THE PLANT;

A BIOGRAPHY.

On Zinc by J. Erxleben *London, Publish[d] by H. Bailliere 1848* *Day & Son Lith[rs] to the Queen.*

THE PLANT;

A BIOGRAPHY.

IN A

SERIES OF POPULAR LECTURES.

BY

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"OUTLINES OF STRUCTURAL AND PHYSIOLOGICAL BOTANY."

WITH FIVE COLOURED PLATES AND THIRTEEN WOOD ENGRAVINGS.

LONDON:

HIPPOLYTE BAILLIERE, PUBLISHER,

FOREIGN BOOKSELLER TO THE ROYAL COLLEGE OF SURGEONS,

219, *REGENT STREET.*

PARIS: J. B. BAILLIERE, 13, RUE DE L'ECOLE DE MEDECINE.

1848.

LONDON:
Printed by Schulze and Co., 13, Poland Street.

ADVERTISEMENT.

Professor Schleiden, the Author of these Lectures, is one of the most distinguished Botanists of the present day, and he has added to the obligations which his brother Botanists are under to him, by presenting their favourite Science in such an attractive form to the general Public.

At the commencement of my pleasant task of preparing them for the English reader, I thought of adding a few notes, especially to those passages relating to certain views which are not universally received; but further consideration induced me to confine myself to a simple translation, since, while foot-notes would have disturbed the integrity of the plan of the Work, had they been placed in an Appendix, probably they would not have been much read.

There is an especial difficulty in rendering works like the present into a different language, since style must be attended to as well as faithfulness to the literal meaning. The accumulation of adjectives in descriptive portions is often very embarrassing; should some of these be found rather un-English, I must beg for the indulgence of the reader, on the plea of an earnest endeavour not to lose any of the peculiar character of the Original.

The Translator.

London, May, 1848.

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INTRODUCTION.

The following Lectures have been composed during the course of the last eight years, at the instance of an intelligent and cultivated circle, free from "the dust of schools," and were by no means intended for publication; in this point, however, I have yielded to the wishes of my friends, and so now find myself compelled to add a few words, in order to place the Lectures in their proper light.

From the nature of the circumstances which led to their composition, they were not, of course, intended to teach the positive substance of the science, to bring forward new results from my own researches or to solve problems of inquiry. Here and there even may perchance be found, in spite of all my efforts to avoid it, some trifling matter not quite correctly stated; but this defect will not at all interfere with the design I had in view in the preparation of these little essays. My chief aim was, in fact, the satisfaction of what may be called a class-vanity. A large proportion of the uninitiated, even among the educated classes, are still in the habit of regarding the Botanist as a dealer in barbarous Latin names, a man who plucks flowers, names them, dries and wraps them up in paper, and whose whole wisdom is expended in the determination and classification of this ingeniously collected hay. This portrait of the Botanist was, alas ! once true, but it pains me to observe, that now, when it bears resemblance to so few, it is still held fast to by very many persons; and I have sought, therefore, in the present discourses, to bring within the sphere of general comprehension, the more important problems of the real science of Botany, to point out how closely it is connected with almost all the most abstruse branches of philosophy and natural science, and to show how almost every fact or larger group of facts tends, as well in Botany as in every other branch of human activity, to suggest the most earnest and weighty questions, and to carry mankind forward beyond the possessions of sense, to the anticipations of the spirit.

If, through my efforts, the reader of these sketches shall hereafter hold a worthier opinion of Botany, and the Botanist shall form a more accurate conception of the compass and objects of our Science, I shall be content. Should they excite an interest for Botany itself in a wider circle, should one or other reader be led by my words to wish to penetrate further into these so agreeable and so inexhaustible questions, my desires will be more than accomplished.

A few words more, as to the mode of treatment of the subject may here find place. True to my own convictions, I have kept free from all the pratings of the physiophilosophers of the Schelling school, and I am firmly persuaded, that Science has no need of these fopperies to make it appear interesting to the uninitiated. Humboldt in his Views of Nature, Dove in his masterly Lectures on the Climate of Berlin, have proved that science may really appear lovely and captivating, without adorning herself with the false tinsel of those conscious or unconscious falsehoods, which would substitute poetry for thought, imagination for knowledge, or dreams for truths. I have endeavoured to adorn these essays with as many graces as my imperfect æsthetic culture enabled me to impart, but that it has not been my intention to enter the lists with those masters of language, need scarcely be mentioned. I believe, however, that if men of science would more often seek to introduce truth into society, in fair attire, the path of that intolerable, mystical and pretentious, empty chattering, would be more effectually arrested than by any rational argumentation against it. The Germans have too sound a judgment, too pure a taste, not to prefer, without much hesitation, the true and valuable to empty straw, if the two be but offered them in equally palatable form.

With regard to the contents of the individual Lectures, from the circumstances under which they originated, each is of course complete in itself and independent of the others, at the same time a kind of thread runs through all, essentially connecting them. I may be allowed perhaps to make this more evident by presenting it here in an isolated form.

The vegetable world, if it be but looked upon as something more than the materials for a herbarium, offers so many points of contact to the human race, that those who devote themselves to its study, instead of having to complain of want of material, become oppressed with the multitude of interesting questions and problems which crowd upon them. The different subjects of consideration may be conveniently arranged under four aspects; firstly, the condition of the plant itself as a question of scientific inquiry; secondly, the relations of the individual plants to each other; thirdly, the relations of plants as organisms to the organism of the whole earth; and fourthly, the relation of the human race to the vegetable world. But since each of these four relations is fulfilled by the plant at one and the same time, it is infinitely difficult, if not impossible, to keep each aspect clear and unmixed, and when we enter upon one of these relations with the desire to subject it to closer investigation, we are always involuntarily constrained, sooner or later, to direct our attention to the rest and to draw them within the circle of our researches. Though we establish upon these questions, according to their order, the following branches of study: *Theoretical*, or Pure Botany; *Systematic* Botany; *Geographical* and *Applied* Botany; yet not one of these can be treated from its own principal point of view alone, if it would lay claim to a scientific or profound character; still more difficult is it, however, to keep strictly within the boundaries of these four divisions when the object in view is not dry scientific teaching, but a lively demonstration of the more important points. In the following essays, therefore, the division into these four branches can only be adopted to a limited extent, and a freer treatment becomes necessary from the abundance of material which continually allures us to turn aside from our path, to gather here and there a bright or fragrant flower; or the companionship in which we wander through the land of science, induces us oftentimes to leave the straight, but dusty and fatiguing high-road, now to pursue our course through lanes which wind among pleasant meadows, now to explore a shady forest path. Let us see whither we are going.

A plant is not, like a crystal or a pure fluid, a perfectly homogeneous body, to fathom the nature of which it suffices to know the substance composing it and its external form, it is far more than this; built up of many minute and most curiously formed cells, filled with most varied matters, a thorough and penetrating examination of its internal Structure must precede all other considerations (II). But the little bodies, which I have just named, the cells, are in almost every case so small, that the unassisted eye is not by any means equal to the task of their investigation. The microscope is the necessary instrument, without this the Botanist can make no step forward in security. Now there are many persons labouring under the delusion, that for microscopical researches merely an eye and an instrument are necessary, and all may be done. But not only is the use of the microscope an art to be acquired only by considerable pains, but scientific vision with even the naked eye has its difficulties; so that it is particularly necessary to indicate at least the point of view, from which the use of the Eye and Microscope is to be regarded (I).*

Advancing a step, the next question that meets us is, to discover what then combines all those little organisms, the cells of the plant, into a single individual; and our attention is thus directed to the consideration of the forms which are constructed out of these cells. Morphology, or the study of form (IV) makes its own distinct claim to the exertion of our perceptive faculties. Here, however, we rarely find that we have to deal with a simple plant, for most vegetables consist of a multitude of individuals grown together and vitally connected, like the colony of polypes on a coral; these are the product of the propagative activity of the plant, and, therefore, before we enter upon morphology, it appears more judicious that we should trace out to some extent the Propagation of Vegetables (III).

* Quekett, "Practical Treatise on the Use of the Microscope." Baillière.

When we have become acquainted with the internal and external structure of the plant, we see how it rejoices in an untiring power of development, ever calling forth new plants in inexhaustible abundance, careful that no bare spot shall show itself in the rich and variegated carpet with which nature clothes the naked earth. The development of the form and organs of the plant, the calling forth and the production of numerous descendants, requires material. It must come into existence, maintain itself and multiply, and thus we are led to the Nutrition of plants. At this point, more particularly, we are compelled to observe the relations of the plant to its supporter, the earth, and to its destroyer, man. The whole animal world, and, above all, mankind, asserts its claim upon the vegetable world; this must furnish sustenance to a countless poor, since it subsists and grows subject to the destination that the matter applied to its own development shall, moreover, serve for the food or uses of the other earthly organisms. This nutrition of plants, however, may be looked at in two ways, for, to express it briefly, if we burn a plant, a portion only is destroyed, which combustible part we call the organic matter of the plant, and this claims our especial interest (VI), because it includes the main substance of the nutriment of the animal world. But a varying proportion of the plant remains behind, as ash, after the burning; and this also, which we call inorganic matter, invites our attention (VII), so much the more, indeed, when we find that this ash, improbable as it may at first appear, likewise plays no unessential part in the nutrition of animals and man. In both ways of looking at the subject, we are reminded that man, where advanced civilization has crowded him more closely upon small areas, is and can be no longer content with what mother-earth freely brings forth and proffers to him as food, but agriculture must furnish him with the means to satisfy his increased necessities. But man only ploughs the field and strews the seed; in faith he awaits a blessing from above. All vegetation depends far more closely than is usually believed upon the phenomena which, in sunshine and cold, drought or rain, in the storm or the soft breath of the south-western breeze, constitute that which we call weather and climate. We shall, therefore, justly make the considera-tion of Weather precede the investigation into the nutrition of plants (V).

While the fact of the plants preparing their nutriment is the most important basis for the existence of the animal world upon the earth, man is also entitled and enabled by his industry to make an incomparably greater use of plants and the matters contained in them. Thus is opened a new, and, indeed, almost unbounded field. Need I enumerate all the crafts which derive the material on which their labours are exerted from the vegetable kingdom? Every one who looks around his chamber or his household, will be at once aware of how many of the conveniencies and pleasures of life he must be deprived if the vegetable world should cease to pay its tribute. Need we open all the drawers and boxes of the grocer or the druggist, to see what a store of means vegetation contributes here also? A general summary would give but a dry catalogue of names; a detailed account of all would occupy many volumes. We will be content with a single example, and examine some-what closely the Milky Juices of plants (VIII).

The formation of milky juices is not confined to one, nor to a small number of allied plants, but we find at least three very large groups, which principally furnish this inte-resting substance. The number of distinct species of plants is so great (probably, according to the estimate of some writers, 200,000), that to enable us to survey this mass, a scientific expedient has been requisite, in the shape of a systematic arrangement of the different genera. Fortunately, Nature meets us half-way. In all the external forms, in the number, the arrangement and the structure of the separate parts, in the laws which regulate their development, the larger groups of species of plants exhibit a great agreement among themselves, and by this very fact are distinguished from other groups. Who can notice, at the time of blossoming, a carrot, the hemlock, parsley, chervil, anise, dill and the rest, without being struck with the agreement of these plants in general structure? Who would not, in like manner, perceive the close relation which exists between the various kinds of cabbage, the mustard, horse-radish, radish, turnip and similar plants? Any one who examines a little more closely, will recognize a multitude of plants which are distinguished by a strong aroma, the balm, mint, sage, thyme, marjoram, lavender &c., and a wonderful agreement of structure will be observed. Thus Nature herself indicates to us the path we are to take; following out such traces, Botanists have gradually recognized and characterized a great number of these groups of plants, which they have called Families. That in this, as in the foregoing case, there is no space here for completeness, need scarcely be mentioned, but we could not deny it to ourselves to take one family, as an example, and characterize it more accurately (IX).

In the group selected, the Cactus plants, our attention is attracted, among many other things, to their remarkable distribution over a comparatively small part of the earth's surface; and this leads very naturally to the question, how the different species of plants spread themselves over the earth in greater or lesser groups; whether this distribution is the result of accident, or is regulated by laws, and if so, what laws? Well, let us follow Humboldt's footsteps and committing ourselves to the care of such a guide, let us enter a new, widely-expanded region, first discovered by him—Geographical Botany (x).* A science of a peculiar nature, still young and burdened with all the faults of youth, overflowing with the fulness of life, certain of a fair and powerful manhood, but still disorderly and obscure, gathering much, at present unintelligible, for use in riper years, and as yet dreaming much more than thinking. A brief outline of its attractive phenomena cannot but prove interesting. This youth leads forward a sister, still younger, yet indeed in the tenderest age of childhood, but a hopeful bud nevertheless. Let us turn with friendly ear to her childish prattle, the chords full of promise of a future harmonious beauty; if she do not teach us very much, she will help us pleasantly to while away a brief hour. Why should we not then afford a little place to her, the History of Plants? (XI).

And ought we here, above all places, to shun children? Are not children, flowers—flowers, children? An unconscious unfolding, a peaceful, sweet but dream-like existence. How close is that comparison which poets have so oft expressed:

> "Sweet flowers gaze on us
> With gentle child-like eyes."

It is referable to the similar tone which is set vibrating in our souls by the contemplation of children and of flowers. But every one will readily admit, that this resem-

* "Kosmos; a General Survey of the Physical Phenomena of the Universe." Baillière.

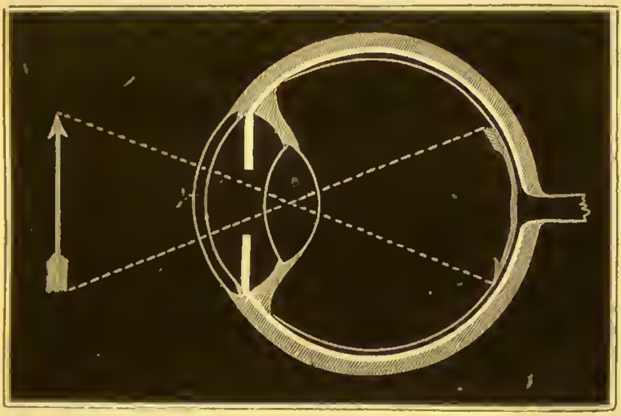
blance is limited to certain flowers. No one will assert it of the white Lily, of the toad-like speckled Stapelia, or of the magic Queen of the Night. Still less will the parallel hold good for the whole vegetable kingdom. Rather does this make the most varied impression on the human sense, according to the manifold shapes in which it presents itself; but ever one so difficult to repel, that scarcely can the rudest of mankind altogether avoid it. Like all nature, the vegetable world is to us a hieroglyphic of the Eternal; in the material fashionings do we seek and find the indication of a spiritual existence. Well might we here look for a special study of these matters, the Æsthetics of Plants (XII), which should contemplate them in their relation to the human spirit. But, alas! we have none. A few fragmentary indications must supply its place.

This will suffice to show the chain which binds the contents of the separate Lectures into a settled whole; it is necessary, however, to add a few words respecting the garb in which the Lectures appear before the public. "Fine feathers make fine birds," it is said; and so why should not a fine book make fine Lectures? In point of fact, this is not altogether a jest; to a certain extent, it is unpleasant earnest. These treatises were not written for the reading, absent public, but for the hearing and seeing audience. All could be made lively and attractive to those present, by living illustrations, demonstrations under the microscope and the exhibition of abundance of pictures. These adornments may have given the essays an interest in the eyes of favouring friends, which led them to desire their publication. The charm thus upheld, where one has all the facts before one's eyes, and, following the exposition, feels as if deducing the conclusions of science itself from observation; this charm necessarily disappears when such a treatise is read; with the ornaments goes also the estimation in whieh the matter is held, and is wholly, or for the most part, lost. The author has, therefore, to dread, espeeially when he speaks of relations of form, in whieh the best deseription ean never represent the appearanee, that his reader will be wearied, when he eould easily keep up a lively interest in his hearers and speetators.

To obviate this difficulty, it beeame neeessary to bring at least some little aid to the reader, in the shape of pietorial illustration. But, sinee I could not aim at eostly copper-plates, whieh would have defeated the purpose in view, I was compelled to restriet myself a little more to assist the faney of the reader with sketches and make a demand upon his imaginative faeulties. Thus originated the pictures whieh have been determined on as illustrations to these Leetures, regarding whieh I have but a few words to say. They relate, in every instanee, to the contents of the Leetures in whieh they are found and for the most part are amply deseribed there. The title vignettes are explained by some remarks upon the foot of the title itself; to some, explanation is unneeessary. May then the garb be gay enough to hide the faults and weaknesses of the matter, or at least to render them less evident; in short, may these really unpretending thoughts find indulgent and friendly readers.

First Lecture.

THE EYE AND THE MICROSCOPE.



Oculus ad vitam nihil facit, ad vitam beatam nihil magis.

SENECA.

The eye, no servitor of duty,
But minister of all life's beauty.

The vignette represents an ideal section through the little camera-obscura, which is called the eye-ball. The arrow and the dotted lines indicate the manner in which the picture is brought on to the retina (the receiving plate of the apparatus).

LECTURE I.

The words of an ancient sage, so apt a motto for this discourse, may not perhaps remain wholly uncontested; at all events, pretty general experience shows that while all perfectly deaf persons are sad, gloomy and hypochondriacal, all the blind are gay and cheerful; the eye leads only into the world of matter, but the ear into our proper home, into the communion of spiritual existence. Nothing can be more unquestionable, however, than that among all our senses, there is not one to which we either actually owe so many elements of our knowledge of the world we live in, or attribute so much of that which we have, it may be an incorrect, knowledge of, as to the sense of sight. Above all, it is *the sense* which originally introduces and unceasingly expands our whole knowledge of the corporeal world, and we may, therefore, with great propriety, call it the Sense of the Naturalist. We can scarcely imagine natural science to exist without it, and it the more pre-eminently deserves a close examination, since this itself will be the more fruitful, that most of the general laws which our investigations make us acquainted with, not only regulate it, but, making allowance for special peculiarities in the particular senses, are applicable to sense generally.

As we run through the history of the gradual development of our knowledge of Nature, we are met by a phenomenon which has ever had the greatest possible influence, almost always intermingling itself with our researches, checking and perplexing us, and bedimning our vision of the simple and clear conformity to law. Reflecting Man, feels himself at once a citizen of two worlds. His existence is not wholly comprehended in the mere corporeal world; a freer, more spiritual existence, in which he seeks immortality, in which he bethinks him of God as a beneficent ruler, claims its share of his being. Most mysterious and, while we are but men, ever incomprehensible is the blending of soul and body—the spiritual and material—in our nature. Where is the limit of the one and the commencement of the other? Mankind in general, and even the most gifted seekers after knowledge, answer us: We know not; no boundary can be detected; they pass over and inter-penetrate each other in every direction.

Here lies the path of delusion, pressing itself so closely on the notice of the inquirer, that only by unceasing effort can he avoid it, that often it misleads the most intelligent; and yet a path utterly delusive, since mind and body are in us so strictly, so inevitably separated, that the chasm between them is at no point bridged over. This is not the place to unfold all the relations of this connection, or fundamentally to discuss it in its whole extent, but the careful examination of that which we call Sight, will give us occasion to point out, at least in one instance, the great gap between the corporeal and the spiritual, as the unconsciousness of their separation in the eye has often led the greatest observers into perplexities.

What is the world wherein the eye finds its home—what the domain of sight? The world of light and colour. The light—

> "From matter streaming, it makes matter bright,
> Matter arrests it on its onward flight—
> And so I fancy 'twill but have its day,
> And when the matter vanishes, so fade away."

In a few powerful touches, Mephistopheles thus reviews the whole doctrine of light Light, if we contemplate it wholly by itself, is not transparent, not yellow and blue and red; light is a motion of a matter of extreme tenuity extending through all space, the ether—vibrations which are propagated in straight lines through this, like the waves of sound through the air. In their straight course they strike upon bodies which lie in their way and if the body is what we call opaque, recoil like billows striking on the sea-shore; but if the body is transparent, they pass through like waves through a canal opening into the sea. Coal-gas burns, and during its combination with oxygen, it sets the ether vibrating, it emits light; the coal-gas is burnt, and with the matter which has "vanished," "faded" the light. An infinite ocean of ether filling the whole universe, and in it thousands upon thousands of waves hastening in every possible direction, crossing, destroying or deadening each other; this is the material nature of light and colour. Who can say that he has seen this light, these colours? So little are we in a condition to do it, that the acuteness of the greatest intellects was required to unfold to us this the true nature of light.

Through the thick roof of vine-leaves, a sunbeam trembles in the calm, favouring shade; you believe it is the ray of light you see; but far from that, what you perceive is nothing but the fine dust, carried through the air by the most gentle breezes; and these are by no means the waves which chase each other in restless succession through the ether at a speed of more than 190,000 miles in a second. If the natural philosopher could extricate himself from his human nature, and look upon the world around with the eye of science alone, he would behold but a desolate, colourless and lightless mass, a gloomy and vast piece of clock-work, in which thousands of substances and motive forces were united in an ever-varying dance.

But let us now look on the fairer reverse of the picture. Night is past; the vivifying ray of the morning sun comes darting over the distant hills. The verdant meadows glow, warmed by the touch of heavenly light. Here the flower opes her crown of radiant hues to the wished-for elements; soon flutters the awakened bird his gorgeous plumage through the blue air; the splendid butterflies caressing swarm around the lovely rose,—while close at hand, the busy beetle in his emerald coat creeps up the dusky moss to quench his thirst in sparkling dew-drops. A whole, full, beauteous world of light and radiance, of colours and shapes, lies outspread before us; every motion is life, is beauty, and beautiful in its freedom. "And I see all," says man, and turns his thoughts in ecstasy to the Giver of all good. But what is this sight? It is not a perception of what actually exists without. It is a magical phantasmagoria, which the mind itself produces in free creation, guided and restrained only in a wondrous fashion by that which actually exists without, and all unconscious meanwhile of this very actuality.

When the voyager on the ocean reaches the southern latitudes, the majestic form of the Southern Cross emerges before him from the distant horizon, shining in the deep, dark heavens, with a glory which we can scarcely imagine. "Glory and thanks to the Almighty Creator," he cries, and irresistibly impelled, he sinks upon his knees in adoration. Well may such thanks be offered to the holy Source of all existence, but not because He has made the world so fair, since this itself is neither fair nor foul; but because, as the old sage tells us, he breathed his spirit into Man and thus bestowed on him the gift, to feel life, freedom and beauty in all that surrounds him.

As distant from each other as these two sketches, lie the worlds of matter and spirit. When the fresh green of Spring fills us with joyful hopes, when the yellow, falling leaf of Autumn pierces us with melancholy like a parting sigh, the leaf is but *to us* green and yellow and in these colours an emblem of moral relations, in itself, to the tree which bore it, to the earth on which it falls, in a word, to all material nature, the leaf has no colour but contains a substance repelling certain waves of light which then strike upon our eyes; in Autumn it gives off some atoms of oxygen and the same waves pass unhindered through and through it, while other waves of a different nature are reflected.

Let us dwell still a moment on this example. If we apply the fresh verdant leaf upon our tongue, and afterwards try that bleached autumnal one, our sense of taste at once bears evidence of the difference in the chemical nature of the two conditions, but it produces no conception of the colour. If we crush near our ear a fresh and green, and a dried leaf, the difference of sound indicates that the latter has been deprived of its water, but nothing tells us here that light will be reflected in different ways by the fresh and dried leaves. In a word, we find that each of our senses is only sensible to a certain definite external influence, and that the excitation of each sense calls forth a wholly different conception in our minds. Thus, the organs of sense stand as mediators between the outer soulless world, which is laid open and made practicable to our footsteps by science, and the beautiful world which we spiritually discover within us. These first experience the impressions, these deliver over then the suggestions to the mind, suggestions guided by which the mind executes its world-pictures in colour and form. Let us now seek for what is essential in these organs of sense—the artfully contrived skeleton, at once so firm and mobile, the powerful muscles which by their contraction set in motion that lever-work of bones —the heart with its multitude of tubes—the veins, a hydraulic engine of masterly execution, which drives the nutrient fluid, the blood, through every part—the whole complicated structure of receptacles and canals into which the food is received, in manifold ways chemically decomposed and again combined, here mingled with the blood, there rejected as useless—the multitude of fibres and membranes which bind all parts together, enclose the whole and round it into the fair form of humanity—it is none of these. No part of all this reaches up to the domain of spirit. But through all these structures, penetrating all, pass millions of the most delicate filaments, the nerves, which at one extremity spread out in those parts, at the other gather together in a single hemisphere, the brain. These filaments it is which are excited by contact with the motions and changes of the external world, and convey this stimulus to the brain. But the brain is the mysterious place where soul and body meet. Every alteration in the brain is accompanied by change in the play of our ideas; with every thought directed to the external world, there is a concurrent alteration in the brain, which is conveyed by the nerves, as a command to the organ which the will would move. The nerves, therefore, are the peculiarly essential part of the organs of sense, in which we have to seek the intermediate links between mind and body; if we would use them to instruct ourselves as to the nature of our union with the material world, we must thoroughly inquire into their legitimate action.

Two points only require especial notice, but these are peculiar enough. The master has a curious way of proceeding with his servants; he, the mind, translates all that they, the nerves, bring him word of into his own language, and for every one of the servants has he a fellow. Let the fibres of the optic nerve be struck by what they will, let waves of light agitate them, the finger press them, the over-filled vessels pulsate on them or an electric spark dart through them, the mind translates all these different impressions into the language of light and colour. If from excitement the blood, distending the vessels, presses upon the nerves, we feel it as pain in the finger, we hear it as a humming in the ear, we see it as dartings of light in the eye. And herein we have the most distinct proof that our ideas are free creations of our mind, that we do not conceive the external world as it really is, but that its action upon us gives rise to a peculiar mental activity, the products of which have frequently a certain definite connection with the outer world, but are also frequently totally unconnected with it. We press upon our eye and behold a luminous circle before us, but there exists no luminous body. How full and dangerous a spring of errors of all kinds here flows forth, is at once evident. From the odd shapes of the moonlight cloud-landscape, to the maddening visions of the ghost-seer, we have a series of deceptions, none of which fall to the charge of Nature or her strict conformity, but belong to the domain of the free, and for that very reason, fallible activity of the mind. Great circumspection, a very comprehensive training, must the mind possess, before it can free itself from all its own misconceptions and learn wholly to command itself. Sight, in the common sense of the word, appears to us so easy, yet is it a difficult art. Only by degrees do we learn what messages of the senses we may trust, and how to form our conceptions from them. Men of science may themselves err here—err often, and the oftener, the less they comprehend where they have to seek for the source of error.

But still more striking than the relations just unfolded, is the fact, that the master, that is the soul, receives messages from his servants, the nerves, and delivers orders to them without being conscious at the moment of their presence. Not at first, but after his knowledge has progressed far forward, does man discover that nerves exist and have their appointed functions. He sees and knows not of his optic nerve, a burnt hand pains him but he is all unconscious of the fibres that convey the impression; he moves the tongue playing with fluent rapidity, but is ignorant of the course of its appointed nerves. In a word, we never experience the condition of a nerve, but form a conception of an external object immediately the nerve is excited, and it required scientific intelligence to recognize this object as the cause of the excitement of a nerve.

However, to retain the comparison we have chosen, if the relation of the master to his servants is one wholly peculiar, the servants are no less of a quite especial kind. No one of them knows anything of another, is at all aware of his existence and activity, or shares it with him. Nay, what is still more important, no one of them, that is no nervous fibril, can carry more than one single, simple message at a time, and therein they resemble simple-witted servants. Two notices given to them simultaneously, become blended into a single one. This is most readily exhibited by touching with the points of an open pair of compasses, those parts of the body where the nerves are much isolated and lie far apart, as in the upper arm or the median line of the back. When the points are as much as an inch apart, one single prick only is felt on the places mentioned, because the nerves are so distant from each other that the two pricks fall in the district of one fibre, and this is incapable of conveying away more than one impression at a time.

After these general explanations of the peculiar nature of nervous action, we may again approach our proper subject, by the special consideration of the optic nerve. Where this enters the eye-ball, it consists of a tolerably thick bundle composed of numerous distinct nervous fibres, and these expand in the eye-ball into a hemispherical plate, in such a manner that every fibre occupies a small portion of this plate. The eye-ball itself, however, perfectly resembles an optical instrument, a *camera obscura*, and the hemispherical layer of the optic nerve, called the retina, corresponds to the sheet of paper which receives the picture. Every one of the fibrils on which the picture falls, immediately catches up a point of it, and brings an account thereof to the brain where the conceiving soul has its abode, and then this has to construe the picture out of all these separate points. Whether this is truly or falsely construed depends on the training and cultivation which the mind has received. I may be told that we have not the slightest consciousness of this construction, and that sight must be a much more simple matter than this. However, we can easily find some examples, showing that it is only habit which makes the matter so easy that we become wholly unconscious of the efforts of the mind. A child who has not had this practice often construes falsely, grasps at the stars, as at the shining buttons on his father's coat; tries to blow out the moon, as he would the light upon the table. And we find that the same phenomena are observed in those born blind, who have been operated on; one remarkable case of this kind, is, in particular, recorded in the annals of opthalmic surgery, where a man born blind obtained his sight in his later years, when he was capable of giving an account of his experiences, and who was able fully to report how he gradually learned to collocate the different sensations of light and colour into orderly vision. But the most distinct proof of the correctness of the assertion advanced lies in the fact, that we, when the conditions are misleading, construe falsely, when the picture on the retina has given no cause. For instance, the moon appears larger when it rises, than when it is sailing over us in the dark ocean of the sky. But measurements show that the size is actually the same in both cases, and that its picture on the retina is always of the same diameter. The reason of the false construction is this; when the moon rises above the horizon, between hills, trees or houses we are familiar with, we judge of its distance from the objects surrounding it, the real distance of which we know. But when the moon is above in the vault of heaven, we fancy it nearer because there are no objects between it and ourselves, by which we can estimate its distance. Thus in the act of judging, deceived by the distance, we construe differently one and the same retina-picture; therefore, under any circumstances *once* falsely.

These investigations, which I have rather sketched out and indicated, than given a complete picture of, lead to the following result: in the actual world a multitude of substances and forces exist in a continual round of metamorphoses; when these come in contact with the nervous fibres of our bodies, they alter their condition, and this altered condition is the cause of the production of those pictures of the world, which our mind itself executes. This self-sustaining world makes the most lively impression on us when the exciting conditions are in relation with the optic nerves, but even here we can most distinctly prove that the world of our conceptions, though always dependent on the world without, is never homogeneous or identical with it.

One more example may serve to render this clear, and at the same time to bring us on our way to the subsequent considerations. Undoubtedly the simplest condition which we can imagine to exist in the external world is that of substance, matter or whatever we please to call it, which occupies a certain space. Therefore, to make our conception of the world agree at all with the actual world, we must first of all know, how great the space is, and how large a portion of the space the matter, for example a rock, occupies. But we have no scale by which to estimate the size of space and, therefore, no definite notion of the size of the world. When we say: "this man is six feet high," that only means, "in the world of our conceptions the conceived man is six times the height of the conceived foot;" it is but a comparison of two conceptions. Thence naturally originate the questions: how long is a foot, an inch, a line and so on? and we can only answer by comparison with other just as indefinite magnitudes. We see at once that not even in the most simple case, can we arrive at a knowledge of the actual world from the play of our conceptions; the whole of our ideas of magnitude are without essential significance in relation to the world, they belong only to our conceptions. And yet the microscopist talks of magnifying, and thinks thus to understand the objects better than before. To comprehend this, we must yet philosophize a little longer about magnitude, to invest this ambiguous notion with more distinctness and substantiality. We call the foot of Schwanthaler's "Bavaria" colossal, the foot of a full grown man large and that of a lady small, and why? This is easily answered; if we divide each of the three feet into twelve inches, each inch into twelve lines, and each line into twelve parts, we shall find these twelfths of a line undistinguishable in the lady's foot, in the man's tolerably plain, but in the "Bavaria" we might divide these twelfths again into twelve parts, and every one of these would still be quite distinct. Here then we have at once found a simple definition of magnitude. A thing is *large* to us in proportion to the number of parts into which we can divide it.

But there is another consideration which may occur to us in this definition of the idea. We have accompanied a parting friend as far as the hill beyond the town, once more we embrace him, once more gaze long and deeply on his countenance, to impress more firmly on our soul each dear, familiar feature. At last he leaves us, hastens thence, while we stand lingering, gazing after him. He turns, and still we recognize the well-known face. But the distance continually increases, and by degrees the peculiarities of shape vanish. A turn in the road hides him from us for a while; then he emerges yet again on the slope of the farthest hill, a little, moving, black point; he stops, waves his handkerchief, but we are scarcely able to distinguish this motion and at last he disappears wholly in the distance. The farther our friend retreated from us, the less distinctly could we see him, the smaller he appeared, till at last a pin's head held before the eye would have been the larger. While we here remark how an object well known to us becomes gradually smaller, and at last totally disappears, we become aware of the means by which we can enlarge an object, so as to see it more distinctly and distinguish a greater quantity of separate parts in it, namely, by bringing it nearer to the eye.

Experiment shows us, surely enough, the applicability of this means; but we soon discover that there is a certain limit here, beyond which the object cannot be brought, in approaching it to the eye, without the loss of all distinct vision. The cause of this lies in the construction of the little camera obscura, which we call the eye-ball. This, like the similar instrument of the optician, can be adapted only to certain distances, and if we wish to look more closely at anything, we must make a corresponding alteration in the optical apparatus, which is done very simply, by bringing before the eye a transparent body, shaped according to a certain law; and for this purpose we generally use glass, ground into a particular form. Such a glass is a lens or simple microscope, and its action consists in enabling us to see distinctly an object placed in such close proximity to the eye, that it would otherwise be invisible. It is unnecessary to enter into an explanation of the optical laws by which this action is regulated. I will only observe, that they render it very easy to determine how much an object must appear to be enlarged by a simple microscope of this kind. It is assumed, that on an average, the human eye sees distinctly at the distance of ten inches, but not when the object is brought nearer. Now, if I use a glass which permits me to see the object distinctly at a distance of five inches, it appears twice as large; at a distance of two inches and a half, four times; at one tenth, a hundred times as large, and so on; in a word, the enlargement depends alone upon the degree of proximity to the eye into which the object is brought. In former days, these simple microscopes were used very extensively and almost exclusively for the purposes of science, because the compound microscopes were then so bad as to be far inferior to the simple instrument The celebrated Leuwenhoek made all his wonderful microscopic observations with simple spheres of glass, which he made for himself, by melting fine threads of glass in a lamp. In the present day, the simple microscope is generally used where very small magnifying power is required, the compound instrument where any considerable enlargement is desirable. While the latter fatigues the eye comparatively little, observation with the simple microscope, especially with high magnifying power, is so great a strain upon it, that disease of the eye is but too frequently the result.

The principle of the compound microscope is also very easily explained. It depends on a combination of the camera obscura with the simple microscope. The common camera obscura consists, essentially, of some glasses ground into the shape of a lens; the rays of light proceeding from an object pass through these glasses and produce behind them a picture of the object, which is usually received, in the common optical toy, upon a plate of ground glass or a surface of white paper. The further the object is removed from the glasses, the smaller appears the picture. Bringing the object nearer, the picture grows till picture and object are of equal size. But if the object is now placed closer to the glasses, the picture becomes larger than the object. We never use the camera obscura in this condition, but we do the magic lantern, which in its essential construction is in no way different from it. In the compound microscope, an apparatus of this kind is made use of in such a manner, that the enlarged picture of the object is not seen immediately by the eye, but looked at through a simple microscope and thus again considerably magnified. For example, if the picture is a hundred times larger than the object, and we magnify this picture ten times, the object, of course, appears a thousand times larger. Therefore, the compound microscope is composed of a double optical apparatus; first, the glasses which are directed to the thing to be examined, or object, of which they project an enlarged picture, these are called the object-glasses, or objectives; secondly, of a simple microscope, by which the enlarged picture of the object is again magnified, and which from being turned towards the eye, is called the eye-piece or ocular.

From the foregoing statements, it might be imagined that we can magnify to any degree we like, since the size of the picture depends solely upon the extent to which we approach the object towards the object-glass, and then the enlargement of the picture is only conditional on the approximation of the picture to the eye. But so many practical difficulties oppose this theoretical possibility, that the instruments actually constructed all fall far short of the theoretical limit.

I shall here mention only the most important circumstance, and in order to make this clear, make use of a very familiar fact. Books intended for very general use, such as bibles and hymn-books, are printed in many different types, sometimes with very small, sometimes moderate sized and, for the old and weak-sighted, with very large letters. A single word in the type of the last kind, is perhaps six times as large as in the first and is very easily recognized, but at the same time we of course see no more letters in this than in the others. The same word also may be written by a clever penman so small, that to the unassisted eye it will look like a single black point. By magnifying the point it might be resolved into its separate parts, so that the letters and their flourishes would be distinguishable, but a further magnification would then merely enlarge the scale on which the letters were seen, without bringing into sight any finer parts before invisible. A similar condition occurs in the microscope. Up to a certain point, the picture which the object-glass throws up is such, that the individual parts of the object are resolved or made distinct by the eye-piece. But a limit is soon found, beyond which, on account of the imperfection of the object-glass, the picture which this throws up may, indeed, be enlarged, but this does not render any more of its individual parts visible. It is composed, as it were, of a certain number of letters, which when more magnified are more easily distinguished, but the increased enlargement does not show any apparently simple letter to be composed of two still smaller. From this cause arises the important circumstance, that with a well-constructed microscope we can often see far more, that is more of the individual parts of the object, with a low power, than when it has been much more enlarged by means of an inferior instrument. Now as in all scientific investigations, every thing depends upon the recognition of the individual parts and structural relations, the enlargements by the microscope are only so far of consequence as they enable us to do this more completely.

The limit occurs in all the instruments yet constructed at an enlargement of from three to four hundred diameters, and all stronger magnifying is either useless trifling or, and indeed most frequently, only nominal, like the magnifying millions of times by the oxy-hydrogen microscope which the charlatans boast of, and which in most instances does not exhibit so much as the fifty times of a good common microscope.

From these observations it will be evident that to the scientific inquirer it is of infinite importance to be able to form an accurate judgement of the goodness of an instrument in this respect, and the greatest efforts have been used to discover some means thereto. To this end, have been sought what are called test-objects, which generally consist of objects exhibiting some delicate structure, difficult to make out. Either artificial or natural objects may be chosen for such test-objects. The former have only been prepared hitherto by Robert, an optician in Königsberg, and consist of glass plates on which are ruled with a diamond, systems of a hundred lines which, ten by ten, approach closer together and are finer, according to a definite standard. With most instruments only the sixth and seventh systems can be distinctly made out to be composed of separate lines, superior instruments reach the eighth and ninth. No instrument yet constructed has resolved the tenth system into its component parts. These systems of lines when they are perceived, are very evident, but they have the essential fault that they do not quite exactly resemble one another, and consequently every inquirer gets a different standard. With incomparably greater accuracy works nature, and therefore the scales of butterflies are always regarded as the best test-objects. These are mostly little longish plates having a little stem, beset upon their surface with fine longitudinal furrows, which are united by the most delicate possible transverse striæ. These two kinds of striæ are of very different degrees of fineness in different butterflies, and the cross-striæ of *Hipparchia Janira*, a very common brown butterfly, are in particular so delicate that only the very best instruments exhibit them distinctly.

Besides these common scales, there are many others of different shape and differently marked upon their surface, and when we have pursued the investigation of them for any length of time we are overwhelmed with infinite abundance of forms, which Nature has here developed in the most insignificant and diminutive parts. Many indeed, and especially in former days, have been content with the delight which the contemplation of these elegant forms afforded them, and scarcely anticipated the importance of microscopic investigations to science, as may be seen from the titles of so many of the works published in the last century, such as Ledermüller's "Microscopic delights for the Eye and Soul," (Nuremberg, 1761), Rösel von Rosenhoff's "Insect Recreations," (Nuremberg, 1746—61), &c. Yet observers were not wanting even thus early, who saw fully the seriousness of this branch of natural history studies, and we have an example even of an excess in Swammerdam, who in his last days committed to the flames, a great portion of the results he had obtained only by the most tedious labours, because he thought that the Creator had not veiled these minute circumstances from the eyes of man without wise purpose, and it were sacrilege to profane God's mysteries. But such a notion, if consequently carried out, would oppose every advance of humanity beyond the rudest and almost brute condition of Nature.

It was reserved for our century to apply the microscope to its true use, to the study of Nature, and it is most delightful to observe how the application of this instrument continually opens new paths, and what ever-widening circles of the most interesting results are won.

It may readily be conceived that the study of the conditions of the minuter structures of animals and of man himself, must throw a wholly new light upon the physiological processes which go on within the body, and, in point of fact, in all branches of medical science, a new era must be dated from the application of the microscope. And it is equally evident, that the microscope must be a most distinct "turning-point" in the knowledge of the more minute organisms of the animal and vegetable world. But it is not quite so plain, how microscopic observation should find its peculiar field in the departments of chemistry, mineralogy and geognosy. Nevertheless, it has its importance here; this has, indeed, been already recognized by some of the most distinguished inquirers, and must, ere long, be generally comprehended. In organic chemistry, especially, an instrument cannot be spared, which alone, oftentimes, will enable us to decide whether we have to do with a simple substance, or a mechanical mixture of various constituents. Many purely imaginary subtances would never have cumbered the field of science, the powers of great inquirers which have been wasted on them would have been saved, had the nature of these things been first investigated by the microscope. Thus we find even the first chemists, such as Berzelius, Liebig &c., speaking of substances which have no existence. Thus, the starchy fibre of potatoes, by which is understood the unprofitable portion, is a mixture of starch and ligneous fibre or cellulose, both wholly of the usual kind; so is pollenine, as the elementary constituent of pollen is called, a multifarious mixture of a great many distinct and well-known substances. Innumerable examples of the kind could be furnished.

Still more striking is the importance of the microscope in mineralogy and geognosy. Here it affords us an entirely different and more accurate acquaintance with the peculiar nature of whole systems of rocks, of vast formations, or individual mineral substances—an acquaintance such as these sciences could not hitherto give us. Formerly, in the mountain-chains which stretch along Western Asia, girdle the north of Germany and France, and again appear in the Grecian Archipelago, we only saw a shelly mass of carbonate of lime which, from its peculiar condition, we called chalk; in the tripoli, mountain-meal, &c., finely-divided silex; in dysodil, only a mixture of silex and bitumen; and in most opals and flints, only denser, glass-like silex; but Ehrenberg's microscopic researches have laid open to us a wholly new world, full of life. We find the origin of no inconsiderable portion of the firm crust of our planet dependant, in the most remarkable manner, for its peculiar form, on the life of animals so small that they are invisible to the naked eye, which, by their almost miraculous rapidity of multiplication, make up through absolute number and the indestructibility of their remains, what they want in magnitude.

Certain of the Infusoria consist wholly of a gelatinous animal substance; but besides these, there are other kinds which, like snails and cockles, are enclosed in firm shells of the most elegant forms, which are composed either of carbonate of lime or silex. The dead animal itself soon decays, but the dwelling which it had built itself, the shell, remains, and in circumstances favourable to the life of the animals, these shells accumulate to such an extent, that whole systems of rocks are found almost solely consisting of them. The siliceous shells sometimes become blended together by a peculiar proeess, not yet explained, and so form flints and opals. The Botanist must not disdain a nearer aequaintance with these siliceous animalcules, for the question which has long been agitated, even with some bitterness, whether these little organisms are animals or plants, is not yet set at rest. In regard to magnitude, the formations originating from the calcareous Infusoria are still more important. A considerable portion of Russia, on the Wolga, of Poland, Pomerania (*e. g.* Rugen), Mecklenburg, Denmark, Sweden, of the south of England, Northern Ireland, the north of France, Greece, Sicily, of the north of Africa, and perhaps also Sahara, of the north-western and Arabian portion of Asia, consist of such calcareous soils and masses of chalk rock, the thickness of which may often be estimated, as in England, at a thousand feet. The imagination halts in the attempt to rcalize these masses of organie life, when we remember that a single chalk-enamelled visiting card forms a zoological cabinet of, perhaps, a hundred thousand shells.

As Galileo, Kepler, Newton and Herschel introduced us into an infinite world of huge magnitudes, as Columbus, Magellan and their successors first unfolded to us one entire half of the earth, so in the present day, has Ehrenberg, by his untiring industry, laid open to us a wonderful world of organie life, which, small as are the individuals composing it, invisiblc to thc kccnest eye whcn unassistcd, through the inconceivablc activity of dcvelopmcnt, through the number, vast beyond expression, of singlc beings, heaps up masscs, before which man himsclf sccms insignifieant.

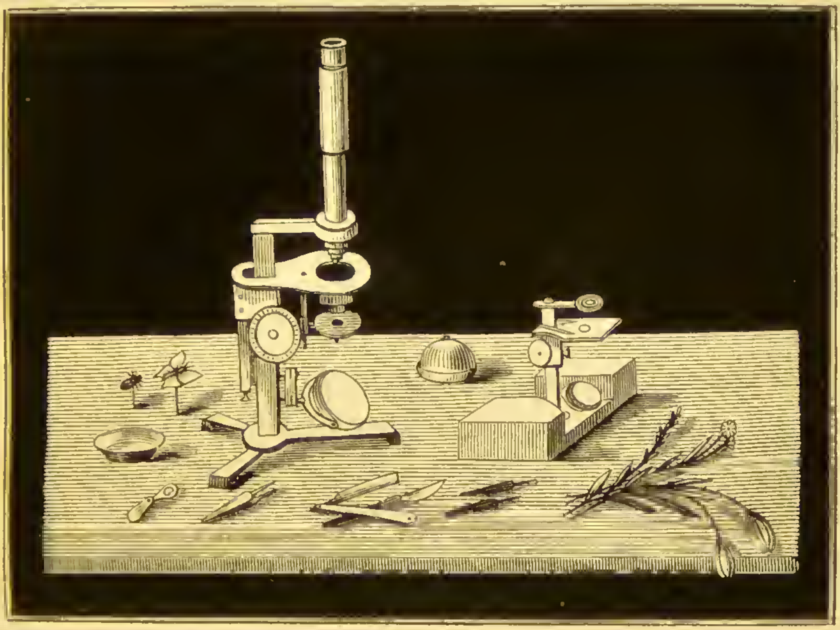
On the 26th of January, 1843, a great crowd colleeted at the Round Down Cliff, near Dover, in anxious expccta- tion, to witncss the event of the grandest and most daring blasting ever attempted by the skilful combination of human ingenuity. The labour of years had been expended on the preparations, in the opening of shafts and galleries. The largest quantity of powder ever yet used, 185 cwts., was ignited at once by means of a gigantic galvanic battery. Almost in silence was the enormous cliff hurled into the sea; in one minute were a million tons of chalk torn away, and a surface of almost fifteen acres covered twenty feet deep with its fragments. From this may be estimated the tremendous force which must have been exerted. And with what did the power of the human mind enter into this giant struggle? With the remains of creatures, a thousand of which might be annihilated by the pressure of a finger. We wonder, and ask ourselves: What does "small" mean, in Nature?

There can, however, be no possible doubt that it indicates a most barbarous age, or a very low state of refinement, when the value, the importance of a thing is measured by great and small, a standard indeed which finds no application in all that we know most essential and valuable, for the human mind is not to be defined by foot, inch or line. Physical magnitude imposes only on the sensuous nature; cultivated man seeks to know the object of his contemplation perfectly in all its relations; and then only, from the perfect knowledge, does he permit himself to judge as to the essential and inessential; very frequently this leads him to declare that the most significant which has the smallest dimensions.

This observation is especially applicable to Botany. There was an era in this science, in which it began to work its way out of the mediæval night of Nothing; when, therefore, only its crudest elements existed; this was the era of the Linnæan school. We wish not to detract from the merit of Linnæus, since greater is the glory to discover, to shape out a science, than to build it upward after the foundations have been laid; we wish not, as we have said, to disparage Linnæus, when we describe him as the author of one of the saddest of prejudices, which has long kept Botany in the lowest condition, and even now is not so totally overthrown but that its evil operations are still, in many ways, obstacles in the onward path of science. We mean Linnæus's objection to the microscope, and his contempt of all knowledge only to be obtained by its help. The influence of the Linnæan school was so pernicious in this respect, that almost all that which had already been achieved by a few distinguished men, particularly by Malpighi, at the close of the seventeenth century, became so completely lost to science in the eighteenth, that in the beginning of the present century, even the most excellent observers did not by a long way attain to the rank of Malpighi in all points. The following Essay, however, will, among others, bear testimony how a scientific treatment of Botany—a treatment which shall be more than an empty, fruitless, wilderness of names committed to memory—can scarcely be thought of without an almost constant employment of the microscope. Hither has the whole new direction of science turned, and names like Robert Brown, Brisseau-Mirbel, Amici and Mohl, mark the commencement of a new and richly-blessed epoch.

Second Lecture.

THE INTERNAL STRUCTURE OF PLANTS.



" The Great you have no power to touch,
And so attempt the Small."

FAUST.

The vignette exhibits the whole stock in trade of the scientific dealer in small wares, the microscopist; to the right, a simple microscope for the preparation of small objects; to the left, one of Amici's compound instruments; around them, the forceps, lens, knife, razor, needles, &c.

LECTURE II.

As we watch a clever juggler, exhibiting the magic-like operations of his art, we become gradually quite lost in amazement, until at last he elicits from us the expressions of admiration which are the usual accompaniments and reward of his success. But if we are then allowed to walk on to his stage, in the strictest sense of the phrase "to look at his cards," how our amazement fades away when we become aware of the complicated preparations required, of the many aids which must be at hand, in a word, of the various and abundant means he must make use of, to bring about results which yet after all have no relation to the means employed. And taking a wider field, when we look around us on all the circumstances of life, do not we soon find it to be a characteristic feature of the circumscribed position of Man, that his boldest efforts attain, at last, to little or nothing, that when he has availed himself of all the assistance talent and favouring circumstances can afford, he must in the end confess, that what he has obtained by all this toil and labour, is but a small recompense for the outlay?

Nature offers a direct contrast to this. Accustomed, from our youth upward, to see her works outspread before us in eternally renewing riches, we commonly pass them coldly by. The contemplative mind is attracted by her, and begins to divine, with a kind of softened terror, the mysterious powers in action round us. With what wondrous means, we think, must not this great artist be provided! What wondrous chains of powers, yet unknown, must there not yet lie hidden in her bosom! Science seeks the solution of this enigma, and in trembling assumes its task, fearful lest perhaps human intelligence be unequal to comprehend and grasp a complexity so marvellously interwoven, and the farther we penetrate, the greater waxes our amazement. Every step brings us to a simple solution of an entangled question; every compound phenomenon directs us back to simpler causes and forces, and our astonishment becomes at last converted into devout adoration, when we behold with what small means Nature attains the most stupendous results. By the simple relation, that bodies in motion have a mutual attraction, Nature arches over us the whole starry heavens and prescribes to the sun and its planets their undeviating courses. But we need not ascend to the stars, to recognize how little Nature requires to the unfolding of wonders.

Let us tarry a moment with the vegetable world. From the slender palm, waving its elegant crown in the refreshing breezes, high aloft over the hot vapours of the Brazilian forests, to the delicate moss, barely an inch in length, which clothes our damp grottos with its phosphorescent verdure, from the splendid flower of *Victoria Regina* with its rosy leaves cradled in the silent floods of the lakes of Guiana, to the inconspicuous yellow blossom of the duck-weed on our own ponds—what a wonderful play of fashioning, what wealth of forms!

From the six thousand years old Baobab, on the shores of Senegal, the seeds of which perhaps vegetated before the foot of man trod the earth, to the fungus, to which the fertilizing warmth of a summer-night gave an existence which the morning closed—what differences of duration! From the firm wood of the New Holland oak, from which the wild Aboriginal carves his war-club, to the green slime upon our tombs, what multiformity, what gradations of texture, composition and consistence! Can one really believe it possible to find order in this embarrassing wealth, regularity in this seemingly disorderly dance of forms, a single type in these thousandfold varieties of habit? Till within a few years of the present time, indeed, the possibility was not yet conceived, for as I have before remarked, we may never expect to be enabled to spy into the mysteries of Nature, until we are guided by our researches to very simple relations. Thus could we never attain to scientific results respecting the plant, till we had found the simple element, the regular basis of all the various forms, and investigated and defined its vital peculiarities. By the help of the improved microscopes, we have at last advanced far enough to find the point of departure of the general theory of the plant.

The basis of the structure of all the so very dissimilar vegetables, is a little closed vesicle, composed of a membrane usually transparent and colourless as water; this Botanists call the "cell" or "vegetable-cell." A review of the life of the cell must necessarily precede the endeavour to comprehend the whole plant, nay it is as yet, properly speaking, almost the only really scientific part of Botany.

But in these investigations our organs of sense fail us.

The human eye, unassisted, can see nothing of all these mysteries, and therefore it must be observed, that none of the following facts can be brought to light without the aid of the microscope. To meet the temporary requirements of my readers, I have given pictures of the most important objects, obtained by means of a good microscope.

If we remove the outer, compact membrane of the snow-berry *(Symphoricarpos racemosa,)* a plant common enough in our gardens, we come to a mass of substance composed of small, slippery, shining white granules. Each of these is a separate perfect cell. (Pl. I, Fig. 1.) If we strip off the outer membrane of the leaf of the common pink, we find a velvety, green tissue, a portion of which may easily be scraped off. In water, this separates into little green points; these, too, are perfect cells which only differ from the foregoing in containing a quantity of green granules in addition to the viscid yellowish substance and transparent fluid sap (Pl. I, Fig. 2.) These two kinds of cells, and in like manner all living, vegetating cells, have this in common: their wall consists of a double layer, a firm colourless one, the proper cell-membrane and a semi-fluid, viscid and rather yellowish substance, which invests the whole internal surface of the cell-membrane, and thus constitutes one of the coats of the cell. The latter layer is connected most closely with the life of the cell. Not unfrequently, and then not necessarily separated from the cell-membrane, the yellowish, viscid substance is found wholly or in particular, denser, streak-like portions, in continuous flowing movement, which is called the circulation of the cell-sap. The proper cell-wall is composed of cellulose, a substance formed of carbon, hydrogen and oxygen; the semi-fluid investment, on the other hand, called by Hugo von Mohl the primordial utricle, contains also nitrogen. It can be made more evident by applying a drop of nitric acid to the cell, when, being of a very similar nature to albumen, it coagulates and contracts from the action of the acid, so as to lie as a loose sac within the cell. (Pl. I, Fig. 3.)

The origin of the cell is by no means yet quite clearly made out; only this much is certain, that a peculiar little body appertaining to the primordial utricle and called the cell-nucleus, (Pl. I, Fig. 1, *a*.) plays a very important part in it.

These cells in the course of their development become crowded closely together, and thus form the whole mass of the plant, the cellular tissue, which however may be divided into three principal classes of tissue, according to the different forms of the cells, and more especially according to their importance to the life of the plant.

But before we betake ourselves to the consideration of these three tissues, we must make a somewhat close acquaintance with the metamorphoses which the cell may pass through during its life. We may regard the cell as a little independant organism, living for itself alone. It imbibes fluid nutriment from the surrounding parts, out of which, by chemical processes which are constantly in action in the interior of the cell, it forms new substances which are partly applied to the nutrition and growth of its walls, partly laid up in store for future requirements, partly again expelled as useless and to make room for the entrance of new matters. In this constant play of absorption and excretion, of chemical formation, transformation and decomposition of substances, especially consists the life of the cell and—since the plant is nothing but a sum of many cells united into a definite shape—also the life of the whole plant.

In the nutrition and growth of the cell-wall, two conditions may be distinguished. The growth, namely, may be solely confined to the alteration and enlargement of the boundaries of the cell. Hence, very various forms gradually arise out of the originally roundish cells. In the next place when they become crowded closely together, they lose their roundly protruded shape, press each other flat, and then appear like very irregular honey-comb cells or, in a delicate cross section, like many-sided meshes, (Pl. I, Fig. 13, *a*.) Other cells take a stellate figure in their expansion, and form elongated processes which sometimes convert them into elegant six-rayed stars, and as often give them very irregular and curious shapes. Others again become flattened by pressure on two opposite sides, and, finally, others become elongated and assume the appearance of cylinders, prisms, &c., or when still more stretched out, are found spindle-shaped or in the form of long, thin filaments, (Pl. I, Figs. 6, 7, 8, and 13, *b*.)

Throughout all these changes of form, the wall of the cell may retain its original thickness; it always remains closed and perfectly entire. But a second change generally occurs, the thickening of the wall. The way in which this is produced, is by the deposition of a new layer upon the inside of the original cell-wall, between it and the primordial utricle. There are some peculiarities in this process; the new layer is never a similar perfectly entire membrane, but seems broken up in a great variety of different ways. Sometimes it is perforated all over with little chinks, (Pl. I, Fig. 6; Pl. II, Fig. 8, *b*,) at others with longer slits, (Pl. I, Fig. 4,) now it appears like a net-work, now it is completely cut up into a spirally-wound band, (Pl. I, Fig. 5,) and in another case it exhibits itself only in the form of separate rings, (Pl. I, Fig. 7.) These are named, according to these appearances of the thickening layers of the cell, porous or streaked cells, reticulated, spiral, or annular fibrous cells. When one thickening layer has been formed in this manner, a second and third frequently follow, and often so on until almost the whole cavity of the cell is filled up. It will easily be conceived how from these changes, in conjunction with the variations of form mentioned just before, even from so simple an element as the cell may proceed an almost countless number of differences in the tissue, and in plants we actually find such. Added to this, foreign matters, such as lime, silex, &c., are frequently deposited in the cell-wall and its thickening layers, whence originate numerous modifications of softness and hardness, tenacity and brittleness.

We have yet one more important peculiarity of the vegetable cell to discuss before we can go further. If the nutrient matter, within the cell, increases in quantity beyond a certain measure, new cells are formed from it within the first, called secondary or daughter-cells; they propagate, and in the usual course the mother-cell then gradually dissolves and disappears, while the two, four, eight or more young cells produced by it, occupy its place. The whole process, which we call growth, in plants, consists in its essential elements of a continuous propagation of cells of this kind, whence the number of cells becomes multiplied beyond calculation, nay, almost beyond credibility. From an approximative calculation, for example, in a rapidly growing fungus, the *Bovista gigantea*, 20,000 new cells are formed every minute.

Elegant as the above-described forms of the cells may be when seen beneath the microscope, interesting as may be to the Botanist the search for the laws on which depend the formation of these innumerable varieties, they are at present of no importance to us, since the life of the whole plant is the question before us, and here, passing by all those distinctions, we must endeavour to establish other, quite different divisions of the tissues of plants, which, as we shall see, in some cases have no agreement, and in others but a very moderate one, with the definite forms of the cells.

