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## PART FIRST.

## Analytical and Critical Reviews.

### Review I.

1. *Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals.* Delivered at the Royal College of Surgeons. By Richard Owen, F.R.S., Hunterian Professor to the College. Second Edition. Illustrated by numerous Woodcuts.—*London*, 1855. 8vo. pp. 689.
2. *General Outline of the Organization of the Animal Kingdom, and Manual of Comparative Anatomy.* By Thomas Rymer Jones, F.R.S., Professor of Comparative Anatomy in King's College, London, &c. Second Edition. Illustrated by Four Hundred Engravings.—*London*, 1855. 8vo. pp. 842.

It is a somewhat singular coincidence, that the only two British Treatises on Comparative Anatomy which can be pointed-to as in any degree representing the present state of that science, and which made their first appearance almost contemporaneously, should have reached a second edition at the same time. The 'Lectures' of Professor Owen originally appeared as the notes of Mr. White Cooper, revised by the Professor himself; and were published in numbers as they were delivered, the completed volume bearing the date 1843. The 'General Outline' of Professor Rymer Jones also originally appeared in numbers, and the complete volume bears date 1841. Having published in the interval the first volume of his 'Comparative Anatomy of the Vertebrata'—the 'Anatomy of Fishes,'—and intending, as we trust, to complete that great work in a manner worthy of his unrivalled knowledge of Vertebrated Animals, Professor Owen has thought it desirable to re-issue his 'Lectures on the Invertebrata' in an enlarged form; adding a considerable quantity of new matter, and inserting numerous references to the original authorities for the facts and opinions advanced; and taking, of course, the entire responsibility upon him-

self. We are led to suppose that the author considers himself, in these additions, to have brought his work up to the existing state of knowledge on this subject; and he advances no reason why it should not be fairly tried by the standard which he has himself raised.—Professor Rymer Jones, on his part, after referring to some of the most important advances which have been made by Continental and British labourers in this field since the publication of his previous edition, tells us that he "has endeavoured, to the best of his ability, to keep pace with their diligence and onward progress, so as adequately to record and acknowledge their contributions to the general stock of scientific lore."

It will be our duty, and, we are sorry to say, our by no means pleasing duty, to inquire how far the additions and alterations made in these Treatises can be considered as placing them upon the level of our existing knowledge of the subject of which they treat. In doing this, however, we must limit ourselves to one particular department,—the group of animals constituting the Radiata of Cuvier;—since it will be necessary for us, in order to show our readers what are our grounds of complaint, to enter into some preliminary detail as to the present aspect of the borderground between the Animal and Vegetable kingdoms, which will not, we hope, be unacceptable to them. It is, of course, to the first of the works before us that we shall more particularly address ourselves. Professor Owen occupies a position second to none in that department of Comparative Anatomy which he has made more particularly his own—viz., the Osteology of the Vertebrata; and considering the vast advances which the Comparative Anatomy and Physiology of the Invertebrata have made of late years, and the large number of labourers whose contributions must be individually studied in order to embody them in any general system, we opened the work with a misgiving that his acquaintance with these would be found to be far from complete, and that many old errors would be retained, many new truths passed by. It is quite enough, indeed, for one man's work, to keep pace with the rapid progress of any single department of this science; and Siebold, one of the most laborious and conscientious of continental systematic writers, as well as himself one of the most accurate and zealous of original inquirers, exercised a wise discretion in restricting himself, in the production of his admirable 'Vergleichende Anatomie,' 1848,* to the Invertebrated classes; the anatomy of the Vertebrata being undertaken by his colleague Stannius. It would be well if men of great ambition and comprehensive grasp of mind would act more upon the time-honoured adage, "*Non omnia possumus ommes.*" The authority which they acquire by their labours in one department, gives them a *prestige* in regard to any others that they may undertake to elucidate, which becomes mischievous, when, as too often happens, they do their work imperfectly by grasping at too much. Professor Owen's authority is deservedly so high on the subjects which he has made his own, that we are most desirous for his sake that he should not lower it by striving for what it is impossible in the nature of things that he can thoroughly attain; and we feel called upon to watch with a careful eye

* An American translation of this masterly work, with numerous Notes and additional References, by the late Dr. W. J. Burnett, bringing it down to 1854, is, in our opinion, by far the best Treatise on Invertebrate Anatomy, that the English student can have recourse to.

that it be not employed to the positive detriment of science, in perpetuating error and retarding the progress of truth.

The aim of Professor Rymer Jones's treatise is less high, and his authority is of less weight; but from its popular style, the generally-good selection of its subjects, and the beauty of its illustrations, it has acquired a reputation amongst students, of which we should gladly see it rendered more worthy.

A good-natured criticism of such works, in which their excellences alone should be dilated-on, and their defects altogether passed by or scarcely noticed, would be much more agreeable to ourselves, as well as more palatable to the subjects of it. But we must speak out as the interests of truth and justice seem to us imperatively to demand, whatever be the cost to ourselves.—With these preliminary remarks, we enter upon that general survey of the lowest forms of Animal life, which will enable us to inquire how far their nature and meaning have been understood by our authors.

The association of a large assemblage of these forms under the designation *Protozoa*, as first proposed (we believe) by Siebold, has come to be very generally accepted among the Zoologists and Physiologists of Germany, although there is not yet a complete accordance as to the definition of the group, and the range of forms which it should include. The definition given by Siebold stands as follows:—"Animals in which the different systems of organs are not distinctly separated, and whose irregular form and simple organization are reducible to the type of a cell." The fundamental idea contained in this definition was more fully expanded by him in a valuable essay 'On Unicellular Plants and Animals,' published in the first volume of Siebold and Kölliker's 'Zeitschrift;' wherein he discusses the relations which his Protozoa bear to the *Protophyta* that constitute the parallel group in the Vegetable kingdom, and inquires into the validity of the characters which have been assigned as the basis of their separation. Although the correctness of many of the details contained in that essay has been disproved by subsequent research, and although the general doctrine of *cells* in vogue at the time of its production has been conclusively shown to require revision,* yet the fundamental idea still remains unshaken—viz., that there is a division of the Animal kingdom, among the members of which there is no more differentiation of organs than there is in the simplest Plants, and which in this respect correspond to the earliest embryonic states of the higher animals. Whether this division may be fairly considered to have been permanently established, or whether it must be regarded for the present as provisional only, is a question which we shall be in a better position to discuss, when we shall have examined some of the principal facts that bear upon it.

The general result of recent microscopic investigation, in regard to the lowest forms of Vegetable and Animal life, seems to us to lead to this conclusion—that organisms may possess an independent existence, may go through all the phenomena of growth, multiplication, and reproduction, and may even possess considerable power of spontaneous motion, without having advanced even so far in the differentiation of their parts as to

* See Mr. Huxley's paper in the British and Foreign Medico-Chirurgical Review, vol. xii. p. 285.

possess those attributes which are involved in the ordinary idea of a "cell." By way of explaining our meaning, we shall select an illustration from each kingdom; and the comparison of the two will enable us to inquire in what lies the essential difference between them.

One of the humblest of known Protophytes—the *Palmoglæa macrococca* (Kützing), whose multiplication gives origin to the green slime that is found on damp stones and walls,—consists of isolated particles of a spheroidal shape and greenish colour, commonly imbedded in a stratum of gelatinous matter, which an ordinary observer would at once pronounce to be vegetable cells. But a careful examination shows that there is here no definite distinction between "cell-wall" and "cell-contents;" the whole particle being composed of a nearly-homogeneous mass of "protoplasm," through which chlorophyll-granules are dispersed. In the midst of these, however, a nucleus may be sometimes discerned; and this is usually brought into clear view by the action of tincture of iodine, which turns the nucleus dark-brown. These particles, increasing in size, undergo duplicative subdivision by the usual process of elongation and constriction; and it is observable that the nucleus gives indications of the commencement of this subdivision earlier than the particle which encloses it. Each new cell (if such it may be called) then begins to secrete from its surface a gelatinous envelope of its own; so that, by its intervention, the two are usually soon separated from one another. Sometimes, however, this is not the case; the process of subdivision being so quickly repeated, that there is not time for the production of a separate gelatinous envelope to each particle; so that a series of spheroids, hanging-on one to another, is produced. There appears to be no definite limit to this kind of multiplication; and extensive areas may be quickly covered, in circumstances favourable to the nutrition of the plant, by the products of the duplicative subdivision of one primordial cell. This, however, is simply an act of *growth*, precisely analogous to the multiplication of cells in the earliest embryonic condition of the higher Plants and Animals, before any differentiation of organs begins to show itself. And as every cell thus produced is similar to every other, and may live independently of it, such plants may still be appropriately designated as "unicellular," notwithstanding that they may be composed of large aggregations of cells connected by a gelatinous matrix, instead of being mere agglomerations of cells completely isolated from each other. The Palmoglæa not only thus grows and multiplies, but it also performs what is now coming to be generally recognised as a true *generative* process; which takes place, as might be expected, on the simplest of all types. For this process consists in the *conjugation* of any pair of cells, the substance of the two undergoing a complete mutual fusion, which is not obstructed by the intervention of any limiting membrane; the communication is usually made at first by a narrow neck or bridge, and gradually extends through a large part of the contiguous boundaries, until at last the whole of each particle is involved in it. A "spore" is thus formed, which is the "primordial cell" of a new generation, and which gradually evolves itself into an aggregation resembling that out of which it arose, by a renewal of the process of duplicative subdivision. This spore is something very different, both in aspect and in composition, from the body

that would be produced by the mere coalescence of two particles; for the green granular matter disappears, its place being taken by oil-particles, which are at first small and distant, but gradually become larger and coalesce so as to form oil-drops; and the colour of the body changes, with the advance of this process, from green to a yellowish-brown. When the spore begins to vegetate, on the other hand, producing a pair of new cells by binary subdivision, a converse change occurs: for the oil-globules disappear, and green granular matter takes their place, whereby the ordinary colour of the plant is restored. This is precisely analogous to what occurs in the maturation and germination of the seed among higher plants; and the analogy is rendered yet more complete by the fact, that the spore, like the seed, is capable of remaining dormant for an unlimited period, when deprived of moisture.

