or more; the lower or older coal-measures, which attain a thickness of 4000 feet or more, and which abounds in "valuable beds of coal and ironstone, beds of bituminous limestone, and numerous underclays with *stigmaria*." In the upper series of the coal measures, this fossil, from Mr Dawson's statement of the characteristic fossils of the newer coal measures, does not seem to occur, or is rare, since we find no mention of it in the list, nor does sigillaria appear among the characteristic forms. The lower portion of the carboniferous formation has a thickness of 6000 feet or more, and is composed of red and gray sandstones, conglomerates, shales, limestones and gypseous beds. This portion of the series, from the nature of some of its beds, was formerly regarded as new red sandstone, until Sir Charles Lyell pointed out its true carboniferous nature. This enormous thickness of carboniferous strata is remarkably well seen in the "cliffs fronting Chiegnecto Bay and Cumberland Basin," where the "finest and most complete section of the carboniferous rocks in Nova Scotia, and one of the finest in the world is seen." It is the well-known South Joggins section of geologists; and in it we have exposed 14,000 feet of perpendicular strata, from the marine limestones below, to the top of the coal measures, and through this distance more than 70 seams of coal occur.

The lower portion of the carboniferous formation of Nova Scotia is characterized by the usual fossils of this part of the series. In the limestones we have forms of brachiopoda, such as are common to carboniferous limestone of Great Britain, associated with crinoids, and in the accompanying sandstones, trunks and branches of trees occur, indicating the drifting of vegetables from the adjoining land.

In the black limestone which overlies these sandstones, we have abundance of ganoid scales, and the limestone itself, which is of a bituminous nature, probably owes this nature to the decomposition of the fleshy portion of the fish of which these scales formed the covering. In connection with these bituminous limestones are argillaceous sandstones and nine thin seams of coal, and in the sandstones numerous remains of plants characteristic of the coal measures are found. These sandstones are extensively wrought for grindstones, which are largely exported to the United States. Above these limestones, argillaceous sandstones and thin coal seams are seen; also reddish shales and reddish and gray sandstones, with a few imperfectly preserved fossils; and when we reach the summit of these, having passed over 7636 feet of perpendicular strata, we arrive at the commencement of the true coal measures, and the several members forming these are given in detail, the table having previously appeared in the Quarterly Journal of the Geological Society.

For the sake of more easy reference, Mr Dawson divides the coal measures as they occur in the Cumberland district into twenty-nine groups, and he devotes the ninth chapter to a detailed examination of these groups, and the conditions under which they originated. As might be expected, the features presented by these are similar to those which the European coal measures manifest; but from the perfection of the Nova Scotia section, we can become acquainted with these to a much greater extent than elsewhere. Numerous fossil forests occur in the several strata, indicating in the first instance a soil covered with a luxuriant vegetation, and furnishing organic matter for the production of coal. These buried forests also tell of subsidences, and the accumulation above them of mineral matter, until the surface of the water was again nearly reached, and conditions again prevailed capable of yielding another crop of luxuriant aquatic vegetables; for the nature of the roots and rootlets of sigillaria, the most abundant form of carboniferous plants, indicates an aquatic, or at least a swampy habitat, and these conditions we have repeated and well shown in Nova Scotia through an immense thickness of strata.

Here, too, we meet with the little crustacean so common in the coal measures of Europe, the *cypris*. But it does not appear that in the coal measures of Nova Scotia we can learn so much of its habits and food as from some of the beds of the British coal-fields.

There are, in some portions of these latter, thin black coaly shales, known under the name of black basses, and in many instances these abound in the remains of fishes in the form of *detached* scales, spines, and teeth, and with these are associated large quantities of cypris. The office of these small creatures in the waters of the carboniferous epoch seems to have been that of scavengers, living on the dead fish, consuming the fleshy portions, and leaving the solid scales, spines, and teeth, to be scattered along the bottom of the water; and so voracious do these small creatures appear to have been, that they entirely destroyed all the soft tissues, since we always find that if fish remains occur along with cypris, the former are in a most perfect fragmentary state.

One of the groups of the coal measures (XV.) is remarkably interesting, as in the interior of a fossil tree, embedded in argillaceous sandstone, Sir Charles Lyell and the author found the remains of a small reptile, *Dendrerpeton acadianum*, and a small land-shell allied to *Pupa*. These had been drifted into the interior of the tree after the woody portion was removed by decay, and with them were associated other remains in the form of decayed wood and fragments of plants. In this land-shell we have the only evidence of the existence of terrestrial gasteropoda during the whole of the palæozoic period.

As regards the fossil plants of the Nova Scotia coal measures, these are found under such favourable circumstances, that much can be learned as to their nature and affinities. Many forms of conifera, having the auricaurian type of structure in their tissues, are seen, and these seem to appertain, as already stated, to Witham's genus *Pinites*. Calamites are also extremely common, and Mr Dawson is disposed to regard them as allied to the modern Equiseta; an opinion which is liable to much questioning, since it is only in their rib-like surface, and in having nodi, that they approach this form. Hitherto we know nothing of the internal structure of these plants, and until something of this has been discovered, the nature and affinities of calamites will remain uncertain. Many geologists are disposed to regard them as having some relation to sigillaria, and the circumstance that we never meet old calamites or young sigillaria, affords some support to this inference. And if we obliterate the nodi from the former, they would possess the external characters of the latter, and this circumstance is in part affected by the growth of calamites.

Concerning sigillaria, we have abundant examples of the intimate relation which exists between this plant and stigmaria, the former being the stem and the latter the root. This connection was shown to exist by Mr Binney, as Mr Dawson states, "in June 1845; and before the close of 1846, Mr R. Brown of Sydney had described still finer instances of the same kind from the Sydney coal-field." Our author does not seem to be aware that when Mr Binney described the St Helen's specimen in June, it was only partially uncovered. In October of the same year, a more full account of this specimen is given after it had been better exposed, and in this instance we have as perfect an example of the intimate connection between sigillaria and stigmaria as can be seen. When we consider the great abundance of sigillaria in the coal measures, the circumstance that hitherto nothing is known concerning its foliage is a subject of singular interest. The internal structure of their form shows a relation to both conifera and ferns; and when we consider the great abundance of what are termed ferns in the coal measures, we are led to inquire if those fronds have no connection with the foliage of this form. The absence of fructification in these fronds is strongly antagonistic to their being ferns, and the foliage of a modern cycad, the *Stangeria*, having all the characters of the leaflets of vascular cryptogams, strongly supports the conclusion that some of the so-called ferns of the carboniferous formation were the foliage of the sigillaria.

In the coal-field of this portion of Nova Scotia we have two instances of coals without stigmaria under-clays. One of these occurs in the twenty-third group, and consists of "an inch of coal loaded with poacites," and over this is what was originally a sandy soil, with stigmaria roots and rootlets. In this instance it would appear that the usual conditions for the production of coal did not occur; and these thin seams without the usual under-clays have probably resulted from the drifting of vegetable matter, in the same manner as we find in the thin seams of coal among the calcgrits of the Yorkshire oolite, which bear about them every evidence of drifting.

The coal of the Cumberland basin in its nature differs little from the ordinary coals of Great Britain, and in all respects seems to have been formed from the same plants, and under the same circumstances as that of our own country.

This remark does not, however, apply to the coal which occurs in New Brunswick, and which appertains to the lower portion of the coal measures. The coal of this district is wrought at Albert Mine, Hillsborough, and here the strata are remarkably contorted. Some of these strata consist of bituminous shales, containing fishes of the same genus as that occurring in the Joggins coal measures (Paloconiscus.) The coal of this mine has been the subject of considerable litigation in the law courts of the province; and much doubt still remains as to its nature and origin. In its external aspect the product of the Albert mine is widely different from any ordinary coal, having much more the appearance of asphalt than any other mineral substance. Its mode of occurrence among the strata with which it is associated is also peculiar, and all the circumstances connected with it lead to the supposition that it is far removed from ordinary coal. The sections, given by Mr Dawson, of its mode of occurrence in the bed, show how much it differs from coals in general; and in one section Mr Dawson remarks that "both at the roof and floor, the coal shows distinct evidence of a former pasty or fluid condition, in having injected a pure coaly substance into the most minute fissures of the containing rocks." The manner in which this substance is found in connection with the stratified beds is rather that of a vein than a seam of vegetable matter deposited in the usual manner of coal, and this peculiarity Mr Dawson attributes to a fault which has given to the Albert coal its singular position, and our author regards this substance "as a fresh-water formation," resulting from vegetable matter "of a peculiar character, belonging to the lower carboniferous period, and very singularly *distorted by mechanical disturbances.*"

There are, however, many features about this substance which this theory fails to explain, and one of these is that by chemical solvents it yields, in some instances, about 30 per cent. of bitumen, a circumstance which points out a great distinction between this substance and coals, which rarely yield 1 per cent. of bitumen when treated in the same manner; and by what means this vegetable matter could become pasty or fluid we are left in darkness by our author. Vegetable matter, when simply decomposing, does not afford bitumen, and how then can we account for the large portion of this substance which is found in the Albert coal?

