health, unless where they are pressed upon by the finger or some other cause of resistance.

In what part of a plant the vital principle chiefly exists, or to what quarter it retires during the winter, we know not; but we are just as ignorant in respect to animal life. In both it operates towards every point; it consists in the whole, and resides in the whole; and its proof of existence is drawn from its exercising almost every one of its functions and effecting its combinations in direct opposition to the laws of chemical affinity, which would otherwise as much control it as they control the mineral world, and which constantly assume an authority as soon as ever the vegetable is dead. Hence the plant thrives and increases in its bulk; puts forth annually a new progeny of buds, and becomes clothed with a beautiful foliage of lungs (every leaf being a distinct lung in itself*) for the respiration of the rising brood; and with an harmonious circle of action, that can never be too much admired, furnishes a perpetual supply of nutriment, in every diversified form, for the growth and perfection of animal life; while it receives in rich abundance, from the waste and diminution, and even decomposition of the same, the means of new births, new buds, and new harvests.

In fine, every thing is formed for every thing; and subsists by the kind intercourse of giving and receiving benefits. The electric fire that so alarms us by its thunder, and by the awful effects of its flash, purifies the stagnant atmosphere above us; and fuses, when it rushes beneath us, a thousand mineral veins into metals of incalculable utility. New islands are perpetually rising from the unfathomable gulfs of the ocean, and enlarging the boundaries of organized life; sometimes thrown up, all of a sudden, by the dread agency of volcanoes, and sometimes reared imperceptibly by the busy efforts of corals and madrepores. Liverworts and mosses first cover the bare and rugged surface, when not a vegetable of any other kind is capable of subsisting there. They flourish, bear fruit, and decay, and the mould they produce forms an appropriate bed for higher orders of plant-seeds, which are floating on the wings of the breeze, or swimming on the billows of the deep. Birds next alight on the new-formed rock, and sow, with interest, the seeds of the berries, or the eggs of the worms and insects on which they have fed, and which pass through them without injury; and an occasional swell of the sea floats into the rising island a mixed mass of sand, shells, drifted sea-weed, skins of the casuarina, and shells of the cocoa-nut. Thus the vegetable mould becomes enriched with animal materials; and the whole surface is progressively covered with herbage, shaded by forests of cocoa and other trees, and rendered a proper habitation for man and the domestic animals that attend upon him.

The tide that makes a desolating inroad on one side of a coast, throws up vast masses of sand on the opposite: the lygeum, or sea-mat-weed, that will grow on no other soil, thrives here and fixes it, and prevents it from being washed back or blown away; to which the lime-grass,† couch-grass,‡ sand-reed,§ and various species of willow lend their aid. Thus fresh lands are formed, fresh banks upraised, and the boisterous sea repelled by its own agency.

Frosts and suns, water and air, equally promote fructification in their respective ways; and the termes, or white ant, the mole, the hampster, and the earth-worm, break up the ground or delve into it, that it may enjoy their salubrious influences. In like manner, they are equally the ministers of putrefaction and decomposition; and liverworts and funguses, the ant and the beetle, the dew-worm, the ship-worm, and the wood-pecker, contribute to the general effect, and soon reduce the trunks of the stoutest oaks, if lying waste and unemployed, to their elementary principles, so as to form a productive mould for successive progenies of animal or vegetable existence. Such is the simple but beautiful circle of nature. Every thing lives, flourishes, and

* On the leafing of trees, there is a curious and valuable paper in the Swedish Amœnitates Academiæ vol. iii. art. 46, by H. Barck, 1753, entitled Vernatio Arborum.

† Elymus *arenarius*. ‡ Triticum *repens*. § Arundo *arenaria*.

decays: every thing dies, but nothing is lost: for the great principle of life only changes its form, and the destruction of one generation is the vivification of the next.* Hence, the Hindoo mythologists, with a force and elegance peculiarly striking, and which are nowhere to be paralleled in the theogonies of Greece and Rome, describe the Supreme Being, whom they denominate Brahm, as forming and regulating the universe through the agency of a triad of inferior gods, each of whom contributes equally to the general result, under the names of Brahma, Visnu, and Iswara; or the generating power, the preserving or consummating power, and the decomposing power. And hence the Christian philosopher, with a simplicity as much more sublime than the Hindoo's, as it is more veracious, exclaims, on contemplating the regular confusion, the intricate harmony, of the scenes that rise before him—

> These, as they change, Almighty Father! these
> Are but the varied God. The rolling year
> Is full of Thee.

LECTURE IX.

ON THE GENERAL ANALOGY OF VEGETABLE AND ANIMAL LIFE.