Now for such a mass of protoplasm to become converted into what is ordinarily regarded as the type of the Vegetable cell, a series of changes must take place in it, involving a differentiation between the cell-wall and the cell-contents; and this involves, on the one hand, a greater consolidation of the external layer of the protoplasm, and a more complete liquefaction of its internal portion. The membrane that is first formed, which has been termed by Mohl the "primordial utricle," is identical in composition with the albuminous protoplasma, as is shown by the effects of re-agents; and it does not always seem distinctly separable from the layer of protoplasm by which it is lined. Some recent Vegetable Physiologists, indeed, question its proper existence, affirming that it is merely the superficial layer of protoplasm, more tenacious than the rest. But to us it appears that, looking to the origin and nature of this membrane, the question is simply one of *degree* of differentiation. When the external layer, call it what we may, has such a tenacity that the substance of two cells brought-together cannot coalesce without a rupture of this integument, we must call it a membrane, even though it may differ but very little from the viscid matter it surrounds.—The typical cell, if isolated, subsequently acquires a complete envelope of cellulose, secreted from the surface of the primordial utricle; but this, which is commonly known as the cell-wall in Vegetable cells, seems to have no other than a protective function; and where the cells are packed closely into a parenchyma, their cellulose-walls coalesce, like the gelatinous envelopes of the particles of Palmoglæa which are homologous with them, so that the boundaries of those proper to individual cells cannot be distinguished. Now whilst this process of consolidation is taking-place externally, a reverse change, that of liquefaction, is in progress within. This commences by the formation of *vacuoles* in the substance of the protoplasm; these, however, not being empty spaces, but cavities filled with a fluid more watery than the protoplasm. These "vacuoles" increase in number and in size, the smaller ones coalescing to form larger; and at last they come to occupy nearly the whole interior of the cell, the primordial utricle being still lined by a layer of viscid protoplasm, to which the colouring matter is usually in great degree restricted, although this is sometimes diffused through the whole cell-contents. And thus the typical Vegetable cell comes to consist of—1. The cellulose wall; 2. The primordial utricle; 3. A layer of protoplasm in contact with it; 4. The

watery cell-sap of the interior; and 5. The nucleus, usually imbedded in the protoplasm-layer;—these parts being developed, by a process of gradual "differentiation," out of a minute mass of protoplasm, in which the nucleus was the only part to be separately distinguished.

The successive stages of this formation may be best traced-out by careful observation of the process of cell-growth in the higher Algæ; but the study of the development of new organs in Phanerogamic Plants leads to the same conclusions; and the results at which Mr. Wenham* has lately arrived, from observations chiefly made on the newly-imported aquatic weed, *Anacharis alsinastrum*, are so instructive that we shall subjoin a brief summary of them. He finds that when a new leaflet is being formed from the main stem, it commences, not (as is commonly supposed) in a single cell, but in the simultaneous development of some hundred at once, which make their first appearance in the midst of a mass of protoplasm which is enclosed in a membrane that subsequently seems to become the epidermis of the leaf. This mass is at first homogeneous; but it is soon seen to contain a multitude of cavities of irregular size and shape, filled with liquid, whilst the protoplasm between these becomes more viscid. The number of these is often increased, and their size rendered more uniform, subsequently to their first formation, through the division of the larger cavities into two by the interposition of a narrow bridge of protoplasm, or into three by the interposition of a broader bridge, in the substance of which another cavity developes itself; whilst new cavities appear wherever there is any considerable accumulation of protoplasm not already hollowed-out. These cavities are next observed to be lined with a definite membrane; and within this, protoplasm, chlorophyll, and cyclosis-currents subsequently become distinguishable.

On the importance of the independent support afforded by these observations to the doctrine of Mr. Huxley already referred-to, it is quite unnecessary for us to enlarge; and we shall only remark that not only are we fully satisfied of the competence and fidelity of Mr. Wenham as an observer, but his view harmonizes with a number of facts which have fallen under our own cognizance, and which the ordinary doctrines of cell-development have not served to explain.

Turning now to the Protozoa, we find in the *Amœba* and in the *Actinophrys*, types of animal existence, which, in so far as we are yet acquainted with them, may be legitimately ranked on the same level as the Palmoglæa, although placed on the other side of the boundary line, for reasons which will presently be apparent. The body of each of these creatures is a minute mass of a substance which long since received from Dujardin the appropriate name of "sarcode," and which seems to be the equivalent of the protoplasma of the Protophyta; resembling it very closely in chemical composition and in general attributes, but being endowed in addition with a high degree of contractility. The body is not enclosed, in either of these beings, by a distinct limitary membrane, although the outer stratum of the sarcode obviously possesses more consistence than its inner part, the latter being semifluid. Vacuoles or clear spaces are seen in various parts of the sarcode-body; and in these are very commonly observable alimentary particles, introduced in the way to be presently

* Transactions of the Microscopical Society, 1856, p. 1 et seq.

described. Besides these vacuoles, a "contractile vesicle," which pulsates at tolerably-regular intervals, is always to be distinguished; sometimes in the interior of the body, sometimes near its surface, and sometimes projecting above its surface. The chief difference between Amœba and Actinophrys, which agree in the foregoing particulars, lies in the nature of the changes of form which both of them exhibit, and in the mode in which food is received through their means. In the Amœba, the contour of the whole body is continually undergoing change; for the shapeless mass puts-forth one or more finger-like prolongations, which are simply extensions of its sarcode-substance in those particular directions; and a continuation of the same action, first distending the prolongation, and then (as it were) carrying the whole body into it, causes the entire mass to change its place. After a short time, another prolongation is put forth, either in the same or in some different direction; and the body is again absorbed into this. When the creature, in the course of its progress, meets with a particle capable of affording it nutriment, its sarcode-body spreads itself over this, so as to receive it, through any part of its parietes, into some of the vacuoles in its interior; a sort of stomach being thus extemporized, within which the alimentary particle undergoes a sort of digestion, the nutrient material being extracted by the enveloping sarcode, and any indigestible part making its way to the surface, and finally escaping through any part of it with which it happens to be in proximity. The form of the Actinophrys, on the other hand, never seems to depart widely from the globular; but its sarcode usually extends itself into a great number of contractile filaments, termed *pseudopodia.* The number and length of these, however, are continually varying; and sometimes they entirely disappear, in which case the animal cannot be certainly distinguished from an Amœba, until it begins again to put them forth. It is by the agency of these filaments, that the food of the creature is obtained; for whilst the body remains at rest, the pseudopodia act the part of the tentacula of the Hydra, being so many fishing-lines which are ready to entrap any suitable particles that may come in their way; and not merely comparatively inert and lowly-organized beings, but various small animals of great activity as well as high organization, are thus laid-hold of. When any such body happens to come into contact with one of the pseudopodial filaments, this usually retains it by adhesion, and forthwith begins to retract itself; as it shortens, surrounding filaments also apply themselves to the captive particle, bending their points together so as gradually to enclose it, and then themselves shortening progressively until the prey is brought to the surface of the body. That the threads of sarcode of which the pseudopodia are composed, are not furnished (any more than the body itself) with an investing or limitary membrane, is shown by their complete coalescence or fusion with each other, when they happen to come into mutual contact. The food thus drawn to the surface of the body by the contractility of its pseudopodial extensions, is introduced into its substance by the continuance of the same kind of operation, and gradually passes from its peripheral to its central part, where its digestible portion undergoes solution, the indigestible part (such as the shell of a minute Crustacean, or the hard case of a Rotifer) finding its way out, as in the Amœba, through any part of the surface of the body.

