THE VENTRICULIDÆ

OF

THE CHALK:

THEIR MICROSCOPIC STRUCTURE, AFFINITIES, AND CLASSIFICATION;

INCLUDING

FIGURES AND DESCRIPTIONS OF EVERY SPECIES.

BY

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THE following pages first appeared in a series of papers published in the 'Annals and Magazine of Natural History,' to the courtesy of the proprietors of which Journal I am indebted for the opportunity of reprinting them. The first of those papers was published in August 1847, the last in May 1848.

The investigations carefully continued from the time of the publication of the first of those papers have served only to confirm, and greatly to strengthen the evidence of the truth of, the conclusions therein expressed. Should these investigations have served to open up the true reading of one page in an obscure, but most interesting, chapter of the great Book of Nature, the time and labour given to them will not have been mis-spent.

I have had much pleasure in acknowledging, at pages 10, 42, &c., my obligations to various gentlemen for their kind assistance.

An explanation of the Plates, fulfilling also the purpose of an INDEX, will be found at the end of the volume.

J. T. S.

Highgate, 20th May, 1848.

[*From the* Annals and Magazine of Natural History *for July* 1848.]

The remarks of Dr. Mantell in the 'Annals of Natural History' of the present month call for a few brief observations from me. I must always regret a difference of views from any one for whom I have a respect,—and especially with whom I have been in habits of friendly intercourse,—when, but only when, any feeling of reserve or asperity arises out of that difference of views instead of the cordial desire for still further discussion and investigation, and so getting, in the end, nearer to the truth.

Dr. Mantell imputes to me presumption in stating that "the field was an entirely untrodden one and the task a new one," and that "the nature of this class of animals was totally unknown before." I wish to make two answers to this imputation; first, as regards an implied denial of justice to himself; second, as to the matter of fact.

First, as to my notice of Dr. Mantell himself. In pp. 1 and 2 I use the following language. Having named Dr. Mantell's paper in the 'Linnæan Transactions' I add:—"That paper was but one among the many results of the indefatigable labours of its author in a field then little trodden and by few feet. * * It can be no reflection on the Discoverer of the Wealden and First Investigator of the Chalk to show that, amid the multitude of objects which engaged his attention, one was not followed out exhaustively." Again, on entering on the classification, I use, at p. 50, the following words:—"I have been unwilling, out of respect for the many labours of Dr. Mantell in the field of palæontology, to reject, as others have done without assigning any rea-

son, this generic appellation; * * I am glad that a modification in the meaning of the word enables me to retain a name which will always bring to the inquirer's recollection the long and successful labours of Dr. Mantell." The candid reader may judge from these and other passages whether I have wished to depreciate the labours of Dr. Mantell or his reputation.

Second, as to the matter of fact. The question simply is, *what is knowledge* of a class of animals. I apprehend that "knowledge" of any creature is not merely the sight, or bare handling, or even giving an arbitrary name to a specimen; it must imply some knowledge of structure and functions, in the same way as Professor Owen justly tells us that "the *knowledge* of the organized beings now called *Polypi*, as members of the animal kingdom, is of comparatively recent introduction" (Comp. Anat. i. p. 81), though these had been seen and handled on the sea-shore for ages. I certainly must repeat the assertion that, previously to the publication of my papers,—papers as to which Dr. Mantell himself has been pleased to say that "the subject has recently been investigated by a gentleman of distinguished ability" (Wonders of Geology, 6th ed. p. 638),—the nature of these beautiful fossils was "*totally unknown.*" Neither Dr. Mantell nor any previous writer had ever even suspected the existence of any membrane whatever in the Ventriculidæ. On the other hand, "I have demonstrated that the basis of the Ventriculidæ is a simple unperforated membrane; that, therefore, the descriptions so long before the world, and so often repeated, are fundamentally erroneous,—the conclusions as to the œconomy of the animal being necessarily, therefore, as fundamentally erroneous" (p. 48 *note*). In addition to this, and other points to which I cannot now allude, I have discovered and described and figured, as existing in this membrane, an entirely new form of animal structure; of which Dr. Mantell himself has said (somewhat in inconsistency with what he now considers as due to his courteous readers):—"*Of the accuracy of Mr. Toulmin Smith's beautiful microscopic examination of the intimate tissue of these zoophytes I have no doubt*; and will only remark that the octahedral form, represented as that assumed by the inosculating fibres of the membrane of the Ventriculidæ, *is a very extraordinary anomaly in animal structures.*" (Wonders of Geology, 6th ed. p. 638 *note.*) I think Dr. Mantell's own words, addressed to the very readers whom he now twice assures of his own accuracy, and whom he is so anxious to treat with all due courtesy, are the best testimony that he is doing me injustice.

I am surprised that Dr. Mantell should speak of an "incongruous assemblage" of forms. I might take almost any family of either animal or vegetable kingdom to show the futility of

this objection. The Acacias *platyptera, pendula* and *grandiflora* are, for instance, at first sight, almost as incongruous as are *Tubulipora patina, Gemellaria loriculata* and *Halodactylus diaphanus*.

I doubt not that when the first priest of old nailed to the column's head, after the solemn sacrifice was done, the scalp which he had torn off the devoted ram, he thought he knew very well what a ram's head was, and would have pitied any unhappy wight who might have suggested any resemblance between the head and the tail of the beast which had just smoked upon the altar. It has been reserved for modern science not only to suggest but to demonstrate, by one of the most beautiful, most logical, most philosophical, and at the same time most scientifically important trains of investigation that has been ever followed up, that between these so "incongruous" parts there are clear and positive homologies, and that no one can truly "know" either part who does not study those homologies. It has been by treading, though at an humble distance, and, I am fully conscious, with a too faltering step, in the path by which those important truths have been obtained that I have arrived at what Dr. Mantell thinks fit to term "sublime transcendentalisms;" but which, to my mind, constitute, in every branch of science, the main charm, and the most important end, of the pursuit.

In conclusion I may be allowed to say, that it is of little importance to the world what may be Dr. Mantell's *opinion* or my own on the present matter; but it is of importance whether, in pursuing the subject, any fragment of truth has been got at. I had hoped Dr. Mantell would have discussed my facts and arguments, and not "replied" to my conclusions. I hope that he will do so yet. It is only by full discussion, close examination, and careful consideration that the truth or falsity of my conclusions can be tested. Such discussion, examination and consideration I shall be ready and most glad to meet from any one in a fair and cordial spirit. But all hope of truth and all scientific investigation is at an end, if it is to be considered as a "reply" to a long and most carefully conducted train of investigation that, some years before, one or two of the objects whose natural history and relations are thus elucidated had been described in quite a different way; and that, *therefore*,—for that is Dr. Mantell's only argument,—the more recent investigations must be all wrong. I am glad to say that my collection has been already visited by several of the most eminent palæontologists and anatomists of this country; and I know that some of these, who have the most carefully examined the series, are satisfied of the truth of my conclusions. Of the opinion of others I have perhaps no certain information at present; but I will only add, that, to these or any

others really wishing to compare the facts or to examine into the nature of this most beautiful and interesting class of fossils, the contents of my cabinet will, after August of the present year, be at all times most freely open for inspection.

J. Toulmin Smith.

Highgate, 16th June 1848.

ON THE

VENTRICULIDÆ OF THE CHALK.

Almost one hundred years have now elapsed since Guettard drew attention to "some fossil bodies little known," the elucidation of which he attempted in an elaborate paper*. Of the two classes of bodies described by him it is clear that the *Choanites* are one. The figures and descriptions appear conclusive on this point, and the true affinities are very shrewdly pointed out by the writer, while the prevailing notion of the bodies described being petrified figs and other fruits is completely disposed of. It may not perhaps be quite so clear that the other class of fossil bodies described by Guettard comprises some of the forms of the Ventriculidæ. The true characters of the Ventriculidæ will be presently seen to be in almost all cases so obscured from the general observer, and even, without careful attention to the mode of observation, from the experienced palæontologist, that we cannot expect to find in either the figures or description of a century ago positive evidence of identity. Still I think those of Guettard warrant the conclusion that objects of this class were before him.

It was not till Dr. Mantell in 1814 figured and described in the 'Linnæan Transactions,' vol. xi. p. 401, "a fossil Alcyonium from near Lewes," that any particular attention appears to have been given in this country, or, since the time of Guettard, in any other, to these bodies. That paper was but one among the many

* Mém. de l'Acad. Royale de Sciences for 1751. The paper is erroneously cited by Parkinson under the year 1757. I have found no other direct notice of it. Michelin, in his 'Iconographie Zoophytologique,' p. 121, cites M. Guettard's 'Mémoires Académiques.' I have been unable to obtain that work, but conceive it to be merely a reprint of M. Guettard's various scientific papers, including the one above named.

results of the indefatigable labours of its author in a field then little trodden and by few feet. The views expressed in it seem to have undergone little modification since; for though, apparently rather in deference to the opinions of others than from any conviction of his own, changes of opinion on some points have been expressed by Dr. Mantell in later works, they are expressed without any grounds being stated whereon they were adopted*. It can be no reflection on the Discoverer of the Wealden and First Investigator of the Chalk to show that, amid the multitude of objects which engaged his attention, one was not followed out exhaustively. It is sufficient at present to say that, whatever Dr. Mantell may have left undone in reference to the Ventriculidæ, has been hitherto filled up by no other hand.

The different members of the large family of Zoophytes have done so much towards the actual formation of the solid crust of the earth, that anything which relates to any branch of it must be interesting and important; and it is certainly remarkable that, amid the great attention given within recent years by so many eminent observers to this family, no one has entered on an investigation of the Ventriculidæ. And yet the wide development of these forms and their great elegance and variety cannot but have attracted the attention of all who have ever glanced at the contents of any good and extensive series of chalk fossils;—an elegance and variety which the most untutored eye cannot fail to notice and admire.

I doubt not that the difficulty of the investigation affords the real explanation of the neglect to which these bodies have been subject. To investigate the living structure and affinities of an entirely soft-bodied animal whose only remains have come down to us encased either in intractable flint or in friable chalk will be at once felt to be a task of no ordinary difficulty. Such a task is very different from the examination of any living forms, to whatever class they may belong, or even from that of any of the more solid fossil forms, which latter themselves however call into activity the greatest patience and skill of the ablest observers.

Space will not permit me to examine in detail all the notices which have incidentally been taken of different forms of the Ventriculidæ. I must confine myself to a brief glance at the different works in which any direct allusion to these bodies may be found, leaving it to the full details hereafter to be given of

* I allude particularly to the separation of "*Ocellaria*" in the 'Medals of Creation,' p. 279; to the stating Ventriculites to be a composite instead of single animal in note to p. 272 of the same work; and to the still more remarkable entire separation of "*V. quadrangularis*" (p. 283 *ib.*) and placing it among *Flustræ*.

the results of my own investigations to show wherein the figures and descriptions in which such allusions consist have erred or fallen short.

To the paper of Guettard I have already alluded. It is sufficient further to say, that he was not content with that mere superficial glance which most later observers have given. He expressly says* that, though at first he regarded these bodies as related to the sponges, he was obliged to abandon that idea when he had given a more careful attention to the examination of them; and he concluded that their nearest affinity was to the Madrepores.

In 'Edvardi Luidii Ichnographia' (1760), tab. 2. fig. 176, is figured a Ventriculite, which he describes (p. 10) as "Astroitæ congener Radularia cretacea."

Parkinson, in his 'Organic Remains of a former World' (1807), alludes to the paper of Guettard, and gives descriptions and figures of several fossils which he considers as allied to *Alcyonia*, but whose differences from which he yet felt to be marked. Plate 9. (of vol. ii.) figs. 2, 6, 9 and 10; pl. 10. figs. 12, 14, 15 and 16; and pl. 12. fig. 9 I consider to be certainly forms of Ventriculidæ; and I think it probable that pl. 11. figs. 1 and 6, and pl. 12. fig. 8, are so also†.

In Mr. Parkinson's later 'Outlines' (8vo, 1822) he makes some sound observations on the necessity for separating from the *Alcyonia* the various bodies figured and described in his former work, but he gives no additional details of importance.

On p. 54 of the 'Outlines,' Mr. Parkinson, alluding to what are undoubtedly true Ventriculidæ, describes them by characters which are purely external, and treats as generic characters those which are merely accidental and non-essential.

The 'Organic Remains' of Parkinson did not in the least degree forestall the labours of Dr. Mantell, whose figures and descriptions (1814) convey far more information on the subject than all else that has even yet been published. It is but justice therefore to extract at some length the description given by him of these bodies.

The generic characters assigned by Dr. Mantell, as corrected in his very valuable work on 'The Fossils of the South Downs' (1822), p. 168, are:—"Body inversely conical, concave, (1) *capable of contraction and expansion*: original substance spongeous? or gela-

* Mém. p. 259.

† The frontispiece to the second volume, which is mentioned by Mr. Rose (citation below, p. 339) as "so beautifully delineating" the structure of the Ventriculite, is no Ventriculite at all, but an exceedingly different fossil in all respects, viz. a Wiltshire sponge.

tinous?*: (2) *external surface reticulated*†: (2) *internal surface covered with openings or perforated papillæ*: base imperforate, (1) *prolonged into a stirps, and* (1) *attached to other bodies.*"

Of the characters thus described as generic I shall hereafter show that all those which I have put in italics are erroneous; those marked (1) being altogether in opposition to the fact; those marked (2) being characters which are merely accidental and non-essential.

In describing these bodies in the above-cited paper Dr. Mantell says:—"The specimens which occur at Lewes, though generally considered as *Alcyonia*, do not entirely conform to the characters of that genus as given by modern writers; yet they are evidently very nearly allied to it. It is certain that the recent animal possessed great powers of contraction and expansion which enabled it to assume various dissimilar forms. In a quiescent state it was more or less funnel-like; when partly expanded cyathiform; and when completely dilated it presented the figure of a broad circular disc. To this versatility of shape is to be attributed the great diversity of appearance observable in its reliquiæ, whose forms must have been derived from the contracted or expanded state of the original at the period of its introduction into the mineral kingdom. That the animal enjoyed the power of contraction and expansion above ascribed to it, will appear evident from an investigation of its structure. The epidermis or external coat is composed of *fasciculi of muscular fibres, which, arising from the pedicle, proceed in a radiated manner toward the circumference, and, by frequently anastomosing, constitute a reti-form plexus* capable of dilating, lengthening and contracting, according to the impressions it received‡. The fasciculi are further connected by lateral processes§, which increase the firmness and coherence of the external integument. From the inner surface

* This language and query show that the author had found no specimen which enabled him to ascertain the actual internal structure.

† The "reticulation" here meant was merely that of the "*anastomosing tubuli*" named by Parkinson (8vo, p. 54), and has no reference whatever to the beautiful reticulated fibrous structure hereafter to be described, and which appears never to have come under Dr. Mantell's notice. If proof of this remark were wanted, it is found as well in the extract which follows from the paper in the 'Linnæan Transactions' as in the *specific* description given by him in the same page (South Downs, p. 168), where he speaks of the "external integument composed of *cylindrical, anastomosing fibres, radiating from the centre to the circumference.*"

‡ Mr. Parkinson had already expressed a similar opinion as to some of the fossils above named as figured by him. See 'Organic Remains,' vol. ii. p. 145.

§ These lateral processes are in reality the fibres going off to the polyp-skin hereafter described.

of the muscular envelopment arise innumerable tubuli, which pass direct to the ventricular cavity, and terminate in openings on its surface. In *some specimens* a substance of a sponge-like appearance fills up the interstices between the tubuli, and probably is the remains of a membrane which served in the recent animal to connect the tubes and assist in strengthening and uniting the whole mass. The sides of the ventricular cavity are generally about one-third of an inch in thickness. From the bases or pedicle proceed fibres by which the animal was attached to its appropriate habitation."

The portions of the structure here described as internal, and considered by Dr. Mantell to be absorbents, are in the 'Wonders' and 'Medals' of Dr. Mantell considered as polyp cells, and the animal described as a composite and not a single one. I shall show that each appropriation of those so-called tubuli is erroneous.

The paper in the 'Linnæan Transactions' is accompanied, as is the description in the 'South Downs,' by many figures, the truthfulness of which, as conveying the general characters of outward form, has never been even approached by any later writer.

M. Ramond in his 'Voyage au Mont Perdu' (before 1815; but this is the only case in which I have been unable to obtain access to the original work) figured the silicified remains of one species and the cast of the same under the two names of *Ocellaria inclusa* and *Ocellaria nuda*, assigning to them characters which a very little study of the nature of flint and of the process of fossilization would have prevented.

In the first edition of Lamarck's 'Animaux sans Vertèbres,' (1816, vol. ii. p. 187), the bodies thus figured and described by Ramond are included. In the second edition of that work (1836) Milne-Edwards expresses doubts (p. 291) of the correctness of the description which had been given of the *Ocellaria*, but without affording any fresh insight into the real structure of the fossils. In the same edition are included (p. 459) three species of what Goldfuss had previously named *Coscinopora*, and which is a form of the Ventriculidæ.

William Smith, the "Father of Geology," in his 'Strata Identified' (1816), figures two Ventriculidæ in flint (tab. 3. figs. 1 and 2), of which the first is a very characteristic figure. He calls them *Alcyonia*.

In the 'Icones Fossilium Sectiles' of König (1820), Ramond's figures are copied (pl. 8. figs. 98 and 99), but without any description.

In the 'Exposition Méthodique des Genres de l'ordre des Polypiers' of Lamouroux (1821) the so-called *Ocellariæ* are also

figured and described, p. 45. pl. 72. figs. 1, 2, 3, 4, 5, but with no fresh information.

The Ventriculidæ were justly considered by Conybeare and Phillips so interesting and remarkable that a larger proportionate space is devoted to their description in the well-known 'Outlines of Geology' (1822) than to any other fossil, and they are the only fossils figured throughout their volume (p. 76). They only however abridge the description given in Dr. Mantell's paper, suggesting, however, that they were composite instead of single animals as described by the latter.

In Goldfuss's 'Petrefacta' (1826) there are given, under still new names, figures which appear to represent some of the Ventriculidæ. I think it quite clear however that the two forms which alone are referred to in Mr. Morris's 'Catalogue' as figured by Goldfuss (*quadratus* and *radiatus*, pl. 33. fig. 1, and 65. fig. 7) are not figures of any of the family of Ventriculidæ. Goldfuss himself (p. 243) refers the genus *Ventriculites* to his genus *Scyphia*, though it is clear one of his *Coscinoporæ* is a Ventriculite also.

It appears to me that the following figures in Goldfuss represent forms of Ventriculidæ; but there is nothing in the descriptions which enables us to identify them: tab. 2. figs. 8, 9, 10, 11, 12, and perhaps 15 and 16; tab. 3. figs. 1 and 5; tab. 30. fig. 10; and perhaps tab. 32. figs. 3 and 8. It is to be observed however with respect to all these figures, that they are too imperfect to enable me to speak with absolute confidence of any one. It is certain that he has no figure of any one of the most characteristic forms of Ventriculidæ. And this is not the less the case though he professes to give magnified views of some of the structure; those magnified views themselves exhibiting, without exception, want of accurate observation, and so being calculated to mislead rather than aid the inquirer.

Mr. Rose published in vol. ii. of the 'Mag. of Nat. Hist.' (1829) a paper "On the Anatomy of the Ventriculites of Mantell," in which he professes to detail the intimate anatomical structure of those fossils, and accompanies his descriptions with figures. The figures however, which are in wood, are not such as to convey any correct or clear idea of the originals, while the whole paper certainly does not elucidate the structure further than had been done by Dr. Mantell*. The writer considers them single animals like the *Actinia*.

* I had proposed briefly pointing out the cause of the essential errors into which Mr. Rose has fallen, but my limits prevent (see note *ante*, p. 75). The course which I subsequently show to be absolutely necessary to the investigation of these bodies is the best explanation of the imperfect and erroneous notions hitherto prevailing in regard to them.

In Miss Bennett's 'Catalogue of Wiltshire Organic Remains' (1831) are given, but again without any description, the best figures yet published of one form of the Ventriculidæ, which is there called *Choanites subrotundus* (tab. 16. figs. 1 and 2: figs. 3, 4 and 5 are bad).

In Woodward's 'Geology of Norfolk' (1833) two figures are given (tab. 4. figs. 20, 21) of what the author calls *Ventriculites infundibuliformis*, but unaccompanied by any description, and the figures are too indefinite to afford any information: the author includes *V. radiatus* in his list (p. 46).

Blainville, in his 'Manuel d'Actinologie' (1834), figures on pl. 76. figs. 4 and 4 *a* the *Ocellariæ* of Ramond, and on pl. 60. fig. 5 the *Coscinopora* of Goldfuss; but in his description of each, pp. 386, 430, he intimates doubts as to their real nature. He describes each, however, as having a stony polypidom!

Phillips, in his 'Illustrations of the Geology of Yorkshire' (1835), vol. i. p. 118, gives several figures, unaccompanied however by any description, and which figures are so very imperfect that it is impossible to make out from them any character at all. It would indeed be impossible to know that any of them represented Ventriculidæ, did not the heading of the list of figures state such an intention. This imperfection of these plates is the more to be regretted, and the absence of all description the more surprising, inasmuch as the able author himself remarks (p. 121), that "the remains of the [so-called] *Spongiæ** are nowhere so well-developed as in England, and perhaps nowhere in England so well as in Yorkshire. On the shore near Bridlington they lie exposed in the cliffs and scars, and, being seldom inclosed in flint, allow their organization to be studied with the greatest advantage."

Bronn, in his 'Lethæa Geognostica,' (1835–7) allows a place to two of the Ventriculidæ under that name, and figures another under Goldfuss's name of *Coscinopora* (tab. 29. fig. 1). He figures Goldfuss's *Scyphia Oeynhausii* as *V. radiatus* (tab. 27. fig. 18), in which he is clearly mistaken. Neither the figure of natural size nor magnified has any resemblance to any of the Ventriculidæ.

In 'Die Versteinerungen des Norddeutschen Kreidegebirges' of Roemer (1840) are figured, with very meagre descriptions, some forms which seem intended to represent some of the Ventriculidæ. They are however too indefinite to enable me to fix

* Though thus called "*Spongiæ*" by this author, and though some other writers have so called them also, it is really needless to expend one line in showing the total absence in them of all resemblance to sponges. No two classes of objects in natural history can be more different, and the affixing of such a name can only arise from an entire want of opportunity for the examination of specimens.

with confidence on particular figures. All are described under the name of *Scyphia*. The nearest forms are perhaps tab. 3. figs. 2, 9, 11, and tab. 4. fig. 1, but others are probably intended for these objects.

In Portlock's 'Report on the Geology of Londonderry' (1843) are contained descriptions, but no figures, of *Ventriculites radiatus* of Mantell, and *Scyphia alternans* of Roemer (tab. 3. fig. 9), and also of the one figured by Goldfuss (pl. 30. fig. 10) as *Coscinopora infundibuliformis*; but this writer does no more in effect than repeat the descriptions given by former authors.

Michelin, in his 'Iconographie Zoophytologique' (1843–7), has figured (pl. 30.) and described (p. 121) under the name of *Guettardia*, a variety of the Ventriculite already figured by Dr. Mantell (South Downs, tab. 15. fig. 6) under the far more characteristic name of *V. quadrangularis*.

On pl. 38. fig. 3 of the same work is a very imperfect figure* of *Ventriculites Bennettiæ*. On pl. 41. fig. 3 is a far better figure than had before been given of the so-called "*Ocellaria nuda*;" while on pl. 40. figs. 3 *a* and 3 *b* are figures of what he calls *Ocellaria grandipora*, being really a very different species of Ventriculite from the other so-called *Ocellariæ*. These figures admirably represent the original as it appears when first broken out of the flint. The description (p. 145) contains however, in this as in other cases, nothing new. On pl. 40. fig. 4 *a*, 4 *b*, is also represented, under the name of *Retepora crassa*, another form of Ventriculite.

In 'Die Versteinerungen der Böhmischen Kreideformation' of Reuss (1846) no new details are given, while the figures (tab. 17. fig. 14, and tab. 18. fig. 11) are remarkable, in a work marked by the general beauty and correctness of its figures, for the want of any character or truthfulness whatever.

Such are the notices of this very interesting class of bodies which I have met with. Doubtless others may exist in works which have not fallen into my hands. The above will satisfy every reader that all that has been done by recent palæontologists has been to copy from one another. It is important to observe that in none of the figures or descriptions which I have cited does there exist the slightest indication of what I shall show to be the actual structure of these remarkable bodies, and without an insight into which all attempts at classifying them and determining their affinities must necessarily be uncertain and unsatisfactory and a true knowledge of their natural history impossible. Dr. Mantell is, indeed, the only author who has presented

* Probably a mere copy,—for Michelin's plates are usually very good and characteristic.

us with an extensive series of figures and descriptions. And although, as he himself properly remarks*, "some respectable writers have amused themselves with either giving them new names or arranging them as *Spongiæ*, *Alcyonia*," &c., those writers have assuredly done nothing more; and thereby, instead of advancing the knowledge of these fossils, they have introduced all the confusion and uncertainty which it has been possible to do as to even their identity.

Dr. Johnston, in his 'British Zoophytes' (2nd ed. 1847, p. 180), merely takes a passing notice of the Ventriculidæ; but his work does not profess to include fossil species.

Finally, Mr. Morris, whose wand has in many instances restored order where numberless writers had "amused themselves with giving new names," while he properly readmits the Ventriculidæ to their position as a separate genus, has placed them among the *Amorphozoa*. It is needless to dwell on the impropriety of that position, as Mr. Morris is now fully satisfied, from an inspection of my collection, that they deserve a very different place. And if constancy and elegance of form, delicacy of structure, and a high state of organization are to be taken as tests, the Ventriculidæ will assuredly have hereafter to be ranged in a very different group from that of the *Amorphozoa*.

Having thus shown what has been already done in the field upon which I have entered, it is necessary, in order that the reader may have any confidence in the results and observations which will be presented to his notice here, to state the course which I have myself pursued in these investigations.

The first specimen of the Ventriculidæ which came under my notice strongly attracted my attention from its great elegance of form and the peculiarities I observed in it. I was disappointed in finding any satisfactory information on its nature, and soon perceived that every one of the characters described in the books had reference to some superficial characters only, and not to the intimate structure of the animal. Being fully satisfied that "it is only by a strict investigation of the *intimate structure* of the various forms of these animals," as an accurate observer has well remarked†, "that any permanent arrangement that shall indicate their true and natural affinities may be hoped for," I set about that task myself: this has now engaged my attention for upwards of two years; and in now publishing the results of my careful observations, I feel that I may add with even more truth than could be done by that writer, that the task I have undertaken "is a task of no little difficulty in the accomplishment,

* Geology S.-E. England, p. 97.

† Farre on the *Ciliobrachiata*, Phil. Trans. 1837, p. 387.

and one that may fairly entitle him who enters upon it to expect to meet with indulgence,"—an indulgence, however, which those best qualified to judge of the value of such observations will, happily, be also most able and willing to yield*.

My first step was to obtain as large and varied a series as possible. I have in truth examined and compared with laborious care several thousand specimens, of which certainly upwards of one thousand are at this time in my own collection. These specimens are in all conditions and from various localities.

But I soon felt a new difficulty. These bodies exist both in the chalk and in the flint, substances about as different as well may be. I saw that much error and inconsistency had arisen from not comparing and regarding the differing conditions in which these fossils exist in such different substances. Hence a preliminary step seemed to be, an examination of the nature and mode of formation of the flints themselves. The conclusions resulting from that examination have, to a great extent, been communicated in two papers in the 'Ann. and Mag. of Nat. Hist.' for January and May of the present year.