Under certain peculiar conditions coal is capable of affording a large amount of bitumen; and these conditions consist in the distillation of this substance at temperatures not exceeding 600° Fahr. in close vessels. Under such circumstances coal would produce a substance resembling that which occurs in the Albert mine, and afford a material sufficiently fluid to inject the most minute fissure, as is seen in fig. 23 in the *Geology of Acadia;* and from such a condition a substance capable of filling up cracks in the disturbed strata would be produced, and the vein-like mode of arrangement in which the Albert coal occurs would be fully accounted for. The supposition of such an origin for the Albertite, the name by which this substance is known in New Brunswick, is supported by the circumstance that in another district of the area, in Pictou, "the lowest carboniferous rocks are conglomerates interstratified with beds of amygdaloidal trap which have flowed over these surfaces as lava currents;" and although the flowing of these traps seems to have ceased before the deposition of the Albert coal seam, still the influence of that cause, to which these traps owe their origin, may have been sufficient at an after period to distil bitumen from this bed of coal.

The next district described by Mr Dawson is that of Colchester and Hants; and this area contains deposits which appertain to the lower portion of the carboniferous series, in which none of the thick seams of coal are reached. The limestones of this series, as in the Cumberland district, abound in the usual carboniferous fossils, and among these is a form of pteropod *Cor-*

nularia, a genus which, for the most part, has, in Great Britain, been met with in the Silurians, but of which one species, *C. quadrisulcata*, has been found in the carboniferous rock of some localities in England and Scotland.

Of the Colchester and Hants districts, consisting for the most part of the lower carboniferous series, we have the strata which form this portion of the carboniferous formation described in detail in the eleventh chapter.

In this part of the carboniferous group in Nova Scotia the thick beds of gypsum occur, which induced many geologists, guided exclusively by mineral characters, to regard this as appertaining to the trias. Alluding to the origin of the gypseous strata, Mr Dawson considers that they have their origin from the action of sulphuric acid dissolved in water on previously existing limestone beds, by means of which carbonate of lime was converted into sulphate of this substance. This sulphuric acid our author attributes to springs or streams issuing from volcanic rocks. The occurrence of gypseous strata low down in the carboniferous formation is, so far as we yet know, confined only to Acadia, but in many other formations we find it associated with other beds in the same manner as it occurs in Nova Scotia. In Great Britain the Keuper portion of the trias is the position where we principally meet with it. But this is not its exclusive position in this country. It also occurs in the permians at Barughmouth, near Whitehaven, and here it is accompanied by clays and limestone as in Nova Scotia; and in several portions of the world we meet with it in like positions. If we adopt Mr Dawson's theory of the gypseous beds of Nova Scotia, we must also apply it to other localities affording this substance. And as there are many circumstances which rather support the inference that beds of sulphate of lime have originated from the deposits of sea water, we are at a loss to see why these beds of the Acadian peninsula should not have had a like origin.

The lower portion of the carboniferous formation, as this is developed in the district of Pictou, contains beds of trap associated with the aqueous deposits, pointing out the operation of volcanic forces in this area during the earlier part of the carboniferous epoch.

In this area, at the Albion mines, we have two compound seams of coal, one of which attains 39 feet 11 inches, and the other 24 feet 9 inches in thickness. These remind us of the 10-yard seam of the South Staffordshire coal-field, in which we have seams of coal; and coaly shales called *Batts* attaining a thickness of 30 feet. These thick compound seams tell of the long intervals of time which have been consumed in the accumulation of such a great thickness of vegetable matter,—for the associated *Batts* of the 10-yard coal of Bilston, and the coarse coals of the main, and deep seam of Pictou are simply inferior coals in which earthy matter prevails to such an extent that they are incapable of being used as fuel. Among these compound seams of Pictou we have ironstones, and these may change their nature in different localities, and put on a more coaly character; for in the Scotch coal-fields there are instances of parrot coals passing gradually, from a loss of coaly matter and an acquiring of ferruginous matter, into black-band ironstone. In one of these ironstone bands in the Albion seams the remains of an interesting reptile, having batrachian characters (*Baphetes planiceps*, Owen), has been discovered. These coal seams are cut off by a singular bed of conglomerate, and this is succeeded by some higher coal measures; but the sections of this portion of the carboniferous formation are not well exposed in this part of Nova Scotia.

In the island of Cape Breton we have the carboniferous formation also occupying a large area, consisting of the lower and middle portion of the series. One of the coal mines of this district, the Sydney main seam, yields about 80,000 tons per annum; and in these coal measures we have the same occurrence of fossils, and the same manifestations of the conditions which are so well seen in the South Joggins section.

Some of the localities of Nova Scotia afford, among the rocks of the carboniferous formation, ichnolites, desiccation cracks, and rain-markings; and altogether it is, as Mr Dawson remarks, one of the most interesting and perfect examples of the carboniferous formation in the world. The strong point in Mr Dawson's book is his description of this portion of the sedimentary deposits of Acadia, and in it we have ample details showing the labour and attention which the author has devoted to this portion of geology, and we must regard it as a fortunate circumstance that Nova Scotia possessed an individual so well capable of appreciating the geological features and phenomena of his country.

The carboniferous rocks of Acadia rest unconformably on strata which Mr Dawson refers to the Devonian and Silurian systems. The deposits which make up these formations consist of "shaly, sandy, and calcareous," beds containing abundance of fossils. Slaty rocks also occur, and the axes of these older rocks are formed of plutonic masses. Our author's account of these several rocks is neither so full nor so satisfactory as his description of the carboniferous formation, and it would appear that much still remains to be done before we can arrive at correct opinions concerning these older sedimentary rocks. Mr Dawson observes, that "with respect to the age of these rocks, it is certain that the fossiliferous parts are Devonian." Now the list of fossils which he gives in the appendix as derived from these strata certainly does not justify this conclusion, since we have in it a family of zoophytes (Graptolithus) which is *exclusively* SILURIAN; and if this family occurs along with the other fossils mentioned, the strata containing it must be regarded as Silurian rather than Devonian. The unconformability between the carboniferous and the underlying strata points out a want of sequence which corroborates, to some extent, the conclusion as to the older age of the lowest fossiliferous rocks of this district. As regards the slaty rocks, these also in some localities contain fossils similar to those occurring in the rocks devoid of this structure; but we have no information concerning the period when the slaty cleavage was impressed on the rocks in which this structure appears. There are many matters on which we could have wished more information concerning the phenomena which this slaty structure present; for geology is not so rich in facts in connection with cleavage, that it can afford to lose any observations in a district where this occurs, more particularly in such an area as Nova Scotia, where the influences of causes from which this structure arises appear to have operated on an extensive scale.

In these older rocks of Nova Scotia veins and beds of ironstone occur in considerable abundance. Of the former, one vein, besides containing the usual ores of iron, affords a large quantity of ankerite, a triple carbonate, consisting of lime, iron, and magnesia, which seems capable of yielding a considerable amount of iron. The southern coast of Nova Scotia consists of metamorphic and plutonic rocks, the age of which cannot be easily determined. Mr Dawson, however, seems disposed to refer them to the base of the Silurian. The age of rocks of this description can in general only be broadly made out, and whether these ought to be referred to the group to which Mr Dawson assigns them, or to the Laurentian group of Mr Logan, is a matter which, at present, it is difficult to determine. Concerning the metamorphic schists of this district, there is one thing on which we could have liked more detailed information, viz. on the foliation of these, for we are greatly in want of observations on this subject, in order to determine the cause which has given to rocks of this character their foliated structure. Mr Sharpe refers this structure to the same agent which has produced cleavage, but other geologists are inclined to regard it as emanating from chemical forces; and until we are in possession of more extensive observations, the matter is likely to remain a *vexata quæstio*. If Mr Dawson could be induced to apply his industry and powers of observation to this subject, we should expect something interesting from a field so extensive as Nova Scotia: and if, in connection with this, he would make us better acquainted with the phenomena of cleavage as they present themselves in Acadia, physical geology would be as much indebted to him as carboniferous palæontology now is. We have also a wish to know something more about the older fossiliferous rocks of his country; and, if put in possession of these desiderata, geologists might then regard Acadia as one of the best explored and most completely described fields of palæontology and geology which could be found in Her Majesty's dominions.

Books generally present to us two features. In the one they reflect the mind of the author, in the other they radiate the soul of the writer. Sometimes we have these two features combined, and, when this is the case, we rise from the perusal of the book not only instructed but delighted, more particularly when the soul of the author, as it shines in the book, looks bright and vigorous. A little unpretending book, with the quaint title *Old Stones* possesses these qualities to a high degree, affording ample information concerning the geology of Malvern, and combining therewith the delightful charm which indicates that its author is a noble-hearted geologist.

There is no subject involved in greater obscurity than the original state of the earth. What the condition of our planet was previously to the time when water wore away portions of its solid crusts, is a matter on which conjecture has been very unsatisfactorily employed for many years, and geologists have now very generally left the affair to be settled by physicists.

But still the puzzling question is often presented to us by even casual observers, and some answer is necessary before we can place ourselves in a position to show how sedimentary rocks originated. Our author, therefore, commences his descriptions of the Malverns with a considerable portion of his first chapter devoted to the consideration of plutonic rocks; and as this form of rock, in the state of syenite, constitutes the axis of the Malvern chain, a notice of plutonic rocks is an excellent base from which to start in a geological survey of these interesting hills.