Every plant in its course of formation, and every undeveloped part of a plant, consists exclusively of small, delicate, roundish cells. Differently as the individual cells of this tissue may be modified afterwards, there are yet only two portions which in their subsequent development and their importance to the life of the whole plant, distinguish themselves essentially from that fundamental mass, which forms the chief tissue of the plant in the subsequent full-grown condition. One is the whole external layer of the plant, which developes in contact with water or earth, but which is more especially exposed to the air. The cells of this layer are so firmly united together, that it may generally be stripped off the plant as a continuous membrane. It becomes clothed, sooner or later, with a layer of varying thickness, of a homogeneous substance, which receives besides, a thin coating of wax or resin; thus the enveloping membrane becomes impenetrable by fluids, and even repels them, since water runs off it as from a greasy substance. In certain places, however, little orifices are left between the cells, leading into the interior of the plant. In these orifices usually lie two crescent-shaped cells, having their concave sides applied together, so as to leave a slit open between them, but otherwise closing up the orifice. These slits, through which the plant communicates with the atmosphere, and expires gases and watery vapour, are opened wider or contracted as may be required. The orifices with the crescentic cells are called stomates, and the whole layer in which they occur is the epidermis of the plant (Pl. I. Fig. 12).

In every actively vegetating part of a plant exists a continuous influx of new nutrient matter, which is absorbed by the roots while its superfluous water is evaporated through the stomates. This movement of the sap transforms the tracts of cells through which it passes, moving with especial activity in the elongated cells. Most of them become very much thickened, some also lose all at once their fluid contents, and receive air instead; such are called vessels (air-vessels), and thus are formed, in the mass of cellular tissue, bundles of elongated cells and vessels, called vascular bundles (Pl. I, Fig. 13, *b*), which to the naked eye look like dense fibres running through the tissue of the plant. In one great division of plants, in the Monocotyledons, to which the Grasses, Lilies, Palms, &c., belong, the development of these vascular bundles stops short at a certain stage, and they undergo no further alteration. In another class, on the contrary, in the Dicotyledons, to which belong our forest-trees, kitchen vegetables and many others, there is a continuous development of cells on the outer side of each vascular bundle, which become in turn vascular bundle cells, and so unceasingly increase the thickness of the bundles. In consequence of this, the bundles gradually close up together into a firm tissue, into that which in common life we call wood (Pl. II. Figs. 8, 9, 10).

When we seek to discover the relation in which these three parts of the plant stand to the wants of Man, here again we find a threefold distinction. In its common condition, the epidermis is useless, but in perennial plants, particularly in trees, bark becomes developed from it, which in some trees (for example, in the Cork-oak, *Quercus suber*) is very soft and elastic and, as *cork*, is applied to a number of purposes. The vascular bundles are important on account of the substance of their cell-walls constituting wood and woody-fibre or bass. The remaining tissue, the cellular, is chiefly useful on account of the contents of the cells.

Of all the forms of cells, the wood and bass-cells are undoubtedly the most important in the domestic economy of mankind. The different kinds of wood may be easily distinguished by the microscope, even in the most minute fragments; the distinction of the most consequence, is that between the peculiar wood of the Fir and Pine tribe and that of all other trees, and this is perceptible even in petrified wood (Pl. II. Figs. 8, 9, 10). The "bass-cells" are the longest of all; their walls are generally very thick and mostly much bent (Pl. I. Fig. 8), but very rarely marked with pores or spiral fibres; only in the silk-plant (*Asclepias Syriaca*), the Oleander and allied plants is a spiral striation of the walls observed. No other bass-cells are easily distinguishable by the microscope, however different may be the plants from which they have been taken. The bass-cells, however, on account of their length and curvature, supply almost the sole material of our woven fabrics and cordage. As I have already observed, plants of the most different kinds are used for these purposes. Among us, flax and hemp are the staple; in the Philippine Isles, the bass from the leaves of a species of Plantain; in Mexico the leaves of some wild species of Pine-apple furnish a similar substance. The New Zealand flax has recently become of some importance for naval purposes; this is obtained from the leaves of a Liliaceous vegetable. Peculiar fabrics are prepared in the West Indian Islands, without spinning or weaving, from the bass of the Lace-tree, (*Palo di laghetto* of the Spaniards), and in Tahiti from the Paper-mulberry.

An endless variety of plants are used for cordage, for almost every country applies its own plants to this purpose. By the kindness of a friend in Berlin, I once obtained a little piece of string, which had been tied round a wine-vase in Pompeii, and I found to my astonishment, that it had been prepared from the easily recognizable bass cells of the Silk-plant (*Asclepias Syriaca,*) which so far as we know, are now nowhere applied to this use.

Cotton, which forms a hairy down around the seeds of the cotton-plant, is very different from these bass-fibres. It is, indeed, also composed of long cells, but these have very thin walls, whence, when dried, they collapse into a flat band with rather rounded borders, while the bass-fibres form a perfectly smooth, thick cylindrical filament, (Pl. I, Fig. 9.) By this distinction, which is decided enough, we are enabled by the microscope, to perceive in a moment the mixture of cotton with linen ; and by this means, even the origin of the fabrics in which the Egyptian mummies are rolled, has been distinctly shown. We may here remark, by the way, that the fibre of wool, (Pl. I, Fig. 11,) and the fine filament of the silk-worm, (Pl. I, Fig. 10,) exhibit equally striking characteristics, as a glance at the engraving at once shows, and the microscope is perhaps really the only perfectly certain means by which every mixture of these various filaments, in textile fabrics, may be immediately detected.

We have now seen how the simple cell, in its various forms, is the basis of every plant, in all the multiformity of their appearances ; but what makes the matter infinitely more curious, is, that these cells, which have all been formed in the same way, and even when their subsequent shape remains exactly the same, have the power of producing the most varied substances in their interior, and thus become a means, in the hand of Nature, of multiplying to infinity the riches and beauty of the vegetable world.

This leads us to the peculiar vital processes of the vegetable cell. Every separate cell has, as it were, its own especial life. Its walls, indeed, are not perforated, but, nevertheless, the fluid which it requires for its nutrition makes its way in. This is composed of water, carbonic acid, salts of ammonia and other soluble salts of the soil. The few substances absorbed by the cell, become changed by its peculiar power, and from them are formed all the various materials which give the plant value, either in the eyes of the æsthetic observer, or in the household of the economist.

A great many cells contain merely colourless sap, this is the case with the wood and bass-cells; many merely air, as for instance, the so-called vessels. But others display the most splendid tints in their juices, some giving flowers and fruits the charm of their lovely enamelling of colour, while others cause various parts of plants, otherwise green, to assume a chequered, mottled aspect (Pl. II, Fig. 7.) Here we find every shade of red, blue and yellow. The green colouring of plants depends, on the other hand, on wholly different causes, for the sap of plants is never green. When we examine, with the microscope, cells which to the naked eye seem green, we see that the green appearance is produced by separate granules of a green substance (chlorophylle, or leaf-green,) which adhere to the inside of the wall of the cell (Pl. I, Fig. 2, 13, *c*.) The splendid colour, indigo, is nothing but a peculiar modification of this green colouring matter, which is produced, in especial abundance, in the various kinds of indigo *(Indigofera tinctoria* and *anil,)* in woad, *(Isatis tinctoria)* and the dyer's knot-grass (*Polygonum tinctorium*).

In some cells we find exceedingly elegant crystalline formations, consisting either of single crystals or bundles of needle-shaped ones, or of a number of them collected into a little crystalline nucleus (Pl. II, Fig. 1.)

The contents of the vegetable cells, however, which are most interesting to mankind, are those which furnish him with necessary food, agreeable refreshment or stimulating spices, and not less important are those substances which, administered to the diseased organism, bring back the uninjured capability of enjoying anew the rich gifts of creative Nature. This field of observation is one of extraordinary extent, and not yet nearly sufficiently explored; nevertheless, the researches which have already been followed out, have led to an interesting law, namely, that those plants which are nearly allied in their external form, also contain similar or closely connected substances in their corresponding organs. Thus there are whole families in which all the plants are more or less poisonous, as the Nightshade plants, the allies of our potato and tobacco; while others are insipid, and tasteless, and therefore devoid of any peculiar substance, such as the allies of our garden pink. It would lead us too far, to attempt to enumerate here all the different matters, and where they occur in the vegetable world; we must content ourselves, therefore, with a few general observations, and a more minute examination of some of the most interesting substances.

The substances which we find in the cells of plants, may be divided into those soluble in water and the insoluble. Regarding the former, we can arrive at no conclusions by the microscope, since they disappear in the watery cell-sap; chemistry alone can then demonstrate their presence. To this class belong, among others, albumen, gum, sugar and the agreeable acids of our fruits, such as the malic and citric acids. The sap of the Sugar-cane is perfectly clear and transparent in the cells, the dissolved sugar only appears after the expression and evaporation of the fluid.

The fluid oils, on the contrary, are very readily distinguished beneath the microscope, both the fat oils, which swim in the cell-sap in the form of little shining yellow globules, as in the kernel of the almond, and the aromatic (etherial) oils which usually occur alone and fill a whole cell in one large drop.

Two of the most important constituents in the vegetable cell, however, are the semi-fluid, half-granular mucus, composed of a nitrogenous substance, which either wholly fills the cells or occurs with oil or starch, and this latter substance itself. Certain nitrogenous constituents form the peculiar nutrient matter in plants. One portion, albumen, occurs dissolved in the cell-sap; another and more important, in small mucous granules. If we make a cross-section of a grain of wheat or rye, and place it under the microscope, we perceive very distinct layers in it as we examine from without inwards. The outer of them belong to the husk of the fruit and seed, (Pl. II, Fig. 2, *a*,) and are separated as bran in grinding. But the mill-stone does not separate so exactly as the eye may by means of the microscope, not even so accurately as the knife of the vegetable anatomist, and thus with the bran is separated also the whole outer layer of the cells of the nucleus, and even some of the subjacent layers. A glance at the Fig. 2 in Pl. II, shows, however, at once, that the contents of the outer cells of the nucleus are very different from those of the inner; for while the latter enclose a great quantity of starch and very little nitrogenous matter, in the outer layer of cells we find only the latter substance which, in the cereal grains, usually receives the name of gluten; thus the anatomical investigation of one of these corn grains at once explains, why bread is so much the less nutritious, the more carefully the bran has been separated from the meal.

But starch is, after all, the most remarkable substance that we meet with in the cells, not merely because it plays so important a part in the nutrition of mankind, but also, setting that out of the question, on account of the peculiar and elegant forms which it exhibits under the microscope, and which indicate a high degree of internal organization.

It occurs in every plant, in every part, but only the roots, tubers, seeds, fruits and, more rarely (as in the Sago palm), the pith contain it in sufficient quantity to serve as food, or to repay the trouble of separating the starch from them.

We have to thank an exceedingly curious peculiarity of starch for our power to recognize it in any spot and in the smallest quantity in the interior of plants. This is the sudden assumption of a beautiful violet-blue colour when it is moistened with a solution of iodine.

Starch itself consists of little shining transparent granules, from twenty to thirty of which often lie in one cell, (Pl. II, Fig. 2, *c*.) The separate granules sometimes exhibit a very compound structure. They consist of a small nucleus around which a varying number of layers have been deposited. As these layers are usually thicker on one side than on the other, the nucleus hardly ever appears in the middle, (Pl. II, Fig. 3.) This structure is not in all cases so readily perceptible as in the egg-shaped granules of the potato, or of the genuine West India arrow-root, (Pl. II, Fig. 5,) (for this is nothing but a very pure starch,) or as in the flat, disc-shaped granules of the East India arrow-root, (Pl. II, Fig. 6.) In other plants it exhibits another peculiarity, two, three, four or more starch-granules being, as it were, grown together. This is seen very beautifully in the corms of the meadow-saffron, *(Colchicum autumnale,)* and similar forms occur much more often than the true form, in the adulterated West India arrow-root of the shops, (Pl. II, Fig. 6.)

I have thus delineated, in a hasty, superficial sketch, the interior of the plant. How simple are the structure and relations, and yet how infinite the results, which Nature obtains by these simple means! The few allusions which I have allowed myself to make, to the influence of plants on the well-being of mankind, nay even on their very existence, must suffice. A complete exposition of this subject would lead us too far. Worthily indeed, are the richness and beauty of the vegetable world, the ever inexhaustible theme of all poets, of all times and nations,—but here I draw back, since the dry earnestness of science reaches not into those bright regions.

Third Lecture.

ON THE PROPAGATION OF PLANTS.

"In air, in water and on earth
A thousand germs come struggling forth,
In drought and damp, in heat or cold."

FAUST.

LECTURE III.

Deep in the soul of man abides the feeling, that in his better nature he belongs not to this material world which environs him,—that a world of independent living spirits is his proper home; and readily does he soar in inspired anticipation to those regions, which seem to him his truer sphere. Returning from such a flight, for which the feeling of his origin lent him wings—when, after such exaltation, he is again transplanted into the dead world of matter, he tears himself unwillingly from the fair pictures, and readily, especially in the youth, both of individuals and of the whole race, invests surrounding Nature with the free spiritual life, so congenial to himself. Youthful fancy lends to the rock, the tree, the flower, an animating genius, and in the thunder hears the voice of God. Then comes earnest science stripping Nature of that inspiring charm, and substituting the unvarying law of blind necessity. The real aim of man is to place his spirit in its true sphere, independent and irrespective of external Nature, and in the full understanding of this Nature, with pious hope to exalt over all, the Highest Being; but in the transition to this elevated condition, the warmer feelings are severely tried, and it is indeed with bitter sorrow, that man tears himself from the living shapes with which he had peopled his world.

This disunion, this separation, which has not yet resolved itself into the higher reconciliation, has rarely been so beautifully expressed as by Schiller, in his "Gods of Greece."

My mission too it is, according to my powers, to labour at this unspiritualizing of Nature, and I took occasion in my former Lecture, to point out how the forms of the world of plants, impressing themselves so vividly on the sensuous nature, have their mysterious and silent weavings and workings transformed before the eye of the instructed naturalist, into chemico-physiological processes, which take place on and in an invisible utricle, the vegetable cell. The whole plant, however, is not one cell, but merely a compound of them, composed, indeed, according to so definite a rule, that for thousands of years, on all parts of the earth, the same firmly fixed forms recur. It is naturally asked, is then this assembling and combination of cells into entire plants, subject to definite natural laws? Before we can arrive at the answer to this question, we must look closer into the manner in which certain forms of plants are preserved in Nature; in a word, into the Propagation of Plants.

I must be allowed to approach this question by a somewhat indirect course. A review of the mass of animal life existing on the earth, will most conveniently lead us to it. Whithersoever man is guided by his wants, his self-interest or the more noble spirit of inquiry, animal life accompanies him. On the ocean, the active hosts of Nereus play around him, the pilot-fish glides before his ship, and the voracious shark follows, waiting for his prey. On land, the manifold forms of the animal world are everywhere in friendly or hostile motion around him. In the icy North, the faithful dog and the useful rein-deer are his companions, the seal his captive, yielding clothing, food and light, and the polar bear meets him in fierce strife. Beneath the vertical rays of the glowing sun, the sharp tooth of the great cats threatens him, the slender gazelle sports around him, "the ruminant with cloven hoof," furnishes him with food and clothing. The butterfly fluttered round Humboldt and his companions on the chilling snow plains of Chimborazo, and yet the giant condor floated at an incalculable height over them. Even in the firm coat of the earth, on which we tread, the worm burrows his dark track. And all this mass of life, not excepting man himself, is sustained at the sole expense of the organic matter which the vegetable world prepares for it. No single living creature which is reckoned among animals, can live on inorganic matter. The few examples which have been made known to us, the earth-eating Otomacs, the negroes who swallow pellets of clay, mentioned by Humboldt, the instances of men, pressed by want, eating the so-called mountain-meal, or as Ehrenberg as recently pointed out among the Finns, consuming the shells of fossil Infusoria, when accurately investigated by physiologists, have shown merely that these inorganic substances are to be regarded, not as food, but as means of deadening the irritability of the stomach.

But let us go back to an earlier epoch of our earth's duration; there appear masses of living beings, formerly peopling our globe, of which we can hardly form a conception, and which, be it observed, were almost all animals living upon vegetable food. The vast herds of Mammoths which traversed the plains of Siberia, the countless remains of gigantic oxen, sheep, stags, swine and tapirs, give us evidence of the enormous consumption of vegetable substances in former ages. And yet, all that we can make out as to the number of the great animals of the past world, dwindles into nothing before the masses of diminutive creatures which have been preserved to us. The whole of those elevated ridges, partly still subsisting, partly destroyed by later floods, for instance, from Rugen to the Danish islands, the white chalk rocks, which gave England the name of Albion and stretch through France to the south of Spain, the whole of the chalk mountains of Greece to which, among others, Crete owes its name,—consist, according to Ehrenberg's researches, of the shells of minute animals, partly destroyed, partly well preserved. When we turn to these, the smallest creatures which Nature exhibits, existences which make up by the number of individuals what the individuals want in size, animalcules which are mostly so small as to be invisible to the naked eye, yet fulfil an important purpose in the universal life of Nature, the imagination is wholly unable to express the quantity in abstract numbers. Ehrenberg's discovery of fossil Infusoria has deservedly attracted great attention, for every picture here fails to enable us to grasp the conception of such numbers. In one cubic inch of the tripoli (polir-schiefer) of Bilin, there are forty-one thousand millions of animals, and the whole deposit extends over from thirty to forty square miles, with a varying thickness of from two to fifteen feet.

Making a more special examination of the animal world in general, we find two great divisions determined by the nature of their food, whether vegetable or animal. The latter contains by far the smallest number of species, and the particular species appear in small numbers. The vegetable feeders, on the contrary, are innumerable; if we may adopt the excessive estimates of recent works, we shall assume 560,000 species of insects alone, the greater number of which feed on plants, to live and multiply upon the earth. And this is not all, the species of vegetable feeders almost always exceed the animal feeders in individual number. All great herbivora live a social life, forming great herds, and the swarms of insects especially set all control at defiance, replacing, by number and enormous voracity, what they want in bodily magnitude: the oak alone has to support seventy different insects.

For all these hungry guests, Nature spreads the table when she brings forth plants, and if she would not let one of her worlds, the animal, become extinct, she must provide so surely for the multiplication of plants, that spite of all injurious and destructive influences, a general famine shall be impossible.

That this may not be effected by a simple, well-defined form of multiplication, as in the higher animals, is in itself evident, and becomes still more so when we observe, that mankind and most animals draw upon those parts of the plants for their nourishment, which we usually consider to be the peculiar organs of reproduction: I mean the seeds.

The first observation which affords itself to the searching glance of man, is, that most plants form certain organs, out of which, under suitable circumstances, a new plant is produced; and this may indeed be seen in the larger kinds, already shaped out and enclosed by its proper envelopes, in the seed. The comparison of this with an egg is very close, with an egg in which the germ is already matured into a young animal,—the embryo. But we do not stop here. At a very early period, it was noticed that in many species of plants, two different forms of individuals appear, only one of which bears seed, as in the hemp *(Cannabis sativa,)* the Date palm *(Phœnix dactylifera,)* or the

Pistachio (*Pistacia lentiscus.*) It was also early observed that the seeds of the one plant are never perfected, unless a specimen of the other form grows and flowers simultaneously in its vicinity. Theophrastus and Pliny even, tell us that the country-people who were engaged in the culture of Dates, hung up flowering branches of the one tree among the flowers of the other, the seed-bearing form, and thus caused the development of the seed and fruit. Kämpfer relates that in an inroad of the Turks into Bassora, the inhabitants accomplished the expulsion of the enemy, solely by hastily cutting down all the palms of the one kind, so that the others remained sterile, whereby the enemy was deprived of his only source of food. Still more striking appear the proceedings observed by Micheli, in an Italian water-plant, (*Vallisneria spiralis.*) This plant has two different kinds of flowers; those in which the seeds are developed have long stalks, and elevate themselves to the surface of the water; the others are shortly-stalked, and therefore fixed at the bottom. At a particular period, the latter break away from their stems, come to the surface and swim to the others, which then become capable of perfecting their seeds.

This fanciful account, which, however, is not supported by any accurate scientific observation, led the way to the making of husband and wife of these two flowers, to investing the natural phenomena in question with the mysteries of the love with which the human heart is blessed. Scarcely was the idea broached when science seized upon it, extended it, in all its particulars, to all plants, and even at the present time we call the Linnæan arrangement of plants, the sexual system.

Unfortunately, these beautiful dreams, which poets especially have so often tenderly dwelt upon, were attacked by the new discoveries of science, which uses only its senses, and showed us that all these visionary comparisons with the totally differently organized animals, are devoid of the smallest foundation. It was my lot, in the share I have taken in the advancement of Botany, to bring this result to light.

In order to sketch briefly the actual processes of the multiplication of vegetables, I must recall to recollection some points stated in a former lecture. I observed there, that among its other characters, the individual vegetable-cell is endowed with the power of forming new cells in its interior, and thus, as it were, of propagating itself. Now the newly-formed cells have also this peculiarity, they grow and arrange themselves conformably to the cell in which they originate. Thus is the power given to all plants, to develop new plants out of any of their cells, when these come to be placed in favourable circumstances, and by this power is explained the facility with which almost all plants may be multiplied.

We can, however, distinguish several very different states, according to the difference of the conditions under which Nature renders possible the development of the single cell into a new plant.

1. In the cells of the plant in general, as I have expressed the law, it very seldom occurs, because it is only in rare cases that the necessary conjunction of all the favouring conditions is brought about. Nevertheless, there are actually some such striking instances of the kind, where leaves of a plant lying on the ground, and even in a herbarium, have suddenly become covered with buds, that is to say the foundations of new plants, so that we cannot doubt the validity of the law.

2. Instances of a somewhat more limited application of

the law, on the other hand, occur with exceeding frequency, for whole *definite* parts of leaves can be made to bring forth young plants. If, for example, a leaf of *Bryophyllum calycinum* is placed upon moist earth, young plants are developed from all the indentations of the leaf, and these can only derive their existence from the extraordinary development of certain, appointed cells (Pl. III. Fig. 5). The same phenomenon occurs on broken surfaces of detached leaves of the beautiful scarlet-flowered Echeverias, and in many other succulent plants, as also in the Orange-tree. Gardeners take advantage of this phenomenon to multiply these plants, and even in the Middle Ages, an Italian, Mirandola, travelled about, boasting of a secret art by which he could make trees out of leaves. If a notch is made in one of the thick veins of the splendid Gesneria, a new young plant is produced on the broken surface in about a week.

3. In other plants, we find little protuberances formed regularly and spontaneously upon the leaves, still attached to the stem, and at the points of these, buds which send off rootlets below, thus constituting new plants. This peculiarity is especially common in many Ferns and Aroideæ, the allies of the *Calla æthiopica*, or Trumpet-lily, as it is called. The situation where these protuberances and buds are produced, is not indeed perfectly definite here, but it is so far regular that certain parts of the leaf, namely, the angles where veins separate, exclusively possess the power of forming them. When such a leaf dies in the natural course of vegetation, these buds, alone retaining vitality, fall to the earth and grow up into perfect plants. Here, therefore, exists an actual natural propagation, or reproduction of the individual; whereas, before, it depended principally upon external influences.

4. The following condition depends much more upon definite circumstances. Properly speaking, the simple plant consists merely of a simple stem and its leaves; but in the angles of the leaves, particular cells are regularly developed into buds (Pl. III. Fig. 3). Now a bud is essentially nothing more than a repetition of the plant on which it is formed. This foundation of a new plant consists equally of a stem and leaves, and the sole distinction is, that the stem becomes intimately blended at its base with the mother-plant, in its growth, and has no free radical extremity, like that exhibited by the plant developed from a seed. However, this distinction is not so great as it appears at the first glance. Every plant of high organization possesses the power of shooting out adventitious roots from its stem, under the favouring influence of moisture; and very frequently even plants that have been raised from seed are forced to content themselves with such adventitious roots, since it is the nature of many plants, for instance the Grasses, never to develop their proper root, although the germ is actually present.

We are, it is true, accustomed to look upon the matter as though the buds must always be developed to twigs and branches, on and in connection with the plant itself, and thus in common life we regard them as parts of a plant and not as independent individuals, which they are in fact, although they, like children which remain in their paternal home, remain in the closest connection with the plant on which they were produced. That they are at least capable of becoming independent plants, is shown by an experiment frequently successful when the necessary care is taken, namely the breaking off and sowing of the buds of our forest-trees. The well-known garden operations of grafting and budding are other examples of this, and layering only differs from the sowing of the buds, in that the buds on the layers are allowed to acquire a certain degree of maturity before they are separated from the parent plant. All here depends upon the facility with which these bud-plants *root* as it is called, that is, develop adventitious roots, when they are brought in contact with moist earth.

Human art is not by any means the only influence by which the multiplication of plants in this mode is brought about, for Nature herself very often makes use of this method to multiply certain plants in incalculable numbers. In a few cases, the process resembles the artificial sowing of buds, as when the plant spontaneously throws off the perfect buds at a certain period; an instance of this is afforded by some of our garden Lilies, which throw off the little bulb-like buds which appear in the axils of the upper leaves. The more common mode of proceeding is as follows: those buds which have been formed near the surface of the soil, grow up into shoots provided with leaves; but the shoots are long, slender, and delicate, the leaves, too, stunted into little scales; in their axils, however, develop strong buds, which either in the same or following year take root, and the slender shoot connecting them with the parent plant dying and decaying, they become free independent plants. In this manner the Strawberry (Pl. III. Fig. 4), soon covers a neglected garden; in this manner is the Potato almost exclusively propagated, for this useful tuber is nothing but a large subterranean fleshy bud; in a similar way, too, the Duck-weed, which seldom flowers and bears seed, in a very short time covers our ditches and ponds, in the spring, with thousands of individuals. Many more examples might be adduced, but these familiar ones will suffice. This propagation by buds stands in a remarkable relation to the multiplication by seeds we shall presently speak of, since it may be laid down as a pretty general rule, that the less seed a plant ripens, the more it becomes multiplied by buds, and *vice versâ*; Nature has here, as it were, taken care that the plants shall be preserved under any circumstances.

5. All the modes of reproduction hitherto noticed may be placed together under the head of irregular propagation, and be opposed to the regular propagation, which exhibits essentially the following phenomena:—Every plant produces within itself a definite number of single, free, unconnected cells, which at a certain epoch spontaneously separate from the plant. It is the peculiar character of those plants which have true leaves, to produce these cells only in the interior of the leaves, which at the same time often assume a very different form, as for instance in the stamens. Another condition is also worthy of remark. Only in the very lowest plants, flowering wholly under water, is the propagative cell naked (Pl. III. Fig. 1); in all others, it is invested with a peculiar substance, which has not yet been chemically examined, but is mostly yellow and very indestructible. This substance frequently assumes very strange forms. Sometimes it resembles little warts or spines, and often little projecting ridges are formed, taking the shape of arcades, battlements with turrets, &c. Nature, however, has not yet given us the slightest clue to the possible purpose of these varied forms. Elegant as they are, they appear to be of no actual use. Fritsche, of St. Petersburg, in a work especially devoted to them, has given representations of the most exquisite forms. Now these cells are especially destined to the reproductive function, since from every one of them is a new plant developed. An essential distinction, however, occurs in this development; one,

indeed, recognized at an early period, and so exclusively regarded, that the higher agreement was altogether overlooked. The following are the two modes of development.

A. In the one case, the cells destined to the reproduction, are at once scattered on the earth or in the water, where the new plants are to grow. Then either the whole cell is gradually transformed into a new plant, new cells originating in it and taking its place, in these others and so on, which is the case in the Algæ, (Pl. III, Fig. 1) Fungi, Lichens, and part of the Liver-mosses; or the cell expands into a longish utricle or tube, but only one extremity of this tube becomes filled with cells, which gradually grow up into a new plant, the remaining portion of the cell, meanwhile, decaying; this is the case in the remaining Liver-mosses, the Mosses, Ferns, Lycopodia and Horsetails. An example of this kind of development may be found in every hot-house containing Ferns, for they may almost always be found germinating, (Pl. III, Fig. 2.)

All the plants just mentioned were united together by Linnæus, under the name of Cryptogamia, or hidden-flowered, because he mistakenly supposed that they were not devoid of the second organ of reproduction, presently to be mentioned, the "ovary," but that it was merely so small and so hidden that it had not been detected. But the real fact is, that it is either altogether absent, or merely inessential indications of it exist. In all these Cryptogamia, the reproductive cells are called *spores* or germinal grains.

B. In those plants which, with Linnæus, we call Phanerogamia or evident-flowered, the matter is differently arranged. The reproductive cells, which are here called *pollen*, are formed in peculiarly metamorphosed leaves, the *stamens*. But other organs, besides the stamens, are found, either in the blossom of the same plant, or of another individual of the same species. These consist essentially of hollow and generally pear-shaped bodies which have a small opening at the upper end. A body of this kind is called the *germen*, and the orifice the *stigma*. In the cavity occur little protuberances formed of cellular tissue, the *seed-buds*, to which the very inappropriate name of *ovules* was formerly given. In each of the seed-buds is one very large cell, called the *embryo-sac*. At the flowering period, the pollen falls upon the stigma, and then commences the development of the reproductive cells. Each one extends itself into a long filament, exactly as in the Cryptogamia, and in this form penetrates to the cavity of the germen, to enter one of the seed-buds, and finally, into the embryo-sac. The extremity which has passed in, now becomes filled with cells, and these develop forthwith into a perfect, though as yet simple and minute, plantule, the so-called *embryo* or *germ*, (Pl. III, Figs. 6—9.) Simultaneously with the development of the pollen-cell into the embryo, the seed-bud is perfected into a seed, the germen into the fruit. A pause in the growth now suddenly occurs, and the seed may often be preserved for a long time in this apparently dead condition. But when favourable external circumstances come into play, the life begins anew with the further unfolding of the plant, which is commonly called germination, (Pl. III, Figs. 10—12.) How long the vital power may slumber in the seed, is shown by the fact that the late Count von Sternberg raised healthy plants of wheat from grains which were found in a mummy-case, (which, therefore, must have reposed for 3000 years) and laid these before the Assembly of Naturalists in Freyburg. This experiment has also been made in England.

In the plants called "Cryptogamia," it is very evident that the multiplication of the plants is perfectly secured, since the spores, which occur in enormous numbers, fall at once upon the ground, where they may become fully developed. But the matter does not seem quite so certain in the Phanerogamia. In many blossoms, it is true, the germens and the stamens are so closely associated, that the pollen apparently cannot miss the place, the stigma, on on which its development is to begin. But this relative position is not alone sufficient; the two parts, the stamens and the germen, or, more correctly, the pollen and the stigma, must simultaneously stand in the same physiological stage of development; when the anther bursts, when the pollen falls out, the stigma must also be ready to receive it and call forth its power of development. Now, in a great many blossoms, this does not take place; the pollen is probably lost to the stigma of the same flower much oftener than perhaps is usually supposed, either because the latter is not yet sufficiently perfect, or, on the other hand, has begun to decay, at the moment when the scattering of the pollen approaches. And much more adverse are the circumstances in a not inconsiderable number of plants, in which each blossom contains only stamens or only germens, and where these two kinds of blossoms are at some distance from each other, either in the same plant or in different plants, such as those which Linnæus called single-housed (*Monœcia*,) and double-housed (Diœcia.) In many groups of plants, as in the Asclepiadaceæ and Orchidaceæ, Nature appears to have methodically taken pains, in the complicated and irregular structure of the organs, to render impossible the natural application of the pollen upon the stigma. Here totally foreign powers come wonderfully to the aid of the vegetable world, and, in the fulfilment of their own irrelative natural duties, casually exert so essential an influence on the life of the plants, that one would almost believe it was their proper destination. For, be they land plants, the wind drives the enormous quantity of pollen far and wide, and the air is often so filled with it that sudden rain throws it down in visible quantity, as the so-called sulphur-showers. Where there is such profusion, a sufficient number of granules must of course reach their destined resting place. If they be water plants, the germens float in such a manner that the light waves wash over them, and the pollen, driven about in the water, is thus brought to its place. In the two great families, especially, the Asclepiadaceæ, to which belongs the Syrian Silk-plant, and the Orchidaceæ, which, with their blossoms imitating bright, splendid butterflies and strangely fashioned insects, adorn the damp shades of the tropical forests; in these two groups of plants especially is seen, the distinct interference of living creatures in the reproduction of plants. In them the pollen of each anther is glued together by a matter like bird-lime, and it adheres so firmly to the nectar-seeking insect, that he cannot get rid of it. The nectaries are so situated in the flower, that the insect, in order to reach them, must come into close contact with the stigma, and thus the pollen is brought to its destined place. We often see flies crawling on the Silk-plant, with a number of such club-shaped pollen-masses hanging to their legs, and in some localities the bee-keepers speak of a peculiar disease of their industrious little animals, "the club-sickness," which consists solely in the adherence of so many pollen-masses of Orchidaceæ to the heads of the bees, that they are disabled from flying, and thus are lost. A copious work was written at the end of the last century, by Christian Conrad Sprengel, on the share which insects take in the reproduction of vegetables; in the enthusiastic warmth of his investigations he wished to claim for insects the part of Nature's universal gardeners. Easy as it may be to point out, with an ironical smile, the narrow views of this child-like, pious naturalist, in individual instances, it is exceedingly difficult to find the true point of view, from which to form an opinion on this apparently most strange phenomenon in the life of Nature. It is, indeed, a very natural connection, when a glutinous substance is produced with the pollen in a plant; it is easily comprehended that the pollen must then necessarily adhere to the bees; it is certainly simplest and most natural to assume, that in their subsequent rovings, this pollen becomes merely *accidentally* deposited in its right place; that a rivulet should play in little ripples, that in air increased in weight by the hot sand of Sahara, the wind should carry about the light pollen of the Date-palm, are of course natural events, and depend upon invariable laws of Nature. And yet, when we conceive of the phenomena in a mass, as a connected whole, we can neither repel nor answer the questions which press upon us. What has the wind to do with the Date harvest of Biledulјerid, and with the sustenance of millions of men? Knows the inanimate wave, which bears the Cocoa-nut to far and uninhabited islands, on the shore of which it shall germinate—that thus it paves the way to the further diffusion of the human race? What cares the gall-fly that on its activity depends the Fig trade of Smyrna, and the food or support of thousands of human beings? Or does the beetle, whose theft facilitates the increase of the Kamschatkan Lily, imagine that their bulbs shall be the means to save the whole population of Greenland from starvation in the following hard winter? If all this is the result of insubstantial natural laws, whence this wonderful inter-dependance and connection of subordinate forces, to bring to pass events which have so deep an influence on the history of humanity? We do, indeed, see into the mechanism of the puppet; but Who holds the strings, and directs all its motions to *One Purpose?* Here closes the office of the naturalist, and, instead of answering, he turns from the world of space and lifeless matter upward to where, in holy anticipation, we seek the Ruler of Worlds.

Fourth Lecture.

THE MORPHOLOGY OF PLANTS.

All shapes are similar, yet all unlike,
The chorus thus a hidden law reveals.

GOETHE.

LECTURE IV.

Some years ago, I was very intimate with the directing physician of a large Lunatic Asylum, and I used industriously to avail myself of the liberty I thus obtained, to visit at will the house and its inhabitants. One morning I entered the room of a madman, whose constantly varying hallucinations especially interested me. I found him crouching down by the stove, watching, with close attention, a saucepan, the contents of which he was carefully stirring. At the noise of my entrance, he turned round and, with a face of the greatest importance, whispered:—"Hush, hush! don't disturb my little pigs; they will be ready directly." Full of curiosity to know whither his diseased imagination had now led him, I approached nearer. "You see," said he, with the mysterious expression of an alchemist, "here I have black-puddings, pigs' bones and bristles in the saucepan, everything that is necessary, we only want the vital warmth, and the young pig will be ready made again." Laughable as this circumstance appeared to me at the time, it has often recurred to me since in seriousness, when I have reflected on certain errors in science, and if the mere form of the delusion were the criterion of sanity or insanity, even many distinguished naturalists of our time would have to share the narrow cell of my unfortunate Mahlberg.

The purport of the error, expressed in general terms, is this: that a definite mixture of definite substances is at once a perfect individualized natural body; while, in reality, there must be combination of two different kinds; namely, of matter and of form or shape, which two things are equally necessary to complete the special conception of an organism. The defined limitation in space, is exactly that which we consider the chief characteristic of an individualized natural body. The surrounding material world exhibits itself, according to the manner in which we look at it, with three totally different sides, and each of these gives us opportunity to develop a peculiar scientific system. No human being can foresee whether we shall ever succeed in including two, much more all three of these systems in one common scientific theory of the world, proceeding from a single principle. These three systems, which are the primary divisions of natural science as a whole, may be most simply and intelligibly explained by a consideration of our solar system. In this we find, in the first place, certain great bodies which are formed of matters of different kinds. These matters and their peculiarities, the mass, which is the basis of the whole system, is the first subject of our inquiries, thus arises the study of matter or Hylology. But we observe, at the same time, that these ponderous masses of matter are never at rest, that unceasing change of relative position drives them through space. The motions and their regulation become the second object of our research, the study of motion or Phoronomy. But we have not yet exhausted the knowledge of the solar system in these two. Neither from the peculiar properties of matter, nor the laws of motion, can we deduce the reason why fourteen planets circulate round the sun, why only Earth, Jupiter, Saturn and Uranus have satellites, why Saturn alone a ring, why the planes of the planets' paths have this and no other inclination toward each other, &c. In short, there are still definite, permanent, created relations in *space* which do not follow from the law of motion, which cannot be considered as peculiarities of substance or of matter in general, relations which are the cause of the form under which the moving masses appear to us; in a word, the definite shape of this our solar system, which seems accidental in so far that countless other shapes are possible, and, perhaps, in other solar systems are actual. These last considerations give us the study of fashioning, or Morphology. If we pass now from the solar system to the circumstances of our own earth, Hylology becomes Chemistry; Phoronomy, Physics, or, in reference to organized bodies, Physiology; and Morphology gives the characteristic studies, Mineralogy, Zoology and Botany.

The simplest plant we investigate, shows us, quite as well as the solar system on a larger scale, a series of facts, which may be distributed into the three primary divisions of science. The plant, chemically analyzed, is found to be composed of greater or smaller quantities of different substances, the peculiarities of which, so far as we know at present, are most intimately connected with the individuality of the whole plant (Study of matter). But by closer attention, we soon find that these substances are never at rest; that, on the one hand, matters are entering the plant, on the other, leaving it and, in the plant itself, in constant motion from one place to another,—constantly combining and separating

(Study of motion or Physiology of plants). Have we then exhausted the whole existence of the plant? By no means; and, in fact, so far from it, that it is conceivable that all these substances, all their motions (so far as they relate to chemical union and separation) might be imitated in the retorts and crucibles of our laboratories, without any phenomenon occurring to remind us in the most distant manner of a plant. From sugar, gum or vegetable jelly is formed cellulose; but cellulose is not as yet a cell. This cell-formation, consequently the shaping, first changes the substances into vegetable organisms. All existing plants are composed of cells of the same kind, but the different plants are distinguished from one another by the contour, the design according to which the cells are united together. Whether it arises from the essential nature of the circumstances or not, we cannot say, but, at least so far as appearance goes, the production of shape is so prominent a point in the Natural History of Plants, that all the rest has often been forgotten for its sake; and thus the study of form, or Morphology, becomes in any case the most important branch of teaching in all Botany. But it would be a great mistake to suppose that Morphology is merely a meagre enunciation and description of forms. It is also a scientific question: it has also to seek for the knowledge of laws, and must, at least as a preliminary step, arrange the multitude of appearances under primary points of view, place them according to rule and exception, and so gradually approach nearer to the discovery of the actual laws of Nature.

The notion of such a regulation of the shapes of plants, was first expressed by Göthe, in his idea of a typical plant, whereby he signified an ideal plant, the realization of which, as it were, Nature had proposed to herself, and which she had only attained in a certain degree in the individual plants. This conception is certainly by no means faultless. In the first place, it is scarcely necessary to say to any one who is accustomed to refined speculations, that in reference to all these things, human strivings after the archetypes of Nature are mere unsubstantial play of the imagination, which at best can but help a tottering brain to bring the conditions nearer to its power of comprehending them; but this always at the cost of the only true comprehension itself. The setting up of a design, the carrying out, the commission of errors therein, and consequent only partial success of the whole, are conditions which belong only to the imperfect reason of human beings, "whose knowledge is patchwork." This so-called Anthropopathy (humanization), however, is without meaning in the presence of Nature; for *this* is, according to the stand-point which the human judgment takes, either the product of blind force acting under unvarying laws—and then to speak of plan and a greater or less degree of perfection is absurd, since all is rigid necessity,—or, it appears to us as the Creation of a Holy Author, and then plan and execution are equally perfect and complete in the least as in the greatest, but for the son of earth everywhere mysterious and inconceivable. On the other hand, also, Göthe's idea of a typical plant suffers from obscurity, since it is not clear how a man can imagine such a type. This much is certain, that the disagreeable, tasteless heaping up of a number of individually possible forms into such an actual vegetable monster as Turpin has perpetrated in his Atlas to Göthe's scientific works, is anything but what Göthe pictured to himself in his ideal plant. In order to impress the idea upon the senses, we, also, must make use of a representation of an ideal plant, which shall give us the highest development of the vegetable world in its simplest form; from which, therefore, all the lower stages may be deduced by omission or contraction, all the allied by combination and complication.

The accompanying plate (IV) will serve to represent such a plant. It may be regarded as an abstraction of a very simple and familiar plant, the *Anagallis phœnicea*, the large blue-flowered variety of which decorates our windows, under the name of *Anagallis monelli.* A close examination of this picture will render some of the more important morphological conceptions more readily intelligible. A mere glance even shows us the following characteristics:—In the first place, we distinguish a continuous principal trunk (*a* to *a* VI), with various lateral appendages attached to it (*b*, *c* to *c* VII and *d*). Viewed more narrowly, these latter exhibit some very striking differences, which are capable of being arranged into three classes (which, therefore, are distinguished by the three letters *b*, *c* and *d*). Continuing our investigation, we find the organs marked *d* (see Figs. *d* I, *d* II) to be also composed of a main trunk and lateral organs, and, having exactly the same characters as the plant itself in their subsequent development, they are mere repetitions of it, only distinguished by not being free at the lower extremity. We may, therefore, readily exclude these parts, called "*buds*," altogether from our consideration. The organs marked *b* agree so perfectly in all their characters with the inferior free end of the plant, that we have no hesitation in regarding them as portions of it, although science subsequently points out that they differ essentially in many points. We have now, therefore, only two organs in the whole plant. The first is the continuous main trunk of the plant, called "*the axis*," or "*stem-organ*," the latter term being employed because the various forms of the

On Zinc by J Erxleben

London Publish^d by H Bailliere 1848

Day & Son Lith^rs to the Queen

vegetable stem are all developed from this part. The axis is the primary and fundamental portion of the plant from its very origin, and not unfrequently the other organs are but imperfectly formed, or appear in particular special forms, as in the Cactus tribe, the Stapelias, and almost all parasitical plants. The second organ is represented by the lateral bodies marked *c*, exhibiting a multitude of differences in the individuals, yet one essential, fundamental physiognomy, which they never wholly throw aside, and which is especially visible during their development;—they receive the general name of "*leaf-organs*," or "*leaves*." Thus we perceive that even the most perfect plant only possesses two essential organs, namely, the stem and the leaf; therefore, that the ideal plant depicted by fancy, the typical plant, has a basis simple beyond all anticipation. But we must distinguish and name more minutely the following modifications of the primary organs: —

1. Of the axis, we find a lower end, which is called "*the root*" (*a*), with its lateral organs "*accessory roots or rootlets*" (*b*), an intermediate portion (*a* I to *a* V) the proper "*stem*," the supporter of the leaf-organs and buds; lastly, an upper end (*a* VI) which subsequently, after manifold occurrences, developes into a seed, and therefore receives the suitable name of "*seed-bud*." (Formerly an unfortunately chosen term, "*vegetable ovules*," was applied to the seed-buds).

2. A far greater diversity of forms occurs in the *leaves*. The first which are exhibited by the unfolding plant, and which may mostly be found already tolerably perfect in the embryo, are the "*seed-lobes*" or "*cotyledons*" (*c*), their outline being very simple. From these to the middle of the stem, the leaves, according to a tolerably prevalent law, become more diverse and complicated in their outline,

and from the middle to near the upper end progressively more simple again (*c* I—*c* III). These forms are collectively included under the name of "*leaves*," and they alone are known under this name in common life. The succeeding foliaceous organs (*c* IV—*c* VII), together with their intermediate portions of stem, are comprehended in the somewhat indefinite word "*flower*," or "*blossom*," but four degrees of development may be distinguished in them. The first, second and fourth (*c* IV, *c* V, *c* VII), differ only from the true leaves in the delicacy of their texture, and the second more especially by their colour; they are called "*calyx*," "*corolla*," and "*carpels*" or "*fruit-leaves*." The last derived their name of fruit-leaves from the circumstance, that in their subsequent most remarkable changes, they mostly form the essential portion of what is commonly called the fruit. The third state of development has totally different peculiarities, the leaf undergoes such important structural metamorphoses, that it can scarcely be recognised. The chief points consist in this,—it becomes slender and thick, while several (frequently four) long cavities, lying side by side, are excavated in its interior; these become filled with a quantity of perfectly isolated, dust-like cells, which by the regular opening of the cavities are expelled and scattered around. These leaves are called "*stamens*," or, down to the point where the cavities terminate, "*anthers*," and the isolated cells "*pollen*."

If from this ideal plant the more compound leaves (*c* I and *c* II) are omitted, and we imagine the pairs of its leaf organs increased to fives, these to be grown together in four circles, and again, instead of the one seed-bud, a number of them united into a kind of knob at the upper extremity of the stem, we shall thus obtain a plant of the above-mentioned *Anagallis*.

But if we would reduce this ideal plant to a simpler form of vegetable life, *e. g.*, a Fern, Moss, Conferva, &c., we must confound and blend together its parts, till nothing at all remains which retains the slightest resemblance to it. Now, attempts at a morphological legislation are just as little to the purpose, since they engage us, not in the actual world, but on the sportive products of our own imagination, and lead us to content ourselves with explanations and laws, which only find application in a small portion of the vegetable world, while all the rest remains dark and incomprehensible. Göthe's typical plant, therefore, will be of no use to us, and we must seek another path by which to enter upon the contemplation of the relations of form in the vegetable world.

The subject has greater difficulties than at first appear; and to obtain a correct insight into this question, indeed to avoid a gross error which renowned observers both have, and do still daily fall into, it is necessary to take a very comprehensive view of the kingdom of Plants. When we speak of forms, of shapes, we mean the defined, limited bodies existing in nature. The conception of any body whatsoever, however, already presupposes, that it is extended in all three directions of space, length, breadth and depth. A mere line or surface is not a body, and therefore no shape, and it gives us merely the simplest relations to space, consequently, no basis for classification. Now, one or two of these directions of extension may predominate in a body; we easily distinguish a thread from a sheet of paper, simply by these conditions. Here, however, there is but a simple *more* or *less*, but no deeper essential distinction, as is most distinctly shown by the fact, that where the external bounding or definition first acquires a great importance in natural science, namely, in crystals, one and the same kind of crystal may appear as a long needle, a little flat plate or as a body equally extended in all directions. The crystallized oxalate of lime, occurring so frequently in plants, has in all its forms a square surface as its constant basis, upon which a square column is built. When this is very short, a little quadrangular plate is the result, if higher, it gradually approaches the cube; becoming taller, it passes up beyond this, and at last appears as a long slender needle, almost filiform; but the shape of the crystal, the essential form, remains ever the same, a square column; just as we may recognise the same human shape, though mankind are short and stout, or tall and slender. The conclusion which may now be drawn from this is, that we can deduce no characters from the general conception of a body, wherewith to distinguish and classify it. Glorious systems may, indeed, be thought out on paper in the study, but these have no meaning or importance in the actual world. Thus, as we enter upon these things, we must rather modestly inquire whether Nature is inclined to display her mysteries to us; whether she will, in this or that individual instance make manifest what characters are essential in their shape; in a word, what basis she will afford us for the erection of our system.

In reference to this point, our science stands at very different degrees of completion in the different classes of natural bodies, in all, however, yet far distant from its object. This object is, namely, to be able to explain all shapes by the regular action of force in nature, and this is not at present possible in one single case. The preparatory stages, however, by which we are to attain to this object, consist in the first place, in the accurate knowledge and arrangement of different shapes according to their inner affinities, and secondly, in the gradually completed discovery and collection of the external circumstances, under the influence of which the individual shapes are formed. For the latter part of the subject, we have collected here and there a few solitary fragments; for the former half, the arrangement of the forms of crystals is tolerably perfect; in plants and animal worlds, on the contrary, we have only gained, from very various stand-points, a few prospects and surveys, which, on the whole, exhibit but very little inward connection.

The great hindrance in the last case, in relation to certain points, is exactly that phenomenon which we call vitality; wherein the characteristic of this life lies, is but rarely distinctly to be perceived.

The crystal does not spring at once a perfect Minerva from the head of the Jupiter; the matter of which it is formed undergoes a constant series of changes, the final result of which is the completed shape of the crystal. The crystal, too, has an individual history, a biography, but only a history of its *becoming*, its origination. Once *become*, its life is at an end, its consistence excludes every change; the moment of its birth is that of the expiration of its life, it is dead from the moment in which it begins its perfect existence. Plants and animals form the most direct contrast to this, and herein lies that common nature, which induces us to comprehend them in one conception, as organic or living existence. In the following explanations, however, to avoid prolixity, I will restrict myself to the Vegetable Kingdom.

In Spring we commit the barley-corn to its nurse, the earth; the germ begins to move, starts from its envelopes, which fall to decay. One leaf after another appears and unfolds itself; then the flowers display themselves in a thickly-crowded spike; called forth through wonderful metamorphoses, originates in each the germ of a new life, and while this, with its envelopes, becomes perfected into a seed, constant changes in the plant, from below upwards, are in progress; one leaf after another dies and withers, at last but the dry and naked straw-halm stands there; bowed down by the burden of the golden-gift of Ceres, it breaks up and rots upon the earth, while within the scattered grain, lightly and snugly covered by protecting snow, a new period of development is preparing, which beginning in the following Spring, continues on the unceasing repetition of these processes. Here there is nothing firm, nothing consistent; an endless becoming and unfolding, and a continual death and destruction, side by side and intergrafted—such is the plant! It has a history, not only of its *formation*, but also of its *existence*, not merely of its *origin*, but of its *persistence*. We speak of plants; where are they? When is a plant perfect, complete, so that I may snatch it out of the continual change of matter and form, and examine it as a thing *become?* We speak of shapes and forms; when shall we grasp them, disappearing, Proteus-like, every moment, and transformed beneath our hands? As in Döbler's dissolving views, one picture imperceptibly disappears before our eyes and another takes its place, without one being able to determine the moment when the former was lost or the latter began to appear. In every given moment is the plant the ruin of the past, and yet, at the same time, the potentially and actually developing germ of the future; still more, it also appears a perfect, complete and finished product for the present. Here lies the fundamental cause why a morphology of the crystal or the inorganic world must have so essentially different an import and development from the study of the shapes of the so-called living existences; but there is yet another condition, though truly, compared to that just mentioned, one of very little importance, whereby the examination of organic bodies is involved in difficulty and complexity, to which human powers of comprehension are not nearly equal with the assistance at present at their command.

By shape is understood the limitation of bodies in space; the limits or boundaries by which the definite shape is separated from boundless space, are surfaces. Surfaces themselves are either plane, and these again bounded by lines, or curved, and then defined in different ways by the relation of their parts to one or more lines. The plane surfaces are easily constructed and arranged if their boundary lines are straight, as also are the bodies bounded by plane surfaces, like crystals. In planes which are bounded by curves, the difficulty gradually increases to that great complexity which the theory of curved lines presents. On the other hand, only a few of the curved surfaces, such as the sphere, the ellipsoid and so on, are capable of accurate geometrical definition, the conditions soon become so complex that they bid defiance to the most acute combinations of the greatest mathematicians. Now, all lines and surfaces which occur in organized bodies, are curved, and almost always so irregularly, that a geometrical definition of them is at present out of the question. Thus, leaving out of view all the other difficulties, we are already disabled from using accurately defined geometrical terms, even in the mere description of the particular organic forms, and we are compelled to have recourse to comparisons, and a peculiar technical language derived from them, which, from the nature of its origin, is very ambiguous. Even such expressions as cylindrical, prismatic, circular, spherical and the like, have no longer a well-defined geometrical signification in their application to plants, but merely an approximative, comparative value.

From these circumstances, it is evident that very general information and a peculiar tact, I might almost say instinct, for natural science, is necessary to the safe advance of a single step forward in the study of the forms of plants, and that here we must, in the very first place, develop special, guiding maxims from the nature of the object itself, according to which to criticise, reject or admit the innumerable possible systems of Vegetable Morphology. This, indeed, gives us but the negative result, that all the rules tending to the rejected systems are useless, while the admitted acquire only a possibility, but no certainty of correctness. Nevertheless, much has already been gained by it, since the investigations become continually more simple. When, guided by such principles, we direct our attention to the plant, it presents two peculiarities, which make good their distinct claim to regard in all our investigations. One is the composition of the plant out of little, almost independent and individualized elementary organisms, namely the cells; the other is the continuous process of absorption and excretion of matter, the production and dissolution of cells, and as a consequence of both, the constant alteration of the internal and external form, the structure and the shape.

The maxims to be derived from these are :—

"Whatever, in the plant, has not been traced back to its composition from individual cells, is not yet known or understood, consequently cannot be used as the basis of any theoretical considerations." And secondly :

"No individual, persistent, or rather, apparently persistent form, but only the eourse of its development, ean be the objeet of a study of form in Botany; every system which devotes itself to the isolated formal relations of this or that epoeh, without regard to the law of development, is a faneiful air-eastle, whieh has no foundation in aetuality, and therefore does not belong to scientifie Botany."

It is not at all my intention to unfold all the separate positions which Morphology has hitherto seeured, or is believed to have seeured, from the observation of faets under the guidance of these maxims; this would be nothing less than to write a whole system of Botany. Here I ean only proffer a general view of the Vegetable World, sketehed aeeording to its morphologieal eharacters.

Regarding the vegetable kingdom as a whole, as an individual, the various stages of life and development of whieh lie as elose *beside each other*, as they follow *after one another* in a single plant, we are enabled to regard the simplest form as also the eommencement of the Vegetable World; and then we find that this, like the individual plant, is prodaeed and developed from a simple eell. When on old, damp walls and palings, or in glasses in whieh we have let soft water stand for several days in summer, we find a delieate, bright green and often almost velvety eoat, we meet with the first beginning of vegetation. Under the microseope, we detect in these green masses a number of small, spherical eells filled with sap, eolourless granules and chlorophyll. In other plaees oeeur similar eells, but yellowish, brown or red, and almost all, at least at present, may be regarded as perfect plants, whieh have received various names from Botanists. The most suitable name for them is *Protococcus*, *primary vesicle*. From this simple cell, vegetating as an independent plant, the development of the vegetable world takes its departure, and ascends by continually greater combinations and complications, to the most complex plants, which we are compelled to look upon as the highest states, although the uninitiated may think it strange when I name as a representative of this highest expression of vegetable development, the little, common, and therefore despised, Daisy.

The forms immediately following the above-mentioned simplest plants, also consist of a simple cell, but this is elongated into a filament and often branched, thus exhibiting a higher development of form; next the cells arrange themselves into lines in manifold ways; a variety of forms of vegetation soon grows up, which in water appear as the *Silk-weeds* or *Confervas*, generally of a green colour, or on decaying organic bodies, as *Moulds*, in very various and often most elegant forms, with the most brilliant play of colour. Then the cells unite to compose flat structures, known to Botanists by the name of *Ulvas*, and frequently growing in the sea, almost like young Lettuce leaves, sometimes green, sometimes red, often afford a meagre meal to the poor inhabitants of the coast. Next they crowd together into solid masses, forming clumps and balls of the greatest possible variety of shapes. Now commences an unfolding of richer and more varied forms which were possible before in the simple element; but the differences of development in length and breadth, or length, breadth and depth, are especially frequently repeated in the lower stages of the Vegetable World in the individual groups, and in the higher stages in almost all the individual organs.

It will be in place here to call attention to a peculiar condition of plants, which in the animal world either does not occur at all, or in a much less striking degree, and then only in those parts which, even without it, allow the drawing and maintaining of the closest analogies with plants, namely, in the bones and the dermal system. In the inferior plants hitherto mentioned, we can, in general, neither detect definite members in the individual parts, nor a definite distribution of the vitality in separate determinate portions of the whole. Generally speaking, there are no organs here, neither such as, through a definite shape, or through a generally repeated relation of form in one manner to the form of the whole plant, are morphologically definite, nor any to which a definite individual vital expression is always attached by a form different from that of the other parts of the plant, which consequently could be described as physiologically definite. By degrees, indeed, we see in the somewhat more highly developed Sea-weeds, in the Fungi and Lichens, certain quite definite cells, essentially differing from the rest, and destined to the production of the reproductive cells; we find the cells arranged in perfectly determinate forms, according to the varied structure of which we are then able to distinguish the larger and small groups; but there the matter rests in the vegetable world. Up to the most highly-developed plant, we always find, excepting in the organs of reproduction, a perfect independence of the physiological and the morphological import of the individual organs; and mischievous confusion, which it is difficult to get clear of, has been brought into the study of the Forms of the Vegetable World, by the misconception of this relation. One and the same organ may serve the most different vital offices in different plants, and the same vital process may belong to the leaf in one plant, to the stem in another.

After these preliminary remarks, we may extend our review to a further portion of the vegetable kingdom. The whole world of plants is divided into two unequal portions, the smaller of which is composed of the three groups of the *Algæ* or sea-weeds, the *Fungi*, and the *Lichens*. In this division we have, in general, no other organs but the apparatus for the formation of reproductive cells, and for this reason, that the process of development is one and the same in all parts of the plant, each part, therefore, represents the whole plant, and as such may continue to live and grow. The forms are here mostly bounded by extraordinarily vague outlines, especially in the Fungi in which the plant itself is merely a wonderfully perishable interwoven mass of delicate filaments. The bodies usually called Fungi, in common life, are only the reproductive organs, as it were the *fruit* of the plant. A similar indeterminateness of form prevails also in the simpler Algæ, common water plants, and not less in the lower Lichens, the crustaceous kinds which cover walls, stones and palings, with a whitish, grey or yellow scurf. In the highest Algæ and Lichens alone, the forms become somewhat more definite, and often exhibit very constant shapes, which even possess a resemblance to stems and leaves, but without the same import, the same morphological value as in the next great division of plants.