The exposition given by Dr. Turner† of the *origin* of the siliceous fluid,—in the solution of silex consequent on the disintegration of the felspar of igneous rocks, at which moment of disintegration the silex is liable to free solution in water,—was consistent and satisfactory. But no consistent or satisfactory view could be discovered explanatory of the modes and forms in which the *flint* is actually found. I endeavoured in the above-cited papers to show that those modes and forms are owing to the very rapid solidification of the siliceous fluid—induced by special circumstances—combined with the activity of molecular attraction: that those special circumstances were generally the presence of an organic body which acted as a nucleus,—the softer bodies being more operative in this respect than the harder: that some-

* One of the most pleasing duties of the student of natural history is to acknowledge and reciprocate the assistance received from, and always so ready to be rendered by, other naturalists. I take this opportunity of acknowledging my obligations to Professor Owen for, among other things, affording me the opportunity of fully examining several recent specimens of the highest interest, some of which I shall have occasion particularly to mention hereafter; to Mr. Morris, the well-known author of the 'Catalogue of British Fossils,' for assistance rendered in more ways than it would be easy for me to enumerate; to Mr. Tennant of the Strand, and Mr. Harris of Charing in Kent, who have each placed at my disposal several valuable specimens with the liberal permission to make any sections I desired; and to Miss Emma Naylor of Wakefield for the donation of many fine specimens of recent British Polypifers collected by herself. To many others my acknowledgements are also due, for the loan of specimens, both fossil and recent, for examination and comparison.

† Lond. and Ed. Phil. Mag. vol. iii. p. 25.

times mere mechanical action was sufficient to induce solidification. I further showed* that from these facts certain very remarkable and hitherto unnoticed results had followed; namely, that when a mass of the siliceous fluid had solidified thus suddenly round a soft body, a Ventriculite for example, in which the soft parts were existing at the time of its envelopment, it necessarily formed a solid mould round the nucleus: that when the soft body decayed, its gases and softer components having escaped through or been absorbed by the surrounding and hardening chalk, a more or less complete hollow was necessarily left in the solid flint in the place formerly filled by the animal body: that the firmer fibre of such bodies remaining after the softer parts had thus passed away would afford and did afford centres of crystallization for any silex slowly permeating the stratum in a liquid or gaseous form after that stratum had acquired consistency: that according to the greater or less quantity of such permeating silex would be the result in either wholly or only partially filling up the hollows whose origin I thus explained. I showed the accordance of these views with the known laws of the development of crystals†.

The most important results follow from these observations; and I immediately saw that that which had been generally described as the remains of the body itself was in truth the incrustation of a crystallized foreign substance round such remains. It will be obvious how erroneous must be all descriptions founded upon the former notion.

It remained to adopt a mode of examination of the Ventriculidæ in chalk and in flint which should realize the living animal in the same form from an inspection of its remains in either matrix. To effect this I made many sections of chalk specimens in every direction, for examination both as opake and transparent objects, —an attempt which I believe was novel. Aware that it is by

* Ann. and Mag. Nat. Hist. vol. xix. p. 306.

† The mode of crystallization most commonly exhibited in these cases is the acicular. Silex is known to crystallize in this way from sublimation. In the 2nd vol. of the 'Transactions of the Geol. Soc.' p. 274, is a paper by Dr. MacCulloch on an instance observed by him of the actual formation of such crystals, which he there describes aptly as "filamentous crystals crossing each other in all directions." It seems to me, from careful observation, that it was in cases where an almost or altogether entire hollow was left, all the fibre having decayed as well as the soft parts, that the geometric crystals were more disposed to form within the flints. The centres were fewer, the space larger. A botryoidal form is frequently assumed under such circumstances by the aggregation of acicular crystals; and traces of its former existence are visible in many now solidly filled spaces. The greater or less degree of slowness of the deposit no doubt had an important influence in determining the silex to assume the geometric form of so-called quartz or the botryoidal form of so-called calcedony; the quartz being the result of a still slower deposit than the calcedony.

careful personal manipulation only that results can be obtained which may be relied on, I further procured the necessary machinery and made a large number of sections, in every possible direction, of numerous *entire* flints*. The results have far surpassed my most sanguine expectations. I have not only discovered, beyond possibility of question, the intimate structure of the Ventriculidæ,—and in so doing have discovered an entirely new and most remarkable form of animal tissue,—but I shall be able to show the cause and character of all the modifications of form under which the Ventriculidæ are found; and I further hope to afford indications (I wish to express myself here as cautiously as possible) of the natural affinities and habits of the living bodies to which these very interesting fossils owe their origin.

It should be remarked, that the difficulties in the way of observation of structure in chalk specimens is no less, in reality, than of those in flint. The very friable nature of the chalk, coupled with the almost invariable presence of oxide of iron, would be sufficient to obscure and practically to obliterate a structure far less delicate than that of these bodies. Hence the coarser superficial characters which have been seized upon by all authors as characteristic of genus are all that is usually visible. It was not without much difficulty and care that I succeeded in examining satisfactorily the intimate structure of these bodies as actually preserved in that matrix.

It will clearly be only by thus gaining an insight into the true comparative values, if I may so speak, of the facts exhibited by remains preserved in both chalk and flint, that the inquirer can be in a position usefully to commence his researches with the hope of reaching any definite and satisfactory results.

We find specimens of the Ventriculidæ preserved in flint in one of three ways: the place of the body either wholly solid, the crystallized silex having entirely filled up the original hollow: partially solid, and that is generally towards the central parts of the flint,—the marginal parts, and especially the roots, remaining the last to be solidly silicified: or, lastly, the whole occupied by an open network only. Each case may be examined with great instruction, the key to what it teaches having first become thoroughly understood upon the principles above indicated, to the deduction of which principles instances like these were steps, and of which they do but afford illustrations.

It follows from those principles that, where the calcedony†, whether solid or open, began by crystallization round some re-

* The sections of flints usually examined by microscopists are of mere chips and fragments. They can be of no value in an investigation of this nature.

† See note Ann. and Mag. for May last, p. 307.

maining fibres of the body as centres, the fibre itself, when by this process hermetically sealed up, would remain there to this day in much the same condition as it then was, usually more or less charged with sulphuret of iron; and that, where not so hermetically sealed, it would, on its subsequent decay, either leave the incrusting calcedony in the condition of a series of hollow tubes, or such hollow tubes would, still subsequently, be again filled up by a continuation of the process of siliceous crystallization. I have many specimens of the Ventriculidæ in each of these conditions. It will further be obvious, that where, as occasionally might happen,—but comparatively rarely, because dead fibre would have less attraction for the siliceous fluid than soft animal matter,—the fibrous skeleton of an animal of which the soft parts had already decayed away was enveloped in the siliceous fluid, no hollow would ever be formed, but that fibrous skeleton would be preserved hermetically sealed. I have instances of this latter mode of preservation also.

The flint specimens are, in the vast majority of cases, found with flint on both sides; a fact resulting, there can be little doubt, from the operation of some cause connected with electricity, which, though there is in no part any communication between the two surfaces, determined an attraction and affinity between equivalent masses of siliceous fluid on the two opposite sides, just as we see the needle follow the magnet though a solid plate intervene. Cases are however not very uncommon in which the flint exists in a mass only on one side, there being on the other merely narrow filamentous threads of flint. When the mass is thus found on one side only, that side is, in almost all cases, the inside. Now the Ventriculites being funnel-shaped, there would necessarily be a much greater attraction for the siliceous fluid on the inner side of the body than on the outer side, in precisely the proportionate difference that there is between a single exposed plane surface and a surface closed in on all sides by opposite surfaces. If a mass of siliceous fluid were not great in a particular spot, the greater part of it would thus be drawn to the inside, the electric attraction before hinted at operating however generally to attract a small portion to the outer corresponding surface, where it would spread in what now appear as filamentous threads between the foldings of the outer surface of the animal, in which spots the greatest attraction on the outside would of course be, in consequence of the opposite surfaces there present*. Occasionally a similar appearance is found both on the external and internal surface; but that is usually towards the margin of a flint which is otherwise encased on both sides, as in the specimen fig. 2 of my paper of January, and betokens an exhaustion

* See and cf. p. 9 and note to p. 301 of the two articles before referred to. The threads of flint are there found though the body was not encased.

of material. It would sometimes happen that a very small mass of the fluid would approach the outside only of a large Ventriculite. In such case none could reach the inside, and we should find, and do, that it is external only.

It may at first sight be thought that there would be hollows in chalk specimens similar to those in flint, and that these would be as subject as the latter to have any inclosed fibre incrusted with calcedony. A little reflection will however satisfy the careful reader that this could not be the case. The mould of the individuals inclosed in flint was perfectly solid. Though sulphuretted hydrogen were evolved, which it necessarily would be, from the decomposing body, the encasement in that solid matrix would generally prevent the so free deposit of sulphuret of iron as would take place in the open chalk. Consequently the remaining fibre would offer more affinity for the gaseous silex than would such fibre remaining in the open chalk and more highly charged with sulphuret of iron. And the fact is, that specimens preserved in the chalk exhibit a much larger proportion of sulphuret of iron than those preserved in flint,—frequently so much that the specimen, after a short exposure to the air, becomes a mere mass of oxide of iron, and all structure is undistinguishable. In other cases it is less so, and I have in fact found, in several chalk specimens in which the presence of iron is the least marked, that the deposit of crystallized calcedony*—pure and without the presence of a particle of flint on either external or internal surface—has taken place to a small extent, but in a most exquisite manner. It is clear however that, in general, when any part of the *soft* substance of a body encased in chalk decomposed, its place was soon filled up with particles of chalk, which in its then scarcely hardened state were readily carried in. The firmer fibre would, thus inclosed, endure for a much longer period, probably indeed until the chalk had become comparatively dry, on which event its absorption, where little sulphuret of iron was present, would follow and the space be left vacant. The instances of calcedonized fibre in chalk specimens are then quite as frequent, and to just such an amount in individual cases, as might be anticipated, while the frequent excellent preservation of the forms of the Ventriculidæ in the chalk is also explained.

A piece of dead fibrous skeleton in the chalk would evolve but little sulphuretted hydrogen, consequently would induce the deposit of little sulphuret of iron. It follows that, when buried in the chalk mud, it would be at once closely encased. The hardened chalk would, on the absorption of all the components of the fibre, also leave the places of those fibres vacant. On cutting open these, as well as on cutting open specimens encased with their soft parts and whose phænomena it is above attempted to ex-

* *Not flint*:—it is important to remember this.

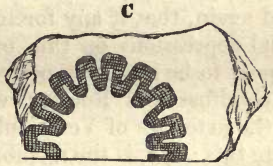
plain, we should find the places of the fibres indicated by hollow tubes disposed through the mass. Of course the presence of great pressure, or the percolation of water or other causes, will have frequently destroyed every trace of the animal, or partially destroyed it, leaving perhaps a mere iron-mould to mark its place; if the fibre were dead, not even that. I am fortunate in having some very beautiful specimens of the dead fibre tubes in my possession,—specimens which naturally escape ordinary attention, there being no colour to attract the eye, and the aid of the microscope being necessary to detect the facts.

In my notes I find several other points examined, but the space to which I am necessarily restricted prevents my entering into further detail here, and I think that I may rely on the candour of every competent observer, that, having thus far touched on material points, others which may occur to him have not escaped my attention. Proceed we now to the *results* of these observations.

I propose to point out, first, some of the general and most important characters connected with the external form of the *body* of the living animal; second, the same of the roots; third, to show what is the intimate structure of both; and lastly, to endeavour to indicate the natural affinities of the whole group. And though it is impossible for me to do otherwise than painfully feel that the attempt is vain to convey, by a few words and figures, that certainty of conclusion which I have derived from such very extended observation, I will hope to impart some consciousness of a reality.

Every reader familiar with the human brain is aware that it consists of a very extensive surface folded up in numerous convolutions in order to pack it in the small compass of the skull, just as for convenience the pocket-handkerchief is doubled up to put it in the pocket. The remarkable resemblance between the annexed section of a Ventriculite (in flint) in my possession, and any cross section of the cerebellum cannot fail to strike every reader,—a resemblance arising from the simple circumstance that both are examples of a similar mode adopted by nature for packing an extensive surface in a small space*. But no one will pretend to assert that those ridges, of which the outline is seen in the section of the cerebellum, are "cylindrical fibres;" nor will any one infer a power of expansion

Fig. C



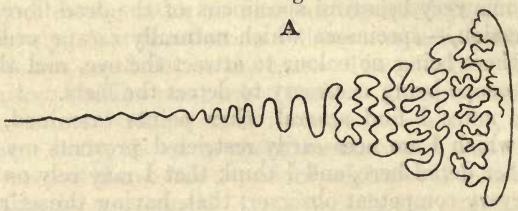
* Plates 63 B, 64, 64 A, and 64 B of Prof. Owen's 'Odontography' afford striking illustrations of the application of the same contrivance to the hardest, as in the brain it is applied to one of the softest, of organic tissues.

and contraction to reside in these bundles, as Parkinson* and Dr. Mantell have done, from a similar appearance, in respect to the Ventriculidæ.

A glance at the following figure will satisfy any one that a simple and plain membrane may be folded up in the most intri-

Fig.

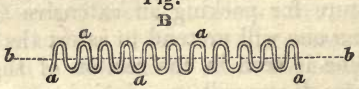
A



cate way without in fact destroying its simplicity, and having the only effect of packing a larger surface into a smaller compass. The mode of folding may be either longitudinal, in which case we shall have the "cylindrical fibres radiating from the basis to the circumference" of Dr. Mantell; or it may be transverse; or it may be more or less intermediate between the two, thus causing those longitudinal ridges to appear to anastomose; or it may be so regularly intermediate as to give to the surface a mammillated appearance. The appearance of the body may even differ on the external and internal surfaces, inasmuch as the folds may assume a different direction as they reach the respective surfaces, as we see familiarly in a rhubarb leaf just burst from its sheath. But none of this can alter the nature of the membrane itself, or serve to establish a generic character. It is further evident that if the folding assume the mammillated character,—that is, if a membrane of some thickness be folded in and out in regular figures,—a section across any part will, according as its direction shall be, represent a series of apparent tubules or of reticulations regularly disposed, as seen in Pl. VII. figs. 1 to 4; and again, that if any foreign substance fill up any of the superficial depressions on this mammillated surface, that surface will appear to be regularly perforated by tubules. Hence the figures of Goldfuss and Roemer, which profess to give magnified views of the exteriors of Ventriculidæ. The following figure will illustrate this: *a*, *a*, is the membrane, which is folded in and out with

Fig.

B



the exactest regularity, each fold being of equal breadth and

* Organic Remains, ii. p. 145.

length, thus making each depression and elevation regularly round. It is evident that a section made in any part from *b* to *b*, in the plane of the surface, would be more or less of the character of Pl. VII. fig. 3, while a section made in any part perpendicular to that plane would resemble the upper part of fig. 4, or fig. C (p. 15).

A very careful examination and comparison of innumerable entire specimens and sections, both in chalk and flint, of every form and variety of Ventriculidæ, early satisfied me that, though contrary to every figure and description that has been published, the above was the true explanation of their forms. Every subsequent observation has confirmed this conclusion. Let the reader examine Pl. VII. figs. 1 and 2, and fig. C (p. 15), and he will see three out of many of the modes in which transverse sections of Ventriculidæ in my possession show that the membrane is folded. Let him, again, examine Pl. VII. figs. 1 and 2, and he will see in fig. 1 a surface perfectly plain and smooth, except so far as the fibrous structure marks it; while in figure 2 he will see the lower part of the surface smooth like fig. 1, but the upper part gradually passing into the mammillated character. These varieties (never before figured) are both in my possession, and I have every shade and variety from the perfectly plain to the most convoluted form of fig. A above. It will easily be conceived what a variety of markings in the chalk and flint,—at first sight wholly inexplicable and unconnected,—will be presented on longitudinal and transverse sections of such complicated convolutions.

Nor does such variation in external form indicate in the least degree a habit or power of contractility. I have shown, by analogy, that it does not necessarily do so. I will show by actual facts that the Ventriculidæ were not contractile. Not only is it an important fact that we find deeply convoluted specimens as wide-open-spreading as any, while we find specimens of the perfectly plain varieties as narrowly funnel-shaped as any, but we find, fixed on the surfaces of specimens of every variety, Ostreæ, Dianchoræ and other shells which are in the habit of attaching themselves by peculiar processes to other bodies. In every such case the shape of the attached shell *departs from its ordinary form*, and is precisely adapted to, *moulded on*, that of the Ventriculite—proving that it *grew thereon*, and thus testifying at once to the firmness of the texture of the body and to its noncontractility, as well as to its durability. Further, we sometimes find delicate Flustræ spread over parts of Ventriculites—always, as before, without trace of distortion or disturbance. But there is, if possible, yet stronger evidence in the fact that an entire and very large group of the Ventriculidæ, and those, too, the very ones which are pointed out as exhibiting the most "contracted state,"

have distinct heads—which heads are perfectly smooth and regular in general form, and with no deep anfractuosities, instead of being, as the contractile theory requires, most of all convoluted. Finally, I shall presently show that there was a special and most beautiful provision in the intimate structure of these animals against contractility either voluntary or by ordinary accident.

Nor is there any want of examples of the presence of similar convolutions without contractility in what I hope to show to be kindred zoophytes of the present day. The *Eschara foliacea* is familiar to every one. But I am indebted to the kindness of Professor Owen for a still more striking illustration of this arrangement in a recent zoophyte. That gentleman a short time ago placed in my hands, with the liberal permission to examine it in any mode I chose, a specimen of *Meandrina* recently brought from the Indian Ocean, and which had been treated with muriatic acid. All the calcareous parts being thus dissolved, there remained only the soft animal parts. I observed with much gratification that these consisted, in fact, of a single membrane folded up almost exactly after the manner of some of the more irregular of the Ventriculites—very much indeed like the *Ventriculites radiatus* described by Mantell and others as having an "integument formed of cylindrical fibres anastomosing," &c.

However much differing in the complexity and mode of the convolution of its membrane, the body of every member of the family of Ventriculidæ appears to have had an opening at its upper part, and that body approached more or less to the form of an inverted cone. They usually grew single. In one or two species they are grouped, and there are occasional instances, but very rare, of double specimens of those whose usual habit is single —just as we occasionally find a double *Actinia*.

Having thus shown the general character and habit of the body of these animals, I next proceed to show the nature of the root.

The attention of Ellis was particularly attracted, in describing his Corallines, to one variety, the *Corallina astaci corniculorum æmula* as he calls it, or Lobster's Horn coralline, as having roots very different from those of ordinary corallines, "which rise up from an irregular mass matted together to form the stem*." The roots of this zoophyte, on the contrary, "regularly enter in in whirls round the joints;" the body of the animal, according to his figure, tapering off to a point in the midst of these root fibres†.

Something after such a type was the habit of the roots of the Ventriculidæ. They were *not*, as described by Dr. Mantell, de-

* Ellis's Corallines, p. 16 and pl. 9. B.

† This peculiarity is not marked either in the description (p. 86, 2nd ed.) or figure (pl. 19) of Dr. Johnston; but the figures and descriptions of Ellis are seldom unworthy of dependence.

rived from the base of the body "prolonged into a stirps and attached to other bodies." The body of the Ventriculite tapers off regularly to a point at the bottom. At about an inch from its base,—the distance varies according to size,—fibres of a very different aspect from those composing the membrane of the body begin to be attached to the external part of that body. They do not begin all round at exactly the same distance from the base, nor, as they increase in mass, is that mass of the same thickness on all sides. They are at first very few and thinly disposed. As the base narrows they increase rapidly in number and mass, till, immediately below the base, they form a bundle of considerable size, which is continued, thus united, for some distance, from one to three inches according to circumstances, when it divides into several radicles, sometimes more, sometimes less: I have counted as many as forty in one specimen. These sometimes extend very far and always terminate in very delicate extremities.

The root-mass is never itself convoluted like the body, even in its upper parts, and where it forms a thin membrane only. It necessarily follows the form of any convolution, usually slight, which exists at the lower part of the body. The mass of the root is not regularly cylindrical, but irregular on the different sides (see Pl. VII. fig. 6). Occasionally it assumes a tubular aspect in places, but this is quite accidental and in nowise characteristic of genus or species.

Pl. VII. fig. 5 gives a longitudinal section in which the difference between the body and root is very clearly seen: fig. 6 is a transverse section of the same specimen. These two will realize to the observer how admirably the body was lodged in this root-case as in a sheath or socket. They remind one of a balloon to which the car is attached by a network of rope gathered in on all sides round the narrow base. Pl. VII. fig. 7 is the external appearance of another specimen, showing the root-fibres commencing round the body and spreading at the root.

The substance of the root was different, as the fibres were differently arranged from those of the body. This is proved by the fact that the root exists generally in a very different condition, both in chalk and flint, to that in which the body is found in the same specimen. In flint its place is much less often solidly filled with calcedony than is that of the body. In the chalk it is the rare exception to find the substance of the root in sound condition. It generally falls away to dust the moment the specimen is opened, while the body of the Ventriculite remains entire and perfect down to its very point, having all around it a hollow space where the root was.

The Ventriculites were never "affixed to other bodies." It is possible that the animal was locomotive like the *Actinia*, and that,

like the *Pennatulidæ*, it fixed itself during pleasure in the soft mud. Among all the thousands of specimens which I have examined, I have never seen one attached to a shell or to any other solid body. Shells are indeed sometimes found *growing onto* the *upper part* of the root, where it was of course immoveable, as they do on the body. The most delicate terminations of the roots may be always traced by their impression in the chalk. If the animals were locomotive, it was by aid of the lower radicles that they progressed.

Occasionally, but it is the rare exception, a small bundle of root fibres is given off from the side of the animal. This is similar in character to the true root, but slighter, and it is merely affixed by apposition of its thick extremity, without any of the encasement. Such instances appear as if some circumstance rendered an additional support necessary in the particular instance. There are instances among our native zoophytes of upright habit, in which a similar circumstance is not uncommon —much more common than among the Ventriculidæ.

I have one example in which there is no encasing root-sheath. And in that specimen, as if to make up for want of it, the rootlets begin to arise about an inch from the base, being already of considerable strength: they spread out immediately on each side, and so support the body just as a tent is supported by the staying ropes on all sides. I have another example having two complete roots, and of course a divided base to the body. Each root is however smaller than usual. These examples only show that the world was under the same laws in the days of the chalk formation as it now is: that then, as now, monstrosities would sometimes appear, which, however, only themselves serve to show the permanence of Law and Unity, inasmuch as in these very monstrosities there is always present some compensating phænomenon which it is interesting and instructive to observe.

I have already stated that my investigations into the *intimate structure* of the Ventriculidæ have rewarded me by the discovery of an entirely new kind of animal structure.

In 1841 Professor Owen read before the Zoological Society a paper* on a remarkable production from the Philippine Islands, of which he says, "in the exquisite beauty and regularity of the texture of the walls of the Cone, the species surpasses any of the allied productions that I have, as yet, seen or found described," and he gives to it the very appropriate name of *Euplectella*. While the *Euplectella* is the only object which approaches the Ventriculidæ in the beauty and regularity of its texture, the latter far surpass it not only in possessing a much higher degree

* Zoological Transactions, vol. iii. p. 203; and Ann. and Mag. Nat. Hist. vol. viii. p. 222.

of that very beauty and regularity, but in the exquisite delicacy of a further texture, of which the *Euplectella* does not possess a trace, and which, so far as I can learn from the best authorities, has never been hitherto observed in any object, animal or vegetable, recent or fossil.

Through the kindness of Professor Owen and the liberality of the proprietor of the specimen, Mr. Broderip, I have had an opportunity of carefully examining the *Euplectella*. While I am thus enabled to speak to the fidelity of Prof. Owen's description, I can also speak with more assured certainty as to points to which, having the structure of the Ventriculidæ before my eye, my attention was more particularly directed.

The *Euplectella* is composed of an arrangement of fasciculi of fibres, *one course over the other*, not anastomosing together: its principal substance consists of two layers, a longitudinal and a transverse one, of which the former is external to the latter. These, thus crossing at regular intervals, form the regular texture which excites Prof. Owen's just admiration,—an arrangement in which they are held by the interlacement of other and more delicate fibres tied by the same fairy fingers which Dr. Johnston describes as knitting the plexus of one of his delicate zoophytes. The squares thus formed are about the eighth of an inch in size,—gigantic in comparison with the squares filling the membrane of the Ventriculidæ.

The membrane of the Ventriculidæ is composed of very delicate fibres arranged in squares, of which the larger ones measure, on an average, considerably less than the 100th of an inch on each of their sides*. The fibres of the Ventriculidæ are not arranged in fasciculi, nor in layers the one overlying the other concentrically or otherwise. Neither are they at their points of crossing wrapped together by other interlacing fibres. The substance of the *Ventriculites simplex* (see Pl. VIII. fig. 1), which is the true type of the whole family, is not quite one line in thickness (about the sixteenth of an inch). It consists of five thicknesses of the squares I have mentioned. Consequently the substance of the body of the animal consists of a membrane composed of an exceedingly delicate fibre anastomosing in every direction, so as to form both in the plane of its surface and of its thickness regular squares (see Plate VII. fig. 8). As the body increases in size from the base to the upper margin the fibres increase in number, and this takes place, not, as in the *Euplectella*, by the "convergence and interblending of contiguous fibres," but by the addition of a fresh fibre, generally at the middle of the outward boundary fibre of a

* The sizes are pretty constant in different species. There is some variation however. Those described are the largest. The *relative* dimensions appear constant.

square,—thus causing less disturbance to the regularity of the squares than happens in the *Euplectella* (see fig. 14). But this is not all the beauty and delicacy of the intimate structure of the Ventriculidæ. A structure remains to be described, to which the expressions of Prof. Owen in describing the *Euplectella* may well justify me in saying that no language can do justice, and which no one can contemplate without delight, wonder, and exquisite admiration.

If the reader's attention has ever been attracted by the roofs of the large railway stations, he will have perceived that they are held together by the mutually counteracting and balancing effects of thin rods obliquely placed—any one of which would singly be very inefficient for any substantial purpose. To give a barred gate strength, or to keep a loose door or window-frame to its true square, we see the carpenter fix a bar obliquely subtending the right angle, which will hold the more securely the nearer it is fixed to each side at equal distances from the angle. The principle of the bracket which supports a shelf or bust is but the same.

But there is nothing new under the sun. Ages before railways or carpenters existed, nature had adopted this very plan, to give strength and stability to the deep ocean forms of the whole family of Ventriculidæ; only, as she ever does, adopting a method far more delicate, complete and beautiful than it were possible for the hand of man to execute.

I have said that the fibre is arranged in a tissue of regular squares, which are formed by the anastomosing, at each angle, of that fibre. But, besides these fibres, of which there necessarily occur at each angle three entire ones crossing each other, or six looking at them as radiating from the angle as a centre, these crossing and anastomosing fibres are strengthened and secured by twelve still finer oblique fibres, each about one-fourth of the length of any one square itself. Each of these fibres subtends one of the angles formed by two of the primary crossing fibres, and of which angles there are of course at each crossing twelve. Each of them anastomoses with one pair of the primary fibres in each position in which they meet to form a right angle. This anastomosis takes place at an equal distance on each primary fibre from the angle itself, namely, at a distance of about one-fifth of the length of one side of the square. Thus it will be seen that at each place of crossing there are twelve subtending fibres and six primary fibres, in all eighteen fibres. Now, taking a Ventriculite of very moderate size, say three inches in height and plain, we shall have a membrane containing at least 750,000 squares, and at least nine million of these delicate subtending fibres, each faultless. What a marvellous piece of workmanship is this!

It will be perceived that by this most admirable contrivance a

regular octahedron is formed round about the point of union of every four squares throughout the whole body of the Ventriculite, thus forming, of course, as many octahedrons as there are squares. See Plate VII. fig. 8, and more clearly fig. 10, as seen in flint, and fig. 9 as seen in chalk*.

It is needless to point out the strength given to the whole membrane by this arrangement, and the obvious design of it to prevent any injury of the animals to which it belonged arising from any yielding or distortion to which it might otherwise be liable from the operation of ordinary causes present in the ocean where they dwelt. They generally suffered fracture rather than yield to such impulse.

