islands; a special application made for skulls from St. Giles's, and the Liberties of Dublin; skulls of extinct tribes earnestly sought; and his Lordship expected to supply a consignment of 200 or 300 skulls, besides their flint and other implements, tobacco pipes, pottery, and so forth, ancient and modern. What would be the commotion here, and what the comments in our newspapers! and yet such a request has been made by the zealous Secretary of the Smithsonian Institute to the Government of the United States of Colombia, and he is likely to prefer the same hint here, now that the *Alabama* claims are in happy way of settlement. The Colombian Government has taken the matter coolly, and published the application in the *Gaceta Oficial*, calling to it the attention of the local authorities. How the local authorities will persuade the local Indians to hand over the solicited pair of recent male and female skulls, appears rather doubtful and dangerous, as will be the polite request of the resident magistrate, or other authority, to the tribes of Achill Island or Connemara. Some of the Indian tribes in Colombia are much more likely to place the skulls of the Government or their emissaries in their own local museums.

It is stated from India that a number of experiments have shown that the madar plant, when mixed with opium, is an excellent substitute for ipecacuanha in dysentery.

The Kava or Ava is well known as a favourite intoxicating drink of the South Sea Islanders. The extraordinary and disgusting mode of preparing this beverage, by chewing the root, ejecting the saliva into a bowl and fermenting it, has been the means of giving it a greater amount of publicity than it would have otherwise obtained. Many stories have been told about its uses and effects. It appears that at one time before the intercourse with foreigners the only intoxicating drink known to the natives was the water in which the roots of the kava plant (*Macropiper methysticum*) had been macerated, and this was comparatively little used, except as a medicine, as it was supposed to prevent corpulence. Since the introduction of foreign spirits into the islands the use of kava has much diminished, though intoxication is none the less common, and with many of the natives kava is still much appreciated, and even many of the lower classes of white people are confirmed kava-drinkers. It is said that, if drunk in excessive quantities, it produces numerous cutaneous diseases, but if taken in moderation has no ill effect upon the system. A drink, prepared in a similar filthy manner, is the South American Piwarri, which is produced by first chewing a sufficient quantity of cakes made of cassava meal (*Manihot utilissima*), and then putting the masticated material into a bowl with water, where it is left to ferment for some days, and finally boiled.

So much has been said about the adulteration of butter and the frequent substitute of a compound for that useful article, in which no trace of true butter exists, that the introduction of Australian butter into this country is a matter not only of commercial importance, but must also give general satisfaction to all classes. The butter is of good quality, and arrives after its lengthened voyage in good condition. It is produced in different parts of the Australian colony, so that we may hope to receive large and continuous supplies. It is a fact worth noting that whereas at one time large supplies of butter were exported from Cork into the colonies, one of these same colonies is now sending its produce to us.

The cultivation of the beet in England for the manufacture of sugar seems in a fair way of at last becoming a *fait accompli*. Besides the works already in operation at Lavenham in Suffolk, Buscote in Berkshire, and other places, a new beetroot sugar company has just been formed under good prospects at Sandwich in Kent.

PROF. WYVILLE THOMSON'S INTRODUCTORY LECTURE AT EDINBURGH UNIVERSITY

(*Continued from page 76*)

THE distinction between inorganic bodies and organised beings instinct with life seems clear enough. Between the animal and the vegetable kingdoms it is impossible to draw a definite line. It is to solve this difficulty that Ernst Haeckel has proposed his fourth kingdom, and we have now to consider whether or not the solution is satisfactory or legitimate.

Plants have the power of secreting and storing in organs which are specially fitted for its reception, usually the leaves, a substance called "chlorophyll," by means of which, acting probably as a ferment or in some way which is not yet thoroughly understood, the plant can, under the influence of light, absorb carbonic acid from the atmosphere, decompose it, and, while the carbon is in the nascent condition, combine it with the elements of water, or with the elements of water and of ammonia, reduced likewise to the nascent state by the same agency. The plant thus gains from the inorganic world, from the water contained in the soil and the inorganic substances dissolved in it, and from the atmosphere, various elementary substances, chiefly, however, oxygen, hydrogen, carbon, and nitrogen, and these it recombines into ternary, quaternary, and still more complex organic compounds.

The operations which take place within the chlorophyll cell of the plant are briefly these:—

1. Water, H_2O, which has been absorbed by the root of the plant from the soil, and pumped up by endosmosis or capillary attraction to the leaf, is decomposed, and its elements are reduced to the nascent condition.