(The subject continued.)

The perfection of an art consists in the employment of a comprehensive system of laws, commensurate to every purpose within its scope, but concealed from the eye of the spectator; and in the production of effects that seem to flow forth spontaneously, as though uncontrolled by their influence, and which are equally excellent, whether regarded individually, or in reference to the proposed result.

Such is the great art of nature: and he who would study it with success must, as far as he is able, trace out its various laws, and reduce them to general principles, and collect its separate phenomena, and digest them into general classes. This, in many instances, we are able to do; and in such cases we obtain a tolerable insight into the nature of things. But so vast, so unbounded is the theatre before us, so complicated is its machinery, and so closely does one fact follow up and press upon another, that we are often bewildered and lost in the mighty maze, and are incapable of determining the laws by which it is regulated, or of arranging the phenomena of which it is composed.

The zoologist, in order to assist his inquiries, divides the whole animal creation into six general heads or classes: as those of mammals, birds, amphibials, fishes, insects, and worms. Each of these classes he subdivides into orders; of each of his orders he makes a distinct section for a multitude of kinds or genera; and each of his kinds becomes a still more subordinate section for the species or individuals of which the separate kinds consist. But he is perpetually finding, not only that many cases in each of his inferior divisions are so equally allied to other divisions that he knows not how to arrange them, but that even his classes or first divisions themselves labour under the same difficulty; since he occasionally meets with animals that by the peculiarity of their construction seem equally to defy all artificial method and all natural order. Thus the myxine *glutinosa*, which by Linnæus was regarded and ranked as a worm, has been introduced by Bloch into the class of fishes, and is now known by the name of gastrobranchus *cœcus*, or hag-fish. The siren *lacertina*, which was at first contemplated by Linnæus as an amphibious animal of a peculiar genus, was afterward declared by

* See upon this subject the Swedish Amœnitates Academicæ, vol. v. art. 80, by J. H. Hagen, 1757, entitled Natura Pelagi.

Camper and Gmelin to be a fish approaching the nature of an eel, and was arranged accordingly. It has since, however, been restored from the class of fishes to that of amphibials, and is in the present day believed by various zoologists to be nothing more than a variety of the lizard. And thus the hippopotamus, the tapir, and the swine, which by Linnæus were ranked in the fifth order of mammals with the horse, are arranged by Cuvier with the rhinoceros and the sokotyro, that have hitherto formed a part of the second order.

The eel, in its general habits and appearance, has a near similitude to the serpent; many of its species live out of the water as well as in it; and, like the serpent, hunt for worms, snails, and other food, over meadows and marshes.

The platypus *anatinus*, or duck-bill (the ornithorhyncus *paradoxus* of Blumenbach), one of the many wonders of New South Wales, unites in its form and habits the three classes of birds, quadrupeds, and amphibials. Its feet, which are four, are those of a quadruped; but each of them is palmate or webbed like a wild-fowl's; and instead of lips it has the precise bill of a shoveler or other broad-billed water bird; while its body is covered with a fur exactly resembling an otter's. Yet it lives, like a lizard, chiefly in the water, digs and burrows under the banks of rivers, and feeds on aquatic plants and aquatic animals. The viverra or weasel, in several of its species, approaches the monkey and squirrel tribes; is playful, a good mimic, and possesses a prehensile tail. The flying squirrel, the flying lizard, or draco *volans*, and especially the bat, approach in their volant endowment the buoyancy of birds, and are able to fly by winged membranes instead of by feathers. The exocetus *volitans*, or flying-fish, and several other fishes, derive a similar power from their long pectoral fins; while the troctilus, or humming-bird, unites the class of birds with that of insects. It is in one of its species, T. *minimus*, the least of the feathered tribes; feeds, like insects, on the nectar of flowers alone, and like the bee or butterfly, collects it while on the wing, fluttering from flower to flower, and all the while humming its simple accent of pleasure. Its tongue, like that of many insects, is missile. When taken it expires instantly; and after death, on account of its diminutive size, the elegance of its shape, and the beauty of its plumage, it is worn by the Indian ladies as an ear-ring.

Such being the perplexity and seeming confusion that extend through the whole chain of animal life, it is not to be wondered at that we should at times meet with a similar embarrassment in distinguishing between animal life and plants, and between plants and minerals. I gave a cursory glance at this subject in our last lecture, and especially in regard to that extraordinary division of organized substances which, for want of a better term, we continue to denominate zoophytes; many of which, as, for example, various species of the alcyony and madrepore, bear a striking resemblance to crystals, and other mineral concretions; while great numbers of them, and particularly the corals, corallines, and some other species of alcyony, as the sea-fig, sea-quince, pudding-weed, and above all the stone-lily (which last, however, is now only found in a petrified state), have the nearest possible approach to a vegetable appearance. Whence, as I have already observed, among the earlier naturalists, who expressly directed their attention to these substances, some regarded them as minerals, and others as vegetables; and it is not till of late years, only, indeed, since it has been ascertained that the chemical elements they give forth on decomposition are of an animal nature, that they have been admitted into the animal kingdom.