As the texture reaches the surface, both external and internal, it assumes a different appearance in order to attach to it the more securely what I shall crave permission to call, for the present, the *polyp-skin*. The regular squares and their octahedral junctions are still present, but under a different aspect; their size being contracted to about the 300th of an inch. This appears to be effected by the *addition* of finer fibres crossing each other within each square, so as to make at least four squares equivalent to each of the larger ones. This membrane presents a solid series of these squares; that is, they extend, in a single layer, as well in the plane of its thickness as of its superficies. The membrane spreads over every convolution and descends every anfractuosity of the body. Plate VII. fig. 11 shows this membrane in calcedony, where several of the actual fibres are preserved and the crystallization round them is very visible.

External to the whole, the polyp-skin itself,—spread over both external and internal surface and depressed also into each of the anfractuosities,—stretches over the delicate membrane last described, with which it is closely united (see Plate VII. figs. 12 and 13, and Pl. VIII. fig. 6). In specimens both in flint and chalk, prepared with care and in a high state of preservation, an equidistant row of apparent denticles seems to extend from the inner substance to the external encasing wall. This is caused by the transverse fibres (in the flint, incrusted with calcedony; in the

* It is obviously impossible to find individual specimens which shall fully show those states of fact which have been only ascertained by careful examination of many hundred specimens. Again, the least obliquity in any section will cause an *apparent* elongation of some and a cutting off of parts of other squares; while the slightest variation in focus will cause fibres in different planes to appear on the same plane. Hence, oftentimes, an *apparent* irregularity which does not really exist, but which may easily deceive an unpractised eye either in the object itself or in the engraving. Figs. 8, 11, 13 and 14 illustrate this. It should be added, that the octahedral structure could not be given with any clearness in figs. 8, 9 and 14, without somewhat exaggerating its relative size. No engraving can do justice to the exquisite delicacy of the original.

chalk, the place of the fibre left hollow and the intervals filled with chalk) of the delicate membrane which underlies the polyp-skin.

The polyp-skin itself is of extreme tenuity, and differs altogether in structure from the internal parts. It is not fibrous, but of a uniformly close texture which yields to the highest powers of the microscope no other than a minutely granular appearance.

It is only in very rare cases that the polyp-skin is found in any degree of perfection. Careful observation and comparison of an immense number of specimens, *with their casts*, led me to infer the existence of this polyp-skin, as matter of unevadable conclusion, long before I was fortunate enough to find, as I have since done, specimens in which it was so preserved as to be found on the body of the fossil itself. In such cases as the latter, the internal structure is always clearly seen where any parts of the polyp-skin are ruptured. See Pl. VII. fig. 12.

I shall presently enter on the consideration of the polyps themselves and the accompanying phænomena.

It will of course be understood that the membranes I have described must, during the life of the animal, have been filled with soft parts, which, with whatever minutely ramifying vessels they contained, rapidly decomposed, and of which therefore I have as yet discovered no trace.

There existed no spiculæ, siliceous or calcareous, in any of the Ventriculidæ; some spiculæ in the adjoining chalk or flint may sometimes deceive an inexperienced observer.

The structure of the root differs much from that of the body. Annexed to the body by short fibres clearly seen on a good section, it is, like the body, arranged in squares, but those squares have not all that regularity which those of the body have. They are, in general, smaller in their average size than those of the body, and have throughout a tendency to elongation in their longitudinal direction, whence they are often narrowed on one or both of their lateral planes. The fibres of the root are also thicker in their longitudinal direction than in their transverse.

It is particularly important to observe that there is no trace in the roots of the octahedral structure, a fact precisely in accordance with the functions of those roots. The safety of the animal would be more secured by the latter yielding to every impulse, and waving their so delicate load from side to side, than by an unbending stiffness. The octahedral structure had therefore no place in the roots.

The integument of the root was also very different from that of the body. It is impossible for a moment to confound the two. Its longitudinal fibres were much thicker than the transverse ones; and, there being no octahedral structure to secure an unyielding exactness, it appears as if disposed in long, narrow, and not very regular meshes. When encrusted with calcedony it appears not

unlike some vegetable tissues (see fig. 7. Pl. VIII.). The deceptiveness of appearances thus caused has been already fully pointed out. This integument was very possibly muscular.

The fibres of the roots, like those of the body, all anastomose together. They do not overlie nor entwine.

When it is remembered that sulphuret of iron is deposited more or less on every fibre that has been actually preserved, it will be obvious that it is impossible to ascertain the exact size of the recent fibre. I have however frequently observed the better-preserved fibre to be less than the 4000th of an inch in diameter in its present condition; much appears about the 2000th of an inch; and the coarser and less perfectly preserved rarely exceeds the thousandth of an inch in its present condition. The fibre is single and solid (never fistular). It is generally found both in flint and chalk reduced, more or less, to its ultimate granular texture, in which case it resembles the granular texture of other animal fibre. This granular texture is finer, even in its present condition, than that of the recent *Actinia*.

The description of another most interesting point which I have discovered in connexion with these animals—the ovarian cells—will more properly come under the next division of the subject, when the natural affinities of the animal are considered. I content myself for the present with stating the fact of the discovery and clear establishment of these ovarian cells, a fact which cannot but be felt by every naturalist to be of the very highest importance, both in relation to the individual beings themselves and as an aid in determining their natural affinities (see Pl. VIII. fig. 3).

And now, having thus too imperfectly described the intimate structure of these animals, so elegant and graceful even in their external forms, I hope that I shall be felt not to have expressed a too strong sense of the exquisite beauty of that structure. I have searched in vain amid zoophytic forms for any structure that may compare with that of the Ventriculidæ in delicacy, beauty, and obvious adaptation. The pride of man may call all those beings who differ most from him in structure the "lower animals;" but I would ask, Where can be found an organization more complex or more exquisitely delicate, or where adaptation more perfect, than is displayed in the structure of the Ventriculidæ? Where can we find a structure affording more conclusive evidence of the all-prevalence of those laws of Unity and Design which it is the grateful task of the naturalist to develope, and of which his inquiries, the further they extend, do but unfold a wider field of illustrations for man to study and admire?

The structure which has hitherto engaged our attention is, strictly, that of the polypidom only. It remains to seek the na-

tural affinities of the group the polypidom of which is marked by these high characters of structure.

The difficulty of this task will be readily appreciated when it is considered that it involves an inquiry into the nature, in respect to fossil bodies, of the parts most perishable and most difficult of observation even in recent species, and that it becomes necessary first to remove preconceived notions, and afterwards to begin *de novo* to find out the true relations. Further than this, in the structure which I have already described, the combined process of induction and direct observation has enabled us to arrive at conclusions which, after the work has once been carefully done, are definite and positive and incapable of being disputed with any show of reason. The present inquiry must depend more entirely upon the process of induction alone, and I cannot but be conscious that conclusions thus arrived at, however satisfactory to some, will be always more open to dispute.

Late writers on zoophytes have been in the habit of treating slightingly a reference to the polypidom in determination of genus and species, and of alleging that little or no reliance can be placed upon anything but observation of the polyps themselves. I apprehend, however, that this originates in some misconception. The Mastodon and the Mylodon are creatures which are well realized to the mind, though no part of the softer tissues of either has been ever seen by their describers. In the 'British Fossil Mammals' are vivified before us hosts of animals, hardly one of which has ever been touched by the hand or seen by the eye of man in other than its harder parts. How is this? We owe it to the ever-present and strong-felt conviction of the all-prevalence of the Law of Unity, whence their describer would as soon doubt the evidence of his senses as the important truth that there are always present certain constant relations between certain parts. Now either the Law of Unity and the whole principles upon which the British Fossil Mammals have thus been vivified are mere empty words and baseless, or the same principles must apply to every part of the animal kingdom. It would be as reasonable to deny the value of comparative anatomy as applied to fossil mammals because they who first found mammoth bones immediately saw in them glorious evidence of the reality of "those days" in which "there were giants on the earth," as it is to treat as of slight value the forms and structure of the polypidoms of zoophytes because Lamouroux and others may have erred in their application of what they saw or thought they saw in them. The cause of the false deductions (they have not been real inductions) drawn from observation of polypidoms appears to me very simple. Keeping now to fossil forms and turning over the pages of Goldfuss and others, no one having any knowledge of

the subject can fail to perceive that, in the hurry to name and figure as many objects as possible, the merest superficial characters of external form have been alone observed, without the least examination of the true characters of those forms or their true texture and habit. I have so fully shown already the necessary consequences of this course in treating of the folding up of the membrane of the Ventriculidæ that it is unnecessary to enlarge upon it here. The result has been that, in Goldfuss for example, we have heaped together, without order or method, under the name of *Scyphia* (for instance), an immense number of objects differing totally from one another in every character, and many of them having no one essential character in common with the definitions of the genus. From the same hurry in jumping to conclusions, and eagerness, at all risks, to name and figure, has resulted the disposition in our own country to call everything which it is found difficult to understand and troublesome to investigate either a sponge or a coprolite. We have seen that the Ventriculidæ have, like many other as widely different things, been thrown into the former category, and I have little doubt that, by others, they have been thrown, with equal correctness, into the latter.

Observation then of mere external superficial form, as it is presented in recent specimens, still more as it always must be presented in fossil bodies, whether preserved in a hard or soft matrix, can never lead to other results than we have seen to have been arrived at by the numerous band of writers already named. By such a course we can only again have, as we have had already, a soft-bodied animal gravely described and figured by even such an author as Blainville as having a central stony axis with deep tubular cells—the so-called axis being the chalk or flint which had filled the central cavity, and the so-called tubular cells being simply the folds of the membrane forming the polypidom. The same care is necessary to investigate the true structure, character and habit of the polypidom as those of the polyps. Without the nicest manipulation and observation neither can be known or understood. And as without the aid of every artificial means the very existence and nature of the whole class of recent Polyzoa could have been never known, so the polypidoms of fossil zoophytes can never be known or understood unless we go to work —to vary the words of Van Beneden applied to a kindred subject—with the hand upon the slitting-wheel and the eye upon the microscope. It is important too to remember, that even those means are vain unless we have *first* made ourselves masters of the nature and origin of the matrix itself in which the fossils are preserved. Without that preliminary, nothing but confusion and contradiction will appear in the observations. Without it, it will

be sufficiently evident that the important and satisfactory results already arrived at as to the structure of the polypidom of the Ventriculidæ never could have been attained, and without it they never can be verified.

I cannot give a more conclusive or satisfactory illustration of what may be done towards attaining a correct knowledge and just classification of the polyps themselves by a careful investigation of the true nature and structure of polypidoms superficially very different, than by reference to the labours of Milne Edwards in respect to the Tubulipores*. That writer was enabled, chiefly by this means, to correct the errors of numerous former writers, and to show the true affinities of objects theretofore grouped in most widely different relations.

If these observations are well-founded, it will follow that attention to the nature and structure of polypidoms in general is a matter of much higher importance in determining the true character and affinities of zoophytes than is generally admitted, and it will appear that a true and careful examination of the *combined* characters [not any individual points] of structure of polypidoms will afford as safe and important guides in determining the affinities, and thereby leading to a just classification, of zoophytes as is afforded by fossil bones to the comparative anatomist in his attempt to vivify the long-departed forms of mammals. No one imbued with the true idea of the Law of Unity, without which science is a mere name, can doubt but that in the one case as in the other, constant relations must exist between one part and another of the entire organization of the recent animal†.

Nor can this reasoning be in the least degree affected by any theory as to the mode of formation of the polypidom. This will be too obvious to need more than bare allusion.

The importance of the application of these principles in the investigation of a class of objects like the zoophytes, of which the polyps themselves are so perishable, will be sufficiently evident to the student either of the recent or fossil forms of this most interesting family.

To apply these principles in the present case. In the polypidom of the Ventriculidæ, to some of the principal and more striking features in the structure of which our attention has pur-

* Ann. des Sciences Naturelles, April 1838, p. 193.

† Thus the "affinity" named by Dr. Johnston as existing between the polypidoms of *Alcyonium* and *Alcyonidium* is only "apparent," being of the merest superficial character. Hence it is that I use, below, Dr. Farre's name of *Halodactylus* instead of that of *Alcyonidium*; not because I like the prevailing taste for Greek names, but because the two names *Alcyonium* and *Alcyonidium* are so nearly alike as almost necessarily to engender erroneous ideas of an affinity between the animals to which they have been applied.

posely been hitherto alone directed, many remarkable characters have been found which distinguish it at once from the polypidom of any zoophyte, recent or fossil, hitherto described. At the very first step of our inquiry into affinities we seem then, at first sight, to be put at fault. And this is true in so far as that it becomes obvious that we can range these bodies among those of no recent genus or even family. But that point alone is something definite. And further, the character of a difference is oftentimes a guide where points of analogy fail. In what respect does the structure of the polypidom of the Ventriculidæ differ from that of all other known fossil and from all known recent forms? It differs in the much higher character, the much greater complexity and delicacy of its organization; in the peculiar adaptation in it to the nature and purposes of polyzoic life. It has been seen that the polypidom of the Ventriculidæ exhibits, in the most marked and exquisite manner, *structure*,—in the true sense of that word and as opposed to that mere mechanical *arrangement* which is exhibited by most vegetable and many animal tissues, and which results from the forms taken, more or less regularly according to circumstances, by the mere close compression against each other of circular cells, which causes them to assume a hexagonal, square or irregularly angular form. The octahedral structure of the Ventriculidæ on the contrary must take rank with the highest forms of animal *structure*, as one of the most striking as well as the most elegant and delicate of the evidences which the animal kingdom can afford of design and adaptation.

The first conclusion then which must be drawn, if the principles above indicated be sound, is that the being for whose support this so delicate framework was organized must have belonged to a very high order; to a higher order than any *known* zoophyte recent or fossil.

With an indication of this kind before us, the next legitimate step in the inquiry seems to be to ask, are there any individual characters which distinguish any among the higher orders of zoophytes of which any traces can be found to have been preserved to us in the fossil forms of the Ventriculidæ?

And by a different process we are brought pretty nearly to the same point. It will be useful, as a confirmation of the value of the test above applied, briefly to allude to this. When it is found that the so-called (at one time) polyp-cells and (at another) absorbents are neither the one nor the other, the inquirer has lost hold of any hint or suggestion from any previous inquirer as to the true character and affinities of these bodies. He asks first, on entering on the inquiry for himself, whether there be no characters in common between these bodies and the single and simple zoophytes of the present day or the more simple of the compo-

site zoophytes. But he finds nothing which can connect them with any of either the *Hydrozoa* or *Anthozoa* of Owen (*Anthozoa* of Johnston). The structure of the polypidom of the *Alcyonium*, which it is desirable specially to mention as these bodies have been so often referred to that affinity, is found to be essentially different. If he refer to the excellent figure and description given on p. 176 of Johnston's 'Zoophytes*,' or, still more conclusively, if he examine the two admirable preparations by Mr. Goadby in the Museum of the Royal College of Surgeons, and which exhibit sections, transverse and longitudinal, of the same *Alcyonium*, he will perceive an arrangement of canals or tubes bound together by an irregular network, and will at once perceive that in no one point does this resemble the structure of the Ventriculidæ, in which there are no tubes whatever†. He is thus necessarily led to the same point, to which, by another means, we have already arrived, though with less suggestiveness of the true position of the objects before him.

Starting then from that point, it must be always remembered how much has been already determined as being *essential* in contradistinction to any accidental or specific characters of these objects‡. It has been shown that they formed,—though soft-bodied as distinguished from stony or from a toughly flexible

* Second ed. 1847. It is proper further to remark, that the characters assigned by Dr. Johnston (p. 174) as *generic* coincide with this figure and description. It must be presumed that those generic characters have not been assigned without a sufficiently extended observation, not confined alone to British species.

† I would refer to note, p. 35, for another marked and characteristic difference between the polypidom of the Ventriculidæ and any of the Anthozoa.

‡ Some, even shrewd observers, appear to find the greatest difficulty in divesting themselves of the influence of ideas arising from mere general external shape. This is extraordinary when there is no one branch of comparative anatomy, not to say natural history, in which its little importance is not evidenced, and errors arising from it being daily exposed. They point to the cupshaped sponges as so very like the Ventriculidæ. I admit a partial superficial likeness to *some* forms of Ventriculidæ, but that is all. And it may be a relief to such objectors to remind them of the external form of several Polyzoa, e. g. *Tubulipora patina*, which is described by Johnston, p. 267, as having a "polypidom like a little saucer:—it varies a good deal in the deepness of its centre, for sometimes it is properly described as being cupped, at other times it is so shallow that a saucer or plate becomes the best object of comparison." There is a real analogy here to the external form and habit of the Ventriculidæ: and see the forms of *T. truncata*, *T. penicillata*, &c., all much more like some Ventriculidæ than any sponges are; and Milne Edwards points out a development of roots (*ut ante*, p. 211) which forcibly recalls the Ventriculitic root. In the Museum of the College of Surgeons there has been deposited, within the last few weeks, a most superb coral from the Indian Archipelago which precisely resembles in its general external form some of the more usual forms of the Ventriculidæ.

sponge-like mass,—a firm and enduring body, not contractile*, and with a peculiar structure for maintaining its normal shape. The variety of actual form under which they are found being very great, it must be particularly remembered also that any essential character dependent on any apparent tubules, external or internal, is most distinctly and unequivocally negatived. Were other proofs wanting, this point is established by the fact that such apparent tubules are found in some few special forms only, while in the greater number of the forms of Ventriculidæ—all marked, in common with those last-mentioned, by those characters of structure above described,—and which therefore must necessarily constitute *the essential and generic* characters of the whole group—all trace of such tubules is absent. Some characters must therefore be found common to *all* these forms,—or common to many different forms, and the apparent absence of which, if undetected in others, can be explained,—before we can hope to have got any hint pointing to the affinity of these bodies with any recent forms.

Having already investigated with every care the structure of the central polypidom, while we know that in the actual integument of recent zoophytes very peculiar characters generally reside, it seems most proper to come back, for the purpose just indicated, to the more careful examination of that which has been hitherto only cursorily mentioned,—namely, what I have called the *polyp-skin*. But I have already stated how rarely this exists in any degree of perfection: hence this investigation is attended with great difficulties. And in truth the task is one so difficult that I have frequently been on the point of relinquishing all hope of being able to effect it,—when the observation of some character which had theretofore escaped attention has renewed my hopes. But for the slitting-wheel and the microscope, coupled with a careful study of the matrix, those characters must ever have escaped me.

It will be convenient, and not in strict language incorrect, if we distinguish the parts of which we have now principally to treat, as the *epidermis, cuticle,* or *polyp-skin* already mentioned, and the *dermis, cutis,* or *under-skin,* being the delicate membrane already described as immediately underlying the polyp-skin.

It will be remembered that, in the vast majority of specimens, both in chalk and flint, the central framework of the polypidom is alone preserved†. Both polyp-skin and under-skin, owing to

* In addition to the points before named, it seems obvious that the contractile theory requires that the animal should be strictly a single and not a composite one. It cannot be conceived that a polypiferous animal should have its polypiferous surface contractile over itself.

† As *Tubulipora patina* would be, stripped of its cells, and as it is actually described by Mr. Thompson. See Johnston's Zoophytes, p. 268.

their delicacy and the difficulty of extraction, are usually wanting or very imperfect. But it is these latter that must now be scrutinized.

A careful examination makes it clear that the Ventriculidæ cannot be considered, as Milne Edwards describes the *Berenicea diluviana**, as self-enveloping polyps,—one series overlying a range of the empty cells of another. Else we should find specimens of the same species having different degrees of thickness, and there would be no distinct under-skin such as I have described. It is quite clear that these polypidoms are true polypidoms, the living skeletons of living polyp-masses, and not the remains of dead polyps piled one tier above another.

The careful examination of a suite of the best-preserved specimens in my possession at length revealed to me a character which I immediately felt must prove of the utmost importance in the present question. I observed, in *casts* of some of the most perfectly preserved specimens, minute perforations extending from the surface which had been in apposition with the fossils inwards into the matrix of the cast. Further observation satisfied me that this was no accidental appearance, but that it owed its existence to the original of the fossil itself. I found traces of the same appearance also in the casts of specimens preserved in a fine state in flint in those cases in which the remains of the Ventriculite were found in the condition of an open network only, the phænomena of which have been above explained.

In order to arrive at any just conclusion from these observations, it was necessary to apply here again all the considerations which have been already noticed, as to the nature of the two very different matrices in which the Ventriculidæ are found. Those considerations showed it to have been a necessary condition that the substance, whatever it was, which gave origin to these perforations, was neither of the merely soft and readily decomposable nature of the substance which filled the central tissue of the polypidom, nor yet either composed of a minutely fibrous membrane like the fibrous parts of that polypidom, or being a single projecting fibre overspread with soft or mucilaginous matter, like a sponge. Were it the former, its place would be most usually filled up, in chalk specimens, by chalk, as the intermediate spaces of the squares have become filled up. Were it either of the latter, we should sometimes find in the flint traces of the fibres hermetically sealed, and in flint and chalk we should find the tubular incrustments and other conditions already stated as marking the former presence of the central

* Mémoire sur les Crisies, &c., Ann. des Sciences Nat. 1838, p. 228.

fibre. But none of such conditions has been ever found. It follows that a substance differing from either formerly filled these minute perforations, a substance little if at all less durable than the skeleton fibre, far more durable than the mere soft intermediate substance. Such a substance precisely answers to the terms under which a true epidermis is properly described, which is not fibrous in texture but pretty nearly homogeneous, and so strong as to have been described by a well-known modern author as "resisting suppuration, maceration, and other modes of destruction, for a great length of time*."

I have already stated that I had previously satisfied myself of the existence of a distinct polyp-skin or epidermis. A peculiar appearance of corrugation, very difficult to describe but always present in good casts, and with a vacant space between it and the actual fossil, left this beyond a doubt, though at that time no specimen had been found showing the remains of the epidermis itself preserved on the actual fossil. In specimens since found with remains of epidermis preserved, there is, of course, no such vacant space. Attached to this epidermis and of a similar nature, and at least as durable† as itself, there evidently existed during the life of the animal hair-like processes scattered over a large part of its surface.

Plate VIII. figs. 4 and 5 show examples of the appearances of casts of two very different species of Ventriculidæ, in each of which these perforations are present. It will be seen that a different arrangement of them exists in the two cases.

It would be only tedious to the reader to carry him through the whole process of induction, by which, not through any hasty conclusion, but as the result of careful and very cautious investigation, the reality seemed to force itself upon me that the sources of these perforations corresponded to those curious moveable processes which exist on the surface of some few of the higher zoophytes, and which have been well described by Prof. Reid‡. The determination may seem obvious enough on its an-

* Elliotson's 'Physiology,' 5th ed. p. 270; and see Todd and Bowman's 'Anatomy and Physiology,' vol. i. p. 414. The appearance of the polyp-skin, as preserved by the deposit in it of sulphuret of iron, and examined under the microscope, has been recognized by some of my friends wholly unfamiliar with these or other fossils as bearing a striking resemblance to the human epidermis examined in the same way.

† I have found by actual experiment that, at least in some species, the hair-like processes of recent polypifers are, though hollow, less easily destructible by maceration in *liq. potassæ* than are the other parts of the epidermis. And I cannot avoid noticing here, that on such maceration a granular appearance was assumed very similar to that of the Ventriculidæ. It is unnecessary to dwell on this effect of the potash contained in the same felspar rocks to whose disintegration the siliceous fluid has been ascribed.

‡ Ann. and Mag. Nat. Hist. vol. xvi. p. 385, &c.

nouncement thus in a few words, but it was not so easy to be made.

After I had satisfied myself as far as I was thus able upon this point, I determined, if possible, to test the correctness of the conclusion. Taking, therefore, a very fine specimen of *Membranipora pilosa**, in which the processes, exhibiting every character described by Prof. Reid, were well-preserved, I immersed its face in very finely prepared plaster of paris. On removing it after the plaster had hardened, I found, under the microscope, an appearance identical, as to the perforations, with that presented by the casts of the Ventriculidæ.

The reader who may search for these remains of the moveable processes on the Ventriculidæ, and, as many will, may not find them, and who may therefore too hastily doubt the accuracy of my observations, will do well to refer to p. 332–3 of Johnston's 'Zoophytes,' where he will find that, in even recent specimens, "they are not present in every specimen of any of these species, and indeed are very rarely to be seen on some of them, and when present it is only upon some of the cells." If this is the case in recent specimens how much more is it to be expected in fossil specimens that the traces of the former existence of these processes will be sometimes few, sometimes altogether absent! The universal friableness of the chalk and the general solidification of the flint often almost or totally obscure them. Doubtless, moreover, the originals of many of the specimens which remain both in chalk and flint were dead when enveloped,—for the views already stated require only that the soft parts should have been yet undecomposed, not that the animal should have been alive.

I am enabled, by some specimens in an extraordinary state of preservation with which frequent personal excursions into the field have rewarded my careful search, to add some description of these processes as existing in the living Ventriculidæ and derived from other observation than that of mere casts only. When the places of all are preserved, which is very rarely the case, they are disposed not without some regularity: it would appear that one was appropriated to each polyp, whose cell's mouth it doubtless swept in the living state as the mouths of the polyp-cells of the *Cellulariæ* described by Prof. Reid are swept by the processes existing in those species. As in those cases, the process was affixed to a slight projection of the polypidom on the outer edge of each polyp-cell. As in those cases also the processes tapered off gradually to a point in the Ventriculidæ, though the base of the

* In this specimen there are all the parts described by Prof. Reid as appurtenant to these processes, though Dr. Johnston does not describe the species as exhibiting them.

process was rather proportionally broader in the latter than in the former.

Any special peculiarities in these processes exhibited by any species will be noticed in the descriptions hereafter to be given of each separate species.

The discovery of these moveable processes was certainly an important and very interesting point in the anatomy, as it was an essential aid towards determining the proper position and true affinities, of the animal to which they belonged. It will be observed that these processes are affixed to the strict *polypidom*, not to any distinct and separable external cell, thus adding another to the many evidences afforded by the Ventriculidæ that the whole of every polyzoic polyp-mass is a true entire animal, of which the polypidom forms but one essential and inseparable part.

The last observation leads naturally to the inquiry—if the moveable processes are not attached to any distinct and separable external polyp-cells*, as in *Membranipora*, *Eschara*, &c., have any traces of the existence and position of the polyps been discovered? Now it is undoubtedly the fact that the surface of the vast majority of these fossils exhibits no trace of polyp-cells. And remembering that many of the most highly organized of the recent Polyzoa† present very faint external traces of cells

* The separateness, externally, of the polyp-cells is a matter more apparent than real. The Ventriculite cells were quite as individually separate, the independence of each other, therefore, of their inhabiting polyps at least as great, as in *Eschara*, *Flustra*, &c.; indeed more so, there being in the former a distinct extent of the under-skin between each. In the *Halodactylus diaphanus* the cells merely assume a hexagonal form "from their pressure upon each other." This is very inferior to the Ventriculidæ: see Farre's paper above-cited, p. 409, and above, p. 29. Space forbids me to enter so fully into this subject as I could wish, and as its importance might render desirable were it not that the line of argument would be thereby interrupted. I will do no more now than recall the reader's attention to the fact of the organized external integument common to the compound Ascidians, which the under-skin of the Ventriculidæ certainly resembles more than does the connecting medium of the *Eschara*; and to two quotations from Dr. Johnston (Zoophytes, p. 255—257) bearing directly on the point. "The cell," he says, "is in fact the outer tunic of the polyp analogous to the envelope of the compound mollusca, * * in organic connexion with the interior parts, and liable to organic changes;" and in *distinguishing* by a marked character the Polyzoa from the Anthozoa, he says, "In the *latter* the polyps are simply developments of the common central fleshy mass, identical with it in structure and texture; in the *former* each individual is a distinct organism, and the medium which binds them together, whether vascular or ligamentous, has its own peculiar character." If this is correct, there can be no doubt that the Ventriculidæ answer to the second description and not to the first, and that indeed in a much more marked manner than do *Eschara*, *Flustra*, &c.