Thus in these creatures, although they have neither digestive cavity, mouth, nor anus,—although they are to all appearance nothing else than particles of animated jelly not even confined within a definite membrane, —the prehension and ingestion of food, the extraction of its nutritive portion by a digestive process, and the rejection of what cannot be thus reduced, by an act of defecation, are performed as characteristically, and in reality as perfectly, as in the highest animals. They multiply, however, after the manner of Protophytes, by self-division; and it has been found, in the Amœba, that portions separated from the sarcode-body, either by cutting or tearing, can develope themselves into independent beings. It has been thought, too, that, as in the Protophyta, their generative function consists in an act of "conjugation;" but recent observations have shown that it is by no means unfrequent for two, three, or even more individuals to coalesce together for a time, without the formation of any product at all analogous to the vegetable spore; the compound body afterwards separating again into detached individuals, which do not, however, always present the relative sizes they had before the occurrence of this curious fusion. Hence we must confess ourselves ignorant at present of this essential part of the life-history of these Protozoa; and neither can it be predicated in what their Generative operation is likely to consist, nor have we any idea of the nature of its product. It is quite possible, from the analogy of other low forms of animal organization, that after multiplying almost indefinitely in the Amœba- or the Actinophrys-form, some entirely different form may evolve itself, with which we may be already acquainted, though without entertaining the least suspicion of its relationship to this group; by this the generative operation may be performed, and its first products may be Protozoa of the one or of the other kind respectively. Or it would also be consistent with what we see elsewhere, that this generative act should be performed in the Amœba- or the Actinophrys-condition, and that its product should be an animal of some very different organization, which in its turn reproduces the Amœba- or Actinophrys-type by an act of gemmation. We dwell upon the deficiency of our knowledge on this point, and on the possible contingencies of the solution, to show how little we yet know about these curious creatures; and thus, on the one hand, to prevent their place in the scale from being considered as definitely fixed, and, on the other, to stimulate and direct further observation.

If, now, we compare an *Amœba* or an *Actinophrys* in its quiescent state, with a *Palmoglœa*, or any equally simple Protophyte, we can scarcely assign any *structural* characters by which one could be differentiated from the other. But when we look at their *physiological* actions, how wide is the distinction. The Protophyte, like the Phanerogamic plant, obtains the materials of its nutrition from the air and water that surround it, and possesses the marvellous power of detaching oxygen, hydrogen, carbon, and nitrogen from their previous binary combinations, and of uniting them into chlorophyll, starch, albumen, and other ternary and quaternary combinations: but the Protozoon, in common with the highest members of the Animal kingdom, is (to all appearance) destitute of any such combining power; and is consequently dependent for its support upon organic substances previously elaborated by other beings; so

that it must in the end derive its sustenance, directly or indirectly from the Vegetable kingdom. Again, the Protophyte obtains its nutriment by the absorption of liquid and gaseous molecules, which penetrate its body by simple imbibition: whilst the Protozoon, though destitute of any permanent mouth, stomach, intestine, or anus, extemporizes (so to speak) all these organs for itself whenever there is occasion, ingests solid particles into the interior of its body, and there subjects them to a regular digestive process. But further, the Protophyte in its ordinary condition is motionless; and although many of the aquatic forms pass through a motile stage, this seems to have reference simply to their dispersion, and depends merely upon the rhythmical vibrations of ciliary filaments with which they are endowed in that phase of their lives: whereas the movements of the Protozoa which we have described, bear a much closer resemblance to those of the higher Animals, being executed by changes of shape in the general contractile substance of the body, and are subservient to the acquisition of food.

Thus, then, by attending to the nature of their food, the mode of its introduction, and the character of their respective movements, a line of distinction may be drawn between the Protophyte and the Protozoon, scarcely less definite than that which separates the insect from the plant whose leaves it devours, or the elephant from the tree on whose tender shoots it browses.

But although our fundamental idea of a Protozoon should be based on such examples as the preceding, yet it must be capable of extension, so as to comprehend a much wider range of forms and conditions than are displayed in the Amœba and the Actinophrys. These are, in fact, the types of a group to which the name of *Rhizopoda* was first assigned by Dujardin, and which has been proved, by recent discoveries, to have been of no mean importance in former ages of the earth's history, though now comparatively insignificant. For, as was long since asserted by Dujardin, we are not only to rank under this head the comparatively few and minute forms which inhabit fresh water, but the vast class of *Foraminifera;* whose beautifully-regular chambered shells had not unnaturally suggested the idea of their Nautiloid affinities to such as were unacquainted with the organization of their soft parts; which had been pulled-down by Ehrenberg from the rank of cuttle-fish (assigned them by D'Orbigny) to that of polypes; but which have now been finally demonstrated, by the concurrence of microscopic observations made upon the living animals, and more especially by the admirable researches of Professor Schultze,* to be true Rhizopods. They are distinguished from ordinary Rhizopods, however, by their possession of the power of forming calcareous envelopes, of which the successive segments produced by gemmation remain for the most part attached to one another, and thus give origin to shells, whose forms will vary according to the plan on which the segments increase, but are nearly always characterized by a symmetry and beauty that become most marvellous when it is remembered that they originate from minute particles of animated jelly. That the vast multiplication of the minuter forms of Foraminifera, in the seas of the Cretaceous epoch, contributed largely towards that accumulation of white mud at their

* Ueber den Organismus der Polythalamien (Foraminiferen). Leipzig, 1854.

bottom, which constitutes what we now know as Chalk, there can be no doubt whatever; although it would probably be too much to affirm (as some have done) that Chalk is entirely or even chiefly formed of their remains. But this group appears to have attained its greatest development early in the Tertiary period, to which are restricted by far the greater part of its larger forms, and in which its structural types seem the most complete and most strongly marked. The Nummulites, Orbitolites, and Orbitoides, which have now almost entirely disappeared from our ocean-waters, must then have been among the most numerous and the most widely-diffused of all forms of marine life; for a vast band of "Nummulitic limestone"—through nearly the whole of which these three types present themselves, blended in various proportions,—may be traced from the Atlantic shores of Europe and Africa, through Western Asia to Northern India, and thence to the Pacific shore of China, often 1800 miles in breadth, and frequently of from 1500 to 2000 feet in thickness; and a similar formation prevails likewise over vast areas of North America. This Nummulitic limestone does not merely *contain* Nummulites, &c., but is in general almost entirely (if not completely) made-up of them; the matrix or rock-substance in which the recognisable specimens are imbedded, being usually composed (as microscopic examination of their sections demonstrates) of the comminuted particles of similar organisms, with which smaller Foraminifera are intermingled.

Another development of the Rhizopod type seems to be presented to us in the *Polycystina;* a group of minute animals distinguished for the most part by the remarkable forms and elaborately-worked aspect of their siliceous casings. These, although occasionally met-with in the existing seas, are chiefly known to Microscopists (for whom they furnish a set of marvellously-beautiful objects) by that vast aggregation of their fossilized exuviæ, which was discovered a few years ago in Barbadoes, by Sir Robert Schomburgk. The recent observations of Professor J. Müller upon living specimens of Polycystina, seem to leave no doubt as to the close relation of the animals which form them to those of the Foraminifera.

But the most remarkable modification of this type is presented in the *Sponge*-tribe; which seems to us to have been clearly proved by recent investigations into its minute structure and developmental history, not only to be unquestionably animal in its nature, but also to form the connecting link between the Protozoa and the Polypifera. For the soft flesh with which the skeleton of the Sponge is clothed, has been found to consist of an aggregation of Amœba-like bodies; some of which are furnished with long cilia, by whose agency those currents are kept-up, which were long since observed by Dr. Grant to be continually traversing the passages and canals of the entire mass. And from the recent observations of Mr. Carter and others upon the early development of Sponges, it appears that they begin life as solitary Amœbæ; and that it is only in the midst of aggregations formed by the multiplication of these, that the characteristic sponge-structure makes its appearance. The formation of spicules is the first indication of that organization which makes the Sponge-body one whole; and these appear to originate in the calcification or silicification (as the case may be) of particular cells, or rather segments of sarcode, a distinct animal basis being found to remain when the mineral

matter of the calcareous spicules has been dissolved away by an acid. The transition between Foraminifera and Sponges is much less abrupt than at first sight appears; for among the lower forms of the first of these groups, there are some which may be described as discoidal masses of sarcode traversed by a reticulated calcareous skeleton, and only wanting a system of pores and canals to be true Sponges; whilst in certain Sponges the ordinary fibrous skeleton strengthened with spicules, is replaced by a continuous mineral reticulation. And a remarkable connecting link between the two seems to be presented in the curious *Thalassicola*, first discovered by Mr. Huxley,* and since observed by Professor Müller, which is considered by the latter as also having relations with the Polycystina. On the other hand, the passage between Sponges and the Alcyonian Zoophytes has always appeared to us to be clearly established by those intermediate forms, in which the existence of polype-mouths seems quite subordinate to that of the general spongioid body; and especially by the fact long since announced by Professor Milne-Edwards, that in the new offshoots of certain Alcyonians, the spongioid body is developed, with its system of ramifying canals, before any polypes make their appearance at their orifices.