The plutonic axis of this range is not, however, its most interesting feature, although we owe to its action the exposition of circumstances which are full of exciting truths. To use the words of our author,—

"These fine old Malverns, the components of which are coeval, for aught we know, with creation itself, call upon those *rational* beings that live around their base to investigate their most startling history, yet how often are they passed by altogether unobserved! They can tell of associations connected with a period when 'life was first breathed upon the waters;' but they are familiar, and they escape attention."

In the low-lying sedimentary deposits which rest upon the syenitic axis, some of the strata of which have been influenced by the causes which have originated volcanic rocks, we meet with some of the earliest traces of organized beings. The Lower Silurians of Malvern, in deposits which consist of black schists, afford the earliest trilobites occurring in the forms of Olenus and Agnostis; and let any one take *Old Stones* in his hand, and follow the directions of the author, and if he does not come upon the strata which contain these fossils, there must be something wrong with his eyes or his intellect; for so concise and perfect is the description contained therein, that any one who runs may read. The sandstones which support the black shales—the "holly-beech sandstones" of Professor Phillips—are fully pointed out by our author, and in these we have the lowest sedimentary rocks of the Malverns, and here the first traces of organisms occur in the form of fucoids. Under like circumstances do the lowest Silurian strata occur in Sweden,* but in this latter country we have a greater abundance of trilobitic forms making their appearance in the black shales; yet in both localities the Olenus and Agnostis are found.

"For the geologist, the valley of the White-leaved Oak has charms that no other part of the hills possess, for he may here explore strata charged with the earliest life upon the planet's surface, which he can only do elsewhere by a journey to the North Welsh mountains."

Our reverend geologist has, however, in this instance been led away by the glory and antiquity of the Holly Beech sandstones and the black shale; he has overlooked a remark which he had previously made concerning an ancient coral found at Brayhead, Wicklow. When using the language of the illustrious author of *Siluria*, he says, "look with reverence on this ancient zoophyte," for, notwithstanding the most assiduous researches, "it is the first animal relic we find at this early stage of the planet's surface."

Leaving these most ancient sedimentary rocks of the Malverns, we come upon a series of strata which represent, not the succeeding Llandeilo beds as these are developed in North Wales, but the Caradoc sandstone, the strata consisting of gray and purple sandstones and conglomerates. Our author points out, with his usual precision, where the best sections of the Caradoc sandstone may be seen, and also the localities where it is traversed by traps, as well as the spots which are most prolific, the brachiopoda and lamellibranchiata of this portion of the Silurians. In one locality below the obelisk, in a conglomerate, the remains of the *Pterygotus problematicus* has been met; an important circumstance showing the great geological range of this crustacean, which is obtained also from the "Tile stones" near Kingston.

Concerning the "Caradoc Transition beds," our geologist remarks that, "they are the most unsatisfactory deposits that occur along the Malvern range." They occur in situations difficult of access, and many of the fossils which they furnish are in an imperfect state

* Siluria, 318.

from drifting and wearing. These, however, are of important characters, since they consist of both upper and lower Silurian forms, so associated together as to show that palæontologically the two groups shade off gradually into one another. The lithological characters of the strata forming the upper and lower beds of the two groups also in some localities, became nearly united, and Mr Symond's observes that we learn from our Malvern data, compared with other evidence, that the lower Silurian and upper Silurian are linked together, sometimes by a mineral transition, sometimes by an interchange of fossils. The same intimate connection has been already alluded to by Sir Roderick Murchison;* and in other localities we have a similar mixture of fossils, leading to the inference that the Silurians, both upper and lower, are one great palæontological group.

The lower Silurians in the Malverns, therefore, are found to consist of a series of strata of sandstone, the Holly Bush sandstone of Professor Phillips succeeded by deposits of black shales; and these, according to this geologist, attain a thickness of about 2000 feet, being covered by the equivalents of the Caradoc sandstone, which have a thickness of about 1000 feet; and all that requires to be known concerning these lower Silurian strata, so far as their localities are concerned, may be learned from *Old Stones*.

The last chapter of *Old Stones* is devoted to the old red sandstones of Herefordshire, a county which abounds in interesting matter connected with physical geology, but which must yield to Devonshire and the North of Scotland in the matter of palæontology. Several important localities are mentioned where fossil fish may be obtained, and we are promised more on the subject of fossils from the labours of the local natural history societies, which are springing up in this country.

A good watch upon the fine surfaces of the strata of Puddlestone quarry will no doubt lead to important results; for the conditions under which the beds were deposited here much resemble those which prevailed when the Elgin sandstone was being formed; and along with the tracks of crustaceans, which are found in such perfection in this locality, the feet-marks of a higher tribe of animals may be expected to occur.

There is something in the concluding remarks of *Old Stones* which leads us to regret that the clergymen of Great Britain have among them so few who can, like Mr Symonds, fully appreciate the importance of natural objects in a religious point of view. Were it otherwise, we should have that love of nature, which the Almighty has implanted in every breast, cultivated, and the love of the sublime, the beautiful, and the good, as manifested in his works, developed in every heart—purer and more exalted notions

* Siluria, p. 96.

of the Great Creator would prevail; and the people, instead of seeking for happiness in debasing pursuits, would devote their leisure hours to objects which would exalt them in the scale of beings, and better fit them for that higher destiny which the Almighty has designed for his intelligent creatures.

There is one little matter in connection with this interesting book, which calls for blame. This is the imperfection of the sections. The first one "showing the succession of strata, west and east of the Malvern range," is incorrect, and the others convey erroneous impressions. To the geologist who has only a short time at his disposal to visit the Malvern, we should say take with you every day, when geologising, *Old Stones*, (never mind the sections), it will save you many an hour. In the evening look over the Memoir of Professor Phillips in the second vol., Part 1 of the Memoirs of the Geological Survey, and if you are not well made in the geology of the Malverns, blame yourself and not your aids; for with such guides no one need be ignorant of the structure of this delightful district.

Contributions to the Natural History of Labuan and the adjacent Coasts of Borneo. By JAMES MOTLEY of Labuan, and LEWIS LLEWELLYN DILLWYN, F.L.S., &c. Part I. London: Van Voorst, 1855. 8vo.

When the Island of Labuan was occupied by the British, and coal had been ascertained to be found there, Mr Dillwyn was applied to, in order to find a person capable of superintending the mining operations contemplated on the island, and Mr Motley was recommended and appointed to fill that situation. The choice has been an admirable one; for, in addition to the search for coal having been successful, and carried on with skill, the spare moments of that gentleman have been given up to the investigation of the natural history of the island, and several collections have been sent to Mr Dillwyn, who has undertaken the charge of describing them, and of editing Mr Motley's notes made upon the spot. No better plan could have been devised for the investigation of the productions of any locality, particularly of an island, than an active observer on the spot, and a careful editor who enjoys the advantage of access to every information at home. The result has been the publication of the first part of the above-named work, commencing with the Mammalia, and running also through interesting selections from the Birds and Reptiles as they were received. The prospectus thus indicates the intention of the work:—

"It is intended that the 'Contributions' shall contain descriptions of such animals, both vertebrate and invertebrate, as inhabit the island. These will be accompanied with original notes on their habits, and other particulars connected with their natural history. Illustrations will be given of such animals as it may appear to be desirable should be figured, of such more especially as are new, or of which figures are not easily obtainable." The lithographs of the animals and birds are drawn by Mr Wolf, those of the reptiles by Mr Ford—two of the best artists that could have been selected. When the work has further advanced, we shall endeavour to give a review of the Fauna and the geographical distribution of animal life in Labuan and its vicinity.

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science.

The Glasgow meeting of the British Association, commenced on the 12th and terminated on the 19th September, under the presidency of His Grace The Duke of Argyll, has been one of the most interesting and successful meetings of that body. The number of communications has been unusually large, inconveniently so, indeed; for the last two days of the sectional meetings, it became necessary to curtail the papers, and altogether to abandon discussion. The total number of papers amounted to 347, and among them were several of much importance, while there was a smaller proportion than usual of those frivolous communications which cannot be avoided at such meetings. Considering the late period at which the meeting terminated, we cannot attempt to give a full account of the proceedings, but we are unwilling to allow our present number to pass without some notice of the more important papers.

The Duke of Argyll's address formed an interesting sketch of the value of science, and doubly important as indicating the probable prospect that Government may be soon induced to increase the niggardly support which it has hitherto held out to British scientific investigation. The necessity for some such step has been long acknowledged by men of science, and the whole question of improving the status and encouraging the pursuit of science has formed the subject of an extremely important report, which was laid before the Association, and contains a number of valuable suggestions, which we trust may ere long be acted upon.

The meetings of the Sections commenced on the 13th.

The more important papers in Section A. were,

Sir D. Brewster *on the Radiant Spectrum.* From an extensive series of experiments, the author concludes that every luminous ray in the spectrum is accompanied by invisible rays of greater refrangibility than the luminous ray itself; that these rays are rendered visible by the dispersive action of the solids and fluids on which they are incident, and by which they are refracted, reflected, or transmitted. He believes that these invisible rays occupy the same place in the spectrum as the chemical rays, and that they are probably connected with the phenomena of phosphorescence.

Mr J. P. Joule. *Experiments on the Force of Electro-Magnets.* The most remarkable results of these experiments are those dependent on the retentiveness of the magnets, which seems to follow some law connected with the strength of the current. It appears also that a state of intense magnetization is not entirely removed by reversal of the magnetization, but causes the iron to be more powerfully magnetized by currents in one direction than the other even after the reversals are frequently repeated.