† I use the term *Polyzoa* in preference to *Bryozoa*, first, as having a prior

when dead, I had little hope of ever finding absolute evidence of the presence of those cells in the Ventriculidæ. Even in the Escharidæ they are often obliterated, while in the *Halodactylus diaphanus* it is rarely that they can be traced in specimens preserved in spirits. Even in the recent animal they can only be detected by aid of the microscope. I was then fully prepared to find this part of my researches unsuccessful.

A very minute examination, however, of my most delicately preserved specimens at length threw some light even on this point. I found that, in all the most marked varieties of form of the Ventriculidæ, in that membrane which I have described as lying external to the central part of the polypidom and immediately underneath the epidermis, and which membrane is above distinguished as the *under-skin*, there were numerous spots, scattered over the surface, which that membrane did not fill. The size of these, though varying, as was to be expected, in different species, does not do so very greatly, and may be stated as ranging between the 100th and the 200th of an inch. These are arranged in some species with more, in others with less regularity. A very rigorous examination of such specimens, tested by sections, led me, after a length of time, to the conclusion, that these vacuities are the true polyp-cells*. I may observe, first, that they are found in the most different species, including the so-called *Ocellariæ*; secondly, that they correspond in mode of position and character to the polyp-cells of many of the Polyzoa and especially of the *Halodactylus diaphanus*, differing only from the latter in being circular, because implanted in a more strongly developed and highly organized connecting medium or tunic which is found regularly separating each one from its neighbours†,—a fact consistent with the higher degree of organization of these animals, and seeming again to point to the singleness of the entirety of the whole polypiferous mass; thirdly, but not least importantly, that I have since found specimens in which the polyp-skin is, through the deposit of sulphuret of iron as already explained, well-preserved, in which specimens these cells are seen marked with full as much distinctness in that polyp-skin as in any specimen of *Halodactylus diaphanus* or of many other recent polypifers. On

title, second, as having some significance, which *Bryozoa* has not. It is quite enough to perpetuate error by calling a class *animal plants*, without increasing it by calling one order of that class "*moss-animals*"!

* It is important to observe, as again showing the absence of any analogy with the *Alcyonium*, that not in these polyp-cells or on any part of the surface of any of the Ventriculidæ is there any trace of those stellate figures which distinguish the surface of the Alcyonidæ, and indeed of all the Asteroida, and traces of which would necessarily have been preserved had they or their related objects ever existed.

† See note, p. 35.

Plate VIII. fig. 6 is a figure of this polyp-skin in a species in which there is considerable regularity in the arrangement of the polyps.

The polyp-cells are lodged in the substance of the under-skin, extending in the plane of its thickness the whole depth. They lie at distances from one another about equal, or rather more, to their own diameter. In the *V. simplex* their figure of arrangement has a degree of regularity partaking of the *quincuncial*, a figure so characteristic of the Polyzoa. In the convoluted varieties it is (perhaps apparently only) less generally regular.

What gave a vastly greater importance to and safety in reliance on the facts thus observed, both as to the polyp-cells and the moveable processes, was this: that I found that each of them was only present in certain cases, always absent in others; and that those places where both were always absent were *constant**. Neither polyp-cell nor process is ever found on any part of the root; nor in those varieties characterized by a head,—to which I have already alluded,—is either ever found on any part of that head†. It will be felt to be necessarily consistent with the character which I have shown to mark the roots of the Ventriculidæ that neither polyps nor processes should be found there. I consider it to be the characteristic of the head-bearing Ventriculidæ that those heads are *apolypous*. The polyp-skin and under-skin are perfect on those heads,—exactly the same in all respects, excepting in the entire absence of polyp-cells and processes, as the polyp-skin and under-skin covering the rest of the body. The examination of those heads serves therefore as an important test.

Every fact observed in less perfect specimens is consistent with the important results thus obtained.

By a section most happily made, I have obtained (Pl. VII. fig. 13) a transverse view of a few polyp-cells in flint‡. The section is somewhat oblique, which it is almost impossible in such minute structure to avoid, and hence the fibres appear irregular owing to those which lie in really different planes striking the eye in the same focus. A slight variation of the focus shows that the under-skin is closely attached to the polyp-skin,—rising

* I have sometimes thought that I could detect obscure traces of cells *under* the upper part of a root on the body of the Ventriculite. This would be quite consistent with well-known phænomena, and I will only refer to Milne Edwards' paper, already cited, p. 211, for a very apt illustration of this obliteration of cells and overgrowth of root-fibre.

† The existence of this head-bearing group is another strong evidence of the unity and entirety of the whole polypiferous mass.

‡ This section was obtained long before I had satisfied myself of the existence and character of the polyp-cells; and it was only when I had satisfied myself of those facts by other means that I re-examined this specimen and found its entire consistency with those inferences.

where it rises, depressed where it is depressed, but without any distortion. The same variation shows, in perspective, other elevations than those most forward, lying beyond them, as faintly indicated in the engraving.

I conceive that the processes which I have mentioned, and which had been lost in this specimen before its envelopment, had their places upon the more elevated parts seen in the figure. If the reader will refer either to an actual specimen of *Halodactylus diaphanus* or *hirsutus*, or to the figures of the former in Dr. Farre's paper, pl. 25. figs. 2 and 3, he will perceive that the actual place of protrusion of the polyp itself is not more plainly seen in these recent specimens than in the specimen which I am describing; and the peculiar mode of drawing-in the body which characterizes this order at once explains the reason of this apparent obliteration of the cell's mouth. I apprehend that the preservation of this fragment is owing to the circumstance of its having been suddenly torn from a living animal, the portion of polypidom attached to it having lost its soft contents in, or soon after, the rupture, and the torn fragment having thus become hermetically sealed up, according to the process already described, in solid flint. Such is the actual condition in which it is found, and in no other condition or manner can I conceive it probable that any of the polyp-skin itself would be preserved in flint*.

It will be understood from what has preceded, that in the Ventriculidæ the entire exposed surface, external as well as internal, except the roots and the heads of the head-bearing species, were covered with polyps.

Another point remains to be noticed in which the Ventriculidæ are found to agree with the *Halodactylus hirsutus*.

In describing the *Alcyonidium hirsutum* (*Halodactylus hirsutus*), Dr. Johnston (p.361) characterizes it as "marked with numerous yellowish circular spots irregularly disposed;" and informs us that "these yellowish spots are produced by clusters of ova lying *imbedded in the cellular texture*." The ovarian cells of the Ventriculidæ might best be briefly described in exactly the same terms; and this mode of development of the ova is another illustration of the singleness and entirety of the whole polyp-mass†. The

* It appears obvious that from the very nature of the epidermis it would never be likely to be hermetically sealed up like an isolated fibre—since, though inclosed, there would be communication between its parts, which, over such a continued extent of surface, would not be likely to be entirely destroyed. Hence, like fibre which preserved its connexion, it would in time decay away, and either leave a hollow or be subsequently filled up by calcedony. See *ante*, p. 13. The epidermis would readily separate after death, but any fragments of it in this state would form but an indistinguishable mass whether preserved in chalk or flint.

† I had prepared an extensive series of notes illustrative of the general

ovarian cells in the Ventriculidæ lie imbedded in the substance of the polypidom, replacing, where they occur, the substance of the central polypidom, but entirely inclosed, on each surface, by the polyp-skin (Pl. VIII. fig. 3.) Their character is the same in all varieties. No polyps or processes exist on that part of the polyp-skin which overlies them. It is perhaps not unworthy to be noticed that there are generally found, on specimens having no ovarian cells, small patches, of the same shape and scattered in the same way over the surface as the ovarian cells, in which there are no polyp-cells. The suggestion naturally occurs, whether these are the spots in which, at the proper season, ova would be developed? The under-skin is entire in these places.

Sufficient it is hoped has been adduced to show that the Ventriculidæ must have been zoophytes of a very high order*; that, in point of fact, characters are found in them which belong only to the higher among the Polyzoa or Ascidian polyps; and that those characters belong to different groups among those Ascidian polyps. It has been seen that the moveable processes found in some recent Escharidæ and a few other forms were combined with some important characters found principally marked in the recent *Halodactylus*; and it is not unimportant to remark, that the *Halodactylus* is superior to most other recent Polyzoa in not being a mere aggregation of distinct cells, but in having a distinct central polypidom†, other than the membrane containing its immediate polyp-cells, and other than the remains of dead polyp-cells. The central polypidom of the *Halodactylus* is composed of a network, very irregular however, which the polyps surround on all sides. In this it approaches the Ventriculidæ, but the latter far exceeded it in the perfection of all parts of that polypidom, as they obviously did also in firmness‡ as well as in regu-

analogy between the embryology of the Ventriculidæ and that of many recent zoophytes, but I have not embodied them above, fearing that it would tend to complicate the subject and distract attention from the connected argument which I have endeavoured to set forth demonstrative of the affinities of the Ventriculidæ.

* I use the language here of those who include *Eschara* and *Flustra* among zoophytes. If they were true Ascidians, the Ventriculidæ were true Ascidians also, only more highly developed.

† This also marks *Tubulipora patina* very beautifully, whose general likeness to many Ventriculidæ has been already noticed. I have found a remarkably fine specimen in the London clay of a polypifer, folded up after the manner of *Eschara foliacea*, but with a distinct and very regularly constructed central polypidom. The species (? genus) is undescribed. My specimen is five inches square and four inches in thickness.

‡ It will occur to the reader that the security of *Eschara*, *Flustra*, &c. was ensured either by their parasitic growth or the calcareous nature of their polypidom. The Ventriculite, having neither of those characters, had the special provisions exhibited in its polypidom to secure, still more perfectly, the same objects, while the separate and peculiar nature of its root gave to its polypiferous surface a wider range and sphere than either *Eschara* or

larity and elegance of form. They thus *combined* the characters of different members of the highest orders of recent zoophytes with the *addition* of other and very important characters present in none of the latter. And those characters are peculiarly interesting as leading perhaps to some settlement of the long-moot question both as to the nature and mode of growth of polypidoms*. Let the beautiful and delicate tissue of the central polypidom—its entire separation and distinctness both from the substance and structure of the root—its investing under-skin still again differing in structure—be considered, and it must be perfectly obvious that the polypidom of the Ventriculidæ was no transudation or excretion from the body of the polyps; and it will surely be no less evident that it owed its origin to no mere vegetative principle. In addition to the peculiar character and beautifully regular structure of the whole mass, pervaded as it is with one aspect of admirable unity†, let the special adaptations of each part, as already pointed out, to subserve the ends of the preservation and safety of the whole and of each individual polyp be considered; and can the conclusion be resisted, that the entire creature, the whole polypidom with its whole array of polyps, formed one peculiar and highly organized animal, many-headed or rather with many separate special organs of nutrition undoubtedly, but still a unity, an entire animal, of which the polypidom was one constituent and essential part, which can no more be properly considered without reference to its polyps, or its

Flustra enjoy—a not unimportant point. In these very facts the higher rank of the Ventriculite seems indicated. In this case, as in those, the security of the polyps was the object of the polypidom. The more elaborate the provision for securing any end, the higher that end must be conceived to be, for nature never wastes or squanders her resources.

* An apparent inconsistency is found on this point in Dr. Johnston's valuable work, the Asteroida being described in terms exactly opposite on pp. 140 and 255.

† In all the observations as to the unity and entirety of the polypiferous mass, the whole groups of *Eschara*, *Flustra*, &c. are necessarily included. It may be matter of discussion whether the individual polyps of these are not separately true Ascidians. There can be no question, at any rate, that it is a part of the necessity of their nature to exist *always* grouped thus, and inseparably united by an organized medium. That organized medium is clearly therefore necessary for the safety and security and existence of *each polyp*; and whether we look at the mass of an *Eschara foliacea* or of a *V. simplex*, the argument is the same. That organized medium being thus necessary for the safety, security, and existence of each individual polyp, or, if you please, Ascidian, the more perfect the provision in it for that individual safety and security—and therefore for the fulfilment of the ends of the individual existence—the higher must be the rank of the creature, whether looked at as one entirety or as an aggregation of individuals. What those provisions are in the Ventriculidæ has been seen. The octahedral structure is a special and elsewhere unapproached provision for the security of the *individual* polyps (or Ascidians).

polyps without reference to it, than can the bones of a mammal be considered without reference to its soft parts, or the soft parts without reference to the bones?

Classification.

I HAVE thus described with some detail the structure which marks a large group of fossils from the chalk, and have, further, endeavoured to show what are the natural affinities of the group thus marked. The only clue has thus been obtained towards arranging, in a true and natural classification, those widely varied forms to which, under various secondary modifications, this structure belongs. The few of these which have hitherto been known have been uncharacterized except by names as various as the different writers, and which, being names merely, could leave no impression of reality on the mind of the inquirer.

It will assist the inquirer, and will much enhance the importance of the present investigation, if, before entering on the description of their modifications, something is said of the stratigraphical distribution of these fossils.

From what has already been stated, it will be obvious that these fossils require to be *sought*: they can seldom fall in the collector's way as do fossils having solid parts, Testacea, Vertebrata, &c. If found at all in the hands of the dealer they will usually be fragmentary only, or in a matrix, the flint, the deceptive character of whose obvious appearances has been already shown. By far the greater part of the forms assumed are, besides, such that no blow of the hammer can disclose the character of the fossil.

It is necessary to premise thus much that it may be understood that the fact of these fossils not having yet been recognized in particular localities or strata is no proof that they do not exist therein; and, now that the true structure characteristic of them has been described, it may be hoped that the presence of some representatives of the family may be detected much more widely than has been hitherto suspected. A mere fragment may now serve for the detection of that presence*.

As far as can be gathered from the various authorities already cited, it would appear that these fossils are more abundant in England than in any other country. In the chalk of Kent, Sussex, Norfolk, Wiltshire, and the respectively adjoining localities, some of the forms are abundant, though in each region the localities in which they abound are certainly restricted. In the chalk of Yorkshire they appear to be much less abundant. Indeed many bodies which have heretofore been grouped as *Ventriculidæ* from that region have no relation to that family; while

* Of course not for the determination of species, or, necessarily, even of genus.

the forms hitherto collected there of true *Ventriculidæ* are very rare, if we may judge from the specimens in the museum of the Yorkshire Philosophical Institution, for the opportunity of carefully inspecting which specimens I am indebted to the courtesy of Mr. Charlesworth*. In England these fossils have not hitherto been recognized in any other than the Cretaceous group. It is probable that careful search will reveal them throughout all the members of that group. At present they have been found in five divisions of it; viz. the Upper Chalk, the Middle Chalk, the Lower Chalk, the Chalk Marl, and the Upper Greensand. The prevalence indeed of certain forms is characteristic of certain of these divisions†; a result which unexpectedly displayed itself after the classification presently to be exhibited had been worked out from a cautious study of the individuals, and the value of which result must therefore strike every inquirer. The particular divisions characterized by the predominance of one or the other class of forms will be shown in severally describing those forms.

There is no *à priori* reason why representatives of these forms should not be found in older and in newer formations than these cretaceous beds. Still the fact of their not having been thus found in England, where, in those cretaceous beds, some of them so much abound, leads to some hesitation in relying implicitly on the alleged much lower stratigraphical position of some foreign forms. The foreign forms from the true chalk appear to be few and rare; but there are several figures in Goldfuss, to some of which I have already alluded‡, probably representing forms belonging to this family, which are there given as from the "Jurakalk." In the

* In addition to the acknowledgements which I have already made, I have the further pleasure of now recording the kindness, in affording me the means of examining different specimens from very various localities, of Mr. Lyell, Mr. Wetherell and Mr. Oakeshott of Highgate, Mr. Cunnington of Devizes, Mr. Catt of Brighton, and Mr. Whittle of St. John's College, Cambridge, besides that of Mr. Charlesworth as above-mentioned. I must also acknowledge the kind assistance afforded me by Mr. Waterhouse of the British Museum, in facilitating the task of inspecting the specimens in that collection. To the President of the Geological Society I am also indebted for the prompt courtesy with which he has enabled me to avail myself efficiently of illustrations from the valuable museum of that Society. I would take this opportunity of saying that I shall be greatly obliged by any illustrations and opportunities similar to those which have already been so kindly and liberally afforded to me.

† See observations in the Ann. and Mag. of Nat. Hist. vol. xx. p. 337. An interest beyond even that which they are calculated intrinsically to excite is thus given to these fossils, of the same nature as that which attaches to a series of Ammonites from different beds.

‡ *Ante*, p. 6. It is proper to state that there are many forms, besides those thus specified, figured by Goldfuss as from the Jurakalk, and which I have not much doubt are Ventriculidæ. I have only enumerated the more obvious.

British Museum, again, is a large and valuable series of fossils, which I have carefully examined, and which I can therefore state with assured confidence to belong to this family*, and which are stated to be from Mount Rhanden in Switzerland; a locality the strata of which are declared to be equivalent to the lower beds of the Middle Oolite of England. The matrix *appears* much the same as that of our English chalk marl; but that test is, of course, very incomplete. The point requires careful investigation; and, as the true character and importance of these fossils will have now become known, it may be hoped that the attention of some of the many competent foreign observers may be directed to it. As I shall show the changes which these forms have undergone in passing from one division of our English strata to another to have been great, it will be peculiarly interesting to ascertain exactly to what strata these foreign forms do actually belong; for many of them differ much from our English forms. It is interesting at present to remark that the form which is of the greatest vertical range in the English beds (*Brachiolites digitatus*) is unequivocally found in these Rhanden beds.

On p. 510 of the first volume of the Journal of the Geological Society there is described by Mr. Lonsdale, under the name of "*Ocellaria ramosa*," a fossil found by Mr. Lyell in the Eocene deposits at Jacksonborough in Georgia, United States. Did this fossil exhibit any true affinities with the group which has been called *Ocellaria* it would necessarily belong to the Ventriculidæ, and I was anxious to ascertain the facts. Mr. Lyell has obligingly enabled me to do this by placing in my hands all the specimens found by him, and which are, it is believed, all that have ever been found. The result is, that the fossil is found to present none whatever of the characters of *Ocellaria*; and I cannot understand upon what grounds it has had this name affixed to it by Mr. Lonsdale, except that he appears, from his observations, never to have had an opportunity of examining any actual specimens of the so-called *Ocellaria*, and to have been misled by some of the figures†. These fossils however answer to no part of the generic description given by Ramond, or any subsequent writer, of the *Ocellaria*. The tubules in the Eocene fossils are tubules ramifying through a massive substance, and there is not any polyparium which is "*explanato-membranaceum*," and "utro-

* These treasures are at present unarranged. I should be happy to assist in that task, and to complete it by adding, as far as possible from my private collection, all the British forms, should the present Commission result in any prospect of improvement in that department.

† The figure specially referred to, and which is copied by Lamouroux, pl. 72, fig. 5, has certainly a considerable resemblance to a special fractured surface of the Eocene fossil.

que latere porosum." The characters of *Ocellaria*, as given by all the authors*, are clear and unmistakeable so far as they go; and there cannot be a moment's doubt as to what the true relations of the so-called genus are, as will presently be seen. It is perfectly certain that this so-called *Ocellaria ramosa*† has none of these relations, and therefore that it does not serve to bring the Ventriculidæ within the tertiary period. No trace of this family has, then, yet been anywhere discovered higher than the upper beds of the English chalk.

As it is desirable to have the treatment of the subject as complete as possible, so far as it goes, and as the materials which I have collected from the English chalk are sufficiently abundant to lead me to hope that such completeness may be given, for all practical purposes, to the description of the forms found in those beds, I shall confine myself at present to these last; which I the rather do in that, while it would be *à priori* probable that the examination of so extensive a series of beds would at any rate afford a full series of typical characters,—and therefore a sound basis for a permanent and generally applicable system of classification,—the examination of the Rhanden specimens in the British Museum has satisfied me that all of them will range within the typical groups which the forms of the English chalk have led me to assign.

I have already indicated‡ in what direction we must look for the essential characters which mark this whole family. It is extremely improbable that a structure so extraordinary, so peculiarly bearing the marks of special design and adaptation as the octahedral structure, should be otherwise than characteristic of the family in individuals of which its existence has been discovered. Until, then, it has been found elsewhere, the philosophical inquirer will take that structure as his guide in the deter-

* Those characters are, "Polypier pierreux, *aplati en membrane*, diversement contourné, subinfundibuliformée, à superficie arénacée, muni de pores sur les deux faces." The observations of Milne-Edwards, on an inspection of the actual fossils, are alone sufficient to show that the present fossils could not be *Ocellariæ*, their apparent tubules being, as stated on p. 511, sometimes penetrated by fibres in a radiated manner. Milne-Edwards expressly says (Lamarck, Anim. sans Vert. ii. p. 291), "L'axe *solide*, qui remplit assez ordinairement les trous, et qui a été pris pour une partie du Polypier lui-même, n'est que la gangue qui s'est moulée dans ces trous, et qui s'est cassée au niveau de la surface du Polypier, lorsque celui-ci a été détaché de la masse qui le renfermait."

† The fossil is however a very curious and interesting one. Its whole aspect and character recall those of the Alcyonium, both in its massiveness, its cylindrical tubules, and their connecting plexus of fibres. I have many analogous fossils from the chalk, into the investigation of which it is my intention to enter when the present subject shall be completed.

‡ *Ante*, p. 31.

mination of the members of this family. My careful attention has therefore been directed to ascertaining the presence of that structure under every various mask of external form, and I have hitherto invariably found that presence accompanied by certain other characteristics, which would necessarily be present if the affinities which I have already attempted to show are those of the Ventriculidæ be the true ones. Without full confidence in the Law of Unity as a sure guide, I cannot conceive of any progress being made in any scientific investigation. I have not found that guide to fail me yet in the present investigation, and am therefore content to take it as the basis of such exposition as I am now able to give of the genera and species of the family VENTRICULIDÆ.

Proceeding therefore on this basis, it may be stated generally, that all those fossils which are marked by a membranous structure made up of cubic squares, with equally subtending octahedral fibre at the angles of union of those squares, belong to the family Ventriculidæ, and that all members of that family are marked by that structure. We shall find, it is true, thus associated, forms externally most diverse*, and the alleged affinity of which would at first sight startle the inquirer; which have indeed hitherto had places the most different assigned to them: but I shall be able to show that other and most interesting Unities prevail through all these various forms in addition to that structural one; and these diversities will thus become only another useful addition to the often repeated but too often neglected lesson, that no guide is more fallacious than likeness or unlikeness of mere external form†.

"A natural classification," says Milne-Edwards, "is nothing else than a description of the modifications, more or less important, observed in the structure of animals, and a specification of the differing degrees of likeness or unlikeness which the latter bear to each other‡." Nothing is easier than the multiplication of genera and species. But it is no slight task, though a most important one, to determine what are the material modifications on which distinction of genus should be founded; what the ma-

* On the other hand, I shall take a future opportunity of showing that forms externally bearing much resemblance to the Ventriculidæ have in truth a very different structure and affinities.

† Parkinson long ago remarked, that "if the *figure* of the fossil be assumed as the leading character of the species, substances, differing materially in their structure, will be classed together in the same species; and, on the other hand, if the species be formed on the external *structure*, we shall have under the same species substances differing widely in their forms." Vol. ii. p. 128. It would have been well if Goldfuss and others had paid a little attention to these important truths.

‡ Sur les Crisies, &c., p. 233.

terial points of likeness or unlikeness which should mark separate species*.

The only principle upon which I can understand any philosophical or natural classification to be founded, is the taking some principal and most easily recognizable point in the œconomy of the living animal, and examining all the individuals under review in reference to that one point. Can we apply this test in the present case? It has been already seen that the Ventriculidæ belong to a high type of the Molluscan Polyps,—to the Polyzoa,—approaching most nearly to the recent *Eschara* and *Halodactylus*. The fossilized remains of animals of this order, the organization of whose recent congeners has been but so lately understood, might seem at first sight to baffle any attempt to seize on such a point. It seems to me however that such a one may be found. In all recent animals of this order the first essential to their life and well-being is the presence and free access of the sea-water. Various contrivances are adopted to secure this end,—some genera and species being parasitical, some loosely floating, some stiffly erect; each, varying as they also do in form, adapted to the peculiar circumstances of the locality which it inhabits, and each, according to the particular plan adopted, exhibiting some characteristic differences in habit and organs. This is precisely consistent with the observations already made† as to the constant relation existing between the polypidom, *rightly examined*, and the nature of the inhabiting polyps. Such differences no doubt existed in the recent Ventriculidæ; and though it is obviously impossible that we should ever be able, in these fossils, to ascertain the points of difference in habits and individual organs, we may, by care and patience, ascertain those differences in the contrivances displayed in the structure of the polypidoms which we must thus be satisfied were intimately and necessarily connected with such differences in habits and individual organs. I allude to the various modes of folding of the delicate membrane‡ which forms the framework of every individual of this family, and on whose surface the minute and numberless colony of polyps dwelt. I ap-

* Were I to follow the example of some botanists, who, for example, in a favourite tribe, the *Cactus*, have amused themselves with hair-splitting of genera to a marvellous extent, I might readily succeed in perplexing the inquirer with a great multitude of unintelligible names. Between many of the species which I have grouped together, differences far more marked exist than those by which these gentlemen—and too many palæontologists—have overlaid the intelligibility of their classifications as *generic* distinctions.

† *Ante*, p. 26–28.

‡ A membrane, it will be remembered, which, by its structure, was firm like the *Eschara* (though not calcareous), and not loosely floating like the *Halodactylus*. This is important in considering the permanence of the different modes of folding adopted.

prehend that it can need no detail of argument or mathematical demonstration to show, that upon the mode and degree of folding of this membrane, the greater or less freedom of access, change, and circulation of the water, and its consequent power of being acted upon by the numerous ciliated tentacles and moveable processes, must have depended. Every one who is familiar with the difference in mere circulation of air between the narrow street and the open road, between the deep valley and the hill top, will recognise the essential importance in this respect of every difference in that mode and degree of folding; and, when the extreme minuteness of the individuals is considered, it will appear that variations of fold hardly appreciable to the eye will have probably had a material influence on the condition of the tenants of these wonderful structures. I cannot doubt that every *constant* difference in the mode and degree of folding of the Ventriculitic membrane was accompanied by some modification in the organs or habits of the animals, adapting them to that particular mode and degree of access, change, and circulation of sea-water which that mode and degree of folding made a matter of absolute necessity*.

Taking then the Ventriculidæ as a family of the *Polyzoa*, I shall first endeavour to show that there are certain broad and very marked constant modifications in the mode of folding† characterizing certain extensive groups which yet have many points of constant difference between the individuals which, as groups, are respectively thus characterized. These groups will form distinct genera. I shall show that certain subordinate but yet important modifications mark, in common, several of the individuals of each of these genera, which individuals yet have further still subordinate but constant and therefore characteristic points

* Sir J. G. Dalyell, in his recent work on 'Remarkable Animals of Scotland,' especially notices the importance of attention to the *varying* condition of the water in which specimens are kept as the great secret of their preservation; and even his care has often failed. A "low organization" and slight sensibility have been hastily attributed to Polyzoa from their enduring great changes of heat and cold. There is no animal capable of enduring greater changes in this respect than man. But take another class, and it is well-known that from the same heap of frozen fish one may be dashed to shivers on the ground, while another, put into a pail of water, will, in two minutes, be swimming about.

† The inquirer will at once perceive the difference between this and mere external form. The same general external form may mask numberless most different modes of folding. My object is to aid in realizing, by classification, the living animal in all its integrity and varieties. By the accumulated names *Scyphia*, *Coscinopora*, *Guettardia*, &c., nothing ever was or can be vivified; no real idea conveyed to the mind. But the object of the naturalist should surely be, not an accumulation of mere *names*, but the realization of living and true ideas of various absolute modes of actual existence, be they past or present.

of difference. The inquirer is thus further relieved from the detail of specific differences by the division of each genus into sections. The still subordinate but constant points of difference last named will be characteristic of species.