In the latter, we first meet with two so essentially different processes of development in one and the same plant, that we are obliged to regard their products as essentially different elementary organs.

One organ is the first, the original, and developes itself unceasingly at its two free extremities, these extremities are always its youngest, last formed parts; this organ we call the *stem*, in the widest sense of the word, or *the axis of the plant.* On this original elementary organ, and out of it, grows a second, the free end of which originates first, and, therefore, is the oldest part of the organ; it grows only at the base, where it is connected with the stem, and this only for a certain length of time, being thus, as it were, pushed up out of the stem. This is a *leaf* in the widest signification of the term. While the former exhibited unlimited growth, the latter is through the very mode of its formation arrested at a certain boundary. We perceive two things here: *first*, that the stem and the leaf are actually contrasted with one another; only where the one is present can we speak of the other. From this we draw a distinction in the plants of this primary division, and separate the *stemless* plants from those *with stems*. *Secondly*, it follows, from what has been premised, that the plant in general can have but two essentially different organs, namely, leaf and stem, and that all the remaining so-called organs of the plant must be only unimportant variations of form of one of these organs, or, structures resulting from the combination and blending together of both. This proposition was first definitely expressed by Caspar Frederic Wolff and Göthe, and the result of the observation, that all the organs of a plant possessing a stem may be traced back to one or other of the elementary organs, has given rise to a peculiar study, which is universally known by the name given to it by Göthe, "the metamorphosis of plants." What has already been revealed by publications now in our possession, includes but a very small part of that branch of study, which, as Morphology, will hereafter be the most essential section of all Botany.

We might here easily give a brief review of this subject, by an example, without entering into all the individual points which still contain many difficulties and unsolved problems. The most important, however, have already been dealt with in the explanation of the idea of a typical plant, and therefore we shall only need some little additions in reference to the formation of the flower, which exhibits some complexity.

In the place where the carpels or fruit-leaves, and seed-buds are situated in the typica plant, that is, in the centre of the flower, most plants display an organ which is closed in all round, but hollow; it encloses the seed-buds, and its cavity only communicates with the external air by a canal which is usually almost imperceptible. This body, as a whole, is called the "*pistil,*" that part which encloses the seed-buds the "*germen*" (also fruit-bud), and the opening above, the "*stigma.*" If the body is elongated into a kind of stem between the germen and the stigma, this portion is called the "*style*" (Pl. IV. Fig. 2). Now, this body is especially variable in its composition; sometimes it is wholly formed of one or several carpels, at others, its lower part, the germen or even the whole is a portion of the peculiarly transformed stem. Those portions of the stem, too, which otherwise belong to the blossom (*a* III—*a* V) are often metamorphosed in the strangest ways, and on these two conditions depends in part the great variety of flowers, to which also the conditions of number and position in the remaining portions contribute their share of influence.

The terms which we derive from such scientific examination of plants, appear strange when they are used in common life, and it sounds strangely enough to hear, that the grateful juicy part of a Strawberry is but a portion of the *flower-stalk,* while the actual fruit consists in the little inedible granules; on the other hand, that in a Raspberry we eat a quantity of little genuine fruits, the *carpels* which have become fleshy and succulent, while the same portion of the stem which delighted our palate in the nearly allied Strawberry, is here represented by the little white, spongy cone; that in the Apple we eat a part of the *flower-stalk;* in the Cherry, part of a *leaf*; and that in the Nut and Almond we devour a whole diminutive plant, root, stem, leaves, and buds.

But we must here once more recall to mind, what has already been mentioned at the outset of our examination of the typical plant: namely, that by no means all the individual parts and forms described in the typical plant make their appearance in every plant, nay, even in every plant having a stem. Among those last, indeed, are found a large number with a much more simple structure and, therefore, in order to proceed with the unfolding of the series of steps, we are again obliged to recur to the reproduction of plants.

It will be remembered from a former Lecture, that the general process of the multiplication of all plants consists of the formation of definite reproductive cells, the detachment of these from the place where they were produced, and their development into new plants; but that an essential distinction was founded on the circumstances under which the development takes place: whether the reproductive cell can at once unfold itself into a new plant in water or on the earth, or must acquire a certain degree of maturity within a peculiar organ of the plant, the so-called seed-bud. To the plants of the former kind, which are called *Cryptogamous*, or *asexual*, belong a considerable number of the stem-plants. I will here especially cite only the Liver-worts and Mosses, the *Lycopodiaceæ* or Club-mosses, the Ferns, and the *Equiseta* or Horsetails. In all these groups can be distinguished a distinct stem with leaves, but a peculiar series of gradations is exhibited by them in the formation of the reproductive cells, which, in the Liver-worts and Mosses are found in a morphologically indefinite capsule, in the succeeding groups come into more intimate connection with the leaf, and at last assert so strongly their exclusive claim to definite foliaceous organs, that the said organs lose all their resemblance to the other leaves. As the reproductive cells are called spores, these leaves receive the name of "*spore-leaves*," and in the Horsetails they have the same form as in the succeeding and highest of the great divisions of the stem-plants, which form, in the *sexual* or *Phanerogamous* plants, is that of *stamens* with their *anthers*.

In the Liver-worts, Mosses, and Ferns, we find an organ of a peculiar kind, which in its structure corresponds to the seed-buds of the sexual plants; its morphological import is as yet undetermined, its physiological relations are wholly inexplicable at present, but it certainly has no essential connection with the reproductive functions. These organs are usually called *antheridia*. They remind us very strongly of a phenomenon observed in the progressive gradations of animals, where we also often find an organ prefigured in a group or genus in which it performs no function, acquiring its actual importance to the life of the animal in a neighbouring group.

Stem and leaf as elementary organs, definite leaves transformed into spore-leaves for the formation of reproductive cells, and an organ of an uncertain nature with the structure of a seed-bud, these are the acquisitions with which Nature enters upon the development of the last great division of the Vegetable Kingdom, the group of Sexual Plants. The characteristic of this group is the entrance of the seed-bud upon its true office, that of a reproductive apparatus, and it here distinctly shows itself to be the terminal joint of the stem-organ (*a* VI).

The sexual plants again separate into two divisions of unequal magnitude. In the first and smaller, the inflorescence is still very simple, since, on the one hand, it is devoid of what is understood as a flower in common life; on the other, the seed-bud, and consequently the seed developed from it, is naked and unenclosed in any germen. This division, which includes the Fir tribe, the *Loranthaceæ* with the parasite Misletoe, so injurious to our fruit trees and a family of tropical plants—the *Cycadaceæ*, is contrasted as the class of *naked-seeded* plants, as *Gymnosperms*, with the *covered-seeded* class, the *Angiosperms*.—In the last great division of plants, it is the inflorescence which especially attracts our attention. Here, too, the elements of a graduated series are unmistakeable, but we must first direct our observations to one more speciality which separates the whole of the plants belonging to this class, as it were into two parallel series of developments. As the embryo is gradually developed from the reproductive cell, upon the axis, which of course is first formed—either *one* first leaf is produced, wholly surrounding the axis like a sheath, and completely covering its upper part; or, simultaneously and opposite to each other upon the stem, *two* first leaves appear, each of which half embraces it, and which enclose the upper part of the embryo between them. The first series are called the *one-seed-lobed* or *Monocotyledons*, to which, for example, belong all Liliaceous plants, Palms, Grasses, Sedges, &c.; the second, the *two-seed-lobed* or *Dicotyledons*, for examples of which, common garden plants and trees may be taken. The plants of the two series not only differ essentially in their apparently unimportant characters, but in all the rest of their organization, and are so strikingly distinct in their external appearance, that a little practice enables the eye to recognize them readily at the first glance. The first generally have the fibre-like wood-bundles scattered throughout the stem, as in the stem of the Maize; the second a closed, firm circle of wood like the Willow; in the leaves of the first, the veins are usually parallel as in the Grasses; the veins of the others ramify like the branches of a tree, and thus form an elegant net-work on the surface of the leaf, as in the Lime; finally, we find the number three frequently prevailing in the inflorescence of the former, as in the Tulip, while in the latter it is five, as in the Primrose. These two series proceed, step by step, parallel with one another, and what is about to be stated regarding the inflorescence, holds equally good in both. We have to learn what those elements are, the combination which, into a higher unity, is here the purpose of Nature. The first thing which she does is to enclose the seed-bud in the peculiar apparatus which we have above described as the pistil. Originally, the stamens and pistil have no essential relation to each other in reference to position. Each organ forms a blossom in itself. Then both are united, by the combination of a definite number of stamens, with one or more pistils. Next enter one, then more circles of foliaceous organs into this blossom, and thus form that which people commonly call a *flower*. These leaves acquire different forms, different colours, the structure of a portion of them becomes more delicate and they receive the names of *floral envelopes, calyx corolla*, &c. Finally, in the highest stage, Nature unites a number of separate flowers of this kind into one great, definite whole, in which she arranges them according to a strongly marked type, and surrounds and defines them with circles of leaves. These *compound flowers*, (as Linnæus called them,) characterize the Grasses in the first series, or *Monocotyledons;* in the second, or *Dicotyledons*, that family to which the Daisy, Dandelion, Thistle, Artichoke, and such plants belong, and which, on account of this peculiarity, is called the *compound-blossomed* family, or *Compositæ*. That which the maidens call the *flower* of corn, when they entwine it in their garlands, is, in fact, a whole company of small but perfect flowers. If we would recognize a series, in the progress from the simplest to the most complex, we must evidently regard the Grasses and *Compositæ* as holding the highest station in existing vegetation. Remarkably enough, also, precisely these two families, by their number of species and individuals, constitute the most peculiar characteristic components of the existing Flora, for, in the collective number of about 300 families of plants, the Grasses alone include one twentieth, the *Compositæ* a tenth, therefore both together almost one seventh of the whole number of species known.

I must be content that I have in the preceding sketch brought forward the principal points which, in the present condition of our science, constitute the most important features of morphological inquiry. That countless questions and considerations crowd upon us in the details, must be evident to any one who reflects. To those who have never been accustomed to look *through* the modes of external appearance into the essential internal connection of the variations of form, it will indeed seem paradoxical, to say that the globular, furrowed, fleshy Cactus, with its splendid blossom, is properly nothing but a tropical Gooseberry-bush;—that the Palm-like stem of the *Dracænas*, often thirty feet high, with mighty bunches of great Lily-flowers, belongs to exactly the same circle of forms and development as our plain-looking garden Asparagus;—that the wild Mallow, creeping over and adorning all the banks of our country lanes, is far more nearly allied to the old giant-stemmed Baobab, which has lived to six thousand years on the west coast of Africa, than to the wild Poppy growing beside it; and yet all this is undoubtedly true. Once more, then, to return to the principle above laid down, in organic life it is not the appearance of the *existing*, but the law of *becoming*, which decides between like and unlike, similar and dissimilar; and it is the idea of the course of development, which is the only fruitful thought in the scientific contemplation of life, and determines the value of the study; therefore stands Physiological higher than Systematic Botany, Comparative Anatomy higher than Descriptive Zoology, as History is nobler than Statistics.

Fifth Lecture.

ABOUT THE WEATHER.

Round earth and ocean,
Tempests rush and roar,
And weave a mighty chain
All nature o'er.

FAUST.

LECTURE V.

It has long been agreed in good society, that to talk about the weather is not good *ton*, that no topic can be so tiresome, and that it ought, therefore, to be left to sailors and bashful lovers. When now I enter upon a disquisition concerning the weather, I am quite ready to admit that my Lecture is likely enough to prove somewhat tedious; but I altogether deny that the weather is less talked about in the best society than elsewhere, and must distinctly declare that the weather is not a tedious subject. For what *is* tedious? Seldom or never the subject, but the manner in which it is treated. Can anything be more interesting to ladies (and it may be to some gentlemen) than the fashions? But a lady would think any one very tiresome who addressed her with such a remark as, "The fashions are very pretty now;" quite as tiresome, I think, as if he said, "The weather is very fine." It is very different, when in such conversation, noticing how well the chosen cap or bonnet suits the head, one passes to the head-dresses of different nations, to those of celebrated women, pointing out what influence climate, necessity, and national peculiarities have on the adoption of certain forms of apparel; how taste seizes on certain forms which have thus originated, alters them to suit its own purposes, and, in the end, caprice enters the field, and by its whimsical interference, calls forth the motley variety, which always pleases the eye, save where sated sense and depraved taste have produced manifest ugliness. The same holds good of the weather, and the more that nothing actually so deeply affects our bodily and mental life as this. Who can say his health is absolutely sound, when he thinks of the complicated nature of the vital processes? Need I point to the influences of the weather on those whose health is imperfect; how dependent all those affected with chronic diseases are for their comfort on the condition of the weather? Every one knows the old proverb, "Man is his own calendar;" the continually annoying sensations in a diseased joint, a wound, or the surface of an amputated limb, even when the individual is otherwise perfectly healthy, indicating the changes occurring in the weather. The nerves stretching out in all directions through the body, as so many feelers of the mind, often give us more accurate and earlier intelligence of the changes, than the eye which perceives the phenomena only after they have visibly commenced. And, on account of these very nerves, we cannot but believe that even healthy persons are always open to the influence of the weather. It may, indeed, be demanded of every man that he shall oppose these imperceptible operations by his will; that he shall not allow them any influence over his thoughts and labours; but whoever disowns this operation of the weather upon him, upon the feeling of pleasure or discomfort, upon health and strength, or dejection and debility, I must either accuse of insincerity or imperfect observation, or else set him down as a man of abnormally insensible nerves. Nay, perhaps there is a tone of mind for every shade of alteration in the weather, which may be discovered by its influence on the nerves, on those objects with which it is so continually in hostile contact. Our ancestors knew and named a "joy-month" (May), and in England, November is called "the month of fog, misanthropy, and suicide." It is a fact that most suicides happen there in this month. Frommond relates that when the south-wind blows, in the Azores, the inhabitants walk about with the head bent down, and even the children sit sad at home instead of playing in the streets. Sanctorius remarked that all men feel duller in damp, cloudy weather; and Unzer held that both the sick and healthy are always better when the barometer is high. So early as Hippocrates, we find it noticed that damp Springs are followed by violent epidemic fevers, and it is believed on all sea-coasts, that the greatest number of persons die when the moon is at 90^0 from its culmination, that is at the time of the ebb. I do not bring these matters forward in the belief that the facts themselves are all beyond doubt, but merely to show how generally diffused is the conviction that the well-being of man is dependant on the weather. When we are upon a high mountain, clouds, rain and all disturbances of the weather often lie far below us, and so may they who move foremost among men, the rulers of nations and the great stand, less interfered with by the changes of the weather; but in the lower regions, all the weal and woe of life hangs upon rain and sunshine. Let us go, for a moment, along with Le Sage's Asmodeus, and peep into the interior of the houses;—here abides the loving wife; she hastens joyfully to meet her husband on his return, and is sullenly repulsed; the little child runs rejoicing to his father, and, with dirty fingers, hangs to his clothes; a rude blow is his greeting; the man throws himself gloomily on his couch, and painful silence reigns in the chamber; in a word, where one looks for love and joy, ill-humour and melancholy are found, and why? The continued rain has ruined and washed away the hay-crop; the loss amounts to many hundreds of pounds.

And then, on a sunny autumn morning, a wife's face has rather an anxious expression; when in rushes the husband, embraces her, and says:—"A glorious year, a wine of ''11,' clear profit of 10,000 dollars; I have sold the whole. Rejoice with me, love!" and then he gives her the long-wished-for cashmere shawl; friends come to wish him joy, and, late in the night, the passers-by hear the sound of festivity within. It is the weather which here gladdens, and there troubled.

Lastly, let us ascend to a still higher point of view. The whole earth lies outspread beneath our feet. There we see an effeminate race; the despot revelling in every pleasure, the bonze all-powerful, the pariah oppressed and trodden down, superstition instead of faith, mere mechanical life instead of mind. Here, a mighty people, proud of their power; where, as the poet says, "liberty walks unhindered to the poorest huts, and scatters wealth over the favoured plains."

. . . . . Liberty abroad
Walks, unconfin'd, even to thy farthest cots,
And scatters plenty with unsparing hand.

THOMSON'S SEASONS.

There we see a nation whose mental development and culture surpasses all others, constantly occupied with the highest questions of humanity, and mostly fortunate in their solution, and among these reigns the mental life, almost forgetting the bodily and carelessly leaving the management of their affairs to a few; while under other latitudes the same race, degenerated through luxury, sunk in almost animal enjoyment of sensual delights, over which, as despotic lord it reigns, troubles itself not as to whether there is such a thing as a soul, to give it a higher claim to development and education.

Let us review, in one glance, the gay Tahitans, the dull Fuegians, the formal Chinese, the roving Bedouins, the child-like Hindoos, the manly English, the abstracted Germans, the material Yankees, and we find that all these, and the thousand other varieties of human nature are fundamentally dependant on, or promoted by the weather.

Is it possible then, that Man can longer forget this dependance? And this enormous power which prevails over body and mind, the life of the individual and the history of humanity, should it not be a worthy object of reflection—of conversation? But can we actually penetrate into this workshop of Nature, or is the object unworthy of much interest because we are condemned to remain always upon the surface? Holy Writ says:—"The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh and whither it goeth!"

I cannot, alas! wholly turn aside the reproof, that we naturalists do not receive very much from the Bible. But it is also quite possible, that for the very reason that we do not receive much, we comprehend that little which we do receive more clearly, more purely, and therefore more correctly than others; but this has nothing to do with our subject. I must of course confess, that so far as questions of natural science are concerned, we cannot look upon the Bible as any authority, and therefore believe that, in that passage, it addressed itself to a very circumscribed condition of humanity in an ignorant and uneducated century. We believe now, most certainly, that we know whence the wind comes and whither it goes.

It is next requisite that we should state more definitely what we understand by Weather. The chief point I have already mentioned. In our regions it is the wind which, changing according to its various directions, brings us clouds and sunshine, warmth and cold, rain and snow, calm and storm, and through all these, impresses upon the general character of the season the individual peculiarities which we call weather. All these different phenomena, and, above all, the wind, are merely alterations, various conditions of combination, rest and motion of the subtile matters which surround us, and which we name the atmosphere. When, in the clear night, we go out and look upward at the stars, our eyes perceive no boundary between us and those celestial fires. We, indeed, fancy that an invisible something surrounding us, must extend uninterruptedly to those shining worlds, the light of which appears to stream so unobstructedly upon us. But it is not so. If we could ascend to them, we should arrive at the limit of the atmosphere before we had left behind us a portion of our journey worth speaking of. The poets well name this the aërial ocean, and the adventurous mortals who fly through it, aërial navigators. It surrounds our globe as a thin fluid layer and shares its adventures. With it, it flies through the space of the universe, in its course round the sun; with it, in equal velocity, it turns from west to east around its axis. If it did not, if it moved more slowly than the earth, we who are chained to its surface and revolutions should necessarily be pressed upon by the air; it would seem to come against us like a hurricane—a fact which, as will subsequently be shown, is of great importance in the theory of the wind. I have called the air a fluid, and it is actually such. It flows from one place to another, and this very stream of air is what we name wind. But, it will be asked, where are these places into which it streams, for the air is evenly distributed; consequently, universal equilibrium must prevail, as in a vessel of water at rest. To elucidate this, I must describe somewhat closely one of the most important peculiarities of air. Heat, it is well known, expands the bodies into which it enters. An iron rod, measured at a red heat, is thicker and longer than when it is perfectly cold. The same holds good of air, it expands, and therefore becomes lighter, as is shown by the simplest kind of balloon, which, from its discoverer, is called a Montgolfier; this rises when the common air within it is heated by means of a strong flame placed beneath its open extremity. The air, thus become lighter, rises through the colder air, as oil rises through water, and swims upon it. If cold air lies upon an oblique surface, the warm air flows down over the cold, like water upon a mountain, apparently without mixing with it, when the difference of temperature is great enough.

But since warm air is thinner than cold, that is, because there is less air in an equal space when it is warm than when it is cold, the cold air flows into that space which is warmed, and, because it is heavier, comes to the bottom. If the door of a heated room is opened in very cold weather, the cold air flows in on the ground, and the warm air out above, as may easily be perceived by the motion of the flame of a candle held high up or low down in the door-way. In small things, this is the cause of the draughts so dreaded by the delicate female sex, and even by some delicate gentlemen. In greater matters, it is the cause of that which the mariner, according to circumstances, prays and whistles for, or curses—wind and storm. I shall indeed be answered, that we are none the wiser for this. For when the vernal storm bellows around the bare summit of the Brocken, and whirls the snow up in showery drifts, so that the blinded wanderer, already within a hundred paces of the hospitable house, strays from the path and becomes the prey of death,—the question still remains, where here is the heated room and the opened door? And after all, the old saying is still true, that he is a wise man who always knows which way the wind blows. I will venture, nevertheless, to point out, that it is by no means so difficult a matter, since the said proverb assumes, that as many winds blow over the earth as there are points on the compass, while in fact, there are really only two winds.

Meanwhile, before I pass to the explanation of this seemingly strange assertion, I must make mention of another property of the air, not less important in relation to the phenomena which constitute what we call the weather. I allude to a fact well known to every one. When a glass, quite dry, but very cold, is brought into a warm room, it becomes dim, as we say, that is, it becomes suddenly covered with minute drops of water, and this water is so much the more abundantly deposited, the greater the difference between the temperature of the room and that of the glass. Whence comes this water? Certainly not out of the glass, for this was previously dried, but out of the air of the room. The reason why this previously invisible, aëriform water appears suddenly in the form of little visible drops, lies in the difference of the temperature of the air of the chamber in general, and that of the air cooled by contact with the cold glass; and thereby is indicated the law, that the warmer air is, the more invisible water it can contain. This is the cause of the formation of clouds, rain, snow and similar phenomena of our globe.

The consideration of these two points, the cause of the wind and formation of the watery precipitate of the atmosphere, leads us to a force upon which both phenomena are dependent, namely, heat. Seeking the general source of this, we come to the sun. This is the mover of all upon the earth, and, in a wonderfully simple manner, it maintains a constant circulation of matter, through which alone the life of organic existence, of plants and animals, is rendered possible. The Emperor Aurelian said, that among all the gods which the universal ruler, Rome, had borrowed from the vanquished and gathered together, he had found none truly worthy of adoration but the sun; and among all the forms of heathenism, certainly that is the most elevated form of worship which the Parsee offers, waiting in the early morning on the sea-shore, till the first rays of the sun dart over the shining waves, to prostrate himself before them, and in silent prayer, to greet the return of the all-vivifying and all-producing.

Unhappily, the decision of the Bible, which asserts an equal distribution of the heavenly gifts on all mankind ("The Lord maketh it to rain over righteous and unrighteous") is again wrong, and man has, according to his place of abode, a very different share of the warming and vivifying influence of the sun. It distributes its blessings in greatest abundance only where its rays fall perpendicularly upon the earth, and this, on account of the position of the globular earth in relation to the sun, only happens in a narrow zone on each side of the equator, together only forming a quarter of the length between the north and south poles. From this girdle, its action diminishes so rapidly, that at about 70 degrees of north and south latitude, it can only thaw the frozen earth to a depth of a few feet, and at 80 degrees the surface is stark with unmelted ice throughout the height of summer. The equator itself lies beneath the vertical rays of the sun twice a year, at the two equinoxes; and the same holds good of all the places within the equatorial zone, but in such a manner, that the periods are always approaching together till they fall coincident under the tropics, which are only warmed by the vertical rays of the sun once in the year, namely, the tropic of Cancer at the time of our longest day, and the tropic of Capricorn on our shortest day.

When the vessel on its voyage to the South approaches the equator in the midst of the Atlantic Ocean, anxious fear seizes the whole crew. Sooner or later, according to the time of year, the favouring wind which had brought them thus far, becomes weaker and weaker; at first it ceases for a little while, and at last drops entirely. Around extends the sea, an endless glassy surface. The ship, hitherto speeding onward with a bird-like flight, lies bound on the crystal fluid. The rays of the sun, falling perpendicularly, glow through and through the narrow space in which the men are enclosed. The deck burns through the soles of the shoes. A stifling vapour fills the cabins. A fortnight has the ruler of the sea lain immoveable in the same spot. The store of water is exhausted. Glowing thirst glues the parched tongue to the palate. Each man looks upon his companions in suffering with the wild, murderous glance of despair.

The sun sinks below the horizon, the evening sky is illumined by a peculiar coppery redness; and with the advancing night, arises a black wall to the eastward; a low, shrill pipe resounds from the distance, from whence a streak of foam advances over the black ocean. The ship sways and rocks upon the irregular waves, but the sail still hangs against the mast, flapping dismally upon the spars. Suddenly the storm bursts over with frightful roar:—with a shriek, the sails are torn asunder and fly in ribbons!—a loud crack! a second, and the mainmast goes overboard! By a violent effort the crew succeed in cutting through the remaining ropes, and the ship now flies over the ocean—now borne high upon the backs of the waves—now hurled down into the depths; so that every seam creaks and groans as though it would part asunder. The thunder rolls unceasingly, continuous lightning darts through the agitated atmosphere; the rain falls in streams instead of drops. Ten times the sailors give themselves up for lost, when the quaking barque falls into the trough of the sea, and as many times does it rise over the waves again. At last the storm lulls; single shocks follow, always at longer intervals; the waves become smoother, and when the consoling sun rises in the east, it illuminates the same dreary picture as on the former day. Mirror-like the endless surface again expands, and in eight days is the store of collected water exhausted; and again the silent spectres creep about and turn murderous looks upon each other. A new storm, a new calm, and so on in frightful alternation, till at last the ship is driven into the region of the peaceful trade-wind on the other side of the equator. Hundreds of ships have gone down in storms here; hundreds lost their crews by the most frightful of deaths, that from thirst; and those who have passed the fearful region of calms, turn in earnest worship to Heaven with thanks for their new-won life.

In the German legends, we read of a cavern, in which the Dame Holle sits and brews the weather. That region of calms and storms, is an actual Dame Holle's Hole. The weather of the whole world is manufactured there.

The sun, which comes twice a year to be directly over this region, never goes far enough away from it to allow of any cooling; and the atmosphere is here so much heated, that it becomes thinner and *lighter*, and, therefore, is always rushing upward in a continuous stream *(courant ascendant)*. At the same time, an incalculable quantity of water is evaporated from the vast surfaces of the Atlantic and Pacific Oceans, diffusing itself through the warm air, and rising with it. But in proportion as the air rises higher from the earth, it becomes cooled, the temperature often falling many degrees quite suddenly, and then a large portion of the water taken up becomes suddenly precipitated in the form of drops; by this are caused great alterations in the electrical condition of the atmosphere, and thus arise those frightful storms so rapidly coming and going in that region, where in general there is perfect absence of wind, on account of the continual *ascent* of the air.

Matters are differently arranged at the two borders of this zone. The air, which is continually rising because of the heat, leaves a space behind which contains only extremely rarefied air; and into this space the cold air from north and south incessantly flows with great force and constancy. This is one of the winds of the earth, and as it flows from the poles to the equator, we will call it the Polar current. In the northern hemisphere, it is of course a north wind; in the southern, a south wind. We must bear in mind, however, that this current or wind is only a portion of the atmosphere in motion, and this is bound wholly to the earth and its destiny, revolving with it, as has already been mentioned, round the axis from west to east. Now, this revolution, as a glance at the globe shows, takes place with different velocities in different places. While the air at the poles only turns upon itself, without progressing forward, the air at the equator speeds on through more than 1,000 miles in an hour. Then, if we imagine the air from the pole to be suddenly removed to the equator, some time must elapse before it could acquire the same velocity of motion from west to east which is possessed by the air always there; it would remain behind, therefore, the earth gliding away, as it were, from beneath it, or in other words, it would have the appearance, in going from east to west, of an east wind. Applying this to the Polar currents, we see that the longer they blow, the nearer they approach the equator, the more must they appear as north-east and south-east winds. In reality, there is a region on each side of the region of calms and storms, in which, year after year, there blows in the northern an east-north-east, in the southern an east-south-east wind, which all sailors know by the name of the trade-winds.

I have now only to mention that the polar air is heavier, colder, and drier; that, therefore, in the north, north-east, and east winds, (they are all one wind), the barometer rises, the thermometer sinks and the sky becomes clearer: and thus all the essential peculiarities of one principal wind, the Polar current, have been named.

We must now inquire farther about the fate of the heated air, which forms the constantly ascending stream in the tropics. The higher it rises, the cooler it becomes, and consequently the heavier, so that it begins to sink; but since the heavy, cold Polar current forms, as it were, a firm floor underneath, it flows away over this layer of air towards the poles, and thus forms the second great wind prevailing over the earth, which, from its origin, is called the Equatorial current. To us, it comes as a south wind; in the southern hemisphere it is, of course, the north wind. But just as the Polar current, in its progress towards the equator, becomes gradually changed into an east wind, from the same cause, the stream of air flowing from the equator to the poles, diverted in the opposite direction, becomes gradually a west wind. The Equatorial currents naturally possess directly opposite peculiarities to the Polar currents, being lighter, warmer and moister; they cause the fall of the barometer, the ascent of the thermometer, and give rise to the formation of clouds, rain and snow. By these two streams in conjunction, a continual circulation of the whole atmosphere is maintained, rendering it impossible that any local influence should anywhere cause a complete consumption of those substances, in the atmosphere, necessary to life—oxygen and nitrogen; or that the noxious one, carbonic acid, should accumulate in excess. Thus is the existence of all living nature dependent on this circulation.

At the first glance, the simple and grand features of the fundamental laws of atmospheric changes, as I have endeavoured to sketch them, do not seem to agree at all with what appears to us the capricious variation of the weather, which in virtue of that very character, is taken as the type of changeableness and inconstancy. The following may, perhaps, explain this apparent contradiction. The surface of the earth may be divided into two unequal portions, according to their meteorological phenomena:

into the region of constant weather, and the region of the changeable. So far as the influence of the trade-winds extends on each side of the tropical region, the weather may be prophecied, almost to the day and hour, many years beforehand. The median zone (from 2° — 4° N. L.), is that in which nocturnal showers and storms alternate with excessive heat and calms, without interruption, throughout the whole year. On either side, towards north and south, follows a zone (from 4° — 10° N. L.), wherein such phenomena only occur in the summer; in the winter the trade-wind causes a rainless sky. Next comes a zone (from 10° — 20° N. L.) in which the incessant trade-winds allow no bedimming of the eternal blue of heaven, and often years pass, without one short, rapidly passing shower moistening the parched earth. Finally, one more zone extends north and south from 20°—30° N. L.), the boundaries of the constant weather, in which the trade-winds cause a rainless summer, while the winter brings a warm but not quite constant rain. The approximative statement of the latitude relates only to the northern hemisphere and the Atlantic Ocean, the only place whereof we possess sufficiently accurate observations. To these follow a zone about 24° broad, in which a constant struggle between the Polar currents with the returning Equatorial currents, produces a most changeable climate, which appears to us so capricious and accidental, because the circumstances determining the prevalence of the one or other current in a particular locality, are so complicated, that we have not yet been able to deduce the law of the changes from the various observations. Looking somewhat closely into the matter we find the following facts. According to the statements already made, there are but two wind-currents upon the earth, that blowing from the poles to the equator, and that returning to the poles. Let us imagine a place in the region of what I have called the changeable weather, say in Germany, and let us assume that this spot lies directly in the direction of the Polar current. A north wind blows, the air is cold, the sky serene and remaining so while the wind gradually changes, and at last appears as a true east wind, the dry, highly oxygenated Polar air of which is so perilous to those whose lungs are affected. This wind blows until another replaces it, and this is none other than the Equatorial current which always begins as a south wind, and the meeting of this with the east produces the south-east wind, having an intermediate direction; in this the moist, warm air of the Equatorial current is cooled down by the cold Polar current, and constrained to deposit part of the water it contains in the form of clouds, snow or rain. Gradually the Equatorial current acquires the mastery; in the south wind it becomes warm and bright and so remains till the Equatorial current gradually diverges round to the west. The northern Polar current alone can take its place at a change, and the mixture of this with the moist air in the north-west wind, again gives rise to abundant atmospheric precipitation. These are the cold, damp days in which those persons suffer so much who have nervous complaints.

Thus it goes on, in the same order, which is now first scientifically enounced from the long known facts, in that which Dove has named the law of the circulation of the wind, and we can now prophecy the weather with great certainty even in these regions, only not for defined periods of time, since we are ignorant of the circumstances regulating the duration of one or other current in their strifes in the south-east or north-west quadrants.

It is remarkable enough, that this changeable zone, which might be imagined to be the least favourable to the development of the human race, includes almost all middle Asia, the northern coast of Africa, Europe and North America, consequently the whole arena in which the history of humanity and its spiritual unfolding is acted out. Perhaps this phenomenon may be connected with the fact that in this region such a peculiar influence is exerted on the development of the vegetable world, that without the aid of human activity, it cannot produce a sufficient amount of nourishment for any considerable number of men ; and thus, even for the satisfaction of the first and most pressing necessity, calls upon man for mental effort. Beyond this region, in the neighbourhood of the poles, the climate appears again subject to simpler laws; but from causes easily conceived, we are still in want of sufficient observations in those places, to enable us to speak of them with certainty.

Having thus, on the one hand, roughly sketched out the distribution of the weather on the earth, and found the simple laws which cause its variations, we must not, on the other side, forget that this regular distribution would only hold good for an earth, the surface of which was every where uniform, which was either wholly covered with water or clothed with a smooth, even layer of earth. But this is not the case here; and the distinctions between sea and land, plain and mountain, bare sandy deserts and densely-wooded tracts, &c., cause so many interruptions in the action of those simple laws, that it was long before the simple basis was perceived through the complicated conditions which had been enumerated. Alexander von Humboldt it was, who thus became the discoverer of scientific Meteorology, and Dove he who, with eminent talent, first developed the system on all its sides.

The peculiar distribution of land and water upon the globe, is one of the most important influences which essentially modify the simple regularity of the distribution of the weather. Land, when exposed to the rays of the sun, becomes warm much more rapidly, and acquires a far higher temperature than water, which, however, once warmed, for the same reason cools the more slowly. The immediate consequence of this is, that the hottest zone, the region of the calms, is not divided into two equal parts by the equator, but on account of the greater quantity of land in the northern half, lies wholly on this side. This projection towards the north is most striking in the Indian Ocean, where the north-east trade-wind blows in winter, but in summer is wholly supplanted and replaced by the overpowering south-east trade-wind. But on account of the revolution of the earth, this must deviate to the west so soon as it passes the equator, and thus the two trade-winds are here formed, the north-east and south-west winds, regularly alternating every six months, which are called by sailors the monsoons. To us Europeans, however, it is a fact of greater importance and interest, that by the great Sahara so intensely heated by the sun, the region of calms, and therefore that of the Polar current or trade-wind, is pushed farther northward into the south of Europe; so that the returning, warm Equatorial current does not reach the ground nearly so far south as is the case in Asia and America; or when it descends early, as the *Sirocco* in Italy, or as the *Föhn* in Switzerland, it is much hotter than elsewhere. It is principally on this account, that Europe has a mild climate so much farther toward the pole, than any other place in the same latitude. While Rye is still cultivated in Ranenfiord in Norway, the same latitude of North America is bound in snow and ice almost throughout the whole summer. While Wheat yet grows at Drontheim, at Hudson's Bay, in the same latitude, no human settlements are possible; and in Siberia, under the same parallel, the soil is scarcely thawed two feet deep in the height of summer. Drontheim has pretty nearly the temperature of Canada, which lies further south than Paris. In New York, which is in the same latitude with Naples, the trees begin to blossom at the same time as in Upsala. Spitzbergen has a kind of short summer, while, on a warm summer's day in Melville's Island, three degrees more south, the thermometer is at zero of Fahrenheit.

The circumstance in question, however, is not the only one which Europe has to thank for this pre-eminence. There is yet another force, which takes, and by no means an inconsiderable, part in the distribution of heat, and therefore of the weather, on the globe. I allude to the currents of water in the great Oceans. The elevation of the temperature by the equatorial sun, produces exactly similar phenomena here to those in the aërial ocean; here two Polar currents are caused, which carry the cold water to the line, and returning Equatorial currents, which bring back the warmer water to the poles. These currents, enclosed in beds of firm land, hindered or assisted in their course by submarine mountain-chains, are naturally much more diverted from the regularity which they should follow from the producing principle, than the unfettered air-currents, which often rush over the summits of the highest mountains. One of these returning Equatorial currents, the water of which is, as it were, heated in a kettle in the Gulf of Mexico, flows in a north-easterly direction straight to the west coast of Europe, and brings hither the warmth which it has acquired on the coast of

Tampico and Vera Cruz. This is the Gulf-stream, which carries vessels with the speed of more than six miles an hour from the rock-bound Cape Hatteras to the stormy Bay of Biscay, and drifts the products of the West India Islands even to the coast of Ireland.

Another consequence of the unequal warming of land and sea, is a phenomenon which all coasts exhibit, namely, during the day a strong breeze blows from the cooler sea to the heated land, a "land-wind;" in the evening, in the so-called "sea-wind," a current arises from the rapidly cooling land towards the sea, which retains the heat longer. In the evening the mariner leaves the safe harbour, those departing find consolation in the arms of sleep; in the morning the sailor steers for port, and he whose home again greets him after a lengthened absence, sees it in the glance of the rising sun.

It would lead me too far here, were I to attempt to unfold all the circumstances which act in concert, to impress upon the simple regular progress of meteorological phenomena, the countless minor deviations which give the local character to the climate of every spot. But I must mention, if I cannot thoroughly explain, one other of the most important phenomena connected with the regulation of the weather.

We have seen that heat and its varied distribution according to latitude and longitude, height and depth, is the peculiar fundamental phenomenon, around which the others group themselves, upon which they are dependant. Most intimately is the degree of moisture of the air connected with it, and warmth and moisture are the primary conditions of all vegetable life. On those two principal forces, therefore, hangs almost entirely the distribution of plants over the earth. The animal world follows the plants, since the vegetable feeders are directly, the Carnivora indirectly connected with determinate formations of plants. So that heat and cold are not the only consequences of the position of the sun in regard to the earth, but also the whole life existent thereon: the action of its mightiest forces in the raging hurricane, which hurls four-and-twenty pounders through the air,* to the invisible labour of the most minute Infusorium; the roar of the Chilian Pine, and the low whisper of the northern Birch, from the roar of the lion, the slayer of the gazelle, even to the pipe of the mouse-hunting screech owl, whose discordant note the awakened sleeper's superstition interprets as "*komm mit, komm mit*" (come with me.) The fox and tiger point to the barn-door fowl and the giraffe, these to Barley fields and Acacia groves, these again to the corresponding zones of Europe and to the glowing savannahs of Africa. On the sun depend not only vitality and motion, but also the first arrangement, and its shining rays are the pencils with which it paints the light and shade, the glowing yellow of the arid sand, the cool green of the moist meadow, with which it lays down the geography of plants and animals upon the surface of the earth, and even sketches the design of an ethnographic chart of the human race.

And when we look beneath into the internal connection—when we perceive that all the elements prevailing over the rest, perhaps nowhere appear so irregular and abnormal as in our Europe, while a part of the tropical regions intelligibly expresses every fundamental law, when we thus find the thing which causes

* Report of General Baudrand on the hurricane at Guadaloupe, on the 25th of July, 1825.

the progress of all studies, the understanding of Nature, is scarcely possible except in foreign regions, we gain the explanation of another phenomenon in the history of Mankind, which at first appears enigmatical and inexplicable, namely, the fact that in every study having the most remote connexion with Natural Science, and particularly in this itself, all progress is most intimately dependant on the extension of our geographical knowledge, that the Naturalist though constantly encompassed by one Nature, knows no higher enjoyment than travel, that he often even with mistaken contempt for that which his own neighbourhood affords, grasps at exotic treasures, that hot-houses and herbaria have become indispensible to the Botanist, and Zoological gardens and collections to the Zoologist.

Had I wished to give a more adequate representation, I could but trace out a hasty sketch of the great picture teeming with life; let me hope that I have succeeded at least in making out the principal features with sufficient clearness and distinctness. In any case, I have so managed matters, that if the question be asked, "Was it interesting?" the answer will be, with a shrug, "Well now, he talked of nothing but the Weather."

Sixth Lecture.

WHAT DOES MAN LIVE UPON?

FIRST REPLY.

"The fool, indeed, nought earthly eats nor drinks."

FAUST.

LECTURE VI.

When we ask the student why he broods over the most abstract problems in his solitary chamber, far from all the enjoyments of life—the soldier why he has allowed himself to be subjected to the toil and dust of the hard recruit school—the bustling merchant, to what purpose he early and late strives to equalize demand and supply over the earth by his activity—nay, even when we inquire of the criminal the cause which led him boldly to dare a shameful death, we receive *one* answer from all, which though clothed in the particular language of each, is ever essentially the same: "What can we do? we cannot help it; a man cannot live upon air." This answer appears to every one to afford an explanation; and even the stern judge is so convinced of the validity of this plea, that he allows hunger to be a good ground for showing mercy in certain cases.

But then comes the Naturalist, an impracticable kind of man, who will recognize no authority, and who believes in nothing but what he can grasp in his hand, and says, "You foolish people, man can very well live upon air; nay, in point of fact, he does live on air alone, and nothing else whatever." This seems a very presumptuous speech to the Theologian; he reminds us angrily: "Man, bethink thyself of thine end; from dust thou camest, and to dust must again return." "What nonsense!" cries the Naturalist with a laugh; "that were a strange metamorphosis of matter! Out of air we were created, and at our dissolution we shall return unto it." This vexes the moralist, and he thinks that the reproachful term of "windy boaster" is once more to be proposed as the general title of honour of mankind. The Naturalist now pauses. At bottom it is by no means his wish to affront all these good gentlemen. However, the paradox has been uttered, and he must see how he can make it good.

What do men really live upon? The answers will be various enough. The Gaucho who in the wide Pampas of Buenos Ayres, managing his half-wild horse with incredible dexterity, throws the lasso or bolas to catch the Ostrich, the Guanaco, or the Wild-bull, consumes daily from ten to twelve pounds of meat, and regards it as a high feast-day, when in any hacienda he gains a variety in the shape of a morsel of pumpkin. The word bread does not exist in his vocabulary. The Irishman, on the other hand, regales himself in careless mirth on his "potatoes and point," after a day of painful labour—he who cannot help making a joke even of the name he gives to his scanty meal. Meat is a strange idea to him, and he is happy indeed, if four times a year he can add a herring to season the mealy tubers. The hunter of the Prairies lays low the Buffalo with sure bullet; and its juicy, fat-streaked hump, roasted between two hot stones, is to him the greatest of delicacies. Meanwhile, the industrious Chinese carries to market his carefully fattened Rats, delicately arranged upon white sticks, certain to find a good customer among the epicures of Pekin; and in his hot, smoky hut, fast buried beneath the snow and ice, the Greenlander consumes his fat, which he has just carved, rejoicing over the costly prize, from a stranded Whale. Here the black slave sucks the Sugar-cane and eats his Banana, there the African merchant fills his wallet with sweet Dates, his sole sustenance in the long desert journey; and there the Siamese crams himself with a quantity of Rice, from which an European would shrink appalled. And wheresoever over the whole inhabited earth we approach and demand hospitality, in almost every little spot a different kind of food is set before us, and the "daily bread" offered in another form.

But, we may ask, is Man then really so versatile a being, that he can build the visible house of his spirit, in the same way, out of the most varied materials? Or do all those so varied kinds of nourishment contain one or a few similar matters, which peculiarly serve for the food of mankind? The latter is actually the fact of the matter.

> "Four elements
> In one firm band,
> Give form to life,
> Build sea and land."
>
> SCHILLER.

The whole of that by which we are surrounded, is composed of a very few, somewhere about fifty-three, elementary substances, which have been gradually discovered by chemists. But among these there are four especial ones, which alone take an essential share in the composition of all that which we call organic or living existence. Nitrogen and oxygen form the two most important constituents of pure atmospheric air; oxygen and hydrogen are the two elements by the combination of which water is produced; carbon and oxygen, by their combination in carbonic acid (fixed air), render the Grotto del Cane, at Naples, and the vapour caverns in Pyrmont, torture-chambers for the poor dogs; lastly, nitrogen and hydrogen unite to form ammonia, the volatile alkali, a kind of air which streams forth in enormous quantity from those chimneys of subterranean fires—the volcanoes. Here we have the four elements, carbon, hydrogen, oxygen and nitrogen, which, in combination, form all those substances of which plants and animals are composed; hydrogen, oxygen, and nitrogen, being airs or gases, carbon a solid substance, which in its crystalline form we call diamond.* At the same time, too, we here mention the most important and most generally diffused compounds of these elements, namely, the usually fluid water, which, however, is contained in large quantity by the air, in the form of vapour; also carbonic acid and ammonia, both of which occur as gases in the atmosphere. On the examination of these three compounds of these four elements turns the whole study of vegetable and animal life.

Our atmosphere is a mixture of about $\frac{4}{5}$ of nitrogen with $\frac{1}{5}$ of oxygen, to which are added about $\frac{1}{2000}$ part of carbonic acid, and a yet undetermined quantity of ammonia. Since we have, through Priestley, come to know oxygen, and to comprehend its importance to respiration, we believe that we are able to ascertain the goodness of air by determining the quantity of oxygen it contains. A peculiar science, Eudiometry, has thus originated, which chiefly concerns itself with the estimation of the relation of oxygen and nitrogen in air; the methods have gradually acquired greater clearness and accuracy, and by these means it has

* See Dumas and Boussingault, "The Chemical and Physiological Balance of Organic Nature," 12mo. London, 1844.

been discovered, that even to its thousandth parts, the air, wheresoever it has been examined, has always the same composition.

But conclusions relating to the vital processes of plants and animals have been very hastily deduced from this constant composition of the atmosphere. Our atmosphere, according to Poggendorf's estimate, contains about 1,954,578 cubic geographical miles of oxygen, while the respiration of man and animals, together with the various processes of combustion, consume annually about 2½ cubic miles; consequently 250 cubic miles in a hundred years, or only nearly a ten-thousandth part. Our instruments, however, would not mark a diminution of so small an extent, even were they ever so accurately constructed, and carefully used for centuries. Our methods of determining the amount of carbonic acid in the air admit of far greater accuracy, and a much more certain estimate has thus been obtained, applicable, as will subsequently be seen, to the same deductions. In respiration, for every cubic inch of oxygen he inspires, a man expires a cubic inch of carbonic acid, and exactly the same exchange occurs in processes of combustion. According to this assumption, about 12,500 cubic geographical miles of carbonic acid have been breathed out into the air in the course of five thousand years, leaving out of the question the vast quantity which yearly streams forth out of volcanoes. The carbonic acid in the air, therefore, should be in proportion to oxygen as 1 to 155, while in reality, it amounts to but one-fourth per cent. It is clear from this, that some process must exist by which the carbonic acid is extracted from the air, and brought into some other combination.

Oxygen has the property of combining readily with other substances, especially with carbon and hydrogen; a process which chemists call combustion, even though it is not always accompanied by the production of light, but in which a quantity of heat, bearing a definite proportion to the amount of oxygen consumed, is always liberated. Nitrogen, on the other hand, has but small affinity for the other substances; it is scarcely combustible, but readily unites with hydrogen to form ammonia.

The four elements under consideration form numerous compounds by their union one with another; but only two classes of these have a very deep importance in relation to the organic world. One of the classes comprehends the substances which are compounded of all four elements. This includes albumen, fibrine, caseine, and gelatine. All animal bodies are formed out of these substances, which when separated from them as dead matter, all pass rapidly by decomposition into water, ammonia, and carbonic acid, which are diffused through the air. The second class, on the other hand, includes the substances devoid of nitrogen, namely gum, sugar, starch, the liquors prepared from them, such as spirit, wine, beer, and, lastly, all the various kinds of fat.* All these merely pass through the animal body, since the carbon and hydrogen are burnt off by means of the oxygen received in respiration, and are expired as carbonic acid and water. By this slow but uninterrupted process of combustion is maintained the heat indispensible to life. But by the recent brilliant discoveries in chemistry and physiology, we have become aware that the animal body is incapable of composing from their elements, or of forming from any other substance excepting caseine, the substances, albumen, fibrine, &c., absolutely necessary to its development and support; that the animal must indeed receive substances ready prepared, in order to apply them to its nutrition, or to convert them into gelatine for the

* See Mitchell's "Treatise on the Adulterations of Food, and the Chemical means to detect them," 12mo. London, 1848.

formation of its bony structures. Albumen, fibrine and caseine, are therefore rightly named by Liebig the exclusive *materials for nutrition*; they cannot be replaced by any other substance; when they are entirely withheld, the body must necessarily die of starvation. But the components devoid of nitrogen must also be present, as it were for fuel on the hearth of organic life; and these substances, which are in common life also called food, Liebig appropriately denominates *materials for respiration*. Comparing these requisitions, which the animal body makes in behalf of its maintenance, with the contents of plants which serve for the food of man and animals, we find in all plants, in all their organs, a certain amount of albumen dissolved in the juices. In the inestimable gifts of Ceres, in the seeds of the various kinds of grain, there always occurs more or less of a substance which was formerly called gluten. Liebig* and Mulder have pointed out that this resembles a mixture of gelatine and animal fibrine. The earlier chemists discovered in the Pulses a substance, which from the family in which it was found, the *Leguminosæ*, was called legumine. We now know, from more recent researches, that this is in no way different from animal caseine. Legumine and gluten, or caseine and fibrine, possibly occur in small quantity in the cells of all plants.

The second class, the substances devoid of nitrogen, or materials for respiration, are no less widely distributed throughout the vegetable world. When we review all the nutritive substances which mankind obtains from the vegetable kingdom, we find three groups, the first of which is remarkable for the great quantity of starch contained in the plants composing it. To this group belong the Cereals and Pulses, the

* See Liebig, "Chemistry and Physics in relation to Physiology and Pathology," 8vo. London, 1847.

tuberous vegetables, Potatoes, Sow-breads, Mandioc, Yams, and Tara *(Colocasia ?)*, and lastly, the parenchymatous stems of the Cycadeæ and Palms, which furnish Sago. The second group includes the fruits rich in sugar and gum, which owe their peculiar cooling properties to malic, citric and tartaric acids, and their delicious flavours to the presence of a small quantity of an aromatic substance; in addition to our well-known fruits, appear especially the Date, the Banana, and the Bread-fruit, the Sugar-cane, with its juicy stem, and lastly, the saccharine and gummy, fleshy roots, which constitute so large a proportion of our kitchen vegetables. Finally, the third class consists of the oleaginous kernels of various fruits; the Cocoa-nut, the nut of the Chilian Pine, the Brazil-nut, and the many kinds of nut or almond which in Europe pay their tribute, either to hunger or the satisfaction of the palate. Neither must we here forget to enumerate the many beverages, which are almost all derived from the vegetable kingdom. The European cultivates the Vine wherever the climatal conditions do not render it impossible. Cyder, Beer and ardent Spirits are widely distributed. A peculiar problem, indeed, is presented to the psychologist in the remarkable circumstance, that wheresoever the human race is found, in the highest condition of civilization as in the first dawnings of culture (with the exception, perhaps, of some few races, almost more like animals than men), the custom ever exists, of transporting themselves by various means into a higher condition of mental activity, which in its excessive and evil phenomena is called drunkenness. The Maguey-wine, or Pulque, of the Mexicans, the Palm-wine of the Chilians, the beverage prepared from Maize by the inhabitants of the countries of the Orinoco and Amazon, lastly, the Kumiss of the Tartars, prepared from the milk of mares, all so far resemble our drinks, that in all, the intoxicating principle is spirit produced by the fermentation of sugar or starch.* The action of the Cocca, the leaf of an American tree (*Erythroxylon coca*) is altogether unknown. The greatest enjoyment of the Peruvian "*muletero*" consists in chewing these leaves and thereby producing a dreamy stupor, in which, without being drunk, but merely in a state of agreeable lassitude, he passes the whole day in inaction. The use of the *Amanita muscaria* by the inhabitants of northern Siberia, the smoking of Opium by the southern Asiatics, of the Hashish, or Hemp-extract, by the northern and southern Africans, and lastly, the drink which the South Sea Islanders prepare from a particular kind of Pepper (*Piper methysticum*), are actual narcotic poisonings, which by frequent repetition, very quickly cause the destruction of the physical frame. With all these means of increasing (and at first with agreeable results), the activity of the mind, and especially of the imagination, by influence upon the body, war was very recently declared by two individuals, with, however, very different results. One fought with material weapons and was vanquished, namely, the Emperor of China; the other gained a victory every day by the power of the mind; I mean the dauntless Apostle of Temperance, the pious Father Mathew. The latter has allowed, in compensation for the renunciation he demands, another drink, which we have borrowed from the Chinese. Whether this beverage, Tea, is actually a harmless substitute, it perhaps remains for more accurate investigations than have hitherto been made to determine, and these I cannot pause to consider here. But I cannot refrain from calling attention in this place to a most interesting and as yet unsolved physiological problem.

Treatise on the Adulteration of Food."

In the year 1554 a violent tumult arose in Constantinople; the chiefs of the priests attacked the Sultan and threatened him with all the terrors which their office placed at their command, the reason being the brilliant success of the first coffee-houses, which were in that year opened. These were crowded all day, while the mosques were almost deserted. The Sultan relieved himself from the difficulty by the means most profitable to himself; he laid a heavy tax upon the coffee-houses, and thus, quieting the Muftis, obtained a considerable revenue; for in spite of this, the use of coffee spread with wonderful rapidity over Europe. In 1652, the Greek, Pasqua, opened the first London coffee-house in George Yard, Lombard Street, (according to McCulloch, in St. Michael's Alley, Cornhill, in the place where the Virginia coffee-house lately stood); and in 1671, the first in Marseilles was established. The present production is probably about 250,000 tons, while a hundred and fifty years ago, it scarcely exceeded 5,000. In 1820, A. von Humboldt estimated the consumption in Europe at 75,000 tons, valued at £4,500,000; while the value of the present consumption of 125,000 tons, does not perhaps reach £3,700,000. Whence came this custom of drinking Coffee? Who discovered the precious substance? We know not. We find the most trustworthy account in the work of the Scheikh Abd-Alkader-Ebn-Mohammed, dated in the year 1566, which has been published by Sylvestre de Sacy in his "Chrestomathie Arabe," and which bears the title of: "The Prop of Innocence, in reference to the lawfulness of Coffee."

According to this account, the very learned and pious Scheikh Djemal-eddin-Ebn-Abou-Alfaggar introduced the drinking of Coffee in the beginning of the fifteenth century, into Aden, the city which has in recent times acquired such great political importance, and from thence it soon spread to Mecca and Medina. He himself became acquainted with this beverage in Abyssinia, where it had been known from time immemorial. The common notion, therefore, that Coffee was originally indigenous in Arabia, is altogether incorrect. At that time, a decoction of the roasted shells was as often drunk as that of what from the Arabian word *Bounn* are called the *Beans.* The beverage was in both cases called *Kahwa.* Wise men, like, for instance, Tadjeddin-Ebn-Jacoub, even at that time, recommended cold water to be drunk with the Coffee, to prevent the sleeplessness resulting from its use. But this was in direct opposition to the cause of the introduction of Coffee. It was used by those who wished to keep themselves awake during the holy nights of prayer. The Coffee was originally drawn from a large brown vessel into small cups, which were handed round, more particularly during religious services, and this affords a ready explanation of why this beverage immediately became, to some of the orthodox Mahometans an object of enmity, and above all, a subject for exceedingly learned theological researches. The opposers of Coffee went even so far as to affirm that the countenances of those who drank Coffee, would, on the day of resurrection, appear blacker than the Coffee-grounds. Since, however according to the Koran, women do not enter Paradise, they may indulge without fear in the enjoyment of their favourite beverage.

According to the other accounts published by Abd-Alkader-Ebn-Mohammed, it appears also that the custom of Coffee-drinking goes back beyond the time of historical record in Abyssinia, and that in Arabia even, Coffee only supplanted a drink of similar properties, the Cafta, made from the leaves of the Cat (*Celastrus edulis*, Forsk)., the use of which they also inherited from their ancestors, without any account of its origin.

When the Spaniards first landed in Mexico, they became acquainted with a native beverage, which had been used from time immemorial, called by the natives *Chocollatl*, and prepared from the seeds of a tree, which they named *Cacahoaquahuitl* (Cacao-tree). Wherever the Spanish dominion has subsequently extended to, there also has the use of Chocolate reached, and the rest of Europe has asserted an abundant claim to a share in this new beverage.

In the commencement of the seventeenth century, a quantity of carefully-packed, dried green leaves, were presented to a Russian Embassy in China, in return for their gifts of splendid sable furs, and even forced upon them in spite of their protestations against such useless wares. But when they brought the same to Moscow, and had them prepared according to the directions, the Tea, for such it was, found equally great approval. Almost at the same time, the Dutch East India Company attempted to sell to the Chinese, Sage, which at that time was used as Tea is now, and they obtained in exchange Chinese tea. In 1664, the English East India Company considered that they made a brilliant present to the Queen of England, in the shape of two pounds of Tea. The use of Tea as a beverage in China, goes back to the earliest periods, and the traditions speak of it distinctly so early as the third century. The oldest Chinese legend reminds one strongly of the course of the introduction of Coffee into Arabia. It narrates: "A pious hermit, who in his watchings and prayers had often been overtaken by sleep, so that his eyelids closed, in holy wrath against the weakness of the flesh, cut them off and threw them on the ground. But a god caused a Tea-shrub to spring out of them, the leaves of which exhibit the form of an eyelid bordered with lashes, and possess the gift of hindering sleep." At the period when the Europeans first became acquainted with it, it was already spread generally over the whole of south-eastern Asia, and Europe did not long remain behind its teachers. No less than 25,000 tons are annually exported by sea from China; over Kiächta some 5,000; to Thibet, India, &c., perhaps nearly 15,000. In China and Japan themselves, certainly 200,000 tons are consumed, so that the whole produce is not over-estimated at 250,000 tons.

With the same passion with which the Chinese takes his Tea, the Brazilian and almost the whole population of South America rejoice in their Maté, or Paraguay tea, the leaves of a Brazilian Holly (*Ilex Paraguayensis*), which is sometimes confounded with the *Camini*, the leaves of the *Cassine Gongonha*, or with the *Guarana*, a kind of Coffee, prepared from the seeds of *Paullinia sorbilis*. The use of Maté also has been a custom in Brazil from time immemorial.

Thus have all these beverages become everywhere necessaries of life; everywhere is the origin of their use enveloped in mythical obscurity; everywhere has man, not led by rational considerations, by knowledge of the properties and action, or by comparison of them with already known nutritive substances, but, as it were, instinctively added them to the number of his daily wants.