Among plants, in like manner, we often meet with instances of individual species that are equally doubtful, not only as to what kind, order, or class of vegetable existence they belong, but even as to their being of a vegetable nature of any kind, till their growth, their habits, and their composition are minutely examined into. But independently of these individual cases, we also perceive, in the general principle of action and animal life, that the more it is investigated, the more it is calculated to excite our astonishment, and to indicate to us, so far as relates to the SUBORDINATE POWERS of the animal frame, the application of one common system to both, and to demonstrate one common derivation from one common and Almighty Cause. Having, therefore,

in our last lecture, submitted to your attention a brief outline of the structure of plants, I shall now proceed to point out a few of these general resemblances, and shall endeavour to select those which are either most curious or most prominent.*

Plants, then, like animals, are produced by ordinary generation; and though we meet with various instances of production by the generation of buds and bulbs, or of slips and offsets, the parallelism, instead of being hereby diminished, is only drawn the closer; for we meet with just as many instances of the same varieties of propagation among animals. Thus the hydra, or polype, as it is more generally called, the asterias, and several species of the leech, as the hirudo *viridis*, for example, are uniformly propagated by lateral sections, or pullulating slips or offsets;† while almost every genus of zoophytic worms is only capable of increase by buds, bulbs, or layers; and some of these animals, like the houseleek and various grasses, by spontaneous separation. In effect, most of the kinds now referred to, whether animals or vegetables, may be regarded less as single individuals than as assemblages or congeries of individuals; for in most of them every part exists distinctly of every other part, and is often a miniature of the general form. The various branches of a tree offer a similar example, and present a striking contrast with the various branches of a perfect animal. In the latter every distinct part contributes to one perfect whole: the arm of a man has no heart, no lungs, no stomach; but the branch of a tree has a complete system of organs to itself, and is hence capable in many cases of existing by itself, and producing buds, layers, and other kinds of offspring, when separated from the trunk. The different parts of the polype are equally independent, and are hence equally capable of a separate increase. It is owing to this principle that we are able to graft and bud: and M. Trembly, having applied the same kind of operation to the animals we are now speaking of, found that, by numerous grafts of different kinds upon each other, he was enabled to produce monsters as wild and extravagant as the most visionary poet or fabulist ever dreamed of.

The blood of plants, like that of animals, instead of being simple is compound, and consists of a great multitude of compacter corpuscles, globules for the most part, but not always globules, floating in a looser and almost diaphanous fluid. From this common current of vitality, plants, like animals, secrete a variety of substances of different, and frequently of opposite powers and qualities,—substances nutritive, medicinal, or destructive. And, as in animal life, so also in vegetable, it is often observed that the very same tribe, or even individual, that in some of its organs secretes a wholesome aliment, in other organs secretes a deadly poison. As the viper pours into the reservoir situated at the bottom of his hollow tusk a fluid fatal to other animals, while in the general substance of his body he offers us not only a healthful nutriment, but, in some sort, an antidote for the venom of his jaws: so the jatropha *manihot*, or Indian cassava, secretes a juice or oil extremely poisonous in its root, while its leaves are regarded as a common esculent in the country, and are eaten like spinach-leaves among ourselves; though the root, when deprived, by exposure to heat, of this poisonous and volatile oil, is one of the most valuable foods in the world, and gives bread to the natives, and tapioca as an article of commerce. Its starch is like that of the finest wheat-flour, and, combined with potatoes and sugar, yields a very excellent cider and perry, according to the proportions employed. In like manner, while the bark of the cinnamon tree (laurus *cinnamomum*) is exquisitely fragrant, the smell of the flowers is highly offensive, and by most persons is compared to that of newly-sawn bones,—by St. Pierre to that of human excrement.‡ So

* Consult also Mr. Knight's article, Phil. Trans. 1810, part ii. p. 179—181.

† Thus Aristotle, upon a subject which is generally supposed to be of modern discovery, "Ὥσπερ γὰρ τὰ φυτὰ καὶ ταῦτὰ (scilicet) ἔντομα διαιρούμενα ὀύναται ζῆν· "For, like plants, such insects also maintain life after slips or cuttings."—*Hist. Anim.* lib. iv. ch. 8.
See a variety of other curious instances in the author's translation of Lucretius, note to b. ii. ver. 880.