I have already alluded to the important and valuable test of the soundness of these principles of classification afforded, unexpectedly and after the work was completed, by the stratigraphical harmony exhibited by the table of classification. It will be sufficiently obvious that the ocean of different ages would have such modifications as would not be adapted equally to all varieties. We accordingly find among the Ventriculidæ, as in other divisions of palæontology, a few species enduring through many changes; others dying out; while with every fresh æra fresh forms display themselves.

It will be understood from this, that mere *size* does not enter as an element into the determination of genus or species. Of many species I have specimens from an inch to eight or nine inches in diameter. It is not necessary to enter very fully, therefore, into the question of *growth*. That question, always a difficult one in palæontology, is difficult even in recent forms of the families allied to the Ventriculidæ. It would be vain to hope to throw much light upon it by fossil forms. Where *constant* differences are found under all varieties of size, we are bound to consider them as distinct species. I shall touch briefly on the question of growth in introducing each separate genus.

It will be also understood that the mere external (outward or inward) general *form* of the fossil does not enter as an element into the determination of genus or species. I have shown how deceptive that criterion must ever be. In the present instance the same general external form conceals essential differences in the mode and degree of folding of the membrane.

It will occur to the reader that to follow the fold of a membrane, the trace of which is preserved only in a hard and solid matrix, must be a work of great difficulty; and especially when that matrix is either so friable as the chalk, or so impracticable as the flint. The actual amount of the difficulty* cannot however be fully appreciated without actual experiment. The presence of that very oxide of iron, without which the forms could not be, in general,

* In order that the actual nature, importance, and results of the present investigation should be properly understood, it is necessary to remind the reader that from the time of Dr. Mantell's first work to his latest, and either by him or the other latest writers (see Portlock's 'Report, &c.' p. 342), it has never been suggested or suspected that *any membrane whatever existed* in any of the Ventriculidæ. They all describe them as composed of anastomosing "*cylindrical fibres*," (see *ante*, p. 4,) between which, on the inside, papillæ or tubuli arise. I have demonstrated that the basis of the Ventriculidæ is a simple unperforated membrane; that, therefore, the

even detected, necessarily stains the matrix beyond the structure itself; and it requires the nicest and most painful discrimination to determine what is due to structure and what to mere iron stain. Feeling however that such a course of investigation could furnish the only true materials of a natural classification, I have endeavoured to overcome these difficulties. And it may save the task both of making and answering many objections if I now state that I have, with this object, dissected with elaborate care numberless specimens, in addition to many hundreds of sections of specimens both in flint and chalk, which, with the like purpose, I have made. There is not one species which I have established which I have not determined from actual and personal section of specimens either in chalk or flint, usually both, and in which, with scarcely an exception, I have not followed and traced out the actual fold with the knife and needle.

My aim has been to present such a classification and nomenclature as should be intelligible and at the same time expressive; which, whether respect be had to genus, section, or species, should give some accurate and specific idea of the point on which the respective division has been founded; that thus a mere inspection of the table of classification may carry with it some real and true ideas as to the objects included*. The name

descriptions so long before the world, and so often repeated, are fundamentally erroneous,—the conclusions as to the œconomy of the animal being necessarily, therefore, as fundamentally erroneous. It is upon the same laborious care which has enabled me to demonstrate these facts, that I rely in attempting the descriptions now to be given of the different *modes of folding* assumed by that membrane, and the superficial appearances of which have misled these observers.

* It is usually unadvisable to alter names once applied; but where the character of an object has been wholly misunderstood, not even its generic or structural character having been known (see the last note), there can be no claim to retain old names. Their retention is then generally mischievous as a mere perpetuation of error. I fully agree with Dr. Farre (*ut ante*, p. 405, note) that oftentimes "confusion and doubt (in nomenclature) can only be dispelled by beginning *de novo*," and so applying new names in harmony with a system founded in nature and upon some definite principle. I think it better to give here all the names which occur in Mr. Morris's Catalogue whose objects appear to belong to the Ventriculidæ,—a list which will, moreover, show the "confusion and doubt" which have hitherto prevailed in the nomenclature of this family.

Names in Morris's Catalogue.	*In the following classification.*
Choanites flexuosus	Ventriculites latiplicatus.
Choanites subrotundus	Cephalites constrictus.
Ventriculites alcyonides [Ocellaria]	Ventriculites quincuncialis.
—— alternans	Probably V. bicomplicatus.
—— Bennettiæ	One of the Cephalites annulati, but no accurate description; and the figures of Michelin and Mantell totally differ. (V. cavatus)
(V. infundibuliformis)	

applied to the whole family and to the first genus is the only apparent exception to this rule*. The name *Ventriculites* would certainly not have been applied to any of these bodies, or to the family, by myself. It was applied by Dr. Mantell to the few forms found by him, under the idea of the internal cavity being the true digestive surface of a single animal. Though the idea under which the name was thus applied has been shown to be wholly erroneous, I have been unwilling, out of respect to the many labours of Dr. Mantell in the field of palæontology, to reject, as others have done without assigning any reason, this generic appellation; and I have justified myself in its retention by the classical use of the same word, though in a secondary sense only, in a very different way, viz. as applied to mere sacciform cavities†. It will be understood, therefore, that the terms *Ventriculidæ* and *Ventriculites* bear no reference to any *digestive* cavity, but simply to the fact of the creatures to which they are applied always assuming forms which display a central cavity more or less simple. I am glad that this modification in the meaning of the word enables me to retain a name which will always bring to the inquirer's recollection the long and successful labours of Dr. Mantell.

It is impossible to examine an extensive series of remains exhibiting the characteristic structure of the Ventriculidæ, without perceiving that, however widely in other respects the individuals differ from one another in the mode of fold of their membrane, they all range themselves within one or the other of three strongly marked and constant modifications, quite independent of mere size.

The first in natural order, as having most of that simple *pouch* form which is implied in the name *Ventriculidæ* as above ex-

Names in Morris's Catalogue.	*In the following classification.*
Ventriculites infundibuliformis	Ventriculites cavatus or bicomplicatus.
—— quadrangularis	Brachiolites angularis.
—— quadratus	? not a Ventriculid.
—— radiatus	Ventriculites radiatus.
Ocellaria inclusa	—— quincuncialis.
—— nuda	Ibid.
Spongia Townsendi	Ventriculites simplex.
—— labyrinthica	Brachiolites convolutus.
Scyphia Fittoni	Fragment of Brachiolites digitatus.

* The termination "*ites*" is not in itself very classical, but has been so generally employed as to be a convenient and intelligible distinctive mark of *fossil* generic appellation. Hence I retain it in "*Ventriculites*," and am therefore obliged so to terminate the other generic names. I am glad to be able to retain, consistently, Dr. Mantell's specific name *radiatus*.

† Thus Cicero: "Ex ea [anima] pars concipitur cordis parte quadam, quam *ventriculum* cordis appellant, cui similis alter adjunctus est in quem sanguis a jecore per venam illam cavam influit."—*De Nat. Deor.* ii. § 55.

plained, are a large number whose general form is that of a more or less open or close sac, the wall of which rounds or thins off to a marginal edge. All of this kind are single, and supported on a single root, unless in those few abnormal cases before mentioned*, and which afford no exception to the principle either of the structure or classification. Where, as very rarely occurs, two are united, it is at the roots that they are united. They are not branches of one body.

All these forms I distinguish by the name of VENTRICULITES.

Next to these are naturally placed another group, all the members of which are much rarer than the last, most of them of great rarity, but yet exhibiting a diversity of forms as great, well-marked and constant as the different individuals of the genus *Ventriculites*. All however are marked by the very striking peculiarity of the wall of the pouch not thinning or rounding off to a marginal edge, but being crowned by a broad and distinct head, prominent and well-defined, and totally differing in aspect, structure, and function from the rest of the body. This characteristic suggests, as peculiarly appropriate, the generic appellation of CEPHALITES.

The two genera thus distinguished each exhibit, though with striking modifications, more or less of the simple pouch form in their internal cavity, or of obvious singleness in the general shape which the fold of the wall of their cavities, or their apolypous head, assumes; but a large group remains to which neither character applies, and all the members of which stand out conspicuously as folded in many lobes and in many broadly separated parts. The word *brachium* being often used by the best authors in the sense of projection simply, I use the diminutive of that word to distinguish all of this group by the name of BRACHIOLITES.

But, again, the individuals comprised within the description of the genus *Ventriculites* are found to exhibit two broad modifications in the general aspect of the membrane composing the wall of the pouch. The two sides of the wall correspond in the one group, both surfaces being either smooth, or, if marked with folds, the depression of one side having a corresponding elevation on the other; in the other this correspondence is absent, owing to some change in the direction of the fold before reaching the opposite surface, as already alluded to†. It will materially assist the memory and researches of the inquirer if we accordingly divide the genus *Ventriculites* into two sections, which I distinguish by the names *Simplices* for those species having corresponding surfaces, *Complicati* for those which change the direction of their fold between the two surfaces.

* *Ante*, p. 18.

† *Ante*, p. 16.

So the individuals comprised within the description of the genus *Cephalites* exhibit two broadly-marked modifications; the head of the one group being only of the same breadth as the thickness of the wall, and being placed exactly at the top of that wall, and nearly at right angles, at every point, to the outer and inner surfaces of that wall; the head of the other group being much broader than the thickness of any part of the wall, and never lying flat at the top, but extending more or less down over the sides of the wall. These marked differences are accompanied by important differences in the mode of fold of the membrane. I distinguish therefore the genus *Cephalites* into the two sections *Annulati*, being those in which the head extends as a mere broad ring round the flat top of the wall, and *Dilatati*, being those in which it is spread out so much more extensively.

And so also the members of the genus *Brachiolites* are at once separated into two groups, by the remarkable circumstance that some of them have the extremities of those projecting lobes into which they are divided *open*, others *closed*. The latter I distinguish as the sectional division *Operti*, the former as *Aperti*.

I shall hereafter point out the minor modifications accompanying these more striking ones, and endeavour to show the final purposes of the respective modifications themselves.

It will of course be well understood that, as in every class of fossil forms the exact determination of the species of individual specimens is often difficult, frequently impossible, such must sometimes be the case with respect to the Ventriculidæ. The conditions under which they are found render them peculiarly liable to this difficulty; and the inexperienced observer who has not yet learned to distinguish that which is a mere *cast** from a specimen in which some of the actual body is preserved,—a task of no slight difficulty, and only to be successfully undertaken after acquiring a full knowledge of structure,—will often find himself baffled in the attempt at specific identification. Hence the importance of attention to those sectional and generic characters already noticed, and which he will rarely be unable to distinguish.

These broad modifications, and the respective relations thereto

* Michelin's *Ocellaria grandipora*, pl. 40. 3*a* & 3*b*, is a mere *cast* of external and internal surfaces. The imperfection and indefiniteness of almost all the figures yet published have been already noticed (*ante*, p. 6–8). It would therefore be a useless attempt to endeavour to identify them. Objects of this class require to be well understood before they can be truthfully represented by figures. The figures of Dr. Mantell are no exception to this remark, as they only give the broad external characters of one species (which they however do) without any indication of the mode of fold of the membrane which gives rise to those characters, and the very existence of which membrane Dr. Mantell denies.

of the minor modifications, will be the better understood from the following table of classification, in which I have arranged the species belonging to each genus in such relative position as should best display the transition from one general character of folding to another, and thus gradually realize the true relations existing between the very different forms which lie at the two extremes.

Class MOLLUSCA TUNICATA *.

Order Polyzoa †.

Family Ventriculidæ.

Ventriculites, *Mant.*	Cephalites.	Brachiolites.
§ *a.* Simplices.	§ *a.* Annulati.	§ *a.* Operti.
1. simplex.	1. longitudinalis.	1. tuberosus.
2. impressus.	2. guttatus.	2. elegans.
3. quincuncialis.	3. paradoxus.	3. convolutus.
4. muricatus.	4. alternans.	4. angularis.
5. tessellatus.	5. bullatus.	§ *b.* Aperti.
6. cavatus.	6. retrusus.	1. foliaceus.
7. striatus.	7. catenifer.	2. racemosus.
§ *b.* Complicati.	*Var.* annulatus.	3. digitatus.
1. mammillaris.	8. compressus.	4. tubulatus.
2. latiplicatus.	§ *b.* Dilatati.	5. fenestratus.
3. decurrens.	1. capitatus.	6. labrosus.
Var. tenuiplicatus.	2. campanulatus.	7. protensus.
4. radiatus, *Mantell.*	3. constrictus.	
5. bicomplicatus.	4. perforatus.	

* It is quite beyond my present purpose to discuss the exact position of the Polyzoa. The main truth of Professor E. Forbes's opinion is however so generally recognized, that I am justified in the above designation of *class*, which must always be felt to be an important element in giving vitality to a classification. Professor Forbes says, "The anatomical structure of the Ascidioida or Bryozoa removes them altogether from the class of Zoophyta into that of Mollusca, where they should form an order of Mollusca tunicata parallel with the group of compound Tunicata of which *Botryllus* and such forms are examples."—Ann. and Mag. of Nat. Hist. vol. xiv. p. 390. See Owen's Lect. on Comp. Anat. I. pp. 100 and 269, 270; Van Beneden, Recherches sur les Bryozaires, p. 37; Johnston's British Zoophytes, p. 2. (See also Thompson and Farre.) The actual and important distinctions are noticed by the last writer, p. 256; and the vast superiority in vital activity of the Polyzoa to the Ascidians, is well pointed out by Sir J. G. Dalyell (*ut ante*) pp. 229, 230. I have heretofore used the general term "zoophytes" in conformity, as already intimated (*note*, p. 39), to what is at present the ordinary language of authors, and a departure from which would, therefore, have caused ambiguity and unnecessary confusion. [The reader may be usefully referred, hereon, to the earlier pages of Forbes and Hanley's 'British Mollusca.']

† *Thompson*; Bryozoa, *Ehrenberg*; Ciliobrachiata, *Farre*.

Descriptions of species.

Family VENTRICULIDÆ.

Character. Structure. Polypidom membranous: membrane composed internally of fibres arranged in several—usually five*—layers of cubic squares, equal, for the most part, in the plane of thickness and of superficies, and connected at all their angles by other fibres having a regular octahedral arrangement: exterior to this, both within and without, a dermis composed of a single layer of smaller squares, and in which the polyps are lodged, usually on both surfaces: exterior to this a simple epidermis: roots distinct, less regular in structure and without octahedral fibre.

Habit. One or more central cavity, the principal opening to which is at the top: roots ensheathing base of polypidom and extending below into radicles; never affixed to solid bodies.

The details which have been already given render further observations on the characters of the family unnecessary.

Genus VENTRICULITES.

Character. Pouch-shaped; varying greatly in size and dilatation: cavity single and regular: membrane forming the wall of the cavity either simple and smooth on both surfaces or more or less closely and regularly folded (thus giving it a rugose character): margin of wall thinned or rounded off to an edge: polypiferous on both external and internal surfaces.

The structure of all the Ventriculidæ is obviously designed for the purpose of securing permanence of form, and thus safety and free access of water to all the individual polyps. This object is here effected by two means: first by the very remarkable structure of the membrane already described; secondly, by the regular, often nearly hemispherical figure which the whole body assumes.

Specimens of *Ventriculites* are found of all sizes, and it can easily be understood that, from the earliest period of their development, the same general form is assumed, which, as they increase and spread, is still retained. Thus the question of their growth seems to involve fewer difficulties than, at first sight, strike the observer in respect to the other genera.

The access of sea-water was well secured in this genus, inasmuch as, though the folds of some species are close, the expan-

* I believe it to be always five; but the difficulty which exists, from the causes already named, in ascertaining these minute points in all individual instances induces me thus to qualify the generality of this character.

sion of the whole mass and relative size of the central cavity are usually greater than in any other genus, thus compensating for the frequently looser nature of the fold in the other genera. It may perhaps be inferred that the ocean in which this genus dwelt was subject to such modifications that its waters were less liable to disturbance than those of the ocean in which *Cephalites* and *Brachiolites* originated; so that a larger size could be attained in safety, and with less multiplied provision for security against such disturbances.

The whole genus *Ventriculites* is characteristic of the upper chalk. I have a few specimens which may possibly have come from the middle chalk*; but every such case is doubtful, while I have carefully ascertained that the mass are certainly from the upper chalk.

§ *a. Simplices.*

Inner and outer surfaces corresponding.

1. *Ventriculites simplex.* Pl. VIII. fig. 1†.

Membrane simple and without trace of fold: moveable processes minute or absent.

This is the type of the whole family, and it is a most happy circumstance that it exists. That existence at once destroys all the theories as to the anatomy and physiology of this group of fossils which have been suggested from examination of some special forms only; while it affords the means of demonstrating some important points. It appears to be a rare species, as, though I am fortunate in having myself obtained a very perfect series, I have certainly never seen half a dozen specimens out of my own cabinet.

When the underskin and polyp-skin are absent, as most often happens, the specimen, if uninjured, is particularly beautiful. It exhibits, over its whole surface, with the utmost regularity, that square arrangement of fibre, with the subtending octahedra, already described. When the underskin is present without the polyp-skin the squares are not seen, but the whole surface is covered with a much smaller-meshed tissue which appears dotted all over, the dots being the polyp-cells. When the polyp-skin is present it hides each of these appearances, and is marked only

* See Ann. and Mag. Nat. Hist. vol. xx. p. 337.

† It is not possible to give illustrations, in this work, of all specimens of full size, several of them often exceeding in diameter the size of the page. It will be understood, therefore, that all the specimens of the present genus figured on Pl. XIII., with the exception of fig. 9, are of specimens below the usual size.

with slight depressions in the places where the dots are seen under the conditions last named.

The traces of the moveable processes appear slight, often quite wanting, in this species. This is what might be expected if the object of those processes was to sweep the surface clear of obstructions from the mouths of the cells. The surface being plain, such obstructions would be far less liable to accumulate around it than near those rugose surfaces which other species present, and on the most rugose of which the processes are most strongly marked.

I have specimens varying from 7 inches to 1 inch in diameter.

It appears to me that the fossil called by Dr. Mantell *Spongus Townshendi* (South Downs, p. 164) is nothing more than a *V. simplex*, in flint.

2. *Ventriculites impressus.* Pl. VIII. figs. 2 & 3*.

Membrane more or less slightly folded at upper part, but generally without regular figure: moveable processes frequently conspicuous.

The basal portion of this species is usually plain like *V. simplex*, but it soon exhibits marks of fold. These are sometimes slight, sometimes deeper. They vary much in different specimens, so that it might be thought advisable to distinguish varieties. It has seemed to me, however, better to include all under one name only. They may be generally known at once by the basal portion being quite plain as in *V. simplex*; by the much less depth of the folds than in the next species; by the depressions being usually more or less oval instead of round; and by the want of any regular figure in the arrangement of the folds.

This being the first species in which the membrane is folded, it will be well to consider the principle, if any, upon which the fold in all the Ventriculidæ is arranged; and also to inquire whether the polyps existed, during the life of the animal, over the inner parts of all the folds.

To treat of the latter question first: I have already intimated that, as a general rule,—exceptions may, as in *Eschara* and *Flustra*, be found to this general rule,—both external and internal surfaces of the Ventriculidæ were polypiferous. And notwith-

* The object of fig. 2 is to illustrate the very deceptive appearances which the difference in the state of perfection of the fossils will occasion. On the lower part of that figure all remains of the actual body are lost. On the upper part an *Ostrea* is seen, and, near it, a small part of the actual body remains. The difference between this and the rest of the figure must be very apparent.

standing the closeness of the folds in many species, I believe that the inner parts of all the folds were polypiferous also. The inquirer familiar with recent Polyzoa will find no difficulty in realizing this as true, as he will be aware that these minute creatures are often packed in spaces so close, that it would seem to be, and perhaps is, impossible that all should be protruded at the same time. This fact has attracted the attention of all observers. Dr. Farre notices that the individuals of *Halodactylus diaphanus* "are so closely set that there seems to be hardly room for their several operations;" and that, on this account, it is often "scarcely possible to make any observations upon them" even with the microscope*. And the most recent writer on the Polyzoa, Sir J. G. Dalyell, in his 'Remarkable Animals of Scotland,' calls attention several times to the extreme complexity of the mass and to the difficulty of even microscopic observation on that account †. And in the plates of both these writers (pl. 25. fig. 1, Farre; pls. 43, 44 A, &c. Dalyell) the same fact is well shown. It thus becomes obvious that, in recent allied forms, individuals are packed in positions quite as close as, if not closer than, in any of the Ventriculidæ, and in positions apparently more hazardous to the free action of the individuals themselves, inasmuch as the form of the recent species specially referred to is less fixed and unyielding than, from the very nature of their structure, the Ventriculidæ have been shown to have necessarily been.

Having thus shown that there is no improbability that in fossil forms the surface should have been thus closely covered, in all its parts, by the polyps, I will add, that the results of positive observation establish the fact that the inner parts of the folds in the Ventriculidæ were thus polypiferous. I have carefully dissected several folds in specimens, both in chalk and flint, in which the fold is the closest of any species, and I have found, by aid of the microscope, the presence of the polyp-cells clearly and unequivocally marked.

With respect to the arrangement of the fold, the elaborate dissection of many individuals of more than thirty different forms of Ventriculidæ has fully satisfied me that here, as elsewhere, Unity is prevalent; and that the fold of the membrane forming the wall of the pouch is not capricious and without method or principle, as at first sight it might appear. I have fully satisfied myself that every form and variety of fold‡ which different species of Ventriculidæ exhibit is based on a modification of the

* As before, p. 405.

† See, *inter alia*, pp. 233, 234, as to *Cellularia loriculata*.

‡ It is necessary to distinguish the folding of the membrane forming the

simple *plait*. Unimportant as the question may, at first sight, appear, it is in reality of much importance. Every illustration of the Law of Unity is, and ever must be, interesting to the student of natural history, and important as the surest indication that some point of truth has been attained. And without the guide of some simple unity of this nature, it would be quite impossible to make the structure of the different species of Ventriculidæ understood by the inquirer. The multiplied dissections which I have made is a labour which few would have the inclination, and as few the opportunity, to undergo.

In the present genus and section we shall meet with one species in which the form of the simple plait is found without any modification. In the present species, and in several others, the primitive plait is not so obvious; but the comparison of several specimens, and especially, as is so often the case in the illustration of a Law of Morphology, of particular instances assuming a somewhat abnormal character, will enable the careful observer to trace, even in these species, this primitive plait. The limits within which I am necessarily restricted prevent me from entering more fully into, and illustrating at greater length, this question, —which I certainly regard as one of very much interest and importance. In the present section of the genus *Ventriculites*, in which every depression of one side answers to an entirely or nearly corresponding depression on the other, the existence of the plait is less material to the understanding of the character of the wall of the pouch than where the fold assumes that complexity which it does in the section *Complicati*. I shall dwell only slightly upon the point, therefore, in describing individuals of the present section, leaving the fuller illustration of it to those specimens from which the illustrations of Pl. XIII. figs. 13, 14 and 15 are drawn, and which will I hope satisfy every careful and candid inquirer that the most apparently differing external forms may depend on the different modifications which the upper and lower fold of a simple plaited membrane may undergo.

3. *Ventriculites quincuncialis*. Pl. VII. fig. 7, and Pl. XIII. fig. 11.

Membrane deeply folded, usually from base to margin, of nearly equal width the whole depth of the fold, and in regular quin-

wall of the pouch, where the whole body is a single pouch, from the subdivision of the body itself into distinct *lobes or branches* as found in *Brachiolites*. It will presently be seen that the wall of these lobes and branches is marked by the same characters as the wall of the single-pouch forms now under more immediate consideration.

cuncial figure: moveable processes conspicuous: wall often thick.

In this, as in the former species, must be included forms which, at first sight, vary to a considerable extent, but which I conceive to mark either distinct varieties or distinct ages. It is however almost impossible, in specimens in a good state of preservation, to mistake the species, the characteristic type of fold being found in all with little variation. The wall is usually much thicker than in *V. impressus*, and the fold begins from the base. In some specimens the fold is so deep that a thickness of nearly two lines, —sometimes even more*,—is attained in the wall of the pouch. The folds are almost equally broad down their whole depth, so that in this species the general aspect, both external and internal, is level, contrary to what takes place in *V. muricatus*, and which difference will best be understood by comparing figs. 11 and 12 of Pl. XIII. which represent sections of these two species†.

It occasionally happens that the outer surface is not quite so regularly marked as the inner, though still each depression on one side is accompanied by a corresponding elevation on the other. This variance is probably owing to some circumstance connected with the process of the fossilization of the individual. Hence even a partial angularity in the margin of the folds is, in some such specimens, seen on the outer surface of the wall of the pouch. Such specimens appear to have been partly crushed before or during fossilization. The inside preserves all the usual regularity of the fold.

It occasionally, though rarely, happens that the quincuncial figure is not maintained; in all specimens there must necessarily be places where it is not truly kept, owing to the mode of increase of the animal from base to margin.

The so-called *Ocellariæ*, so often mentioned, belong to this species. What are thus named are either young specimens, or the lower parts of full-sized ones. These are usually nearly cylindrical at the upper part and taper very gradually to the base; or form, altogether, a very acutely pointed inverted cone.

There is no species which affords more entire disproof of the contractile theory than this. It is obviously impossible that any membrane should contract in the way in which this form exists, —and with no variation whether forming a close cylinder or an almost flat disc.

I am well-aware that this is the species to which appeal will always be made in opposition to the views which have been stated

* I have an instance in which the thickness of the wall exceeds a quarter of an inch.

† In the specimen figured on Pl. VII. fig. 7. the folds are unusually narrow, but the quincuncial character is well-displayed.

as to the fold of the membrane. It will often be triumphantly referred to as affording evidence of perforation. There may be no *primâ facie* reason why the Ventriculidæ should not, like the recent *Retepora*, have been perforated. When however it is found, through a vast number of differing forms, that one plan, that of the folded membrane, has been unquestionably adopted; and when it is found that in no other case in which Ventriculitic structure is present is a thickness of more than five of the solid squares attained by any part of the fold which forms the wall of the pouch, while it is found that, in this species, the thickness of the entire wall *varies* from one line to three lines,—thus exhibiting, if the actual wall be but a perforated mass, the extraordinary and, upon every principle, anomalous fact of there being no *constancy** in the structure of the central polypidom; there is certainly every reason to conclude that Unity is not violated in this case, and that, like others of the family, this is truly a folded and not a perforated membrane. The various deceptive appearances which the mere fossil may put on have been already more than once remarked. In the examination of the present species, above all, the greatest skill and care are necessary, because it is obvious that the very depth and narrowness of the fold must, if any abrasion or injury of the external surface† take place, destroy the traces of the membrane covering the top of each depression, and because the small size of the depressions and elevations renders it very difficult to follow the fold which forms them from one surface to the other. Feeling therefore to the fullest extent the difficulty of ascertaining the actual *fact* in this case, and at the same time the importance of ascertaining that fact, both as an exception, if it should prove such, to the Law of Unity, and as a determination of a point in palæontology which has been now mooted for more than thirty years, I carefully dissected numerous specimens, both in flint and in chalk, and both with the slitting-wheel and the needle, and followed up and down the so-called (sometimes) cells or (sometimes) perforations to their terminations. The clear and unequivocal result has been that the so-called *Ocellaria* is no anomaly: that the Law of Unity has not its exception here; that this is a true case of fold of membrane: finally, that I have at this moment before me specimens in which

* It will be obvious to the careful inquirer that there is nothing anomalous in the varying depth of the folds, inasmuch as, in all species, that depth will naturally be dependent, more or less, on the age of the individual.