On account of the importance of the substance itself, and of the interest which must naturally have been excited by the considerations just alluded to, Chemistry has sought to know how far it is able to contribute to the explanation of these strange phenomena. The result has proved contrary to all expectation, and has only still more entangled the problem. Oudry found in Tea a substance crystallizing in delicate white needles, which he called Theine, and the quantity of which amounted to about $\frac{1}{2}$ per cent. Even earlier, in 1820, Runge had detected in Coffee, a substance in fine crystals, with a silky lustre, of which there was scarcely $\frac{1}{3}$ per cent. Runge named it Caffeine. Another inquirer found in Cacao, Theobromine in smaller quantity; then theine was shown to exist in Maté, caffeine in Guarana; and finally, more accurate researches demonstrated that theine and caffeine are one and the same substance, which is distinguished from all other known vegetable substances by the extraordinarily large proportion of nitrogen it contains, and that theobromine if not identical, is most intimately related to it. Is it not in the highest degree remarkable, that a proportion, even though only very small, of one and the same peculiar substance, occurs in all these beverages, which have with such striking rapidity become necessaries of life over the whole inhabited globe? A remarkable problem, from the solution of which we are still so far the more distant, that the experiments hitherto instituted by physicians and chemists, have as yet furnished no evidence of a special action resulting from the administration of large quantities of pure theine; the substance, therefore, appears devoid of any striking action on the animal economy.

I return from this digression, which, however, is not altogether foreign to the main question, to my peculiar subject. Man requires for his nutrition three principal substances, rich in nitrogen, fibrine, caseine, and albumen; and these occur not only in the animal kingdom, but are generally distributed in the vegetable world. Further, for the maintenance of respiration, and therefore of heat, he consumes a certain quantity of substances devoid of nitrogen, which are afforded him both by the fat of animals, and, in the greatest abundance, by the majority and most widely distributed of the vegetable substances.

We now readily comprehend some of the most striking phenomena of the mode of respiration of man and animals. Nations of hunters and carnivorous animals, require a large quantity of their usually fatty nourishment. In violent corporeal activity, they first decompose their nitrogenous food into two constituents, one containing the whole of the nitrogen, another which contains a part of the carbon and hydrogen, and the latter is applied to the purposes of respiration, since on account of the incombustibility of nitrogen, the nitrogenous substances are not fitted for it. Hence comes the explanation of the inquiet, restlessly active habits of the rapacious animals, as of the hunter, since only by violent efforts of the body can they decompose so much nitrogenous food, and furnish the necessary material for the respiratory process. The great quantity of nutriment which such a mode of life requires, is likewise explained by this, particularly as much more animal life is usually destroyed than immediately corresponds to the requirements of nutrition. From both causes the carnivorous animals, as well as the nations of hunters, require an extended area for their existence, and this condition always necessitates scanty population.

Where the breeding of cattle is carried on, we have a transitional state, since Man here makes use of the domestic animals to provide himself, in addition to meat, with the substances devoid of nitrogen, in the constituents of milk and the rich fat of the domestic animals, which is almost wholly absent in the wild kinds.

But a skilful agricultural people leads the most judicious life, mingling the nutriment exactly in the same proportions as Nature has mixed it for the suckling in milk. For this contains the nitrogenous nourishment in the caseine, and the material for respiration, in the most accurate proportions, in the butter and the sugar of milk. We meet with the other extreme among the nations which, as in the East Indian races, the Negroes and the inhabitants of certain tracts in Europe, live wholly on rice, bananas, potatoes, or similar vegetable substances, in which very little nitrogenous matter exists. Hence the enormous quantity which these nations are forced to take, in order to collect the necessary amount of actual nourishment from the mass of material for respiration. These nations approach those of our domestic animals living wholly upon vegetables and the rest of the vegetable feeders, which pass the whole of their life in feeding and sleeping, and must necessarily consume a great quantity of food, because only a relatively small quantity of actual nutriment is contained in it. Finally, in the Polar regions in general, we find an immoderate consumption of fat inseparably united with the habits of life in these climates. This instinct also is very readily explicable from the foregoing considerations. Here man must produce a greater quantity of heat in order to live, and requires thereto a larger amount of combustible matter, or *fuel*. For this purpose there could scarcely be any substance so applicable as the fat of animals, which always consists solely of carbon and hydrogen.

Our investigations have thus led us to recognize that the whole animal world lives upon the vegetable kingdom, either immediately by actual vegetable food, or mediately by the vegetable feeders collecting the peculiar nutritive matters for the carnivora, from the plants, depositing the material for respiration, which contains no nitrogen, in the form of fat. But we do not arrive at the conclusion of our inquiries here; for now the question comes: What do plants live upon?

The reply to this question comprehends the subject of the most lively discussion that has occupied science in recent times; it includes the theory of the most important mode of applying his industry that Man has invented, namely Agriculture. The correct solution of this question had already been in part found by vegetable physiologists and chemists, in the middle of the last century, and has been subsequently undergoing more minute development by particular individuals, but was first asserted with so much liveliness and clearness in the present times by Liebig, that an active and universal strife has been stirred up, which will end in the general recognition of the true basis, and its introduction as new-found letters into the A B C of science.

In the first place we must ask, what is the plant composed of? Disregarding for the moment, as we did in regard to the animals, the inorganic constituents, the earths and salts, the answer has been already given in the foregoing account of the two classes of substances. The body of the plant is made up of constituents which contain no nitrogen, namely of cellulose and vegetable jelly, which have altogether similar composition with the other matters, sugar, gum, and starch, and are only different from the various fatty and waxy substances, in that the latter contain a smaller proportion of oxygen. But besides these, the plant requires nitrogenous matters; not indeed to form part of its frame, but to give rise to those chemical processes, through which the transformation of the nutrient matter which has been taken up, is effected. The inquiry into the nutrition of the plant includes, therefore, the inquiry into the sources of carbon and nitrogen; oxygen and hydrogen being sufficiently provided by water and atmospheric air. The notion which has hitherto been generally received, is, that the plant extracts its carbon and nitrogen from manure, or from the humus of the soil.

All animal and vegetable bodies, so soon as they are dead, pass over into a state of decomposition, by means of which they are dissipated, sooner or later, in the atmosphere, being changed into carbonic acid, ammonia and water. So long as this process is incomplete, a residue, itself much altered, of a brownish or black colour, remains, which at the commencement of the decomposition is called manure, and toward its close, humus or vegetable mould. It is a complex mixture of very manifold products of decomposition. Now it was argued thus: carbon and nitrogen are abundant in humus; in a soil that is rich in humus or is well manured, plants thrive better than in one which is poor in humus; consequently, humus is the source of the carbon and nitrogen of plants. But this reasoning is altogether inconclusive.

There was a period of our earth's existence when yet no vegetation clothed its solid crust, in which no animal lived, in which no humus could possibly be present. From this soil, devoid of humus, gradually developed vegetation, in such vast quantity, in such gigantic luxuriance, that the same, buried and preserved for us by subsequent revolutions, assumes a most essential place in human economy in the present day; I mean the vegetation of one of the oldest geognostic formations—the coal period. The annual consumption of coal in Europe amounts to more than 33,875,000 tons, and geognosy shows that, even if the consumption of coal should increase, the store will certainly last for five hundred years longer. Such a store corresponds to about 12,025,000,000 tons of carbon, which these plants evidently could not have acquired from the soil of the ancient world, in which no humus existed. That unsound argument does, in fact, silently pre-suppose the following hypothesis:

"There exists on the earth a definite quantity of organic matter, which circulates between the vegetable and animal kingdoms; the decaying animal serves as nutriment to the plant, and the developed plant again to the animal."

Now this might certainly be the case if the putrefactive process did not come between, through which undoubtedly at least a portion of the organic matter is continually being withdrawn from the pretended circlé, and dissipated in the atmosphere in the shape of inorganic compounds, carbonic acid and ammonia. In the course of thousands of years, the organic substance, which it is thus assumed was at once created with the earth, must have long since been used up. But we find exactly the contrary. Equally in the course of the great geognostic periods, and in the course of the history of the earth beginning with mankind, there is seen, in the former from period to period, in the latter from century to century, an ever-increasing fulness of organic life, an incessant multiplication in the animal and in the vegetable world. Whence springs this, if there is no process by which the inorganic matter is carried over into the circle of the organic? On the other hand, we may easily imagine what enormous quantities of ammonia and carbonic acid must have been poured forth into the air during the thousands of years, by respiration and combustion, from the decomposition of so many thousand millions of animal and vegetable bodies, and by the continual flow from the great volcanoes; while the fact is, that ammonia only occurs in exceedingly small, uncertain quantities, and carbonic acid takes a definite but exceedingly small share in the composition of the atmosphere. There must, therefore, exist a regular and invariable drain, by which those matters are withdrawn again from the atmosphere and re-embodied in the organic world. And we can demonstrate this both on a large scale and on a small, in portions of the world and in still smaller spheres.

In the Pampas of South America, existed, at the period of their occupation by the Spaniards, the same thirsty vegetation of the steppes as at present—excepting that the immediate vicinity of the towns has been altered by the running wild of the great Pampas Thistle and the Artichoke—the same scanty population, the same quantity of indigenous animals that now wander over its desert plains. The Spaniards introduced the horse and neat cattle, and these multiplied in incredibly short time in such profusion, that Monte Video alone annually exports 300,000 ox hides; that the military expeditions of General Rosa cost many hundred thousand horses, without any diminution becoming observable.

The native organic life and its quantity have, therefore, since the discovery by the Spaniards, not diminished, but importantly increased, and millions of pounds of carbon and nitrogen, combined into organic substances, have been exported in the trade in hides, without the land receiving the smallest appreciable return of organic matter. Where could these masses have come from, if not from the atmosphere? If we leave out of view all the other constituents of tea, China exports more than 300,000 lbs. of nitrogen in the half per cent of theine, without receiving any considerable return. From forests maintained in good condition, we annually obtain about 4,000 lbs. of dry wood per acre, which contain about 1,600 lbs. of carbon. But we do not manure the soil of the forests, and its supply of humus, far from being exhausted, increases considerably from year to year, from the breakage by wind and from the fall of the leaf. The hay-maker of Switzerland and Tyrol mows his definite amount of grass every year on the Alps, inaccessible to cattle, and gives not back the smallest quantity of organic substance to the soil. Whence comes this hay, if not from the atmosphere? The plant requires carbon and nitrogen, and in South America, in the woods and on the wild Alps, there is no possibility of its acquiring these matters except from the ammonia and carbonic acid of the atmosphere. The northern provinces of Holland, Friesland, Gröningen and Drenthe, export annually about a million pounds of nitrogen in their cheese. They obtain it through the cows from their meadows, which receive no manure but that from the cattle grazing thereon. The meadows receive no return by this, since all that the cows produce comes itself from the meadows. Whence then these enormous quantities of nitrogen? Perhaps Vesuvius or Etna, or the great fire-abysses of the Cordilleras pour forth this abundance of carbonate of ammonia, which is carried by currents of air to the plants of the Dutch meadows, and then, through the cows, becomes as caseine, an object of trade and of delight to the palate.

These and innumerable similar facts, taken together, give us a very safe conclusion, which has finally been placed beyond doubt by the experiments of Boussingault, the most extensive and almost the only really scientific researches which have been instituted in agricultural inquiries. Boussingault devoted, on his estate at Bechelbronn, in Alsace, four hectares of land (nearly five acres) to experiments which were pursued with undeviating accuracy for many years. The length of time and the extent of the area, remove all those objections which may readily be made to experiments on a small scale. Boussingault allowed those four hectares to be cultivated in the usual Alsatian manner during twenty-one years of the inquiry. But the manure which was used was carefully weighed, as well as all that which was each year harvested, and the quantity of carbon, hydrogen, oxygen, nitrogen and ash of both, were always accurately ascertained by chemical examination. The result of these experiments was that, on an average, the annual harvest gained from the soil, twice as much nitrogen, three times as much carbon and hydrogen, and four times as much oxygen, as had been given to it in manure—presupposing here that the whole contents of the manure enter the plants, which is in reality not the case.

Since then carbonic acid, ammonia and water form the food of plants, and we find that these matters never can be so combined as not to contain far more oxygen than the substances occurring in plants, free oxygen gas must necessarily be set free in the vital processes of vegetables.

And thus, as the final result of our inquiry, we arrive at the following grand view of the interchange of matter between the three kingdoms of Nature. Decomposition and the process of respiration set free all vegetable and animal substances (diminishing the amount of oxygen in the air), in the form of carbonic acid, ammonia and water, which diffuse themselves in the atmosphere. The plant takes possession of these substances, and forms from them, accompanied by an incessant increase of the oxygen of the atmosphere, compounds rich in carbon and hydrogen, but devoid of nitrogen, such as starch, gum, sugar and the various fatty matters, and others rich in nitrogen, namely albumen, fibrine and caseine. These compounds are for the service of the animal, which builds up its corporeal frame from the latter and burns the former in the respiratory process, for the maintenance of the necessary heat.* This theory stands now firm and unshakeable upon the facts which have been brought forward, and the naturalist is perfectly correct when he says, that Man, through the mediation of plants in the first instance, lives upon air. Or we may express it in this way: the plant collects the matters from the atmosphere, and compounds from them the food of Man. But life itself is but a process of combustion, of which decomposition is only the final conclusion. Through this combustion all the constituents return back into the air, and only a small quantity of ashes remain to the earth from which they came. But from these slow, invisible flames rises a new-born Phœnix, the immortal soul, into regions where our Science has no longer any value.

* See Dumas and Boussingault's "Organic Nature."

Seventh Lecture.

WHAT DOES MAN LIVE UPON?

SECOND REPLY.

"Dust shall he eat, and gladly,
As does my cousin, the renowned Serpent."

FAUST.

LECTURE VII.

WHETHER the words of our motto, which the poet has placed in the mouth of the Evil Spirit, are true; whether the saying of common life, as of the sacred poetry, that Man springs from dust, and to dust and ashes returns, is more than a poetic figure—only natural science—only physiology can tell us.

I took leave, in a former Lecture, to defend the naturalist when he asserted that Man lives on air alone, springs from it, and again returns into the same. Decomposition dissolves all animal bodies into ammonia, carbonic acid and water, and these exhale as gas and watery vapour into the air. Mankind extract their food, mediately or immediately, wholly from the vegetable kingdom, and this lives essentially at the cost of the carbonic acid, ammonia, and water of the atmosphere.

These views, for which we have to thank the researches which the most distinguished inquirers of the last hundred years have occupied themselves in following out and completing, have, in the present times, however, been first so expressed by Liebig, as to attract universal attention. Loud cries have arisen against him, in very various quarters, but the reasons and objections which have been made good, are exceedingly different in their character. One part of the opposition was not directed against the views, such as I have already been permitted to detail them, but against the very indefensible rudeness with which Liebig depreciated sciences which were wholly strange to him, and indiscriminately defamed the men who opposed him, while at the same time he displayed the grossest ignorance in these studies. Another portion of the objections comes from the ignorant and narrow-minded heads of the old school of naturalists, who are devoid of no less than everything, but particularly of a solid acquaintance with physics and chemistry, which would fit them to give an opinion on these points. Lastly, another portion arose out of a misunderstanding which Liebig himself gave occasion to, by want of clearness of comprehension, and by faulty expression of his views. It was imagined, namely, that this theory of the interchange of matter through the three kingdoms of Nature, was intended for a theory of animal and vegetable life, and therefore it was thought that this theory itself might be overturned, by pointing out that very much remained unexplained and obscure, and that very many things could not be made to square with it. But the relation of that grand theory to animal and vegetable life, is quite a different one. Those general outlines are in themselves firmly and unshakeably completed and established.* But in regard to the vegetable and animal kingdoms, they only afford us guiding maxims, in accordance with which we are to attempt the more exact delineation of the picture; according to which we have to discriminate as to the admissibility of hypotheses in individual cases; and it may be, that we have yet long to seek

* See Liebig, "Chemistry and Physics in Relation to Physiology and Pathology," 8vo. London, 1847.

before we shall discover all the separate links, which shall perfectly complete the chain. The theory of the interchange of matter tells us only in general terms, what goes on between plants and animals, animals and atmosphere, atmosphere and plants, but says not what processes occur *in* the plant, *in* the animal, but it indeed restrains our further investigations so far, that we must henceforth reject every illustrative experiment as false, which contradicts that theory of the interchange. All experiments, for instance, for the purpose of deducing the nutrition of plants from the organic constituents of the soil, are at once rendered vain, because we know certainly from that theory, that we can never account even for the fourth part of the plants growing upon the soil, from the whole of the organic matter contained in it.

But an objection here starts up, quite independently, which appears very unfavourable to the whole theory. We most undoubtedly see that cultivated plants thrive better in soils rich in humus or well manured fields, than in those not manured. If then the plant draws carbonic acid, ammonia and water from the air, if this is its only source of food, what is the use of the manure? Why must we use it, if we would not renounce that flourishing condition of the plants under culture? This question can only be met by two answers, one derived from physics, the other from chemistry; the one explaining the action of humus in general, the other the especial necessity for, and advantage of, the use of manure.

Carbonic acid, ammonia and watery vapour are certainly the food of plants, but the question is, by what organs do they absorb these matters? In regard to water, there is no doubt it must be wholly, or up to 99 per cent. absorbed by the roots. From the experiments of the Englishman, Hales, and the German, Schübler, it seems to follow that plants consume a much greater quantity of water than falls in the shape of rain. A sun-flower consumes daily 22 ounces of water; consequently, if every plant occupies four square feet of the soil, the plants of one acre would require 1,826,706 lbs. in the four summer months. But the ground between them is overgrown with grass and weeds, and these consume water, which may again be estimated at about the same quantity. Therefore, an acre of land, planted with sunflowers, would require altogether more than three million pounds of water.

By similar calculations it is found, that an acre planted with cabbages, requires more than five million pounds of water; an orchard stocked with dwarf apple-trees, an equal quantity; and an acre planted with hops, as much as six or seven millions of pounds.

The experiments on which these calculations are founded, were made in England, where, during the summer months, at most not more than 2,325,000 lbs. of rain fall on an acre of land. But it would be a great error to suppose that all this rain-water is available to the plant. A large portion is diffused by evaporation through the air, and a yet greater portion runs away, and is carried to the sea by springs, brooks and rivers. We do not at present possess any measurements and calculations sufficiently accurate to enable us to determine this latter quantity. It is, however, very remarkable, that as in the course of centuries the methods of determination have been gradually developed and improved, and the observations become more accurate, it has turned out that these quantities of water were formerly estimated at much below the real amount. The older natural philosophers assumed that one-sixth of the water falling as rain was carried away by rivers to the sea. The much more accurate estimates of Dausse for the Seine, and Dalton for the Thames, show that we may at least assume one-third. Still more exact are the statements of Berghaus with regard to the lower part of the Rhine's course, and Studer's for the Upper Rhine; according to which, in the former case three-fourths and in the latter four-fifths of all rain, snow and dew, runs away through the Rhine. Lastly, the facts respecting the Weser, published by Berghaus, and going very much into detail, are such, that it becomes almost probable that this river carries away even more water than atmospheric precipitation can furnish; therefore, that some other natural process must supply it with water. However, if we assume that altogether only half the rain-water flows away, we yet see how improbable it is that the remaining 1,162,500 lbs. of water, putting evaporation out of the question, can cover the necessities of the plants, which amount to from three to six millions. The watery vapour of the atmosphere must, therefore, be brought to the plant in some other way, and this happens through the property of absorbing the moisture of the atmosphere, which is possessed by most of the constituents of the soil. No substance possesses this property in so high a degree as the humus, originating out of the gradual decomposition of organic matters. The humus is also remarkably distinguished for its special power of extracting and, as it were, collecting the carbonic acid and ammoniacal gas of the air; no solid substance of the soil equals it in this particular, and water itself only ranks second after it. Humus consequently contains, under all circumstances, water impregnated with carbonic acid and ammonia, and in proportion as this is withdrawn from it by the roots of the plants, the loss is replaced out of the atmosphere. This is certainly the principal road by which water is conveyed into the plant, most probably the most essential canal through which it is fed with ammonia, and there is no doubt that at least a great portion of the carbonic acid is thus brought to it.

Look at a recently exposed surface of a block of granite, for instance, on the summit of the Brocken; there we find that vegetation is soon developed, in the form of a little delicate plant, which requires the microscope for its recognition; and this is nourished by the small quantity of atmospheric water impregnated with carbonic acid and ammonia. This, the so-called Violet-stone, a scarlet, pulverulent coating over the bare stone, which on account of the peculiar smell of violets which it emits when rubbed, has become a curiosity, industriously sought by the thoughful wanderer on the Brocken. By the gradual decay and decomposition of this little plant, a very thin layer of humus is by degrees produced, which now suffices to procure from the atmosphere, food sufficient for a couple of great blackish-brown lichens. These lichens, which densely clothe the heaps of earth round the shafts of the mines of Fahlun and Dannemora in Sweden, and through their gloomy colour, which they impress on all around, make those pits and shafts look like the gloomy abysses of Death, have been appropriately called by the botanists the Stygian and Fahlun Lichens. But they are no messengers of death here; their decay prepares the soil for the elegant little Alpine Moss, the destruction of which is speedily followed by the appearance of greener and more luxuriant mosses, until sufficient soil has been formed for the Whortle-berry, the Juniper, and finally for the Pine. Thus, from an insignificant beginning, an ever-increasing coating of humus grows up over the naked rock, and a vegetation, continually stronger and more luxuriant, takes up its position, not to be nourished on that humus, which increases instead of decreasing with every decaying generation, but by its means to be supplied with nourishment from the atmosphere.

Boussingault, in his "Economie Rurale,"* brings forward a still more interesting example. In his first sojourn in America, he visited a spot in the neighbourhood of La Vega da Supia, which, during his stay, was converted by an earthquake into a waste surface of fragments of porphyry, whereby all vegetation was destroyed, and buried many fathoms deep beneath the rocks. When he returned to the same spot, after an absence of ten years, the wild and bare masses of rock were already clothed with a young, luxuriantly-vegetating Acacia grove. And without doubt, the rock-islands arising by volcanic force from beneath the floods of the ancient ocean, at a period which lies hundred, thousands of years beyond the human history of our globe, were gradually clothed in a similar manner with vegetation until, in favourable places, those masses of humus were at last accumulated, which serve as the luxuriant substratum of the inexhaustible vegetable life of the primeval forests of the tropics. In this physical property of humus, and not in its chemical constituents, we have to seek the reason why a more luxuriant vegetation thrives upon a soil rich in humus, than on one in which an admixture of this substance is wanting.

But how now? If carbonic acid, ammonia and water form the sole food of plants, if these matters are already present in sufficient quantity in the vast reservoir of the aërial ocean, if even without humus these matters may be

* "Rural Economy, in its relations with Chemistry, Physics and Meteorology," by J. B. Boussingault, translated into English. Second Edition, 8vo. London, 1846.

brought to a scanty vegetation, if these prepare the soil for better plants by their decay—wherefore occurs, in spite of any supply of humus, so great a difference in vegetation? Why does one and the same plant thrive most luxuriantly on this soil, while on that it is stunted, or does not develop at all?

> "Non omnis fert omnia tellus,
> Hic segetes, illic veniunt felicius uvæ."
>
> VIRG. GEORG.

> "Not every soil, each grateful gift supplies,
> Here waving corn—there, happier, vineyards rise."

The beautiful Orchidaceous plant, the Ladies'-slipper, grows over all parts of the Swiss Fore-Alps, where the soil is formed of the Alpine limestone; it accompanies the whole Swabian Muschelkalk, and disappears suddenly when we come to the sand of the Jura and Keuper formations on this side of the Danube. It next makes its appearance on the Muschelkalk of Thuringia, and comes down with that on the Werra as far as the neighbourhood of Göttingen, then leaps over the Bunter-sandstone of the lower Eichsfeld, the granite of the upper Hartz, and again gladdens the eye of the wanderer on the calcareous formations eastward of the Brocken. It is sought in vain over all the clay and sand formations of the northern German plains, till in the extreme North it again shows itself at Rügen, where the chalk rocks of Arkona and Stubbenkammer lift their heads. On the western coast of France grow various insignificant-looking shore-plants, species of *Salsola* and *Salicornia*, which the inhabitants there use to obtain soda from the ashes. When we travel from thence toward the east, we everywhere miss these little plants, even when searching most carefully, and merely one or other of them makes its appearance in such places where the soil is moistened by some salt spring. At last we arrive at the great Steppes of the south-east of Russia, which in summer are often covered with a thick crust of salt, showing themselves to be the ancient bottom of some dried-up sea, and here these plants are found growing in the same abundance and luxuriance as in the west of France. On the northern coast of Germany, the little pale-red Maiden-pink grows upon the arid sand-dunes, and is universally distributed over the sandy plains of northern Germany; but these are succeeded by the granite, clay-slate, and gypsum of the Hartz, the porphyry and Muschelkalk of Thuringia, and our little pink is not met with again till we arrive at the Keuper-sand plains, on the further side of the Maine, surrounding the venerable city of Nuremberg. It extends further south, through the Palatinate, till the Muschelkalk of the Swabian Alps again sets a limit to it; but it leaps over these and the whole Alpine region, and at last appears again on the sandy soils of northern Italy. How is it that these plants everywhere disdain the richest soils in their range of geographical distribution, and are confined to perfectly determinate geognostic formations? Must not the lime, the salt, the sand, or rather the silex, have a most distinct influence in the matter?

And it may further be asked: How does it happen that one and the same soil can bring the one plant to the highest state of development, while another soil is not able to sustain its life? Wherefore is it, lastly, that we see the life and healthy condition of most of our cultivated plants so distinctly connected with the manuring of the soil with organic substances? This question has been first answered in a profound and truly scientific manner by Liebig. How is it, he asks on the other side, that wheat does not flourish in soils rich in humus, in pure vegetable mould? Because wheat contains a substance, silex, without which it cannot exist, and which it does not find in vegetable mould. If we burn a plant, be it what it may, we obtain a residue which does not become dissipated with the products of combustion—a variable quantity of ash. Lime, silex, soda and potash, common salt and a mixture of carbonate and phosphate of lime (called bone-earth, because it forms the incombustible portion of bones), gypsum and some other constituents, are the substances of which the ash is usually composed. When we compare among themselves, the results of the investigation of the ashes of a large series of plants, we arrive at some remarkable laws. We find that any given plant always yields very nearly the same relative quantity of ash, that this ash, within certain very narrow limits, defined by chemical principles, has a regular composition. We discover, lastly, that different plants leave behind after combustion, ashes composed either of very different substances, or of very different mixtures of these substances.

Unreasonable as it would be to maintain that Arrow-root only forms so pure a starch, in order that we may make use of it for the food of our children and invalids, and that this substance has no definite importance to the life of the plant itself, it would be equally preposterous to assume that plants only take up a perfectly definite quantity of the constituents of the ash from the soil, in order that we may here and there obtain potash from them, or that this ash should be a troublesome residue in our stoves. We must rather, from the phenomenon that certain plants regularly take up certain inorganic, mineral constituents from the soil, be led to the opinion that these constituents are as essential to the existence, and consequently to the nutrition, of the plant as those elements out of which it composes its organic structures. It is quite a matter of indifference here whether we are enabled by the condition of our science to point out, in every individual case, what import this or that particular substance possesses in the life of the plant. It suffices that we know that these substances are indispensible to the healthy growth of certain plants.

Novel and strange as the assertion may at present appear to many, that the insignificant quantity of ash in a plant deserves our chief attention in its life, it will readily be allowed and become familiar, so long as and because this circumstance is always regarded as a secondary consideration, if also in its way a necessary one. But the matter assumes quite another aspect when, acquainted with the fundamental principles and the course which science must and will take in the coming time, we now anticipate the final results, for the complete establishment of which we have perhaps to labour for another century. Thus then will run our aphorism:— The whole wealth and the whole manifoldness of terrestrial vegetation, its whole variety, as well when we compare zones of longitude and latitude as wild nature with cultivated lands, are exclusively dependant on the variety of inorganic constituents which the plant takes up from the soil. When we look to the wild vegetation of our own latitudes, we find two principal classes of soil: one a peat or bog soil, which consists almost wholly of humus, therefore of decomposed organic matter, the other of calcareous, sandy, or argillaceous soils, in which the inorganic constituents prevail in so great a degree, that the humus, in the blackest soils, does not amount to more than 10 per cent. at most, and even in the most fertile, and those clothed with the richest vegetation, often scarcely forms ½ per cent. And that peat or bog soil, so rich in humus, can only afford sustenance to 300 of the 5,000 flowering plants growing in central Europe; and there are not perhaps fifty plants, therefore not one per cent, of which the actual conditions of healthy growth are furnished by the bog soil, which would not also thrive exceedingly well in other places, if the necessary moisture were afforded them. Most of the plants belonging to these soils so rich in humus, are members of the families of the Rushes and Sedges, which are wholly useless, and odious enough to the agriculturalist under the name of sour pasture. On the other hand, the other class nourishes the whole vegetation of our latitudes, in a multiplicity which is varied enough to our eyes, unused to the tropical world, and we generally find the richest abundance on the soils which are poorest in humus but richest in inorganic constituents, on basaltic, granitic, porphyritic and calcareous soils. All those different plants return to us year after year in the same form, the circle of their characteristics is limited within narrow bounds; and if we search through the newest geognostic formations, we find the plants of the present world with exactly the same characters as those they now exhibit, enclosed in the ruins of the last revolution of the earth's surface. For instance, all Hamburg, its harbour, and a broad tract toward the south-east and north-west of the city, rest upon a sunken forest, which now lies buried from 30 to 100 feet below the surface. This forest was composed of Limes and Oaks, exactly like those we now meet with in that place; excavations for very different purposes have there brought to light, thousands of hazel-nuts, which differ in no respect from our hazel-nuts of the present day. Thus the wild vegetation of our latitudes has retained, during thousands of years, the same character which it assumed when the climatal conditions were adjusted, after the last great change upon the globe, in the way in which we in the present day observe them to exist. The case is quite different with the soils we have cultivated, of which I will here only consider garden-land, because it exhibits the prominent peculiarities in the most striking manner.

Our careful culture is confined to a certain relatively small number of vegetables, and the selection of them, left to accident in earlier times, but now not unfrequently conducted with knowledge according to definite principles, becomes especially determined by one primary consideration.

Our cultivated plants collectively exhibit characters which they do not possess in a wild condition, but which are exactly those which give them value to us. The sweet, juicy Altringham Carrot, weighing from five to six pounds, is in a wild condition, a dry, slender root, unfit for food; the delicate, well-flavoured Vienna Glass-kohl-rabi, as large as a man's fist, is a slender, woody, dry stem when wild; the white, soft, aromatic Cauliflower, is in its natural locality, in its natural habit, a thin, branched flowering stem, with little green, bitter flower-buds, and so with the rest. All these various properties, through which the plants have become such important attendants of human economy, have been called forth by a peculiar chemical process originally foreign to the plant, the necessary conditions of which lie, not in those organic elements which are the same for all plants, and are almost equally distributed in all, but in the inorganic constituents present in the soil and taken up by the roots. Wherever the soil is rich in the various salts occurring most abundantly in plants, the characters of the latter become altered; varieties and monstrosities originate which never occur in the wild condition, where the plant always keeps to the soil exactly agreeing to it. Plants, however, exhibit very varied dispositions to the alteration of their peculiar nature by such external influence. While some retain exactly even the most minute characteristics, under the most diverse conditions, others run readily into innumerable varieties. While in some, the varieties exhibit very little stability, passing readily again into the wild form, or into new variations, other plants produce manifold aberrant forms, which, after some years' culture, may be propagated with full certainty by their seeds, and thus arise what are called sub-species. It is exactly this character of plants which fits them to become advantageous objects of cultivation; that they readily produce very *different* and *stable* varieties, out of which Man selects those most profitable for his purposes, and receives them into the number of his vegetable subjects.

We have then three opposite conditions here: the common soil, bog soil and that of gardens. The first nourishes an abundance of different plants, which, however, remain the same, in fixed consequence, through thousands of years. The bog soil is extraordinarily poor in vegetables; it only brings forth the most formless and useless plants. Lastly, the garden soil not only nourishes in luxuriance every plant that is committed to it, but even continually multiplies the abundance of vegetable forms to infinity, to which, however, opposing climate sets a limit so soon as the favouring influence of culture is withdrawn. Then two other conditions present themselves, in contrast, to our consideration. We have on the one side the common soil, possessing little or no organic remains, and abundance of plants; on the other, the bog and garden soils, both rich to superabundance in the black constituent called humus, which has been formed by the decomposition of animal and vegetable organisms. And nevertheless, we find such a difference of influence on vegetation between the bog and the garden land. But this is readily explained by the manner in which they have been formed. The peaty soil originates from the decomposition of organic substances in the presence of much water. The consequence of this is, that the water takes up and carries away all the soluble salts which were contained in those organisms, so soon as ever they are set free. In the garden soil, on the contrary, all those soluble salts remain behind, come immediately into the possession of the plants, and, under a rich culture of the soil, accumulate in them to an extraordinary degree, while the organic constituents, through uninterrupted decomposition, are continually diminished in quantity, and so can never accumulate in the way they do in the peat or bog soils, where the presence of water, after a certain time, restrains or very much retards the further progress of decomposition. A more striking proof of the correctness of the new views of the nutrition of plants could not easily be given, than these statements; views which were almost simultaneously established and made known by one of the most distinguished chemists, Liebig, and one of the most eminent of practical agriculturalists, Boussingault.

But I must take leave to return once more to the question which was first raised: "What does Man live upon?" We have seen that the nutrient fluids contained in his body, that muscles, skin, and the gelatine which forms the basis of bones, are essentially produced from substances containing nitrogen, which the plants furnish to him as food. But gelatine alone does not complete the bony structures; we find in these, besides the gelatine, the so-called bone-earth, a compound of carbonate and phosphate of lime. This it is to which the bone owes its solidity, its hardness, through which alone it is fitted to become the foundation and support of the whole body; we know that when this bone-earth is not present in sufficient quantity, a dreadful disease, the rickets, ensues. Whence does man obtain this no less essential constituent of his frame? We know, moreover, that all the fluids of the body contain definite amounts of certain salts, that without these they cannot execute the functions to which they are appointed. Of these substances also must we render an account, if we would explain the nutrition of the animal body. Of the inorganic, as of the nitrogenous portions of the frame, a certain quantity undergoes continual decomposition through the activity of the body, is excreted, and therefore must be renewed. We here involuntarily think of the earth-eating Ottomacs, of the Negroes swallowing clay, of the countless instances of men who have eaten, in the pangs of hunger or from fancy, the Mountain-meal, a fine siliceous or calcareous earth. But we at once turn from these ideas when we observe they do not refer to any universal food, but merely to some few abnormal phenomena, proceeding from diseased conditions of the gastric nerves, or from necessity. The source from whence the animal body draws the inorganic constituents, must be universal, and we find ourselves thus directed back to plants. If then bone-earth and nitrogenous constituents build up the animal body, if we know that alkaline salts always accompany the bile, which, according to Liebig's view, plays an important part in the process of respiration and combustion, through which the animal heat is maintained, it must naturally astonish us to find, in plants, the nitrogenous materials for nutrition constantly accompanied by phosphate of lime, the materials for respiration, devoid of nitrogen, constantly associated with alkalies. Thus has the wise care of Nature united these matters at once in plants, which in exactly the same determinate combination, are afterwards to be applied to the use of animals.

But natural science must not stop at such teleological considerations; and it next becomes our object to demonstrate that those inorganic salts have a perfectly definite importance to the plant itself. Nay, even if we are not yet in a position to afford this demonstration, we must still, from the constant occurrence of determinate mineral constituents in determinate plants, conclude their necessity to the existence and well-being of the plant, as Theodore de Saussure was the first to do, in his immortal "Recherches sur la Végétation." Supported by these views, Liebig now states: That since the organic nutriment stands everywhere in equal abundance at the service of all plants, the cause of the great difference of vegetation cannot be sought therein, consequently it must lie in the inorganic constituents, and it is essentially indifferent whether we convey manure to the field, or burn it first and strew the ashes on the soil, since its efficacy is dependant solely on the constituents of the ashes.

It is easy to see that this principle, applied to agriculture, suddenly throws a new, bright light over all those phenomena, to explain which man formerly wearied himself in vain. Now, we can easily conceive why an irrigated meadow can annually yield a large quantity of hay, without manure, since the necessary quantity of salts are brought to it by the spring water. It becomes clear how the Peruvian may obtain a luxuriant harvest of Maize on the arid sand-drift, if but a little rill brings it the needful soluble earth-salts from the snowy peaks of the Andes. Hundreds of similar phenomena are at once explained by this ingenious idea of Liebig; but hundreds of new ideas also are suggested, fruitful for the completion and improvement, the simplification and insuring of Agriculture, which will be the prize of the next following time; and we now find it natural that England, where agriculture stood at so high a pitch, according to the former standard, should applaud and overwhelm with fêtes and demonstrations of honour of all kinds, him, the founder of a rational, in opposition to the former purely empirical, culture of plants, in a manner which scarcely any man, and certainly no foreigner, has experienced in that country.

When we examine the ashes of plants, we find in particular the four following constituents, giving them their characteristics: readily soluble alkaline salts; earths, especially lime and magnesia; phosphoric acid, and silicic acid or silex. Sometimes one, sometimes two of these substances predominate in the ashes of the plant.

According to this, Liebig divides the cultivated vegetables into:

1. Alkali plants; to which belong Potatoes and Beets.
2. Lime plants; Clover, Peas, &c.
3. Silex plants; the Grasses.
4. Phosphorus plants; comprehending Rye and Wheat.

But besides these, plants contain many other substances, the quantity and importance of which we do not understand so well at present. With the progress of science, however, those divisions of Liebig will assume a much more complete form.

All those substances are met with in the various rocks of the firm crust of the earth, but almost all in a perfectly insoluble and sometimes crystalline condition, therefore altogether unavailable to the plant. Geognosy alone can inform us how these substances are rendered soluble, and how they become gradually converted into soil.

If we transport ourselves, in imagination, into a time which the grand poetic tradition of the Hebrews describes: "And the earth was without form and void: and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters," we behold the earth enveloped in dense cloud, in great part covered with water, from which, forced up by volcanic power, the mountains arose, coming to light as molten fluids, or in a still gelatinous condition, and cooling into solid, more or less crystalline masses—the primeval rocks. Simultaneously, through the same forces, the bottoms of the neighbouring seas became upheaved above their glassy surfaces, and the stratified precipitates of which they consisted, displayed themselves as the transition rocks. Then came the decomposing influence of the atmosphere into action. Into the flaws and cracks which the cooling process had caused in the hard rocks, the water of the atmosphere penetrated. Expanded by frost, it split off the superficial layers, and the detached blocks rolled down the mountain-sides. This process was repeated upon these blocks until they and their successors at last crumbled into dust, which was in part washed over the level land by torrents of rain, in part carried by the mighty rivers to the sea, where it was again precipitated in layers, which, thrust up as before in subsequent periods by the ever actively ascending molten masses, now presents itself to us as the secondary and tertiary strata and diluvium. The larger masses scattered over the solid land were washed into heaps by the fearful torrents of rain, and all the naked rocks underwent, besides the mere mechanical destruction by which they were reduced into small fragments and dust, unceasing corrosion by chemical decomposition, whereby wholly new compounds were formed, which were washed together by rain and by the lesser streams, to form what we know as alluvium.

Thus was the naked crust of our planet formed. But formative processes, of which we neither have nor can have any conception now, were in action from the very first; where the oceanic deposits lifted themselves, as transition rocks, into the air, vegetable germs originated, which found their sustenance in carbonic acid, ammonia and water, and the products of the atmospheric corrosion of the rocks. A world of organisms, teeming with life, originated on the globe, the varied multiplicity of which was not dependant on those four elements which, in a truer sense, form their organic constituents, but rather on the infinite variety of chemical processes which were called forth by the manifold kinds and quantities of inorganic substances. On the other hand, the humus, the black substance resulting from the decay of living beings, rendered possible the development of the innumerable organisms in greatest force, since it furnished to them organic nutriment. But the weathering of rocks, and their chemical decomposition into soluble constituents, depend upon heat and the chemical composition of the atmosphere. Conditions like those which now we find only under the tropics, allow of rapid weathering and rapid decomposition, and thus cause the rich and luxuriant vegetation of the tropics. At a former period, however, our atmosphere must have been everywhere more moist, denser, and consequently warmer; and in this age could unfold itself, without limit, over the whole earth, that fulness of organic life which we now find buried in a fossil condition in the stratified rocks, altogether without relation to geographical latitudes.

To return to my subject. The ingenious views established by Liebig consequently point out, that those constituents, which we are accustomed to despise and overlook, are exactly those which have the most essential importance to the vegetable world. All the nitrogenous components of plants, which we use as food, consist, it is true, of merely carbon, hydrogen, oxygen and nitrogen. But the presence of these substances alone does not help the plant in the least; it cannot form from them a granule of albumen or gluten, unless it contains, at the same time and in the proper relative condition, salts of phosphoric acid. The useful starch, the sweet sugar, the cooling citric acid, the aromatic oil of oranges, are indeed composed solely of carbon, hydrogen and oxygen; but the plant cannot prepare those gifts for us, out of ever so great an abundance of these elements, if it does not possess also alkaline salts. The slender stalk of the wheat could not lift itself to ripen its grain in the sun's rays, unless the soil furnished it with silex, through which it gives its cells that solidity necessary to enable it to maintain an erect position.

Supported by these facts, Liebig has recently sought to revolutionize our whole agricultural system, by the recommendation of a mineral manure he has discovered; for the preparation of which he has taken out a patent in England, and sold it to Messrs. Muspratt and Co. His aim is to furnish to every kind of soil and plant, a proper compost of those mineral substances which the plant requires and the soil is deficient in, and in such a peculiar state of combination, that the substances shall be soluble enough to be taken up by the plants, and yet not so readily soluble, that the rain can wash away any considerable quantity. Whether Leibig has attained to this end, can only be determined after experience has given its evidence. In theory, it must be affirmed, that the principle is correct and the carrying out possible. But vegetable physiology will, with good right, make an objection to this system of manuring, and experience will confirm it;—namely, that though the humus, as already shown, is by no means a nutrient substance, yet without it, there can be no healthy and strong vegetation on such soils, and they are rare, as are not most propitiously mingled with clay, which may, to a certain extent, replace humus. Liebig's chemical one-sidedness, in this respect, will probably be mischievous to those agriculturalists who cannot neutralize this fault by their own thorough knowledge of Natural Science, just as on the other side, the absence of a thorough study of Natural Science, and crude empirical prejudice, have in these later times prevented many, particularly German agriculturalists, from taking part in the improvements called forth by the progress of science. Perhaps, however, an event which is sad enough in itself, will give rise to an earnest observation of the results of science, and will thus, by producing an essential transformation of our agricultural management, become a blessed moment in the history of our cultivation. I mean the Potato Disease, which in the last few years has appeared in such a threatening form, that it is, indeed, calculated to awaken the most indolent from their slumber, and in which we have one of the best proofs of the correctness of Liebig's theories.

The phenomenon of these recent times is by no means an isolated one, for, during more than one hundred years has the disease shown itself in Potatoes; and in each recurrence of its appearance, has it exhibited greater extension and activity. That it is not dependant solely or essentially upon meteorological influences, is shown even by the form continually becoming worse; but, in particular, by its extent in the year 1845, when it manifested itself with equal formidableness in southern Sweden and in South America, which two countries had been favoured (contrary to what happened in central Europe) with remarkably fair wheater. Besides, the Potato was not wholly exempted from the evil by any position, any method of culture, or in any variety, and this points out to us, at once, that the actual cause of the disease must lie in a thorough degeneration of the plant, and not in any single external influence. If we ask how such a degeneration could have occurred, the following considerations alone can guide us to an answer. The wild Potato is a small, greenish, and bitter-flavoured tuber, containing, however, a great deal of starch. It is one of those plants which readily produce varieties in cultivated soils, which exhibit tolerable permanence when the conditions of culture remain exactly the same. When this is not the case, new varieties arise, they "sport" as it is called. The difference of these varieties consists only in part in the far less essential alteration of the form of the Potato, in its quicker or slower ripening. Far more important is the difference in the chemical process by which the relative amounts of starch and albumen in the tuber become altered. Starch, a substance containing no nitrogen, is the peculiarly characteristic constituent of the Potato, a substance which withstands decomposition for a long time. The formation of this requires the presence of a large quantity of potash, and therefore the Potato belongs especially to the alkali-plants. Albumen, on the contrary, rich in nitrogen, is particularly prone to decomposition and rotting, and its presence, in large quantity, renders the other substances also which can, alone, long withstand decay, *e. g.* cellulose and starch, much more liable to this process of solution. The production of albumen pre-supposes the presence of a great quantity of salts of phosphoric acid.

If we examine a healthy normal Potato, we find the proportion of the nitrogenous to the unnitrogenized constituents to average as 1 : 20 ; the proportion of salts of phosphoric acid to alkaline salts is as 1 : 10. On the other hand, freshly-manured cultivated land—from physiological reasons which it would lead me too far to unfold here—contains the inorganic constituents mentioned, almost in the proportions of 1 : 2. The consequence of this is, that in such soils the plant is forced to take up the phosphates in larger quantities, in proportion to the alkaline salts, than its nature requires, and thence a greater abundance of nitrogenous matter, of albumen, is formed in it, than it would contain in a normal condition. This latter must infallibly render the components of the Potato, which always contains a great deal of water, still more prone to processes of decomposition, which then appear under the most varied forms, sometimes, as in the dry-rot formerly observed, principally seizing upon the starch, and sometimes, as in the recent moist-rot, especially attacking the cellulose. That such a disposition may in a moment show itself as a ruinous disease, when external influences, particularly unfavourable weather, come into operation, is readily conceivable, and it stands to reason that when the injurious influences which produced the seeds of the disease continue, the degeneration of the Potato, and its proneness to disease, must be always increasing. In such cases, the theory of Liebig and Boussingault again affords us a certain means of avoiding the evil. A careful consideration of the inorganic substances soon affords us the law, that it is not alone enough that the different substances are present in sufficient abundance in the soil, but, that they must also be present in the proper proportion to each other; that regard to these proportions is of the highest importance in reference to those plants which are naturally inclined to produce varieties; above all in reference to those plants, the chemical composition of which renders them most liable to essential injury by alteration of their constituents. All this especially concerns the Potato, but does not much affect our grain, Rye and Wheat. When we compare the constituents of the ashes of these latter with the contents of a freshly manured soil, we find the proportions of the two almost alike, and what is very remarkable, when we abstract the constituents of the ash of Rye from the contents of the soil, almost exactly that proportion of the particular matters remains, that we find in the ash of the Potato. The conclusion is therefore simple: that we must in future never cultivate the Potato as the first crop, as has generally been hitherto done throughout the greater part of Europe, but we must begin with Rye, and allow the Potato to follow it, or perhaps still better, to come two years later, after Clover, if we would raise a healthy produce, and in future be rid of the plague to which we have recently been subject. The fundamental proposition will henceforward stand firmly established, that the nutrient matter which the plant itself takes up from the soil, consists essentially only of the inorganic constituents of the same, and that these, and not the organic substances, constitute the peculiar richness of a soil.

But the inorganic compounds are inseparably connected with the organic in the plant, and if we would take possession of the latter, we must receive the former into the bargain.

Yet they are not merely useless ballast, but substances essential to our bodies and their maintenance. Let us see what Man is really composed of. According to Quetelet, a full-grown man weighs on an average 154 lbs., and if we subtract the great quantity of water which runs through all parts of our body, keeping them supple and pliant—some 38 lbs.—14 lbs. of this comes from the bones, and 24 lbs. from all the remaining parts. The former contain about 66 per cent., the latter 3 per cent. of earthy constituents, which are left behind after combustion. Man consists, therefore, in more than a third part, of inorganic substances, which are necessary to his existence; and which he must, therefore, receive with his food. He must, in fact, as the Evil Spirit says, feed upon dust.

Exactly as the softer organs of the human body, in their every motion partly worn out and consumed, become replaced through nutrition, so does man continually lose a portion of those inorganic substances, and must make good this loss by food. But during life, a peculiar relation is maintained between the two kinds of matter which are received. In the child, still growing, whose organs are still in the process of development, far more of both classes of substances, of the organic equally with the inorganic, is taken up than is worn out; in the adult, the receipt and the expenditure are in equilibrium; in old age, on the other hand, a peculiar disproportion occurs. The old man consumes continually more organic matter than he can replace by food. The strength of his muscles disappears, the quantity of blood becomes smaller, he grows thinner. But the inorganic matters are not wasted in the same quantity as they are received in the food. Man thus goes back again to the stage of childhood, and we obtain a view of life and death, almost directly in contrast to that formerly unfolded. Ever more and more earthy matter is added; organs which formerly were soft and pliant, become ossified and refuse their office; ever more heavily does the dust draw him down to dust, till at last the light-winged Psyche, weary of the pressure, throws off the chrysalis-shell—become too gross. She leaves the dust-born body to the slow combustion which we call decay. A little pile of ashes remains to the earth from which they were borrowed. The soul, itself immortal and incorruptible, returns from the slavery of natural laws to the Disposer of Spiritual Freedom.

Eighth Lecture.

ON THE MILK-SAP OF PLANTS.

"Here is a juice that swift intoxicates."

FAUST.

The vignette represents an Indian family busied in the preparation of Cassava from the Mandioc: the wife is dipping one of her husband's arrows in the poisonous milky juice dropping from the compressed mass of bruised roots.

LECTURE VIII.

In the brilliant arena of the polite world, the entrance to which is decorated by the celebrated obelisk of Luxor, on that field where, in bloodless battles, the victories of fashion are decided,—albeit, the ground was originally consecrated to the "*humilité de Notre Dame*,"—in Longchamp, not very long ago resounded the question, "Paletôt, or Mackintosh?" For the moment the Paletôt triumphed, but soon to fall before the Burnous and other successors, while the Mackintosh, if no longer ruler of the mode, still survives. It may be worth while to ask, what it really is that has given the Mackintosh such value that it will still be long retained in the wardrobe, as indispensible for certain purposes. There are, besides the champions of fashion, two opposite parties, one of which asserts the excellence of, the other absolutely rejects, the Mackintosh. Shall we not hear them?

The defenders extol the lightness which is combined with perfect imperviousness to water and great warmth. These excellences depend wholly upon the peculiar substance with which the cloth is made into Mackintosh, the gum elastic, or Caoutchouc. This has recently acquired such extensive application in manufactures, that a closer acquaintance with it will certainly not be uninteresting. The English use this peculiar product of the vegetable world most largely. In 1830, more than twenty-six tons were imported into England. In the year 1829, nearly fifty tons. In the customs'-year, ending in 1833, duty was paid on more than eighty-nine tons. Since that time, the consumption has been continually increasing. In one manufactory in Greenwich, alone, eight cwts. are daily submitted to dry distillation in iron vessels. The residue is a peculiar greasy substance, which never loses its tenacity and pliability, bidding defiance to every influence of air or water; and it is, therefore, made use of in the English navy for steeping the cordage in, to render it more durable. The fluid distilled over is a volatile, inflammable oil, which possesses the property of readily dissolving Caoutchouc, and leaving it, after evaporation, in its original condition. Thus it becomes possible readily to give the Caoutchouc any desired form, and to impart its impenetrability by air and fluids of almost all kinds, to every other substance. Thus are produced the many waterproof fabrics, one of which has been called after its discoverer, Mackintosh. The great elasticity is also turned to account in the greatest variety of ways, this property being in the highest degree valuable for many purposes. For this, the great masses of Caoutchouc are cut by proper machines, first into thin plates, and then into very fine filaments. These filaments are covered with linen, cotton or silk thread, and then woven with other customary yarn, which serves as the woof, into bands, &c. Finally, Caoutchouc in an unprepared condition, is applied to many uses, of which I will only mention the so-called "goloshes," or India-rubber shoes.

South America is the country which supplies the largest quantity of Caoutchouc for this great demand; but a great deal is also imported from the East Indies, and even Africa might furnish it, if the social condition of the natives did not oppose itself to their availing themselves of their indigenous resources. All the countries which count Caoutchouc among their products, belong to the torrid zone. A. von Humboldt, in his "Ideas of a Geography of Plants," remarked, that the plants yielding milky juices multiply as we approach the tropics. This *milky juice* of plants it is which contains the peculiar elastic substance. The tropical heat seems to exert a distinct influence in its perfect formation, for it has been remarked, that the same plants which, under the equator, yield abundance of Caoutchouc, contain instead, with us, even in hot-houses, a substance which resembles the bird-lime obtained from our native Misletoe.

Who among my readers has not seen our indigenous Wolf's-milk or Spurge, the white milky juice of which popular superstition recommends as a remedy against warts? Who has not in youth at least become acquainted with the Celandine, from the broken stalk and leaf of which, a bright orange-coloured juice runs out? Who has not observed that the Lettuce, when it has run up to flower, ejects a milk-white fluid at the slightest touch? But the occurrence of milky juices in plants is not limited to these few. The vegetable world presents to us most useful as also poisonous matters in this milky sap, and I will content myself at present with recalling to recollection Opium, the dried milky juice of our large garden Poppy.

A great number of plants, which principally belong to three great families, namely, the Spurges, the *Apocynaceæ*

(Juss.), and the Nettle plants, are distinguished by a peculiar anatomical structure. In their bark, and also partly in their pith, we find a quantity of long, variously curved and branched tubes, which are not unlike the veins of animals. Through this similarity, Professor Schultze, of Berlin, was led to develop a comprehensive theory of a circulation through these structures of the fluids contained in them, which he called vital juices, which theory, unhappily, cautious science was compelled immediately upon its promulgation, which made so great a show, that it appeared as one of the treatises honoured by the Paris Academy with the Monthyon prize, to demonstrate to be a mere brain-spun phantom. In these tubes we find a thick juice of the consistence of very rich milk, whence it is called milk-sap. Its colour is usually milk-white, but yellow, red and, very rarely, blue milk-saps are met with, but more frequently still they are wholly colourless. Like animal milk, this juice consists of a colourless fluid and small globules. The composition displays the most varied constituents, and upon the variation of quantity and modes of mixture of these matters, depend the abundant varieties of this juice. All contain more or less Caoutchouc, which occurs in the form of little globules. These are prevented from coalescing by an albuminous substance, in the same way as are the butter globules in milk. Exactly like the cream (the butter) in milk, the Caoutchouc globules rise to the surface of the milk-sap of plants when left to stand, here form a cream and coalesce, and cannot, any more than butter, be separated again into their distinct globules.

All those three great families which are distinguished by their abundance of milk-sap, although differing very widely botanically, exhibit some most remarkable agreements through the nature of their milk-sap.

It will not be uninteresting to give a more detailed account of these three families, and to mention the more important plants belonging to them.

The Spurges or *Euphorbiaceæ* constitute the most important group in reference to the amount of Caoutchouc contained. From the Port of Para in South America, from Guiana and the neighbouring States, an incredible quantity of India-rubber is shipped for Europe, and this is principally obtained from a large tree growing in those regions, called the *Siphonia elastica.* In the year 1736, the celebrated French *savan*, La Condamine, first directed attention to Caoutchouc, and minutely described the mode of obtaining it. That beautiful tree, the *Siphonia*, is about sixty feet high, and has a smooth brownish-grey bark, in which the Indians make long and deep incisions down to the wood, from whence the white juice then abundantly flows forth. Before it has time to dry, it is spread upon moulds of unburnt clay, usually of the shape of a small, roundish, short-necked bottle, and then dried over a smoking fire. The spreading of the Caoutchouc upon the mould is repeated until the coat has acquired the desired thickness. By this operation, in which the foreign matters are not separated from the juice, which becomes still more contaminated by the smoke, the Caoutchouc acquires a brown or black colour, while pure Caoutchouc is white, or of a yellowish colour, and semi-transparent.

We owe a subsequent more accurate knowledge of the tree and its distribution, to Fresneau, in the year 1751; but especially to the indefatigable naturalist, Aublet du Petit-Thouars.

Many other plants of this group contain Caoutchouc, but from none is it so easy to obtain it in large quantity.

Though the sap of *Siphonia* is at least harmless, though the juice of the *Tabayba dolce* (*Euphorbia balsamifera*, Ait.) is even similar to sweet milk and, thickened into a jelly, eaten as a delicacy by the inhabitants of the Canary Islands, as Leopold von Buch relates in his interesting description of the Canaries; yet most of the plants of this group are to be counted among the suspicious, or even most actively poisonous, on account of this very juice. And yet, strangely enough, they also furnish a most wholesome food, which we have scarcely anything to compare with. Throughout all the hotter part of America, the culture of the Mandioc-root (*Jatropha Manihot*) is one of the most important branches of husbandry. The native savages and the Europeans, the black slave and free man of colour, alike substitute for our white bread and rice, the *Tapiocca* and the *Mandiocca farinha*, or Cassava-meal, and the cakes prepared from it (*pan de tierra caliente* of the Mexicans); which are obtained from that most poisonous plant. The sweet Yucca (*Yuca dulce*), which is the name applied there to the Mandioc plant, must be distinguished from the sour or bitter kind (*Yuca amara*). The former, which is therefore cultivated with great care, may be eaten at once, without danger; while the latter, eaten fresh, is an active poison. They serve the uncivilized son of the South American tropics for food, and we will watch him for a moment in his haunt. In a dense forest of Guiana, the Indian chief has stretched his sloping mat between two high stems of the Magnolia, he rests indolently smoking beneath the shade of the broad-leaved Banana, gazing at the doings of his family around. His wife pounds the gathered Mandioc-roots with a wooden club, in the hollowed trunk of a tree, and wraps the thick pulp in a compact net made from the tough leaves of the great

Lily-plants. The long bundle is hung upon a stick, which rests on two forks, and a heavy stone is fastened to the bottom, the weight of which causes the juice to be pressed out.* This runs into a shell of the Calabash gourd (*Crescentia Cujete*), placed beneath. Close by squats a little boy, and dips his father's arrows in the deadly milk, while the wife lights a fire to dry the pressed roots, and by heat to drive off more completely the volatile poisonous matter. Next, it is powdered between two stones, and the Cassava-meal is ready. Meanwhile, the boy has completed his evil task; the sap, after standing some considerable time, has deposited a delicate, white starch, from which the poisonous fluid is poured off. The meal is then well washed with water, and is the fine white Tapioca, resembling, in every respect, Arrow-root. In a similar, more or less skilful manner, are the Mandioca and Tapioca, everywhere prepared. The sated savage saunters round to seek a new sleeping-place, but woe to him! inadvertently he has prepared his couch beneath the dreadful Manchineel (*Hippomane Mancinella*), and in a sudden shower, the rain drips from its leaves upon him. In frightful pain he wakes up, covered with blisters and ulcers, and if he escape with life, he is at least the richer of a fearful experience of the poisonous properties of the *Euphorbiaceæ*. But this will seldom happen to a native; the Manchineel is avoided in America with the same mysterious and almost superstitious awe, as the fabulous Poison-tree in Java. Happily, the Trumpet-tree (*Bignonia leucoxylon*), the sap of which is the surest antidote against the Manchineel, usually rears its beautiful purple blossoms close at hand, the constant companion of that dangerous Euphorbiacean.