2. Carbonic acid, CO_2, which exists as a gas in the atmosphere to the amount of about 1 vol. to 2,500 of air, and which is consequently in contact with the surface of the leaves, is absorbed, and its elements are reduced to the nascent state.

3. Ammonia, NH_3, an abundant product of the decomposition of organised bodies, which exists in small quantities in the water of the soil, and much more abundantly as a gas in the atmosphere (in the proportion of about 1 vol. to 1,000,000 of air), is decomposed, and its elements are reduced to the nascent state.

4. The nascent carbon of the carbonic acid is combined with the elements of water in varying proportions, and by the re-combination of the elements of these binary compounds, ternary compounds; for example, cellulose, starch, dextrine, and gum, which have all apparently the same composition, $C_6H_{10}O_5$, or some multiple of these proportions; sucrose or cane sugar $C_{12}H_{22}O_{11}$; dextrose and levulose, grape and fruit sugar, $C_6H_{12}O_6$; the glucosides, such as tannine, $C_{27}H_{22}O_{17}$; the fixed and essential oils, some of which latter, however, as turpentine and its isomers, are binary, $C_{10}H_{16}$; and many like substances, are produced.

5. The nascent nitrogen of the ammonia, sulphur, which is probably derived from a trace of sulphuretted hydrogen in the atmosphere; phosphorus, derived from the decomposition of certain minerals contained in the soil or of vegetable or animal matter, are united to form quarternary, quinary, and more complex compounds, such as vegetable albumen, fibrin, casein, and protoplasm.

	Albumen.	Casein.	Fibrin.
Carbon	53·5	53·8	52·7
Hydrogen	7·0	7·2	6·9
Nitrogen	15·5	15·6	15·4
Oxygen	22·0	22·5	23·5
Sulphur	1·6	0·9	1·2
Phosphorus	0·4	0·0	0·3

and the vegetable alkaloids, for example, nicotine $C_{10}H_{14}N_2$, morphine $C_{17}H_{19}NO_3 + H_2O$, and narcotine $C_{22}H_{23}NO_7$. Under the guidance of the vital property, and through the medium of a peculiar substance called protoplasm, whose exact composition it is difficult to determine, but which seems to be closely related to albumen, which is constantly present where vital actions are going on, and in which alone apparently the peculiar property called life resides, these different substances are adjusted as to their related proportions, and selected and applied each to its destined object in the plant economy, to enlarge the cell or to strengthen the cell-wall, to lay the foundation of a new cell, to be stored up in a special reservoir for future use, to contribute, in short, to the development or maintenance of the special specific form of the organism of which it forms a part.

A plant cannot assimilate pure carbon, or hydrogen, or nitrogen; it seems that it can assimilate no elementary substance except oxygen, unless it be presented to it in the nascent condition. An animal stands in precisely the same relation to the binary compounds, carbonic acid, water, and ammonia. However abundantly, therefore, it might be supplied with these binary compounds which actually contain all the elements necessary for its sustenance, it would surely die of inanition. In order to be capable of affording nourishment to the animal kingdom, these substances must be elaborated to the condition of ternary and quaternary compounds, and this can only be done in the cells of plants. This, then, is the broad and practical distinction between the vegetable and the animal kingdoms. Plants have the power of absorbing, modifying, and organising inorganic substances, while animals are entirely dependent upon the organic substances thus prepared for their support. Taken in this sense, the distinction between the two kingdoms is most marked, and of the highest practical value; but when we set aside this one peculiar property, which is possessed only by some plants, and only by certain parts of those plants at certain periods of their life, and especially when we observe certain minute forms, of low organisation, on the verge of either kingdom, it becomes absolutely impossible to assign any definite distinctive character. The character which is, perhaps, most palpable and universal, is that a mass of vegetable protoplasm is at some time during its existence, inclosed in a cell-wall, which is composed of cellulose, or some very nearly allied ternary compound. Animal protoplasm is rarely, if ever, confined in this way; that is to say, in nucleated cells, with cellulose walls, which are found in all plants, and are not found in the animal kingdom.