‡ Mr. Marshall's account delivered to the Royal Society. See Thomson's Annals, Sept. p. 242.

the cascarilla bark and castor oil are obtained from plants poisonous in some part or other.

The amyris, in one of its species, offers the balm-of-gilead tree; in another, the gum-elemi tree; and in a third,* the poison-ash, that secretes a liquid gum as black as ink. It is from a fourth species of this genus, I will just observe as I pass along, in order the more completely to familiarize it to us, that we obtain that beautiful plant which, under the name of rose-wood,† is now so great a favourite in our drawing-rooms.

The acacia *nilotica*,‡ or gum-arabic tree, is a rich instance in proof of the same observation. Its root throws forth a fluid that smells as offensively as asafœtida; the juice of its stem is severely sour and astringent; the secernments of its cutis exude a sweet, saccharine, nutritive gum, the common gum-arabic of the shops, and its flowers diffuse a highly fragrant and regaling odour. So the arenga palm produces sugar, an excellent sago, and a poisonous juice that even irritates the skin.

But perhaps the laurus, as a genus, offers us the most extensive variety of substances of different qualities. This elegant plant, in one of its species, gives us the cinnamon tree;§ in another, the cassia, or wild cinnamon;‖ in a third, the camphor tree;¶ in a fourth, the alligator-pear;** in a fifth, the sassafras;†† in a sixth, a sort of gum-benjamin,‡‡ though not the real gum-benjamin, which is a styrax; while in a seventh, the L. *caustica*, it exhibits a tree with a sap as poisonous as that of the manchineel.

And truly extraordinary is it, and highly worthy of notice, that various plants, or juices of plants, which are fatally poisonous to some animals, may not only be eaten with impunity by others, but will afford them a sound and wholesome nutriment. How numerous are the insect tribes that feed and fatten on all the species of euphorbia, or noxious spurge! The dhanesa, or Indian buceros, feeds to excess on the nux vomica; the land-crab§§ on the berries of the hippomane or manchineel-tree, and the loxia (grossbeak) of the Bahamas on the fruit of the amyris *toxifera*, or poison-ash.‖‖ The leaves of the kalmia *latifolia* are feasted on by the deer and the round-horned elk, but are mortally poisonous to sheep, to horned cattle, to horses, and to man. The bee extracts honey without injury from its nectary, but the adventurer who partakes of that honey after it is deposited in the hive-cells falls a victim to his repast.

There are some tribes of animals that exfoliate their cuticle annually, such as grasshoppers, spiders, several species of crabs and serpents. Among vegetables we meet with a similar variation from the common rule in the shrubby cinquefoil,¶¶ indigenous to Yorkshire, and the plane-tree of the West Indies,*** which most readers know sends forth every spring new colonies by means of runners, as we usually denominate them, in every direction, that, shortly after they have obtained a settlement for themselves, break off all connexion with the parent stock.

Among animals, some are locomotive or migratory, and others stationary or permanent; the same variety is to be traced among vegetables. Unquestionably the greater number of animals are of the migratory kind, yet

* A. *toxifera*.
† A. *balsamifera*.
‡ Mimosa *nilotica*, Linn.
§ L. *cinnamomium*.
‖ L. *cassia*.
¶ L. *camphora*.
** L. *persea*.
†† L. *sassafras*.
‡‡ L. *benzoin*.
§§ Cancer *ruricola*.

‖‖ See on this subject the following curious papers in the Swedish Amœnitates Academicæ, vol. ii. art. 25, par Sueisens, by N. L. Hesselgren. The same subject continued by G. P. Tengmalon, Amœn. Acad. vol. x. art. x. Usus Historiæ Naturalis, by M. Aphonin, art. 147. Ib. in respect to birds, entitled Esca Avium domesticarum, by P. Holmbergen, p. 481, art. 163.

It is also well worthy of remark, that various herbaceous plants which spring up among others that are esculent, yet are rejected by cattle when offered alone, give a higher relish and even salubrity to the fodder with which they are intermixed. This, as Sir J. E. Smith has admirably observed, is particularly the case with the grasses. "As man cannot live on tasteless unmixed flour alone, so neither can cattle in general be supported by mere grass, without the addition of various plants in themselves too acid, bitter, salt, or narcotic to be eaten unmixed. Spices and a portion of animal food supply us with the requisite stimulus or additional nutriment, as the ranunculus tribes, and many others, season the pasturage and fodder of cattle."—*Engl. Flora*, vol. 1.