We have not yet done with this Rhizopod type of life. For there now appears to be no doubt, that we are to associate with it the curious *Gregarina*, whose place in the scale has of late been a subject of no little controversy in Germany. Considered in reference to its habitat, this creature is an Entozoon; for it is found exclusively in the intestinal canals of other animals, being almost invariably present in the Earth-worm, very common in Insects, and occurring also in Mollusks and Fishes. Each individual essentially consists of a single cell, more or less ovate in form, and sometimes considerably elongated; a sort of beak or proboscis frequently projects from one extremity; and in some instances this is furnished with a circular crown of hooklets closely resembling that which is seen on the head of Tænia. The Gregarina exhibits a decided advance in grade of development as compared with Amœba; for the cell-wall is quite distinct from the cell-contents, the former being a pellucid membrane, whilst the latter consist of a milk-white fluid, usually minutely-granular, in the midst of which a pellucid nucleus is commonly to be seen. The membrane with its contents, except the nucleus, are soluble in acetic acid. This animal does not put forth digitate extensions like the Amœba, nor radiating pseudopodia like the Actinophrys; but it possesses contractility enough to be the subject of considerable changes of form, by which it executes movements of progression. In regard to its reception of food, it is conformable to the type of the Cestoid Entozoa; for these have no proper digestive cavity, and obtain their nourishment by the absorption of the juices in the midst of which they live, through the whole of their permeable surface; and it appears to be for the purpose of renewing the stratum of fluid in contact with that surface, that it is clothed with cilia. Thus, whilst not less dependent than the true Rhizopoda, upon nutrient material previously elaborated by other living organisms, the Gregarina does not perform the ingestive and digestive process which is so remarkable a feature in their life-history; this being

* Annals of Natural History, second series, vol. viii. p. 433.

rendered unnecessary in them, as it is in the Cestoid Entozoa, by the state of preparedness of the fluids they imbibe, which have been digested for them (so to speak) by the animal whose intestinal canal they infest. The multiplication of the Gregarina is sometimes effected by the simple act of self-division; but sometimes by a process which seems analogous to the formation of "zoospores" among the Protophyta. The granules dispersed within the cell aggregate into corpuscles, which, at first spherical, afterwards become boat-shaped, a large number being thus formed within each Gregarina-body. These corpuscles, at first designated "pseudo-naviculæ" from their shape, but now more commonly known as "psorosperms," are set free by the rupture of their parent-cyst; and they have been found, by the recent researches of Dr. Nathaniel Lieberkühn, to develope themselves first into Amœba-like bodies, from which Gregarinæ are subsequently evolved.* A sort of "conjugation" has been seen to take place between two individuals, whose bodies, coming in contact with each other by corresponding points, first become more globular in shape, and are then encysted by the formation of a capsule around them both; the partition-walls between their cavities disappear; and the substance of the two bodies becomes completely fused together. This conjugation, however, can scarcely be regarded as having any more significance as a true generative process, than the fusion of two or more bodies of Amœba or Actinophrys; since its products do not seem to differ in any respect from those which may be formed without conjugation in the interior of a single Gregarina-cell. Hence it seems clear that we do not yet know the whole of the life-history of this curious creature; and it is quite possible that, in common with Amœba and Actinophrys, it may give origin to some very different form.

In respect to its distinct cell-wall, and to the more complete limitation of the body which it affords, Gregarina may be considered as in some sort establishing a passage towards the group of *Infusoria* proper; the distinguishing character of which is, that the sarcode-body is included within a well-defined membrane, and that this membrane has a definite oral aperture, through which alimentary particles are introduced, with a separate anal orifice in many instances, through which the rejectamenta can be got rid of. By most of the German Microscopists, the Infusoria are considered as single cells, chiefly (as it would seem) on the ground of a "nucleus," or what appears to be such, being present in each,—notwithstanding the existence of the oral and anal openings into their interior, and the frequent presence of organs with which it is difficult to conceive of single cells being endowed. The group of Infusoria, as thus characterized (we adopt Siebold's limitation of it, excluding his order *Astoma*, of whose vegetable nature subsequent research leaves scarcely a doubt), is far less comprehensive than that of the so-called Polygastrica of Professor Ehrenberg. For it is now quite certain that among these were ranked a large number of forms belonging to the Vegetable kingdom; to which the progress of inquiry is continually adding. Thus of the vegetable nature of the group of *Desmidiaceæ* we believe that no unprejudiced observer would now entertain a doubt; for all their characters are such

* See his account of the Evolution of Gregarinæ, in Mém. de l'Acad. Roy. de Belgique, tome xvi., and subsequent notices in the Bulletin of the same Academy, tome xxi. Nos. 3 & 7.

as would lead us to associate them with Protophytes, no single attribute of animality unequivocally existing among them. And although opinions are less unanimous with respect to the *Diatomaceæ*, the preponderance is now decidedly in favour of their affinity to Desmidiaceæ. That almost everything which Professor Ehrenberg has affirmed of their organization is untrue, is the unanimous verdict of the many observers who have within recent years devoted themselves to their study. They seem, in fact, to be nothing else than isolated cells, growing and multiplying under the same conditions as those of ordinary Protophytes, and being chiefly peculiar in the consolidation of their external coat by silex. The contents of these cells have all the essential characters of a vegetable endochrome; and there is strong reason to believe that their siliceous envelope has an organic basis of cellulose. The vegetable nature of the *Volvocineæ*, advanced as probable by Siebold, has been placed beyond a question by the researches of Williamson and Busk. And to the preceding we may now add almost with certainty all the genera included by Siebold in his order Astoma, save one or two which appear to be larval forms of some higher animals. As a striking instance of the extent, to which the careful study of the life-history of the simplest Protophytes tends to modify the doctrines to which the authority of Ehrenberg has given a temporary currency, we may advert to the case of *Protococcus pluvialis;* out of the different phases of which one Plant, according to the careful observations of Dr. Cohn, Professor Ehrenberg has constructed about forty *species* belonging to fifteen *genera* of *Animalcules.*

The limits of our space forbid us from going into any details upon the varieties of form and structure presented by the true *Infusoria;* but we shall place before our readers what we believe to be the essential facts determined by recent research, with regard to their organization and life-history. The sarcode-body, which is enclosed in a distinct membrane, has usually a tolerably-definite form, and seems itself but little endowed with contractility (save in a few exceptional cases), its movements being chiefly executed by the instrumentality of its ciliary appendages. These, whether few or many, are always so disposed as not only to be subservient to the general locomotion of the body, but also to create a current towards the oral orifice. The internal substance of the body is composed of soft sarcode, in the midst of which are seen numerous "vacuoles," and also "contractile vesicles" (two to sixteen in number) which execute rhythmical movements of contraction and dilatation at tolerably regular intervals. The alimentary particles introduced through the mouth, are commonly moulded into little aggregations of a rounded form, which are received into the vacuoles; and they are often seen to execute a sort of circulation through the cavity of the body, which seems, however, to be merely maintained by the successive introduction of new alimentary particles, each aggregation of which pushes-on its predecessors. Thus the pellets that first entered, gradually make their way to the anal orifice, yielding-up in their course their nutritive materials; or, if no such orifice exist, they either find their way back to the mouth, or (it is believed) force their way out by an extempore anus through the limitary membrane. The multiplication of Infusoria by the process of duplicative self-division, is a process that has long been familiar to Microscopists; but various other

modes of propagation have become known of late years. Thus it has been shown by Stein, Jules Haime, and others, that many Infusoria at certain times undergo an *encysting* process; the phenomena of which were completely misapprehended by Professor Ehrenberg. The Animalcule loses its activity, its form becomes more rounded, and its cilia or other filamentous prolongations are either lost or retracted. The body then secretes from its surface a sort of gelatinous case, which hardens so as completely to enclose it; the Animalcule, however, still remaining free in the midst of its coffin-like investment. This condition was not unknown to Professor Ehrenberg, who considered the encysting process as the expiring effort of life; but if the cysts and their contents be attentively watched, it will be seen to be preliminary to the production of new individuals. This production may take place in different modes. For sometimes the substance of the body appears to break up into numerous "gemmules," analogous to the "psorosperms" of Gregarina, and to the "zoospores" of Protophytes; and these, when set free by the bursting of the cyst, swim forth to develope themselves into a new brood of Animalcules of the same type with that from which they sprang, though at first perhaps bearing little resemblance to it. But in other instances, only a single offspring is developed from the nucleus of the original cell-body; which offspring may have a very dissimilar form. Thus the *Vorticella* gives origin, through this encysting process, to an *Acineta*, which is very like an Actinophrys; and this Acineta, acquiring a stalk but still retaining its general characters, assumes the form which has been distinguished as *Podophrya*. From the nucleus of this is evolved an internal bud, which gradually comes to present the form of a young Vorticella; and this, escaping from the Acineta-body by a gap formed in some part of its wall, goes forth to originate a new colony of Vorticellæ; whilst the Acineta, the gap in whose wall soon closes-up again, goes-on stretching out and retracting its radiating filaments, and after a time produces in its interior a new nucleus for a second Vorticella bud.

Neither of these processes, however, can be fairly looked-on in any other light, than as modifications of the general plan of multiplication by gemmation, which corresponds, in its essential features, with the *growth* of the higher animals. With anything that can be truly accounted their *generation*, we are yet entirely unacquainted; and it is, therefore, quite possible, that the complete life-history of Infusoria may include some phases of which we have not at present any idea. By Professor Agassiz, indeed, it has been asserted that *Paramecium* and *Bursaria*, two genera which are usually considered as among the most typical of Infusoria, are nothing else than the larvæ of Planaria; and if this were proved in regard to them, we should be disposed to regard the entire class as merely consisting of embryonic forms of higher animals. But we cannot help believing that Professor Agassiz has been misled on this point by imperfect observation; more especially since, as we have lately learned from Dr. Wagener, the Cercaria-like embryos which come forth from the ova of some Trematode worms, although so like Infusoria in their general aspect as to be readily mistaken for them, differ from them in this essential particular,—that they possess the water-vascular system characteristic of the adults, in the same rudimentary form in which it presents itself among the Rotifera.