The protoplasm of the cells of plants has the power, without developing colour and without the aid of light, of absorbing, decomposing, and assimilating the elements of already prepared organic ternary and quaternary products, whether they be derived from the soil or surface to which the plant is attached, as in the case of fungi; or from sap already elaborated by another part of the same plant, as in the growing root; or even of another plant, as in pale parasites. Most growing points in plants are pale, and the protoplasm in the cells of a pale shoot, or of a colourless plant, has precisely the same vital powers and relations as animal protoplasm. It is only in cells in which protoplasm elaborates and incorporates with itself endochrome, which seems to be a more powerful catalytic agent, capable of disengaging the component atoms of the more stable binary compounds when loosened by the vibrations of light, that the special function of the vegetable cell is performed. The cells of a pale growing point develop the characteristic cellulose wall, but the supply of material is abundant, for the protoplasm of these cells is either confluent, through the porous cell-walls, with the protoplasm of chlorophyll cells, or, as in the seed, it is in connection with a *cache* of preserved food, prepared and stored up by the protoplasm and endochrome of previous leaves.

The difference between the great mass of plants, as represented by their familiar and higher groups, and the higher animals, is very palpable; it is only among the comparatively obscure forms near the limits of either kingdom that a difficulty occurs. The general chemical composition of plants differs markedly from that of animals. A plant consists mainly of ternary compounds, cellulose, dextrine, starch, &c. In an animal, ternary compounds, although some of them—such as oils and fats—are of great importance in its economy, play altogether a subordinate part, and the bulk of the body is made up of substances of the albumen series—albumen, fibrin, and gelatin. Until lately this chemical distinction was regarded as absolute, and still it holds good generally, though glycogen and glucose (animal starch and sugar), and now recognised as being universally present in the tissues of the higher animals whether in health or in disease. A colouring matter apparently undistinguishable from chlorophyll is found in the green bodies of Hydra and Stentor, though there is as yet no evidence that this animal endochrome possesses the power of decomposing carbonic acid; and cellulose, perhaps the most special of the vegetable products, is found in the testa of ascidians. Endochrome is absent in many fungi.

The intimate structure of plants is usually very different from that of animals. Plants and all their parts consist of but one histological element, the cell with a cellulose wall, and its very simple modifications; the texture of plants is therefore to a great degree homogeneous. Animals, on the contrary, consist of many tissues highly differentiated, among which the nucleated vesicle with a definite wall, and tissues simply derived from it, are comparatively rare. The structure test fails also, however, on the borderland, for the most simple animals, such as Amœba and Gromia, are mere minute masses of jelly-like sarcode, which show no structure and no differentiation of tissues, and seem to differ only from the unicellular fungi and algæ in the absence of the cellular wall, while the free amœbiform cell-contents of the myxomycetous fungi are perfectly undistinguishable from such animals without a knowledge of their history.

The general plan of the organs of nutrition is strongly contrasted in the two kingdoms. One of the higher plants absorbs its peculiar food and assimilates it by means of an enormously extended external surface of roots and leaves. An animal, on the other hand, receives its prepared nourishment into the interior of its body by a mouth, and then subjects it to complicated processes of digestion and assimilation in contact with an extended internal absorbing and secreting surface, of which special portions are organised for the performance of the several steps in the process, till at length the unassimilable residue is rejected; but as we descend in the animal series, the digestive cavity becomes more and more simple, and in certain undoubted animal forms, such as the cestoid worms, the gregarinæ, and the foraminifera, it is entirely wanting, and nutrition is effected by absorption through the external surface as in plants.

No special character can be derived from the function of reproduction. Most plants, and many of the lower animals, are multiplied by gemmation and fission, and probably all animals and plants are propagated under certain circumstances by a nearly uniform process of sexual generation. The reproductive elements are produced internally in the higher animals and externally in plants; but even this minor distinction fails very early, for in large groups of the simpler animals ovaries and testes are external.

It is true in the general sense that animals possess organs and functions of relation which are absent in plants. Most plants remain permanently rooted to the ground, and neither the whole plant nor any visible part of it exhibits any spontaneous movements, either voluntary or automatic. It never performs any independent or consequent acts, from which one would deduce the existence of consciousness, intelligence, or will; still, there are certain phenomena even among the higher plants, connected with the habits of climbing plants and with the functions of fertilisation, which it is very difficult to explain without admitting some low form of a general harmonising and regulating function comparable to such an obscure manifestation of reflex nervous action as we have in sponges and in other animals in which a distinct nervous system is absent. The protoplasm in the interior of the vegetable exhibits movements so characteristic and special as almost to be sufficient, were other evidence wanting, to prove its absolute identity with the sarcode of the rhizopods; and when we reach the confines of the two kingdoms, the test of locomotion fails like the others, for the branched and plant-like sponge remains permanently rooted to the ground, while the freed cell-contents of many of the lower plants move actively, either by contractility of the sarcode substances, as in the plasmodia of the myxomycetous fungi, or by circlets or bunches of cilia, as in the zoospores of *Volvox*, *Euglena*, and *Chætophora*.