† In every instance, both in chalk and flint, with very rare exceptions, some of the body adheres to the matrix. In the present species, where the bases of the folds are so small, it will necessarily, therefore, often happen that just those bases adhere to the matrix. Hence alone will result an apparent perforation of the wall, the remains of the membrane not being present, and not therefore traceable, over those bases. See Pl. XIV. fig. 14.

I can as clearly see the fold in and out of that membrane as it is seen in fig. 11. Pl. XIII. I wish to be specific and precise on this point because I know that a bare description will be questioned. I am obliged to state that such a reality as is represented "magnified" on p. 279. fig. 2 *b* of Dr. Mantell's 'Medals of Creation' never had existence * in the nature of the animal of which fig. 2 gives a view of the natural size of the fossilized remains.

In the museum of the Yorkshire Philosophical Institution there is a fragment of a specimen of this species almost discoidal, which still measures more than nine inches across, and, when entire, must have been of still greater size. This is an unusually large size for the species to attain, but the variation in that respect is very great. There is another interesting specimen of this species in that museum in which the whole body has become converted into chalcedony. The outer surface is nearly entire, as is also a considerable part of the inside. The structure is, as usual in solidified chalcedonic specimens †, obliterated throughout the greater part, but it can, in places, be still clearly traced. The individual underwent pressure before or during the process of fossilization, and also some decomposition, so that the external character has become somewhat modified, and it is only in parts that the internal arrangement can, at places of section, be seen. The peculiar state of the specimen,—solidly chalcedonic without the presence of any true flint,—renders it however very interesting ‡.

4. *Ventriculites muricatus.* Pl. XIII. figs. 1 & 12.

Membrane deeply folded, without regular figure: folds unequal in width throughout their depth: moveable processes often conspicuous: wall of moderate thickness.

The point wherein this species differs most essentially from the last will be at once understood by comparing figs. 11 & 12 of Pl. XIII. It has been already explained that, through the uniformity in the breadth of the fold, the general surface of *V. quin-*

* And see p. 280: the polyparium of this species is no more "calcareous" than that of any other of the Ventriculidæ. Treated with acid it is acted on in precisely the same way and to the same extent as are all specimens of Ventriculidæ preserved in flint, and leaves an exquisitely delicate cast of the body of the animal and of the structure of its polypidom.

† See before, p. 13.

‡ It has already been stated (p. 14), that "*in general* when any part of the soft substance of a body encased in chalk decomposed, its place was soon filled up with particles of chalk." The above instance is one of the rare exceptions to this general fact; and the peculiar condition of the Yorkshire chalk (which is much more compact than that of Kent, &c.) may lead us to expect more numerous instances of these exceptions from that region than from the chalk of the south-east of England.

cuncialis is smooth. It will be perceived that where, as in fig. 12, the folds are broad on each surface at their margin and narrow to a point at their base, the effect must be to give to the whole wall of the pouch a rough surface. The wall is usually not very thick. I have never seen it attain so great a thickness as *V. quincuncialis* often does. The height and depth of the folds render it difficult ever to confound it with *V. impressus*, in which also the same smooth general appearance of the surface as in *V. quincuncialis* is usually maintained, and for the same reason as in that species.

5. *Ventriculites tessellatus.* Pl. XIII. figs. 2, 3, 4.

Membrane folded in regular quadrilateral and rectangular figures usually more or less oblong: wall of moderate thickness.

In Mr. Morris's Catalogue mention is made of a *Ventriculites quadratus*, and reference is made to Goldfuss, pl. 33. fig. 1. I have already* stated that this is no Ventriculite. The description is, "*seriebus pororum oblongorum rectis parallelis decussantibus*," —an error into which I cannot conceive it possible that Goldfuss could have fallen if he really had the present species before him. And the magnified sketch given in fig. 1 *b* of the same plate,—unless fancy and not actual observation be there copied,—differs as widely from any characters of the present species, and from any form of Ventriculitic structure, as does the description which has been cited.

This form is rare; and it is still rarer to find a perfect specimen. I have several fragments, excellently well displaying structure and fold, and during the summer of 1847 I was fortunate enough to find a perfect specimen, with roots and margin, and both body and cast, entirely perfect, and five inches in diameter; but I was so unfortunate as for it to break in pieces before I could convey it home, a danger to which the collector of these delicate fossils is peculiarly liable. Though this loss is not easily to be replaced, the opportunity of verifying the entire form of the species was important. The rarity of the species has prevented me from making sufficiently extended observations on the moveable processes to state, with confidence, anything definite in regard to them.

In this species the plaits may often readily be traced, with the oblong depressions running along them on each face of the wall. This being borne in mind, the figures often displayed on section will readily be understood, when, instead of the regular alternation of depressions seen at one place of section, as in fig. 4

* Ante, p. 6.

(Pl. XIII.), the character represented in fig. 3 will, at another place of section, be seen.

6. *Ventriculites cavatus.* Pl. XIII. fig. 5.

Membrane folded in concavities of considerable breadth, rarely regular in disposition: wall of moderate thickness: moveable processes often well-seen.

This species can never be confounded with the last. The shape of the fold, its sloping edges, and the want, in general, of regular figure, at once distinguish it. A linear arrangement of the depressions is often traceable, marking the places of the primitive plait.

This species might readily be divided into two or three varieties, marked by the fewness or abundance, the small or large size, and the greater or less degree of regularity, of the folds. The principle of the fold,—which in all cases is the groundwork of the present classification,—appears however to be the same in all these cases, and they may, not improbably, be but modifications indicative of a difference of age. The concavities are usually somewhat elongated in specimens of which the pouch is closely cylindrical.

In this case, as in all others, it is necessary that both sides, or a good section, of the specimen should be examined, as *V. radiatus* will be found to be marked on the inner surface by characters bearing some superficial resemblance to those distinguishing both surfaces of the present species, while *V. bicomplicatus* bears, both on the external and internal surfaces, characters which may sometimes mislead the observer. A section of the present species however will show the wall much thinner and the cavities shallower than in either of those species, while, in well-preserved specimens, the entirely different character of the fold cannot fail to be seen.

7. *Ventriculites striatus.* Pl. XIII. figs. 6 & 13.

Membrane folded from base to margin in regular close and simple plaits: processes very conspicuous: wall of moderate thickness.

This is an exceedingly interesting and very marked species. The plaits, which have heretofore been traceable only by careful comparison and an effort of induction, become in this species the one characteristic feature. Not a trace is present, on either surface, of the "tubuli"—assumed to be polyp-cells or absorbents—of Dr. Mantell, and the presence of which is expressly stated by him to be characteristic of the genus and species*; upon the assumption of which indeed all his views and descriptions have

* See ante, p. 5.

been based. The inquirer will be well-prepared for this entire absence of any such tubuli from its having been seen that, in the preceding species, the depressions (which alone are what could, even on a superficial observation, be called tubuli) have the greatest diversity of form and character, a diversity which at once negatives their being of the nature assigned to them by Dr. Mantell. It has moreover been seen that, as a matter of fact, they are in no instance tubuli, but that they can, on the contrary, be traced as folds of the membrane forming the polypidom itself.

On the other hand, the present is the only species which could seem to lend any support to the contractile theory. The observer however who has studied the several preceding species will probably ask for no proof that the present does not stand out as an anomaly and an exception from them all. If he need such, he may be referred to the observations already made *, generally, on the matter. These have full application in this as in every other case, and sufficiently show that this species offers no violation to that Unity which prevails through every branch of the present inquiry.

Different specimens vary in the size and depth of the plait. It is suggestive, perhaps, as before, of difference of age. It is where the plait is deepest and broadest that the moveable processes become most conspicuous.

The plaits are not narrow at the base and of increasing size as they approach the margin. They maintain the same size from base to margin, and the increase of surface is effected by the increase in number of plaits as the margin is approached; an increase effected by the division, from time to time, of one plait into two,—each of equal size with the original one,—a mode of increase which generally prevails in all species in which the plait can be distinctly followed. The species is not common.

§ *b. Complicati.*

Inner and outer surfaces not corresponding.

1. *Ventriculites mammillaris.* Pl. XIII. figs. 7 & 14.

Inner plaits simple and regular: outer plaits raised in large hollow bosses at regular intervals: processes very conspicuous: thickness of wall considerable.

This is the first instance in which we find the direction of the fold changed between the external and internal surfaces. There is no species more strongly marked, and none which affords a better illustration of the value and importance of a principle of Unity as the essential and most valuable means to true scientific

* Ante, p. 17.

research. The fact of the mammillated external appearance of this species is easily seen and as easily recorded: so is also the fact of the striated internal appearance. But it would be difficult, by any description, to make it clearly understood how such apparently contradictory appearances could result from the folding of a simple membrane*, until it had been ascertained, by careful and multiplied dissections, that this and all other characters of the fold of the membrane forming the wall of the pouch are grounded upon one single and simple unity of plan of which all present clear and intelligible modifications.

On the outside of this species as usually seen in a fossil state, and as it must usually have appeared in a recent state, no mark of the plait is seen. Large rounded elevations scattered, at first sight irregularly, over the whole surface, are all that meet the eye. If however the reader will carefully consider figs. 13 and 14 of Pl. XIII. he will see, in fig. 13, the simple plaits, regular and uninterrupted, within and without, as in *V. striatus*; while in fig. 14 he will see that the perfect plait is still present, and that the *inner* surface [the lower part of the figure] is still simple and uninterrupted, but that the *outer* plaits are interrupted along their whole length by rounded elevations,—not solid, but hollow, —elevations of the membrane into those shapes instead of the plait being plain and simple. These figures are somewhat exaggerated in size in order that the principle may be more clearly understood.

It will be found that in each of the forms which follow, and

* As the extraordinary complications in the fold of the membrane of many species were gradually developed by multiplied dissections, I long despaired of being able, by any descriptions, to make them understood. When by degrees the unity of plan which I have endeavoured to indicate above, as the groundwork of all that complexity, opened upon me, I felt an important key to have been obtained, which experiment proved to be applicable to every case. I indulge some hope that the development of this unity may be of a utility beyond the mere understanding of the forms now under discussion—however interesting those may be to myself and others. In the descriptions of numerous tissues in human and other branches of anatomy, I have often myself felt the want of some clear and simple basis of unity in the descriptions attempted of those tissues; which want has caused them to be often unintelligible. Any pains which the investigation of the present subject may have cost will be more than rewarded if the suggestion of an unfailing unity in the arrangement of all complex tissues shall be felt to be (as I cannot doubt that it is) generally applicable. It seems to me, that as, by application of this principle, forms varying so entirely as it will be found that many of the Ventriculidæ do in mere general external characters, and therefore heretofore classed in entirely different natural groups, are now demonstrated to belong to one group, so the application of the like principle may, in many points of anatomy, lead to the discovery of intimate relations, not now suspected, between tissues which appear very different in structure.

which appear so widely different from each other in all that meets the eye of the general observer, the characters which each exhibits may be as readily understood as in the present species by taking as the basis that simple Unity of plan which has been thus illustrated.

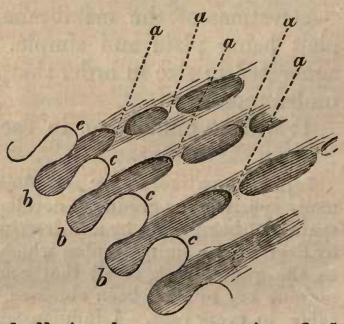
2. *Ventriculites latiplicatus.*

Plaits very broad and deep: outer plaits simple and regular: inner plaits inclining, at intervals, towards, and anastomosing, a little below the surface, with, adjoining plaits: wall very thick.

This is a very interesting species. It presents us with the first instance of the plaits departing from their entire individuality, and of a connexion being formed between adjoining ones. In the present species that connexion is merely by a slight anastomosis at distant intervals. There being no depression in the plait, on either surface, the access of water is perfectly preserved without any additional provision such as we shall find in *V. radiatus* and many others.

In *V. mammillaris* the departure from the simple plait took place on the outside. In the present species it takes place on the inside, and is more marked in its character and degree; but it is none the less an illustration of the principle of Unity which it has been endeavoured to explain, being clearly but a modification of the simple plait. This will be understood from the following figure, in which *b, b, b* are the lower plaits; *c, c, c,* the upper plaits; and *a, a, a,* the points of anastomosis. We shall, in the next species, find the complexity of the fold much increased.

Fig. D.



The wall of this species is thicker than that of any other species of the genus *Ventriculites.*

3. *Ventriculites decurrens.* Pl. XIII. fig. 8.

Plaits often irregular in direction: outer plaits constricted at distant and unequal intervals: inner plaits depressed at short and nearly equal intervals; bulging on each side around depressions till adjoining plaits meet and open into each other: processes conspicuous: wall of moderate thickness.

Var. *tenuiplicatus.* Pl. XIII. fig. 9.

Plaits close and delicate: outer plaits nearly regular in direction

from base to margin with slight occasional constrictions: inner plaits depressed at regular intervals; bulging on each side around depressions till adjoining plaits meet and open into each other: processes conspicuous: pouch very often nearly cylindrical: wall thin.

Marked specimens of these two varieties are very distinguishable, but, upon the principles to which I have confined myself in discriminating species, I do not think it proper to separate them; the elements of the modification of the fold being similar in each variety. Specimens in which the two varieties run into each other are not unfrequently found.

The variety *tenuiplicatus* is a most beautiful and delicate fossil. I have several specimens on which the polyp-cells are finely seen.

In examining each of these varieties the importance of the clue afforded by the principle already explained of Unity in the fold of the membrane becomes strongly felt. Let the reader compare figs. 13, 14 and 15 of Pl. XIII., always remembering that fig. 13 is the basis of every modification. In fig. 15 he will see the *lower* plait [it is immaterial for the present purpose whether that is to be looked at as the inner or outer surface] retaining its simplicity, while along the top of the upper plait he will see a series of circular depressions at short and equal intervals. At the sides of these depressions the membrane bulges out,—in order to preserve the walls of the plait below the depression clear from contact*,—until the bulgings on the two adjoining plaits meet and anastomose. These then open into each other in the centre of the place of anastomosis, leaving, however, below them and on each side a clear space; so that strength and security are gained to the whole mass, and, consequently, the safety of the individual

* This is but one other among the numberless beautiful illustrations afforded by the anatomy of the Ventriculidæ of obvious design and adaptation. Did these walls touch, there would be a great loss of surface and little or no additional strength. By the actual arrangement there is a vast gain of both surface and strength, as well as an additional security for free access of sea-water to all parts of the inner surface. It has already been seen that this additional provision not being needed in *V. latiplicatus* is not found in that species. It is proper to add, that the fact that, around the depressions, the adjoining plaits do not only anastomose but *open into each other* has been ascertained by most careful examination and dissection of specimens in chalk and in flint; but that, having clearly ascertained the fact in instances where there is thus such an obvious purpose for such an arrangement, I cannot doubt that, under similar circumstances of structure in adjoining parts, such is always the arrangement of the fold in this particular, though the minuteness of the parts generally prevents the possibility of clearly distinguishing it in chalk specimens. The place of the opening does not usually exceed, in the necessarily somewhat collapsed state in which it is exhibited in the fossil condition, the 40th of an inch in diameter, a space which the iron stain in the chalk is more than sufficient to obliterate.

polyps is ensured, together with a great increase of polypiferous surface.

I am aware of no instance among the Ventriculidæ in which a mere ridge or flap of membrane is added on,—as this would practically be if the membrane forming the sides of these depressions came in contact with that forming the sides of the plaits. There are, on the other hand, very many cases in which, as in the present species, additional strength to the whole mass is afforded by a means which gives a very great additional surface for the development and security of that life, the manifestation and multiplied means of enjoyment of which were the end of the existence of the whole creature.

On each side of the places where these meeting bulgings blend, the vacant spaces between the plaits put on, naturally, from the shortness and regularity of the distance between the bulgings, a circular form. As one of these must, of course, lie between each double pair of the depressions, a quincuncial figure is thus assumed by the whole (see the darker spots in fig. 15 of Pl. XIII.). The inquirer will thus at once understand the appearance presented by the inner surface of many species of Ventriculidæ. He will clearly see that the "tubuli" of Dr. Mantell are things without existence. He will understand that though, at the surface of a fossil of which all the interstices are filled with chalk, all the circular marks appear alike, yet the dissection of alternate rows of them will reveal very different conditions; one row consisting of more or less shallow (in the present species usually rather shallow) and closed depressions; the other having no true depressions at all, but consisting of cavities extending to the bottom of the intermediate plait, and indeed, before and behind, underneath the intermediate bulgings, running into and forming part of the longitudinal cavity of that plait.

The wall of the variety *tenuiplicatus* being usually thin, the depressions on the inner plaits, though shallow, are sometimes to be seen through on the outside, if the specimen has come very clean out of the chalk. It is very rarely, however, that specimens can be got out of the chalk in this clean manner, portions of the matrix usually filling up the spaces between the plaits. In the recent state, and when, instead of being in the collapsed condition in which we find the fossils, the animals were alive and fully distended with all their fluids*, no doubt the lower surface of all the depressions on the top of the inner plaits could be seen from the outside. The living creature must have appeared as composed of a number of plaits which, on their inner surfaces,

* Every reader must perceive the difference between the comparative states of *collapsion and distension* and those of *contraction and expansion.*

exhibited numerous shallow depressions; and which plaits, on each side of these depressions, were united together by small transverse tubules, the mouths of which tubules were directed towards the *outer* surface of the whole body, and opened, always, into the interspaces between the outer plaits.

It will be obvious that sections, whether made longitudinally or transversely to the plaits, will vary in numberless ways in the figure which will be seen, according to the particular point of the plait through which the section passes. This must be remembered when the section seen at the edge of a flint or fractured chalk specimen is examined. This observation applies as well to the present species as to almost every other which will subsequently come under notice.

The plaits of *V. decurrens* are not very regular in their course. On the contrary, the outer plait, where the course is easily traced, is often very winding, though several generally run parallel to each other. The constrictions occur at irregular and distant intervals, and cause the surface to appear as if several of the round elevations of *V. mammillaris* had run together down the surface, —a modification which may truly be considered to represent the fact. Hence the specific name. The constrictions do not extend the whole depth of the plait. They do not appear ever to extend so deep as to interfere with the mode of fold characteristic of the inner surface. It is owing to the winding course of the plaits in this species that the rings seen on the inside do not assume, as in *V. radiatus*, a perfectly regular quincuncial figure; the places of the depressions and accompanying characters of structure varying, of course, in places, as the plait winds. In *V. tenuiplicatus*, where the plaits are more regular, the quincuncial figure on the inside is correspondingly more regular. The constrictions on the outer plaits of that variety are much slighter than in *V. decurrens*. They resemble much more a very slight exhibition of the normal characters of *V. mammillaris*. They thus rarely interfere with the continuous course of the plait.

4. *Ventriculites radiatus*. Pl. XIII. figs. 10, 15.

Plaits broad and deep: outer plaits regular, and with an occasional lateral connection: inner plaits deeply depressed at short and equal intervals; bulging on each side around depressions till the adjoining plaits meet and open into each other: processes very conspicuous: wall thick.

I have retained for this interesting species the name *radiatus* of Mantell, as being the species which comes nearest in superficial external and internal appearance to his descriptions already cited*.

* Ante, p. 4.

This species unites the characters observed in *V. latiplicatus* and *V. decurrens*. In the former mere points of connection exist, on one surface, between the plaits; in the latter the remarkable depressions, bulgings and openings into each other last described exist, also on one surface only. In the present species the latter characters are found on the inside, the depressions being, however, deeper than in *V. decurrens*; while, the plaits being deep, they exhibit, on the outside, and at distant intervals, points of mere connection (no depressions being present on that surface) as in *V. latiplicatus*.

The difference between the constrictions which mark the outer plaits of *V. decurrens*, and the points of connection, without any constriction, which exist between the outer plaits of the present species, is alone sufficient to distinguish the two. In addition to this, however, the present species is much thicker and more massive than *V. decurrens*; it often attains a thickness in the wall of the pouch nearly as great as *V. latiplicatus*. The regularity in the direction of the plaits is another distinguishing character.

Owing to the regularity of the plaits in this species, the figure assumed by the inner folds is very regularly quincuncial.

The inquirer must be careful not to be misled by inspection of an inner surface only into determination of this species, as such surface in either *V. cavatus* or *V. bicomplicatus*, especially the latter, and sometimes in *V. decurrens*, will be difficult to distinguish. It cannot be too often insisted on that parts of both surfaces, as well as sections, should be examined before determining species with certainty.

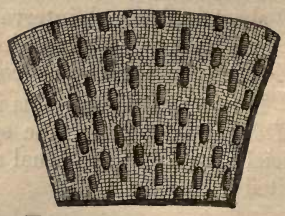
This species is very local in its distribution, being very rare in many places.

5. *Ventriculites bicomplicatus.*

Plaits broad and deep: both outer and inner plaits deeply depressed at short and equal intervals, which alternate in adjoining inner and outer plaits; bulging on each side around depressions till adjoining plaits open into each other: processes very conspicuous: wall very thick.

In the present species we meet with a much greater complexity of fold than in any preceding one. The plaits on both surfaces undergo a marked modification which resembles the modification seen on the inner plaits of *V. radiatus*. The form of the depressions on the external surface are, however, generally oval instead of round, as in fig. E.

Fig. E.



The descriptions which have been given of the mode of fold on the inner surface of *V. decurrens* and *V. radiatus* render it unnecessary to dwell on the nature of the modifications which the present species exhibits, and which are but the reduplication of the remarkable characters exhibited in the species just named. It may be suggested, however, that sections of this species will vary so much, according to the direction in which they are taken, that no one figure can be depended on as certainly indicative of the species, without very extended and careful comparison. Notwithstanding, however, the complexity of the folding in the present species, the application of the observations already made in respect of *V. decurrens* will make it clear that the free access of sea-water would be perfectly maintained to all parts of the very extended polypiferous surface which is thus gained.

In all these deeply folded species we have seen that the moveable processes are very conspicuous. They are thus conspicuous on that portion of the fold which is most exposed. There would obviously not be room for their operation within the folds, and the traces of them are not found there as they are on the external surface. If their object be that which has been suggested*, their presence and action on this exposed external surface would be amply sufficient for the protection of the polyps in the deeper recesses of the folds, and the presence of the processes there would be useless. The absence of their marked development in those parts is therefore in harmony with that admirable adaptation of means to ends which the results of every part of the present investigation have displayed.

In examining the various and complicated forms which have been thus noticed as included within the genus *Ventriculites*, nothing is more striking than to find that, be the wall of the pouch thick or thin, the thickness of the membrane itself remains always the same. It may be folded up in the most complicated way, but it still retains, in any single piece of it, precisely the same characters as have been described as typical in respect to *V. simplex*. Were other facts wanting, this would alone go far to induce the conclusion which other courses of investigation have already seemed to demonstrate, viz. that we have before us a true Polyzoic *polypidom*; and that polypidom one of the most admirable construction and contrivance. No less interesting illustrations of that conclusion will be found in the widely different forms and modifications of folding which remain to be examined.

* Ante, pp. 34 and 56.

Genus Cephalites.

Character. Pouch-shaped: very constant in size and dilatation: cavity usually regular and with a single opening; sometimes winding and with more openings than one: membrane forming the wall of the cavity always deeply folded: marginal edges—and, sometimes, most prominent points—of the plaits attached to a simple apolypiferous membrane stretched across their whole breadth and forming the upper margin or head of the wall: membrane of wall polypiferous on both external and internal surfaces.

The differences between the genera *Cephalites* and *Ventriculites* are so broadly marked that, except in one or two species, it would be difficult to confound even fragments of the two. In every species of *Cephalites* the head is conspicuous and unmistakeable. This very remarkable peculiarity is alone sufficient to distinguish the genus*.

The provisions found through the whole family of Ventriculidæ for ensuring the free access of sea-water to all parts of the surface, and for securing permanence of form as one great means to that end, have been already noticed†. The present genus offers fresh and most remarkable illustrations of those provisions.

In every species of this genus the fold is, comparatively to the size of the whole body, much deeper and broader—in many species positively much deeper and broader—than in any species of the genus *Ventriculites*. The size also is much smaller than the average size of the *Ventriculites*; the height of specimens of the present genus seldom exceeding two inches, rarely attaining three inches‡. The form is never expanded, as usual in *Ventriculites*, but, with few exceptions, approaches nearly to the cylindrical, as in *V. tenuiplicatus*.

Extent of surface was thus gained in this genus by the increased depth and complexity of the fold. But this depth and complexity would endanger the safety of the polypiferous surface were there no special provision for maintaining the normal position of the individual plaits. This was perfectly effected, and at the same

* See ante, p. 51.

† Ante, pp. 46, 54. It was the circumstance of the Ventriculidæ being polypiferous on *both surfaces* that rendered these provisions so necessary. In *Halodactylus*, &c. one surface only is polypiferous. See note ‡ p. 46.

‡ Hence all the figures of this genus are of specimens of average size. I have much pleasure in acknowledging here the pains and care bestowed by Mr. Sowerby over these plates. The novelty of the forms and structure presented many difficulties, especially as the engravings were made only from my drawings. But nothing can be more generally successful or truthful than the figures which Mr. Sowerby has realised.

time with great simplicity and beauty, by stretching across the flat upper edges, or, in a few cases, the more prominent points*, of the plaits a simple and entire membrane†, which, spread over the whole breadth of those edges and from point to point of those prominences, retained all the plaits securely in their position; thus ensuring the safety of the whole colony and of the entire polypidom which was covered by it. See Pl. XIV.

The general constancy in the size and form of specimens of this genus throws difficulties in the way of the question of growth. It is not easy to understand why we do not find young individuals of this genus as of *Ventriculites*. It has occurred to me that, probably, the ocean in which this genus dwelt being, apparently, a more disturbed one than that in which the *Ventriculites* dwelt‡, and the head possibly not forming till a certain age and size had been attained, individuals dead or destroyed below that age very rapidly lost their form and are therefore found only as shapeless masses. I do not suggest this solution of the difficulty, however, without considerable hesitation.

The whole genus *Cephalites* is characteristic of the Middle Chalk. I have never found a single specimen which I could with any probability refer to the Upper Chalk, though it may be expected that some forms will be found which endured into that later epoch. Certainly none have been ever yet found in the Lower Chalk.

§ *a. Annulati* §.

Head narrow and flat: plaits compact and regular.

1. *Cephalites longitudinalis.* Pl. VII. fig. 1, & Pl. XIV. fig. 1.

Plaits delicate but often deep: outer plaits slightly winding: inner plaits depressed at short and regular intervals; bulging on each side around depressions till the adjoining plaits meet and open into each other: processes very conspicuous: wall moderately thick.

This species much resembles in external aspect the smaller cylindrical specimens of *Ventriculites tenuiplicatus*. It is however smaller than that species usually is, the plaits less winding, and

* These latter cases form, however, no exception to the principle of the marginal edge of the plaits being always attached to the cephalic membrane. The cases in which prominent points of the plaits are attached to the head are cases of an *additional* provision for security. In those cases, as in all others, the marginal edge of the membrane, after having undergone all its varied modifications of fold, reaches and is attached to the head. See the description of *C. campanulatus* and *C. constrictus*.

† As to structure and nature of this see ante, pp. 24, 37.

‡ See ante, p. 55. § See ante, p. 52.

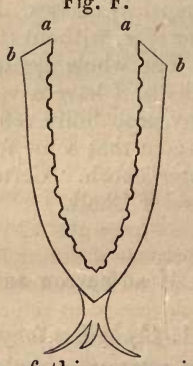
the wall thicker. The depressions on the inside also are generally smaller, closer, and more regular than in that species. The head alone is sufficient to distinguish the two at a glance.

This is the only species of *Cephalites* in which the longitudinal fold remains unmodified on the outer face. Hence its specific name. A transverse section of it is seen on fig. 1 of Pl. VII.

It is a rare and delicate species: indeed all the species of the present genus are rare. They do not seem to have abounded in the older seas of the Middle Chalk as the *Ventriculites* did in the Upper Chalk. Though thus rare, however, their modifications are not the less clearly marked.