* See the Vignette.

The planter of the Cape strews over pieces of flesh the pounded fruit of a plant that grows there (*Hyænanche globosa*, Lam.), and lays them as an infallible poison for the Hyæna. The wild inhabitants of southern Africa, according to Bruce, poison their arrows with a Spurge (*Euphorbia caput Medusæ*). Virey states, that the Ethiopians make a similar application of others (*Euphorbia heptagona*, *E. virosa* W., *E. cereiformis*), while the savages of the most southern part of America use the sap of a third (*E. cotinifolia*). Nay, even our seemingly so innocent Box, which also belongs to this family, is so injurious, that in places in Persia, where it much abounds, no camels can be kept, because it is impossible to prevent their feeding on this plant, which is deadly to them. I cannot take leave of this family without mentioning a remarkable phenomenon, reported to us by Martius, in that work so full of information, his Travels through Brazil. A Spurge grows there (*E. phosphorea*, Mart.) the milk of which, when it flows forth from the stem in the dark, hot summer nights, emits a bright phosphoric light.

While the family just alluded to, the blossoms being generally insignificant, attract the attention of our horticulturists almost solely through their strange forms, which, in some of them, approach to those of the Cactus plants—the family of the *Apocynaceæ* is, on the contrary, a rich ornament of our gardens and hot-houses, on account of the wonderful beauty of its blossoms, and is often still more attractive from the remarkable structure of the flowers, and the aberrant, also Cactus-like form of the plant itself. What lover of flowers knows not the splendid blossom of the species of *Carissa*, *Allamanda*, *Thevetia*, *Cerbera*, *Plumieria*, *Vinca*, *Nerium* and *Gelseminum*—

the strange stalk and toad-coloured, ill-smelling flowers of *Stapelia?* But this family is not less interesting in other respects. The best Caoutchouc at present known, that from Pulo Penang, comes from a plant of this family (*Cynanchum ovalifolium*). Also that from Sumatra, (*Urceola elastica*, Roxb.), from Madagascar (*Vahea gummifera*, Poir), a part of the Brazilian (*Collophora utilis*, Mart. and *Hancornia speciosa*, Mart.), and the East Indian (*Willughbeia edulis*), are obtained from plants which belong to the group of *Apocynaceæ*.

Most strangely, this family also, as well as the following and last, exhibits the peculiar phenomenon which was described in the first-named, the *Euphorbiaceæ*, namely, that the milk-sap is in some species rich in Indian rubber, in others, it is tempered into a clear, agreeably smelling, and wholesome milk, while in certain others, on the contrary, this fluid grows, step by step, through successively increasing quantity of noxious matter, to a most dreadful poison. In the forests of British Guiana grows a tree which the natives call Hya-Hya (*Tabernæmontana utilis*, Arn.) Its bark and pith are so rich in milk that an only moderate-sized stem which Arnott and his companions felled on the bank of a large forest-brook, in the course of an hour coloured the water quite white and milky. This milk is perfectly harmless, of a pleasant flavour, and is taken by the savages as a refreshing drink. Still more pleasant must be the taste of the milk of the Ceylon Cow-tree, the Kiriaghuma (*Gymneura lactiferum*, Rob. Br.) which, according to Burmann's narrative, the Cingalese use exactly as we do milk.

Dreadful, on the contrary, is the action of the terrible Wourari poison, which the inhabitants of the banks of the Orinoco concoct with mystic conjurations, the chief ingredients of which are furnished by the juice of a plant belonging here (*Echites suberecta*), and the bark of another, likewise an Apocynaceous tree, *Strychnos guianensis*, Mart. and *Str. toxifera*, Schomb.) Schomburgk has recently given us a highly poetical description of the preparation of this poison in the valuable Reports of his Travels, which hitherto, unfortunately, have only appeared in fragments in particular journals.

Pöppig during his romantic wanderings in South America, had often an opportunity of becoming acquainted with the frightful action of the Wourari. A large, long reed is hollowed out by the Indians, and very carefully polished. The arrows, about a foot long, are cut out of very hard wood; the point is dipped in the poison, and the other end wrapped round with cotton, so as exactly to fill the tube. Armed with this fearful weapon, the savage steals upon the unoffending foe, who is perhaps busy preparing a dainty meal from the newly killed deer. No rustling nose betrays the practised foot that comes gliding on; no eye perceives, through the dense thicket, the deadly reed from which, impelled by a strong puff alone, the winged messenger of death noislessly and surely reaches, even at a distance of thirty paces, the unwarned and defenceless victim, who, from the slightest wound, in a few minutes expires in convulsions.

The North Americans also use an Apocynaceous plant (*Gonolobium macrophyllum*, Mich.) to poison their arrows; and Mungo Park related the like of the Mandingoes of the Niger, (according to him it is a species of *Echites*).

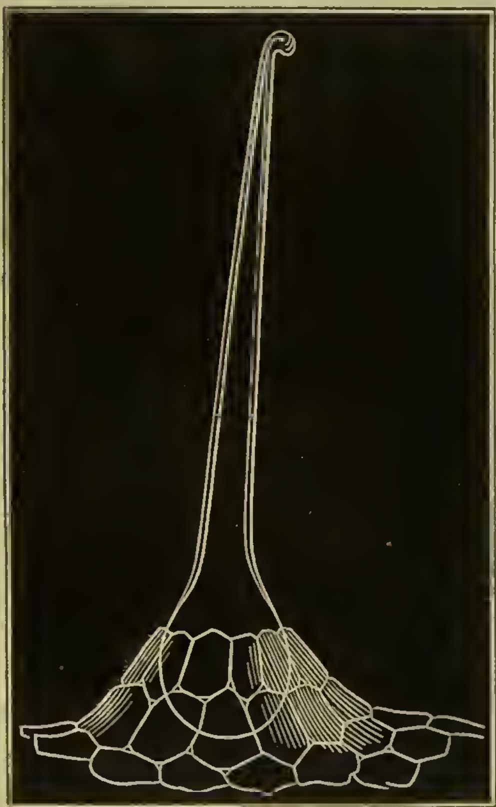
Many other allied plants are among the most active poisons (*Cerbera Thevetia*, and *C. Ahovai*), and the seeds of this group, in particular, are almost more remarkable for their deadliness than those of the foregoing, for two of the most violent vegetable poisons, Strychnine and Brucine, occur in them. Some of our most active medicinal substances are especially known on this account; for instance, the St. Ignatius's beans (*Ignatia amara*, from Manilla), and the Nux Vomica (*Strychnos nux vomica*, distributed throughout the Tropics.)

I must not neglect to mention here a strange custom of the inhabitants of Madagascar, among whom, in a kind of divine judgment, the strength of the stomach decides upon guilt or innocence. When any one is accused of a crime, he is compelled, in an open assembly, under the directions of the priests, to swallow a Thangin nut (from *Tanghinia venenifera*): if his stomach is in a condition to reject this frightful poison upward, he is pronounced innocent; if not, the demonstration of his guilt becomes at the same time his punishment, and the death of the unhappy creature concludes the evidence.

It would not be difficult to make some of the more important characters of the two families I have mentioned, so clear, even to a person unacquainted with Botany, that he would be enabled readily to distinguish any plant belonging to them. Very different is it with the following, the last group, the Jussieuan family of Nettle-plants or *Urticaceæ*. The plants belonging to this vary in the most striking manner in their external forms, from the smallest, most insignificent weeds, like our common Pellitory of the wall, and our Nettles, to vast and most stately trees like the Bread-fruits (*Artocarpus integrifolia* and *incisa*), which, with their wide-stretched branches and broad beautifully formed leaves, overshadow the huts of the South Sea islander, who lives upon their savoury fruit. As in the family of the Spurges, only some few plants bestow, in their seed, a pleasant, nut-like kernel (as *Aleurites triloba* in the Moluccas, *Conceveiba guianensis* in South America); as in the Apocynaceous group, several trees afford cooling, juicy, and therefore, highly-valued fruits to the inhabitants of hot regions (*Carissa Carandas* in the East Indies, *C. edulis* in Arabia, &c.), so the family of the *Urticaceæ* includes the strangest multiplicity of fructifications. The little oil grains of the Hemp, the green grape-like bunches which gracefully adorn the slender twining Hop, the aromatic Mulberry, the sweet Fig, the useful Bread-fruit, all these so various forms belong to one group of plants, and the Botanist traces in all the same fundamental structure, however incongruous these manifold shapes may appear to the eye of the uninitiated. One peculiarity, alone, extends without exception throughout all the species of this large order, namely, the presence of fine, but strong bass-fibres in the bark. The German name for muslin, *Nessel-tuch* (nettle-cloth), denotes the source from whence the fibre of which it is made was originally obtained (*Urtica cannabina*), and the skilful industry of the gentle Tahitan prepares the most delicate stuff, without spinning-wheel or loom, from the fine white bass of the Auté or Paper-Mulberry, (*Broussonetia papyrifera*, Vent.)

An elegant tree, allied to the last, the *Holquahuitl* of the Mexicans, or *Ule di Papantla* of the Spaniards (*Castilloa elastica Deppe*), furnishes the Caoutchouc of New Spain, and the inconceivable quantities of this substance which are brought to our ports from the East Indies, are collected in great part from the venerable Fig-trees in which that Asiatic tropical world is so rich. On a trunk of giant girth, but seldom more than fifteen feet high, rests the enormous crown of the Banyan or Holy Fig (*Ficus religiosa*); the branches often run a hundred feet horizontally out from the trunk, sending down to the ground, at various intervals, long straight roots, which quickly penetrate and take firm hold, thus becoming props to the long branches. These wonderful trees, each one resembling a small wood, are dedicated to the god Fo, and the helpless, lazy Bonze builds his hut, not unlike a bird-cage, in its branches, in which he passes the day sometimes asleep, sometimes dreaming in contemplative indolence in the pleasant cool shade. These great Fig-trees (*Ficus religiosa*, *indica*, *benjaminea*, L., *elastica*, Roxb.) have sweet fruits, and their milk-sap contains the interesting Caoutchouc. Some of these plants also yield a harmless juice. By far the most remarkable in this respect, is the *Palo de Vacca* or *Arbol de Leche*, the Cow-tree of South America (*Galactodendron utile*, Kunth), which was first made known to us by A. von Humboldt. When a tolerably large incision is made into the trunk of this tree, a white, oily, fragrant and sweet fluid, very similar to animal milk, flows out in sufficient quantity to refresh and satisfy the hunger of several persons.

A striking contrast to this is afforded by the properties of other Nettle-plants. One is tempted to call them the serpents of the vegetable kingdom ; and the parallel is not difficult to carry out. The similarity between the instruments with which both produce and poison their wounds is very remarkable. The snakes have in the front of the upper jaw two long, thin, somewhat curved teeth, which are perforated lengthways by a minute canal, which opens in front at the sharp point. These teeth are not fixed firmly in the jaw like the others, but moveable, like, but in a less degree, the claws of a cat. Beneath each tooth, in a cavity in the jaw, lies a little gland, in which the poison is prepared, and the excretory duct of this gland runs through the canal in the tooth, and opens at its apex. When the animal bites, the resistance of the bitten body pushes back the tooth, so that it presses upon the gland, which squeezes out of it the deadly fluid, into the wound.



If we examine, now, the hairs on the leaf of the Nettle, we find a wonderful agreement. The stinging hair consists of a single cell, terminating above in a little knob. Below, it expands into a small sac, which contains the irritating juice.

The slightest touch breaks off the brittle point with the little knob, the canal of the hair is thus opened, and it penetrates any soft substance; in consequence of the pressure which the resistance to its entry exerts upon the sac, a portion of the poisonous juice is ejected out into the wound. The poisons of our native Nettles and Snakes are not of much consequence, but the nearer we approach the tropics the more frequent and more deadly they both become. Where the glowing Indian sun ripens the poison of the fearful Spectacle-snake, there grow the most dangerous Nettles. Every one among us has felt the slight but irritating sting of the Nettle, which it produces by its slender poisonous hair, but we have no notion of the torture which its near allies (*Urtica stimulans*, *U. crenulata*, Roxb.) produce in the East Indies. A gentle touch suffices to cause the arm to swell up with the most frightful pain, and the suffering lasts for weeks; nay, a species growing in Timor (*Urtica urentissima*, Blume), is called by the natives *Daoun Setan* (devil's leaf), because the pain lasts for years, and often even death can only be avoided by the amputation of the injured limb.

We do, indeed, find many violent poisons in this family, and even some species of Fig are included among the most dangerous plants (*Ficus toxicaria*, L.), but it is not worth while to linger among those of lesser importance. The tales recounted of the Upas and the Poison-valley mingle almost like a dark and gloomy legend in our knowledge of the East Indian Islands. The crown of the Dutch colonies, Java, destined, both from its favourable position and inexhaustible wealth of production, to become, in time, the central point of the great Indian Archipelago, has at all times attracted the attention of naturalists in the highest degree. Holland has always had the glory never to have forgotten, at any time or in any of her colonies, to note the natural productions of the countries she has acquired, and to encourage the efforts of Natural Science, to aid and to reward them Swammerdamm, Leuwenhoek, Rheede tot Drakensteen, Rumph, and others, not to speak of the living, will ever shine as immortal names in the annals of Science. For the descriptions we now possess of the Poison-tree, of which we are speaking, we have to thank the encouragement and assistance which the Dutch Government granted to naturalists, especially to the yet living Drs. Blume and

Horsfield, the latter of whom, although an Englishman, began his researches, under the protection of the Dutch Government, so early as 1802, therefore eight years before the short occupation of Java by the English.

In the 16th century, stories circulated about the Macassar Poison-tree of Celebes; and physicians and naturalists came gradually to tell of the action of the poison, the descriptions of which had become so terrible, that if the smallest quantity entered the blood, not only immediate death resulted, but its action was so fearfully destructive, that within half an hour afterwards the flesh fell from the bones. The first description of the tree was given by Neuhof, in 1682. Dreadful as the poison is represented to be by this old author, his accounts are free from the gloomy fables which subsequent writers promulgated. At the end of the 17th century Gervaise asserted, that merely to touch or smell the tree was fatal; and in Camel (1704), we find the story, that the vapour from the tree destroyed everything living for a considerable distance around, and that the birds which settled on it died, unless they immediately eat the seeds of the Nux Vomica, by which, indeed, their lives were saved, but with the loss of all their feathers. Before this time, Argensola (*Conquista de las islas Molucas*) had told of a tree, in the neighbourhood of which every one fell asleep and, if he approached on the west side, died; while, if he came to it on the east side, that very sleep shielded him from the deadly action. It was now said, also, that the collection of the poison was committed solely to criminals whose lives were forfeited, and who escaped their punishment if they successfully completed their task. From Rumph we learned that the Poison-tree is also met with in Sumatra, Borneo, and Bali, as well as in Celebes. But the Dutch surgeon, Försch, first spread the wild tales of the Poison-tree of Java about the end of the eighteenth century. His letter upon it appeared originally in 1781, and, after a time, was translated into almost every European language, —its contents being received into all the manuals of Natural History and Geography. The Commissioners of the Batavian Society, Van Rhyn and Palm, gave a very different report in 1789, for they not only declared that all Försch's narratives were false, but wholly denied the existence of such a Poison-tree in Java. Staunton, Barrow, and Labillardière expressed similar opinions; while, on the other hand, Deschamp, who sojourned in Java several years, declared that the Upas occurred pretty frequently in the district of Palembang, but that there was no more danger in its vicinity than in that of any other poisonous plant. In 1712 the cautious and sober Kämpfer added, in his ample account of the Poison-tree of Celebes, "but who could repeat anything after an Asiatic, without mixing up fables in his statement?" Nevertheless, the more recent researches of Leschenault (1810), of Dr. Horsfield (1802-18), and lastly of Blume, have fully confirmed the accuracy of all the different reports, and shown us how the confounding and mingling of very distinct things gave rise to all those certainly partly fabulous narratives.

Two very different trees grow in those little visited primeval forests of Java. All the paths leading to them are closed and watched, like those leading to the gates of the Holy of Holies. With fire and axe must the road be made through the impenetrably interwoven mass of Lianes, the Paullinias, with their clusters of great scarlet blossoms several feet long, the Cissi or wild Vines, on the wide-spread creeping roots of which thrives the giant flower of the *Rafflesia Arnoldi.* Palms, with spines and thorns, Rush-like plants, with cutting leaves, wounding like knives, warn the intruder back by their attacks, and in every part of the thicket threaten the fearful Nettles formerly mentioned. Great black ants, whose painful bite tortures the wanderer, countless swarms of tormenting insects pursue him. Are these obstacles overcome? yet follow the dense bundles of Bamboo stems, as thick as a man's arm, and often fifty feet high, the firm glassy bark of which repels even the axe. At last the way is opened and the majestic aisles of the true primeval forest now display themselves. Gigantic trunks of the Bread-fruit, of the iron-like Teak (*Tectona grandis*), of *Leguminosæ*, with their beautiful blossoms, of Barringtonias, Figs and Bays, form the columns which support the massive green vault. From branch to branch leap lively troops of apes, provoking the wanderer by throwing fruit upon him. From a moss-clad rock the melancholy Orang-outang raises himself gravely on his staff, and wanders into deeper thickets. All is full of animal life; a strong contrast to the desert and silent character of many of the primeval forests of America. Here a twining, climbing shrub, with a trunk as thick as one's arm, coils round the columns of the dome, overpassing the loftiest trees, often quite simple and unbranched for a length of a hundred feet from the root, but curved and winding in the most varied forms. The large, shining green leaves alternate with the long and stout tendrils with which it takes firm hold, and greenish-white heads of pleasant smelling flowers hang pendant from it. This plant, belonging to the *Apocynaceæ*, is the *Tjettek* of the natives (*Strychnos Tieuté*, Lesch.), from the roots of which the dreadful *Upas Radia,* or Sovereign Poison, is concocted. A slight wound from a weapon poisoned with this,—a little arrow made of hard wood, and shot from the blow-tube, as by the South Americans,—makes the tiger tremble, stand motionless a minute, then fall as though seized with vertigo, and die in brief but violent convulsions. The shrub itself is harmless, and he whose skin may have been touched with its juice need fear no consequences. As we go forward, we meet with a beautiful slender stem, which overtops the neighbouring plants. Perfectly cylindrical, it rises sixty or eighty feet smooth and without a branch, and bears an elegant hemispherical crown, which proudly looks down on the more humble growths around, and the many climbers struggling up its stem. Woe to him who heedlessly should touch the milk-sap that flows abundantly from its easily wounded bark. Large blisters, painful ulcers, like those produced by our poisonous Sumach, only more dangerous, are the inevitable consequences. This is the *Antiar* of the Javanese, the *Pohon Upas* (signifying Poison-tree) of the Malays, the *Ipo* of Celebes and the Phillippines (*Antiaris toxicaria,* Lesch.). From it comes the common Upas (*anglicè* poison), which is especially employed for poisoning arrows, a custom which appears to have extended formerly throughout all the Sunda Islands, but which is now, since the introduction of fire-arms, only to be met with among the savages of the rugged and inaccessible mountains of the interior of the islands. At once awful and grandly sublime is the character of these mountains, which, like the whole island, owe their origin to the most terrible volcanic forces. Everywhere are still seen the traces of the subterranean fire, even in those forests, especially if the gradual ascent of the mountains is commenced where the woods clothe their feet. The highest peaks are the fearful volcanoes, the terrors of which have long been known. To these succeed the remarkable mud-volcanoes, which, without fire or light, often break out suddenly, and without the slightest warning. The mountain Galungung thus discharged itself on the 8th and 12th of October, 1822, turning forty English square miles into a desert, filled up valleys forty to fifty feet deep, dammed rivers, and buried in its filthy flood 11,000 men, countless draught oxen, 3,000 acres of Rice fields, and 800,000 Coffee trees. Lower down, at the foot of the mountains, appear springs of all kinds, many of them sour from the great amount of free sulphuric acid present, others petrifying the neighbouring trees with the silex dissolved in them, or displaying a milky whiteness, from the quantity of fine powder of sulphur diffused through their waters. In other places are found crowded groups of cones of gypsum, three to five feet high, from the points of which hot or cold water unceasingly bubbles, ever increasing the size of the cones by its deposits. Large tracts are desolated by the action of the great volcanic phenomena. But new, fresh life springs up everywhere, side by side with destruction, and clothes once more the naked earth. Only particular regions make exceptions to this rule. Leaving the thickets of the old forest and climbing a moderate hill, suddenly, in a narrow flat valley, a horrible wilderness, a true palace of death, spreads itself out before the eyes of the shuddering wanderer. No trace of thriving vegetation screens the naked sun-scorched earth. Skeletons of all kinds of animals bestrew the ground. There is it often seen how the terrible tiger, in the moment when he has seized his prey, is himself overtaken by destruction; how the bird of prey, hurrying to feed upon the fresh carcase, falls into the maw of death. Dead beetles, ants and other insects, lie in heaps around, and testify still more how apt the name, "Valley of Death," or "Poison Valley," as these places are called by the natives. The formidable character of these localities arises from the exhalations from the soil, consisting of carbonic acid gas, which, on account of its weight, is a long time diffusing itself in the air. Exactly as in the celebrated *Grotto del Cane*, at Naples, in the vapour caves of Pyrmont, this gas causes inevitable death by asphyxia to all near the surface of the soil. Man alone, to whom God has given it to walk erect, traverses usually uninjured these deserted tracts, since the poisonous exhalations do not reach up to his head. As the natives of the Himalayas ascribe the difficulty of respiration experienced in the higher alpine passes, 15,000 and 16,000 feet above the sea, to the exhalations of poisonous plants, so were the terrible phenomena of the death valleys connected with the action of the Antiar poison and the deadly touch of the Pohon Upas; and it is natural that the legends should have gradually assumed their so frightful character, since, even up to the present time, no antidote to those violent and rapidly acting vegetable matters has been discovered. We will not envy the inhabitant of the tropics the milk of his Cow-tree—and, content with the gift of the useful Caoutchouc, we will readily resign the luxuriant nature of those regions, which have so much of the terrible mingled with their beauty. No remedy yet restrains the operations of those poisons; like the destroying Ænigma, they oppose themselves to the human race, and make good the proposition, that the bright lights of tropical nature necessitate black shades among them, and that more than one Dragon watches these gardens of the Hesperides.

But I observe with dismay, that I have strayed far from my original subject. Paletôt and Mackintosh were the watchwords of the strife; the superiority of the latter was to be my theme, but I have, indeed, wandered too far away from it to think of returning to it here.

Ninth Lecture.

A SKETCH OF THE CACTUS TRIBE.

"To him who from this lofty spaee looks down
On that wide realm, it seems some painful dream,
Where shapelessness on shapelessness is piled,
Irregularity holds systematie rule."

FAUST.

LECTURE IX.

We may, more especially through the progress of reeent times, define the purpose of all investigation in Natural Seience, the lowest equally with the highest, as an attempt to show that the whole world around us is bound by exceptionless, mathematieal laws, and to deduee from sueh laws, every mutation that oeeurs. Very dissimilar are the degrees of completion in the different branches of Natural Seience, nay, the degrees even in which they have attained the eoneeption of their highest aim, or have more or less advanced toward it. Between astronomy, the most perfeet portion of human scienee, and the knowledge of organie existenee, yawns a vast gap, to the filling up of which mankind has yet tens of centuries to labour to carry over it a firm and solid road. Sinee it really does not lie in the industry of the inquirer, we must seek in the matter itself the reason why our scientific knowledge of organic existenee is yet so far distant from its ideal, that there are even still Natural Historians who will not for a moment aeknowledge the final conclusion. In Nature, we find manifold substances whieh act and reaet one upon another; and hence proceeds an incessant play of activity, the clearest and grandest example of which is afforded by the fixed regularity of the movements in our solar system. Even here this play of force exhibits a determinate form, for the paths of the planets do not all, in like manner, circle in one and the same line drawn around the sun, but each in its own way deviates from this line; while the magnitudes of the planets do not increase or decrease, &c., in a constant ratio, from the sun. Here, at present, our knowledge is at a stand, and we are unable to find a regular deduction for these forms of the solar system. But the peculiar forms become far more complex in the natural processes upon the earth; and here, where they at once present themselves without our seeking and can readily be reviewed as a whole, we call them "shapes." We might anticipate, in regard to crystals, on account of their regular mathematical forms, that they are subject to rigid laws of formation; but even here, it always appears to be purely accidental that common salt and iron pyrites crystallize in true cubes, and not in eight-sided bodies, like fluor-spar. Lastly, in plants and animals, the forms become so varied and so aberrant, that a mathematical basis is out of the question. All here seems pure accident, or capricious sport of a blindly-acting force of Nature. Yet there lies in Man an irrecusable necessity, never, in his contemplations of the world, to allow of *accident*, which would leave him comfortless and hopeless in the presence of the forces of Nature, to which he is subject; and, therefore, where the understanding of the law is at present denied to him, he makes the circumstances yield to a conformity according to the standard of his own modes of action, the final cause of which he seeks in a mighty and wise Creator and Sustainer of the World. But how insufficient this is for the scientific examination of Nature is evident at once, from the fact, that in such an act of judgment, we do not make one step toward the accomplishment of our purpose. In reference to the animals nearest approached to ourselves, we are readily able to comprehend the relations of form to the mode of life; we clearly perceive that a bird's form is most perfectly adapted for flight, a fish's for swimming, and we admire the intelligence with which Cuvier made use of the purpose for which the animals were destined, to unfold with convincing certainty their form and the minutest distinctions of their anatomical structure. But let us enter the Grotto of Antiparos, where thousands of crystals refract the light of the torches with such wonderful brilliancy, and realize to us the legends of the fairy world; let us break a path through the dense forests of Guiana, where the giant stems of the thousand-yeared Bertholletias stand side by side with the slender pillars of the Palms, the delicately feathered frond of the Ferns strangely contrasted with the broad simple leaf of the Banana, where the bare, thin, hundred-feet-long stem of the Liane stretches from tree to tree like the rigging of a ship, up and down which clambers the slim tiger-cat—while thousands of elegant little Mosses and Liverworts clothe the trunks; let us mark how the most varied colours and most wondrous forms of the splendid flower-world of the tropics fill up the intervals—then, indeed, the boldest imagination pauses at the seeking out and establishing of definite conceptions of conformity for the manifold forms and fashionings, and Nature leaves us no other criterion for judgment of her work but the principal of Beauty; this alone still speaks to our feelings and leads us to adore the higher Existence, of which this immeasurable wealth of varied shape becomes a holy revelation. But, alas! we become aware that not even this idea is sufficient to serve us as a guiding star through the countless forms of Nature. With the feeling that, where we cannot explain by law, where we cannot decide from the purpose, yet, at least, the inexplicable existence of Beauty may suffice to interpret in mysterious fashion the symbols of Nature—let us leave the forests of Guiana, the last mat-roof of the Guaranese between the trunks of the Mauritius Palm, and enter the Pampas of Venezuela, of which Humboldt has sketched such a clever and vivid picture. No smiling verdure clothes the glowing rock-soil here; here and there in its crevices the Melocactus displays its round balls, " horrid " with threatening thorns. Ascend we thence the Andes; instead of tender grass, the earth is covered with pale, grey-green globes of spiny Mammillarias, while, intermingled, rises the serious and mournful old-man Cactus, with its venerable-looking long gray hair. Borne on the wings of fancy further north, we descend into the plains of Mexico, where the gigantic fragments of the city of the Aztecs, a product of a solitary era of civilization long lost to history, display themselves; the landscape spreads out before us as the bare and naked *Tierra caliente*, parched by the glowing sun; of a dull green hue, without a branch or leaf, the angled columns of the Torch-thistles rise twenty or thirty feet high, hemmed in with an impenetrable thicket of irritably pricking Indian Figs, while round about appear the strangest, ugliest forms, in the groups of the *Echinocacti* and little *Cerei*, between which creeps snake-like, or as some great poisonous reptile, the long, dry stem of the great-flowered Cactus (*Cereus nycticallus*). In short, one family accompanies us through all our wanderings, that of the Cactus Plants, which seems in all its wondrous forms to withdraw itself entirely from the principle of Beauty, and yet at the same time presses forward so strikingly, so determinately marking the peculiar character of the landscape, that we are compelled to turn our attention to it. And in truth, a group which appears to retreat so far from all the laws of other plants, deserves our interest in a very high degree. It has received it in rich measure, and for those whose circumstances do not permit of their making acquaintance with these children of a humourous freak of Nature in their own native land, our gardens, in which the Cactus Plants have come to be among the most fashionable, will exhibit an abundant selection of shapes. A somewhat minute examination of this peculiar family will, therefore, not only be instructive to the lover of Nature, but may possess also an especial interest at this particular time.

Linnæus was acquainted with only about a dozen species out of the whole family, and these he united together under the name of Cactus; at present, more than four hundred species are known, which are distributed by Botanists into somewhere about ten genera. Most of these are under cultivation in Germany. The richest collection is probably that in the Royal Botanical Garden at Berlin, which possesses more than three hundred and sixty species; next follows, undoubtedly, the collection of the Prince Salm-Dyk Reifferscheide. The Royal Botanical Garden at Munich, the Garden of the Japanese Palace at Dresden, are the next in importance. Those most perfect in the neighbourhood of Jena are, the Collection of Haage at Erfurt, and Breiter's Garden in Leipsic.

Everything about these plants is wonderful. With the exception of the genus *Peireskia*, no plant of the order possesses leaves. Those parts of *Cactus alatus*, and the Indian Fig, which are commonly called leaves, are nothing but flattened expansions of the stem. On the other hand, they are all distinguished by an extraordinarily fleshy stem, which, clothed by a greyish-green, leathery cuticle, and beset, in the places where leaves are situated in regular plants, with various tufts of hairs, spines and points, gives by its very varied degrees of development, the varied character of the plants. The Torch-thistles rise in form of nine-angled or often round columns, to a height of thirty or forty feet, mostly branchless, but sometimes ramifying in the strangest ways, and looking like candelabra; the Indian Figs are more humble; their oval, flat branches, arranged upon one another on all sides, produce special forms. The lowest and thickest Torch-thistles connect themselves with Hedgehog and Melon-Cactuses, with their projecting ribs, and thus lead us to the almost perfectly globular Mammillarias, which are covered very regularly with fleshy warts of various heights. Finally, there are forms in which the growth in the longitudinal direction prevails, which with long, thin, often whip-like stems, like that of the Serpent-Cactus, so often cultivated here, hang down from the trees upon which they live as parasites.*

Few families have so limited a range of distribution upon the globe. All the species of Cactus, perhaps without a single exception, are indigenous in America, between the parallels of 40° S. lat. and 40° N. lat. But some of them were so rapidly distributed through the Old World directly after the discovery of America, that they may almost be looked upon as fully naturalized there. Almost all delight in a dry situation, exposed to the burning rays of the sun, which contrasts strangely with their fleshy tissue, tumid

* See the Vignette, in which the principal forms of this group of plants are represented.

with watery, and not unpleasantly flavoured acid juice. This peculiarity gives them inestimable value to the fainting traveller, and Bernardin de St. Pierre has aptly called them the "Springs of the Desert." The wild Ass of the Llanos, too, knows well how to avail himself of these plants. In the dry season, when all animal life flees from the glowing Pampas, when Cayman and Boa sink into death-like sleep in the dried-up mud, the wild Ass alone, traversing the steppe, knows how to guard against thirst; cautiously stripping off the dangerous spines of the *Melocactus* with his hoof, and then in safety sucking the cooling vegetable juice. In vertical extension, the Cacti are not confined within such narrow limits, and they stretch from the lowest tracts along the coast, through the vast plains, up to the highest ridges of the Andes chain. On the shore of the Lake Titicaca, 12,700 feet above the level of the sea, are seen the tall-stemmed *Peireskias* with their splendid deep brown-red blossoms, and on the plateaux of southern Peru, near the limit of vegetation, therefore about 14,000 feet high, the wanderer is surprised by peculiar shapes of a yellowish-red colour, which at a distance look like reposing savages, but which a closer inspection reveals to be shapeless heaps of low Cacti, closely beset with yellowish red spines.

What Nature has withheld, however, in external aspect, she has, in most, richly replaced in the magnificent blossom. We are astonished to find the deformed grey-green mass of the Mammillaria decked with the most beautiful purple-red flowers. Strange is the contrast between the wretched and gloomy aspect of the naked, dry stem of the large-flowered Torch-thistle (*Cereus grandiflorus*) and its large, splendid, Isabel-coloured, Vanilla-scented flowers, which, unfolding under cover of the silent night, beam like suns, and in the wonderful sporting of their stamens, seem almost to strive towards a higher—an animal life.

But it is not the beauty of the blossom alone which gladdens us, not the refreshing sap alone that revives the languishing traveller. The economic uses are also manifold. Almost all the Cacti bear edible fruit, and a portion of them are among the most delightful refreshments of the hot zones which ripen them. Almost all the larger Opuntias, known by the name of Indian Figs, furnish, in the West Indies and Mexico, a favourite dessert fruit, and even the little rose-red berries of the Mammillarias, which with us are tasteless, have, beneath the tropics, a pleasant, acidulated, sweet juice. We may say, in general terms, that their fruit is a nobler form of our native Gooseberry and Currant, to which also they are the nearest allies in a botanical point of view. Succulent as is the stem of most of the Cacti, yet, in the course of time, they perfect in it a wood as firm as it is light. This is especially the case in the tall columnar species of *Cereus*, the old dead stems of which, after the decay of the grey-green rind, remain erect, their white wood standing ghost-like among the living stems, till a benighted traveller seizes it in that scantily wooded region, to make a fire to protect him from the musquitoes, to bake his Maize-cake, or burns it as a torch to light up the dark tropical night. It is from the last use that they have obtained their name of Torch-thistles. These stems, on account of their lightness, are carried up on mules to the heights of the Cordilleras, to serve as beams, posts and door-sills in the houses; as, for instance, in the mayoral of Antisana, perhaps the highest inhabited spot in the world (12,604 feet). Just as their allies, the

Gooseberry bushes, are used by our country people to form hedges to their gardens, are the Opuntias in Mexico, on the west coast of South America and in the southern part of Europe, and with greater success in the Canaries; their firm, shapeless branches soon interweave themselves into an impenetrable barrier, opposing, by their dreadful spines, an insuperable obstacle to the intruder. Lastly, the medicine-chest does not go away empty, for the physicians of America make abundant use of the acid juice for fomentations in inflammations, and give the boiled fruit in affections of the chest; not to mention some other prescriptions.

In the same way that grass and clover are not immediately valuable to man, but serve as food for useful animals, so is it with a number of Cacti, which support an insect of extraordinary importance. This is the Cochineal insect (*Coccus Cacti*), a little, very insignificant creature, externally just like the little, white, cottony parasite, which is so often found upon the plants in our hot-houses, and yet, through the invaluable colouring matter it contains, so infinitely different from it. Formerly the culture of Cochineal was confined to Mexico alone, and the Government took great care to keep it secret. In the year 1725, there were animated debates in Europe, as to whether the Cochineal was an insect or the seed of a plant. Thierry de Menonville carried it, at the peril of his life, to the French colony of St. Domingo, in 1785. It was also introduced into the Canaries, through Berthelot, in 1827. In recent times, successful experiments in its culture have been made even in Corsica and in Spain. But although it is now abundantly raised in Brazil and the East Indies, Mexico still produces the greatest quantity and the finest kind. According to Alexander von Humboldt* the export of

* Essai politique sur la nouvelle Espagne, Vol. III.

Cochineal from Oaxaca alone, is now valued at £500,000, an enormous sum, if we recollect that a pound costs about thirty shillings, and contains some 70,000 insects. The provinces in which the culture of Cochineal is most largely carried on, are Oaxaca, Tlascala and Guanaxuato. The *Tuna Cactus (Opuntia Tuna)* is raised in fields in the great mayorals, which are called *Nopaleros*, from the Spanish name of the Opuntia *(Nopal)*. The Cochineal Cactus *(Opuntia coccinellifera)* as it is called, is used only in the West India Islands and Brazil. It is necessary to renew the plantations frequently, as the insect rapidly exhausts the juices of the plant, so that it dries up and dies. The traders distinguish two kinds of Cochineal, the *grana fina* and the *grana sylvestre;* the former is richer in colouring matter and its colour is brighter, the substance which invests the insects is also more pulverulent, while in the latter it is flocculent. However, it has not yet been made out whether these differences indicate two different species of the insect, or depend on a difference in the mode of culture and the species of plant on which the animal lives. When the animals are fully developed, they are swept from the branches of the plant with a squirrel's tail, and killed by the heat of the sun or hot water, dried and brought into the market. We prepare from them the costly carmine by the addition of a preparation of tin, and the carmine-lake (Florentine lake) by a combination with pure alumina.

While the ugly form, the splendour of the blossom, and the manifold uses of the Cactus plants attract general interest in a high degree, they are not less interesting, in a narrower sphere, to the Botanist. Zoologists have at all times found in the examination of monstrosities and aberrant forms, rich material toward the clearing and expanding of their knowledge of the regularly developing organism. It is to be expected, therefore, that similar conditions will have similar value in the vegetable world; and what family could be better selected for this purpose than the *Cactaceæ*, which seems to be but a natural museum of monstrosities, where the forms are, in some cases, so abnormal, that no other name could be thought of for one species, but that of the Deformed Cactus (*Cereus monstrosus*). They have attracted the attention of Botanists on several accounts, and many peculiarities, both anatomical and physiological, have been discovered, through which they are separated from all other, even the nearest allied plants. The results would, indeed, be still much more interesting, if it were not so infinitely difficult to obtain the material for researches, since gardeners and amateurs are but seldom inclined to devote their darlings to the knife of Science.

The *Cactaceæ* have long been compelled, in science, to serve as the prop of a statement which, altogether false, has yet been frequently put forward by distinguished Botanists; I mean, the assumption that many, or even all, plants are capable of imbibing their nutriment from the air. Even in the present day has this idea been again revived with all the long ago refuted reasons, by Liebig, whose Organic Chemistry has made so imposing an appearance. It is believed, that from the vast amount of watery juice in the Cactus tribe, joined to the fact that most of them, and exactly those richest in sap, vegetate on dry sand, almost wholly devoid of vegetable mould, where they are besides exposed often three-fourths of the year to the parching sun-beams of an eternally serene sky; from this combination of circumstances, even, it is thought that we may the more safely conclude, that these plants draw their nourishment from the air, since in our own hot-houses also it has been observed, that the branches of Cactus stems, cut off and left forgotten in a corner without further care, far from dying, have frequently grown on and made shoots three feet long or more. De Candolle first found the right path, when he weighed such Cactus shoots which had grown without soil, and found that the plant, though larger, was always lighter, therefore, instead of abstracting anything from the atmosphere, must rather have given up something to it. All the growth takes place, in such cases, at the expense of the nutritive matter previously accumulated in the juicy tissue, and it generally exhausts the plant to such a degree, that it is no longer worth preserving. It is that succulent tissue which enables the Cactus plants,—one might compare them with the Camels,—to provide themselves beforehand with fluid, and thus to brave the rainless season. Their anatomical structure also assists them in this respect, in a peculiar manner. We know, from the experiments of Hales, that plants chiefly evaporate the water they contain, through their leaves, and the Cactus tribe have none. Their stem, too, unlike that of all other plants, is clothed with a peculiar leathery membrane, which wholly prevents evaporation. This membrane is composed of very strange, almost cartilaginous cells, the walls of which are often traversed by elegant little canals. Its thickness varies in different species, and it is thickest, and therefore most impenetrable in *Melocacti*, which grow in the dryest and hottest regions, while it is least remarkable in the species of *Rhipsalis*, which are parasites on the trees of the damp Brazilian forests.

Another striking point about this group, is the formation of an extraordinary quantity of oxalic acid. If this acid were collected in large amount in the plant, it must necessarily be deadly to it. The plant, therefore, takes up from the soil on which it grows, a proportionate quantity of Lime, which combines with the oxalic acid, forming insoluble crystals, which occur in abundance in all the *Cactaceæ*. In some species, as for instance, in the Peruvian and old-man Cactus, the plant contains eighty-five per cent. of oxalate of lime. Oxalic acid might certainly be obtained with profit from these plants in the tropics.

A third peculiarity is exhibited in the globular forms of *Melocactus* and *Mamillaria*, in the structure of the wood, which differs entirely from that of the common ligneous plants. Common wood, for example that of the Poplar, is composed of long *wood-cells*, the walls of which are quite simple and uniform, and of cells containing air, the so-called *vessels*, the walls of which are very thickly beset with little pores. Wholly unlike this, the wood of the Cactus, above mentioned, exhibits only short, spindle-shaped cells, inside which wind most elegant spiral bands, looking like little spiral staircases.

Lastly, the hairs, spines, &c. situated in the places of leaves, deserve a special mention. Generally speaking, three forms may be distinguished, all three usually occurring together on the same spot. The first are very flexible, simple hairs, which form a little flat, soft cushion; among these is found a bunch of longish but thin spines. These it is chiefly, which, on account of their peculiar structure, make the careless handling of the Cactus plants so dangerous. These little spines are very thin and brittle, so that they readily break off, and are covered with barbed hooks directed backward from the point. When touched, a whole bunch at once penetrate the skin; if an attempt is made to draw them out, the separate spines break in the skin, and the fragments pierce in other places; when the hand is drawn over them, they catch in, and an insufferable itching, terminating in a slight inflammation, spreads over all the parts which have been touched. The *Opuntia ferox* is especially remarkable for these spines, whence its name, the *savage*. Among the hairs and smaller spines arise very long and thick spines, in different form and number, which give the best characters for the determination of the species. In some, these are so hard and strong, that they even lame the wild Asses which incautiously wound themselves, when kicking off the spines to reach the means to still their thirst. In *Opuntia Tuna*, which is the kind most frequently used for hedges, they are so large that even the Buffaloes are killed by the inflammation following from these spines running into their breasts. It was this species also, which was planted in a triple row, as a boundary line between the English and French in the Island of St. Christopher.

This brief review may then suffice to justify the interest which this family has now generally awakened. The closer investigation of it affords rich matter for the Naturalist, its manifold uses, especially in its native clime, worthily occupies the attention of State Economists; but more significant than this, through the universal ugliness of form, they become for the philosopher of Nature a subject which reminds him how inadequate, at present, is all that we have imagined toward the deeper comprehension of Nature, and how endless a road still lies before us, which must be traversed before we may venture to commence the building of a system of the Philosophy of Nature, if we would not bring forward, instead of scientific proof, the fair but ever false dreams of a poetical imagination.

Tenth Lecture.

THE GEOGRAPHY OF PLANTS.

"The spot becomes a Paradise,
The whole world blossoms here."

GÖTHE.

"In Rome upon Palm Sunday
They bear true Palms,
The Cardinals bow reverently,
And sing old Psalms;
Elsewhere, those Psalms are sung
'Mid Olive branches.
The Holly bough supplies their place
Among the avalanches;
More northern climes must be content
With the sad Willow."

GÖTHE.

The following Lecture will especially want the quality of *reality*, which no power of language could confer upon it. I must entreat the friendly reader to take up a good map of the World, and the excellent plates of Geographical Botany in the Physical Atlas of Berghaus (and Johnston,) to supply the place of the demonstration which so conveniently assists oral delivery, and I will readily allow that perhaps a glance at those plates will convey a livelier impression, and give rise to as much reflection as this Lecture.

THE

DISTRIBUTION OF PLANTS

ON

THE SURFACE OF THE EARTH.

LECTURE X.

If we divide the globe by a great circle into two halves, so that one half includes as large a surface as possible of land, strangely enough, London lies exactly in the centre of this hemisphere. Could we choose a better starting-point, if we would, for any purpose whatever, make a survey of the earth? We enter this metropolis of trade, we seek a relief from the restless traffic, in St. James's Park, and thence we bend our steps, by Carlton Terrace, into Waterloo Place. A party of somewhat foreign-looking men induce us to turn with them into Pall Mall, and to approach a handsome new building between the Athenæum and Reform Club Houses. It is the Travellers' Club House. In England, every man freely follows the bent of his own humour. Lord John Russell makes it his glory to be the leader of a Whig Parliament, O'Connell to agitate the Irish; Colonel Sibthorpe is famous for his moustache, Count D'Orsay for his whiskers, and Lord Ellenborough for his curls; the members of the Travellers' Club covet no other honour but to have journeyed far and wide; and the waiters of the Club House catch flying, from the conversation of the guests, more geographical knowledge than if they had been for years industrious scholars of Ritter. Wherefore should we not also try to draw some benefit from this place? We step up to a table, at which sit three men in lively conversation, whose sunburnt visages at once betray the eager sportsman, often gathering, in the pursuit of a day's whim, impressions which many a Naturalist would envy.

"In the middle of October of last year," related one, "I was among the beautiful mountains of Moray. Before me lay one of those quiet, mirror-like mountain lakes which ornament that county, one bank extending out into the low moorland, covered with Moss and Sedge, and the white-topped Cotton-grass, while, on the other shore, rose picturesque precipices of grey, wild rocks, sparingly decked with Birches and Hazel-bushes, and sometimes rising into lofty cliffs, around which the cawing crows were circling. The thick autumn mist gradually began to retreat before the sun, which made the slight hoar-frost on bush and copse sparkle like a thousand diamonds. The light vapour rolled itself up in fantastic shapes through the mountain-passes, and disclosed the neighbouring hills, red with the heather, or hurried up higher on the mountains through the light, vigorous crests of Scotch Firs, which grew more and more distinct. I had been long tracing the vagaries of a particular, odd-shaped cloud, when all at once the light morning breeze whirled it round and threw it off, leaving a hill-side clear, on which, in quiet majesty, reclined a stag of sixteen antlers. My first thought was to place myself out of his sight, so I threw myself down and ercpt backward till I could only just see the points of his horns. His position was as disadvantageous as eould be imagined, and my only hope of seeuring him lay in a little brook whieh wound along between us and fell beyond, over a steep eliff, into the lake. By making a considerable cireuit I sueceeded in reaching its bed unnoticed; the steep bank eoneealed me so that I could steal along, always keeping the points of the horns in view, to within about a hundred paecs. Here I had a full view of the noble beast, as he lay there stretehed out among the red heather and the pale green rushes, now and then rubbing his flanks with his horns. At last he rose, stretched himself and walked leisurely toward a turn in the brook, from whieh I was only separated by a smooth, narrow hilloek, round whieh the water wound. I grasped my rifle, providently ehangcd the eap, and erept along the bank till I caught sight of the brute some fifty paces before me, standing up to his knees in the water and drinking in long draughts. I fired at his neck, elose to the head. He fell to his knees, but rose again and sprang up a hill, but already too far gone for sueh an attempt, he staggered, turned baek toward the brook, and fell apparently dead a few steps before mc. I threw down my gun, and rushed with a joyful halloo! and with drawn hunting-knife upon, as I thought, my ecrtain booty. But scareely had I touehed the noble beast when he sprang up and with a thrust hurled me baekwards against the rock, so that I rose again with pain and aching limbs. I was half stunned and in an unpleasant position. Behind me was the steep eliff over whieh the brook fell into the lake, before me was the angry animal, dripping with sweat and water, and, as it seemed, preparing for a fresh attaek. Thus, for some anxious minutes, did we stare one another in the face, till I had somewhat recovered myself, and rapidly executing a sudden resolution, I swung myself up on to the bank, before my antagonist had time to thrust again. Then I flung my plaid, from above, over the head and eyes of the exhausted animal, and again threw myself upon him. But I did not give him the death-wound without a despairing struggle on his part, and then I sank down exhausted on the damp moss beside my prize."

"It is not unusual," began the second, "for such a noble and strong animal to bring the hunter into a dangerous dilemma; but some years ago I witnessed a most ridiculous scene, in what, without my interference, would have been a hopeless combat of a man with one of the weakest and most cowardly of animals. Early on one fine Sunday morning, I was rambling on the wide plains of Gipps' Land. My thoughts were wholly withdrawn from my special intention of hunting, by the peculiarities of Nature by which I was surrounded. First my path led through those shadeless woods of New Holland, formed by the leafless Casuarinas and the Eucalyptus and Cajeput trees, with their sparing foliage, the narrow leaves of which, oddly twisted, turn not their surfaces but their borders up and down. With amazement I watched the strange world of insects, among which a kind of locust which exactly resembled a straw, especially engaged my attention. Next I entered on a broad sandy plain, in places decked with the wonderful Grass-tree.* The trunks, several feet high, bear on their summits a bunch of gigantic grass, from the middle of which the shaft bearing the spike of flowers rises from fourteen to twenty feet. Sometimes the soil was moist, and the vegetation, though merely low bush, almost impenetrable. Only here and

* Xanthorrhœa australis.

there arose the sweet smelling Acacias,* with their splendid golden balls of blossom, often densely wound about with enormous coils of the wild Vine.† In lighter spots the harp-pheasant spread its glorious feathers, and pleased itself by imitating all the natural sounds of this peculiar land, indefatigably repeating the cry of the wild dog and the chirp of the cicada. With some trouble had I worked my way through this dense thicket, and had reached a marshy district, now however dried up by the glowing sun, and only exhibiting a few rills and puddles, which alternating, in strange sport of Nature, with dense bushes of gigantic Sedges and broad-leaved Rushes, served as an abode for the ornithorynchus. Among the somewhat better turf, a pleasant souvenir of the far-distant home attracted my glance, the only one in this foreign land, and I stooped gratefully to pluck the solitary little Daisy, when a loud cry for help, mingled with shrieks and imprecations, assailed my ears. I hurried towards the spot from whence this sound, so unexpected in this wilderness, appeared to come, and was not a little astonished at what I discovered there. In the middle of a rocky pool stood a fat male kangaroo, seven feet high, upright on his hind legs,—on the bank before him lay a dog bleeding from many wounds. I lifted my gun and levelled, but my attention was diverted by the countenance of a man which displayed itself, scratched and bleeding, among the rushes on the bank. I immediately ran to his assistance; but while I was helping him out of the mud, the 'old man'† sought safety in flight, and disappeared. The wounds of the unlucky hunter were fortunately not so dangerous as they looked, and he soon recovered himself sufficiently to be able

* Acacia mollissima, affinis, &c. † Cissus antartica.

‡ The settlers call the male kangaroo "old man."

to relate his adventure. That morning he had set out on a kangaroo hunt, without a gun, and only accompanied by his dogs. The dogs soon traced and pursued a troop, but only one of them returned to his master. Nevertheless he had continued his walk through the woods, and soon started the 'old man,' and set his dog upon him. But the knowing old creature, instead of flying, posted himself in that slough, and with his fore-paws kept the dog from reaching his body. The hunter, not wishing to be idle, tried an attack from behind, through the water, but the now irritated animal turned towards him, scratched him over the face, and threw him backwards into the pool. Every time he tried to rise, the 'old man' pushed his head down again under water, so that if I had not come to his assistance, he must inevitably have been drowned. In the meantime, the beast had, probably in some fresh attack, disabled the dog, and thrown him down upon the bank. When the hunter had cleansed himself of the mud and blood, we turned to help the dangerously wounded dog, and at length parted, each to follow his own road, the hunter swearing that he would never quarrel with an 'old man' again without a gun in his hand."

"Such tales may do very well to amuse ladies," commenced the third, "but a man should not stoop to find pleasure in such trifles. Only when life is daily and hourly at stake, when peril shows itself in every form, can one talk of an excitement which shall be amusement worthy of a man; and where do you find it in such a degree as in the Whale-fishery in the North Seas? I recall with pleasure at this moment a scene which nearly cost me my life two winters ago. We had been cruising about the entrance of Baffin's Bay for fourteen days, in fearful storms. The rigging was stiff with ice, the sides of the vessel were covered with great shining masses. The crew were half frozen, and we could not move a rope through a block without pouring hot water upon it. We had but little daylight, on account of the thick fog, and the long awful nights were still more dreadful, when the ship rose uphill over the black waves and sank down again into the abyss, so that every moment we dreaded to be shattered on the masses of ice which the howling storm drove over the roaring sea, like palely shining, foaming night-demons sent for our destruction. One morning, toward the end of the storm, after a fresh fall of snow, an iceberg, five hundred feet high, approached us with frightful rapidity; already was it awfully close to us, when the terrible cry arose, 'It turns!'* On it came, its tottering summit bowing over toward our bows. Our fate seemed decided; the whole of the gigantic mass was sinking over upon our vessel, and must shatter us to pieces. We all fell on our knees, silently praying, and expecting the terrible moment; even the helmsman knelt, but without letting go the tiller. The iceberg was already half-way over, when, from unequal weight of its lower submerged part, it turned, and a moment after fell into the sea a cable's length behind our stern, hurling the water in masses of foam over the very tops of the masts, and blinding us from the force with which the icy drops were splashed over our faces. For a whole minute the waves seemed checked in their course, the sea seemed to boil, the ship trembled and rocked, and

* The loosened masses of Polar ice, driven by storms into lower latitudes, often project several hundred feet high above the sea, but a still more considerable portion remains submerged. This latter is gradually melted by the warmth of the water, and then comes a time when the whole iceberg falls over, the lower end rising above the surface, while the previously visible end sinks down.

even the storm seemed to be interrupted, for the sails flapped against the masts, and threw off the ice with which they had so long been covered. Then the sun broke suddenly through the parting clouds, and, with the peculiar rosy tint of the Red snow,* a broad shore spread out before us, which promised a short rest to the wearied mariner."

How contrasting are the pictures presented to us by these narratives; how it must make us reflect when we note, that in each of these three sketches the conditions of Nature, climate, plants and animals, are such as could not occur in either of the others. Nay, the single agreement which strikes even the uninitiated, the occurrence of an insignificant little plant of our meadows in that most peculiar and foreign country we have yet discovered, only serves to increase our astonishment. Parti-coloured, rich in form and hue, is the tapestry of Nature, but certainly not pieced together, without plan, of separate patches, but like an embroidery from artistic hands, worked from a beautiful design. If we imagine a fly, endowed with powers of sense and comprehension, crawling about a costly Gobelin, and from the coloured points, which he could not see all at one time, conceiving a picture of the whole, of which he could understand and criticize the drawing and the colouring, we should own him to be the greatest genius that ever lived. And in what far less favourable circumstances is man placed upon the whole earth. How many must here combine their observations, even to teach a provisional review of, and insight into a very small portion; how many masters must yet devote their

* On the freshly fallen snow of the Polar Regions and the higher Alps, a little microscopic Alga, the *Protococcus nivalis*, is not unfrequently met with, which, with some little infusorial animalcules, often tinges the whole snow-field of a rosy red colour.

whole life thereto, before we shall obtain full knowledge of the Whole. At present, we can scarcely do more than multiply the separate pictures of those sportsmen, and delineate them rather more minutely.

A brewer's son, of Huntingdon, Oliver Cromwell, raised himself in a few years to be absolute ruler of Great Britain, and by the power of his mind gave law to half Europe. Tradition tells of a speech of his, in early youth: "He goes the farthest who knows not where he wants to come to." This saying may be thus expressed in less paradoxical language, a man only attains to something great, when he, from the beginning, takes the highest object, the unattainable ideal, for his aim. In this manner, we may take Cromwell's maxim as a guide in every science, and we shall find that its power is here in no way belied. At the first glance, a man may indeed fancy that it is easy to satisfy such a demand. It is so difficult not to bring forward and depict to oneself the ethical, or if it be preferred, the Christian ideal, but it is, at the same time, certain that nevertheless very little is *attained to* by individual men in this respect. The conclusion drawn from this is, that far less depends upon the accurate knowledge of the aim than on the activity with which we strive towards it. But two essentially different stand-points are herein confounded, and unfortunately, this error runs through a large portion of our scientific efforts, and brings a considerable portion of misconception, obscurity and error into our judgments. The matter lies thus. On mankind, living on the earth, a double claim is made, in mental activity and development. The first concerns the ethico-religious element; the second his scientific culture. The two interpenetrate and mutually support one another; but their origin, their inner essence, is wholly distinct, and they have an infinitely different import, consequently an infinitely different value for mankind. The ethico-religious development relates to the eternal and incorruptible possession of mankind, his immortal soul, consequently, to the proper, never-ceasing I. Here an universal and necessary claim is made on *every* man, it is the point where all are alike before God, with equal rights and equal burdens, and truly equal, because the simplest self-understanding suffices to the object, to comprehend and express the ideal perfectly and purely. From the most ancient down to the present times, have these claims been in the same manner clearly and definitely set forth, only under various forms of expression at different times. The most important of all things for the *individual*, of course lies here: to answer those claims, and in that he answers them, to legitimate his position as a man in the nobler sense of the word, as a being destined to a higher completion and eternal existence. Without this legitimation he has no right to respect, to acknowledgment of any kind, even though he have ascended to ever so high a stage in reference to the point next to be mentioned.

The second claim made upon mankind, relates, on the other hand, to his culture for his circumscribed position on earth. Here the object is to raise every bodily and mental power of our nature to a state of perfect culture, in order to facilitate and ensure the attainment of the first-named aim. To this belong all sciences which order and promote matters of Church and State, Nature and Art, pleasure and convenience; all, together, be they valued highly or lowly among men in general, stand in one and the same condition of nothingness, insomuch that their importance ceases with life, that they have worth and value only here on this little sun-mote, our earth. A man may have accomplished great things here, but he has not the lowest claim to any respect or recognition if he have not obeyed the higher claims of morally religious culture. Whatever he has done as Artist, as Scholar, I take it and apply to my own purposes, but without thanks, as I place the gold-piece I find, in my pocket, while I throw away with disgust the muddy paper in which it was wrapped. What is gained in *that* field, concludes with the individual, with his development always begins anew, and gives him, and only him, a value. What is gradually obtained by toil and labour *here*, belongs not to the individual, but to mankind, and enters upon time there where the other ceases. The performance of the individual has indeed value for humanity, but it bestows no value on the individual.