Having thus endeavoured to place our readers *au courant* with the general state of knowledge on this subject,—which we have entered into thus fully, because it involves considerations of the highest interest and importance, alike in Physiology and in Zoology,—we have to inquire how far the mode in which it is treated in our two recent British treatises on Comparative Anatomy can be regarded as satisfactory.

Ignoring altogether the term "Protozoa," which seems to us singularly appropriate, Professor Owen ranks as a sub-province of Cuvier's Radiata, under the common designation "Infusoria," the *Rotifera*, the *Rhizopoda*, and the *Polygastria;* the Sponges being altogether left out. Now the Rotifera, since their complex organization was first (however imperfectly) made known by Professor Ehrenberg, have been ranked by all who have attentively studied them, in a far higher part of the animal series, namely, in some part of the Articulated sub-kingdom. Thus Professor Leydig, who has published a most important monograph upon this group, considers it most allied to the Crustacea, and designates it *Cilio-Crustacea.* By Mr. Huxley, again, the resemblance of certain Wheel-Animalcules to the larval forms of certain Marine Worms, and the presence of a water-vascular system in the one group as in the other, is considered (and we think with justice) as indicating that the special affinity of the Rotifera is with the Annelida. And in a recent communication to the Royal Society, Mr. Gosse has given strong confirmation to the doctrine of their Articulated nature, by showing that the parts of their curious masticating apparatus may be fairly considered as homologous with the buccal apparatus of Mandibulate Insects. We looked with some interest, therefore, to Professor Owen's account of this group; expecting to find him assigning some reasons for still keeping it under the Radiated sub-kingdom, and for degrading it to the lowest of the provinces into which he divides this; but have found none whatever. For anything that he tells us, the student would be left in utter ignorance of the general doctrine of the best-informed Naturalists on this point, and would be not a little surprised and perplexed at finding the Rotifera so differently placed in almost every other modern treatise on Invertebrate Anatomy or Zoology.

The retention of the term Polygastria, as the designation of the group to which Siebold and those who follow him limit the term Infusoria, seems to us extremely undesirable, as tending to keep before the mind the *polygastric* hypothesis of Professor Ehrenberg, which has now been fully proved to have been founded upon an entirely erroneous conception of the real nature of these animalcules. Even Professor Owen speaks of this hypothesis as borne down by the weight of opposing evidence; yet he repeats some of Professor Ehrenberg's descriptions, and allows his large figures of the "Monad of Volvox," "Vorticella," and "Leucophrys," still to stare his readers in the face, as if for the very purpose of impressing his erroneous views on their minds. Further, although he adopts the term Rhizopoda, he makes no distinct separation between them and the Polygastria; the Foraminifera are not so much as mentioned; while Sponges are left, together with a number of undoubted Plants, in that limbo between the Animal and Vegetable kingdoms, "in which the character of the organized fundamental nucleated cell is retained, with comparatively little change or superaddition;"—all those recent additions to

our knowledge of them which seem to have conclusively established their title to rank as Animals, being entirely ignored.

But this is by no means all. Professor Owen has attended so little to the recent progress of inquiry upon the border-groups of the Animal and Vegetable kingdoms, that he seems utterly unaware that the place of many creatures which he continues to describe and delineate among Animalcules, has been definitely shown to be on the Vegetable side of the boundary-line; and his chapter on the Polygastria is consequently made-up of a most heterogeneous collection of "facts and figures," in which Diatomaceæ and Desmidiaceæ, Volvocineæ and Palmelleæ, are made to do duty as Animalcules, in opposition to the conclusions of the most competent among the recent investigators into their nature and history. And it is from not having applied himself to the impartial consideration of the evidence, that he raises objections to the physiological distinction which has been drawn between the two kingdoms—as we believe, upon the most satisfactory grounds. For he deems it a sufficient invalidation of the doctrine that true Plants make their own organic compounds, whilst true Animals derive theirs from bodies previously organized, to say that masses of Animalcules have been known to decompose carbonic acid and to give off oxygen, like Plants, under the influence of sun light: the fact being, that the supposed Animalcules (*Frustuliæ, Chlamydomonas, Euglena*) are the very creatures which have now been proved by *other evidence* to be really Plants; so that here, as in many other cases, *exceptio probat regulam.* —Let us compare this with another somewhat analogous instance.

Suppose that the distinguished Professor by whom the importance of the characters furnished by the minute structure of the *teeth* was first demonstrated, had been led to distrust the value of any deduction respecting the nature of a *bone* that might be drawn from its microscopic appearances, because a bone which he believed to be that of a Bird was pronounced on that authority to be that of a Reptile,—and suppose that this very bone was afterwards proved, even to the satisfaction of the Professor himself, to be reptilian,—would not the value of the microscopic test, instead of being invalidated by the supposed disproof of its reliability, be immensely raised by this evidence of its essential superiority to characters furnished by imperfectly-preserved external configuration? This, as Professor Owen well knows, is no hypothetical case; and its parallelism is obvious.

Until reliable evidence shall be offered to the contrary, therefore, we think it may be held as certain, that the peculiar attribute of the higher Plants is equally characteristic of the lower; and that whenever any aquatic organism is found to decompose carbonic acid under the influence of sun light, and to set free oxygen, that organism may be ranked as a vegetable, however active may be its movements. It may be said that this is "begging the question;" but we reply that in all the cases hitherto cited of this kind, the proof of the vegetable nature of these organisms has been drawn from independent sources. We may mention the following case in illustration, as having occurred to ourselves about ten years since. The water of a rain-water cistern, which had been thoroughly cleaned out, and which had been filled a few days afterwards by a heavy thunder-shower, was observed to present a greenish tinge; and it was

noticed that a green froth, full of minute bubbles, came to the surface whenever the sun shone on it. On examining a portion of this froth under the microscope, we found that the water was crowded with green cells in active motion; and although the only bodies at all resembling them of which we could find any description, were the so-called Animalcules constituting the genus *Chlamydomonas* of Ehrenberg, and very little was known at that time of the motile conditions of Plants of this description, yet of the vegetable nature of these organisms we could not entertain the smallest doubt. For in all their essential microscopic characters, and in their mode of multiplication, they corresponded with undoubted Protophytes; they appeared in freshly-collected rain-water, and could not, therefore, be deriving their support from organic matter; and under the influence of light they were obviously decomposing carbonic acid and setting free oxygen. Our attention was soon attracted from these little beings to an enormous swarm of Wheel-Animalcules, which soon made their appearance, and which greedily devoured their predecessors. But had we followed out their complete history, as Dr. Cohn has since done, we should have found that our Chlamydomonas was nothing else than the *motile* form of *Protococcus pluvialis*, that alternates under certain conditions with a *still* form, in which its Vegetable nature is manifested beyond a doubt.

In his general treatment of this part of his subject, Professor Rymer Jones seems to us to have a much truer appreciation of the present aspect of our knowledge of it, than is displayed by Professor Owen; but when we come to particulars, we find some very unaccountable blemishes. He adopts the designation Protozoa, and gives to the group precisely the same range as we should ourselves assign to it. But strange to say, the first order of beings described by him under this head, is that of *Spermatozoa;* which, as the history of their development and actions fully demonstrates, have no more title to be regarded as independent organisms than have blood-corpuscles or ciliated epithelium-cells. From these he proceeds to an account of Amœba and Actinophrys, and thence to the Rhizopods, Foraminifera, and Sponges; as to his description of all of which we have only to speak in terms of commendation. In his description of the so-called polygastric Infusoria, he returns to the views which he had the merit of being one of the first to promulgate, in opposition to the authority of Professor Ehrenberg, as to the non-existence of an alimentary canal and multiple pedunculated stomachs; having, in the interval between his first and second editions, avowed his conversion to the polygastric doctrine.* The general account of the group remains essentially the same as in the previous edition, the chief additions being derived from the treatise of M. Dujardin, with just enough reference to Siebold to show that he was acquainted with his views. Of everything that has been done by Stein, Cohn, Haime, and others, during the last few years, he seems to be in profound ignorance.