¶¶ Potentilla *fruticosa*.
*** Platanus *occidentalis*.

in every order of worms we meet with some instances that naturally appertain to the latter, while almost every genus and species of the zoophytic order, its millepores, madrepores, tubipores, gorgonias, isises, corallines, and sponges, can only be included under it. Plants, on the contrary, are for the most part stationary, yet there are many that are fairly entitled to be regarded as locomotive or migratory. The natural order SENTICOSÆ, the ICOSANDRIA POLYGYNIA of the sexual system, offers us a variety of instances of which the *fragaria* or strawberry genus may be selected as a familiar example. The palmate, the testicular, and the premorse rooted tribes afford us similar proofs:—many of these grow from a new bulb, or knob, or radicle, while the old root, of whatever description it may be, dies away; in consequence of which we can only conclude that the vital principle of the plant has quitted an old, dilapidated, and ruinous mansion, to take possession of a new one. Insomuch that were a person, on the point of travelling to the East Indies, to plant the root of an orchis,* or a scabious,† in a particular spot in his garden, and to search for it in the same spot on his return home, he would be in no small degree disappointed; and if he were to remain abroad long, he must carry his pursuit to half an acre's distance, for thus far would some of these roots perhaps have travelled in a few years.

The male valisneria sails from shore to shore over the water in pursuit of his female. And a multitude of sea-plants float through the ocean, and having plenty of food wherever they go, send out no roots in order to search for it.

Plants, like animals, have a wonderful power of maintaining their proper temperature, whatever be the temperature of the atmosphere that surrounds them; and hence occasionally of raising the thermometer, and occasionally of depressing it. Like animals, too, they are found to exist in most astonishing degrees of heat and cold, and to accommodate themselves accordingly. Wherever the interest or curiosity of man has led him into climates of the highest northern latitudes; wherever he has been able to exist himself, or to trace a vestige of animal being around him; there, too, has he beheld plants of an exquisite beauty and perfection: perfuming, in many instances, the dead and silent atmosphere with their fragrances, and embellishing the barren scenery with their corols.

It is said that animals of a certain character, the cold-blooded and amphibious, have a stronger tenacity to life than vegetables of any kind. But the assertion seems to have been hazarded too precipitately; for admitting that the common water-newt‡ has been occasionally found imbedded in large masses of ice, perfectly torpid and apparently frozen; and that the common eel,§ when equally frozen and torpified, is capable of being conveyed a thousand miles up the country, as from St. Petersburgh, for example, to Moscow, in which country, we are told, it is a common practice thus to convey it; and that both, on being carefully thawed, may be restored to as full a possession of health and activity as ever; yet the torpitude hereby induced can only be compared to that of deciduous plants in the winter months; during which season we all know that, if proper care be exercised, they may be removed to any distance whatever without the smallest inconvenience.

Plants, again, are capable of existing in very high degrees of heat. M. Sonnerat found the vitex *agnus castus*, and two species of aspalathus, on the banks of a thermal rivulet in the island of Lucon, the heat of which raised the thermometer to 174° of Fahrenheit and so near the water, that its roots swept into it. Around the borders of a volcano in the isle of Tanna, where the thermometer stood at 210°, Mr. Forster found a variety of flowers flourishing in the highest state of perfection; and confervas, and other water-plants, are by no means unfrequently traced in the boiling springs of Italy, raising the thermometer to 212° or the boiling point.

Animals are capable of enduring a heat quite as extreme. Air has often been breathed by the human species with impunity at 264°. Tillet mentions

* Orchis *morio*, or *latifolia*.
† Scabiosa *succisa*, or devil's bit.
‡ Lacerta *aquatica*.
§ Muræna *anguilla*.

its having been respired at 300°; the Royal Academy asserts at 307°, or 130° Reaumur, in an oven, for the space of ten minutes;* and Morantin gives a case at 325° Fahr., and that for a space of five minutes. Even in the denser medium of water, animals of various kinds, and especially fishes, have been occasionally traced alive and in health in very high temperatures. Thus Dr. Clarke asserts, that in one of the tepid springs of Bonarbashy, situated near the Scamander, or Mender, as it is now called, notwithstanding the thermometer was raised to 62° Fahr., fishes were seen sporting in the reservoir.†

So in the thermal springs of Bahia in Brazil many small fishes are seen swimming in a rivulet that raises the thermometer to 88°, the temperature of the air being only 77½°. Sonnerat, however, found fishes existing in a hot spring at the Manillas at 158° Fahr.;‡ and M. Humboldt and M. Bonpland, in travelling through the province of Quito in South America, perceived other fishes thrown up alive, and apparently in health, from the bottom of a volcano, in the course of its explosions, along with water and heated vapour that raised the thermometer to 210°, being only two degrees short of the boiling point.§