Rev. Dr Scoresby *on the Magnetism of Iron Ships.*

Professor W. Thomson. *Effect of Mechanical Strain on the Thermo-electric Qualities of Metals.*

The author having found that iron and copper wire, when stretched by forces insufficient to cause permanent elongation, had their thermo-electric properties altered during the continuance of the strain in a direction opposite to the effects which Magnus had obtained when wires are permanently elongated, by passing through the draw-plate, has examined the effect of the longitudinal and lateral compression and extension, and he finds that the peculiar thermo-electric qualities produced are those of a crystal. As regards iron, the general conclusion is that its thermo-electric quality when under pressure in one direction deviates from that of the unstrained metal towards bismuth for currents in the direction of the strain, and towards antimony for those perpendicular to it, and the residual thermo-electric effect of the permanent strain is the reverse of that which subsists during application of the strain.

Mr Wildman Whitehouse. *Experimental Observations on an Electrical Cable.* Experiments were made with wires of different lengths from 1125 miles to 20 feet, and it was found that the current took about 1½ seconds longer to pass through the greater, than through the shorter length. As the result of a large number of experiments, it appears that no advantage would result from enlarging the gauge of the wires at present in use for submarine telegraphs, and that America and India are quite accessible with wires similar to those now employed.

Professor Tyndall. *Experimental Demonstration of the Polarity of Diamagnetic Bodies.*

Captain Jacob *on Certain Anomalies presented by the Binary Star* 70 *Ophiuchi.* The anomalies observed are quite at variance with the laws of gravitation; but the author stated as his opinion, that the conjecture that those laws might not exist in remote space, was not to be adopted except as a last resource, and considered that the irregularities in the orbit of this star might be explained by assuming the existence of a dark body attracting it.

Sir John Ross *on the Aurora Borealis.* The author gave an account of some experiments tending to show that the Aurora was due to reflection of the sun's rays from the surface of the polar ice.

Mr Robert Russell of Kilwhiss read an elaborate paper on the *Meteorology of the United States and Canada;* and one whole sitting of the section was occupied with various meteorological papers.

Professor Piazzi Smyth gave an account of a number of new instruments for nautical observations.

In Section B. the papers most worthy of notice were,

Professor Andrews of Belfast *on the Polar Decomposition of Water by Frictional and Atmospheric Electricity.* By an ingenious arrangement, the author was enabled to show that water is decomposed by the common machine; and also, by using an electrical kite, he was able, in fine weather, to produce decomposition, although so slowly, 1-700,000th of a grain of water was decomposed per hour.

Dr Mathieson exhibited specimens of the Metallic Bases of the Alkaline Earths.

Mr Stewart read a paper *on the Density of Sulphuric Acid*, and in which he endeavoured to show that the points of greatest contraction of a mixture of water and sulphuric acid corresponded with definite hydrates.

Dr Penny *on the Composition and Phosphorescence of Plate Sulphate of Potash.* In this paper the author showed that the salt is really a double compound of sulphates of potash and soda, represented by the formula $3\ KO\ SO_3 + NaO\ SO_3$, and described the remarkable phenomena of phosphorescence it presents.

Dr Frankland *on Organic Compounds containing Metals.* The author described some new compounds which he had obtained, and particularly one prepared by the action of nitric oxide on zinc ethyl, which may be regarded as an ammonium in which one atom of hydrogen is replaced by zinc, another by ethyl, and the remaining two by oxygen.

Dr Andrews *on Allotropic Modifications of Chlorine and Bromine analogous to the Ozone Form of Oxygen.* In this important paper the author showed that chlorine and bromine, when submitted to a series of electric discharges, acquire the power of dissolving platinum which they do not possess in their ordinary state. By agitation with water active chlorine is absorbed, and converted into its ordinary state.

Professor Bunsen and Dr Roscoe *on the Chemical Action of Light.* This paper communicated the results of a series of researches still in progress. It appears from the experiments hitherto made that the amount of chemical action of the sun's rays is dependent by constant amount of light on the length of time of insolation, and that in the same space of time the decomposition is proportional to the intensity of the light.

Dr Calvert of Manchester detailed a series of experiments he had made on *Alloys of Iron and Aluminum.* He had found that a number of alloys, in definite proportions of these two metals, were produced. The properties of these alloys appear to recommend them for technical uses.

Dr Douglas Maclagan *on the Composition of Bread.*

Mr George F. Wilson *on a New Method of producing Glycerine.*

Dr Daubeny *on an indirect Mode of determining the presence of Phosphoric Acid, and on the existence of that Acid in the Silurian Rocks of Connemara.*

Section C. Geology. Sir R. I. Murchison, *President.*

Mr Hugh Miller *on some of the less known Fossil Flora of Scotland.*

Mr Dawson *on the Coal Formations of Nova Scotia.*

Captain Sir E. Belcher *on the discovery of the Ichthyosaurus and other Fossils in the Arctic Expeditions.* These remains were found on the summit of Exmouth Island, about 700 feet above the sea, the upper stratum of which is a bed of limestone about 30 feet thick, containing the fossils. The specimens have been submitted to Professor Owen, who considers them to resemble the *Ichthyosaurus actetus* of the Whitby lias.

Mr Allan described the present condition of the Geysers of Iceland, and stated that all the phenomena observed by him seemed to indicate that the eruptions were gradually diminishing in frequency and duration.

Mr Evan Hopkins and Mr Campbell read papers on the *Auriferous Deposits of Australia.*

Mr H. C. Sorby *on the Structure and Mutual Relations of the Older Rocks of the Highland Border.* This paper related chiefly to the contortions and cleavage of these rocks, and the author endeavoured to show

how these might be accounted for on mechanical principles by the lateral pressure of other and harder rocks.

Sir R. I. Murchison, Bart., *on the relations of the Crystalline Rocks of the North Highlands and the Old Red Sandstone of that Region, and on the recent Fossil Discoveries of Mr C. Peach.* This paper contained an elaborate discussion of the position of the limestones of Durness and Eriboll in the geological series. The author stated that the fossils discovered by Mr Peach, in the former of these limestones, have been submitted to Mr Salter, who considers them to approach very closely to the genus Raphistoma found in the Lower Silurian limestones of Girvan. He stated that in the North of Scotland there appeared to be a regular succession of rocks from the older to newer, in passing from west to east.

Mr R. Chambers *on Denudation and other effects usually attributed to Water.*

Numerous important and valuable papers were also read in the Natural History Section, and in Geography, Statistics, and Mechanics. These papers embrace so great a mass of details that we cannot attempt, within the limits of the Journal, to give any account of them.

Some of the more important papers read at this meeting are published *in extenso* in our present number, and others will appear in January.

Botanical Society of Edinburgh.

Thursday, 12th July 1855.

1. *On the Introduction of the Cinchona Tree into India.* By Thomas Anderson, M.D., H.E.I.C.S.

2. *On the Presence of Diatomaceæ, Phytolitharia, and Sponge Spicules, in Soils which support Vegetation.* By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

Ehrenberg, in his late work, "*Mikrogeologie*," has stated that in specimens of soils from all parts of the world, he has found many microscopic organisms; he divides these into Siliceous and Calcareous, the former including Diatomaceæ, Phytolitharia, and Polycystina, as well as Sponge Spicules, the latter minute Mollusks and other shells. The present observations are confined to the siliceous organisms, and among these, chiefly to the Diatomaceæ, with Phytolitharia, and Sponge Spicules, the soils examined being such as are connected with fresh water, in which the Polycystina do not occur.

Many of Ehrenberg's observations were made on the small portions of soil found adhering to dried plants in herbaria, and I requested Professor Balfour to supply me with such portions of soil if possible. By his kindness I obtained upwards of 60 such specimens, almost all of which were of very small bulk, on an average, not exceeding that of a pinch of snuff, and sometimes less. Of these a certain number consisted chiefly of earth, with some half decayed vegetable matter, and many contained hardly anything but decaying vegetable matter, with a mere trace of earth. Of course, the latter are not fair specimens of soil, but I have subjected all to the same treatment, namely, boiling with nitro-muriatic acid, washing, straining through gauze, and examining the fine insoluble residue. This, of course, contained all the siliceous matter present, but it also contained much organic matter, of a brown or red colour, insoluble in acids, which, if necessary, might be destroyed by ignition, when it would leave a trifling ash.

In every case I found Diatomaceæ in the residue, as well as Phytolitharia. Sponge spicules apparently of fresh-water sponges, were less frequent, but occurred in many. In a few cases, where the acid caused effervescence, there was calcareous matter present, but in most this was not the case.

Of course, in those cases in which the proportion of earth was small, the residue consisted chiefly of the insoluble organic matter, through which, however, Diatoms and Phytolitharia were scattered, in greater or smaller proportion.

In the cases where the proportion of earth was larger, the residue was much richer in Diatoms and Phytolitharia, but almost always contained also the dark insoluble organic matter. In several the proportion of Diatoms in the residue was so large, that it had the appearance of a regular Diatomaceous gathering after boiling with acids. The most remarkable soils in this respect were one from the Sandwich Islands, one from Lebanon, one from the roots of a German moss, and one from Ailsa Craig.