If we take a water-reed from a pond in summer, and carefully scrape off the slimy matter adhering to it upon a slip of glass and place it under a microscope, we may probably see in the field some minute oval bodies like the small seeds of a plant. These are the bodies of an animal belonging to the genus Gromia, a genus of the Rhizopoda, grouped among Haeckel's Protista, but usually regarded as true animals. If we break up one of them under the microscope, we find it to consist of a little mass of apparently perfectly structureless viscid semi-fluid jelly inclosed in a thin membranous oval shell, with a large opening at one end. This gelatinous mass is under the highest powers destitute of anything which can be called structure. A transparent colourless matrix contains extremely small globules and fine granules scattered through it, and here and there are rounded spaces, which seem to contain a homogeneous liquid. If instead of breaking up the animal we allow it to remain quiet in the water, probably in a few minutes we see a set of very delicate threads protruded from the opening in the test. These threads increase in length, and spread like a branching root in the water. When we examine these closely, we find that they are continuous with the jelly of the animal, that they are, in fact, mere processes of that jelly. When two of the threads touch they flow together, and coalesce, as two streams of treacle might do, showing that they are bounded by no membranous wall; and, when one of the threads comes in contact with an organic particle in the water, the particle sinks into it, and then the thread begins to flow back again into the body of the animal bearing the particle with it, as a stream of treacle might entangle, and carry along a crumb of bread.

The organic particles are introduced into the body, into any part of it, and there they are dissolved and assimilated. I believe that the granules observed in the gelatinous substance are particles of the various products of this assimilation, and that the living matter is perfectly homogeneous and transparent. If the creatures be kept for a few days in water nearly pure, they become less and less granular.

If the thread-like pseudo-podia, as they are called, be rudely touched, they at once contract, and flow rapidly back into their test. The membranous test cannot be truly regarded as a part of the animal, it is a mere excreted defensive covering incapable of any further change, or of manifesting any of the phenomena of life. The body of the animal can be easily squeezed out of it entire, and in that case it shortly begins the excretion of a new shield.

Here, then, we have a homogeneous substance which has the power of inducing and controlling chemical and physical forces, and of moulding into indefinite form the products of the regulated changes taking place within it, which therefore possesses life. The gelatinous matter which in this animal and in the whole sub-kingdom to which it belongs can thus feed and digest without a mouth or stomach, contract without muscles, display irritability without a nervous system—in fact, exhibit all the essential phenomena of living beings without a trace of organisation, is Protoplasm.

If now, laying aside the Gromia, we examine with the microscope the water-plant on which we found it, we find that the whole plant from end to end and in all its parts is honeycombed, that is to say, composed of a congeries of minute chambers separated from one another by well-defined walls, the walls giving the plant its support and consistency.

We place in the field of the microscope a small portion of the growing point of a leaf or stem, and we easily make out that the chambers are minute vesicles each complete in itself, adhering according to a definite arrangement to one another. As these cells have occupied a very prominent position in modern histological and physiological speculation, having been regarded, and being still regarded by many as the units of organisation, the centres and sources of all vital activity, I should wish to sketch distinctly their structure and properties. It is of no consequence whence the cell is selected. All vegetable cells appear to have the same structure at first, during their growth and while their vitality lasts; subsequently most of them undergo great changes, their walls being thicker and their cavities clogged with various secretions. There are some beautiful transparent-beaded hairs at the bottom of the flower cup of the white variety of the Virginian spider-wort. If we place one of these hairs in a drop of water in the field of the microscope, we find that it is simply composed of a row of oval cells attached end to end. The cell is in this case a minute vesicle with an extremely thin transparent wall. This wall consists of cellulose, a substance composed of thirty-six parts of carbon and thirty parts of water. The membrane is perfectly structureless under the highest powers of the microscope, and apparently continuous. It must, however, be minutely perforated, for water and various secretions and excretions pass through it freely. From its composition and structure it is impossible to imagine that vital force should reside in the vegetable cell-wall. We must regard it as an excretion of dead matter moulded as a boundary wall to the cell cavity by some external agent, but incapable of originating any vital action. The cell is full of water or mucous solution, and watching carefully with a proper arrangement of the light, and a moderately high power, we can distinctly trace threads of dense gelatinous matter moving slowly into the inner surface of the cell-wall. These streams commence wider in the region of a nucleus, which was at one time regarded as the heart of the cell, as it were, the centre of its vital activity, and gradually branch and diminish at a distance from it. Under the microscope granules appear in these streams, and with these granules embedded in them, as crumbs are embedded in a stream of treacle, the currents flow round and round the cell, the granules gradually disappearing and being absorbed. The observations of Prof. Max Schultze and of others have, I think, placed it beyond a doubt that this gelatinous substance occurring within the living cell, and forming, at all events, a large proportion of the cell-contents, is identical with the protoplasm which forms the entire substance of such an animal form as *Gromia*.