The next of Professor Owen's "sub-provinces" is that of *Entozoa;* which he divides, as in his former writings on that subject, into Cœlelmintha and Sterelmintha; nominally adding thereto the division Turbellaria (founded by Ehrenberg, and more precisely and completely established

* See Cyclopædia of Anatomy, vol. iv. p. 14.

by Oersted and Schultze), but in his more detailed account of it continuing to rank it with the Trematode Worms. To continue to keep the Intestinal Worms out of the Articulated sub-kingdom, with many undoubted members of which they have the closest affinity, seems to us to imply an unaccountable want of appreciation of the essential features of their organisation; and as all the most eminent Continental Naturalists agree, we believe, with Siebold and Quatrefages, in ranking the *Helminthes* (Entozoa), *Turbellaria*, *Rotifera*, and *Annelida*, as the Vermiform subdivision of the Articulate series, we should have been glad to learn Professor Owen's reasons for leaving them where he does. We can find no other than the filamentous character of the nervous system; a part of the organism whose completely subordinate rank in these creatures, entirely forbids, as it seems to us, any especial value being attached to such a condition as a basis of classification. Both our authors, in treating of this group, notice some of the important Continental researches, by which it has been conclusively proved that the so-called Cystic Entozoa are nothing else than abnormally-developed Cestoid Worms; but neither of them seems to be at all acquainted with the completeness which has been given to these researches during the last four or five years; for none of the more recent memoirs on this point are cited (even the important work of Van Beneden, reviewed in our tenth volume, being altogether unnoticed by Professor Owen), and the Cestoidea are still ranked in each work as a separate group, although we are told in both that they are all *probably* tænioid larvæ. We are sorry to be obliged to add, moreover, that both authors continue to repeat the erroneous statement, that the longitudinal canals of the Tænia and other Cestoid worms, represent a digestive apparatus; the fact having now been most fully substantiated (especially in the recent beautiful monograph of Dr. Guido Wagener), that these canals constitute a "water-vascular" system, as was affirmed by Siebold in 1850. And we must here add, that this system, whose proper interpretation by Siebold constitutes one of the most remarkable of all modern advances in invertebrate anatomy, and whose true import and relations are an object of special attention with every real student of Helminthology, is scarcely mentioned by name in either of our British systematic treatises.

The sub-province *Radiaria* seems intended by Professor Owen to include those of Cuvier's Radiata, in which radial symmetry is a predominating characteristic; since he associates in it the Echinodermata, Acalephæ, and true Zoophytes, still retaining in immediate connexion with the latter the Bryozoa (more properly Polyzoa), notwithstanding what he himself admits to be their strong Molluscan affinities. We are sorry to be again called-upon to remark upon certain notable omissions and errors, which detract very much from the general excellence of Professor Owen's two lectures on Polypi. Thus in treating of the sexual generation of the Compound Hydrozoa, a subject which is rendered difficult by the apparent variety of the organs by which the function is accomplished, he omits to notice Professor Allman's valuable memoir on *Cordylophora*,* in which the essential conformity existing amidst all these varieties is pointed-out, in accordance with the interpretation suggested by one of the most

* Philosophical Transactions, 1853.

remarkable of their intermediate forms. Whether the reason of this silence lies in the fact, that Professor Allman takes occasion to state his accordance with us (vols. i. and iv.) in our interpretation of the so-called "Alternation of Generations," and thus implies his dissent from Professor Owen's hypothesis of "Parthenogenesis," we can of course only surmise. Again, in describing the anatomy of Actinia, he repeats the now antiquated error, that the convoluted tubes which lie in the chambers that surround the stomach are testes, and that these animals are consequently androgynous; the fact having been clearly proved, that these tubes contain "thread-cells," or "filiferous capsules," exactly resembling those of the integument, and that the so-called ovaria contain sperm-cells and spermatozoa in some individuals, and ova in others, the sexes being separate, as was shown fifteen years since by the independent researches of Kölliker and Erdl.—Like errors of omission and commission are found in Professor Rymer Jones's treatment of this part of the subject; and he seems to have made no attempt to extricate himself from that strange confusion between the different subdivisions of the Anthozoa, arising from his adherence to a principle of classification now entirely exploded, under which he laboured at the period of his first edition, and which his article Polypifera, in the 'Cyclopædia of Anatomy and Physiology,' showed to have been not cleared-up by the detailed study of the group. He separates the Bryozoa from the true Zoophytes by the interposition of the Entozoa; but he says not a word of their Molluscan relations; indeed, by ranking them between Entozoa and Rotifera, he would seem rather to regard them as having vermiform affinities. Professor Owen, however, seems fully sensible of the close approximation made by the Bryozoa to the Compound Ascidians which form the lowest step in the Molluscous series; and he justifies his wide separation of the two on the ground of what he affirms to be an essential difference in their developmental history:—"No compound Ascidian," he remarks, "quits the ovum as a gemmule swimming by means of cilia either generally diffused, or aggregated on special lobes after the type of the Rotifer," as is the case with the embryos of certain Bryozoa; "and no Bryozoon quits the ovum in the guise of a Cercarian, to swim abroad by the alternate inflections of a caudal appendage." But does he forget that such an embryonic condition as that of the Bryozoa is characteristic of some of the most typical Mollusca; whilst the tadpole-like embryo of the Ascidians is unlike every other Molluscan embryo, its peculiar endowments being limited to that one group, and being consequently a special Ascidian, and not a general Molluscan character?

Let us see how this case stands. That Bryozoa should have been formerly ranked as Zoophytes, is not surprising, when we consider their similarity to that group in habit of life and in general aspect; but in proportion as their true structure has been disclosed by microscopic research, have their points of difference become more and more apparent, and their points of approximation to Mollusca (first pointed out by Milne-Edwards and Audouin) more clearly discernible. Thus, in the first place, all true polypes use their tentacula to grasp their food and convey it to the mouth; and if their surfaces possess cilia, these take no share in the ingestion of aliment. On the other hand, in Bryozoa, as in all Acephalous Mollusca, the nutritive particles are drawn in by a ciliary current, which also serves

to aërate the fluids. In no true polype is there a separate intestine and anal orifice, nor does the digestive apparatus hang freely in the visceral cavity; in the Bryozoa, as in the Mollusca, we find both these characters of elevation, together with (in certain species) a gizzard-like organ, and a cluster of biliary follicles in and around the stomach, closely resembling those of the Compound Tunicata. The relative position of the oral and anal orifices, again, and the position of the single nervous ganglion between them, are essentially Molluscan characters. The absence of a heart and circulating system in Bryozoa is, it is true, a character of degradation; but this apparatus is already so extremely degraded in the Tunicated Mollusks, as to be only removed by one step from that provision for the movement of fluid in the general cavity of the body, which represents in Bryozoa the blood-circulation of higher animals. The propagation by gemmation, although formerly supposed to be a character exclusively Zoophytic, is common also to the greater part of the Tunicata. And although many of the composite fabrics of Bryozoa have a stony density, and closely resemble the solid polypidoms of certain Anthozoa, yet in others, especially among the fresh-water species, we find a very close resemblance to the gelatinous bed or leathery crust in which the Compound Ascidians are lodged. To us, therefore, it seems clear that the Bryozoa and Tunicata ought to be placed in close approximation to each other, their general plan of conformation being no more different than that of any other two classes of the Molluscous series; and that, taking the same rank in that series with the Vermiform group among the Articulata, they present various relations of *analogy* to members of that group, though none of *affinity*. The term *Molluscoida* has been proposed by Milne-Edwards as a distinctive designation for this group; but such a separation seems scarcely required by any essential difference in *plan* from that of the true Mollusca, to whose "archetype" it has been shown to approach very closely,* the chief differences lying in grade of development. Professor Owen again adverts to this question, when treating of the Tunicata in a later part of the volume; and the following sentence will, we think, afford pretty satisfactory evidence, in the obscurity of its ideas and the involution of its style, that he has by no means "thought himself clear" upon the subject:

"If these significant indications of the fundamental affinity of the Polypes, with the retention of the polype form, and the absence of a respiratory organ in the highest of the class should beget a doubt as to the propriety of calling a Bryozoon a Mollusk, and thereby losing the advantage of the latter term as a definite and intelligible sign of a certain advance of organization, the comparative anatomist, whilst admitting the full amount of the affinity of the Bryozoa with the Tunicata, and thereby illustrating his view of the Molluscous series as constituting a great parallel branch of the Animal kingdom with the articulate series, may anticipate a verdict in favour of his judgment, in the necessarily artificial mode of successively treating of the different types and grades of organization, if he should select the compound Ascidians as the point at which, for his needs of description and generalization, he severs an unequivocally natural series of animals from the wide-spread root or base from which it springs." (p. 473.)

If our readers comprehend this, it is more than we can do.

* See the article Mollusca in the English Cyclopædia, vol. iii.

At the commencement of Professor Owen's ninth Lecture, On the *Acalephæ,* we are startled by the following statement:

"In the preceding lecture we saw that, whilst the new individuals propagated by gemmation were for the most part like the parent, those that came from the ova were in very few instances like the parent, but underwent a considerable metamorphosis. They quitted the egg-state either as a ciliated planula under the guise of a leucophrys, or were partially ciliated on special lobes, like a rotifer; or, what was more extraordinary, they came forth under the form of an animal which is usually ranked as a member of the higher class of Radiata, viz., a free-swimming, bell-shaped, or discoid medusa." (p. 157.)