On the other hand, I cannot withhold my respect, my recognition from a noble, spiritual being, who has proved his right to this recognition by morally religious life, though he have attained to never so little in any other branch of human culture. The last claim is, indeed, not necessary and equal upon all men, but subject to manifold modifications according to the countless gradations of external conditions, of restraints and facilities. It is not universally equal and necessary, for the reason that here, in direct opposition to the perception of the object, the proposition of the question to be solved is by far the most important, and, of course, by him alone is a correct answer to be expected who correctly puts the question. This holds good, especially, in all studies of Natural Science; and it would be but a slight exaggeration to say: ask but correctly, and Natural Science cannot answer falsely. Its imperfection, its relatively circumscribed position, lie solely in this, that it is so difficult to state the question correctly. Series of facts accumulate, evidently allied in their nature; if the quantity become considerable, they are collected, in systematic arrangement, into a so-called science, but the seeker wanders hither and thither without hold or aim; material is heaped up, and yet science does not advance one step. Then comes a man eminently gifted with genius, or frequently even merely one happily favoured by accident, and gives definite expression to the problem, for the solution of which men had been tormenting themselves without knowing it; and now all the mental powers of the inquirers are suddenly directed to this one point. Down fall the barriers in rapid succession, and Science advances with giant strides, till she comes again to a point where all progress is obstructed, where everywhere is met a flat and impenetrable wall, and now the same process of development must be repeated anew, in a higher stage, till again a new leader strike on the right place, where the wall rings hollow, and thus betrays the possibility of a further advance. In the domain of moral religion we have also problems, but we seek the Sciences, which ensure their solution; on the other hand, we have numerous Sciences, which ever move round in a circle, till now this man, now that, through Providence, declares a new object, and so they become capable of an onward movement.

A striking voucher for these views is afforded us, for example, in the Geography of Plants. In the earliest days of Botany, in every description of a plant was noted the place where it was found, but no one anticipated that these notices enclosed the germ of a new Science. The clever Botanist, Tournefort, made a journey to the Levant, and in the ascent of Ararat it struck him, that in its gradual elevation above the level of the sea, the vegetation assumed essentially different characters, and that these changes corresponded very closely with what was observed in the progress from Asia Minor to Lapland. Here was a problem stated, and eagerly was the solution sought for. Adanson, not less distinguished than Tournefort, first expressed the fact that the Umbelliferous plants seldom or never occur within the tropics; and thus was another question raised, which also awaited its answer. In the year 1807 appeared Humboldt's "*Essai sur la Géographie des Plantes*," wherein he sought to bring the observed peculiarities in the distribution of vegetables into connection with the specialities of climate. But it was ten years later, after the mass of facts had a second time been heaped up, without men knowing how to make anything really new out of them, when Humboldt made the last step; comprehending the whole earth in one intelligent glance, he made the Geography of Plants part of a theory of the earth, and showed the dependance of the distribution of plants, on a great scale as on a small, upon the physical qualities of the globe. But by this there was no Science perfected, merely its foundation laid; it had acquired a determinate point of departure, but what its final aim shall be is at present difficult, even where it is possible to unfold. At least, it is very easy to point out, in certain instances, that fully half the phenomena give as yet no hint, whence, from what circle of natural laws, the grounds of their explanation are to be drawn.

No Oranges grow on this side the Alps. The Grape does not ripen beyond the latitude of Berlin. In Schoonen, and in the most southern point of Norway, the Beech attains its most northern habitation. From Bjornoe, northward of Drontheim, a line extends across Norway, through Jämtland and Herjedalen, which intersects the east coast of Sweden at the most northern part of Gefleborg, and is the boundary beyond which the cultivation of Wheat cannot be extended northward. Higher up, the Fir forms the woody vegetation; but where even the easily satisfied Birch will no longer thrive, a short but at least occasionally warm summer, allows of the culture of the quick-growing Barley. It is not difficult to find the explanation of all this series of facts; they are altogether dependant on climatal influences, and an accurate investigation of the conditions of temperature quite suffices to afford an explanatory account of all these circumstances.

Very different is it with the following phenomena. From the southern point of Africa to the North Cape in Mageroe, the Heaths extend throughout the Old World, merely leaping over the proper tropical regions. With the same latitudes, the same climate and similar conditions of soil, we find not a single species of true Heath in all America. Other allied plants replace them, plants which at least belong to the same family (the *Ericaceæ*); but if we go to Australia, we find under corresponding conditions, not one Ericaceous plant, but in their place appears an allied, but wholly peculiar family of plants, the *Epacris* tribe. In a little corner of Asia grows the Tea-shrub, and it is certainly not the absence of corresponding climatal influences in all the rest of the world that confines the Tea to China. In a small girdle on the Andes of the northern half of South America, grows the race of Peruvian Bark trees: is there no spot on all the earth in which the like conditions of temperature and soil coincide? Enough, even one single example would suffice to call attention to the fact, that there exists upon the globe a mode of distribution of plants, which is not produced by the conditions of vegetation at present understood, nor can be explained by them. We here obtain, side by side, two wholly distinct groups of known circumstances, which refer to the same plants, for every one of these exhibits in its own way, both kinds of distribution. Side by side, lie a soluble and an insoluble problem, the former soluble because the question can be stated definitely, and has been stated by A. von Humboldt, namely—the Dependance of the Distribution of Plants on the Physical Conditions of the Earth—the second insoluble, because no definite proposition can be laid down which the inquirer may apply himself to elucidate. In regard to the first, therefore, we can bring the collected facts into explanatory coherence; from the second point of view, on the contrary, we obtain nothing but an aggregate of incoherent facts, at present incapable of any explanation, but perhaps having even on that account so much the greater claims on our interest. With permission I shall slightly sketch the conditions of plants on the earth's surface in both relations; and in conclusion, delineate with somewhat greater completeness, as it were as a more fully perfected example, the distribution of the most important nutrient and economic plants upon the globe.

THE DEPENDANCE OF THE DISTRIBUTION OF PLANTS ON PHYSICAL CONDITIONS.

We must here take our departure from the smallest, most limited circle, in the intention to spread ourselves at last over the whole earth. The origin of the comprehensive Geography of Plants was no greater thing than the daily question: Where does the plant grow? And every Botanist treats, more or less superficially, a chapter of the so-called habitations, the place of growth and the native country of the plant. Through these small beginnings of Science have light and order gradually come into our conceptions, and much indeed still remains intricate which the future alone can explain. Two essentially different points have to be distinguished. The Heath plants *occur* on dry, sunny, sandy plains; they *extend* from the Cape of Good Hope, through Africa, Europe, and northern Asia, to the extreme limits of vegetation in Scandinavia and Siberia; these plants are *distributed* in this great region in such a manner that South Africa has innumerable distinct species, of which, however, never more than a few individuals grow side by side, that then, towards the north, the number of species suddenly diminishes in an important degree while the number of individuals increases, till at last, in the north of Europe, a single species, the common Heather,* overspreads whole countries in millions of single individuals. In the first place, we readily see that only the first determination, that of the *occurrence*, relates necessarily to each individual; while, on the contrary, the *range of extension*, and the *mode of distribution* indicate causes which have scarcely any importance in reference to the single individual, but very great in relation to the larger groups of plants, which we call species, genus, tribe, &c. From this it follows that the former only, the occurrence of plants, is related wholly, while the other two are related but partly to conditions explicable by physical influence; yet we must, at first, keep more to that arrangement, since it is strictly logical, which will remain fixed for incalculably long time, while, of course, the last arrangement only holds good for the existing condition of Science. When namely, we review the various influences upon which the life and healthy vegetation of a plant, are, according to our present physiological

* Calluna vulgaris.

knowledge, dependant, we quickly find that only a small number of physical forces are as yet detected by us, in their action on the organism, that on the other hand, a proportionately large number at present altogether baffle our endeavours after a more accurate comprehension of their action, although we may safely assert that the life of the plant is, and must be, as much dependant on them as upon the others. Merely by way of example, I will mention light, electricity, and the pressure of the atmosphere. The two first, as continually in action in every chemical process; the last, of essential importance in all the processes and relations between gases and vapours, must likewise powerfully affect the life of the plant, which consists in progressive chemical combinations and separations, in continual absorption and excretion of vapours and gases. The *how* is as yet a complete mystery to us, and many of the at present wholly incomprehensible conditions in extension and distribution of species, may sooner or later find sufficient explanation in these influences.

If from the snow-covered ice-plains of the extreme North, where the Red-snow Alga alone reminds us of the existence of vegetable organization, we turn toward the south, a girdle first expands before us, in which Mosses and Lichens clothe the soil, and a peculiar vegetation of low plants with subterranean, perennial stems, and generally large, handsome flowers, the so-called Alpine plants, gives a special character to Nature. Almost all the plants form little flattened, separate tufts; *Pyrola*, *Andromeda*, *Pedicularis*, *Cochlearia*, Poppies, Crow-foots, and others, are the characteristic genera of this Flora, in which no tree, no shrub flourishes. Leaving this region, which Botanists call the Region of Mosses and Saxifrages, or after one of the founders of Geographical Botany, Wahlenberg's region, we go southwards, and at first we see little low bushes of Birches, then more compacted woods, into which the Pines and other Coniferous trees assemble, and we at last find ourselves in a second great zone of vegetation which is characterized by the woods consisting almost exclusively of Conifers, which thus impress a peculiar character upon the Flora; Firs and Pines, Siberian Stone-Pines and Larches, form great, widely-extended masses of forest; by brooks and on damp soil, occur the Willow and the Alder. On dry hills grow the Reindeer Lichen and Iceland Moss. In the Cranberry, Cloud-berry,* and the Currant, Nature gives spontaneously, though sparingly, food; and a rich Flora of variegated flowers serves for the decoration of the zone, which stretches, in Scandinavia, to the already mentioned northern limit of the cultivation of Wheat, but in Russia and Asia, almost to Kasan and Yakutzk; we will call it the zone of the Conifers. Even in the neighbourhood of Drontheim, the culture of fruits begins, though sparingly; soon appears the sturdy Oak, called with rather too much poetic licence "the German;" in Schoonen, Zealand, Sleswick and Holstein, flourish the first woods of Beech. In about the latitude of Frankfort-on-the-Maine, another tree joins company, which, in its bold picturesque mode of branching, takes its stand beside the Oak—which in the beauty of its foliage, as well as the utility of its fruit, it far surpasses—namely, the noble Chestnut. The Pyrenees, the Alps and the Caucasus form the southern limit of the zone, in the more eastern portion of which the Lime and Elm contribute so abundantly to the composition of the forests, that the former even withstands the devastation which the Esthonians

* Rubus Chamæmorus.

make, in the manufacture of their shoes from its bass. In the Hop, the Ivy and the Clematis, we find here the first representatives of the tropical climbers. The smiling green of the meadows alternates with the gloomy shadows of the forests; and Man has taken possession of the earth, restraining the wild vegetation to that absolutely needful for wood and hay, and rich crops reward his industry. We leave this zone of the Deciduous Woods to scale the rocky barrier of the Alps, with which a wise Providence has confined the German on the south, which he too inquisitively scaled to fetch from the sensual and corrupted South infinite misery, and a chronic sickness wasting his people for centuries. Here suddenly appear quite different plants; with the great woods of trees, the coriaceous shining leaves of which last through the mild winter, and round the mighty stems of which climb the Vine and flame-coloured Bignonias, unite the similar bushes of Myrtle, Tinus, Arbutus and Pistachio. Here and there the dwarf Palm is met with; Labiate plants and Crucifers, and fair-flowered Rock-roses replace in summer the spring Flora of scented Hyacinth and Narcissus; but rarely, even in the most favoured spots, is the eye, dazzled by the brilliancy of ever-green leaves, or the glaring play of colour of the naked, jagged mountain chains, gladdened by the mild radiance of verdant meadows. In recompense, mankind has, in this zone of Evergreen Woods, seized upon the fruit of the Hesperides. It is

> "the land where the Citrons blow,
> Through the dark-green leaves the gold Oranges glow."

But onward, ever onward strives the insatiable son of Iapetus; no legend of African deserts, no death-news of the many adventurous travellers who have gone forth to seek the source of the Niger, frighten him back. On the west coast of Africa, in the Canary Isles, is, indeed, no longer found the gigantic dog, from which, as Pliny told, the islands derived their name, but Flora gives for booty richest treasures which she, by aid of the tropical sun, has succeeded in extracting from the soil, moistened by the vapours of the ocean. Round Sycamores twine mighty Cissus stems; Capers and Bauhinias interlace in the thickets of balsamic shrubs. The slender Date-palm soars aloft, and the Baobab grows up into gigantic masses of wood. The wondrous Cactus-like forms of the leafless Spurges, distinguished by their poisonous or pleasant-flavoured, sweet milk, as the case may be, betray a peculiar formative power in Nature; and the Dragon-tree in the garden of Orotava, in Teneriffe, a gigantic arborescent Lily-plant, recounts to the musing listener the traditions of thousands of years.

Six zones of vegetation have we thus passed through, in which the continually increasing temperature of the climate called forth ever a different, ever a more luxuriant vegetation, and we conclude our wanderings, after a short rest under the five-thousand-yeared Dracænas, by climbing the Pic of Teyde. Man has taken possession of the soil of the plain at its foot, and dislodged the original vegetation. Through vineyards and Maize-fields we ascend, till the shades of the evergreen Bay-laurel surround us. Trees of the Lace-bark tribe and similar plants succeed; we wander for a time through a *zone of evergreen forest trees.* At a height of 4,000 feet we lose the plants which had so far accompanied us. A very small number of peculiar plants mark a quickly traversed *zone of deciduous trees,* and we come among the resinous trunks of the Canary

Pine. A *zone of Conifers* shields us from the sun's rays up to a height of 6,000 feet, then the vegetation suddenly becomes low,—from humble bushes it passes into a Flora which bears all the characters of the Alpine plants, till finally the naked rock sets a limit to all organic life, and no snow and ice bedeck the summit of the mountain, only because its height of 12,236 feet does not, in a position so near the tropics, extend up to the region of eternal snow. Counting by the limits of vegetation, we have re-surveyed in a few hours' climb, the wide way from Spitzbergen to the Canaries, an extent of more than fifty degrees of latitude.

In the whole way, downwards toward the south and upwards toward the summit of Teyde, vegetation changed conformably with the climatal conditions, and we can almost account for the observed distribution of plants by the mere increase and diminution of heat. If we extend our researches farther, we can even name particular plants which are peculiar to particular northern latitudes, and in lower latitudes again regularly recur at particular heights on the mountains. Nevertheless, this case is comparatively of rare occurrence, and we are finally compelled to refer instead to another influence, less or scarcely at all understood. When we find places in the tropical mountains, which, in reference to moisture and temperature, as well as to the constitution of the soil, exactly correspond to certain places in northern latitudes, and which in spite of this support a vegetation, which is, indeed, similar in general character, but wholly distinct in the genera and species, nay, when we notice that the agreement between northern latitudes and elevation above the level of the sea in southern latitudes, can be superficially demonstrated only up to a height of about 6,000 feet, we are thereby directed to attribute an essential influence to light, pressure of the atmosphere, &c., even though we may not be able to unfold the *how*.

We get the most definite notion of such a future development of Science, when we make a close survey of its past progress, and thus become aware how the gradually increasing accuracy of the knowledge of determinate physical conditions, has also rendered explicable here, many phenomena which previously were very enigmatical. This is most strikingly shown in the doctrines of the distribution of warmth on the globe. Originally, as in the cases of Halley, Euler and others, the attempt was made to refer this distribution to the position of the earth in relation to the sun, a proceeding which, for the moment, appeared very admissible, since the sun is actually, if not the only, yet certainly the most essential source of heat to the earth. But in what violent contrast the so-obtained results stand to the actual phenomena. Under such considerations the temperature must naturally decrease regularly with the increasing latitude; but while the Russian army, on the march to Chiwa, perished from cold under the 40th degree of latitude, in the Faröes, under the 62nd degree, the sheep remain at pasture through the whole winter. All such calculations have, in fact, only value under the assumption, that the whole earth is equably and homogeneously covered with substances on both sides of the equator, which substances always have an exactly similar relation to the heating rays and, finally, are always at rest. Now not a single one of all these conditions is fulfilled. We were, therefore, directed to immediate observation. It was found that even if the heat was differently distributed, in reference to season, yet the same place had pretty nearly the same temperature every year. If, for example, the average number of degrees of heat are taken from a number of daily observations, and these average numbers collected for every day in the year, and again another average drawn, this last average varies but few degrees from that of the preceding or following year. Taking a greater number of years, for instance, twenty, a value is obtained, which differs scarcely the tenth part of a degree from the foregoing or succeeding twenty years. Humboldt then first arrived at the ingenious idea of connecting, by a line upon a map, all the places upon the globe which have the same mean temperature, obtained by the mode of estimation just described (Isothermal Lines, or lines of equal heat) ; and now it was found, that although the curves of these Isothermal Lines deviate so much from the parallels of latitude, yet the boundaries of vegetation cling much closer to them than to the latter. But many riddles yet remain unsolved. Drontheim, for instance, has the same mean temperature as the most southern point of Iceland ; the Hebrides, Orcades and Shetland Islands, have something like 5^0 higher mean temperature. Nevertheless, in Drontheim fruits and Wheat are still cultivated, while the growing of Wheat first begins at Inverness, in Scotland, and of fruit still farther south. Thus inquirers were at last led to draw within the circle of their investigations, the distribution of heat within the Seasons, since it is evident that the vegetation is often more essentially determined by this, than by the mean temperature, or sum of the heat which it receives. The mean summer and winter temperatures are now estimated in the manner indicated, and the places which agree in these relations are connected in the same way by lines—Isotheral (lines of equal summer heat) and Isochimenal (lines of equal winter cold). Now Drontheim, for example, has a mean winter cold of 24^0 34′, while the

Faröes have a mean winter temperature of 37° 4′, and the Shetland Islands 39° 12′; but the mean summer heat of Drontheim amounts to 60° 5′, while in the Faröes only to 50°, and in the Shetlands to 52° 4′; and therefore neither Wheat or fruits ripen, although the latter will bear a much more severe winter temperature than 24° 34′. At Moscow, which has an excellent vegetation, the mean winter temperature is 13° 51′. The 15 degrees more northern Mageroe, situated quite beyond the limits of cultivation, has a mean winter temperature of 24°; that of Astracan, 10 degrees more south than Moscow, and where both the Vine and Maize flourish, is the same. But the mean summer heat of Mageroe is 42° 55′, that of Moscow 61° 4′, and that of Astracan 71° 36′; and it is altogether the heat which prevails during the season of vegetation which determines the conditions of the plants. In annual plants, or to speak more correctly, in summer plants, the matter is self-evident; and perennial plants mostly enter in autumn into a condition of inactivity, an actual hybernation, which allows of their suffering severe degrees of cold without evil results.

But in spite of all the researches we have not nearly attained the mark; it will be the duty of the next generation to break up the divisions of mean summer and winter temperature still further, into the mean temperature of the single months, since the half-yearly sections are far too large to admit of an accurate comparison of the vegetative periods. Very probably the result will be, not merely to discover what temperature the plant generally requires during its stage of vegetation, but also, essentially, how this temperature is distributed over the epochs of germination, growth, blossoming, and maturation of the fruit. Here, as everywhere else, the acute Naturalist sees endless labour before him, and only the ignorant prater thinks that he knows something, just because his weak eyes can reach no farther than the book, from which he has so laboriously collected his crumb of wisdom.

In former Lectures have at least been touched upon, the chief points on which depend the Life of Plants, their variety on the globe, and consequently the variety of vegetation. The explicable life of the Plant is, formation of organic matter out of inorganic compounds. The plant is therefore dependant on the condition of the soil, in the widest sense of the word, on the store of nutriment it contains, and on all that influences the chemical process of formation, consequently, above all, upon a determinate temperature. Now that I have, in the foregoing paragraphs, treated of the conditions of temperature, I will here briefly consider more minutely the influence of the soil. Usually two very different so-called stations of plants have been distinguished, but they have never been, properly speaking, defined according to physiological principles. The universal, indispensible nutrient substance of plants, and, at the same time, the matter by means of which all the rest are conveyed into it, is water. Without water there is no vegetation. This element of the ancients presents itself to the plant in three different forms, and according to these must we, above all things, discriminate the stations of plants. The Orchidaceous plants of the tropical forest let their peculiarly constructed roots hang down from the branch to which they cling, in the moist, warm atmosphere, and absorb water in the form of vapour. Our Water-lilies and the proper bog-plants will only flourish when surrounded by liquid water, or, at least, with their roots dipping in it. The case is quite different with the great majority of plants; they have to extract their nutriment from the earth, which contains the moisture to be absorbed into them in a peculiar condition. If to these three classes of Air, Water, and Earth-plants, we add one more, namely, the true Parasites, which, like our Dodder, draw their organized nutriment from other plants, we have obtained the principal divisions of stations. Next come the subdivisions, which are determined by the matters which the water holds in solution and thus conveys to the plant. I have already decided that carbonic acid and salts of ammonia must always be present among these, to render vegetation possible. Perhaps even here the more or less of these two ingredients and their relation to each other, may make a distinction which we are not yet in a position to estimate. The relations of the inorganic constituents, the salts dissolved in water, to the plants, are more evident to us. Science has in this very point gone astray in the most varied and opposite directions. So late as the commencement of the present century, there were men who asserted, that plants could themselves form all their organic and inorganic constituents out of air and distilled water. Superficial experiments, which yet were crowned by academicians devoid of judgment, fantastic prating, instead of logical accuracy of thought, allowed such distorted views to obtain a temporary worth among a number of naturalists. Subsequently, the error was in the other extreme, for there was an inclination to ascribe a peculiar Flora to each geognostic formation; and this last error even yet haunts the agricultural doctrines which would determine the goodness and intrinsic worth of a soil by the plants that grow upon it. Truth here lies between the two extremes. I have already had opportunity to demonstrate what very different amounts and kinds of inorganic matters plants demand in their vegetation. When we find that the ashes of Lucerne, of Tobacco, of Clover, contain more than 20 per cent. of lime and magnesia salts, we cannot be surprised if we do not meet with them on pure sandy soils containing scarcely a trace of lime; but it would be drawing a false conclusion from this, to say that the Muschelkalk, or the Keuper-limestones, or the Jura-limestone, or any other calcareous stratum of any given formation, is exactly the proper soil for these plants. That a plant like the great Sugar-tangle,* which is so rich in soda, iodine, and bromine, occurs only in the sea, and not in fresh water, where soda is very sparingly, and iodine and bromine not at all present, is certainly easily conceivable. But it is certain, at the same time, when we decide upon the soils on a large scale according to geognostic principles, that there are very few plants characteristic of particular constituents, and this relation is, indeed, neither very natural nor necessary. In the next place, it may be asserted that all plants contain the same constituents in their ashes, but in very different proportions. On a soil, therefore, composed purely of one kind of earth, for instance, lime, silex or gypsum, no plant at all could flourish. Every soil which bears plants contains also in its composition all the substances required by all plants, only the proportions differ, and the predominance of silex, lime, or common salt, must consequently favour especially the growth of Grasses, Pulses, or Shore-plants, although these are by no means exclusively confined to the proper sandy or calcareous soils, or to the sea-side. In reference to this point, I know really no other plants than the carbonate of lime plants, the gypsum and salt plants, which I could bring forward in evidence.

In addition to the chemical conditions, there is yet another, which modifies the former and, where it brings

* Laminaria saccharina.

about the same actions, contributes to chain particular plants so much the more firmly, exclusively, to particular soils, or contrarywise, also contributes to conceal or obliterate the connection between plants and the chemical nature of the soil. This consists in the mechanical condition and physical peculiarities of the soil. There are plants which will only settle on unbroken *rocks*, which when the other conditions coincide, spring from these rocks over on to our *walls*, like the Wall Rue Spleenwort,* a little Fern, the name of which denotes its station. Others occur only where weathering has broken up the solid rock into small fragments, *drift* plants, which clinging to mankind, select *rubbish heaps*, which most resemble their natural station; our great Nettle and Henbane may serve as examples. Lastly, other plants grow only where the rocks have been reduced to fine powder, in *sand* or in the fine grained *clay* produced by chemical decomposition. The so-called German Sarsaparilla, the Sea-reed,† is an example of the first condition, but there is no definite condition corresponding to it in the vicinity of human habitations. Clay, on the other hand, stands beside the black substance, humus, resulting from the decomposition of organic matter. Both rich in soluble salts, important to vegetation, both distinguished in regard to their property of absorbing from the atmosphere, and thus conveying to the roots of plants, gases and aqueous vapour, they cause, singly or in combination, the most luxuriant vegetation. We thus obtain three stages in reference to the qualities of the soil; pure earths, wholly devoid of vegetation—mixed earths, without clay or humus, with an arid but characteristic vegetation—and lastly, soil rich in clay and

* Asplenium Ruta muraria. † Ammophila arenaria.

humus, with the greatest abundance and variety of plants. Even in the north, the eye of the uninstructed observer is struck by the greater richness and stronger development of the vegetable kingdom, upon the argillaceous, basaltic and porphyritic soils, and simple quartz sand is, under the tropical sun, a desert, if water and therein foreign matters be not furnished to it.

DISTRIBUTION OF PLANTS UPON THE GLOBE WITHOUT DEMONSTRABLE DEPENDANCE UPON PHYSICAL CONDITIONS.

In the narratives introductory to the present Essay, I have already noticed that Australia has, in common with Europe, a very common plant, the Daisy. The same little flower is found in northern Asia, in some regions in Africa and South America, and where it occurs, it climbs the mountains from the level of the sea up to the snow-limit. The little Enchanter's Nightshade, the delicate Linnæa, the Bitter-sweet, the Bird's Knotgrass, the blue Gentian, the Dwarf Birch, and the Herbaceous Willow,* and several others, are indigenous both in Europe and North America. The common Self-heal, the Duckweed, and our Reed,† grow in New Holland. The Bog-moss‡ covers the moors of Peru and New Granada, as well as those of the Hartz, and of Dovrefjeld in Norway. The brownish Parmelia § which clothes all our walls, palings and old trees, is no less

* Circæa alpina, Linnæa borealis, Solanum dulcamara, Polygonum aviculare, Gentiana Pneumonanthe, Betula nana, Salix herbacea.

† Prunella vulgaris, Lemna minor, Phragmites communis.

‡ Sphagnum palustre.

§ Parmelia subfusca.

present on the only ninety-years-old Yorullo in Mexico. The bluish Bristle-grass,* which is one of the commonest garden and field weeds on sandy soils with us, grows also in the interior of Brazil on suitable soil. A characteristic plant of our sea-shores, and the vicinity of salt-springs, *Ruppia maritima*, grows equally on the northern coast of Germany, in Brazil, and the East Indies. But it is needless to accumulate examples, for these so hasten to present themselves, that the view finds some support in observation, which assumes that every plant must exist in every part of the globe where the known conditions of its vegetation are present. But on that account have I placed those three scenes at the very commencement of my disquisition, so as to draw attention before-hand to the point, that exactly the cases just mentioned, which, at first sight, appear to be natural and necessary consequences of vegetable organization, only occur as rare exceptions thereto. Even the little Daisy exhibits a certain wilfulness. It is wanting all through North America; and that which we tread down as an insignificant weed in our meadows, is there reared with the most tender care in the Botanical Gardens. If we pass in review the vegetation of different countries, we see that causes appearing similar in our present knowledge of them, bring forth, indeed *similar*, but by no means the *same* forms of plants. To the plants of a particular northern latitude correspond in the analogous height of the Alps, situated southward, other species of the same genera, or other genera of the same family; or the plants of America are represented in the same latitudes in the Old World by plants which are different, but closely allied in their development. Nay, even plants which belong

* Setaria Glauca.

to totally different families, assume, at least in their outward appearance, similar shapes. Thus the Cactus plants of the New World correspond to the leafless fleshy Spurges of the torrid Africa.

If, again, we anticipate that a greater variety of conditions of vegetation is the cause why the variety of vegetation, the number of species of plants, continually augments from the pole towards the equator, and that on the same account the number of sociably growing plants, of species which clothe great tracts in countless individual specimens, also increases in the same measure, we find that we are still far from being enabled to give a scientific account of the matter. It seems to us wholly the result of caprice, that particular plants are distributed widely over the globe, while others must live cribbed in the narrowest spot, as, for instance, the Wulfenia, occurring exclusively on the Carinthian Alps; that particular families, like the *Compositæ*, flourish abroad over the whole earth, while others, like the Peppers and the Palms, only occur between very definite degrees of latitude on either side of the equator, the *Proteaceæ* only in the southern hemisphere, the Cactus tribe only in the western half of the earth. Just as inexplicable is the *mode of distribution* of the families of plants. While the Palms diminish in number from the equator into higher latitudes, the *Compositæ* attain their highest development in the zones of mean temperature, their number of species diminishes from these in both directions, equally toward the equator and toward the poles; while, finally, the Grasses increase constantly from the equator toward the poles.

But there yet remains to be brought forward a peculiar mode of consideration, according to which the distribution of the families is usually determined.

The Sedges, for example, appear to the number of 134 species in the Flora of France; in the Flora of Lapland, on the contrary, only to 55. France is therefore unquestionably richer in species than Lapland. But the matter stands in a different light when we consider these plants in relation to the total vegetation of the two countries, and since by this means we come to comprehend the characteristics of the region of vegetation, we can only allow this mode of consideration to be valid. France possesses altogether about 4,500 Phanerogamous plants, and the Sedges constitute only $\frac{1}{27}$th of these; the Phanerogamia of Lapland are confined to some 500 species, and the Sedges form $\frac{1}{9}$th of these. The Sedges are therefore a much more essential part of the Lapponic Flora than of the French; the former has a relatively larger number of species than the latter. This it is alone that is understood by the increase of species in a given direction.

This, to us inexplicable, mode of distribution of plants, according to species, genera, families, orders and classes, gives rise to certain peculiar regions on the globe, which are characterized by the predominance of certain forms of plants, or by the exclusive occurrence of particular families. These portions of the earth's surface, of which we at present enumerate about 25, are called Geographical Regions of Plants, and to them have been applied the names of the men who have made themselves especially famous by the investigation of these places.

I have already alluded to the region of Saxifrages and Mosses, or Wahlenberg's region, which extends from the eternal snow of the poles, or the summits of the mountains, down to the limit of the growth of trees, and is distinguished by the absence of arborescent plants, and even of the taller shrubs. Adjoining this comes the great Linnæan region, including northern Europe and northern Asia, to the great chain of mountains which extends from the Pyrenees to the Alps. Woods of Conifers, or Deciduous trees, luxuriant meadows and broad heaths, in Asia the peculiar salt steppes, especially determine the characters of this region, which, at least in its European portion, is now too widely taken possession of by cultivation to exhibit its natural physiognomy. The wide basin from the Alps to Atlas, the deepest part filled by the Mediterranean Sea, forms a third region, distinguished by the abundance of aromatic Labiate plants, fair, but fleeting Lily plants, and the resinous Rock-roses. The solitary Dwarf-palm and Balsam-trees denote in this, De Candolle's region, the transition to the tropics. Parallel to the two last-named regions, North America is divided into a northern region named in honour of Michaux, distinguished by peculiar Conifers, Oaks and Walnuts, by innumerable Asters and Golden-rods, from the Linnæan region, and a southern, Pursh's, region, in which most strikingly appear the trees with broad shining leaves and large splendid flowers, like the Tulip-tree, the Magnolia, and others, defining the character. Between Kämpfer's region, comprehending China and Japan, Wallich's in the highlands of India, and the Polynesian, or island region of Reinwardt, renowned for its Poison-tree and its Giant-flower, lies Roxburgh's region, which extends through both the Indian peninsulas, which conceals among the shadows of the monster Fig-trees, the *Scitaminaceæ*, or Aromatic Lilies, like Ginger, Cardamums and Turmeric, or in little woods of aromatic Barks, like the Cinnamon and Cassia, matures in thick shapeless stems the starch of the Sago. We pass over Blume's region in the mountains of Java, Chamisso's in the Archipelago of the South Sea, and Forster's region in New Zealand, and turn again to Africa, where the Desert, Delile's region, ripens, in the oases, the Date, and in the tender-leaved Acacias concocts the abundance of Gum Arabic and Senegal, which commerce brings to the service of our industry. To this, eastward, adjoins Forskäl's region, where the Balsam-trees predominate; on the south, Adanson's, the characteristic plant of which also perpetuates the name of that enlightened Botanist, the thousand-yeared giant stem of the *Adansonia digitata*, the Baobab, or Monkey's-bread. The little-known Africa gives only one more region, at its southern extremity, Thunberg's, bedecked with Stapelias, Mesembryanthemums, brilliant Heaths and evil-scented Bucku-shrubs, but poor in woods. New Holland and Van Diemen's Land bear the name of their first and most profound Botanical investigator, Robert Brown; and Central and South America distribute their vegetable riches into eight more regions, which are dedicated to Jacquin, Bonpland, Humboldt, Ruiz and Pavon, Swartz, Martius, St. Hilaire, and D'Urville; among these, Jacquin's region is remarkable for its strange Cacti, Humboldt's on the heights of the South American Andes for its Quinoa forests, and that of Martius, in the interior of Brazil, for its abundance of Palms, for its quantity of climbing plants or Lianes and Parasitic plants.

These few outlines will suffice, not to sketch a picture of the Flora of the World, since that would require the knowledge of a Robert Brown and the pen of a Humboldt, but simply to indicate what wealth lies hidden here, of which, at present, the industry and genius of the most distinguished inquirers have only been able to make a part accessible to us. I turn now to the last section of my essay, to a

SKETCH OF THE DISTRIBUTION OF THE MOST IMPORTANT OF THE PLANTS YIELDING FOOD.

There is not one region among the foregoing which has not been compelled to deliver up some of its inhabitants for the decoration of our pleasure-grounds, or to the service of Science in our Botanic Gardens; and although we are obliged to afford artificial warmth in winter to those from the proper tropical kingdoms of Martius, Jacquin, Adanson, Reinwardt, and Roxburgh, and even to protect them from the unpropitious climate in the summer, yet there remains a great number of plants from all parts of the earth, and the mountain plants, at least, from the tropics, which when cultivated by us in the open air, seem to corroborate the proposition, that Man is, in this respect, lord of Creation, and that howsoever Nature may have arranged the vegetable carpet of the earth, he has the power to alter this arrangement according to his liking, and, above all, for his service. But it is not so; and the facts on which the statement is founded are but illusory when we look, not at a little spot of earth like a Botanical Garden, but at cultivation on a large scale, which alone is really of importance. Here Man again reassumes his character of a helpless creature; his activity in ploughing and manuring is but an insignificant aid to the prosperity of cultivated plants, to which climatal variations prescribe as distinct ranges of distribution as to the wild Flora, and which the favourable or unfavourable influence of a season brings to luxuriant development or destroys. All over the globe has Man, for the supply of necessary food, selected almost solely summer plants, that is, such plants as complete their whole vegetative processes, or at all events, the development of all the parts containing nutrient matter, within the course of a few months. By this means he has rendered himself independant, in the half tropical regions of the evil action of the dry season, and in the higher latitudes of the destructive influence of cold, and thus ensured the possibility of cultivating plants, which there must be killed by the drought of summer, here by the cold of winter. Setting aside the cultivation of fruits which serve rather pleasure than necessity, there remain but three arborescent vegetables in the whole world which can be included among the true food plants, namely, the Bread-fruit, the Cocoa-nut and the Date, which actually furnish the chief proportion of the food of great bodies of men, and over widely extended areas, and thence have become objects of culture; the *Cycadaceæ* and Sago-palms, on account of their starchy parenchyma, can at most perhaps be taken into our reckoning only in a very limited circle in the East Indies. All the rest of the food-plants are either such as possess a subterraneous, usually tuberous stem, which sends up shoots above the soil, persisting but a few months, on which develop flowers and fruit, while during the remaining time, sleeping, as it were, beneath the protecting coverlet of earth, it sets the disfavour of the climate at defiance, or such as die at the end of a short period of vegetation, and ensure the future reproduction, in the slumbering germ of the seed. To the former belong, for instance, the Potato, derived from the Cordilleras of Chili, Peru and Mexico; to the latter, almost all our corn-plants.

One plant alone distinguishes itself among the cultivated plants by a peculiar mode of vegetation, a plant which was perhaps the earliest gift of Nature to Man awakening to life, and thus the object of the earliest culture, I mean the Banana.* And this plant was not merely the first, but the most valuable gift of Nature; its slightly aromatic, sweet and nutritive fruits are the sole, or at least the chief food of the major part of the inhabitants of the hotter regions. A creeping subterraneous root-stock sends out on high, from lateral buds, a shaft fifteen to twenty feet long, which consists merely of the rolled-up, sheath-like leaf-stalks, bearing the velvet-like glancing leaves, often ten feet long and two feet broad; the midrib of the leaf alone is firm and thick, but the blade of the leaf on either side so delicate, that it is readily torn by the wind, whence the leaf acquires a peculiar feathered aspect.† Among the leaves presses up the rich cluster of flowers, which within three months after the shoot has arisen, forms from 150 to 180 ripe fruits, about the size and form of a Cucumber. The fruits weigh, altogether, about 70 or 80lbs., and the same space which will bear 1,000lbs. of Potatoes, brings forth, in a much shorter time, 44,000lbs. of Bananas; and if we take account of the nutritious matter which this fruit contains, a surface which, sown with Wheat, feeds one man, planted with Bananas affords sustenance to five-and-twenty. Nothing strikes the European, landing in a tropical country, so much as the little spot of cultivated land round a hut, which shelters a very numerous Indian family.

Not till long after did Man learn to know and cultivate the gifts of Ceres. It must, in fact, surprise us, at present, to see that but a few species of a single family of plants furnish the principal food of the greater proportion of mankind, namely, the so-called Corn-plants or *Cerealia*, of the family of Grasses. This family includes nearly

* Musa sapientum.

† Vide the frontispiece, just below the Cocoa-palm.

4,000 species, and yet not twenty of them are cultivated for the food of Man. In their real nature, these cultivated Grasses are all summer plants, but varieties have been obtained from some of the most important of them, which, in the proper climate, sown in autumn, germinate and pass the winter under the warm covering of snow, so that they are in a condition to shoot out strongly in the spring, while the soil is being prepared for the other summer plants. Bearing in mind these exceptions, it may be said, that the prosperity of all the *Cerealia* is dependant upon the temperature of the summer, or period of vegetation; and if we lay down their distribution on a map of the earth, it exhibits a girdle which does not deviate so much from the course of the Isotheral lines as many other conditions of vegetation.

But the conditions of temperature under which the Corn-plants vegetate, may perhaps be more accurately unfolded than is possible through a plan of the Isotheral lines. In Egypt, on the banks of the Nile, Barley is sown at the end of November, and harvested at the end of February, the period of vegetation therefore amounts to about ninety days, and the mean temperature of this season is 69° 48′. In Tuquerés, near to Cumbal, under the equator, the time of sowing in the mountains, for Barley, is about the 1st of June, the time of harvest, the middle of November; the mean temperature of this vegetating season of 168 days, is 50° 12′. At Santa Fé de Bogota they number 122 days between seed time and harvest, with a mean temperature of 57° 24′. If now the number of days is multiplied by the figures of the mean temperature, we obtain 6282 for Egypt, $8433\frac{36}{60}$ for Tuquerés, for Santa Fé $6489\frac{48}{60}$, therefore as nearly the same number as the uncertainty in the estimate of the days, the accurate mean temperature and the want of knowledge whether or not the same kind of Barley is cultivated in all the places, will allow us to expect. Similar results are obtained for Wheat, Maize, the Potato and other cultivated plants. We may express these results thus:—Every cultivated plant requires a certain quantity of heat for its development, but it is the same thing whether this heat is distributed over a shorter or longer space of time, so that certain limits are not exceeded; for where the mean temperature sinks below 36° 24′, or where it rises above 71° 36′, Barley will no longer ripen. Consequently, to define accurately the conditions of temperature which a plant requires, to maintain it in a flourishing condition, we must state within what limits its period of vegetation may vary, and what quantity of heat it requires. This most remarkable circumstance was first observed by Boussingault, but unfortunately, we as yet possess not nearly sufficiently accurate accounts of the conditions of culture, in the various regions of the earth, to enable us to follow out this ingenious view in all its details.

I have chosen the Barley as an example, in the preceding remarks, because it has the widest range of distribution of all the Cerealia, and is cultivated from the extreme limits of culture in Lapland, to the heights immediately beneath the equator. But it has by no means the same importance everywhere that it has in the northern region, where, in a little narrow zone, it appears as the sole bread-corn; and in the following observations on the distribution of the more important Cerealia, it will be considered only in reference to this last point. In Lapland and northern Asia, Rye soon appears beside it, but by the inclemency of the climate confined to favourable years, and therefore not properly to be regarded as the principal food. First in Norway, Sweden, Finland and Russia does the Rye become the peculiar bread-corn ; and Wheat takes its place beside it in the north of Great Britain and Germany, as the Rye before joined Barley. In the centre of Germany, in the south of Great Britain, in France, and in a wide range toward the East, including the whole of the Caspian Sea, Wheat is the prevailing cultivated plant, which in the basin of the Mediterranean and throughout North America is associated with Maize. Rice takes the place of the latter in Egypt and in northern India, and holds undisputed rule in the peninsulas of India, in China, Japan and the East Indian Islands, shares it in the west coast of Africa with Maize, which, on the other hand, is the exclusively cultivated corn-plant of the greatest part of tropical America, with only some unimportant exceptions. In southern America, Africa and Australia, Wheat again enters the field, with the decreasing temperature. The culture of *Tef** and *Tocusso,*† in Abyssinia, of Millet‡ in western Africa and Arabia, as well as of *Eleusine*§ and Millet‖ in the East Indies, are quite of subordinate importance.

Some other plants bear a far more important share in the nutrition of mankind than the Grasses last named. Even in the most northern zone of the Barley and Rye, the Buckwheat is an object of tolerably extensive culture. With the already named Banana, the Yams,** the Mandioc†† and the Batatas‡‡ contribute largely to the daily food of

* Poa Abyssinica.

† Eleusine Tocusso.

‡ Sorghum vulgare, and others.

§ Eleusine coracana and stricta.

‖ Panicum frumentaceum.

** Dioscorea sativa.

†† Manihot utilissima.

‡‡ Batatas edulis.

the inhabitants of the tropics, of the Old as of the New World, added to which, upon the Andes presents itself a peculiar vegetable, the Quinoa,* a plant which simultaneously produces edible tubers and abundance of seeds, comparable to those of Buckwheat. Lastly, we may not pass over the *bread-fruit*, in the proper sense of the word, which is the principal food of the inhabitants of the large islands which extend from the East Indies, through the whole tropical ocean, to the west coast of America, the gift of a large and beautiful tree of the family of the Nettle Plants, which from the use it is turned to is called the Bread-fruit tree.† For the sake of variety, some also cultivate with it the Tarroo-root,‡ the *Tacca* tubers,§ or some Ferns,‖ the farinaceous leaf-stalks of which afford a dainty meal. Last of all I will mention the Potato, which has spread over the whole earth with such rapidity, from the mountains of the New World, that in many places it threatens, not exactly to the advantage of mankind, to supplant every other culture. Only a portion of its native land itself, Mexico, remains exempt, and but in recent times has cultivated a few poor tubers, at points on the coast, to set before the spoiled European guests what, with a strange perversion of the conception, one may call their native dish. A land, indeed, which perhaps thousands of years' culture of Maize has so little exhausted, that after a very little labour a bad Maize harvest yields two hundred-fold profit, which in good years amounts to six hundred-fold, does not want the Potato.

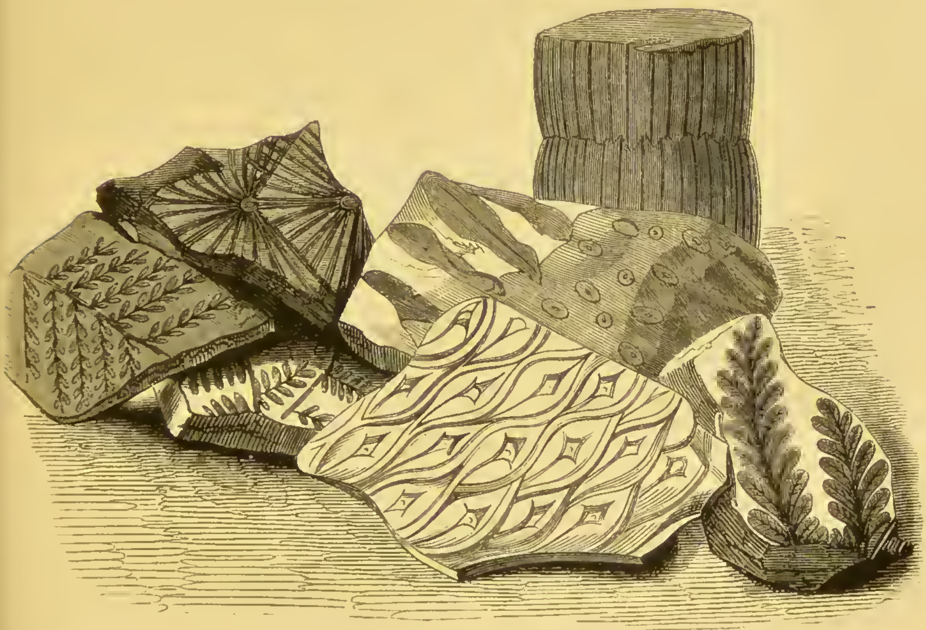
* Chenopodium Quinoa,
† Artocarpus incisa.
‡ Arum esculentum.
§ Tacca pinnatifida.
‖ Acrostichum furcatum, Pteris esculenta, &c,

And we, who flatter ourselves that we are great agriculturalists, who plough, manure and sow with ingenious machines, imagine that we have done great things when we reap a twelve-fold harvest. Even this we do not owe to our art, to which we might so readily ascribe it. The worst-tilled soil produces a better harvest in a favourable year, than we can extort from the best soil with all our industry in an unfavourable season. Truly, only he who looks no further than the clod, which his plough has thrown up, can preserve the feeling of the importance of human activity in his bosom. He who lets his free glance rove over the earth's ball, and looks at large over the play of active forces, laughs at the digging, dragging, bustling, panting ant-hill, which we call Humanity, and which with all its imagined wisdom is not able to alter the slightest working of the laws which the tyrant giantess, Nature, has prescribed to her slaves.

Eleventh Lecture.

THE

HISTORY OF THE VEGETABLE WORLD.



" All nature feels the secret power
And through eternal change, obeys ;
Up from the deepest region creeps
The trace of life of former days."

FAUST.

The Vignette represents a group of fossil plants or impressions of plants ; in the back-ground the stem of a Calamite ; right and left, some impressions of Fern leaves, &c,

LECTURE XI.

It may appear strange that mankind from the very earliest times, have turned their minds so readily to nothing, nothing so amply developed, and of nothing so circumstantially taught and written, as of that whereof Man neither does nor can know anything. However, the circumstance is very naturally accounted for, by human indolence on the one hand and vanity on the other. So soon as the first stage of sensual excitement and mere life of habit is overpassed, Man in general begins to find pleasure in intellectual movement; the ambition, too, awakens to know more, to look deeper, than others. But the true road to this point, comprehensive knowledge and persevering, earnest and definite reflection, is far too painful, and therefore not everybody's business; and instead of striving along this path toward the actually comprehensible, Man prefers to use his imagination, a power, the activity of which, on account of its half-sensual nature, seemingly finds an incomparably greater delight in those regions, where inconvenient facts and surely-judging logic cannot interpose, where the imagination, not subject to the decrees of truth, can make one story as good as another, and consequently has no contradiction to fear from there; and where Man, cunningly leaping clear over the basis of the dreams he brings forward, at once retreats behind the impregnable intrenchment: "Prove me the opposite!" I will not here enter upon the various religious phantasmagorias and the inquiries into what is to take place after death, and the like, but merely cite the cosmogonies, which every people, nay among some nations almost every individual, delineates, and recall remembrance to the fact, that the truth of the Mosaic history of the six days' Creation, has been contested with more zeal than has ever been applied to unfold the apophthegm: "*Love thy neighbour as thyself*," in all its meanings, and to act according to it. While the haughty English High-church, much more despicable than Popery in its most offensive extreme, fattens on the sweat and blood of millions of poor hungry Irishmen, she hunts down with all the unworthy means that stand at her disposal, every scientific inquiry which appears to contradict her narrow view of the literal truth of the old Jewish poetry. Never is Man more, and indeed almost only then, intolerant, when a scientific proof or confutation is out of the question. He who places himself in direct opposition to sound human understanding, on the domain of the demonstrable, subjects himself to the curse of ridicule which nothing can withstand. But where no proof in favour, and consequently, in most cases, no proof against a thing is possible, conceit, when it is united with power, compels the recognition of its visions, and asserts indeed with really blasphemous audacity, that the Eternal Ruler of the world has vouchsafed to it, in preference to all the rest of mankind, special mysterious communications. But the worst of the matter is, that while Man gives himself up to the spinning-out, the attaek and defence of dream-ereations coneerning *incomprehensible things*, his time and opportunities are frequently lost, not merely to do his duty and to learn to live in the fear of God, but with calmness and elearness to seize upon the conditions, to eolleet the facts, whieh are neeessary to further and develop *possible* knowledge.

The naturalist eannot go beyond the simple expression ; " God is the Holy Author of all things, and His Wisdom, His Love, has ereated the world." It is to him as to every thinking man, a truth whieh may not be touehed. But he does not value this truth in that he earries it over into what exists in time and spaee, or in the mere earthly. He asks not of the Almighty, the Means in the sense of the narrow human " How ? " not of the Eternal, Timeless, the Consequenee of Cause and Effeet, whieh finds its place only in Time.—He knows that where he pursues the nature whieh surrounds him, baekwards and forwards, with observation and thought, he ean only find an infinite series of changes of the Created, never an Origin or a Disappearanee.

The simple poetieal tradition of the Jews, the so-ealled history of the Creation, naturally deals with a point of view, where the earth alone bounded the vision of mankind, when the sun, moon and stars were friendly lights, to brighten day and to adorn the night. Refleetions upon Nature as a whole, and on a sublime Nature not yet broken up by the eonfusing mass of separate eoneeptions, might in early times have awakened, in the eultivated state of the Egyptian priests, a fore-shadowing of the idea that prodigious revolutions first brought our earth, by slow degrees, into the condition in which we now find it. Refleetion on the mighty play of natural forces, may have here given birth to more definite views of the gradual formation of the

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solid earth-crust, the previous appearance of vegetable development to that of animal, and the final entry of Man upon the scene, as the most perfect organism that we know upon the earth, before which it is quite natural to place the less perfect in a preceding, graduated series. These views of the gradual formation of the earth, which to the men of those days meant the world, were first collected by the greatest and most intelligent brain of antiquity, Moses, and delineated by him in a picture of the Creation of the World. But the few features of natural history knowledge which it contains, are not the grandest; the feature in which it far surpasses all other national traditions, is the declaration: "The earth has not existed from eternal time, is not a play of blind formative forces, not a product of inflexible Necessity, a Fate, but the free act of a Holy Author, an eternal Love." No other race has risen to the conception of *Creation* in this sense, for even the nearest and evidently allied Brahminic tradition, is, compared with this simple, clear idea, confused in its imaginative portions, and obscure in the sensuous. Ever, till the end of time, will it, unchanged, re-echo: "God made the World!" but we are already far advanced beyond the germs of natural science mingled with it. They relate, not to the world, but to one of the smallest of the specks of one of the innumerable little heaps of dust which dance their endless circles in the ocean of ether. Of the origin and development of all those millions of other larger, wondrous bodies, we know nothing. Of the world, we only know it is here, and now obeys simple, unvarying laws; that Mosaic history of Creation has, on the other hand, dwindled into One Line in the Giant Book which recounts, in time, the alterations of the Created; a line, of which we have now deciphered some few more letters than were known to mankind in the time of Moses, but which we are not yet able to read perfectly. Let us see how far we can eollect the decyphered letters into a comprehensible whole.

The earliest condition of the earth, to the knowledge of which something more than mere dreaming, and, at least, well ordered scientific analogies, at present lead, is that of a molten, incandescent, fluid mass, surrounded by a dense atmosphere which contained, as steam, all the water now flowing over the earth, perhaps a considerably greater amount of oxygen, but certainly an incomparably greater proportion of carbonic acid than it now includes among its constituents. The earth must have gradually cooled down in space which, according to approximative estimates, has a cold of—40 degrees; the fused mass must have solidified and formed a firm crust, upon which a portion of the watery vapour, not now repelled by the cooler earth, fell as rain. Every cooling body eontraets, and thus the crust of the earth must also have contracted; from this cause fissures must have been produced, out of which a portion of the still fluid nucleus would be pressed, rise out over the fissure and become spread around its margins; in this way forming the first inequalities or mountains, and thus also the distinetion between more elevated dry land and the sea covering the level portions. Through the continuous process of cooling, through ever-increasing thickening and contraction of the earth-crust, this process must have been often, and eaeh time more violently, repeated; with more violenee because in the thicker crust the cracks would continually become narrower, and the mass whieh by cooling must have become more viscid, would not, in issuing from the fissures, spread out evenly over the borders, but be pushed upward to gradually increasing heights. But in the same proportion as the firm crust beeame thieker and more capable of resistance, that process must have become more confined to particular localities, and have extended its violently disturbing action over smaller portions of the earth's surface. In many places, merely vesicular elevations were formed, which rose up out of the water, and oftentimes, when the contents consisted of air, sooner or later sank down again.

How often such phenomena may have been repeated on a great scale, we know not. Many geologists assume, from the conditions observed in our present systems of rocks, that 12 to 24 such elevations may have taken place, but the assumption is only valid for the products at present lying before us, since no one can give us an indication how many entire systems of rocks may have existed in earlier times, and again have been totally destroyed or sunk down to the bottom of the ocean. With that consolidation of the incandescent fluid mass, in which perhaps the oxygen of the atmosphere so far bore a share, that it became united with the metals of lime, silica, potash, soda and the rest, into the oxygen-compounds or oxides, of which the existing rock systems are composed—with that immediate formation of rocks out of the cooling and solidifying mass, I say, there came another process, of no less important influence. As soon as the first solid masses of stone became elevated into the air, forces were also already active to destroy them again, forces which we for the most part still see, although perhaps with less violence, restlessly labouring to destroy and level mountain chains. The alternation of heating and cooling caused the masses of stone to split up; into the cracks penetrated water saturated with carbonic acid, decomposing the previously formed chemical compounds, and loosening in this way the internal cohesion of the rocks, which became broken up and finally reduced to dust. In this way we see in the present day, upon the Brocken, great blocks of granite crumbling in the course of a number of years into a coarse granular sand. Then those masses of dust and sand, washed together by mighty floods of rain, which were continually precipitated with increasing violence during the farther cooling of the earth,—into the deep, the great basin of the powerful ocean, and here, when the water was more calm, became deposited in layers at the bottom, till some new eruption lifted up this sea-bottom and the strata deposited upon it, above the surface of the water. It is clear that the masses of rocks thus elevated must also be subject to the process of weathering, and that the products of this, washed away into new accumulations, must give rise to new deposits of a different kind. Nevertheless, the original differences of these deposits are not very distinct in subsequent times, and they may be reduced to sandstone, limestone, and clay or marl, which re-appear in every period. These processes must have lasted for many hundred thousands of years, until the firm crust of the earth gradually approached the shape which it at present exhibits, and until the violent strife between the still incandescent fluid mass and the atmosphere of vapour had become moderated to a certain degree of peace. This account of the formation of our earth leads us to assume the existence of two essentially different kinds of rocks—namely, those unstratified, as they cooled down from the molten condition, and the stratified rocks produced by deposition from water.

In some period of this gradual shaping out of the earth, the first germs of organic existence originated, through forces, which may indeed still be in action, but under conditions and co-operation of those various forces such as now appear no longer possible upon our earth. The ocean was probably the birth-place of these organisms, and their forms as yet very simple. The dead organisms falling to the bottom of the sea, were buried, and either wholly or in their more solid parts (shells and bones) preserved at least their external form, even though the organic substance was in great part decomposed and, frequently, replaced by inorganic matters which penetrated, causing what is called petrefaction. From what has already been told of the history of the formation of the rocks, it follows that such petrefaction can only occur in the stratified rocks. In subsequent periods, organisms also originated upon the dry land, and the remains of these passed as petrefactions into the rocks, and this in two ways—either the bodies were carried into the ocean by floods and the larger streams, or the whole surface of earth on which they lived, sank down in the way above described, beneath the surface of the sea, and thus they became buried in vast masses beneath the deposits from the water.

The careful study of the rock-systems and masses, and petrefactions (fossils), has enabled us now to divide the gradual formation of the earth into determinate periods; not, indeed, limited according to time, but according to their products; and these products are called rock-*formations*, which, arranged in definite series, have such relation to one another, that no formation belonging lower down in the series is ever found deposited upon one higher up in the list, so that we can assume with safety, that they have been formed one after another in this order. Several of these formations are then collected together, so as to form greater *periods* of formation, as it were stages of the earth's age; according to which, therefore, I shall, in the following pages, briefly sketch the gradual development of the vegetable kingdom.

But before I pass to this subject, I must once more recur to the original condition of the atmosphere of our earth, to its climatal condition and gradual alterations. The temperature of our globe has two sources—namely, the proper internal heat existing within, and that which it receives from the rays of the sun. Of the heat, however, which it possesses and obtains, it continually gives off a certain quantity to the cold space of the Universe. Cooling, and warming by the sun, now bear such a relation to each other, that they maintain a perfect equilibrium, and that at least for almost 3,000 years, the temperature of the earth cannot have altered the tenth part of a degree. We have two proofs of this; one astronomical, which is based upon the observations of the moon's eclipses by Hipparchus, which I pass by here, and the other botanical, which was first discovered by the ingenious Arago. The Vine will no longer ripen its fruit where the mean temperature of the year is higher than 84°, and, on the contrary, the Date will not flourish where the temperature sinks below 84°. These conditions exactly meet in Palestine; and the Jews, when they took possession of this country, found the Date and the Grape together. Now, had the temperature of the earth either risen or fallen in the least since that time, one of those plants must either have disappeared from Palestine, or have become unfruitful there, which, however, is not the case.

If the earth at present derives just so much heat from the sun as it again loses by cooling into the space of the universe, this is in other words to say, that the sun is *now* the only source of heat, and, therefore, the heat must be distributed upon the earth in proportion to its position in relation to the source of heat; the tropics must be the hottest, the poles the coldest, as has been already shown in a former Lecture. But this condition did not always exist. So long as the earth was yet in an incandescent fluid state, and was surrounded by a dense atmosphere which would transmit the sun's rays but in a slight degree, the amount of heat which it obtained from the sun remained scarcely appreciable, compared to that which it lost by cooling, or in other words, in the first epoch of the earth's formation, the source of its heat lay, to all intent, within. Here, therefore, there was no distribution of heat over the earth, depending upon its position in relation to the sun, and the temperature was pretty nearly equal over the whole earth. A hot, moist atmosphere, at present characteristic of the tropics, then prevailed all over the globe, and made the polar regions to resemble tropical countries. Only by degrees, as the earth gradually cooled and the atmosphere precipitated its vapour more and more in the form of rain, gave up its carbonic acid to the organic world, and thus became lighter and more transparent, did the sun acquire higher importance; and thus the regions of the higher latitudes and even the polar lands passed, in a series of stages, through the climates, *one after another*, which we now find upon the earth, *side by side*, in going from the equator to the poles. This circumstance will prove hereafter very full of consequences in reference to the explanation of the different kinds of vegetation following one another upon the earth.