In regard to the head it is proper to remark, that while, throughout the present division of this genus, its breadth will always be found a very near approximation to that of a transverse section of the plaits, there is a slight variation in this respect in individual specimens. The head often slopes a little outwards, so that a section of the entire body presents an outline as in fig. F, in which *a*—*b* is the section of the head. The outline of the head is always quite as sharp and well-defined as in this figure. The relative arrangement and proportions of the head and the plaits are such that specimens of this division can never be confounded with any belonging to the section *Dilatati*. It is very rarely in the present division that there is any rounding, or departure from the nearly flat character of the head; a character, on the other hand, never present in the *Dilatati*.

Fig. F.



It is proper to notice that, in every species of this genus, in order to give full strength to the head, the depressions, bulgings, and other modifications of the fold,—where it does not rise, as in *C. campanulatus*, in a simple form,—are so arranged that the membrane of the inner wall, where it adjoins the head, is always, and that of the outer wall most frequently, expanded by a lateral bulging of the plait, so as for the adjoining plaits to meet just at the point of union of the wall with the head. Thus the whole of the inner, and often of the outer, edge of the head is *continuously* attached to the wall, an arrangement of much importance. On this inner edge the membrane often rises up in a narrow and slightly prominent ridge above the otherwise smooth surface of the head.

2. *Cephalites guttatus*. Pl. XIV. fig. 2.

Plaits broad and deep: outer plaits raised in large hollow bosses, often elongated; adjoining plaits having an occasional lateral

connection : inner plaits depressed at regular intervals ; bulging on each side around depressions till adjoining plaits meet and open into each other : processes very conspicuous : wall usually thick.

Nothing can better express the usual character of this species than the term *guttatus*. The outer surface looks exactly as if sprinkled with drops of a viscid fluid which had just begun to run together, in some instances to a greater, in others to a less extent. It is thus generally well distinguishable, even on the outside, from *Ventriculites mammillaris*. The plaits being much broader than in *C. longitudinalis*, the depressions on the inner plaits are larger than in that species.

The lateral connection between adjoining external plaits, as in *Ventriculites latiplicatus* and *radiatus*, which is only rarely seen in *C. longitudinalis*, is always more or less present in this species, and furnishes another characteristic by which it may be at once known from *V. mammillaris*.

3. *Cephalites paradoxus*. Pl. XIV. fig. 3.

Plaits narrow but deep : outer plaits depressed irregularly ; bulging around depressions till the adjoining plaits meet and open into each other : inner plaits regular and simple : processes conspicuous : wall thick.

I have given to this remarkable species the name *paradoxus*, because it differs from every other species of this genus in having the plaits simple and regular on the inside, while all the complexity is on the outside.

The depressions, and consequently the interspaces between the anastomosing bulgings on the outside, are not of a regular figure, as is the case on the inner surfaces of *Ventriculites radiatus* and other species. They are varying and elongated ; often almost angular ; though, as the plaits are narrow, never very large. There do not appear to be any points of anastomosis* between the adjoining inner and regular plaits, such as are found between the outer plaits of *V. radiatus*.

4. *Cephalites alternans*. Pl. VII. fig. 2, & Pl. XIV. figs. 4 & 5.

Plaits rather broad and very deep : both outer and inner plaits depressed at unequal intervals ; bulging on each side around

* The appearances seen on dissecting away the inner surface must not be mistaken for this anastomosis. They are, in fact, the bases of the depressions on the outside of the outer plaits. See the description of a similar appearance on the outside of *V. tenuiplicatus*, p. 68.

depressions till the adjoining plaits meet and open into each other: processes conspicuous: wall thick.

The mode of fold in this species resembles that of *Ventriculites bicomplicatus* in the fact of being repeated on the plaits of each surface. It differs essentially, however, in the fact that the depressions, though generally round, are, on neither surface, at regular intervals: consequently no regular figure is assumed in the general aspect of either surface.

I have named the species *alternans* from the circumstance of the repetition on the two surfaces of the same manner of fold; while the straight plait is clearly traceable in the central portion of the wall. A transverse section of a specimen of this species is seen on Pl. VII. fig. 2. Its difference from a similar section of *C. longitudinalis* is very marked.

This is an extremely rare species.

5. *Cephalites bullatus.* Pl. VII. fig. 3, & Pl. XIV. figs. 6 & 7.

Plaits broad and deep: outer plaits raised in large and very prominent projections at considerable intervals, and in such manner that they range spirally round the whole body: projections nearly lozenge-shaped and terminating abruptly in an almost flat and somewhat expanded top, having a slight depression from the upper angle towards the middle: inner plaits having large circular depressions at equal intervals; bulging on each side around depressions till adjoining plaits meet and open into each other: processes very conspicuous: wall very thick.

This is a most curious and interesting as well as rare but well-marked species. The depressions on the inner folds are much larger than in *C. guttatus,* which latter have been seen to be larger than in *C. longitudinalis.* But the external fold is the most deserving of attention. When the specimen is first opened there are seen only a number of nearly semilunar marks. On carefully applying the point of the knife it is found that this semilunar appearance is caused by very prominent projections, the tops of which are all closed, but have a partial depression at their upper extremity, and which depression is filled as usual with the matrix. The projections themselves are of large size, measuring about two lines in their longest diameter. They stand out nearly or quite half the thickness of the wall, which is generally four lines thick (see fig. 3. Pl. VII.*). They differ widely from any-

* This is a longitudinal section taken rather obliquely in order to preserve the roots. It is not quite regular therefore; but, on the side which is preserved, the projections can be well distinguished.

thing we have yet seen. Instead, like *Ventriculites mammillaris*, of being mere rounded elevations on the plait, they stand out prominently from it; and a careful dissection shows that their shape is generally that of a lozenge, with the acute angles in the horizontal, and the obtuse in the perpendicular, line of the whole body. Fig. 7* of Pl. XIV. shows the manner of the projections from the plait and the figure which the peculiar shape of their tops causes to be seen on a clean section exactly through the middle of any one. In all the specimens of this species which I have seen, the projections run in nearly regular spiral lines round the body.

On the inner surface of this and of some other broadly depressed species there is a very small and slight depression between each of the large depressions, and both on the plaits and on the places of the united bulgings. It is barely traceable, and may easily escape notice. It is however worthy of remark as an additional contrivance for gaining extent of surface, and an additional instance of the exhaustless variety of plan which nature adopts in the development of life.

6. *Cephalites retrusus.* Pl. XIV. fig. 8.

Plaits broad and very deep: outer plaits . . . . . : inner plaits raised in rather small but very prominent projections at regular and close intervals, and in such manner that they range spirally round the whole body, and quincuncially relatively to each other: projections cylindrical, rounding off slightly at the top and with an exactly central and rather deep circular depression (sometimes two) on the top of each projection: wall very thick.

This form departs from every other which has been named. It is the first and only instance in which we find projections on the *inner* plaits, which have been already more than once found, and will be so again, on the outer plaits. The fold which marked the outer plaits of *C. bullatus* is here found, with striking modifications however, on the inside. The projections are much smaller and closer than in that species, but no less prominent; while each one is again marked by a deep though small and exactly central depression. It is altogether a very extraordinary form†. In chalk specimens it would at once be distinguished

* In this figure I have connected the inner and outer plaits by brackets, —the outline of each merely being given for the sake of clearness.

† Forms like this afford very strong ground of caution against the hasty adoption of any *development theories*. The whole of the present subject affords, indeed, the strongest ground for such caution. We see *infinite variety* —all subservient to the ends of life; and throughout which one Unity is

from every other species by presenting, on its inner surface, the appearance of a series of small rings, quite unconnected with each other, but arranged with the utmost regularity.

It is an extremely rare species. I have only met with a single specimen, and that is a cast of the inner surface in flint, with fragments of the characteristic ventriculitic structure preserved in places. I am unable therefore to describe the outer plaits. The characters of the inner ones are, however, so marked that those of the outer ones are quite unnecessary in order to establish the specific difference.

The name *retrusus* may be considered either to express the extraordinary degree in which the inner plaits are drawn back to form the projections; or that the most marked characters of the species are hidden from external observation by being on the inner plaits. In either sense the name seems equally appropriate.

7. *Cephalites catenifer*. Pl. XIV. figs. 9, 14, 15, 16.

Plaits broad and deep: outer plaits projecting prominently at irregular intervals; projections horse-shoe shaped, with one arm of a lower projection often linked to the hoop of the projection above it on the same plait; occasional points of anastomosis between adjoining plaits: inner plaits having large and generally oval depressions at regular intervals; bulging on each side around depressions till adjoining plaits meet and open into each other: processes very conspicuous: wall very thick.

Var. *Annulatus*.

Plaits broad and deep: outer plaits projecting prominently at irregular intervals; projections ring-shaped, and generally running into each other on the same plait and often anastomosing with those on adjoining plaits so as to form connected rings over the whole surface: inner plaits having large and generally oval depressions at regular intervals; bulging on each side around

traceable; but a Unity which certainly no more points to a low type of organization, or to a necessary or probable progressive development of one form from another, than does the beautiful and philosophical demonstration of the cranial vertebræ, or the fact of that demonstration being afforded by the most different members of the Vertebrata. It should be noticed that the very remarkable octahedral structure already developed as characteristic of the membrane of the Ventriculidæ has no relation whatever to those "geometrical figures" alluded to by Professor Owen. In the present case it is a *relative*, and not a positive, form; and one assumed by *animal fibre* for a special purpose. It has been already remarked (p. 24) that no spicules, or "calcifying salts" enter into the composition of any of the Ventriculidæ. See Owen "on the Archetype and Homologies of the Vertebrate Skeleton," 1848, p. 171.

depressions till adjoining plaits meet and open into each other: processes very conspicuous: wall very thick.

This is a singular species. The specific name of the typical specimens exactly expresses the appearance of the outer surface, which looks as if several links of a chain were hung about it,—sometimes disconnected,—often connected,—always, or almost always, open on one (and generally the same) side.

This species will be readily distinguished from *C. bullatus* by the fact that the semilunar fold is continued down to the upper edge of the plait, as well as by the links being so often continuous, and by each individual projection being much larger.

Figs. 14, 15 and 16 of Pl. XIV., all taken from the same specimen, will probably assist in the understanding of this modification of the fold. Fig. 14 shows a part of the *core* of the matrix, that which filled the central cavity. The round spots are where depressions existed in the body itself, and where, consequently, the matrix projected outwards from the core. Being broken off at each place, these regular marks are left, contrasting strongly with the portions of the membrane adhering to the matrix elsewhere*. Fig. 16, which should be compared with fig. 14 of Pl. XIII., shows the peculiar elevations on the plaits: and fig. 15 is a transverse section showing three plaits; the uppermost being struck at a point where there is not any projection, the two others just at the bend of two projections.

The specimens which I have distinguished as a variety, under the name of *annulatus*, appear to be cases in which the horse-shoe elevations have become more than usually continuous both on the same plait and by anastomosis with those on adjoining plaits. This character is sometimes seen on the lower part of specimens the upper part of which exhibits the true normal characters of *C. catenifer*, as in fig. 9. Pl. XIV. In some cases, however, the same appearance of connected rings, instead of rows of open links, covers a large part, or the whole, of the surface; and it is important that the true place of such specimens should be understood, whence the utility of distinguishing them as a *variety* of *C. catenifer*.

It generally happens that, even in the most characteristic specimens of this variety, there are places in which the projection on the outer plait stands, as it so often does in the normal *C. catenifer*, single and wholly unconnected with any other projection on the same or on any adjoining plait. In that case, instead of being horse-shoe shaped, the circle is usually complete. We thus find, on an external plait, a fold very similar to that which characterizes the inner plaits of *C. retrusus*.

* See ante, p. 60, *note* †.

8. *Cephalites compressus.* Pl. XIV. fig. 10.

Plaits broad and very deep: outer plaits projecting prominently in very elongated loops often linked at one extremity and enlarged at the other: inner plaits often inclining towards, and anastomosing with, adjoining plaits: pouch very short: processes very conspicuous: wall very thick.

This appears to be quite a distinct species from the last. Its fold is looser, approaching therein to the character of the group *Dilatati*. The external modification of fold is very different from that of *C. catenifer*; while the internal difference is even more marked. Instead of depressions we have here anastomosis with the adjoining plaits; and at the places of anastomosis the figure becomes almost angular, instead of circular as heretofore.

§ *b. Dilatati.*

Head broad and rounding: plaits loose and irregular.

All the species of the present section differ very remarkably from the *Annulati*. In the latter section the heads in all the species were of nearly the same size relatively to the size of the whole body; as also was the central cavity. The various differences of contrivance by which extent of surface was gained at the same time that the free access of sea-water was maintained, were found in the different modes of folding of the membrane of the wall. In the present section the character of the fold of that membrane differs also in the different species; but that difference is accompanied by very remarkable differences in the form and extent of the head. The latter becomes the most conspicuous instead of a mere subordinate part to the observer of the whole body. As, therefore, the difference in the heads is a necessary accompaniment of a difference in the fold of the membrane (though rather in the relation of consequence than cause), it will simplify the labour of the inquirer if the character of the head is adopted as one of specific difference. The names given have therefore a reference to this point.

It will be obvious that, the looser the folds, the more necessary would become the greater extent of cephalic membrane in order to secure the objects already suggested as those for which that remarkable structure was designed. Hence the variations in this conspicuous character in the forms immediately under consideration.

There are minor modifications in individuals of each species which would probably be held by many to justify the assignment of each species as a distinct genus; an arrangement which would

indeed be far better warranted than many such divisions both in recent and fossil classifications. It does not seem to me however that the principles of a sound classification will, in the present state of our knowledge, justify such an arrangement*. Moreover, all the species of the present section are of extreme rarity; so rare, that it is very probable that few even diligent collectors will succeed in obtaining specimens of each, unless some bed abounding in them, and at present unknown, should be discovered.

1. *Cephalites capitatus.* Pl. XIV. fig. 11.

Plaits very deep; dividing longitudinally, and so reduplicating, very constantly, as they pass from the inner to the outer surface; points of anastomosis at irregular distances on both inner and outer surfaces: central cavity small: head rounding and very wide: wall falling in very rapidly but in a regular slope from outer margin of head to root: diameter of whole body greater than its height.

In some specimens of the present species the plaits are very traceable on the outside; in others much less so, on account of the almost total absence of oxide of iron. In each case, however, it is equally obvious that the number of plaits seen on the outer surface is given by the *longitudinal* division and reduplication of the plaits towards that surface, in the same way as the increase of plaits from base to margin has already been described as being effected by a *transverse* division and reduplication†. The accompanying figure will explain the present mode of this reduplication. This arrangement takes place to some extent in most of the *Annulati*, but the very small size of the central cavity in *C. capitatus* renders this peculiarity constant in this species, and one of its most marked characteristics.

Fig. G.

The general form of this species is so peculiar that a vertical section through the fossil displays a triangular figure, of which the base of the fossil forms an obtuse angle, while the external margins of the head form acute angles with the wall. It is thus impossible to confound this species with *C. compressus*, as the wall of that species, like that of every other species of the section *Annulati*, usually forms, inside and outside, nearly a right angle with the head‡.

* See ante, p. 46 *note*, and pp. 47, &c. † See ante, p. 64.

‡ I have an interesting specimen of this species in which two individuals are close together; actually *touching*. But they cannot be mistaken for an example of *C. constrictus*, each individual having separate roots or places of roots, (see before, p. 51,) and not being parts of one single body.

2. *Cephalites campanulatus.* Pl. XIV. figs. 12 & 13.

Plaits very deep; increasing very rapidly from base, and dividing, and so reduplicating, very constantly, both longitudinally and transversely; after attaining the fullest expansion, folding inwards and downwards, and gradually contracting till they more or less nearly approach the base, whence, folded upwards in a single plait, the membrane rises, usually simple and plain, in a funnel form, to the margin of the head surrounding the central cavity, to which its marginal edge is attached: head enwrapping the body and attached to all the prominent plaits as far as the point where they incline rapidly towards the base: diameter of body greater than height.

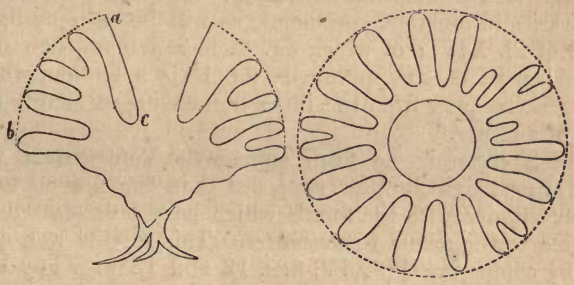
This species differs very widely in outward appearance from *C. capitatus*. In that species the head is indeed so largely developed as to be the most conspicuous part of the entire body; but it still leaves a view to some extent of the wall. In the present species the whole fossil, unless actually looked at from below, is so entirely enveloped by the cephalic membrane,—rendered necessary on account of the great depth and consequent tendency to looseness of the fold,—that no idea of the character of the membrane of the wall itself can be gained externally.

The modification of the fold is exceedingly remarkable, and exceedingly difficult to be ascertained. The description given, however extraordinary it may appear, is the result of very laborious and careful examination, comparison, and section of all the specimens which I have been able to obtain. A familiar illustration may perhaps assist in understanding the arrangement of this membrane. If the inquirer will glance at the hangings of any window, looped up, as usual, in festoons at some distance from the ground by curtain pins or ropes, he will see a contrivance rudely imitating the very elegant plan adopted by nature, to give, in a small space, a very great extent of surface combined with security to the polypiferous membrane of *C. campanulatus*. Take a piece of linen cloth: join together the side-edges along their whole length, gathering the lower edge to a point: fix the upper end of the sac thus formed* to a circular plain wire: at a third of the length from the bottom fix another wire, which, though altogether uniting in a circle, is deeply zigzaged: the upper wire remaining fixed, raise the lower wire equally all round, and so that the drapery hanging from the upper simply circular wire

* To act properly, and to give a full idea of the extent of surface gained, the sac should be very much wider at the middle than at the top or bottom, in order to fill the lower zigzaged wire and yet inclose the plain fold of the cloth without compressing or touching it.

shall fall within, and that hanging from the zigzaged circle shall fall on the outside. Over both wires draw, smoothly, a separate cloth, to which fix both wires. Then, by holding the entire contrivance at any point of the plain wire circle, the whole will be retained in its place. Such a contrivance will afford the best idea of the very remarkable arrangement of the internal membrane of the present species, and of the object and importance of its deeply extended head. It is obvious that, if the lower wire were zigzaged, not only in its horizontal plane but also in a direction perpendicular to that plane, though it would affect the points at which the outer covering or envelope would be touched, it would in no wise affect the principle of the plaits or folds whose extremities touched that envelope. The following two figures may render this matter still clearer.

Fig. H. Fig. I.

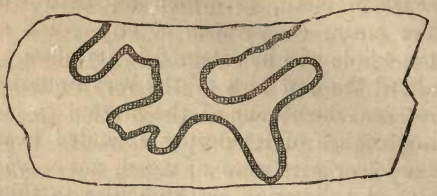


In each figure the dotted line is the envelope. Fig. H is a longitudinal section as it would be seen if one could be taken exactly clear through any spot where there was no lateral division of a plait—the presence of which gives a false appearance of anastomosis to a section. It will be seen that the membrane may be traced from the point of the base to *c* and thence to *a* in a continuous line, and that the projecting plaits are affixed, at various points, to the envelope *a*—*b*. Fig. I is a transverse section taken about the middle of a specimen. The inner circle is the membrane where simple and unwaving, and forming therefore necessarily an unbroken circle. Between this and the envelope the plaits are seen, cut horizontally across.

The membrane begins to fold upwards in its last plait at different distances in different specimens from the inner margin of the head; and it is rarely that the folding upwards will take place on exactly the same plane all around; whence, on section, a deceptive appearance is often given, as if there were a double or triple or still more numerous ramification of the central cavity.

This is seen in the following curious section of a flint of this species in my possession. Such cases only afford instances of the care and caution necessary in the investigation of such a subject as the present.

Fig. K.



It will be clearly seen that the mode of fold, of which an attempt has thus been made to convey an idea, secured free access of sea-water to all parts of the surface of the membrane, external and internal. By the same contrivance that membrane was held securely in its position; the regular funnel-shape assumed by the last plait, with its margin fixed at the top, securing it within *; the campanulate envelope, to which the projecting points of the plaits were affixed, securing it without. The size of the internal cavity varies in different specimens, as will be seen by figs. 12 and 13 of Pl. XIV.; of which fig. 12 is a general view of the external aspect of one specimen; fig. 13 is a section, with the matrix cleared away from the inner funnel-shaped simple membrane, of another.

There is certainly no form among the Ventriculidæ which might, at first sight, be less supposed than the present to have had any affinity with the fossils which have been described as belonging to the genus *Ventriculites*. This will be well understood by comparing Pl. XIV. figs. 12 and 13 with any of the figures on Pl. XIII.

The condition in which these specimens are found,—their deep folds preventing their ever coming free from the chalk, or being developed without the laborious use of the needle,—renders it impossible to make any confident observations upon them as to the processes; a remark which also applies to every other species of the present section.

3. *Cephalites constrictus*. Pl. XV. fig. 1.

Whole body very low, much-elongated and narrow, with roots at one end: plaits very deep, and running longitudinally from the root extremity; each plait constricted at short and not very regular intervals, and sometimes to nearly its whole depth: cephalic membrane covering the whole upper surface and sides, to the margins of which last, as well as to many of the prominent points of the plaits, it is attached; usually constricted

* See observations on the head, before, p. 74.

at considerable intervals, with a single opening in the middle of each compartment thus caused.

The specific description will satisfy the inquirer that this is a very extraordinary form. Externally it has nothing which would indicate any Ventriculitic affinity, and it has indeed been described by Dr. Mantell under the name of *Choanites subrotundus*; but it has no relation whatever to *Choanites*. The appearance of the fossils is so remarkable, that, but for the fixed rule of preserving every fragment which I could not understand, I should never have been able to establish or even suspect the true affinities. A suite of seventeen specimens enables me, however, now to point out the true general characters of the species without leaving any room even for doubt.

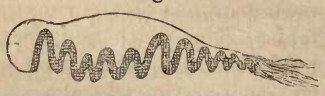
In the two very different states in which the fossil, or fragments of it, are found, it has very different appearances; the one state (see left hand of figure) shows the upper, the other (see right hand of figure) the lower part only, or its cast. The comparison of several of these apparently anomalous fossils led me however to conceive that the connected rounded bodies seen in the former set of specimens had some relation to the very peculiarly complicated and almost angularly raised surfaces seen in the latter. With this clue I cut down some of these rounded bodies, and found the identical surfaces last named below them. Several sections being made, and the whole series being then compared, order and method became at once apparent where all had previously been anomaly and confusion. The characteristic Ventriculitic structure was detected: the Ventriculitic fold was traced: and the Ventriculitic root was found.

I conceive the habit of the animal to have been very different in one respect from that of all the species which have hitherto engaged attention. While the latter stood rising upwards from a central root, this species, attached at one end by a root, and thus secured in its position, floated horizontally, like a ship riding at anchor. It had therefore no central cavity in the direction of its length, but, instead of this, it was covered by a head investing the upper and lateral surfaces of that whole length; and which head, with rare exceptions, for such exceptions do exist, was constricted at intervals, causing the animal, when seen from above and entire, as in the greater part of fig. 1. Pl. XV., to appear like several distinct globose bodies linked together. The fact of the head being occasionally, though rarely, not constricted at all, will satisfy any philosophic inquirer that such an appearance is deceptive, and that the explanation thus given of that appearance is the true one. Besides this, however, if the head be removed, and the lower surface of the fossil only seen, all trace of separation and distinctness is gone. The membrane of the wall

does not divide into lobes, as in *Brachiolites*: there is simply, in order to ensure the greater security of the whole polypiferous surface, an occasional constriction of the head and narrowing of the plaits attached to it; which plaits expand again, like an open fan, in the following compartment.

The appearance of the plaits themselves is very remarkable. Their frequent constrictions give them a puckered or zigzag appearance, so that a vertical section has a figure of this kind. This figure shows, also, how the projecting points of the plaits are often attached, for security, to the head. When the body is broken away the cast left is very curious, the matrix being always broken off in many of the places where it has filled a pucker in the upper plait, depressed where there was a pucker in the lower plait. This is seen on the right hand of fig. 1. Pl. XV.

Fig. L.



The species rarely attained half an inch in height or an inch in breadth, though specimens often extend between two and three inches in length.

It seems to me that the cephalic constrictions most probably mark periods of growth *. They vary in number much in different specimens, and, as has been seen, are sometimes not found at all, in which case there are several openings in the undivided head.

Specimens sometimes assume irregular forms, as if, after death, the long body had become twisted, which I have little doubt was, in many such cases, the real fact.

I have placed this species next in order to *C. campanulatus*, inasmuch as, on the one hand, the mode of attachment of the cephalic membrane to the plaits resembles very much that which is found in *C. campanulatus*, while, on the other hand, the fact of the openings in the head of this species being generally several instead of only one, places it in some relation to the species which will next claim attention.

4. *Cephalites perforatus.* Pl. XV. fig. 2.

Plaits wide and very deep, so as to leave no distinct and single central cavity; dividing, and so reduplicating, very constantly, longitudinally, but not transversely; somewhat winding both longitudinally and laterally; occasional points of anastomosis near the outer surface: head covering the entire top and round-

* Specimens, apparently entire, are sometimes found, having one only of the rounded divisions, and thus bearing some resemblance to a very small *C. campanulatus*, with its root at one end instead of at the base.

ing to some distance down the sides; having several small round perforations arranged without any regular figure: body of considerable breadth and often nearly twice the height of its diameter.

The peculiar arrangement of the plaits and head in the last two species rendered any anastomosis of adjoining plaits not essential in either of them. The much greater height of the present species rendered occasional points of anastomosis an important means of securing the permanence of the position of the folds. The width and depth of those folds rendered a large head necessary, while it made unnecessary any large single central cavity; the several small openings in the head giving sufficient access to the sea-water for the purpose of bathing freely all the internal surface of the polypiferous membrane. The unity of form* is not in the least degree impaired by the existence of these several points of access. The one head still holds in place all the several plaits, a contrivance for the security of the entire animal and of the individual polyps wholly different from that which is found in every species of the family *Brachiolites*.

In all the various and so greatly varying forms which have been thus seen to be included in the genus *Cephalites* one end is found to be subserved, namely, the maintenance of the security of the whole mass, and of each individual of its myriads of living tenants; together with the unimpeded access of the sea-water—that element upon whose constant presence the life and subsistence of those myriads depended. The great diversity is no less striking than is, in each case, the completeness of the varying methods which nature has adopted for securing that ever-teeming, ever-active life which excites the inquirer's increased admiration at every step he takes.

Genus Brachiolites.

Character. Shape and size very various, but always much lobated or branched: internal cavities of lobes and branches always communicating: extremities closed or open: membrane forming the wall sometimes plain sometimes folded: margin of wall thinned or rounded off to an edge: membrane of wall polypiferous on both external and internal surfaces.

Departing altogether from the forms hitherto examined, the present genus is characterized by its lobated or branched divisions†. These divisions communicate internally, either by open-

* See before, p. 58 *note*.

† See pp. 51, 57 *note* ‡, and 85.

ing directly into each other, or by opening into a central cavity, which they surround.

This genus therefore presents the Ventriculidæ in a new light. With far less of the intricate complexity of fold of membrane which is found in the other genera, it exhibits what may, in contradistinction, be called a *convolution* of membrane varying greatly in different species. And that this "convolution" is a distinct thing from the "fold" already noticed will be evident, should its essential distinctness be not otherwise recognized, from the fact that several species have the fold as well as the convolution. In the descriptions which follow, the fold and the convolution will be distinguished as the *primary* and the *brachial* fold.