On turning to the preceding lecture for the justification of this last statement, which seems to us to manifest a complete want of comprehension of the facts of the case, we find it stated (p. 155) that in the marine *Hydrozoa*—

"The offspring developed in the ovi-capsules are, as a general rule, the ciliated larvæ called 'planulæ;' the *Plumularia coronata* offering an exception analogous to the *Alcyonella* in the highest, and the *Hydra* in the lowest, class of polypes; whilst other *Plumulariæ,* the *Corynidæ,* and certain species of *Campanularia,* deviate in a still more remarkable manner by the development and liberation of the locomotive offspring in the guise of a minute *Medusa.*"

Still more astonished at the assertion that a Zoophyte ever produces a medusan *embryo,*—the fact having been established beyond all question that the Medusa is a *bud* from the Zoophyte, containing its sexual apparatus,—we turn back to the lecture on Hydrozoa, where we find it stated correctly enough (p. 131) that the Coryne originally developes a many-armed nutritive polype or individual; but that a set of *buds* developed around the base of the first polype, instead of repeating the form and condition of that animal, take-on a higher form, resembling that of a bell-shaped Medusa, become detached, and swim off to a distance, forming and discharging the ova, which in their turn develope the fixed polype-shaped Coryne. This history, in its essential features, is true of all the Compound Hydroida and of the Medusan Acalephæ; which thus are but two states, or rather parts, of one and the same kind of organisms. As we long ago maintained, in opposition to the "Parthenogenesis" doctrine of Professor Owen, the Medusan buds are the sexual organs of the Hydroid Zoophyte; and neither can be regarded in itself as a complete organism, any more than a Plant can be said to be a complete organism without its floral apparatus, or its floral apparatus without its stem and leaves. Whilst, in the ordinary *Corynidæ,* the Medusa-buds detach themselves, and swim freely away, before maturing their ova or spermatozoa, in the fresh-water *Cordylophora,* the generative bud does not assume the characteristic Medusan form, although presenting (as Professor Allman has shown) the essential features of the Medusan structure, and developes its ova or its spermatozoa whilst still in connexion with its stock; and its ova, when fertilized by the spermatozoa, evolve themselves first into the form of ciliated gemmules, and then into that of Hydroid polypes. So among the *Campanularidæ,* in which the generative buds (like the ordinary polypes) are produced in clusters within horny capsules, these buds evolve themselves in some species into the form of independent Medusæ; whilst in others they do not detach themselves, but expand one after another into the Medusan form at the mouth of the capsule, withering

and dropping-off after they have matured their generative products; and in other cases, again, in which the medusan conformation of the sexual gemmæ is obscured by want of development, the generative act is performed whilst they are still enclosed within their capsules. This last is the only mode of generation that has yet been witnessed among the *Sertularidæ;* for no free Medusoids have been observed to make their way out of the (so called) ovigerous capsules of this family, the bodies developed within which, although commonly reputed to be eggs, are really sexual gemmæ, containing sperm-cells or ova as the case may be, though never attaining the condition of Medusæ. It is a complete misconception to affirm, as Professor Owen does (p. 161), that "the bell-shaped medusoid which Dalyell saw struggling to escape from the ovi-capsule of the *Campanularia,* is the equivalent, or homologue, of the ciliated planula, which in like manner escapes from the ovi-capsule of the *Sertularia;*" for the homologue of the "bell-shaped medusoid" is the ovigerous or spermigerous gemma, which, in the Sertularidæ as in some Campanularidæ, remains within the capsule, unexpanded into a Medusoid; while the equivalent of the "ciliated planula" is the gemmule, which, in the Campanularidæ as in the Sertularidæ, is the first product of the true generative operation, whether this be performed by free medusoids or by gemmæ whose development into the medusan form has been arrested.

Now among the Hydroida, the zoophytic form is that which attracts most attention, and by which, therefore, the organisms belonging to it have hitherto always been designated; the fact that the true generative apparatus of many of them was developed in the form of free-swimming medusans, having until lately escaped observation. On the other hand, the Pulmograde Acalephæ have until recently been known only in the Medusan stage of their existence; their origination as gemmæ from Hydroid Polypes having likewise been a discovery of the present era. But now that the absolute identity of the two processes has been substantiated, can any sufficient ground be assigned for keeping apart the two groups of which they are severally characteristic? The analogy of the Vegetable kingdom will supply us with a useful basis of comparison. In many Phanerogamia, especially the groups that furnish our most valuable timber-trees, the vegetative portion of the organism,—namely, the stem and roots, the branches and leaves,—is so predominant, and the generative apparatus is so imperfectly developed, that our "idea" of an oak, an elm, a beech or a fir, is almost entirely based on the characteristic aspect of their aggregate. But there are other Plants of which the flower or generative apparatus is the only ostensible part, the vegetative being altogether subordinate, and perhaps so completely concealed as to attract no attention; thus, for example, many persons only know the Colchicum by its autumnal blossom, and are not at all aware that it sends-up a leaf-stalk in early spring, which dies-down some months before the flower appears; the remarkable parasitic Rafflesia seems to be "all flower," its nutriment being drawn already elaborated from the plant upon which it sprouts; whilst, again, the *Vallisneria spiralis* only makes its existence known to us in its native streams, by sending its unisexual flowers to their surface, of which the female still remains in connexion with the plant at the bottom through the intermediation of an elastic

spiral stem, but the male detaches itself altogether whilst still quite immature, floats to the surface, expands there, and performs the act of fecundation long after its separation. Now would any one dream of classifying Plants according to whether their vegetative or their reproductive apparatus, their foliage or their flowers, happened to make the strongest impression upon our senses; or to separate the Colchicum and the Vallisneria from other plants, because we may never happen to see any part of them but their blossoms? The *scientific* "idea" of a Plant involves the entire organism, its apparatus of nutrition with its apparatus of generation; and this is common to all the cases we have cited, notwithstanding the extreme difference which is presented by different tribes in the relative proportions which these two apparatuses bear to one another. And just on the same principle, the scientific idea of a Hydroid Zoophyte ought to be made to include its medusoid as well as its polypoid buds, notwithstanding that the former may be so imperfectly developed as to constitute no obvious feature in their organisation; whilst the scientific idea of a Medusa must include the antecedent polype-stock from which it has been budded-off. Professor Owen, however, justifies his retention of the class by an analogy of a very different kind, that of those Insects which pass the greater part of their lives under ground or in water in the larval state (in which they are on a level with the vermiform articulata), and which only present themselves for a brief period in the perfect or imago state; for he remarks, "we do not class the cockchafer and the May-fly with the Vermes, as we ought to do according to the analogy of the Campanularia and the Coryne." The two cases, however, are far from having the parallelism which he assigns to them. The larval insect is *not* a worm; for however much it may resemble a worm in its general grade of organisation, it has no generative apparatus, and is therefore not a complete animal, to be classed among the Vermes: whilst, again, the whole of its progress towards the higher form is marked by the progressive development of parts which are added or substituted, for the completion of the organism; and it is quite as just, therefore, to take this perfect form as the type of its class, as to base the typical characters of the human species rather upon the entirely-developed organism, than upon any of the earlier phases of it. But the Medusa does not stand to the Hydroid Zoophyte in this relation; for the former cannot be regarded as the perfected type of the latter, any more than the latter can be regarded as a complete organism without the former. The polype-stock alone is like a worm without sexual organs; the medusa alone is like the sexual apparatus detached (as certain worms do detach it) from the body that developed it.

The view which we advocate is supported by all those recent additions to our knowledge of the *Cirrhigrade* and *Physograde* Acalephæ, of which the recent researches of Huxley, Kölliker, Vogt, Leuckart, and other eminent Anatomists have been so productive. Here again we have to notice the unaccountable omission, on the part of both our Authors, of all reference to these masterly investigations, which have contributed to a very general accordance among all those who have studied this curious group of animals, as to their real nature and relations, which are concisely expressed by Kölliker's term "Schwimmpolypen." For the *Velella* and

*Physalia*, the *Diphyes* and the *Siphonophora*, whose nature has been a source of perplexity to all Zoologists who have sought to understand them as *simple* animals, are readily comprehended when their general plan is compared with that of any one of the composite Hydroida, and allowance is made for the speciality of organisation by which it is adapted for free locomotion. Thus, the well-known *Physalia*, or "Portuguese man-of-war," has been anatomised as if its great air-vesicle or float were the essential part of its body; and all sorts of speculations have been put forth with regard to its nature, the cirrhi dependent from its under side being looked-upon as quite subordinate organs. But of these cirrhi it is now known that the shorter ones, like those of the little Velella, are so many hydroid polypes, in mutual communication with each other, so as to form a polygastric digestive apparatus, to which the air-vesicle of the Physalia stands in the same relation, as the delicate horizontal plate of the Velella, with its vertical crest or sail, does to the polypoid cirrhi dependent from its under side; whilst, as these polype-mouths are not themselves furnished with tentacula, additional appendages of this kind are developed for supplying them with food. In each case, the generative function is provided-for by the development of medusoid-buds, which (as in the ordinary Hydroida) sometimes become detached, sometimes remain in continuity with the stock, evolving spermatozoa or ova; and the generative product appears to be a polypoid animal, from which the entire composite body is gradually evolved by gemmation.—We cannot but think it singular that Professor Owen should not have been aware, that Mr. Huxley communicated to the Linnæan Society, as long ago as 1849, a memoir on these Composite Acalephæ, containing the results of observations which he had made upon them during his four years' voyage as assistant-surgeon in the surveying-ship *Rattlesnake;* that the funds of that Society not enabling it to publish Mr. Huxley's memoir, he applied to the Government for the necessary means, and was kept by it in a state of suspense for several years; and that at last, the Government Grant Committee of the Royal Society appropriated a large sum to this purpose, so that the publication of Mr. Huxley's researches (which has been in great part anticipated by that of the observations of Kölliker, Leuckart, and Vogt, though these were not made until after Mr. Huxley's memoir had been communicated to the Linnæan Society) may now be speedily looked-for. And yet, as if he were perfectly unaware that either Mr. Huxley or any one else had already attained the solution of the complicated problem which this group of animals presents, he concludes his Lecture on the Acalephæ with this passage:

"With regard to the development of the ciliograde and physograde species, scarcely anything connected or precise is at present known. The medical officer who may be destined for foreign service, and to whom the study of Nature offers any charm, could hardly contribute observations more valuable to natural history, than such as he might be able to make on the generation and development of the Pelagic Acalephæ."