It is to be noticed, however, that Diatomaceæ were found in every case, without exception, and that in all, their proportion to the whole non-calcareous earthy residue was considerable, and often large. In many of those where the proportion of earth was smallest, there was no siliceous matter in the residue, except Diatomaceæ and Phytolitharia.

The soils examined were from various and distant localities; there were about 20 from the Andes, several from Brazil and other parts of South America, a few from North America, a few from the West Indies, one from the Sandwich Islands, one from New Zealand, a few from India, one from Lebanon, a good many from Germany, some from France, a few from Spain, and some from Britain.

The great majority of the species of Diatoms in all these were found to coincide with our British forms, but a good many species occurred in the exotic soils which have not yet been found in Britain, and most of these not even in Europe, but which have been figured by Bailey, Ehrenberg, Kützing, Rabenhorst, &c.

A good many were observed, which, so far as I know at present, have not yet been figured or described. Lastly, a certain number of species lately found by Smith, Greville, and others, as well as by myself in Britain, and some of which are scarce, have occurred in these exotic soils. Among these I may name here Navicula scutelloides, W. Sm. (Lebanon), Orthosira spinosa, W. Sm., Grev. (Andes, Germany), Cymbella turgida, W. G. (Sandwich Islands), and Navicula varians, W. G. (various soils).

Of such species as are unknown to Europe, I shall only mention here, Terpsinöe musica, one of the most striking of known forms, which I found in the first soil I examined, one from Brazil. It is accompanied by Nitzschia scalaris, a fine form, which occurs in Britain, but is far from frequent here.

I am satisfied that a close examination of such specimens of soil, which are often thrown away in putting up specimens in herbaria, will bring to light many new forms, and supply us at home with many exotic and rare species. It is very desirable that collectors of plants should preserve a little of the earth adhering to their roots, and in this way copious materials would be obtained.

I have not yet worked out the apparently new forms occurring in these soils, but there are a considerable number which require investigation.

The above observations entirely confirm Ehrenberg's statements as to the distribution of the Diatomaceæ. They furnish evidence of the fact that these organisms are far less affected by climate and temperature than larger plants or animals; since many of the very same species are found in every latitude and in every country. For example, such common forms as Achnanthidium lanceolatum, Achnanthes exilis, Gomphonema tenellum, G. constrictum, G. capitatum, Cocconeis Placentula, C. Pediculus, Cocconema lanceolatum, C. cymbiforme, Synedra radians, Navicula elliptica, N. rhomboides, Pinnularia viridis, P. major, P. oblonga, P. borealis, Surirella biseriata, S. ovata, Meridion circulare, M. constrictum, Cymbella maculata, C. scotica, C. cuspidata, Epithemia turgida, Ep. Argus, Himantidium Arcus, H. gracile, H. majus, Odontidium mesodon, Diatoma tenue, D. vulgare, Nitzschia linearis, N. amphioxys, Melosira varians, and many others actually occur in every part of the world from whence these soils have come; and there is absolutely no difference between the exotic and the British forms.

Ehrenberg specifies two species, namely, Pinnularia borealis (P. latestriata W. G.), and Eunotia amphioxys (Nitzschia amphioxys, W. Sm.), as having been found by him in almost every instance. My results confirm this. In no one case have both of these been absent, and in at least nine-tenths of these soils both are present. They are often the predominant forms, and in a few cases almost the only forms present. As both of them occur very much scattered in ordinary gatherings from water, I suspect that moist earth is their usual habitat. I may add that Gomphoneam tenellum and Achnanthidium lanceolatum are also found in a large majority of all these soils.

I am disposed to agree in opinion with Ehrenberg, that the microscopic organisms found in soils contribute materially to the increase of the soil. This is true both of the siliceous and calcareous forms. The Diatomaceæ, for example, live as we may see daily, in moist earth. They obtain silica from the water, and at their death their shells are added to the soil. Where many are present, this process of transference of silica from the rock out of which it is dissolved by the rain, to the soil where it remains in a solid but finely divided form, goes on very rapidly where many Diatoms are living. Now, we have so far evidence that they live (as we know they can do) in these soils, that we find them there very often in the state of self-division, which is not observed in old accumulations of the dead shells.

The peculiar capacity of the Diatomaceæ for resisting climatic changes, whereby the same species can live and thrive as well in the Arctic circle as under the line, corresponds well with the results of the study of the same organisms in the fossil state. In Ehrenberg's late great work, *Mikrogeologie,* will be found very fine figures of the Diatoms occurring in the different forms of Bergmehl, Tripoli or polishing slate, Kieselguhr, pumice, and other volcanic rocks, mountain limestone, amber, &c., and it will be seen that by far the greater number of these species are quite identical with recent ones. Although microscopic organisms have been found so low down as the green sand of the Silurian system, I find that these do not appear to be Diatomaceous, but rather belong to the Polythalaria. But the earliest Diatoms, geologically speaking, yet found, as figured by Ehrenberg, agree in every point, as far as the great majority of the species is concerned, with those now living in our waters, and forming deposits which will become rock at some future time. It is evidently the same power of resisting change by climate, which, as we have seen, leads to the occurrence of many identical recent species in all parts of the earth, that has led to the permanent existence of so many of the same species, from the time of the Kieselguhrs and polishing slates to the present day.

Some years ago, it was supposed that most of the species in the much more recent Bergmehl were no longer to be found living; but since then most of them have been found recent. I myself have lately found two species of the Lapland Bergmehl to be still in existence, namely, Eunotia octodon and Synedra hemicyclus; and I may add that Eunotia incisa, which occurs both in the Lapland and the Mull earths, has been found recent by me in a dozen British gatherings. Yet all these forms were supposed, not long since, to be exclusively fossil. We cannot say that there are no species exclusively fossil; but so many that have been thought so are daily found living, that it is probable the rest may be so found too; and at all events, a very large proportion of the forms in the oldest fossil deposits are absolutely identical with the forms of the present day, as a glance at Ehrenberg's figures will prove.

I have only further to mention, that although so many species are universal in their habitat, some appear to be local. Thus Terpsinöe musica does not occur in Europe, nor has it yet been found except in America, and, I think, in Australia.

Some species are decidedly Alpine; for example, Orthosira spinosa, which Professor Smith found on the Mont d'Or in Auvergne, and Professor Balfour on the Grampians, occurs also in nearly every soil from the Andes.

3. *On the Effects of the Severe Frost of last Winter on Plants in the neighbourhood of Sligo.* By the Right Hon. John Wynne of Haslewood.

4. *Notice of a Botanical Trip with Pupils to Falkland and the Lomond Hills, Fife.* By Professor Balfour.

5. *Report on the Diatomaceæ collected during the Excursion.* By Professor Gregory.

6. *Report on the Musci and Desmideæ collected during the Trip to the West Lomond Hill, Fife, 30th June 1855.* By George Lawson.

In speaking of Splachnum sphæricum, Hedw., Mr Lawson states:—All the tufts obtained were covered with an abundance of ripe capsules, and there were also plenty of antheridia, which were found to be in an excellent stage for examination, most of them being ready to discharge their contents. It was observed, that in the same perichætium there were antheridia in various stages of development, those in the centre appearing to ripen first, even while some of those at the outer edge were of small size, and quite green. There is thus a constant succession of phytozoa produced—a provision which tends to ensure their application to the pistillidia at the proper time. In many of the antheridia examined, slight pressure of the thin-glass cover caused their granular contents to escape. This was beautifully seen under Nachet's lowest object-glass: the matter passes out in a continuous stream through a very small orifice in the apex of the antheridium, afterwards collecting in masses on the field of the microscope, as if of a gelatinous nature. The natural discharge of the contents of the antheridium is probably a much slower process than what we observe under artificial treatment. These granular contents are by a higher power (say $\frac{1}{4}$ inch) resolved into a mass of living phytozoa, displaying the most active and lively movements, each whirling upon its own axis, and quickly moving about the field as if from an intense sense of animal enjoyment. Under Ross's one-eighth the form of the phytozoa was well seen; but the morning being cloudy, there was not sufficient light to show the cilia with which these bodies are furnished. The movements entirely ceased about two hours after their discharge from the antheridium, and on some occasions in a shorter period. In one preparation, however (mounted in water), Mr Forbes observed that the phytozoa still moved actively, two days after mounting. As in this case several antheridia were mounted together, it is possible that some of them, entire when put up, had discharged their contents in the interim, and that the movements were seen in phytozoa of these, and not in those originally discharged. The empty antheridium consists of a bag whose membrane is formed of somewhat oblong cells, most of which contain, in addition to granular matter, a bright red nuclear body, which appears in many cases to become divided into a number of smaller vesicular bodies of precisely the same character, thus presenting a striking *resemblance* to Protococcus nivalis, the curious development of which has excited so much attention.

In Penium Digitus, Ehrenberg, some interesting phenomena were observed:—

1. *Locomotion.*—The power of locomotion possessed by the Desmideæ, in itself highly interesting, derives additional importance from the fact, that it has been brought forward by Ehrenberg and his followers in support of the animal character of these organisms. "That the Desmideæ move," says Mr Ralfs (*Introduction, Brit. Desmid.*, pp. 20–21), "must be admitted, for this fact has been noticed by too many accurate observers to permit any doubt of its truth; and although I have myself failed to perceive their actual movement, I have sufficient evidence of its occurrence;" but again, "the movements of the Desmideæ must be very sluggish, or exercised only under very peculiar circumstances, since I have never witnessed it, notwithstanding I have almost daily living specimens under my inspection. Mr E. Jenner has been equally unsuccessful; and several friends, experienced in the use of the microscope, either have not seen it, or speak of it in uncertain terms." It is therefore useful to notice species in which the movements occur. The motion observed by me in this species was not a continuous one, such as appears to be described by the various writers on this subject, but strikingly similar to the jerking movements of Pleurosigma and other Diatoms. Movements precisely similar were observed in Cosmarium undulatum and other species.