In reality, without wandering from our own country, we may at times meet with a variety of other phenomena perfectly consonant in their nature, and altogether as extraordinary, if we only attend to them as they rise before us. Thus the eggs of the musca *vomitoria*, our common flesh-fly, or blow-fly, are often deposited in the heat of summer upon putrescent meat, and broiled with such meat over a gridiron in the form of steaks, in a heat not merely of 212°, but of three or four times 212°; and yet, instead of being hereby destroyed, we sometimes find them quickened by this very exposure into their larve or grub state. And although I am ready to allow that, in the simple form of seeds or eggs, plants or animals may be expected to sustain a far higher degree of heat or cold with impunity, than in their subsequent and more perfect state, yet it cannot appear more extraordinary that in such perfect state they should be able to resist a heat of 210° or 212°, than that in the state of seeds or eggs they should be able to exist in, and to derive benefit from, a heat three or four times as excessive.

In the vegetable world we meet with other peculiarities quite as singular, and which gives them an approach to the mineral kingdom: we have already observed that some of them, and especially among the algæ and the mosses, are nearly or altogether incombustible, as the byssus *asbestos*, which, on being thrown into the fire, instead of burning, is converted into glass; and the fontinalis *antipyretica*, a plant indigenous to the Highlands, but more frequent in Scandinavia, where from its difficulty of combustion it is used by the poor as a lining for their chimneys, to prevent them from catching fire.

Animals are often contemplated under the three divisions of terrestrial, aquatic, and aërial. Plants may be contemplated in the same manner. Among animals it is probable that the largest number consists of the first division; yet from the great variety of submarine genera that are known, and from nearly an equal variety, perhaps, that are not known, this is uncertain. Among vegetables, however, it is highly probable that the largest number belongs to the submarine section, if we may judge from the almost countless species of fuci and other equally prolific tribes of an aqueous and subaqueous origin, and the incalculable individuals that appertain to each species; and more especially if we take into consideration the greater equality of temperature which must necessarily exist in the submarine hills and valleys.

Many animals are amphibious, or capable of preserving life in either element; the vegetable world is not without instances of a similar power. The algæ, and especially in the ulva and fucus tribes, offer us a multitude of examples. The juncus, or rush, in many of its species, is an amphibious plant; so, too, is the oryza or rice-plant. In other words, all these will

* Hist. de l'Acad. Royale des Sciences, 1764, p. 186, h. 16.
† Travels, part II. Greece, Egypt, and the Holy Land, p. 111, 4to. ed.
‡ He graduates by Reaumur's thermometer, and calculates the heat upon this at 69°.
§ Recueil d'Observations de Zoologie et d'Anatomie comparée.

flourish entirely covered with water, or with their roots alone shooting into a moist soil.

Animals of various kinds are aërial: perhaps the term is not used with strict correctness. It will, at least, apply with more correctness to plants. All the most succulent plants of hot climates are of this description: such are several of the palms and of the canes; and the greater number of plants that embellish the arid Karro fields of the Cape of Good Hope.* Succulent as they are, these will only grow in soils or sands so sere and adust that no moisture can be extracted from them, and are even destroyed by a full supply of wet or by a rainy season. The Solandra *grandiflora*, a Jamaica shrub, was long propagated in our own stoves by cuttings, which, though freely watered, could never be made to produce any signs of fructification, notwithstanding that the cuttings grew several feet in length every season. By accident a pot with young cuttings was mislaid and forgotten in the Kew garden, and had no water given it; it was hereby reduced to its healthy aridity, and every extremity produced a flower.†

And hence it is an opinion common to many of the ablest physiologists of the present day, that these derive the whole of their nutriment from the surrounding atmosphere; and that the only advantage which they acquire from thrusting their roots into such strata is that of obtaining an erect position. There are some quadrupeds that appear to derive nutriment in the same manner. Thus the bradypus *tridactylus*, or sloth, never drinks, imbibes by its cutaneous absorbents, and trembles at the feeling of rain; and, in common with the bird tribes, has only one ultimate or excrementary duct; while the olive cavy‡ avoids water of every kind almost as pertinaciously as does also the ostrich, which is in consequence said by the Arabs never to drink. And yet these are animals almost as succulent as any we are acquainted with.