The necklace-like hair of the spider-wort is, in fact, a chain of cells with dead cellulose walls, and each with a living Gromia body imprisoned within it.

Now, although the power which plants possess of fixing carbon and combining it with the elements of water, is the character which practically distinguishes the Vegetable from the Animal kingdom, I have already shown that we cannot regard this as by any means a universal test. In this respect broomrapes and dodders are animals.

When we pass down by any path we choose, either through animals or plants, we come equally to a great series of very simple forms—mere little masses of protoplasm with a nucleus. Some of these contain peculiarly formed masses of bright colouring matter, green, scarlet, or yellow, and with the possession of such pigment we usually associate the power of decomposing carbonic acid. Many of these bodies have, however, no colouring matter at all, except what is derived from their food. A large number of these simple forms are enclosed in a wall of cellulose, but very many of them are naked or merely covered with a pellicle of firmer protoplasm; while some, such as the plasmodia of the myxogastric fungi are, for some part of their lives, enclosed in a cellulose wall, and for another part, naked. Going still lower, we have Haeckel's Monera, differing from the others merely in the absence of a nucleus and the total want of differentiation of any part. Even these last are sometimes coloured, and from their chemical reactions it seems very likely that they possess some low form of the peculiar vegetable power. Now, the question is, whether all these considerations lead in any way in the direction of establishing a separate kingdom for these simple beings. I think decidedly not, but it seems to me that they prove almost to demonstration that organic nature must be taken as one whole, that the Animal and Vegetable kingdoms are absolutely continuous, and that a tree flinging its green flags into the sunshine and feeding on the winds of heaven, is essentially nothing more than a vast colony of a protozoon, comparable to a gigantic nummulite, only building a cellulose instead of a calcareous shell, and developing a special secretion in special organs for the purpose of enabling it to do so.

MR. BENTHAM'S ANNIVERSARY ADDRESS TO THE LINNEAN SOCIETY

HAVING now for the tenth time the honour of addressing you from this chair on the occasion of your annual gathering, it has been my wish to lay before you a general sketch of the progress making in systematic Biology, the foundation upon which must rest the theoretical and speculative, as well as the practical, branches of the science, to report upon the efforts made further to investigate, establish, and extend that foundation, and to convert the numerous quicksands with which it is beset into solid rock. This subject formed the chief portion of my address of 1862, and again of those of 1866 and 1868; but on the present occasion I have had some difficulties to contend with. Mr. Dallas, to whose kindness I owed the zoological notes I required, has now duties which fully absorb his time, and I have been obliged to apply to foreign correspondents, as well as to my zoological friends at home, for the necessary information. They have one and all responded to my call with a readiness for which I cannot too heartily express my thanks; and if there is some diversity in the extent and nature of the information I have received from different countries, which may prevent any very correct estimate of the comparative progress made in them, it is owing to the questions which I put having been stated too generally, and, though sent in the same words to my different correspondents, they have been differently understood by them. In such a review, however, as I am able to prepare, I propose chiefly to consider the relative progress made by zoologists and botanists in the methods pursued and the results obtained, in the first place as to general works common to all countries, and secondly as to those which are more particularly worked out in or more specially relate to each of the principal states or nations where biological science is pursued, prefacing this review by a few general remarks supplementary to those I laid before you in my first address in 1862.

Since that time systematic biology has to a certain degree been cast into the background by the great impulse given to the more speculative branches of the science by the promulgation of the