As I have already said, the first germs of life probably originated in water, and in agreement with this we find in the oldest stratified rocks, the Grauwacke, or as the English call them, the Silurian rocks, merely some few remains of species of Tangle, accompanied by sea animals, of which solitary representatives were already exhibited in the preceding Cambrian formation. The species of Tangle met with, manifest a great general agreement with those forms now occurring in the tropics. It must not, of course, be forgotten, that the Grauwacke has as yet been carefully examined almost solely in England and Germany, and that in these very places its layers have been so enormously disturbed and altered by the subsequently upheaved rocks, and by the action of the glowing masses of these, that certainly many of the remains enclosed within them must have been destroyed in those revolutions. In Russia, on the other hand, this formation appears to occur to an extraordinary extent in undisturbed stratified condition, lifted very slowly and quietly above the surface of the sea; and from these we shall, hereafter, first obtain an accurate knowledge of these oldest marine deposits.

In the *second period*, numerous islands were formed, the soil of which, consisting for the most part of layers of the former period, supported a rich land vegetation. A part of England and Scotland, the country of the Rhine, the Erzgebirge and the Sudeten, central France, the Vosges, northward, a part of Sweden and Norway, the Alleghanies in North America, and some other points, may with certainty be named as such groups of islands, upon which was developed a vegetation quite tropical in its character, but wholly strange in its individual forms, and consisting in great part of races of plants which have now totally disappeared from the earth. A few Palms and some Cycadaceæ, some gigantic Equisetums or Horsetails, twelve to twenty feet high, are found scattered in thick woods of arborescent Ferns, which alternate with Lepidodendrons (Club-mosses, rising up into mighty trunks), Sigillarias (perhaps plants of the Cactus tribe), with Calamites, Stigmarias, and Conifers. Still we find no trace to show that animals inhabited these islands, but in the sea Sharks were already chasing the smaller fish, the shore was fringed with numerous forms of Coral; the Trilobites, strange Crab-like animals, wonderful creatures allied to the Nautilus, and the elegant, lily-like Encrinites and Pentacrinites, gave rich variety to the aquatic Fauna. Over the whole globe is that Flora the same, from the now frozen caves of Iceland, to the glowing coast of Malabar. Long must this vegetation have endured, often must the soil, covered with a thick layer of humus from the remains of dead plants, have sunk beneath the surface of the ocean, been covered with a new layer of deposits and again been upheaved, affording new soils to successive productions of the same luxuriant vegetation; since it is this vegetation which has left behind the incalculably vast, half-destroyed vegetable masses which, as Coal, now constitute almost one of the most essential portions of the natural riches of a country. We often find from twenty to thirty layers of Coal, one above another, always separated by layers of calcareous deposits enclosing marine animals. We often find the upright stems of whole woods in such carboniferous deposits, proving that the whole land sank down slowly and without any considerable revolutions, beneath the surface of the sea, as even now occurs on the south-west coast of North America; nay, we find such stems, with their roots sunk below in the Coal, that is in the soil so rich in humus which nourished them, while their upper portions are enclosed in calcareous layers subsequently deposited upon the soil. When it is considered, that almost a century is required to form a layer of humus nine inches thick, by the most luxuriant vegetation of the tropics, that this layer, to convert it into Coal, must be compressed into a twenty-seventh part of its thickness, an approximative conception may be formed of the duration of that period; since the super-imposed layers of Coal, in England for instance, often have a collective thickness of forty-four feet, and correspond therefore to a period of time almost equalling 100,000 years. The character of the vegetable world of the Carboniferous period, expressed in the predominance of the great arborescent Cryptogamia, especially the Ferns, reminds us most of the Flora of the tropical South Sea Islands, and the vegetation of these organisms seems to be particularly dependant on a hot atmosphere, saturated with moisture, such as we are compelled to assume to have existed in that epoch of the earth's history.

In the succeeding period of the *Secondary* rocks, the previously existing islands, with their Flora, appear to have become partly submerged again, while other, more extended tracts of land rose up, the soil of which consisted principally of the lime and sandstone of the Coal period. However, these tracts of land partly united with the islands already formed, and thus particular forms of plants of the previous epoch were preserved and continued over into the new order of things, while the most peculiar races partly sank with their soil, and partly died out, in consequence of the gradual essential alteration of the physical conditions. The arborescent Ferns and the Calamites still existed but became more rare, while the *Cycadaceæ* and Conifers developed in great abundance, and in numerous peculiar forms, forming dense forests on the borders of the great lakes, in which great Sedge and Rush-like plants vegetated. Grand forms of *Liliaceæ* rising into trees, the Bucklandias and Clathrarias, perhaps constituted peculiar groups on the more elevated grounds. Among these rolled the giant bodies of the Old World, gavials, lizards, and turtles, fluttered the strange Pterodactyles like colossal bats, and in the dry places played the wondrous opossums; while, in the ocean, the monster Plesiosaurians and Icthyosaurians, half fish, half lizard, fed upon the countless little inhabitants of the liquid element, which was, moreover, alive with ammonites and nautili, strange crabs, and peculiar star-fishes. The conditions of the Carboniferous period were only repeated here on a very small scale, and the remains of that world of plants are found in the so-called *Keuper* formation, as *letten* coal, here and there so abundant, that it has been thought worth the trouble of obtaining by mining operations. The peculiarities of the Coal Flora, consisted in the preponderance of arborescent Cryptogamia, with which were associated only solitary Conifers and Cycadaceæ; in the period of the secondary formations, on the other hand, the latter are the plants which especially determine the character, solitary Monocotyledons occurring among them. But already towards the close of the secondary period, the character of the vegetation became altered, probably through a fresh, slow depression beneath the sea, of a great portion of the existing land, bordered round with coral banks, while in other places more mighty continents, partly corresponding to those existing at the present time, became upheaved. Thence, we find, out of the last formations of the secondary period, scarcely anything but a few Algæ and Monocotyledonous water-plants, and merely indications that the Cycadaceæ and Conifers were not destroyed.

The new arrangement now presenting itself, called by geologists, *Tertiary* formations, began still with a widely extended tropical character; we find in high latitudes, as in England, still a rich vegetation of Palms, which now generally appeared in a striking manner, and appear to have determined the character of the landscape, while the Coniferæ and Cycadeæ, drew back gradually more and more into particular localities, perhaps the former on to the cooler heights, the latter to dry, sunny hills. Among Pandaneæ and mighty Bull-rushes grazed gigantic Tapirs, and the woods, already formed of deciduous Dicotyledons, were filled with birds and the lesser animals. Whales, walruses and seals traversed the seas.

While the earth began to cool down gradually from the poles hitherward, to its present temperature, the plants and animals became always more and more localized; Faunas and Floras of definite zones were formed. Even towards the end of this period, the mammoth required his warm, woolly hair to protect him from the piercing cold in the steppes of Siberia, and used more hardly by Nature than his younger brother the elephant, was forced to live upon the Conifers confined to the north and the higher mountains. The forms of the present world continually made themselves more evident in the Vegetable Creation. Alders and Poplars clothed the new low-grounds; Chestnuts and Figs the sunny hills; and slender Birches contested with the Pines the possession of the drier and cooler soils. The giant stream of North America, the Missisippi, annually rolls down to the sea in its flood, immeasurable masses of dead, floating vegetable bodies, vast trunks of trees from the woods in the regions of its sources. In the sea, the currents are too slow to keep these heavy bodies floating, and they sink at the mouth of the river, the interspaces between them becoming filled up with mud and drift. From New Orleans, marshy low grounds extend downwards for many miles, which consist entirely of such floated-down masses of plants, cemented together by sand

and clay, and gradually decomposed into a substance resembling peat, and which is forming a layer of coal for future ages. In a similar way, did the great streams of this period float into masses and deposit countless trunks, especially of Conifers, in estuaries and fresh-water basins, which perhaps were brought, through later depressions, yet deeper beneath the surface of the ocean, covered with deposits of sand, lime or clay, and then upheaved again. These are the layers of *brown coal*, often so very extensive, which are always a valuable gift of the soil, but still a poor substitute for the true coal withheld.

The new elevation of some important rock systems, in particular those of the Himalayas, appears to have, in great part, put an end to all this life, through the alteration of the level of the ocean which it caused, and since, at the same time, the earth attained the limit of its possible cooling, it thus appears to have produced the present structure of the solid land and its organisms.

All the succeeding changes which now occurred, elevations and depressions of the land, were dependant merely on local actions of subordinate importance.

We may abridge the preceding sketch into the following main points. The gradual development of the vegetable world commenced with the simplest plants, and advanced gradually through the succeeding periods to the most perfect plants of our existing vegetation. The structures of the first period correspond to a tropical climate contemporaneously extended all over the globe, which passed by degrees from the poles towards the equator into the present climatal conditions ; and keeping pace with this, appeared another change, for the plants of the oldest period which seem to have been equally distributed over the whole earth, by degrees were confined into regions of distribution, and so passed into the great geographical variety of the vegetable world. The gradual conversion of the universal tropical climate into the present climatal zones, may be shown in another very interesting manner, in quite a special instance. All ligneous trunks of Coniferous trees continually increase in thickness at all parts of their circumference. In the equatorial regions, where the climate retains the same character uninterruptedly throughout the year, this thickening of the trunk proceeds without interruption and homogeneously; no mark betrays, in a smooth transverse section of the stem, the time which was required for its formation. As we proceed towards the north, however, as the climatal conditions produce continually increasing diversity in the particular seasons, the corresponding growth in thickness shows itself to have been furthered by the favourable season, and restrained or altogether interrupted by the unpropitious times. In a cross section of a stem are seen, the higher the latitude in which it has grown, the greater differences in the structure of the successive portions of the wood; until, finally, in the latitudes where there is a severe alternation of winter and summer, so striking becomes the difference between the wood last formed in summer and that first produced in the next spring, that we may count in the number of annular marks thus produced, in a cross section, with great certainty and accuracy, the number of years which have been occupied in the formation of the trunk. The circular lines upon the cross section, well-known to every forester, are thence called the *annual rings*. When, fortified with the knowledge of this fact, we compare with each other, the trunks of the Conifers which we obtain from the various epochs of formation, we find that the oldest remains exhibit no trace whatever of annual rings; but in the course of time they become continually more defined, so that lastly, in the most recent formations, for instance in the upper Brown coal they appear marked just as distinctly as in the trees now living in the same localities.

A mere sketch, and imperfect, as is my representation of the successive vegetations of the earth, our knowledge of these past times is likewise, on a higher scale, imperfect and fragmentary. If it be considered, how many accidents must coincide in order that organisms, only to a certain extent capable of recognition, should be enclosed in mountain masses in process of formation, what manifold destroying forces must have rendered their influence felt upon the organisms preserved, during the hundreds of thousands of years which lie between the first origin of vegetation and the existing world, it will not be found surprising that our knowledge is here, more than anywhere else, mere patch-work; but we shall not be able to withhold our admiration from the men whose untiring industry, whose ingenious combinations, brought to light and gave so high a degree of certainty to what we know of the ancient history of the Vegetable World. The names of Sternberg, Brongniart, Göppert and Unger, are especially to be mentioned, who have won for themselves immortal credit in the Knowledge of the Flora of the Ancient World.

I have only given a sketch of what we *know*, of *what* existed in the different epochs of the earth's endurance; yet the question of what we know *not*, of the *how* it was, may appear to many to possess no less interest. Here, then, we come almost wholly into the region of arbitrary speculation, we can only here and there draw tottering analogies to endow our pictures with a weak semblance of probability; and, as it naturally occurs that the views of individual inquirers vary to infinity, it is ridiculous and useless to contest about this or that opinion, about the truth or falsehood of a waking dream, as only too often happens.

That the germ of organic life came forth upon the earth once, at least, out of the strife of the inorganic elements, admits of no doubt, but there is another question: has this process occurred more than once? And *must* it have occurred more frequently? Since in these matters every one has, and may have, his own proper fantasies, why should not I too have mine? —I hold the assumption of repeated *creation*, of a totally new origination of vegetable germs, out of unorganized or even inorganic matters, to be superfluous, and therefore not to be admitted, and this opinion I found on the consequences of the following considerations on the gradual development of the Vegetable world. The simplest element of the whole vegetable world, is the cell,* a very simply constructed organism, the origin of which out of the peculiar association of carbonic acid and water, on the one hand, into gum or vegetable jelly, and of carbonic acid and ammonia on the other hand into protoplasm or albumen, is not so very widely removed from a possible explanation, as the sudden origin of a vegetable germ with perfect definite power of development into a peculiar species of plant. That the cell can vegetate as an independant plant, we know from the vegetable Creation at present surrounding us, since many of the simplest plants, especially the *Water-plants*, consist of a single cell, and are only distinguished from one another by the varying forms. The principal causes producing a luxuriant and varied world of forms in the tropics, are moisture and warmth, the causes of their

* See the Second, Third and Fourth Lectures.

multiformity appear to lie in the richness of the soil in readily soluble inorganic matters, which in the first place give rise to a variation in the chemical processes of the plant, and thus to a greater or less deviation in the form.* These two conditions *meet* in the tropics, because they are dependant one upon the other, since the more luxuriant vegetation called forth by the moist, warm atmosphere, prepares by its death and rapid decay, a soil richer in soluble inorganic matters, for the succeeding generation. Similar conditions, that is to say, greater richness in soluble inorganic matter, are exhibited on our manured cultivated lands, and the Alpine regions, which are continually supplied with an abundance of soluble matter from the naked higher rocks more exposed to the action of the weather.† We know, moreover, that varieties once formed, when they have continued to vegetate under the same conditions for several generations, pass into sub-species, that is into varieties which may be propagated with certainty by their seeds, as for instance, our beds of Peas, our Cabbage plantations and our Wheat-fields testify. How then if the same

* See the Seventh Lecture.

† No one who casts a glance over an accurately investigated Flora, can deny that the Alpine plants exhibit a greater richness in form, and series of most striking varieties. It is not so evident in regard to the cultivated land, and I will therefore offer the following brief remarks; among the German families of plants, the Goosefoots and *Oraches* (*Chenopodeæ* and *Atripliceæ*) most especially grow on rubbish, heaps of compost, and in gardens, therefore peculiarly under the inevitable influence of the conditions given by our cultivation; and no collector is ignorant of the abundance of forms and varieties which most of these plants deviate into. If we select from the best and most carefully revised Flora of Germany, those genera which exhibit the most stable species, and at the same time include some species which vegetate in quite a different way under the influences of our cultivation, it at once becomes evident that

influences which have called forth an aberration from the original form of the plant continue to act in the same way, not for centuries or tens of centuries, but for ten or a hundred thousand years; will not, at last, as the variety thus becomes a sub-species, so also this become so permanent, that we shall and must describe it as a species. Then, if the first cell be given, the foregoing points out how the whole wealth of the vegetable kingdom may have been formed by a gradual passage from it through varieties, sub-species and species, and thus onward, beginning anew from each species—in a space of time, indeed, of which we have no conception, for which, however, since there is nothing *real* wanting, we may provide at pleasure in our dreams; for it may be mentioned here that all the recent distinguished Geologists come ever more and more to the opinion, that very much, in the formation of the crust of our earth, which was formerly ascribed to violent, convulsive and sudden revolutions, has rather been the product of forces acting slowly through the course of enormous periods of time. The Falls of Niagara, for

these latter exclusively, or at all events especially, occur in an abundance of sportive forms, whereby they deviate more or less from the primary character of their species. I name as examples, such species as, Thalictrum *minus*, Ranunclus *arvensis*, Viola *tricolor*, Silene *gallica* and *inflata*, Spergula *arvensis*, Medicago *falcata*, *lupulina*, *tribuloides*, Vicia *villosa*, *sepium*, *grandiflora*, *angustifolia*, Knautia *hybrida*, *arvensis*, Scabiosa *gramuntia*, Cirsium *arvense*, Taraxacum *officinale*, Galeopsis *ladanum*, Agrostis *stolonifera*, *vulgaris*, Aira *cæspitosa*, Festuca *ovina*, *rubra*, Bromus *secalinus*. Nay, many species may have originated from such variations, even within historical time, as Thalictrum *minus* and *majus*, Veronica *præcox* and *triphyllos*. But that all true cultivated plants occur in countless varieties it is scarcely necessary to mention, since Peas, Cabbage and Potatoes, not to consider fruits, are each sufficient evidence of this truth.

instance, pour down a vast ravine which has been cut into a terrace of rock; and Lyell has pointed out, that the waterfall originally, that is at the close of all the revolutions and deluges, discharged the water over the edge of that terrace, and has gradually washed out that ravine since. This must have required a space of time equal to at least 20,000 years; and thus long, under any circumstances, North America must have existed in its present configuration and under the same physical conditions. Another similar example has already been furnished above, in the Coal, and it would be easy to multiply the proofs that the space of time which we, with boastful self-sufficiency, delight to call the World's History, is but the last fleeting moment of the infinitely long lifetime of our little planet.

If now we recall to mind the sketches above given of the successive epochs of vegetation, we see that the vegetable world begins in water, under the simplest forms, and in that very family in which the whole plant is represented by a single cell, most frequently, in the present time. In the succeeding periods the other groups are added to this, making their appearance in a series which corresponds through a continually higher organization, *i. e.*, continually more manifold vital processes, to the successively more manifold and complicated physical conditions which come into action. Thus the stemless *Cryptogamia* are followed by those provided with stems and leaves. Then the *Gymnospores* (Conifers and Cycadeæ) enter upon the field; to these succeed the *Monocotyledons*, and lastly appear the *Dicotyledons*. Imperfect as are the documents we have obtained, and little as we have yet decyphered of them, yet in no period do we find the appearance of a wholly new creation, but the organic beings are always added gradually; the lowest members of one period succeeding to the highest members of the foregoing, in such a manner that they at least repeat its principal type; nay, we may even say more than this: if both genera and species, or even families of plants, have disappeared from the earth, there does not exist even in the oldest remains, any peculiar great group, a Form of plants constituting as it were a stage of development of the vegetable world, which has not its representative also exhibited in the Flora of the present world.

This view, that the whole fulness of the vegetable world has been gradually developed out of a single cell and its descendants, by gradual formation of varieties, which became stereotyped into species, and then, in like manner, became the producers of new forms, is at least quite as possible as any other, and is perhaps more probable and correspondent than any other, since it carries back the Absolutely Inexplicable, namely, the production of an Organic Being, into the very narrowest limits which can be imagined.

At the close of all this series of developments, Man first entered in a way which we cannot explain into the circle of the earth's inhabitants, and thus divided the foregoing series of changes, as the Primeval history of the vegetable world, from the succeeding, the history in Time. The boundary line is not very clear, and an error of from 10 to 20,000 years, in the attempt to define the epoch, is very possible and even probable, yet people have been foolish enough to devote themselves to such inquiries, even as there have been madmen who have reckoned the year, month, day and hour, in which God made the world.

From the hand of Nature, Man received the inheritance prepared for him, the Vegetable and Animal Worlds, the Dead matters and their Forces; and how has he managed this inheritance? If he shall have to render an account of it, it is to be feared that here, as everywhere, it will go hard with him.

If we inquire for what Purpose is the Vegetable world, the parti-coloured carpet of the earth, intended, we find a three-fold answer. The meanest purpose, is undoubtedly, to serve the common necessities of mankind, their nourishment and handicrafts, in a word their Economy. I call it the meanest, because Nature here merely satisfies for each individual, what, be they ever so refined and glossed over by cultivation, are but animal requirements. The import of the vegetable world for the regulation of the numerous and comprehensive physical processes of the earth, appears indeed more lofty. The glow of the African desert, its dry rainlessness, and the fulness of life in primeval forests with their torrents of rain, obtain their peculiar characters through the vegetable world. Moisture and dryness of the atmosphere, warmth and cold of the soil, uniformity or rude variability of climate and the like, above all the life of Animals, and finally of Man in the mass, have their conditions in the luxuriance and the nature of vegetation. This import of vegetable life does not relate to the solitary, miserable individual, but to whole countries and regions, to many successive generations, the possibility and facilities for whose existence are intimately bound up with the formation of the vegetable world as a Whole. Lastly, there is a third face, which the world of Plants may turn towards us, without question the noblest and the most exalted. It is, like all Nature, the symbol of the Eternal; behind this play of dead natural forces and their products, we adore a Holy Author and Sustainer. The Vegetable Creation is the rich altar-cloth of the temple of God, in which the recognition of Beauty and Sublimity of forms, constitutes the worship.

And Man in opposition to the Vegetable world? Altering many things, he has laid hands upon it, and the great phases of his History are also catalogued on the green leaf of vegetation. But how has he husbanded it? The history of cultivation would answer us, "Excellently; he has by wise care converted the raw, unyielding material of Nature into those choice gifts which now appear." Well, we will not contest with him the glory, that where interest and animal necessity have driven him, the individual has indeed well understood his own profit, but then, shared the advantage he has gained with fellow-men and those coming after him, only when forced by the laws of Nature. On the other hand, where no temporary profit was to be derived from assisting Nature, or even from leaving it alone, where the question was merely the misery of a thousand or two of future fellow-beings, he has, with barbarous rudeness, demolished and destroyed, for thousands of years, often wickedly squandered the seed which God had vouchsafed, not for himself alone, but also for his successors. And has he striven to adorn and sanctify the temple of God to universal worship? Oh, no! In his selfish labours, in the tears of his brother, rendered miserable by his crimes, in the cry of the scourged slave, the continual remembrance of God had become disagreeable and troublesome to him; he declared the afflatus of the Divine breath in Nature was but a nursery tale, that he might no longer be frightened by his conscience. Beauty, the expression of the Divine in Nature, vanished before selfish profit from the vegetable world, and at most, caring, with narrow heart, but for himself alone, the Individual enclosed a little space in which he used the

Beauty of Nature, not for worship, but as a sensual pleasure. This is now the reality; when thousands of years have past, let us hope to be able to report better things; for we do not despair of Humanity, in it lies the germ of the Divine, capable of eternal development and destined to it. But with derision might we meet the cry of our high culture; for all earnest moral reflection upon History would tell us, that we have yet scarcely struggled out of the mire of the lowest degradation and barbarism. The following facts, perhaps, made use of in a better way, might afford a means to the attainment of a somewhat better result.

The Cradle of the human race, lying back in a distance of time we can never explore, probably stood in a warm, half-tropical climate, shaded by the broad leaves of the Banana, the Plantain, and the delicate, feathery leaf of the Date-Palm. What the first food of Man was, we know not, but he seems to have used these two plants at a very early period, since neither of them, from the oldest times of which we have record, appeared in the condition in which they came from the hands of Nature, but essentially altered by the interference of human cultivation. The wild Banana is a small, ill-flavoured fruit, filled with numerous seeds; the cultivated plant, on the contrary, contains no fertile seeds in its nutritious berry; its maintenance, its multiplication, are dependant wholly on the activity of Man, who propagates it artificially by cuttings. Very early too must Man have made the large-seeded Grasses tributaries to his store-house. We know not the time when any of the plants now used as Bread-corn, were transplanted from the Eden of God into the fields of Man. Their use has passed from one race to another, but when we arrive at the most ancient sources, the legends tell us, in manifold vesture and varied adornment, that they are the gift of the Gods, that these taught men to cultivate corn.

The personification of physical forces and processes, of light, heat, rain, of the floods of the Nile, may have become, in many ways, mingled and united with the worship of the individual personalities which first sought to turn to account the treasures of Nature, in a wider circle, for the profit of mankind. A striking phenomenon, which indicates the enormous antiquity of the culture of the *Cerealia*, is, that in spite of many most profound investigations, we have not yet succeeded in discovering the proper native country of the more important kinds of Corn. Not one of the industriously inquiring travellers in America has ever met there with Maize otherwise than cultivated, or as evidently an outcast from culture. With regard to our European kinds of Corn, we have only very inaccurate indications, that they have been found wild, here and there, in the south-western countries of Central Asia. But history proves that those regions formerly supported so large a population, and that so high a condition of culture there existed, that the assumption can scarcely be justified, that those Corn-plants now found there, are anything but descendants from plants which have escaped from cultivation. From our knowledge of the great eastern portion of China, we know that a dense population can, by a certain degree of industrial culture, succeed in extirpating every wild plant, and in clothing the land exclusively with vegetables intentionally raised. Except some few water-plants, in the purposely flooded Rice-fields, the Botanist finds scarcely any plant, in the Chinese plains, which is not an object of cultivation. So it may not be at all impossible, that the *Cerealia*, perhaps originally, as is the case now with so many Australian plants, confined to a narrow region of distribution, which was taken possession of at an early period by a strongly developing population, have actually wholly disappeared from our earth in the character of originally wild plants.

The oldest kind of Corn are, without doubt, Wheat and Spelt, which are mentioned even in Homer as Bread-corn; and Barley, with which Homer's heroes, like the inhabitants of southern Europe in the present day, foddered their horses. First in the time of Galen was Rye introduced into Greece by way of Thrace. Various kinds of Oats were cultivated in Greece, but not for the sake of their seed, only as green fodder. The proper cultivation of the Oat is first found at a subsequent period in Germany, apparently borrowed from Eastern nations, from whom Germany also obtained its Rye. According to the usual opinion, the culture of Maize throughout the Old World is wholly introduced from America; nevertheless, testimony exists which makes it at least probable, that so early even as the time of Theophrastus, Maize was known by the Indians, and that at all events eastern Europe had obtained it from the East. An exactly similar uncertainty as exists in regard to the so-called Turkish Corn,* is found in the case of the *Cactus Opuntia*, or Indian Fig. This plant, at present growing all over the south of Europe, Africa, and a part of the East, is, according to most authorities, a native of America run wild here; while the researches of others lead us to look upon it as more probably indigenous in these regions. Such wanderings of plants, produced by the operations of mankind, are frequently rocks which we can by no means avoid, on which

* This name even, universal in Germany and Italy, and for which a similar (Arabian Corn) is substituted in Greece, points to an Oriental origin.

the most aeeurate geographical investigations are wreeked, when no definite historieal reeords have been preserved to us.

What has been said of the Corn-plants, that the origin of their eulture lies far baek beyond historical time, holds good also for most of our kitchen Vegetables and Fruits. Nay, it may even be asserted that, with the smallest possible exception, all the important eultivated plants have been known to Man from time immemorial, and that, with the exeeption of the Potato, no plant subsequently reclaimed from the wild eondition plays an important part in our eeonomy.

Of all the influences of mankind upon the vegetable world, one of the most beneficial is, without doubt, the eonversion which he has effeeted of the wild and often almost inedible plants into the delieious ornaments of our table. Even if the Apple, Pear and Cherry trees were originally peculiar species, and have not been produeed by gradual improvement from the Crab and the wild Pear and Cherry, there are still enough plants remaining to prove what great power the art of Man has here exercised over Nature. What resemblanee has the Cauliflower, the Savoy, or the Kohl-rabi, to the dry and nauseous, bitter-flavoured Cole-wort, which is undoubtedly the parent of our delicious vegetables, sinee we ean readily eonvert these again into it by allowing them to run wild. Who, from the comparison of the saccharine, delieate, orange-coloured Carrot, with the woody spindle of the root of the wild Carrot, would believe that they belong to one and the same species?—and still it is the case. In short, Man can here essentially interfere to alter, in the development of individual natural bodies, and as he ean obtain from the sanguinary beast of prey, from the Wild dog, the playful spaniel, the useful hunting companion and the rescuing St. Bernard's dog, or from any rugged sheep the precious Merino-lamb, so in the world of plants he can elevate the Useless which Nature has given him, into an object worthy of his cultivation.

The changes which Man has caused in the distribution of vegetables cannot appear so important as the above interferences. But it is only what we expect, when we find that thc Economic and Food plants follow Man everywhere, where the climatal conditions of their growth are met with. These wanderings of plants are arranged and carried out by Man intentionally. But in the rear of these armies of plants, like the rabble of marauders and thieves following a great human army, a number of other plants are inseparable followers, which Man, when he takes one wild plant, must, as it were, receive as an addition to his bargain, I mean the Weeds. It may safely be asserted, that a portion of our field plants which are never found anywhere with us but among certain definite crops, are not indigenous, but introduced along with the seed among which they are mct with. Among such unbidden guests may be enumerated the lowly Pheasant's-eye, the Bluebottle, the Corn-cockle, the Field Poppy (*P. Argemone*), the Larkspur (*D. Consolida*), the *Lolium linicola*, the Hemp, and many others.

In a still higher degree, spontaneously, and without the conscious co-operation of Man, a certain number of plants attach themselves to the Lord of Creation, and follow him whithersoever he goes, wheresoever upon the earth he takes up his abode; not in company with the cultivated plants he has brought with him, but in his immediate vicinity, settling round his barns, his stables, or on manure and compost heaps. It is more than probable that the different great families of Nations may be distinguished through this circumstance, and from the weeds which have firmly attached themselves to their train, it may with some certainty be determined, whether Sclaves or Germans, Europeans or Orientals, Negroes or Indians, &c., formerly built their huts on any spot. Thus, even to the present day, are marked the footsteps of the bands of nations which in the middle ages emerged from Asia into Central Europe, by the advance of the Asiatic Steppe-plants, such as the *Kochia** and the Tartar Sea-kale,† the former into Bohemia and Carniola, the latter into Hungary and Moravia. The North American savage significantly calls our Plaintain, or Road-weed,‡ "the Footstep of the Whites;" and a common species of Vetch§ still marks the former abode of the Norwegian colonists in Greenland. A more intimate knowledge of these peculiar Floras might probably afford us many more interesting explanations as to the wanderings of the primary Races of mankind, and their alliances, if so many botanical travellers were not so-called Systematists—that is, dull and ignorant collectors of hay. I may mention some more of such examples, vegetables especially accompanying Europeans, the different kinds of Nettle and Goose-foot. But one of the most striking instances of the kind is the gradual extension of the Thorn-apple over the whole of Europe, which has followed the bands of Gypsies out of Asia; this race make frequent use of this poisonous plant in their unlawful proceedings, and hence much cultivated by them, it also occurs, uncalled for, near the places where they have made their habitations. Auguste St. Hilaire says, in the introduction to his Flora of Brazil, "In Brazil, as in Europe,

* Kochia scoparia. † Crambe tatarica.
‡ Plantago major. § Vicia cracca.

certain plants appear to follow in the footsteps of Man, and preserve the traces of his presence; frequently have they helped me to discover the situation of a ruined hut, in the midst of the wastes which extend out beyond Paracuta. Nowhere have the European plants multiplied in such abundance as in the plains between Theresia and Monte Video, and from this city to the Rio Negro. Already have the Violet, the Borage, some Geraniums, the Fennel, and others, settled in the vicinity of Sta. Theresia. Everywhere are found our Mallows and Camomiles; our Milk-thistle, but above all, our Artichokes, which, introduced into the plains of the Rio de la Plata and the Uruguay, now clothe immeasurable tracts, and render them useless for pasture." After the War of Deliverance, in many places where the Cossacks had encamped, was found the Tick-seed,* a plant allied to the Goose-foots, which is quite exclusively indigenous in the steppes on the Dnieper; and in a similar manner was the *Bunias orientale* spread with the Russian hosts, in 1814, through Germany even to Paris.

But such wanderings of plants also occur altogether without the co-operation of mankind. The Seychelles Nut† is driven by the ocean currents on to the shores of the Maldives, and there germinates in the sand. The earliest settlers in the Coral Islands, newly arisen in the silent ocean, are the Cocoa Palm and the Pandaneæ or Screw-pines, the fruit of which, protected by a hard shell, is found everywhere drifting on those seas. Rivers carry the seeds from the higher regions down into the lowlands, and thus, for instance, forms which were originally peculiar to the higher mountains are distributed on the banks of the Alpine streams of southern Germany, in Bavaria and

* Corispermum Marschallii. † Lodoicea sechellarum.

Würtemberg. Man also unintentionally gives the first impulse to such wanderings, which the plant then independantly continues. Thus has the Sweet-flag spread all over Europe, which was originally brought from India and raised in some Botanic Gardens. The Indian Fig and the American Agave have, in running wild, essentially changed the physiognomy of the landscape in southern Spain, Italy and Sicily. In the middle of the 17th century a seed of *Erigeron canadense* came to Europe in a stuffed bird, was sown, and the plant is now distributed throughout Europe, in places to which it has never been conveyed by Man. The structure of seeds and fruits which facilitates their being driven far and wide by the wind, the voracity of birds, which devour the indigestible seeds, then afterwards often germinating far distant from the mother-plants in the excrement of the bird, and similar circumstances, explain this free distribution of plants.

Incomparably more important however than all these changes in small and individual matters, are the climatal alterations which Time or the operations of Man, call forth upon the earth and in the vegetable world. We know truly, that the sum of the heat which our earth has received for thousands of years, has not altered in a sufficient degree to produce the smallest change in the vegetable world, but the distribution of heat over the globe, and in different seasons, may become essentially changed in the course of time, and thus transform the whole physiognomy of a country. The unhappy Iceland, a few centuries ago still shared the culture of grain, which now has wholly ceased, or is confined to a sterile, and in most years failing crop of Barley; the Birch, in earlier periods forming dense woods, is now stunted to a low bush. The essential alteration of the climate which, beginning with the twelfth century, has converted Greenland into an almost uninhabited waste of ice, is well known. Strongly as these processes, in the mass, seem to refuse obedience to the will of Man, yet is this by no means the case, and his continued activity, applied to one determinate point, at length brings about results which surprise even himself, because he does not at the moment mark the gradually accumulating consequences of his labours nor, led by necessary knowledge, foresee the final results. Almost everywhere in the great characters in which Nature writes her chronicles, in fossilized woods, layers of peat and the like, or even in the little notes of men, for instance, in the records of the Old Testament, occur proof, or at least indications, that those countries which are now treeless and arid deserts, part of Egypt, Syria, Persia and so forth, were formerly thickly wooded, traversed by streams now dried up or shrunk within narrow bounds; while now the burning glow of the sun and, particularly, the want of water, allow but a sparing population. In contrast, must not a jovial toper laugh indeed, who looks from Johannisberg out over the Rhine country, and drinks a health in Rüdesheimer to the noblest of the German rivers, if he recall the statement of Tacitus, that not even a Cherry, much more a Grape, would ripen on the Rhine And if we ask the cause of this mighty change, we are directed to the disappearance of the forests. With the careless destruction of the growth of trees, Man interferes to alter greatly the natural conditions of a country. We can indeed now raise one of the finest wines upon the Rhine where, two thousands years ago, no Cherry ripened, but on the other hand, those lands where the dense population of the Jews was nourished by a fruitful culture, are in the present day half deserts. The cultivation of Clover, requiring a moist atmosphere, has passed from Greece to Italy, from thence to southern Germany, and already is beginning to fly from the continually drier summers there, to be confined to the moister North. Rivers which formerly scattered their blessings with equal fulness throughout the whole year, now leave the dry and thirsty bed to split and gape in summer, while in spring they suddenly pour out the masses of snow accumulated in winter, over the dwelling-places of affrighted men. If the continued clearing and destruction of forests is at first followed by greater warmth, more southern climate and more luxuriant thriving of the more delicate plants, yet it draws close behind this desirable condition another, which restrains the habitability of a region within as narrow, and perhaps even narrower limits, than before. In Egypt, no Pythagoras need now forbid his scholars to live upon the Beans;* long has that land been incapable of producing them. The wine of Mendes and Mareotis, which inspired the guests of Cleopatra, which was celebrated even by Horace—it grows no more. No assassin now finds the holy Pine-grove of Poseidon, in which to hide and lie in ambush for the singers hastening to the feast. The Pine has long since retired before the invading desert-climate to the heights of the Arcadian Mountains. Where are the pastures now, where the fields around the holy citadel of Dardanus, which at the foot of the richly-watered Ida supported 3000 mares?† Who can talk now of the "Xanthus, with its hurrying waves"?‡ Who would understand now the "Argos, feeder of horses"?

* Nelumbium speciosum. † Homer, Iliad, 20.
‡ Ibid, 12, 310.

I close this sketch, if not in the words, yet following the train of thought of one of the noblest veterans of our science, the venerable Elias Fries, of Lund.

A broad band of waste land follows gradually in the steps of cultivation. If it expands, its centre and its cradle dies, and on the outer borders only do we find green shoots. But it is not impossible, only difficult, for Man, without renouncing the advantage of culture itself, one day to make reparation for the injury which he has inflicted; he is appointed Lord of Creation. True it is that Thorns and Thistles, ill-favoured and poisonous plants, well named by Botanists *rubbish plants*, mark the track which Man has proudly traversed through the earth. Before him lay original Nature in her wild but sublime beauty. Behind him he leaves the Desert, a deformed and ruined land; for childish desire of destruction, or thoughtless squandering of vegetable treasures have destroyed the character of Nature, and, terrified, flies Man himself from the arena of his actions, leaving the impoverished earth to barbarous races or to animals, so long as yet another spot in virgin beauty smiles before him. Here again in selfish pursuit of profit, and, consciously or unconsciously, following the abominable principle of the great moral Vileness which one man has expressed, "*après nous le déluge*," he begins anew the work of destruction. Thus did cultivation, driven out, leave the East, and perhaps the Deserts formerly robbed of their coverings; like the wild hordes of old over beautiful Greece, thus rolls this conquest with fearful rapidity from east to west through America, and the Planter now often leaves the already exhausted land, the eastern climate become infertile through the demolition of the forests, to introduce a similar revolution into the far West. But we see, too, that the nobler races, or truly cultivated men even now raise their warning voices, put their small hand to the mighty work of restoring to Nature her strength and fulness, yet in a higher stage than that of *wild* Nature; rather dependant on the law of purpose given by Man, arranged according to plans which are copied from the development of manhood itself.* All this indeed remains at present but a powerless, and for the Whole, an insignificantly small enterprise, but it preserves the faith in the vocation of Man and his power to fulfil it. In future times he will and must, when he rules, leads and protects the whole, free Nature from the tyrannous slavery to which he now abases her, and in which he can only keep her by restless giant-struggles against the eternally Resisting. We see in the grey, cloudy distance of the Future, a realm of Peace and Beauty on the Earth and in Nature, but to reach it must Man long study in the School of Nature, and, *before All*, free himself from the bonds of Egotism.

* See the admirable work of Dr. Prichard, "The Natural History of Man;" comprising Inquiries into the Modifying Influence of Physical and Moral Agencies on the different Tribes of the Human Family. Second Edition, enlarged, with 44 coloured and 5 plain Illustrations, engraved on Steel, and 97 Engravings on Wood. Royal 8vo. London, 1845.

Twelfth Lecture.

THE
ÆSTHETICS OF THE VEGETABLE WORLD.

"The import of the Shapes, I wished
In magisterial wise to unfold;
But what I could not comprehend
Might not of course by me be told."

FAUST.

"I recognise the Man of Learning here :—
What you touch not, lies not within your sphere ;
What you grasp not, does not exist for you ;
What you count not, most surely is not true ;
What you weigh not, devoid of weight you call ;
What you coin not, won't pass with you at all."

FAUST.

LECTURE XII.

Inexplicable is the nature of Beauty. Only in the Feeling does the susceptible soul become conscious of it; and to the logically arranging, scientifically connecting, and theoretically deducing Understanding, it remains ever a foreign, closed territory,

> "Where all the Wisdom of the wise man leaves him blind,
> There plays in free Simplicity the child-like mind."

When with our observations and experiments, with analyses, conclusions and proofs, we have unravelled Nature into a plain, intelligible tissue of substances and forces, Beauty and Sublimity enter upon the field, unite the disjointed once more into a single Whole, and mock our endeavours to comprehend the eternally Incomprehensible. We explain it not, yet it is true; we comprehend it not, yet there it is. The pure heart speaks out unhesitatingly what the acutest intellect never finds:

"The heavens declare the glory of God; and the firmament showeth his handywork. One day telleth another: and one night certifieth another."

No matter, that which we cannot comprehend, cannot explain, may yet perhaps be so far capable of arrangement and demonstration, that we may come to understand where and why the Incomprehensible necessarily enters into joint possession of our spiritual life. Though we cannot develope the nature of Beauty in itself, yet it may be possible, perhaps, to discover what it signifies for us, Mankind, under what shape it appears, and what its influencing elements are.

The Investigator of Nature knows and understands no other development than the progress from the simpler to the more complex, from the less to the more Perfect, and thus to him that other doctrine is without meaning, which has here and there been attacked and defended, which says that Man proceeded perfect from the hand of the Creator, and has, through corruption and running wild, become what he now is. I spoke of the progress from the less to the more perfect, but I must observe that this is only a comparison, a human, clumsy conception, which, in reality, finds no application in the products of Nature, much more in the Creation of a Holy Author of Things.

"Though the creatures themselves seem different, they are truly of like goodness."*

We must adopt a very different method in order to bring this progress nearer to our understandings. The whole vegetable world is, like a single, individual plant, developed from one cell. The cell includes in itself the whole life of the Plant, in its most manifold phenomena, in its most complicated combinations; but in it, all is still simple and easily to be surveyed. The vegetable cell

* "'Εἰ γὰρ διάφορα τὰ γινόμενα, ἄλλα μιᾶς εἰσιν ἀγαθότητος."—Chrysostom. περί προνοιας.

proceeds toward its perfect formation, and gradually its separate parts acquire different import. The whole cell is at first the common organ for absorption of nutriment, for appropriation, secretion and propagation. At first only special portions of the more highly developed cell take upon themselves, exclusively, the function of reproduction, the formation of new cells. Gradually a greater number of cells become united within the compass of one plant, and then the special active forces become distributed into especial cells, in which, at the least, they are more particularly prominent. The process of nutrition is at first very simple; from the matter taken up, that which is important to the life of the plant is directly organized, and the superfluity rejected. Subsequently more and more of foreign matters enter the field, and the simple, immediate process of preparation of the food is broken up into a large series of separate processes, the final result alone being the mediate production of the vegetable substance, while from the intermediate stages originate a number of subordinate products essentially indifferent. To trace the comparison further; what seems to us a progress, is in fact a development in the truest sense of the word, an unfolding and separation of the simple parts which, in a higher numeral, are combined into one whole. Thus the number 100 is a simple number, but by development it may be converted into $99 + 1$, or $3 \times 33 + 1$, or $3 \times (32 + 1) + 1$, or $3 \times [(4 \times 8) + 1] + 1$, and so on; we can, from the conditions contained in it, set out a most complicated calculation, instead of the simple mark of 100 units, the final product of which would still be merely 100. This is the course which every development takes in Nature.

The suffering Greek applied to the Priest of Hercules or Æsculapius. A herb which the latter cultivated around the temple, served as medicament, and the sacrifice which the Priest conducted, gave to the mortal trust in the assistance of the immortal gods. And what has developed in the course of time from this simple condition of Nature? The whole complex co-ordination of our ecclesiastical profession and the cure of souls, on the one hand, and on the other, medicine and surgery, with the numerous branches sent out from them, the whole of the Natural Sciences with their separate disciplines; Pharmaceutists and Druggists are the successors of the Priest of Æsculapius; the *Jardins des Plantes,* Zoological Gardens and Botanical establishments, all the tracts of land in which busily trading Man cultivates officinal herbs, are all developments of those gardens of the temples. Many hundreds of men now co-operate with all their mental and bodily powers, to attain better, more definitely, and in a more highly developed condition, what that simple Priest of Æsculapius, if indeed with somewhat smaller results, united in his own person. Therefore we must allow that, if not the work of God, yet certainly Man's work begins with the imperfect and progresses to the perfect; that in human ways and doings the condition least developed is actually the least perfect. At the same time we also find in human development such a separation of distinct elements, which, originally, combined and undistinguishable, lie mingled as it were in a chaos. But we will here only look at one condition, and seek to make it clear, namely, the position which Mankind occupies as opposed to Nature.

In the beginning of development we always find an intimate and complete blending of Physics and Religious institutions, and every original expression of the devout feelings of mankind is a worship of Nature. Thus the Egyptian worship of Isis and Osiris, not to mention the holy animals, expresses, under the immediate form of an adoration of God, the recognition of the natural forces most actively operating and most highly blessing among the Egyptians; thus shapes itself out of the luxuriant Nature of India, the figurative History of Nature of Brahminism, and in the light sunny hills of Iran and Tehran men worshipped the light-bringing sun and its symbol, fire; while in the Northern mythologies we readily recognize the strife of the icy winter and its storms, with the brief summer. But most beautiful, most refined and cultivated appears this religion of Nature in the so highly spiritually gifted Greeks, in whose, on the whole, dry and serene country, all the fertility of the organic world was connected with the local and yearly distribution of moisture, and thus in the deified personifications of the serene Zeus, the cloud-bringing Here, the warming Apollo, and the lightening Hephaistos, and so on, a wonderfully beautiful imagining and blending of religion, physics and poetry, a Mythus was formed, the richness and plastic beauty of which will be an inexhaustible source of delight through all time.

But this condition can only exist in a certain stage of culture of Humanity. The inquiring curiosity of Man makes him soon tear the Isis-veil from Nature, and the more completely he succeeds in raising it, the more do the gods disappear from his immediate vicinity, from the earth, and finally from the starry heavens, and all Nature with her machinery of forces and matters devolves upon "the common significance of things," the unspiritualizing Physics. There remains no longer any substance, anything *essential* in Nature, which requires a God, or contains one; according to dead, unalterable natural laws runs the clock-work, and winds itself up, without Wants—but also without Beauty, without Joy. But strange it is! the inquirer into Nature proves incontestibly there is no colour in Nature, only ether-waves of different lengths; there are no sounds, only vibrations in the air which succeed each other rapidly or slowly, and so forth; and yet the brilliant colours of the rainbow delight him, the deep song of the nightingale fills his bosom with longing, he cannot strip from the great pile of soulless masses which lie spread out before him as a landscape, the "golden mist of morning's blush," through which, more lovely, it whispers to his heart, or in its sublimity elevates his soul beyond the limits of the world of space; whither? he *knows* not; only his *feelings* strike upon the barrier. There must be a Beyond, but where does this lie?

Not in Space, not in Time. The paradise of Nations, as of the Individual, is indeed to be discovered in Time, if not in Space. The Eden of Man is even that first original state, wherein he yet has taken no account of his condition, his position in relation to Nature, where God and Nature yet appear as One to him, because he has false conceptions of both, which he deduces from the analogies of his own nature; conceptions which bring Nature and Divinity nearer together, because they place that too high and this too low. But the place of the Beyond, towards which the cultivated man strives, is defined by no Where and no When. So long and so far as Nature is inexplicable and incomprehensible to Man, he seeks behind this, which he cannot see through, a spiritual existence like to himself, he endows with life the "Nightside of Nature," he peoples it with Spirits or Spectres of his own creation, which fleet rapidly before the light of Science. On the other hand, the wants of his heart make him seek for a Power, in whose intelligent disposition of events he endeavours to find protection against the sport of Accident or the tyranny of Fate, and this Power he paints after the Highest he has yet learned to know, after the Best, the Wisest of Men, and delivers into the hands of this Power, as yet, only the Lordship over the phenomena in which he first learned to fear Accident and Fate, that is, over the play of the Forces of Nature. But Man, with his conceptions of God, ever remains within the circle of the Human, and therefore he always feels sufficiently allied to this God of his own creation, to claim, when not for himself, yet for his happier forefathers, a direct descent from or immediate intercourse with the gods.

The farther Man now progresses in his perfection and development, the clearer, the more transparent, more comprehensible becomes Nature to him, but so much the farther does he become removed from God, and the more incomprehensible does He become to him. To the most highly cultivated man is God the most inconceivable, since he knows that no conception, be it what it may, which he attempts to form of the highest Being, can in any way correspond to Him ; but only few attain this stage of cultivation, only few really so truly understand themselves, that they calmly allow that human *knowledge* reaches not to where God and Immortality have their dwelling. Oh ! the foolish pride of Man, which, that it may not find itself too little, would drag down the Highest Being into the dust of human intelligibility !

But how shall we find our way again, and to our proper subject? I think, in this manner. All Nature shows itself to us, bound up in Space and Time, and even for that reason, necessarily appears empty and valueless. In our very hearts lives the desire, which cannot be repelled, toward something Complete, Unchangeable ; we feel justified in the expression : "only the Perfect actually exists ;" but that which is in Space, is also, like Space itself, without limits, nowhere bounded, nowhere finished, endless, *i. e. incapable of being completed;* that which exists in Time, obeys the laws of *change*, or the distinct sequence of different conditions. Therefore in Time and Space we may not seek That which shall satisfy the longing of our hearts, the truly Existing, Completed; the only actual world of God is not the Nature which encompasses us. What then if all that *intuitively* suggests itself to us be but a teazing delirium, an empty, unreal Appearance? There have, indeed, been people who have come to this strange conclusion, which however, from what we have been discussing seems to have much Appearance on its side. But Appearance is only valid to the man who imperfectly understands himself. For if we seek further, we soon come to the discovery, that Space and Time do not at all belong to the Things themselves, but only to the Manner and Way in which our limited human capacity comprehends the things, and, so long as we remain Men, will be obliged to comprehend them. Space and Time are, as it were, the coloured spectacles, which we all wear from the cradle to the bier, never able to remove them; the power even of the most cultivated being useless here. But the truly cultivated can indeed go so far as to see that he does wear spectacles, which do not and cannot show him the things as they actually exist. Now, we then conclude farther: it is still the Kingdom of God which surrounds and harbours us, and only to our humanly limited stand-point, to our dust-blinded eyes, is it to be ascribed, that we, with the Semblance of the greatest truth, that is, with mathematical certainty, perceive this world as though it were estranged from the eternal and holy Author of all things. A cloud-veil, which we cannot lift, renders the intuition of the Divine in Nature impossible, but a condition will, it must come, where Time and Space, those barriers of our human mode of perceiving, will fall and we shall be *conscious* of that of which we now only have *fore-shadowings.*

"We look now upon a Mirror, an obscure Word; but then face to face."

That seemingly so firm, clear mathematical perception of Nature, and with it all Science, consequently, is fundamentally the poorest, meanest, falsest, because it is merely the humanly limited one. But as the highest Divine world is the foundation of the Nature which appears to Man, so lives in us, in spite of our humanly limited condition, the god-like spark, not extinguished, but only covered for a time with dust and ashes. This spark, the longing after the Eternal, Unchangeable, seeks its satisfaction in its like, and looks upon Appearance as the shadow of the Existence, *the Mechanism ruled by Natural law* of the dead masses, as the fore-shadowing of the *free Godlike,* and that which Man never can succeed in expressing in clear conceptions, lives nevertheless, as his noblest inheritance, in the feelings of his heart. This even it is, which meets him, inexplicable, incomprehensible, in Nature, which withdraws itself from all Scientific treatment, and yet as something Better, Higher, since all Science declares, that this it is which fills us with infinite rapture as the Beauty of Nature, or thrills us with unspeakable, holy trembling, as Sublimity.

And here the Development closes itself into a ring; at the highest stage of Culture we again receive with consciousness and refined insight, that, with which the unconscious, childish understanding set out. Contemplation of Nature becomes again the worship of God, but only after we have separated all the Ungodly, Human, all the Scientifically explicable, Commonly conceivable, out of Nature, and nought is left but the mystery of Beauty. In it buds forth the fore-shadowing of a higher significance of all phenomena, its recognition is Religion, is the purest and most elevated worship of God to which Man can raise himself; in it is the most immediate Revelation of the Holy which Man is capable of receiving. Let us, to avoid misconception, add, that the Beauty of outward corporeal Nature is not the highest that is met with in life. There is yet something more noble than the material world, this is the soul of Man; Beauty of Soul and the noblest blossom of it, pure Love, is a still more perfect reflection of the Divine, and not out of the world of Matter, but out of the innermost life of the human Soul do we therefore derive our highest symbol.

Nature having in this way obtained her proper significance for us, we come apparently to the conclusion of our discourse. Beauty is incapable of any explanatory science. The decisions in which we recognize it, the criticisms of Taste, are not to be built upon inductive reasonings. For each of them stands independant, making its claim to immediate validity, even the more when it presents itself in a totally different shape to the souls of different beholders. Where shall we find matter for a further account of it? If we cannot analyze the Nature of Beauty, yet we may subject the Object which appears Beautiful to us, to more minute investigation; we may become acquainted with its separate parts and characters, their relations to each other, and, in something like a system, unfold what elements and what combinations animate in us the feelings of Beauty and Sublimity. In analogy to the researches into the Harmony of Colours, Rules of Composition, and so on, we may seek out more minutely in the Vegetable World, the peculiarities through which the æsthetic impression which it makes upon us, is effected.

First of all we must premise, that no part of Botany has been so little elaborated with genius and taste, as this, its very highest subject, and that we shall here consequently find little more than sadly unconnected fragments. This may serve as an apology for the slighter even than sketchy character of the following remarks.

The material which lies at our command, arranges itself into three groups, according to the Kind and Way in which plants make their Significance felt. The first is the Symbolization of individual plants. Man, so soon as he is rescued from the rudest condition of a mere Hunter's life, is led by the pastoral vocation of the more softened Shepherd, and still more by the civilizing recognition of property in Agriculture, to the observation of particular plants, their origin and decay, their life and their propagation; finally, their dependance on the favouring or destroying influences of external Nature, referred to the sun, dew, rain and soil. To the man who first awakens to the feeling of his own freedom, who has felt that he is "the doer of his deeds," it is almost impossible to avoid pre-supposing, where he sees Change, Activity; where he sees Activity, Freedom, and therefore Spiritual Life. Thus at first every plant, every tree, every flower, receives a personifying principle, an indwelling God; Dryads people the woods, Fairies dance their light circles in the rustling grass. Still more definitely does the symbolizing Poetry of Life subsequently take possession of particular plants, and in Religion and Poetry rich garlands are entwined from the peaceful realms of Flora. The longing after a Continuance beyond the imperfect earthly life, eagerly grasps every feature in Nature which points to such an immortality.

The solemn and lasting Cypress decked, among the Greeks, the graves of the beloved, and the meadows of the Homeric Infernal world were alive with the blue Asphodelos, the light blossoms of which rising again each Spring from the bulb buried in the earth, told of an eternal revival, a certain immortality. On the still waters of the blessing Nile, the animating influence of the sun-god Osiris called forth from the all-supporting Isis flood, the luxuriant Lotus flower, scattering in their great almond-like seeds, ready food for the oldest races of mankind, and with grateful feelings was this plant consecrated to that mild Divinity ; it even became the symbol of Fertility, the Force of development in Nature, so full of blessings, and after the absolute necessities came to be satisfied in other ways, the use of this fruit, as holy, was forbidden to dust-born Man ; Pythagoras also, together with the wisdom of the Egyptian priests, promulgated among his scholars the prohibition from eating these beans. Athene, the goddess of the serene air, gave to the Greeks the Olive, which loves to dwell in sunny habitations, and the moistener of shores, Poseidon, crowned his brow with the shoots of the Shore-Pine,* consecrated to him.

The union between living contemplation of Nature and dead philological scholarship is, alas! too new to admit a possibility of tracing the symbolization of the vegetable world, through every form of Divine worship that has existed among the various races of mankind. Those very sides of the old religious Myths have up to the most recent times, been most neglected, in which their connection with the life of Nature is expressed, in which therefore would have been found the surest means to their explanation and

* Pinus maritima. "Poseidons Pine Grove."

clearing up; while now the silliest fancies are only too often substituted.

We of course therefore still find an abundance of relations between religious Mythus and the Vegetable World, we are not at present in a position to interpret. The indication of Love and Marriage, for instance, by the Rose and Myrtle, current even among the most ancient nations, certainly does not depend upon a mere æsthetic pleasure, but on a deeper relation to the Greek religion of Nature, the decyphering of which would indeed explain to us, why two of the Graces were characterized with the Rose and Myrtle, but the third with the Dice. The bow also of the Indian God of Love, Kamadawa, made from the Sugar-cane, symbolized something more than the sweetness of Love, which were but a chilling metaphor, and undoubtedly a profound contemplation of Nature gave him the rose-red blossoms of the Amra-tree for arrow-heads.

It will be readily allowed that this symbolization of the world of Plants did not come to an end with a particular epoch of humanity, but that the inexhaustible matter is also progressively shared by the poetic spirit of nations, though the origin of one such parable may now be lost in the multitude of races, or have attached itself definitely to one single genius, which has prophesied to the nations with such true feeling, that these have adopted the foreign thought as common property. Thus it may often be difficult to determine how far up into history reaches the first origin and perfecting of a subsequently universally used comparison, a typical signification of a plant, or a process in its life. The courteous Lily, the modest Violet, the proud Crown Imperial and so on, are such natural and intelligible figures, that we find them alike in almost every cultivated nation, and yet we know neither of these, nor of countless others, what languages directly appropriated the forms, the original authors. We are even in obscurity where the peculiarity of the symbol points to wholly definite times and places in history. The Moslem who returns from Mecca, brings back the Aloe * as the testimony of his pilgrimage, and hangs it up, with the point turned towards Mecca, over his threshold, which then can never more be approached by evil spirits. This custom, the superstitious portion of which has extended to the Jews and Christians in Cairo, has certainly some peculiar connection with the origin of the pilgrimage to Mecca and with the nature of the plant, but what, we know not.

Many of the figures and symbols formerly in use have become transformed in the course of time, others have taken their places when more accurate observation of Nature has shown that these express more vividly and pregnantly the idea to be depicted. Nay, we may often conjecture the castigating satire of a nation in such changes. The old German Honesty † is indeed a somewhat substantial, though rude and thorny plant, but durable in form and indestructibly true in colour, while, on the contrary, what is now called Honesty, ‡ is a little blue flower, falling almost as soon as plucked, and its certainly fair, enticing colour is bleached by a few hours' exposure to the sun.

But why accumulate these particular citations, since every educated person who has a little acquaintance with the spirit of his mother-tongue, will call to mind these figures from the life of plants, in thousands, from its traditions, fairy tales and poems.

It might perhaps be more important and more interesting to seek out more in the mass, the elements of the

* Aloe perfoliata vera. † Eryngium.

‡ Veronica chamædrys.

Vegetable world which are the means to Æsthetic impression. Here again we meet with two distinct subjects. That which delights us in Nature, in the mass, the phenomena of Nature perceived as a Whole, in a word, the landscape, is a mosaic of separate and independently existing and significant things. Wood and meadow, in contrast to each other, and thus producing Beauty, are in themselves, without reference to the share they take in the composition of the greater Whole, characteristic formations of the vegetable world, and each in an especial way composed of particular kinds of plants into a definite æsthetic impression. We might name such groupings of plants as Wood, Meadow, Heath, &c., Plant Formations, and they certainly deserve a far deeper investigation and more careful representation than has hitherto fallen to their share.