But, however true this may be with regard to animals, we have manifest proofs that vegetables of certain tribes and descriptions are altogether supported by the atmosphere that surrounds them; for, important as is the organ of a root to plants in general, there are several which have no root whatever, and can derive nutriment in no other way. The water-caltrop§ is an instance directly in point. The seed of this plant has no rostel, and consequently can never, in the first instance, become rooted. From the horned nut or pericarp of the seed, as it lies in water, which is its natural element, shoots forth a long plumule perpendicularly towards the surface of the stream; during the ascent of which a variety of capillary branched leaves shoot forth from the sides of the plumule, some of which bend downward, and fix the whole plant to the bottom by penetrating into the soil below the stream; the leaves alone in this late stage of germination acting the part of a root, and giving maturity to the still unfinished plant. The cactus genus, in some of its very numerous species, offers us an example of similar evolution; and especially in the opuntia tribe, or that which embraces the prickly pears or Indian figs of our green-houses, of which the cochineal plant‖ is one form. Of these, several grow by the mere introduction of one of their thick fleshy leaves into a soil of almost any kind that is sufficiently dry; they obtain an erect position, but never root, or shoot forth radicles: and hence almost the whole of their moisture must necessarily be derived from the surrounding atmosphere.

Perhaps one-half of the fuci have no root whatever: many of them, indeed, consist of vesicles or vesicular bulbs alone, sessile upon the matrix of some stone or shell that supports them, and propagate their kinds by offsets, without any other vegetable organs. The seeds of the fucus *prolifer* sometimes evolve nothing but a leaf; the plant being propagated also by leaf upon leaf, either forked or elliptic, without root.

The aphyteia *hydnora* is a curious instance in point. This plant is equally destitute of leaves, stem, and root; and consists alone of a sessile, coriaceous,

* The only rain that waters this tract is that which falls for a few weeks in the winter: during the hot and fertile months there is no rain whatever. † Smith's Introduction to Botany, &c. p. 141.
‡ Cavia *acuschy*. This is the more extraordinary, because the *C. cobaya*, or guinea-pig, drinks freely, and the *C. capybara*, or river cavy, is fond of swimming and diving.
§ Trapa *natans*. ‖ Cactus *coccinellifer*.

and succulent flower, eaten as a luxury by the Hottentots, and parasitic to the roots of the euphorbia *mauritanica*; flower propagating flower from generation to generation.

But perhaps the plant most decisive upon this subject is the aërial *epidendrum*,* first, if I mistake not, described by that excellent Portuguese phytologist Loureiro, and denominated *aërial* from its very extraordinary properties. This is a native of Java and the East Indies beyond the Ganges; and, in the latter region, it is no uncommon thing for the inhabitants to pluck it up, on account of the elegance of its leaves, the beauty of its flower, and the exquisite odour it diffuses, and to suspend it by a silken cord from the ceilings of their rooms; where, from year to year, it continues to put forth new leaves, new blossoms, and new fragrance, excited alone to new life and action by the stimulus of the surrounding atmosphere.

That stimulus is oxygen; ammonia is a good stimulus, but oxygen possesses far superior powers, and hence without some portion of oxygen few plants can ever be made to germinate. Hence, too, the use of cow-dung and other animal recrements, which consist of muriatic acid and ammonia: while in fat, oil, and other fluids, that contain little or no oxygen, and consist altogether, or nearly so, of hydrogen and carbon, seeds may be confined for ages without exhibiting any germination whatever. And hence, again, and the fact deserves to be extensively known, however torpid a seed may be, and destitute of all power to vegetate in any other substance, if steeped in a diluted solution of oxygenated muriatic acid, at a temperature of about 46° or 48° of Fahrenheit, provided it still possess its principle of vitality, it will germinate in a few hours. And if, after this, it be planted, as it ought to be, in its appropriate soil, it will grow with as much speed and vigour as if it had evinced no torpitude whatever.

I have said that few plants can be made to germinate when the oxygen is small in quantity, and the hydrogen abundant: and I have made the limitation, because aquatic plants, and such as grow in marshes, and other moist places, are remarkable, not only for parting with a large quantity of oxygen gas, but also for absorbing hydrogen gas freely; and are hence peculiarly calculated for purifying the regions in which they flourish, and in some sort for correcting the mischief that flows from the decomposition of the dead vegetable and animal materials that is perpetually taking place in such situations, and loading the atmosphere with febrile and other miasms.