Here, again, we are tempted to inquire whether Mr. Huxley's very pointed repudiation of the whole doctrine of Alternation of Generations, and of Professor Owen's parthenogenetic modification of it, can have anything to do with the Hunterian Professor's very marked abstinence

from all allusion to his labours on this subject. That he should take no notice of what Kölliker, Vogt, and Leuckart have published, is certainly surprising, but scarcely *so* surprising.

Although Professor Rymer Jones designates the Acalephæ of Cuvier by the term Hydrozoa, yet he appears to have made this change solely on the ground of the polypoid origin of the Medusan forms of the class; and his notice of the Physograda, Cirrhigrada, and Diphyda, the very forms which recent researches have shown to preserve the polypoid character through the whole of life, stands almost exactly as it did in the first edition, the only addition made to it being one that is by no means accordant with the existing state of our knowledge.

Both authors, as might be expected, give a tolerably-full account, with illustrative figures, of the developmental history of the *Cyanæa aurita*, as established by the observations of Sars, Siebold, Dalyell, and others; but neither makes any mention of the fact, which we hold to be of fundamental importance in the interpretation of the process, that the original polype-stock (the *Hydra tuba* of Dalyell), instead of *dividing* itself into medusa-disks, buds-off a pile of medusa-disks, and may even recommence its polypoid mode of gemmation after doing so. It is this fact, which, as we have shown on a former occasion,* establishes the essential homology between the polype-stock of the Campanularia and that of the Cyanæa; the difference between the two lying only in the fact, that the polype-buds of the former remain in continuity with each other, so as to form that composite structure by which the species is best known; whilst those of the latter detach themselves when mature from the parent-stock (like those of the common Hydra), and their medusa-buds, instead of being so minute as to escape notice, unless searched for by a Microscopist, evolve themselves into those massive forms which force themselves upon the attention of every observer. The life-history of the one organism, however, is so completely the same in all its essential particulars, with that of the other, that it is difficult to see on what ground the two could be ranked in distinct classes, if we were now to become acquainted with them for the first time, instead of having our view of them prejudieed by long usage.

Professor Owen's account of the class *Echinodermata*, although not in every respect what could be wished, is on the whole satisfactory. He gives a pretty full account of Professor Müller's recent researches on the curious larval states of this group; but this account is not furnished with the illustrations requisite to enable the descriptions to be comprehended. We will defy any one to form the least idea of their marvellous shapes without the aid of figures; and even the best delineations can give but a very imperfect notion of them. The chief point on which Professor Owen's account of the developmental history of these Echinoderms requires amendment, is his account, on the authority of Sars, of the development of *Echinaster sanguinolentus*. This history is so inconsistent with that of the development of the Star-fish larvæ afterwards observed by Müller, that it obviously needed revision; and this revision was made by Busch (a pupil of Professor Müller) in 1851. He found that the body regarded by Sars as a mere pedicle or organ of attachment for the

* Vol. i. p. 183.

young Star-fish, is really a larva-zooid, having a stomach and probably a mouth of its own, and is thus analogous to the larvæ of other Star-fishes, though of smaller relative size and less complex structure; the difference being apparently related to the peculiar circumstances under which the development takes-place in this type, the larva being retained within a sort of marsupial chamber, formed by the drawing-together of the rays of the parent around its mouth, instead of being sent to sea to take care of itself, as is the case with the Star-fish larvæ generally.—The want of illustrations cannot be charged against Professor Rymer Jones's Chapter on this subject; for in addition to the copious and beautifully-executed figures which illustrated this part of the previous edition, numerous wood-engravings of the same high class, copied from the admirable representations of Professor Müller, have been introduced in elucidation of the descriptions. We cannot, however, speak in terms of commendation of the chapter as a whole; since it contains many glaring errors. The mode, for example, in which Professor Rymer Jones would turn an Alcyonian Polype into an Encrinite (p. 203), shows an ignorance or forgetfulness of some of the most essential features of the structure of the latter; and the assertion (p. 204) that the *Comatula* may be considered "one of the lowest of the Asteroid Echinodermata," must excite a lively emotion of wonder in the mind of every one who is acquainted with its true relations. For, as was long since pointed-out by Professor E. Forbes, the Comatula is essentially *a free Crinoid;* the earlier part of its life being passed in the true crinoidal state; and its entire organization being conformable to that type. One of the most striking features of that type is the presence of an intestinal tube and a distinct anal orifice, which places the Comatula as much above all ordinary Star-fish in this respect, as it is in the activity of its locomotion. Professor Rymer Jones does not give the slightest indication of being acquainted with Mr. J. V. Thomson's twenty-years'-old discovery, that the little body which he had previously considered as a Pentacrinus, is really the larval condition of the Comatula; and like Professor Owen, Professor Rymer Jones repeats Sars's account of the development of Echinaster, without the correction which alters the entire interpretation of the facts accurately recorded by Sars.

We have now arrived at the conclusion of the task which we have imposed on ourselves; and we lay down our pen with the feeling of great regret, that we have been obliged to execute it in a spirit of such constant depreciation. That much labour and ability have been brought to bear by both our Authors in the preparation of these new editions, none can be more fully aware than those who, like ourselves, have had occasion to go over the very same ground. And we can only lament that the want of determination to bring their works *thoroughly* up to the present state of knowledge, has led their Authors too often to rest satisfied with additions, when alterations, suppressions, and entire recastings were quite as much needed. We could easily show, if it were necessary, that this statement is no less true of the portions of both volumes which we have left unnoticed, than it is of those to the critical examination of which the preceding pages have been devoted. And we could also point, in the notes to Professor Owen's lectures, to many allusions to the writings of

contemporary authors, that betray a disposition to exalt himself at their expense, which will assuredly not increase the estimation in which he is held. In more than one instance, moreover, he makes these allusions to past editions of their writings, and cavils at statements which he can scarcely help knowing them to have since qualified or withdrawn. Would Professor Owen like some of his own earlier memoirs to be quoted against himself? Would he take his stand on his first 'Anatomy of the Terebratula,' or on the ornithic character of the wing-bones from the Maidstone chalk?

We cannot charge Professor Owen with any neglect of his predecessors in the way of citation; and the very copious list of works referred to, which concludes his volume, not only bears testimony to the extent of his research, but will be very useful as a guide to those who desire to ascertain the authority for his descriptions. The example of one who has confessedly the greatest opportunities of personal study of Comparative Anatomy at his command, and who never omits to draw the attention of his readers to any point on which he thinks he may lay claim to originality, should be a sufficient assurance that the materials of any such comprehensive systematic treatise *must* be largely drawn from the labours of others; and should make critics hesitate in stigmatizing as mere compilers, writers who honestly avow this necessity. We feel called upon also to remark, that Professor Owen seldom gives the least hint of the source of his illustrations (the number of which in this edition is not increased in by any means due proportion to the text), so that for anything that appears to the contrary, the reader might suppose them to be original. So far is this from being the case, however, that the greater number of them are borrowed without the least acknowledgment; a proceeding of which we cannot see any justification, and which appears to us manifestly unfair towards the original delineators. With the Hunterian Museum at his command, we should have thought that Professor Owen would have considered it more creditable to avail himself of the ample store of subjects it contains for the draughtsman's pencil, than to have recourse to a wholesale appropriation of the delineations of others, which can only be thought excusable when fully acknowledged.

Professor Rymer Jones contents himself with a few references at the foot of his pages; and of these not a few are worthless, his authorities having been often superseded by others more modern and more trustworthy. No fewer than sixty-two new illustrations have been introduced; and these are of the same high character with those which constituted so remarkable a feature of the previous edition. We find ourselves obliged to repeat our animadversion, however, with respect to the unacknowledged appropriation of the delineations of others; since very few, if any, of Professor Rymer Jones's illustrations are original, and their sources are very seldom indicated. We by no means object to a repetition of really good figures, especially when they are taken from Monographs whose authors have made a special study of the organisms they represent, and are equal or perhaps superior to any that could be produced *de novo* from less satisfactory materials; but justice as well as courtesy to the originators of them, seems to us to demand that these be not deprived, even by implication, of their rightful title.