But as we approach closer, we soon find that their peculiar character again is conditioned in manifold ways by the, so to speak, physiognomical expression of the species of plants of which they are composed. The Botanist distinguishes by many kinds of characters, but best and most scientifically by the peculiar differences and resemblances in the entire course of development of Plants, larger and smaller groups, which are commonly called Families. The plants numbered in one family are united naturally by a a narrow bond of relationship, and he who is accustomed to refined physiognomical studies will not overlook the finer family features in which all agree. But as on a large scale, among men, those characteristics of race and marks of variation, Calmuc-eyes, Negro-skulls, Roman-noses, Blonde and Brunette complexions, &c., totally independant of family relationship, first of all strike us, so also among plants, it is not the resemblances or differences which are produced by actual natural relationship, but altogether the more universal, mostly indiscriminately occurring peculiarities of appearance and structure, on which depends their physiognomical importance to the composition of the botanical *formation* and, with this, of the landscape. By taking note of these peculiarities of plants, we are next able to conceive for them certain universal Forms, according to which, without reference to the naturally more intimate relationship, the plants are merely so arranged together as they make a similar common Æsthetic impression upon us, and at the same time come forward as defining the character of the Formations, or the physiognomy of the landscape in general.

Thus, instead of some 300 families which Botanists have now established and distinguished according to finer and more carefully investigated characters, we obtain a comparatively small number of Vegetable Forms.

Generally grey and withered, scurfily smooth or spiny, interwoven like gigantic snow-crystals, causing a chilly shudder, the Lichen-form clothes the barren confines of vegetation, forming as it were the transition from this to inorganic Nature; while the Form of Mosses produces a mostly silky-lustred layer, like a cushion over soil and rock, with its densely crowded, delicate, yellowish-green leaflets. Resembling these, yet attaining not to free shapes but scarcely more than a mere naked surface, clothing not the earth but the waters, developes the Form of the Water Lilies,* of great importance to the Beauty of all landscapes. Large broad leaves, with rounded outline, floating flat upon the water, or in a dish-like form, elevating themselves a little way above it, flowers of splendid colour, beautifully formed and of great circumference, scarcely dipping into the liquid

* The most splendid of all, the *Victoria regina*, with leaves fifteen feet, and white and rosy blossoms four feet in circumference, is represented in the middle of the frontispiece.

element, such are the most characteristic features in the physiognomy of these plants. The Form of the Grasses is distinguished above all others particularly by their sociality; the humble stems bear flattened, narrow, pliant leaves of a vivid and pleasing green, and on thin pedicles their delicate panicles wave in the lightest breeze; in these the vegetable world is still bound to the soil, from which they rise but to a small height, and which they clothe as a soft woolly carpet. Beside these which call forth the impression of a serene pleasure, the shepherd's joy, the luxuriant nourishment of flocks, stands the more gloomy Form of Sedges; from black, marshy earth project dirty, grey-green, stiff and rugged, roundish stems and leaves, here and there bearing balls of brown or blackish blossoms, or white, woolly flocks, the venerable looking hair of the fruits, streaming in the autumn wind; sighing, the husbandman names them sour grasses, and the cattle reject them. On the borders of running waters, and at the same time under the fertilizing influence of the warm, moist tropical climate, the Grass rises to a nobler height, and the broad-leaved Reed-form,* in Hindostan, even overtops the trees,† and forms a meadow above the forest. There, in the region of the Aromatic Lilies, the stem swells with sap, the leaves expand in length and breadth, but become so thin on either side the mid-rib, that they are readily split by the wind; the plant is of a deep green colour, or the warmest yellowish-green, shining like velvet, and in pure and intense colours beam the great flower bunches; thus originates the Plantain-form.‡ Through the splendour of the blossoms

* On the left side of the frontispiece a Bamboo-bush represents this Form.

† Panicum arborescens.

‡ On the right side of the title the bright green leaves of the Banana.

of the Plantain and the Banana plants, through the mode in which the leaves are borne, almost resembling that of the Reeds, the Form of the Lily-plants stands, as it were, between these two,—the only one directly included in this sketch which has found an artistic delineator, in the French flower-painter, Redouté. In the third place comes the form of the Aroids. Triangular or arrow-shaped, green, juicy leaves on long stalks, strange and often brightly-coloured spathes, which enclose the club-shaped inflorescence, form the plants which, dwelling on the mighty stems of the tropical forest trees, mark the transition to the *Orchidaceæ.*

As the Leaf-formation stands out predominantly in all these last-named forms, we now oppose to them some which exhibit an especial development of the stem. In the first place I may mention the Heath-form; humble, branching, woody shrubs, the little, dull-green or grey leaves of which are so densely crowded, that they look almost like a mere roughness of the branches, and even the often beautiful colouring of the dry blossom does not obliterate the melancholy impression, which the plants always produce where they determine the character of the landscape. The *Casuarinæ* may be defined as a subordinate group here, and called the arborescent Heaths, forming the gloomy, leafless and shadeless woods of Australia. Still more strikingly is the formation of the stem favoured in the thorny Cactuses, which consist merely of fleshy, strangely-shaped stems and branches, which Cactus-form recurs again in many other families, for instance in the Spurges, the Stapelias, and, though certainly with more important development of leaves, yet with similar physiognomical expression, in most of the Succulent Plants, Aloes and Mesembryanthemums. Not indeed in reference to their actual organization, but from the considerations regarding the peculiar kind and mode in which they take part in the composition of a picture of vegetation, must we here include among the leafless plants, or rather those influencing merely by their stem, all those which with the Spanish colonists in America, we comprehend under the name of the Llano or Liane-form.* Stretched like strong rigging, or winding serpent-like in and out, now like cords, now flat and strap-like, and now alternately, left and right, with flattened, crest-like protuberances, the Bauhinias, Aristolochias, Convolvuluses, Bignonias and others extend forty, fifty, nay one hundred, or several hundred feet, leafless and without a branch, from tree to tree, in the primeval forests of the tropics; frequently ascending upon one tree, circling it even to choking, then leaping over on to another, next falling in a festoon, and then climbing up again to the topmost summit of a third, where the plant perhaps waves a bunch of the most splendid flowers in the lighter air; while they mockingly leave to the wanderer in the forest's shade nothing but their naked stems, with which they often interweave an almost impenetrable thicket. From this reason, in spite of all the industry of the collectors, there are very few cases in which we know how to refer the numerous specimens of the flowers preserved in our herbaria, to the equally abundantly collected, but often most strangely aberrant forms of stems.

The two elements which present themselves as it were in an isolated condition in the foregoing families are connected into a wholly peculiar design in the next; in the beautiful bunch of highly developed leaves and the true,

* The Frontispiece exhibits one of the smaller forms, as a festoon of a splendid flowered *Ipomœa* across the middle of the picture.

independant, naked stem of the Palm-form, consecrated by religion, celebrated by antiquity and the theme of the poet's song.* But this form splits up into numerous subdivisions, in which the physiognomical character becomes still more individualized by the shape and consistence of the leaves. In these plants generally, the stem rises from quite a humble mass, reminding us of the globular Cactus, up to the slenderest columns several hundred feet high, and the impressions which the Dwarf and Nipa Palms excite, are naturally quite different from that of the majestic altitude of the shaft of the Wax-Palm in the Andes, which attains a height of one hundred and eighty feet; but still it is the arrangement and form of the leaf especially which most importantly modifies the total impression. In regard to this point, we distinguish the arborescent Lilies or the Agave-form, the stem of which is often curved in and out, and sometimes divided above into a few short, thick branches, the extremities bearing bunches, equally expanded in every direction, of liliaceous leaves, often of a dull green colour, and being solid and hard, they are not readily stirred by the wind, so that they afford a picture of immoveable repose. The Thebaic Cocoa-Palms, the gigantic Fourcroyas, the Yuccas of Mexico, the Vellozias and Barbacenias of Chili, the great African Aloes and the Grass-trees of Australia, belong here, and Polynesia furnishes another peculiar form in the *Pandaneæ*, with stiff, bifid, shining green leaves, arranged in very evident spiral lines, whence they are called by the English, "Screw-Pines." The contrast to these is furnished by the Fern-form, which with

* The borders of the Frontispiece are formed on the right by the slender Cocoa Nut, with its feathered leaves, on the left by the stouter Mauritius Palm with fan-shaped leaves.

the finely divided leaves, spreading in the form of an umbrella, above all possesses the character of graceful elegance and, trembling in the slightest breeze, excites the impression of light, free movement. The medium between these two extremes is held by the Palm-form, in the strictest sense of the term, the perfect shapes of which, pre-figured as it were by Nature in a still crude and half-abortive attempt in the *Cycadeæ*, peculiarly condition the imposing Beauty of the tropical world. They deserve that we should spend a few moments among them, and we can scarcely do better than follow A. von Humboldt here.

The trunks of the Palms are sometimes misshapenly thick, sometimes weak and cane-like; sometimes swelling out above, sometimes below, and at others in the middle; now smooth, as if turned in a lathe, now scaly, now densely beset with black shining spines a foot long, now wound about with a delicate net-work of brown fibres. Strange they look when, lifted from the earth by the roots which shoot out high up on the stem, they are, as it were, many-footed, or conceal their origin in a thick mass of root-fibres which have grown down round it. The vast leaves are feathery or divided like a fan; the strong leaf-stalks (that of the Date-Palm formerly used in Genoa for walking-sticks) are sometimes smooth, and sometimes sharply toothed. The green colour of their leaves is sometimes deep and shining, sometimes of a silvery white upon the under side. Now and then the middle of the fan-shaped leaf is decorated with concentric yellow and blue streaks, like the peacock's tail.

In the carriage and physiognomy of the Palms, altogether, there lies a character of grandeur, difficult to express in words, produced particularly by the very direction of the leaves. The parts of these, the leaflets, are in some arranged close together on a flat surface, like the teeth of a comb, with rigid cellular tissue, as in the Cocoas and the Date; hence the glorious reflection of the sun from their upper surface, the green of which in the shore-loving Cocoas is lively, in the Dates which skirt the confines of the Desert, dull and ashy; sometimes the leaf looks like that of the Rushes, woven of more tender and pliant elements and curled towards the apex. The direction of the leaves, as well as the stem, gives an expression of high majesty to the Palms. The more centripetal, the more acute the angle which they make with the stem above, the grander and more elevated is the form. What different aspects afford the pendant leaves of the *Palma de Covija* on the Orinoco, nay even of Cocoas and Date-Palms, and the heavenward striving shoots of the Jagua and Pirijao! Nature has heaped together all the Beauties of Form in the Jagua Palms, which crown the granite rocks of the Cataracts of Atures and Maypure. Their smooth slender stems rise from sixty to seventy feet high, so that they project like a colonnade above the thicket of deciduous trees. Their aërial summits contrast strangely with the thickly-leaved Ceibas, with the woods of *Laurineæ* and Balsam-trees which surround them. Their leaves, seldom more than seven or eight, aspire almost vertically fourteen to sixteen feet upwards. The points of the leaves are curled up so as to resemble a bunch of feathers. The leaflets are of a grass-like, delicate tissue, and flutter lightly and airily about the slowly-waving leaf-stalk. In Palms with feathered leaves, the leaf-stalks either spring from the dry, rough, woody portion of the shaft, or from the rough portion of the trunk projects a grass-green, smooth and more slender shaft, like a column upon a column, from which the leaves proceed. In the fan-leaved Palms, the leafy crown often rests upon a bed of withered leaves, a circumstance which gives a solemn, melancholy character to the plants. In some of the umbrella-Palms, the crown consists of a few fans elevated on long, slender stalks.

In all Palms the inflorescence breaks out from the stem below the origin of the leaves. The way in which it breaks through equally modifies their shape. In a few, the great horn-shaped, rolled-up sheath stands upright, and from it rises the dense bunch of fruit like a Pine-apple. But in most, the sheath, often several feet long, now smooth, now rough and hostile, hangs down, often with dazzling lustre, which glances far in the distance.

The shape and colour of the fruit, too, are more varied than is usually imagined. The Lepidocarya, the Sago Palms, are adorned with egg-shaped fruits, the scaly, brown, smooth surface giving them the aspect of beautiful young Fir-cones. What a remove from the enormous triangular Cocoa-nut, to the berry of the Date and the little cherry-like stone-fruit of the Corozo! But no Palm-fruit approaches the fruit of the Pirijao of St. Fernando de Atahapo, in beauty; ovate, golden and scarlet apples, hang down in crowded Grape-like clusters from the summit of the majestic stem.

This may serve to convey the characteristics of the Palms, but a last primary form yet remains to be considered, in which the leaf and stem formation, most intimately blended and inseparable, determine the total impression, not, however, without this receiving peculiar modifications, sometimes from the stem and its ramifications, and sometimes from the leaves and their forms. The form of *Trees* again falls, in still greater measure than the Palms, into special characteristic sub-forms.

Three are so evident to every one, that it is scarcely necessary to mention them. These are the form of Deciduous or Leafy Woods, with their stems branching in every direction, and their abundant short and broad foliage, forming dense, compact vegetable masses; the Willow-form with loose, wand-like shoots, narrow or long-stalked, fluttering leaves, the lower sides commonly clothed with white hair, investing them with a peculiar silvery splendour, which is represented among us by the Willow and Poplar, in the south by the useful Olive; thirdly, the form of Conifers or Needle-leaved Woods, distinguished by their narrow leaves of dusky green colour, and branches sent off in whorls or expanded like the ribs of an umbrella from the reddish-brown trunk; a dwarfish but dense Sedge-vegetation dwelling on a tree.

In opposition to these range themselves three Forms from the southern or equinoctial regions, which with a totally distinct nature, allow of comparison with them in many respects. The mass of the Leafy Woods, especially the underwood of the *Bush*, is peculiarly characterized in the tropics by the Mallow-form,* in which the great palmately-lobed and usually long-stalked leaves, in all their expanse of surface giving no deep shade, on account of their loose arrangement, are distributed over a stem which is generally short and thick, branching into a crown only at the summit, or, more rarely, sending out long, crooked branches to a great distance. The giant of the

* At the lower part of the right hand side of the Frontispiece, is a *Hibiscus*, which exhibits the broad and yet airy foliage of these plants.

Vegetable World, the sacred Baobab,* the shapeless mass of the barrel-like, swollen trunk of the Bombax, and the purple-blossomed Hibiscus bush belong to this assemblage of forms.

From the peculiar impression which the plants make through the texture and colour of their leaves, the Laurel and Myrtle-form is more allied to the northern Willows, from which many New Holland *Myrtaceæ* are even physiognomically indistinguishable. As a whole, broad, rigid and coriaceous leaves, shining as if varnished, and reflecting the light with dazzling brightness, are certainly the distinguishing features of the plants, but they are strangely modified when a dense white felt, as in the *Proteaceæ*, clothes the lower surfaces of the leaves, and mingles a silvery tint with the shining green. But I should regard the Acacia-form as the most perfect among plants. The varied, often simply-umbelled, often airily-reticulated, often Oak-like gnarled branching of the here slender, there massive stems, is such a source of Beauty in the so favouring abundance of variation of form, multiplied in the highest degree by the light feathery leaves, which now small and elegant are marked out like the most delicate lace and embroidery against the clear sky, now stretching wide in picturesque curves, emulate the Palm leaves. The Robinia, naturalized here from North America, gives but a weak picture of the delicacy, splendour and majesty to which this Form developes beneath the quickening influence of a tropical sun.

Although we restrict ourselves to this sketchy enumeration of the characteristic forms of Plants, Nature

* Adansonia digitata.

herself renders it altogether inadequate to paint her wealth; but it is here that we feel most the want of accurate and at the same time artistic delineations. Travellers, only too often dull collectors, have as yet far too little cultivated this department of the study of Nature. Even among those who have taken account of it, there are many whose vision is not calm and clear enough to separate what appeared to them, subjectively, striking and interesting, from that which defined the character of the landscape; many, in the frivolous desire to say something singular, string together laboriously sought words, yet give no picture, or deliver themselves over to the excess of feeling and the flight of an unbridled imagination. Rarely do we find the classic objectivity and the plastic subjectivity, which distinguish the sketches of Nature of the clear Göthe, of the rich and lively Seatsfield, but above all, of the Master of Science, Artistic perception and Language, Alexander von Humboldt.

I have arranged these forms according as they merely clothe the bare earth or rise above it as independant shapes, and the latter according as they especially by foliage, or more through the characteristic appearance of the stem, or, lastly, through a combination and blending of the two, excite the particular impression which is made upon the beholder of a landscape determined by them. But it is possible to establish another, more important ground of division, one taking up more the artistic standpoint. As we divide the landscape itself into foreground, middle distance and distance, so above all must the characteristic vegetable Forms be comprehended in their varying importance to these three portions of the picture of Nature, and be introduced in accurate drawing. The little Form of Grasses, only of importance in the total impression of their mass, loses nothing by greater distance, while the Plantain and Aroid plants bear to be in the nearest foreground, on account of the beautiful form of their large leaves. On the other hand, the delicate outlines of the Mimosa leaves become confused into a green mass in the back-ground, while the more lofty Palms, if brought too near, are incapable of giving the total impression, and thus their Beauty actually ceases to exist.

Future travellers will multiply the number of vegetable Forms, bring forward their importance more determinately, and teach us to perceive the delicate shades of distinction which will allow those great groups to be broken up into smaller; and we shall especially gain in our attempts to form impressions, when a greater store of such artistic representations lie before us, as the Baron von Kittlitz has, with inimitable truth, furnished in his Views of Vegetation.

Most deserving of study, but as yet almost wholly unobserved and uninvestigated, is that face of these vegetable Forms which they turn towards Man, the history of his culture, his view of Life. Here these types of Nature first acquire their higher significance, and become to the psychologist and the ethnographer, almost as important as to the Botanist. That the Idea of the World must be different to him who obtains his first impressions from the solemn, winter-green Pine-woods of Sweden, to him who grows up among the misty highland moors and heaths of Scotland, and again to that man who from his infancy has been surrounded by the glancing leaf of the Laurel and the Myrtle under the serene sky of Greece, seems to be so plain that it hardly requires mention, and yet the Idea of Life arising from this is more easily felt than clearly and distinctly developed in words. As in

Mythology, so here, the side most fruitful and most full of life has not yet been at all investigated; nevertheless we hold as a general proposition that there is no study, which in any way soever relates to earthly relations, or is realized in such, which is or can be more than a dead Word-learnedness or untrue phantasy, if it have not its foundations in the Science of Nature. Man does not understand the human Soul without connexion with the Body, and this not without its dependance on all Nature, and what there may be besides, whatever can become an object of Science.

This influence, which gives the vegetable world an especial value in the development of Mankind, is not shown by the forms of plants by themselves, but rather only in and through their combination into the already named Plant-formations. Here again, no more can be expected from me than a slight indication of the infinite wealth of Nature, the narrow frame in which my pictures are confined, forbids more. Nay if we intended completely to exhaust the subject, we must even draw the Animal world and Geological elements into the circle of our contemplations. The natural Man lives not with this or that natural body, but with All that surrounds him; the landscape with all its inseparate elements acts upon his tone of mind, and thus imperceptibly upon his entire inward history; only gradually, in advanced culture, does it become possible to extricate the individual components out of the picture and to analyze the general impression into its separate influences. Not the Grass, but the Meadow, not the Tree, but the Wood, not the Myrtle-bush, but the whole surface covered with low, bushy, evergreen plants, which draws itself like a girdle round the Greek mountains, contrasted on one side with the blooming meadows, on the other with the aspiring Pines,—these have worked the mighty influence on the delight or melancholy of men. So will the considerations of the Plant-formations, as they are composed of those forms, have unequal import to us, and the more that herein especially is expressed the peculiar character of different countries.

No inhabitant of our climes, whom a friendly Genius has guided to the rich world of the vertical sun, and happily restored to his home, has found it possible to resist the impression which the peculiarity of tropical vegetation made upon him, and never will he forget it. The common expressions by which men attempt to convey its characters, richness, fulness, luxuriance, &c., are but dull and obscure, nay even false, since he who has ever seen a northern primitive forest, the mighty, spreading trunks, the mouldering bodies of the dead, the plenitude of Ferns and Mosses clothing and enveloping all, living and dead—must come to the next to true belief, that a greater luxuriance of vegetable growth is not well conceivable. But a more accurate conception is awakened by the statement that the nearer we approach the hot regions, the more the *social* plants disappear, and the more the most diverse forms become intermixed. And yet, true as this proposition is, those will be less inclined to admit it who, depending on the physiognomy more than on botanical definition, recall to mind particular characteristic forms of wood, bush, or steppe—for the explanation indeed names the fundamental cause of the phenomenon, but does not demonstrate how the same brings about the final result.

When we have, from the dusky shadows of our thickly leaved Beech woods, formed an ideal conception of the incomparably fuller and more crowded vegetation of a tropical forest, we feel strangely disappointed to find all there so bright and full of light.

This wealth of vegetation, which descends from the loftiest summits of the Palms and Bertholletias, from spray to bough, from bough to trunk, beclothes the earth and hangs in rich festoons across the airy interspaces, would be totally impossible if the indispensable light had not free passage down even to the humblest corners. The dense shade of our woods, which, compared with the tropical forests, even our needle-leaved Firs produce by their closely-crowded branches, — through which they are enabled to resist the autumnal storms, the savage winter, the burdening weight of the snow-masses—prevents that rich and varied development of vegetable life immediately beneath the trees which, under the tropics, fills up and decorates each nook in length and breadth, in height and depth. For the character of the tropical forest trees lies in a peculiar, wide-spreading aërial, ramification, and a foliage which, imitating in little and particular, the bearing of the Palms, only makes good its place on the extremest points of the branchlets. Besides this, there is the great diversity of the plants which are assembled in a little space, and shoot up into the air in such varying modes, that even in the distance, a tropical wood does not present the simple rounded outline of a northern Beech or Lime wood. Lastly, too, comes the predominance, or at least frequent occurrence of shining leaves which, reflecting the light, send it down into duskier shade; or the white surface of the high upraised Palm-leaves and other foliage which, like mirrors, throw the sun's rays into the inmost recesses of the woods. From these and perhaps from countless other separate little features is the picture composed, which meets us with so foreign a character and such attractive charms.

When we speak of *Plant-formations* we borrow this expression from another Science, Geognosy, and think, so far as a comparison is admissible, to mark a similarity. In the same way that in the geognostic consideration of the earth's surface, we first of all distinguish between level land and chains of mountains, we may here also in the application of these considerations to the vegetable world, first divide, as two primary forms, the Plains from the Woods. Each of these primary divisions falls again into particular formations, and these it is, which here and there developed, appearing prominent or repressed, determine here, as in Geognosy the geognostic, the vegetative, landscape character of a country. Especially in the investigation and delineation of these formations really lies the charm which is usually, by a confusion of ideas, ascribed to the Geography of Plants. This can and will pursue scientific aims, set itself theoretical problems and solve them—and

"Grey, dear friend, is every Theory."

But "green, the golden tree of Life;" and it has been pointed out how it is exactly this impassable to rigid science, æsthetic side of Nature, which, though mysterious and difficult to trace in its action, yet interferes most powerfully, determining, restraining or furthering the course of spiritual development. "As the Man, so is his God," is certainly true, but we must go farther than this and add, Man in the earliest stages of his culture is as the Nature amid which he has grown up.

On the other hand, we must not neglect to expose an essential distinction wherein the Geognostic formation differs from the Vegetable. The former stands unalterable and unchangeable in strongly marked fixity, at least far beyond Man thinking and reckoning, at the highest, by centuries; the latter, on the contrary, with the imprint of organic life, follows in its way the play of the mighty forces of the Earth. The design is not fixed and immoveable, but as the character of Nature in the mass alters, it exhibits other features and looks upon Man, as it were, with another countenance, and the same forms which to-day awaken joyful feelings, may perhaps to-morrow depress the soul with a picture of melancholy desolation. The farther we advance up into high latitudes, the more do the Summer and Winter clothing of Nature differ, and according as the climatal conditions cause one, two, three or four Seasons, so is the physiognomy of Nature now fixed and unchanging, now with characters alternating in manifold ways. But not on this or that isolated condition, but very especially on the mode in which the history of Nature, the course of its changes, determines the time for the accompanying activity of Man, is founded the mighty influence upon the feelings and their play, on the train of thought and its improvement. While the dull, faded green of the Fir leaves, under the load of their covering of snow, renders the impression of Winter still more gloomy and melancholy, the bright lustre of the evergreen leafy woods of the South, feigns a Summer in the breast of Man, even though the frozen body give the lie to that meteorological error.

It is difficult to give the character of the various Wood-formations in words, with even a small proportion of that vividness and reality which the landscape Painter so readily attains by drawing, foliage, colour and effect of light. Nevertheless, the differences are striking enough to all who approach Nature with open senses. Even the Fir and Pine woods exhibit essential differences in their features; the former with straight stems arranged parallel to each other like columns, with the conical crowns of verticillate branches; the latter bearing on the gnarled, curved trunks, the lines of which cross in all directions in perspective, a flat umbel of foliage, a bearing which is most purely and nobly exhibited by the Stone Pine. These Pine-woods, which extend over miles of country in the Mark of Brandenburg, are repeated in more luxuriant development in the "Pine barrens" of North America. Here, as there, loving a sandy soil, they extend in a broad band several hundred English miles long, down to the coast of Virginia and North Carolina, forming by their mass a very prominent feature in the physiognomy of the whole country.

Still more striking is the distinction between the particular formations of the Leafy Woods; the crowded arrangement of the social Beeches, Limes or Elms, produces woods with dusky shades and a soil void of vegetation, while the proud Oak, repressing the growth of all other trees in its immediate neighbourhood, stands alone upon a soil pleasantly clothed with grass and herbs, or unites in small groups to form those wonderful woodland landscapes, to which the immortal pencil of Ruysdael so often introduces us. Differently acts the massive lustre of the Magnolia woods of the southern part of North America, from the elegant beauty of the African Acacia groves, or the ghost-like transparency of the Northern Birch, and the whole tropical world unfolds a multiformity, the description of which would be an inexhaustible theme. I will only take notice here of a strange contrast afforded in some regions of the hot climate. The rude cold of Winter robs our woods of their fairest adornments, and leafless stand out the dark branches from the snow or the moist black soil, in the grey, gloomy November air; as a reverse to this, the Brazilian traveller wanders in the glowing heat through the *Catingas*, woods which through the drying influence of the sun are defoliated in summer, and with their bare branches contrast strangely with the fresh luxuriant green on the banks of some little brook, or against the succulent, fleshy masses of the Cactuses untouched by the burning heat. But even in the freshest foliage the woods may assume the character of awful and terrible wildness. When the dense foliage hinders the action of the sun and the refreshing breeze, and thus retards the decomposition of the vegetable masses, where the ground, flat and without any declivity, allows the accumulation of water, and the more since the heaped-up bodies of dead plants continually increase the barriers to the efflux, and the humus formed greedily sucks up the moisture—there are formed the most extensive swamps. By the progressive accession of the remains of vegetation the ground becomes elevated, and such spongy, semi-fluid masses often lie, at length, far above the level of the surrounding plain, the sun's heat never sufficing, even when storms remove the protecting roof, to dry up the marsh, or to restrain its increase. Such a swamp rises twelve feet above the surrounding plains in Virginia, between the towns of Suffolk and Walden, and is called by the inhabitants "the great Dismal," giving origin to considerable rivers and supplying them with water. The North American Cypress* it is, which with its delicate but dense foliage gives rise to the formation of these structures. It is the same tree which forms the terrible, evilly-renowned Cypress-swamps of Louisiana, on the banks of the Red River and the Mississippi. Gigantic trunks of un-

* Cupressus disticha.

precedented mightiness crowd together, interweaving their branches and spreading an obscure twilight in the brightest day. The soil consists merely of half-decayed blocks piled one upon another, alternating with a fathomless mud, in which the voracious alligators and snapping turtles wallow, the sole lords of this hell, steaming up almost beneath the tropical sun,—thus in the height of Summer; in the Spring the thick, miry floods of the issuing streams impetuously overflow this malignant vegetation for many miles. Thus these Cypress-swamps, of which Seatsfield has given us such a vivid picture, correspond in inland countries, to the Mangrove-woods which border the mouths of almost all the tropical rivers. Composed of a very few species of plants, among which the Mangrove-tree is the most common, they are especially striking from the great number of strong roots, springing out high up the stem, and bearing this aloft above the surface. The peculiar habitation of this plant is the *brackish water*, which consists, at the ebb, of the fresh water of the river, which is dislodged by the sea-water at the flood. The numerous roots often form a so thickly entangled mass that the interspaces may be stopped up by the falling leaves, collecting thus a soil for a new vegetation, beneath which, at different hours of the day, roll the waves of the river and the sea. But more frequently the roots merely operate to retard the flow of the water and to retain in their interlacements the vegetable and animal bodies driven down the river, which then decay here in contact with sea-water and its salts. In these regions the terrible sulphuretted-hydrogen gas is developed so abundantly, poisoning the atmosphere, that the natives who have lived in these abodes from their youth upward, totter about as it were like spectres, while death almost inevitably snatches off the Europeans who enter there. These woods are especially the foe which, hitherto unconquered, has opposed almost all the Niger expeditions, and fearfully thinned the ranks of the bold adventurers. I too had a friend, the lamented Theodore Vogel, who, too early for Science, fell a victim to this demon at Fernando Po.

As the hill between mountain and level land, so between the Wood-formation and the Plain, a link is formed by the Bush and the plains displaying merely small, isolated groups of trees.

A portion of the so-called woods on the northern coast of Australia must be reckoned here, those which clothe the enormous tract extending southward into the interior from Raffles Bay and Essington. They exhibit a wholly peculiar physiognomy, which is repeated almost everywhere throughout this strange country. The trees and bushes have leathery leaves, the majority of them being covered with a white, resinous powder, which gives them the most monotonous, dismal, pallid look possible. The principal trees are species of *Eucalyptus*, *Acacia*, *Leptospermum* and *Melaleuca* (Cajeputs). Many other plants, scarcely to be reckoned by the side of those named, live beneath the shelter of these lofty greyish stems, which stand far apart, and by their meagre, incessantly trembling foliage remind us of the weeping Willow. Handsome tufts of Grass with long, slender halm, grow throughout the whole extent of these Bushes, and in them nestle the kangaroo, with the ring-doves and other birds. The sun's rays readily penetrate between the narrow leaves, always waving on their long petioles, and produce an uncertain light mingled with fleeting shadows. The eye sees far up through the vault of twigs and leaves, and is arrested, not so much by the density of the vegetation as by the continually changing glance of an uncertain mystic light.

Still lighter, still less representative of the closed condition of woods, is the proper Palm-form where the social kinds are grouped together. The real Palm-groves on the northern border of Sahara and on the shores of the Brazilian rivers, more resemble open columned halls with perforated roofs; and on the dry soil of the elevated plains of Mexico the stems of the Yucca, Fourcroya and other high-stemmed Liliaceous plants are collected in a very peculiar way, affording neither shade from the sun nor shelter from the wind. To these approach the deformed masses of the Maguey-plants, with their broad, thick, rigid, dull-green leaves, sharply toothed on their borders, and their flowering stalks twenty feet high, rounded off into strange, fantastic and impenetrable Bush by Cactuses of manifold forms.

The impenetrable *Chapparals* in the extensive plains between the Nueces and the Rio Grande, formed of Musquito-shrubs six to seven feet high, entwined with Lianes; the Palmetto-fields on the shores of the Sabine, Natchez and other rivers of Texas, formed of Rush and Dwarf Palms; the low Acacia Bush of Australia Felix, and lastly the wide jungles traversed by the elephants and tigers in the East Indies, and formed of Bamboos and other lofty Grasses, are all peculiarly characterized Formations of Bush, which often not attaining the height of a man, or but little exceeding it, do not all betray at the first glance the frequently unsuperable obstacle they oppose to the intruder, and even after Man has settled in the neighbourhood can only be traversed by paths which the wild animals have made.

Change, by the movement it produces in sensation or in the thoughts, is an important means to the awakening of æsthetic pleasure or interest. The straight line is not beautiful, indeed neither beautiful nor ugly, but the curved, broken line, inviting the eye to divergent motion, makes a claim to æsthetie eritieism and we eall it beautiful when the movement of the eye is gentle and eontinuous, ugly, when the eye, frequently and suddenly diverted in its course, cannot follow the angular lines with one conneeted movement, but only by immediate ehange of direction. But the feeling of Beauty may also be awakened by eontrast, by opposition, when as it were, the phenomena satisfies an unperceived fundamental law (as in the well-known assembling of the complementary colours) and the demand for the completion of an ideal Whole; and so in contrast itself a eontenting feeling of completion is excited. These remarks will perhaps make us better understand the oft-repeated statement that hot regions lose a main eharm of the landseape in the want of our meadows, for grass-grown, tree-less plains are by no means wanting in the New World, generally, and especially under the tropics of both the Old and New Continents. But when we speak of the beauty of our meadows, we do not in reality at all mean the meadows themselves, that is the grassy level surfaees, but the varying shapes, and thenee agreeable contrasts between the velvet-like green earpet and the bushes rising from them in fair rounded forms up to the majestie hilly woods; and the gloomy Pine-heaths of the Mark would not beeome any more beautiful were their endless surfaces, which eannot be wholly surveyed from any hill occurring there, to be overgrown with ever so rich a vegetation of Grass, in the absence of all timber.

When we now place beside the Wood-formations, those of the Plains, we introduce quite a new æsthetie element into the contemplation of Nature. The woods we cannot imagine divested of the element of Beauty, on account of their wealth of form, the complexity of configuration, which continually excite the feelings and the mind to varying activity. But it is wholly different with the great Plains of Plants, which make quite a peculiar impression on human nature.

With a kind of feeling of disappointed expectation rides the traveller in the Prairies of the West, anything but refreshing appears the monotonous surface uniformly overgrown with high Grass, the line of the horizon unbroken even by the smallest elevation. He rides and rides, but ever boundless space expands before his eyes, in the same uniformity, in the same calm simplicity. The idea which he at first avoided, the Infinity lying beyond little Humanity, will present itself to him, the feeling of hopeless loneliness creeps gradually into his heart. One day after another climbs the east, and sinks into the west. Ever wider and wider extends the Endlessness around him and grows beyond all his previous conceptions of magnitude. Self-consciousness shrinks into narrower bounds, and ever more paralyzing and oppressive lies the feeling of Nothingness upon his trembling soul, and before he has reached the further border, Despair or an infinitely deep and inward Piety has taken possession of his heart. Whenever uniform magnitude makes an æsthetic impression, it is that of sublimity, before which Man sinks in adoration to the dust. One particular modification of these Prairies, is very characteristically named by the settlers "rolling prairie," a boundless sea of smooth, uniform waves of earth, twenty to thirty feet high. I do not venture to describe the other angry glowing visage of these giant meadows, when, in summer, accident or design has kindled the dry grass, and the fire rolls forth over the plain with wild rapidity; after Cooper and Seatsfield, this would be to carry owls to Minerva.

Situated under similar latitudes and climatal conditions, the Pampas of Buenos Ayres have a character similar to that of the North American prairies, only Man by his influence upon Nature has here and there impressed a peculiar stamp. The Thistle and Artichoke coming with the Europeans, have quickly made themselves masters of the free soil, and with incredible rapidity overspread districts of many square miles with their spiny vegetation, which has here developed in a luxuriance unknown in Europe. These Thistle-wastes have become a terrible nuisance, themselves robbers, depriving better plants of the soil, inaccessible hiding-places for the great thievish and sanguinary Cats, and the still more dangerous human bandits, the thorny weed of semi-civilization.

One might almost assert that we are less acquainted with the peculiar Steppes which lie closest to us, than with those natural forms of distant lands which have become almost familiar to us from the descriptions of gifted men, for in fact, one hears only too often in conversation, what mistaken conceptions people have of those extensive plains which are commonly known by the name of the North German Heaths. From the western border of northern France, through Belgium, North Germany and Russia, almost to the eastern confines of Siberia, extends a broad plain rarely interrupted by low chains of hills, and just as rarely affording fitting soil for extensive growth of wood which, on the whole, confines itself to the more favourable soil moistened by the vicinity of rivers. Along the southern border of this plain extends a chain of hills and mountains, now projecting forward like capes into the broad surface, now retreating into broad or narrow creeks, the eoast of a sea formerly eovering the whole plain. Over all this endless expanse has one single speeies of plant established an almost exelusive predominanee, the Heath, whieh has lent its name to these traets of land. Conditions similar to those which produee the distinetion between the Pine Barrens and Cypress Swamps in North Ameriea, are also aetive here to eause an essential difference. The great flatness of the ground, even geologieal eonditions in many plaees, as where slight elevations of the land forming flat enelosed basins, prevent, in many situations, the free dis-eharge of the water, and the Heath, baeked by the speeial vegetation produeed by the moisture, forms by the annual aeeumulation of vegetable matter, whieh in water only beeomes to a eertain degree earbonized or deeomposed, those blaek masses of the remains of plants, whieh as peat bear sueh an important part in the eeonomy of the in-habitants. Thus in various modes of distribution alternate arid, dry Sandy Heaths with moist, spongy Peat Heaths or Moors. On the margins of the latter, more rarely aetually upon them, a more or less healthy vegetation of Trees settles, and on the heaths of Luneburg are often found splendid Oaks, which, over-shadowing one of those pleasant, straw-thatched houses and thrown out by the back-ground of the peeuliar red tint of the glaneing Heather, produee a picturesque eharm whieh would not have been expeeted here. With these great Moors may be assoeiated the Peat Moors of some of the higher mountain ehains of the Broeken, the Röhn and the Fiehtel-Gebirge and so on, and the so-called Mosses of South Germany and Switzer-land.

In another climate, in another zone of vegetation, exist similar eonditions, stretching aeross the extreme north of

Europe. As there the arid Sandy Heaths alternate with the wet Moors, so here in a more varied manner do the dry, waterless tracts, with the marshy grounds. But we are here in Wahlenberg's region of Lichens and Mosses. The arid situations are clothed, in expanses over which the eye cannot reach, with dry, lead-grey Lichens, among which the reindeer seeks his meagre sustenance, and in the half-fluid grounds, which will not bear the lightest footstep, a luxuriant vegetation of Mosses deceives us, in the distance, with the aspect of a smiling meadow. Here the incautious wanderer sinks into the water, which is rather concealed than displaced by the Mosses, while on those Lichen Heaths, *Tundras* the Laplanders call them, in summer the glowing soil makes every step a torture.

The Wood-formations of the South American *Catingas* may be opposed to the northern Leafy woods and, in like manner, the plains of the *Llanos* of Venezuela to the Russian *Steppes*. In the former, of which A. von Humboldt has given such a vivid sketch, the sleep of Nature commences with summer, in the hot, dry season; the vegetation becomes dried up and falls to dust, leaving the ground bare; animal life, in the quadrupeds, flies from the dead land, while the crocodiles and boas burrow into the mud of the gradually exhausted rivers of the steppes, and with this become fixed, till the first torrent of rain, which conjures up a fresh, youthful vegetation on the barren soil, again awakens them to life.

It is different in the Steppes which stretch from southern Russia eastward through central Asia. I will only mention the strange Salt-steppes, which in summer often glance like newly fallen snow, from the salt which effloresces from the soil, and nourish a wholly peculiar vegetation. Yet I cannot refrain from attempting a brief description of the sparingly populated but still inhabited Tartarian Steppes of Pontus. These do not uniformly present a level surface, being broken by the *Durrinas*, low tracts of Bush of Blackthorns, Hawthorns, Roses and Brambles. But the remaining part of the vegetation is also divided by the inhabitants of lesser Russia, according to its use for pasture, into two essentially distinct groups, the *Truwa*, the turf, and the *Burian*, the rough, branching plants which, on account of their woody stem, afford no sustenance to the herds of the Steppes. The Feather Grass* is the principal among the Graminaceous plants. Directly after flowering, it expands its long, delicately feathered awns, not unlike Marabout feathers, from the spike which rises high above the tuft of narrow, dry leaves. The older the Steppe, the higher developes the woody root-stock above the soil, to the annoyance of the mower. Whoever travels but a few miles into the Steppes, soon hears the word *Burian*. Against the Burian inveighs the herdsman with his oxen and horses; over the Burian laments the husbandman; the Burian is the curse of the gardener and the hope of the cook. For in the soil of the Steppe, which is peculiarly fertile for certain plants, which we call weeds, these shoot up to an incredible height, wherever cultivation has loosened the solid soil, which they avoid, and their peculiar use is, that, dried up in the autumn, they furnish the only fuel of these regions. Above all, as in the Pampas of Buenos Ayres, the Thistles distinguish themselves, acquiring a size, a development and ramification, which is really marvellous. Often do they stand like little trees around the humble earth-hovels of the country-people; on favourable soil, they often form

* Scholkowoi Truwa (silk-plant), Stipa pennata.

extensive Bush, even overtopping the horseman, who is as helpless in it as in a wood, since they intercept the sight and yet afford no trunk which might be climbed. Beside the Thistle rises the Wormwood, intermingled with the gigantic Mullein or High-taper, the "Steppe-light" of lesser Russia. Even the little Milfoil grows several feet high and is not a little prized, since the inhabitants, who, from their poor provision, carefully examine the heating power of the Burian, value it as the best material for fuel. But the most characteristic of all the plants of the Burian is that which the Russians call "*Perekatipole*," the "Leap in the field," and the German colonists almost more happily, the "Wind Witch." A poor Thistle-plant, it divides its strength in the formation of numerous dry, slender shoots which spread out on all sides and are entangled with one another. More bitter than Wormwood, the cattle will not touch it even in times of the utmost famine. The domes which it forms upon the turf are often three feet high and sometimes ten to fifteen in circumference, arched over with naked, delicate thin branches. In the Autumn the stem of the plant rots off, and the globe of branches dries up into a ball, light as a feather, which is then driven through the air, by the autumnal winds, over the Steppe. Numbers of such balls often fly at once over the plain with such rapidity that no horseman can catch them; now hopping with short, quick springs along the ground, now whirling in great circles round each other, rolling onward in a spirit-like dance over the turf, now, caught by an eddy, rising suddenly a hundred feet into the air. Often one Wind Witch hooks on to another, twenty more join company, and the whole gigantic yet airy mass rolls away before the piping east-wind. Surely Man does not need a rocky abyss, a mine, or howling sea-storms to give him food enough for Superstition. The Steppe receives a more terrible life when a countryman "cleans his farm," that is, when he has set on fire the Burian upon it, with the remains of old straw and hay, now useless on account of the new harvest, and full of mice and other vermin, and when the dry grass of the Steppe has caught; among the common grass it creeps like a serpent, with measured swiftness; here it seizes a Burian bush, and with a tremendous noise the blaze soars high toward heaven, crackling and hissing, there reaching a tract of flourishing Feather-grass, rises in a light white flame, darts with terrible activity over the waving field, devouring millions of delicate feathers in a few moments. Sometimes, hemmed in between two roads bare of vegetation, or between streams of water, the flame draws itself together and almost disappears, then, suddenly reaching a new dry surface of grass, gains new and fearful power, spreads into a wide sea of smoke and fire, in which the columns of flame whirling up higher and brighter than the rest, mark the unlucky situations of human dwellings. Steppe-fires of this kind often move about over a region for eight or ten days, crossing and diverging in directions which cannot be calculated on, following every alteration of the breeze, bidding defiance to the best considered attempts at escape.

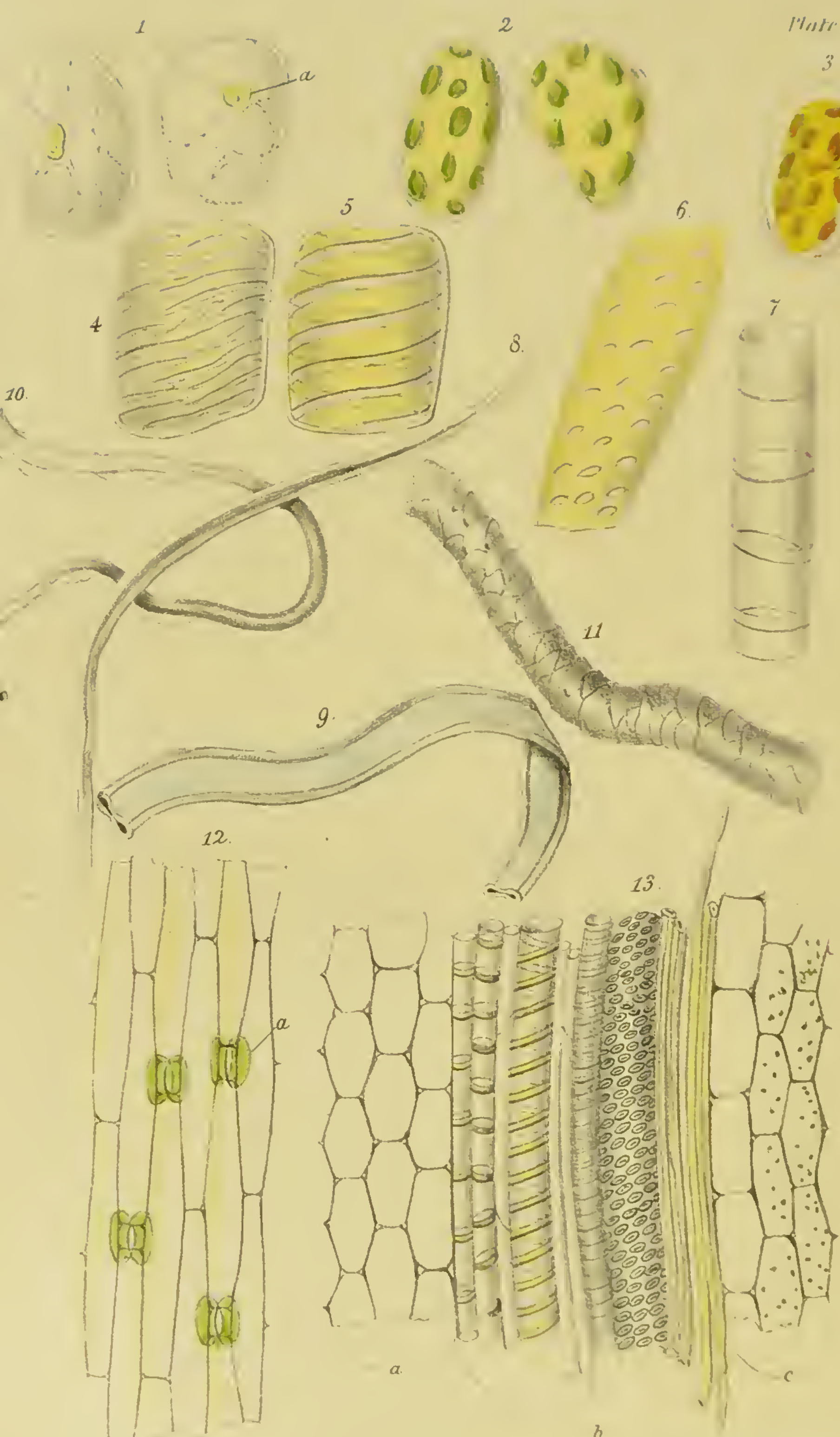
But the Steppe is barren, robbed of vegetation; what the flames had spared is but the victim of the icy breath of the piercing Winter. Ever denser and more gloomy, the clouds draw together, ever thicker falls the snow, and ever more cutting drives the cold north wind over the unprotected surface. The belated traveller urges his horse with the most pressing haste. Silver streaks rise up from the plain, and ascend with increasing frequency; the wind begins to howl and bluster; the air glistens more and more with crystals of snow, and, at last, all this becomes one dense, dim mass, proceeds in one direction till, caught by a whirlwind, it rushes round in a circle or rebounds from the elevated portions of the Steppe. This is the "Buran," the Steppe-storm; long before this the frightened driver has perceived its tokens, and with all the force of desperation lashed his gradually wearying horse. More violently and rapidly the snow-wreaths succeed one another, circling round and confounding everything in painful dizziness, every thought of finding the right path is given up, and all must be trusted to the instinct of the horse, which now flies as if driven by a madman, over the plain. Close by the sledge roars a terrified herd, and the passing glance through the thick snow dust, just allows the traveller to perceive how, blinded by anguish, they precipitate themselves over a precipice, at the foot of which their shattered bones whiten in the following spring.

Every hope seems lost, and death certain; then the night comes on, and the storm begins to flag; the masses of driven snow sink down and, as suddenly as it arose, the Buran subsides after lasting scarcely half a day; the atmosphere becomes again brightened by the evening twilight, and the exhausted traveller sees a human dwelling before him. If it affords but little compensation for the toil endured, it at least allows of slumber. A pleasant dream bears the tired wanderer to the distant home. On the pleasant banks of the stream that glides along there, he strays through fertile meadows—evening sinks upon the warm earth. Moist, misty dews rise, refreshing, from the soil, sweep through the bordering Alders, and clothe them in their veil; Erl-King* and his daughter glide in changeful, sportive forms round about the grey old trunks of the Willows. A gentle sound trembles through the fragrant evening air. The bell of the native village calls him home, returned after restless travel over the great God's World, after rich impressions, exciting adventures, pressing hardships and strange delights, back to rest, to that which, in spite of all intervening things, he never does nor can forget, the paradise of childhood, the house of his parents, his mother's arms.

* *Anglice,* Alder-King.

EXPLANATION OF THE PLATES.

Plate I.



On Zinc by J. Erxleben

London Publish[d] by H Bailliere 1848

Day & Son Lith[rs] to the Queen

EXPLANATION OF THE PLATES.

PLATE I.

ALL THE FIGURES ARE GREATLY MAGNIFIED.

FIG. 1.—Two cells from the Snow-berry. In each is perceived a nucleus *a*, and, proceeding from or towards this, numerous currents of a yellowish mucilaginous substance. In some of them the direction of the currents is indicated by an arrow.

FIG. 2.—Two cells from the leaf of the Pink. In these may be distinguished the colourless cell-wall, a delicate, yellowish, mucilaginous coating, and some large granules coloured by chlorophyll.

FIG. 3.—A cell from the same plant, which has been moistened with a drop of nitric acid and some tincture of iodine. The green granules have become brown, the mucilaginous coat is coagulated and thus has become retracted from the wall of the cell, and forms a sac lying loosely within it.

FIG. 4.—A reticulated fibrous cell from the leaf of the broad-leaved Gesneria (*Gesneria latifolia*).

FIG. 5.—A spiral fibrous cell from the leaf of a tropical Orchidaceous plant (*Maxillaria atropurpurea*).

FIG. 7.—An annular fibrous cell from the stem of the Italian reed (*Arundo Donax*).

FIG. 8.—A very short bass fibre (elongated cell) from the stem of the Flax.

FIG. 9.—A little piece of a cotton fibre.

FIG. 10.—A piece of a filament of raw silk from a cocoon.

FIG. 11.—A small portion of a fibre of sheep's wool.

FIG. 12.—A small piece of the epidermis stripped from a leaf of the Tulip. It is composed of longish, somewhat six-sided cells, and this piece exhibits four stomates or breathing pores, *a*.

FIG. 13.—A delicate section from the stem of the Italian reed, so cut that it only contains one of the vascular bundles (the tough fibres

running through the stem). *a*, Cells of the pith; *b*, vascular bundle composed of elongated cells, and these, proceeding from within outward, having the form of annular, spiral, porous and bass-cells; *c*, cells of the rind, the outermost containing some granules coloured by chlorophyll.

PLATE II.

ALL THE OBJECTS ARE REPRESENTED GREATLY ENLARGED.

Fig. 1.—Some cells from a Cactus, containing various forms of crystals; also some loose crystals of different forms. It must be observed, that in Nature these various forms are never assembled so closely together as they have been here, for the sake of occupying less space.

Fig. 2.—The external portion of a delicate transverse section of a grain of Rye. *a*, Some layers of yellowish flattened cells which form the shell of the grain; *b*, the outer layers of cells of the grain; these are completely filled with a yellowish, mucilaginous matter containing granules; *c*, the interior cells of the grain which contain little else but starch granules, and only here and there a little of that granular mucilaginous matter which is what is called the gluten of the meal, and is the most nutritious constituent of Grain. The Bran which is removed in grinding, contains at least all the layers to *c*; all the remaining cells, forming the white or fine meal, resemble in form and contents those marked *c*.

Fig. 3.—Starch granules, from the Potato.

Fig. 4.—Ditto, constituting East Indian Arrow-root.

Fig. 5.—Ditto, *genuine* West Indian Arrow-root.

Fig. 6.—Ditto, very commonly sold for West Indian Arrow-root. The medicinal properties are exactly similar in both kinds.

Fig. 7.—A small piece of the outer layer of cells from the red-spotted flower-stalk of the greenish-flowered Veltheimia. It is at once seen that the red spots consist of little groups of cells containing red sap, those around being filled with green matter. It also affords a striking proof of the independance and perfect continuity of each cell, since otherwise the different coloured juices must become mingled.

Fig. 8.—A fine longitudinal section of Oak-wood, consisting

Plate II.

On Zinc by J. Erxleben — *London Publish.d by H. Bailliere 1848* — *Day & Son Lith. to the Queen*

On Zinc by J. Erxleben London Publish^d by H. Bailliere 1848. Day & Son Lith^rs to the Queen of wood-cells *a*; and porous-cells *b*, the so-called vessels of the wood.

Fig. 9.—A fine transverse section of the same wood. In this also, the small but very thick-walled wood-cells *a* are readily distinguished from the large but proportionately thin vascular cells *b*. At *c* are perceived some other rows of peculiar cells, called by vegetable anatomists medullary rays, by joiners "silver grain," which run through the wood, radiating from the pith to the bark.

Fig. 10.—A delicate longitudinal section of the wood of the common Pine, consisting of very long porous wood-cells, which are distinguished by a peculiarity of the pores. They exhibit two circles, a large outer one *a*, and a small inner one *b*; a peculiarity which only occurs in this particular form in the wood of Cone-bearing trees, and which enables us to distinguish this even in the condition of coal or fossil wood.

PLATE III.

MOST OF THE OBJECTS IN THIS PLATE ARE MUCH ENLARGED; BUT WHEN THIS IS NOT THE CASE, IT IS EXPRESSLY DENOTED BY THE LETTERS "N. S." (NATURAL SIZE).

Fig. 1.—Development of a reproductive cell of a Conferva, which frequently occurs as a green filamentous slime in stagnant water. *a*. The spore (reproductive cell). *b*. First stage of development; the spore has sent out a thin, tubular process. *c*. Second stage; the process has become elongated, and a new cell has been formed at the opposite end of the spore. *d*. Third stage; the young plant has become attached by its elongated process to a fragment of wood, and is gradually growing out at the other extremity into a perfect filament, by continually forming fresh cells.

Fig. 2.—Development of the spore of a Fern. *a*. The spore, which in this case does not consist of a simple reproductive cell, but has a peculiar dark-coloured coat. *b*. First stage; the cell has broken through the coat and become elongated in a tubular form. *c*. Second stage; in the protruded end of the tube several cells have been formed and are already green, but the original cell remains within the dark-coloured coat. *d*. Third stage; the green cells have become so much multiplied that they form a little roundish leaflet,

the germ. *e.* Fourth stage (*n. s.*); the germ has become two-lobed, or heart-shaped; the spore-cell with its coat and the end of the tube is beginning to decay. *f.* Fifth stage (*n. s.*); in the notch of the germ, which has increased in size, a little protuberance has been formed which begins to grow downward into a root and upward into the first-leaf. *g.* Sixth stage (*n. s.*); the germ has reached its full development and is beginning to decay; the first leaf of the plant is perfect, the second has made its appearance and the root is beginning to branch. *h.* Seventh stage (*n. s.*); the germ has decayed and disappeared; the young plant, now complete, developes without further peculiar phenomena.

Fig. 3.—(*n. s.*). A twig with a leaf, in the axil of which has been formed a bud, that is a new plant connected with the original plant.

Fig. 4.—A plant of the garden Strawberry (one-sixth of the natural size). The parent plant *a* has sent out slender shoots from the axils of its leaves; the shoots, instead of perfect leaves, have scale-like organs situated at a considerable distance from each other; these shoots are called runners. From the axil of each scale is developed a bud which immediately strikes root and becomes a perfect Strawberry plant *c*. In the following year the shoot uniting it with the mother-plant *b* decays, and the latter thus becomes surrounded by a numerous progeny.

Fig. 5.—A leaf of *Bryophyllum calycinum* (*n. s.*), which when placed upon moist earth (damp air has the same influence) gradually produces little plants in all the indentations of its border.

Fig. 6.—A longitudinal section of the pistil of the Heartsease (*Viola tricolor*). In the hollow head-shaped stigma lie a quantity of reproductive cells (pollen), which have been thrown upon it by the bursting of the anthers. These cells have all become elongated into tubes which creep through the canal of the style *b* down into the germen *c*, and here in part enter the numerous seed-buds (ovules) *d* existing here.

Fig. 7.—A single seed-bud (ovule) of the same plant, cut through lengthways, with the whole of the tube of the reproductive cell. This, *a*, is here, as in the Fern, enclosed in a dark coat, which the tube *b* has broken through. The free end of the tube having reached the seed-bud *c*, passes through its different envelopes till it reaches the internal cavity, here it swells up and becomes filled with green cells which are gradually transformed into the embryo, while the remaining portion, with the reproductive cell, gradually decays and

disappears. The great and essential similarity of this process to that described in the Fern is not to be mistaken.

Fig. 8.—The end of the tube drawn out of the seed-bud, at a later period. The tube *c* has begun to decay. The little roundish body of the nascent embryo shoots out to the right and left two little knobs, the first-leaves *a*; at the upper end is the beginning of the stem, the opposite extremity becomes the root.

Fig. 9.—The embryo, now almost perfect, extracted from the seed-bud, which by this time is transformed into the seed. The two first-leaves, the seed-leaves or cotyledons, are complete, *a* and *b*, and cover the bud which has been formed between them; this bud is the foundation of the future stem; at the other end, the root *c* is also perfect. At this period all vegetative power seems to be exhausted. The ripe seed is thrown off by the plant and lies for a varying length of time on the ground, the embryo within manifesting no trace of the persistence of life. At last, at the time appointed, germination commences, for an example of which the Flax-plant may serve.

Fig. 10.—Longitudinal section of a Flax-seed. The embryo cut through lengthways is seen to be enclosed in a double coat, and sends out a rootlet (radicle) below, while it ends above in a little bud (plumule) which is contained between two large seed-leaves or cotyledons.

Fig. 11.—A germinating Flax-seed (*n. s.*) The little plant has burst its coats and is about to throw off its shell.

Fig. 12.—A somewhat later stage (*n. s.*) The young plant has become perfectly independant and the bud or plumule is beginning to develope into stem and leaves.

Plate IV. and the Frontispiece are fully explained in the Fourth and Twelfth Lectures.

THE END.

LONDON:
Printed by Schulze and Co., 13, Poland Street.