2. *Circulation.*—In Penium Digitus I had likewise the opportunity of observing a phenomenon which appeared to me precisely identical in character with that termed the "rotation of the cell sap" in Chara and Vallisneria, and which I have described as occurring in Anacharis Alsinastrum (*Microscopical Journal,* ii. 54). In Penium, as in these plants, large globular granules flow in uninterrupted currents on the inner surface of the utricle, and, as in Vallisneria and Anacharis, are best seen at the edge of the cell. The course of the currents is not very determinate, and they seem to pass each other in close proximity, continuing, however, for hours moving in the same manner. By using the fine adjustment, a single granule may often be followed in its course round the end of the cell, down the edge, and across the suture, thus affording a beautiful demonstration of the unicellular character of the plant. At the suture, however, the manner in which the granule passes seems to indicate a contraction there; its passage is not a slow steady movement as in other parts of the cell; when it enters the clear space its progress is suddenly arrested, and then it quickly starts across into the part containing granules, as if suddenly released from compression; after which it resumes the even tenor of its way. The phenomenon is different from the usual appearance of the "circulation" of Closterium Lunula; but the granules probably owe their movements to the same cause.

7. *Sketch of the Geology of the District visited in the course of Professor Balfour's Excursion.* By Mr James Hector.

8. *Record of Localities for Rare Plants.* By Professor Balfour.

9. *Remarks on Vegetable Excrescences.* By Mr James Hardie, Penmanshiel.

10. *Account of the Origin and of some of the Contents of the Museum attached to the Royal Botanic Garden at Edinburgh.* By Professor Balfour.—(*Continued.*)

SCIENTIFIC INTELLIGENCE.

ZOOLOGY.

Tetragonops ramphastinus (Jardine).—A collection of birds received in the beginning of September last from Professor Jameson of Quito contains a very remarkable form of the *Capitonidæ* or *South American Barbets.* The collection was procured on the Eastern Cordillera between Quito and the Mountain Cayambe, and is accompanied by a map of the route through which it was made, which will be engraved, and a figure of the bird given in our Number for January.

Tetragonops ramphastinus is of a larger size than the greater number of the South American Capitonidæ, and is remarkable for the form of the bill, which is very powerful, and almost square at the base; the tip of the mandible is deeply bifurcated, and into the division rests the curved tip of the maxilla. The base of the maxilla is strongly developed, and the whole bill is richly coloured,—the base yellow and orange, the apical half bluish-black. The distribution of the colours of the plumage is also somewhat peculiar; around the eyes, crown, nape and a nuchal collar, black; wings and tail grayish-black, the latter somewhat cuneated; back, yellowish-brown; rump and upper tail covers yellow; from behind the eyes, and nearly joining upon the nape, there is a broad streak of shining white. The whole chin, throat, breast and sides of the neck are bluish-gray, and are separated from the belly by a band of dark vermilion. The centre of the belly is also vermilion, shading off at each side into yellow; the flanks, vent, and under tail coverts are grayish-green. Length, 8·5; wing, 4·1.

Habits of American Jaguar.—Walking along the beach to prevent sleep, I witnessed a singular spectacle, but (as I was informed by the inhabitants) one of frequent occurrence. An enormous jaguar was extended full length upon a rock level with the water, about forty paces from me. From time to time he struck the water with his tail, and at the same moment raised one of his fore paws and seized fish, often of an enormous size. The fish, deceived by the noise, and taking it for the fall of forest fruits (of which they are very fond) unsuspectingly approach, and soon fall into the claws of the traitor.—(L. Herndon, *Expl. of the Valley of the Amazon*, p. 312.)

GEOLOGY.

New Phyllopod Crustacean.—A drawing of this interesting fossil has been sent to us by the Rev. W. S. Symonds, F.G.S., with the following note. The drawing has been engraved on plate. "The addition of a new species of crustacean to the Upper Silurian list of organic remains is an important fact as regards strata which have been so thoroughly examined as the Upper Ludlow rocks of Great Britain. Plate No. VIII. represents the trifid tail of a phyllopod crustacean, allied apparently to Hymenocaris vermicauda of the Lower Silurians of North Wales. This phyllopod was detected by Mr Lightbody of Ludlow in the Upper Ludlow shales on the banks of the river Teme, and has been forwarded to Mr Salter for examination and description."

Discovery of Gems and Fossils in the Haute Loire. By M. Bertrand de Lom.

For many years Espaly was the only locality in France which yielded corundum and zircon, and the quantity of these minerals which is now obtained there is extremely trifling. In 1844 and 1848 the author announced the existence of three other localities in the same department; viz., Taulhac, where there are found corundum, red spinelle, and zircon; Bessac, yielding corundum, spinelle (pleonaste), and peridote; and Cerey, which affords the corundum and pleonaste in very considerable quantity.

The new locality is very rich in gems, and during six months has yielded nearly 10,000 carats of corundum of various colours, some of a fine blue, and capable of being cut, but all well crystallized, and in crystals weighing from 20 to 60 carats. With it are associated zircon, spinelle (pleonaste), yellow sphene, sometimes transparent and capable of being cut, rutile, peridote in rectangular prisms, with double pyramids, earthy peridote, black pyroxene, amphibole in fine crystals, titaniferous iron, often in large nodules, and containing numerous crystals of apatite, black tourmaline, and a substance of a red colour and nacreous aspect, crystallizing in octahedra; and of which the composition is not yet determined.

The same locality is also rich in fossil-bones, and in the course of a few months has yielded 700 or 800 specimens, of which about 400 have been teeth and fragments of the jaws of two species of Felis, one hitherto unknown in Europe, and which, according to M. Lartet, is the *Felis smilodon* found in the caves of Brazil, and a hyena. Others belong to the Pachydermata, such as Mastodonta angustidens, several species of deer, an antelope, and others which are not yet determined. These fossils are found in a sub-volcanic diluvium, varying in thickness from two to ten metres.—(*Comptes Rendus*, vol. xl., p. 885.)

CHEMISTRY.

Researches on Silicon and Titanium. By M. St Clair Deville.

The author prepares silicon from the chloride by a process exactly analogous to that which he has employed for the preparation of aluminium. Chloride of silicon is passed over sodium contained in a porcelain boat at a red heat. The sodium is entirely converted into chloride, and on washing with cold water the silicon is obtained with all the characters attributed to it by Berzelius. But if pieces which have not touched the boat be introduced into a crucible, surrounded and covered with pure common salt, and exposed to a temperature sufficiently high to expel the greater part of the alkaline chloride, the silicon is obtained in some cases in a graphitoid condition, in others as a fused and often crystallized mass. The crystals have the colour of slightly iridescent specular iron ore; they do not admit of measurement, for their faces are curved; but in general appearance they closely resemble the diamond, and are capable of cutting glass. On analysis 100 parts of these crystals gave 205 of silicic acid. Theory requires 209, and the small deficiency consisted of silicon with iron. It appears then that silicon, like carbon (with which it has been classified among the non-metallic elements), exists in three different states:—

1. As the silicon of Berzelius, which represents ordinary charcoal.

2. Graphitoid silicon, which corresponds to graphite, and is produced under the same circumstances as artificial graphite.

3. Crystallized silicon, analogous to the diamond. Silicon has a remarkable tendency to combine with iron, and takes it wherever it is to be found, even from the crucibles, which are corroded in a remarkable manner. It unites with the metals, particularly with copper, to which it communicates such hardness that it resists the file. The compound is to copper what steel is to iron.

Titanium, obtained by a similar process, and heated in a crucible made of alumina, is a substance infusible at a temperature at which platinum rises in vapour. (?) It resembles very iridescent specular iron, and crystallizes in prisms with a square base.—(*Comptes Rendus*, vol. xl., p. 1034.)

Manufacture of Cinnabar at Idria. By M. Huyot.

The process commences with the preparation of the black sulphuret of mercury. For this purpose, 42 lb. of mercury and 8 lb. of sulphur in coarse powder are introduced into a cask which receives by machinery a reciprocating rotatory movement at the rate of from fifteen to twenty-five rotations per minute. The length of time during which the mixture remains in the casks varies from 2·3 to 3·5 hours, according to the temperature. The combination of the materials is not complete, for particles of sulphur and globules of mercury may still be detected on it, and here and there it acquires a reddish tint from incipient conversion into cinnabar. The mass is then introduced into cast-iron retorts, of which there are twenty-four arranged in four furnaces. Each retort is furnished with an earthenware head connected by a tube with a receiver. The heads being adjusted and properly luted, heat is applied, and the temperature raised to 259°. As soon as sulphureous vapours appear, the tube and receiver are attached, and at the temperature of 716° sublimation goes on with rapidity. The retorts require about two-and-a-half hours to reach the temperature at which sublimation commences, and the charge is sublimed in about five hours. Of every 1000 parts of sublimed cinnabar, 365 are found in the part of the head next the retort, 327 in that nearest the tube, 255 in the tube itself, and 53 in the receiver. The cinnabar is then ground by passing it between stones placed at different distances apart, according to the fineness of the grain required. Chinese cinnabar is ground twice, dark red four times, and bright red cinnabar five times.