But the instances of resemblance between animal and vegetable physiology are innumerable. Some plants, like a few of our birds, more of our insects, and almost all our forest beasts, appear to sleep through the day, and to awake and become active at night: while the greater number, like the greater number of animals, resign themselves to sleep at sunset, and awake reinvigorated with the dawn. Like animals, they all feel the living power excited by small degrees of electricity, but destroyed by severe shocks; and like animals, too, they differ in a very extraordinary degree in the duration of many of their species. Some tribes of boletus unfold themselves in a few hours, like the ephemera and hemerobius tribes (May-fly and Spring-fly), and as speedily decay. Several of the fungi live only a few days; others weeks or months. Annual plants, like the greater part of our insects, live three, four, or even eight months. Biennial plants, like the longer-lived insects, and most of our shell-fishes, continue alive sixteen, eighteen, or even twenty-four months. Many of the herbaceous plants continue only a few years, but more for a longer period, and imitate all the variety to be met with in the greater number of birds, quadrupeds, and fishes; while shrubs and trees are, for the most part, coequal with the age of man, and a few of them equal that allotted to him in the earliest periods of the world. Of these last, the Adansonia *digitata*, or calabash tree, is perhaps one of the most extraordinary. Indigenous to the land of the patriarchs, and still outrivalling the patriarchal age, this stupendous tree, compared with which our own giant oak, in bulk as well

* Epidendrum *flos aeris*.

as in years, is but an infant, seems to require not less than a thousand years to give it full vigour and maturity. Extending its enormous arms over the dry and barren soil from which it shoots naturally, it affords shelter to whole nations of barbarians, and in its pleasant subacid fruit administers an ample supply to their hunger.

Let it not, however, be imagined that, by pointing out such frequent instances of resemblance between animal and vegetable life, I mean to degrade the rank of animal being from its proper level; for it will be one of the chief objects of our subsequent studies to develope and delineate its multiform and characteristic superiorities. I am only tracing at present the common principle of vitality to its first outlines: I am endeavouring to unfold to you, in its simplest and rudest operations, that grand, and wonderful, and comprehensive system, which, though under different modifications, unquestionably controlling both plants and animals, from the first moment it begins to act infuses energy into the lifeless clod, draws forth form and beauty, and individual being, from unshapen matter, and stamps with organization and propensities the common dust we tread upon. And if, in this its lowest scale of operation,—if, under the influence of these its simplest laws, and the mere powers (so far as we are able to trace them) of contractility and irritability, it be capable of producing effects thus striking, thus incomprehensible, what may we not expect when the outline is filled up and the system rendered complete? What may we not expect when we behold, superadded to the powers of contractility and irritability, those of sensation and voluntary motion? What, more especially, when to these are still farther added the ennobling faculties of a rational and intelligent soul,—the nice organs of articulation and speech,—the eloquence of language,—the means of interchanging ideas, and of imbodying, if I may so express myself, all the phenomena of the mind?

Such are the important subjects to which our subsequent studies are to be directed. In the mean time, from the remarks which have already been hazarded, we cannot, I think, but be struck with the two following sublime characters, which pre-eminently, indeed, distinguish all the works of nature:—a grand comprehensiveness of scheme, a simple but beautiful circle of action, by which every system is made to contribute to the well-being of every system, every part to the harmony and happiness of the whole; and a nice, and delicate, and ever-rising gradation from shapeless matter to form, from form to feeling, from feeling to intellect, from the clod to the crystal, from the crystal to the plant, from the plant to the animal, from brutal life to man. Here, placed on the summit of this stupendous pyramid, lord of all around him, the only being through the whole range of the visible creation endowed with a power of contemplating and appreciating the magnificent scenery by which he is encompassed, and of adoring its Almighty Architect—at once the head, the heart, and the tongue of the whole—well, indeed, may he exult and rejoice! But let him rejoice with modesty. For, in the midst of this proud exaltation, it is possible that he forms but one of the lowest links in "the golden everlasting chain" of intelligence; that he stands on the mere threshold of the world of perception; and that there exists at least as wide a disproportion between the sublimest characters that ever were born of women, our Bacons, Newtons, and Lockes, our Aristotles, Des Cartes, and Eulers, and the humblest ranks of a loftier world, as there is between these highly-gifted mortals and the most unknowing of the animal creation. Yet MIND, thanks to its benificent Bestower! is itself immortal, and knowledge is eternally progressive; and hence man, too, if he improve the talents intrusted to him, as it is his duty to do, may yet hope, unblamed, to ascend hereafter as high above the present sphere of these celestial intelligences, as they are at present placed above the sphere of man. But these are speculations in some degree too sublime for us: the moment we launch into them, that moment we become lost, and find it necessary to return with suitable modesty to our proper province,—an examination of the world around us; where, with all the aids of which we can avail ourselves, we shall still find difficulties enough to try the wisdom of the wisest, and the patience of the most persevering.