The product is then refined, as it is called, in order to remove the excess of sulphur employed in the first process. For this purpose it is digested with a ley of wood ashes concentrated until it has a density of 12 B. The cinnabar is then repeatedly washed, and dried on iron plates.—(*Polytechnisches Centralblatt* 1855, p. 661.)

Artificial Preparation of Essential Oil of Mustard. By Zinin, Berthelot, and Luca.

Zinin has prepared the oil of mustard artificially by boiling an alcoholic solution of sulpho-cyanide of potassium with the iodide of propylene. The decomposition is represented thus—

$$KC_2\ NS_2 + C_6\ H_5 I = C_8\ H_4\ N_2\ S_2 + KI.$$

By distilling the mixture and collecting that which comes over between 282° and 291°, a fluid was obtained which had all the characters of oil of mustard. Berthelot and Luca, independently of Zinin, have made the same experiment, and have shown that the product yields thiosinnamine, identical in all its characters with that obtained from the natural oil. They erroneously describe the product as a sulpho-cyanide of sulpho-propylene, whereas it is a sulpho-cyanide of propylenyl, with the formula $C_6\ H_5\ C_2\ NS_2$. They further remark that this experiment may be generalized, and analogous compounds obtained from the homologues of propylene, and promise some experiments in this direction.—(Zinin, *Journal für Practische Chimie*, vol. xliv., p. 504; Berthelot and Luca, *Comptes Rendus*, vol. xli., p. 21.)

BOTANY.

Algæ in Van Diemen's Land.—The neighbourhood of Georgetown appears, by all accounts, to be the best Algæ ground in the island. The *ground* strongly reminds me of Bantry Bay; not so much the aspect of the hills, &c., as that of the marine flora. Everything that grows at Georgetown (as at Bantry) is of a huge size; the leaves extravagantly broad of the leafy kinds, and the stems of the branching ones proportionably long. The *Dasyæ* are commonly two to three feet long; so is *Polysiphonia Hookeri*, and even longer. I have seen bunches of *Griffithsia setacea* nearly two feet long, *G. corallina* almost as large, and *Callithamnia*, which might be laid out so as to cover a large sheet of cartridge paper. From a *single plant* of *Laurencia dasyphylla* I made thirty or forty good-sized specimens; each secondary branch being sufficient for a folio sheet: no paper would have been large enough to lay down the specimen entire. The same luxuriance distinguishes most others. I have not myself gathered *Martensia*, but I have seen fragments of its *fringe* (without the membrane) which indicate that the perfect specimens must have been at least a foot in diameter. It appears to be very rare. *Claudea* seems to be pretty generally distributed through the estuary, though very rare, except in one or two places where it is abundantly cast up. I have not found it growing. The best locality for it is at Point Rapid, about ten or twelve miles higher up the river than Georgetown. I call it *river*, but the water is perfectly salt for upwards of thirty miles, and in many places very deep; and to this depth of water, and the quiet shelter which the plants enjoy, are no doubt to be attributed the extraordinary luxuriance which they attain.—(Harvey, in *Hooker's Journal of Botany*, Aug. 1855.)

British Weeds in Van Diemen's Land.—Many common English weeds are naturalized about Georgetown, and some are perfect pests. *Horehound* is everywhere by the roadsides, and *Chamomile* covers the fields and paddocks, in many places to the exclusion of grasses. *Thistles* are fast going ahead all through Van Diemen's Land, and no one seems to trouble himself with them, although I have seen, I suppose, hundreds of acres given over to them, and growing so thick in some places that I have walked over my shoes in the bed of thistle-down which had blown from the withered stems. *Sweet-briar*, originally introduced as a hedge-plant, is completely naturalized, and in places forms impenetrable thickets. It annually produces millions of *hips*, and, if let alone, will soon become as great a pest as the thistles. The common *Furze* is also spreading, but not so rapidly, in the western country. The Hawthorn grows perfectly, and forms excellent hedges as at home, but keeps within bounds; though it, too, fruits abundantly. I have seen Oaks heavily laden with well-grown acorns; but there are no trees, as yet, of large size. Elms and Ash are occasionally cultivated, but are not common. I do not think I have seen any of the Pine tribe in cultivation, except a few recently introduced to the Botanic Garden at Hobart Town. The great staple, in the garden way, of the colony is in Apples, Pears, and Plums and Cherries; all of which thrive remarkably well; and they have already raised some seedling apples and plums, which are well deserving of cultivation. There is a large trade in apples to Melbourne. The smaller fruits are made into jams, or consumed at home; and often suffered to rot on the trees, from their abundance. Gooseberries, Currants, Raspberries, and Strawberries grow equally well. But Peaches and Nectarines are only fit for tarts, and often fall off before they are ripe. Grapes just ripen and no more, and are of small size. I have been here the hottest months of summer without experiencing greater heat than we often have in England. There is less rain, and a greater number of clear days; but, on the whole, I scarcely think the summers hotter than those of England. People here complain (as in all the Australian colonies) of the rapid changes of temperature, but with less reason for complaining than in any other country I know of. To me the climate seems as nearly perfect as a sublunary climate can well be. —(Harvey, in *Hooker's Journal of Botany*, Aug. 1855.)

In Victoria colony, Müller gathered the following British plants:—*Alchemilla vulgaris*, *Barbarea vulgaris*, *Geum urbanum*, *Carex stellu-*

lata, Veronica serpyllifolia? Botrychium Lunaria, Lysimachia vulgaris, Zostera marina, Potamogeton prælongus, P. crispus, Polygonum lapathifolium.—(*Hooker's Journ.*, Aug., 1855.)

Magnolia seed-coat.—Dr Asa Gray states, that the covering of the seed in *Magnolia* is not an aril, but a proper envelope of the seed. The external coat of the ovule becomes drupaceous in the seed, its outer portion forming the fleshy, its inner the crustaceous seed-coat.—(*Hooker's Journal*, Aug. 1855; *see also Hooker and Thomson's Flora Indica.*)

Caoutchouc in South America.—Caoutchouc is procured in the Amazon and Rio Negro districts, from various species of *Siphonia*. Spruce noticed seven or eight species which yielded the substance. In the Amazon, India-rubber is called *Xeringue*, which is a corruption of the Portuguese word Seringa. The India-rubber collectors are denominated Seringueiros. Alum accelerates the coagulation of caoutchouc, while ammonia keeps it in a fluid state. Seringa trees are tapped about Pará during the dry season from June to December. On the Upper Rio Negro and Lower Caiquiare, the plants which yield the Seringa are *Siphonia lutea*, Spr., and *S. brevifolia*, Spr. They are called long-leaved and short-leaved Seringa. Their average height is 100 feet. The Seringa of Pará is *Siphonia brasiliensis*, Willd. *Siphonia elastica*, Aubl., also yields caoutchouc near the Barra. *Siphonia Spruceana*, Benth., is another caoutchouc tree. It grows about the mouths of the Tapajoz and Madeira. On the Uaupés there are other caoutchouc trees, probably belonging to Sapotaceæ (Micrandra of Bentham). The Rio Uaupés joins the Rio Negro a little north of São Gabriel, and its course is nearly coincident with the actual equator. Many species of Ficus and Artocarpus also yield caoutchouc in South America. The families of Figs and Artocarps abound towards the head-waters of the Rio Negro and Orinoco.—(*Hooker's Journal of Botany*, July 1855.)

Piassaba fibre.—This fibre is furnished by two kinds of Palms, *Attalea funifera* of Martius and *Leopoldinia Piassaba* of Wallace. There are two kinds of fibre in commerce, according to Archer, and they are of different qualities and values. The best comes from the Rio Negro by way of Pará, the inferior kind from Ceara.—(*Hooker's Journal of Botany*, July 1855.)

Sarsaparilla. Extract of a Letter from Mr Spruce, *dated Rio Negro, February* 5, 1855.

Sarsaparilla is growing scarce and difficult to obtain on these rivers, and is now found only at the head-waters of some of the tributaries of the Rio Negro, Orinoco, and Casiquiare. Lower down the same streams it seems to have been all uprooted. Those who go to gather it must spend four or six months in the forest, and endure all sorts of privations. I have never in the whole course of my wanderings come across one of the species of *Smilax* which affords Sarsaparilla of commerce, though I have gathered numerous species of that genus. But in 1852 I saw plants of a *Smilax* near São Gabriel (and I sent specimens of the leaves and fruit to Kew), which had been brought from the Canaburís, and from which I saw the roots extracted and dried for sale.

Those who go to collect Sarsaparilla tell me they are guided by three characters :—

1. Many stems from a root.
2. Prickles of stem closely set.
3. Leaves thin (not coriaceous).

I am assured that the species of *Smilax* possessing these characters united have also numerous long roots, radiating horizontally from the crown; while the single-stemmed species have only a solitary tap-root.

I am aware that the Jamaica Sarsaparilla is said to command a better price in the market than that of Pará, but I thought it had been planted in that island. Of the Sarsaparilla collected in the upper tributaries of the Orinoco, of the Rio Negro, the greater portion goes to the Pará market, where it fetches a better price than at Angostura. I am not aware that it enters into the commerce of any other port in Venezuela except Angostura; and it is curious if the same Sarsaparilla coming to England by way of Jamaica sells for double the price that it fetches when sent by way of Pará.—(*Hooker's Journal of Botany*, Aug. 1855.)

Viola calaminaria.—The calamine hills of Rhenish Prussia, and of the neighbouring parts of Belgium, possess a peculiar Flora. The botanist who traverses these districts is particularly struck with a violet allied to *Viola tricolor*, which occurs in great abundance, and expands its beautiful yellow flowers from spring till autumn. It is called *Viola calaminaria* by some, and by others it is looked upon as a variety of *Viola lutea* of Smith. The species is distinguished from *Viola tricolor* chiefly by its filiform subterranean stems, which enable it to resist the rigour of winter. *Viola calaminaria* is distinguished not only by its habitat from the *Viola lutea* of the Alps, as well as from the forms met with on the granitic and syenitic summits of the Vosges to which Spach has given the name of *V. elegans*, but also by its stem being very low, and dividing near the ground into several branches (hence *V. lutea*, var. *multicaulis*, Koch.,) and by its flowers being in general smaller. Besides this violet, there are other plants which characterize the calamine or zinc hills of Rhenish Prussia. Among these may be noticed *Alsine verna*, *Armeria vulgaris*, and *Thlaspi alpestre*. The colour of the flowers of *Viola lutea* of the Alps and the Vosges varies from a deep violet, through an infinite variety of shades and hues, to pure yellow; whilst the flowers of *Viola calaminaria*, at least in the neighbourhood of Aix-la-Chapelle, are almost constantly yellow, of various shades. It is only on the confines of the calamine soil that we meet here and there with specimens of a clear violet or bluish colour, or rather a mixture of yellow and bluish. M. Braun mentions the occurrence of *Viola calaminaria*, with flowers deep violet, at Blankenrode, in the eastern part of Westphalia, in calamine soil. He considers that there is a connection between the calamine soil and the presence of this violet, and he has determined chemically the presence of zinc in the plant.—(Braun, *Academie des Sciences de Berlin*, 1852.)

MINERALOGY.

Analysis of Phosphorite from the Siebengebirge. By R. Bluhme.

Lime,	47·50
Phosphoric acid,	37·33
Alumina,	3·28
Magnesia,	2·70
Carbonic acid,	2·20
Silicic acid,	3·50
Water,	1·65
Loss,	1·84
	100·00

It contained no fluorine, and only traces of chlorine. The phosphate of lime contained in it is the tribasic phosphate, $3CaO,PO_5$.—(*Annalen der Chemie und Pharmacie*, vol. xciv., p. 354.)

Selenium in Pseudomalachite from Reinbreitbach. By Professor Bœdekir.

Kersten stated some years since that selenium was found in the copper bloom of this locality, but of late great doubts have been entertained of the correctness of this observation. Professor Bœdeker, after having failed several times in detecting it in that mineral, has found it in the pseudomalachite of the same locality. It appears to exist in the form of seleniuret of copper, and amounts to about 0·3 per cent. of the mineral.—(*Annalen der Chemie und Pharmacie*, vol. xciv., p. 356.)

On the occurrence of Feldspar containing Lithia. By Dr Gustav Jenzsch.

Dr Jenzsch has analyzed a pale smalt blue feldspar (pegmatolite) from the neighbourhood of Rodeberg in Saxony, and found it to contain 0·71 per cent. of lithia, with traces of fluorine and boracic acid. It has the usual orthoclase formula, $RO\ Si\ O_3 + R_2\ O_3\ 3Si\ O_3$.—(*Poggendorff's Annalen*, vol. xcv., p. 304.)

METEOROLOGY.

The importance of meteorology is particularly recognised by the Smithsonian Institution of Washington, U.S. "There is no part of physical science in which so much is to be done, even in the way of partial generalization, as in meteorology; and hence the importance of engaging as many minds as possible in its investigation. The Institution distributes full sets of standard instruments made under their directions. Blank forms are furnished liberally to individuals who may desire to record the changes of the weather, or the progress of the periodical phænomena. To render the materials already collected available for the advancement of science, those already collected are in the progress of being reduced to tabular forms, and will be published in as much detail as the funds of the Institution will allow. The materials collected consist of two classes; viz., one which includes all the records of observations published in books and periodicals, or contained in MS. which have been lent us for reduction. The other class consists of the current observations, which now embrace all the returns we have received for several years past."—(*Report Smithsonian Institution for* 1853–4.)

MISCELLANEOUS.

Navigation of the Amazon.—The greatest boon in the wide world of commerce is the free navigation of the Amazon, its confluents and neighbouring streams. The back-bone of South America is in sight of the Pacific. The slopes of the continent look east, they are drained into the Atlantic, and their rich productions in vast variety and profusion may be emptied into the commercial lap of that ocean by the most majestic of water-courses.

The time will come when the free navigation of the Amazon and other South American rivers will be regarded by the people of this country (North America) as second only in importance to the acquisition of Louisiana.

Having traversed that watershed from its highest ridge to its very eaves and gutters, I found my thoughts and reflections overwhelmed with the immensity of this field for enterprise, commercial prosperity and human happiness.

I can bear witness to the truth of the sentiment that the Valley of the Amazon, and the Valley of the Mississippi are commercial complements of each other—one supplying what the other lacks in the great commercial road. They are sisters which should not be separated.—(R. Herndon, *Expl. of the Valley of the Amazon*, p. 193.)

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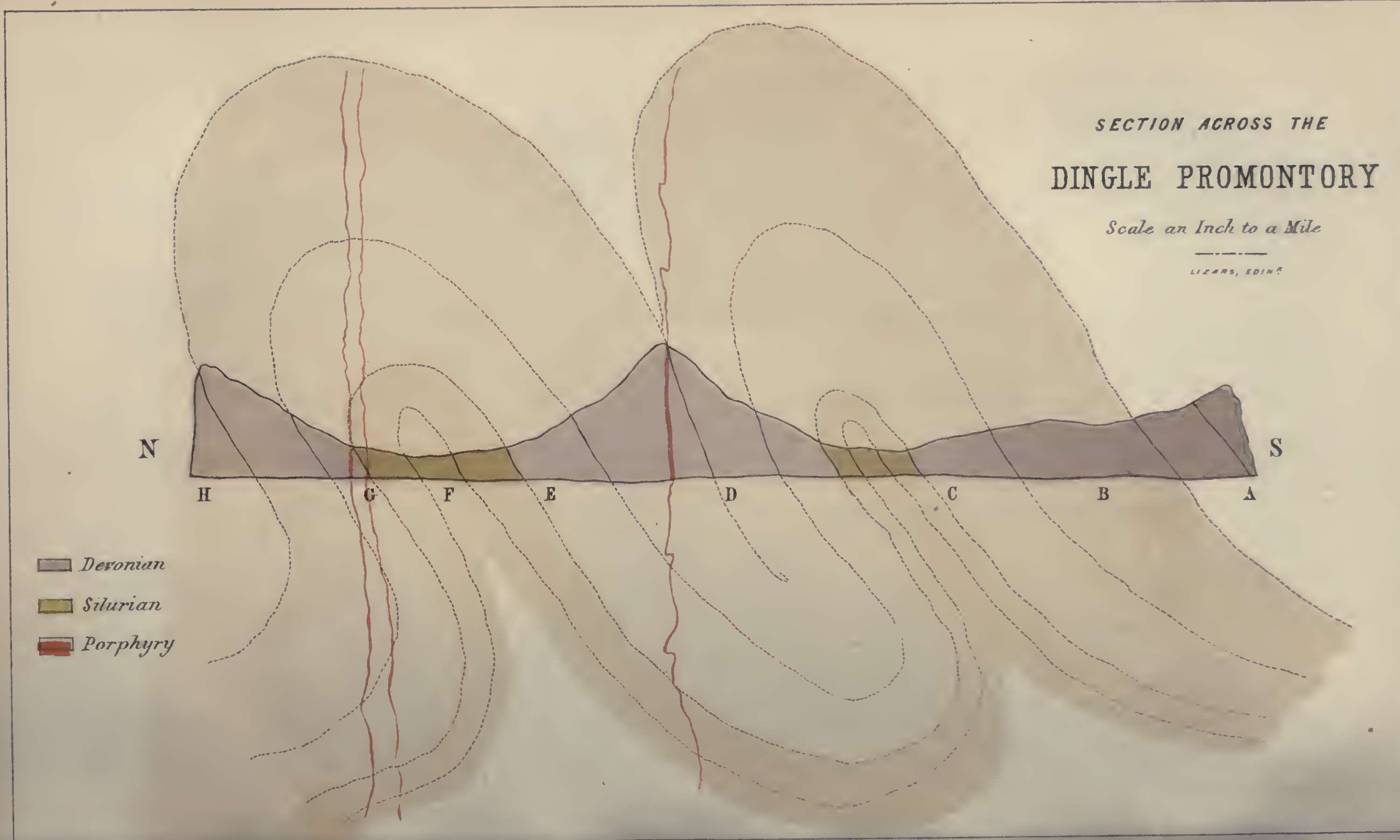

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