This genus, like each of the others, will be found to have all its modifications adapted for the purpose of maintaining strength and stability of form and the free access of sea-water. We shall find some contrivances for these purposes of singular novelty and beauty; and it is upon the marked distinction of two groups in one general arrangement for ensuring to the whole polypiferous surface a full and constant supply of the grand element of the existence of the creatures that the sectional division of the genus is founded;—the one section having the separate lobes of such size, or so arranged with reference to a central cavity, that one main* entrance afforded sufficient access to the sea-water; those lobes in the other being so extended, or so arranged with reference to each other, that additional means were needful for that end.

The roots do not, in general, differ in this genus from the same part in the others; but I shall have occasion to call attention to some special and very remarkable contrivances in the arrangement of this part.

The forms are all well-defined; and though, like *Ventriculites*, specimens of such species as are not of great rarity are found of various sizes, there is little danger of confounding any two of the species unless in a very fragmentary state. As to the question of growth, the present genus may be considered, from the fact just mentioned, to stand on the same ground as the genus *Ventriculites*.

Different forms of this genus are found in the Upper, the Middle, and the Lower Chalk, and even in still lower beds of the cretaceous series. I believe only one, *B. digitatus*†, is strictly

* The very beautiful arrangement of *B. angularis* will be found to be one of those interesting apparent (at first sight) exceptions which prove a rule, the main access being through the central cavity, and the lateral perforations ensuring only the full and free *circulation* of the water entering, by that main access, the cavities of the arms. The contrivance in all the group *Aperti* is of a very different character. See *post*, p. 96.

† See Ann. and Mag. Nat. Hist. vol. xx. 1st Ser. p. 337, and *ante* p. 43.

common to all the beds, and that undergoes a modification of character in the lower ones. Some of the most marked forms are, as far as present observation has extended, peculiar to the lower of these beds.

§ *a. Operti.*

Brachial folds closed at extremity.

1. *Brachiolites tuberosus.* Pl. XV. fig. 3.

Membrane having an irregular and generally slight primary fold: brachial fold arranged subspirally around a wide central cavity, and at rather distant intervals, in tuberous sacs, broad and flattened at the head, with slight depressions in the middle of the head.

Of this remarkable species I am fortunate in possessing four well-marked specimens, all of which were found by myself, though in very distant parts of the country, and they are the only specimens I have ever seen. The form is striking. Rising from, apparently, a very short root, it attains a considerable height, one of my specimens being upwards of three inches high. The sacs usually project about four lines from the central cylinder, and are about four lines wide, though sometimes more, at their broadest part. They open by a broad and trumpet-shaped mouth into the central cavity, which is wide and open at the top. Thus the access of sea-water is freely maintained.

A transverse section gives the accompanying figure, which will be at once distinguished from that seen in a similar section (see fig. G, p. 81) of *Cephalites capitatus* or of any other of that genus.

Fig. M.

The figure (3. Pl. XV.), which is from a specimen carefully developed from the chalk by means of the needle, gives a complete idea of the species. A large part is broken away, and thus the inside, as well as the outside, is cleared out and displayed. Being, however, developed by this means, and the specimen being one in which the oxide of iron very greatly abounds, the primary fold is hardly to be seen. A careful comparison of this with other specimens shows that that fold was, like that of *Ventriculites impressus*, irregular; usually slight; but occasionally deep, at any rate in that part of the membrane which forms the central cylinder.

The remark already made, in describing *Cephalites campanulatus*, as to observations upon the processes, applies equally to

every species of the present genus. Enough, however, can be detected to determine the fact of their presence.

This species must, in its recent state, have been singularly striking. It is difficult, indeed, to conceive anything more beautiful than must have been its exterior with each of its regularly ranged lobes covered with its myriads of living polyps and their ever-active tentacles.

All my specimens are from the Upper Chalk.

2. *Brachiolites elegans.* Pl. XV. fig. 4.

Membrane simple and without any primary fold: brachial fold beginning almost at the acute base, and rapidly increasing in broad and swelling lobes closely arranged round a central cavity, and terminating in a simple and regular crown, open at the top, and which, rising from the midst, reaches to a considerable distance above the highest lobes, and is of about half the diameter of the whole body.

This form is, in its fossil state, frequently so beautiful that I have hence chosen its specific name. The effect is heightened by the fact that the root of this species is usually long, and often maintains the same diameter for a height of nearly two inches.

The primary membrane is exactly similar to that of *Ventriculites simplex*: the brachial folds are deep and broad, their inner surface being freely exposed to access of sea-water from the large internal cavity. The crown is one of the most remarkable features of this species. It is regular and plain; springs from the lower edge of the most deeply folded lobes, and rises, unbroken, to a clear and even margin. A glance at fig. H, p. 83, illustrative of the fold of *Cephalites campanulatus,* will aid in understanding the anatomy of the present species; broad convolutions here replacing the plaits seen in that specimen, and the crown being always straight-sided, and never, I believe, assuming a funnel form. Nothing can show more convincingly than this peculiar crown, that the forms of the Ventriculidæ are not merely arbitrary massings of an amorphous or simply cumulative organism, or mere examples of "vegetative repetition," but that there was a type appointed to each which it should attain, and each having its special adaptations. In perfect specimens this head is never wanting, though it is rarely, if ever, to be seen without the aid of the knife; whence it is that it has never, so far as I am aware, been heretofore observed.

The species appears to be characteristic of the Upper Chalk.

3. *Brachiolites convolutus.* Pl. XV. fig. 5.

Membrane coarse in texture, simple and without any primary

fold: brachial fold developed very rapidly from the base, in broad and deeply undulating convolutions, so deep as to leave no regular central cavity; most prominent surfaces much flattened, and spread laterally till those of adjoining convolutions meet and unite in many places, often presenting, towards the lower part of the whole, a continuous surface.

This species displays many peculiarities. The structure of its simple membrane seems coarse, that is, the squares are larger than in any other species of the Ventriculidæ. The root is exceedingly short. The most curious point, however, is the union of the flattened prominences of the convolutions. A reference to fig. M, p. 89, will show, in *B. tuberosus*, a disposition to flattening of the most prominent part of the convolutions in that species, and will make the nature of the present fold easily understood, where that flattening is so much more extensive that adjoining convolutions meet and unite*. This peculiarity was important in the present species on account of the great depth of the convolutions, which would, without it, have been more liable than in *B. eleyans* and other species to be displaced, and so injury to have happened to the polyps. But a curious phænomenon is often presented in consequence. The flint,—which, from its specific gravity, would always lie, when fluid, near the sea-bottom,—was attracted round the base of the specimen; but, the surface there being usually continuous for a considerable distance, access to the lower part of the inside seldom took place, unless the siliceous fluid was very abundant; any silex attracted towards the inside† in the manner before suggested (p. 13) being specially attracted by the convolutions interposing before it reached the base, solidifying there, and thus preventing the flow of other fluid towards the base. Hence, on the decay of the animal matter, a large hollow was frequently left in the flint, which is often now found only partially filled up by chalcedony. Such flints are cup-shaped, very regularly rounded below, and have a flat top. Near the edge of that top a continuous line is usually found, showing the place of the united membrane. Within this are seen traces of the convolutions of the

* This outer surface, where the polyp-skin is preserved, which very rarely happens, may sometimes appear as if apolypous. A very careful comparison of all the specimens I have, on which remains of this membrane are found, leads me, however, to the conclusion that this is not the fact; but that, the membrane being coarser than usual, the polyp-cells, though present, are not so clearly preserved as in some other species.

† The access of the liquid chalk was often made equally difficult by the collapsion, after death, of some of the lower convolutions on one another. Hence we find the bases of specimens enveloped in that substance often hollow like those in flint. Some deposit of chalcedony has often taken place in those hollows, as in the hollows of the flints.

brachial fold which attracted and retained the siliceous fluid in its descent towards the base. Fig. N is a small specimen of this kind, instances of which are not uncommon in some places.

Fig. N.

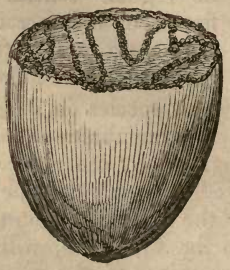


Fig. 5. Pl. XV. represents a specimen which has been longitudinally divided, and has afterwards had the convolutions cleared out by the needle. The white central parts, round the entire edges of which the structure is seen, are the only parts where the true central cavity is cut, notwithstanding the section. The depth of the convolutions will be clearly seen. It will also be observed that there are several places where the flattened convolutions do not unite, thus leaving ample means for the free admission of sea-water to bathe the whole inner portion of what is really the external surface of the membrane, though so much surrounded by the overspreading flattened, and thus actually outer, surface. The true inner surface is bathed by means of the access of water through the upper part in the usual way.

Specimens vary greatly in size. I have them from an inch to at least eight inches in height. The height to which the flattened outer surface is continuous varies in different specimens, being, as might be anticipated, greater in large ones. It is sometimes much greater on one side than on the other, a circumstance, however, which, in the living creature, would not at all interfere with the free access of the sea-water, inasmuch as the communication was free all around within and under this expanded continuous surface.

The species is found both in Upper and Middle Chalk.

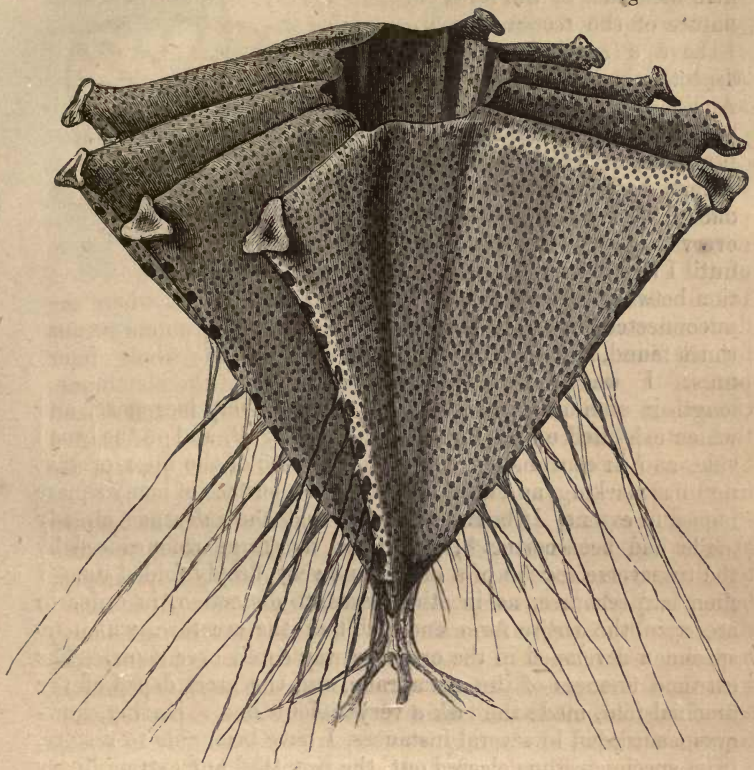
4. *Brachiolites angularis.*

Membrane exceedingly fine in texture, having a primary fold of minute and corresponding depressions arranged in more or less exact quincuncial figure: brachial fold expanding very rapidly into a varying number of arms opening into a central open cavity; each arm having the two walls parallel and flat; closed at upper and lateral edges; terminating at the external angle in a broad triangular lip depressed in the middle; and having at regular intervals, along its lateral edge, complete perforations, between which distinct and single root-fibres are attached to the membrane at intervals from the base upwards.

This is certainly the most extraordinary and interesting of the whole family of Ventriculidæ. It presents some points of such

remarkable structure as must excite the astonishment and admiration of every earnest inquirer.

Fig. O.



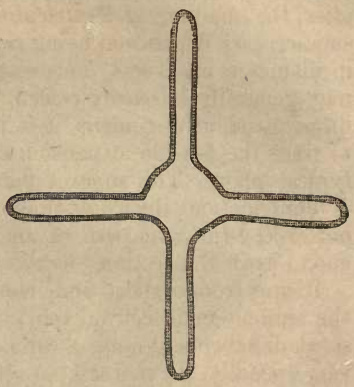
Few fossils have given rise to more varied conjecture than this. A fragment of a specimen found in an unusual condition by Dr. Mantell was originally figured by him under the name of *Ventriculites quadrangularis*. He subsequently abandoned that view,—showing that it had been adopted without the guide of any definite principle,—and, for what reason it is difficult to imagine, and none is stated, placed it among *Flustræ**. Others have amused themselves by discovering analogies to the foliaceous sponges. Remains both in chalk and flint, which had apparently escaped Dr. Mantell's notice, or whose connexion with his figured specimens was at any rate not perceived by him, have even been placed by collectors among the *Asteriæ*.

The form in which the species is necessarily most usually found

* Ante, p. 2, *note**.

is seen in the accompanying figure. This can, in itself, give little idea of the form or nature of the recent animal. I have a specimen of this aspect nine inches across. Anxious to ascertain the true nature of this remarkable appearance, of which no explanation had ever been even offered, I carefully collected every fragment I could find, until I was led to infer a relation between certain flat and unconnected surfaces, sometimes found, and these markings. I was fortunate at length in obtaining two specimens, each of very large size, and which exhibited on one end the aspect of fig. P, and on the broad side, and in continuous connexion with one of the lines of that peculiar marking, an entire and unbroken surface of many square inches in extent. It became obvious that the inference already made had been correct*; that these markings were caused by the transverse section of a membrane very deeply folded up. I then had recourse, as in other cases, to dissection, in order to ascertain the entire form and habit of the creature, which no specimen developed in the ordinary way could ever show. The extreme fineness of the membrane, and the great depth of the brachial fold, made the task a very difficult one. Having, however, succeeded in several instances, I have been able to restore, from specimens thus cleared out, the beautiful and extraordinary form seen in figure O, a form of animal life seldom if ever exceeded in beauty and striking evidence of design and adaptation†.

Fig. P.



The wall of this species is exceedingly thin and delicate, the

* These specimens had been shown by me to several friends, and my inference of the habit of the animal, with a model in paper of what I conceived its form to be, explained to them long before the importation of the 11th livraison of Michelin's 'Iconographie Zoophytologique' (see ante, p. 8). Plate 30 of that work became an interesting illustration of the present species, though giving little idea of its true character, and none whatever of its habit; on neither of which points do the accompanying descriptions afford any real aid. The character of the surface is there very imperfectly represented, and the magnified views are not truthful, which they could hardly be since that author had no idea of the true structure of this class of fossils.

† This figure, as well as all the other woodcuts illustrative of the present subject, has been executed, with great care and faithfulness, by Mr. Frederick Gyde.

squares being smaller than in any other species of the Ventriculidæ. Its membrane is folded up in very small depressions, after the manner of *Ventriculites quincuncialis,* but very much smaller, each depression being rarely more than the sixth of a line in diameter, often less, and usually of an oval form. The plaits may generally be easily traced, as, though these folds assume a quincuncial arrangement, it is usually easy, on a large surface, to trace the fan-like expansion of certain lines,—the lines of the typical plait. The squares being smaller than in other species of Ventriculidæ, the whole thickness of the folded membrane does not exceed the twentieth of an inch. The two surfaces correspond as in the section *Simplices* of the genus *Ventriculites.*

Rising from a short and, comparatively to the whole size of the animal, small central root, the fold is sometimes found for a short distance assuming a tubular form, but it generally puts on, very speedily, its characteristic brachial fold into narrow flat triangular arms. These folds vary greatly in number. The specimen above figured has ten arms, but that number is very uncommon. I have even specimens with only two, but I consider them as abnormal. The arms do not always, though generally, start from exactly the same point. This is the case with the arm on the right of the above figure, as well as with some others the bases of which cannot be seen in the present position of that figure.

Spreading out, sometimes to a very great, sometimes to a very small size, the angular fold terminates, at the top, not in double parallel edges as might have been anticipated, but with the edges united and rounded over as at the lateral margin. Each arm is thus closed on all sides except where it communicates with the central cavity, which is, normally, open at the top. The upper and lateral margins of each arm consequently form with each other an acute angle. Those margins are usually straight; those at the top being also often horizontal, and those at the sides sloping regularly down from their extremity to a point at the base. Instances are found, however, in which these margins have a symmetrical wavy outline. At the extreme outer angle of each arm there is further added a curious triangular expansion, not unlike the expansion at the extremity of each sac of *B. tuberosus.* This lip, as it may be termed, and which, like all the elevations on *Ventriculites mammillaris, B. tuberosus,* &c., is hollow within, is concave at the aspect towards the spectator.

It will be understood from this that, between the two walls of each lobe, there is an open space, narrow and of even width throughout. The communication between the central cavity and these arms being therefore not wide, though continuous, the extent and narrowness of these arms struck me for a long time as

likely to offer some difficulty in the way of the free circulation of the sea-water. Confident however that, if my interpretation of the nature of these animals were correct, the means of free circulation must exist and might be discovered, I resumed the examination with an increased series of specimens. The result was the strengthening of all conclusions as to the physiology of the whole family in general, and of this species in particular, by the discovery of a contrivance by which this end was perfectly effected; a contrivance which, for its novelty and simplicity, may well claim the inquirer's attention.

Equidistant, or nearly so, along each *lateral* margin, I found what at first I took for a larger form of depression, but which, on dissection, I found to be actual perforations* through the membrane. These are found present from near the root to the extreme angular expansion already named. A comparison of many specimens satisfied me that these perforations are never absent; that they are always ranged in the same way, and that their size is proportioned to that of the entire animal and to the width between the walls of the arms. They are usually circular, sometimes oval. They vary from half a line to two lines in longest diameter, seldom however attaining this last size.

It became at once evident that this simple provision could have but one end; but that that end it would fully effect. That end was the fulfilling of the very purpose whose incompleteness had before been felt. A constant access and circulation of sea-water would be maintained over all the inner surfaces of these lobes, deep and narrow as they are; the water, admitted at the opening of the great central cavity, coursing out, by the continual action of numberless ciliated tentacles, through these marginal perforations. And herein it is that these perforations differ from those in the group *Aperti*, and do not bring this species within that group. The large central opening was amply sufficient, in this case, for the admission of sea-water, but the peculiar form of the arms interposed difficulties in the way of its free change and circulation, which were equally necessary to the well-being of these creatures. Hence this beautifully simple contrivance for the water, admitted by the central orifice, to pass out through these perforations. In the group *Aperti*, on the other hand, each perforated lobe offered the principal, if not in every case the only, means of both access and circulation of the

* In some of Michelin's figures traces of some of these are found, which, when their nature is known, will be recognized, but which, as they appear in those figures, suggest nothing but irregular depressions: they attracted, indeed, no attention of that author, but, in his descriptions, they are wholly unnoticed, the margins being only said to be,—in the same words as the "superficiebus laminum,"—"*perforatis*;" which, as applied, is erroneous.

sea-water, just as in any single specimen of *Ventriculites* or *Cephalites*.

But the contrivances in this species to secure the well-being of the myriads of its tenants, and so strikingly indicative of design and adaptation, do not end here. Thin and delicate as the wall is, though greatly strengthened by the fact of the upper as well as the lateral margins of each lobe being closed, the currents, small as they would be, caused by the streams continually pouring out of these lateral perforations, or lungs as they may well be called, might tend to displace the form;—a matter of peculiar danger in species having such extended surfaces in such close apposition, their distance seldom exceeding one line. Besides this, such broad flat surfaces as the lobes or arms here take would offer so much resistance to the slightest impulse that the walls would be more liable than those of other species to suffer displacement; while there is no membrane, as in *Cephalites*, stretching across and attached to each to secure them in position; a contrivance indeed which, though so admirably adapted to all cases in which it is found, the length and depth and entire distinctness of the arms would, in this case, have rendered but very imperfectly effectual.

To secure the animal against such dangers I have further found that, while the central root* is comparatively small, merely acting as an anchor, there depended a single root-fibril from between each of these perforations to a considerable height†, on all sides of the entire animal. By these then was it maintained securely in shape and in position. These depending fibrils acted exactly like the

* In an earlier page, 19, contrasting the *Actiniæ*, which are locomotive, with the *Pennatulidæ*, which are, according to the better opinion, not so, but which are permanently fixed in the soft mud, I suggested that the Ventriculidæ might possibly combine both these qualities, and have a locomotive power, fixing themselves firmly, during pleasure, in the soft mud. However difficult it may be to arrive at certainty on such a point, the inquirer will probably be inclined to acquiesce in the doubtfulness with which this suggestion was offered, after considering the very peculiar arrangement of roots in the present species. The roots of this family of compound animals fulfilled the same purpose as the peduncle of the *Terebratula*. They differ indeed in structure from the latter,—for the opportunity of examining which, in the recent state, I am again indebted to the kindness of Prof. Owen,—but, in this respect, the *byssus* of the *Pinna*, with an analogous function, differs yet again from both. But it is a curious and important fact that the roots of Ventriculidæ are never found attached to rock or shells, though shells are often *attached to* parts of the surface of the body and roots: nor have the minutest shells ever penetrated the substance of the body, as they continually do in sponges.

† How high it is almost impossible to ascertain. It has been with the greatest difficulty that I have ascertained the fact at all, as it is only by following the small fibril with the knife that its presence can be detected or its direction traced.

ropes of a tent, by which alone it is securely kept in a position which, swinging on its single central support, it could not otherwise sustain for an instant*.

Such are the normal characters of this very curious and interesting species. As was to be expected in so delicate a species, specimens are, not unfrequently, found exhibiting abnormal forms; owing either to displacements of the dead mass before or during the process of fossilization; or, sometimes, to incomplete development of the living mass, or accidents to the living animal,—accidents to which, from its delicacy and remarkable form, it would be peculiarly liable. Thus I have a flint ten inches in length covered with irregular markings, but in which may I think be clearly traced displaced portions of an individual of this species. I have similar specimens in chalk in which it appears clear that the originally flat arms have been tumbled and bent over upon one another in confusion. I have myself collected more than one specimen which would seem never to have had more than two of the flattened arms. In such cases compensating provisions are found; and, there being no large central cavity, the lateral perforations are found larger than usual, and on both edges of what thus becomes one elongated double fold. I have another most interesting specimen, in which the opening of the central cavity is in an abnormal position, namely on one side; but still it is there present in all its completeness, thus showing the necessity and the presence of some compensation where any abnormal conditions exist. There is, indeed, no species among the Ventriculidæ which bears more conclusive evidence to the truth of the views heretofore expressed as to the character, affinities, and habits of the recent animal than does *Brachiolites angularis*.

I cannot conclude the account of this species without expressing the strong feeling which its examination impresses of the wonderful variety, and always completeness, of the contrivances by which nature has effected her ever-present purpose of securing the well-being and permanent safety of every creature she has made. The theorists on *mere*† "*Vegetative Repetition*" and on "*Progressive Development*" will find themselves equally at fault in the examination of this species. There is no form which the naturalist can study with greater interest, admiration and instruction than that of *Brachiolites angularis*.

This species is found in both Upper and Middle Chalk.

* The reader will recal the description of an abnormal form of root already given (p. 20). That specimen is of the genus *Ventriculites*. What is there abnormal becomes a special character in the present species.

† This word is used advisedly, to distinguish those who thus theorize from those who philosophically inquire into the important questions of *serial homologies*.

§ *b. Aperti.*

Brachial folds open at extremity.

1. *Brachiolites foliaceus.* Pl. XVI. fig. 1.

Membrane simple and without any primary fold: brachial fold variously winding and irregularly anastomosing, and thus forming irregular but close and connected sinuous cavities, with rounded, but irregularly arranged, external openings: mass rising to a considerable height; expanding slowly from root, and the whole maintaining, throughout, a narrow diameter.

The style of fold of this delicate species is very similar to that of the recent *Eschara foliacea*. The form assumed by the whole mass differs however materially. Instead of spreading horizontally, the habit of *B. foliaceus* was to rise perpendicularly. It sometimes attained six inches in height, but seldom more than an inch in width at its broadest part. The external openings in this species also differed materially; those openings being usually separate, and circular or oval in form, not irregularly running into each other as in *E. foliacea*.

Fragmentary portions in flint or chalk may readily be distinguished from those of any preceding species by the greater delicacy of the membrane and closeness of the brachial fold. The upper part of fig. 1. Pl. XVI. shows the appearance displayed on a vertical section; while the lower part of that figure shows the external appearance of the fossil when entire.

The close anastomosing of the brachial folds of this species must have given great strength to the whole body; while the freely communicating cavities would allow constant access and circulation of the sea-water.

I have a specimen in which the whole animal part is converted into iron pyrites and the cavities are perfectly clear of all matrix.

The species is found in Upper and Middle Chalk.

2. *Brachiolites racemosus.* Pl. XV. fig. 6.

Membrane having a rather deep primary fold, round, and of nearly equal width the whole depth of the fold, and arranged in quincuncial figure: brachial fold beginning at some distance from the base, and running in narrow and short but regular cylinders ranged subspirally round a small central cavity at rather distant intervals.

This species differs essentially from the last in having a deep primary fold; in having a distinct central cavity, though varying in size, into which each of the brachial folds opens; and in these

last being distinct*, and regular in form and arrangement. The term *racemosus* seems peculiarly expressive of the character of this species. The perfect animal rose on a rather high stem. I am fortunate in possessing a specimen in flint, from which the fig. 6 on Pl. XV. is drawn, with the stem and roots entire, a condition in which the members of the present section are very rarely found. I have another specimen in which the processes are very conspicuously seen, also an exceedingly rare circumstance in specimens of this genus.

The wall of the brachial fold is full a line in thickness, often more, owing to the depth of the primary fold, which much resembles that of *Ventriculites quincuncialis*. The central cavity is usually very small, the access of sea-water being abundant, and its circulation free, by means of the open short cylinders which the brachial fold assumes. Occasionally the central cavity is wide however; though the opening into it is not, even then, proportionably wide, a fact which might have been anticipated.

It would be difficult to confound this species with *B. tuberosus*, though the general habit is the same. The primary fold, and the nature of the lobes, open at the extremity, and much larger than those of *B. tuberosus*, at once distinguish the two†.

All the specimens which I have seen of this species are from the Upper Chalk.

3. *Brachiolites digitatus*. Pl. XVI. fig. 2.

Membrane having a deep primary fold of regular quadrilateral and rectangular form, usually more or less oblong, and arranged in tessellated figure: brachial fold branching out irregularly

* I have observed, in one specimen in flint, an indistinct appearance as if two of the cylinders adjoined at one point. If it be a true anastomosis (which I doubt), it is a very rare exception. No symptom of it has been seen in any other instance.

† Through the kindness of Mr. Wetherell I am in possession of one very interesting specimen of this species, strikingly illustrative of the truth of the views expressed in the early pages of these sheets as to the peculiar state in which silicified specimens are found. Each of the cylinders is separately encased in a thin coat of flint, so that the whole was actually taken, by a distinguished palæontologist, for the silicified fruit of a *conifer*. In touching on this subject I cannot forbear citing a passage from Humboldt's 'Cosmos,' published long after my remarks on the formation of flint and on the silicified Ventriculites were written, and which is in direct accordance with, and therefore supports, the views advanced by me on both those subjects. That writer alludes to the siliceous-shelled infusoria as being universally found in sea-water, "*although* the chemical analysis of sea-water has not shown *silica* to be one of its essential constituents; and *it could only indeed exist in water in a state of simple mixture or suspension*." (Vol. i. p. 341.) This, however, is a state of things which Mr. Bowerbank has expressed himself unable, "by any stretch of the imagination," to "conceive." 'Ann. and Mag. Nat. Hist.' vol. xix. 1st Ser. p. 260.

into long and wide regular cylinders either grouped near the base or dividing off one from the other.

This species differs most essentially from the last. Both primary and brachial fold altogether differ. The former exactly resembles the fold of *Ventriculites tessellatus*. The latter is very peculiar. It often displays a group of cylinders radiating out from near the base just like the outstretched fingers of the hand; and the length and thickness of the cylinders increase the resemblance. Hence the name. It is often found however under a modification of this form, rising to a considerable height, and one branch rising out of the other, at considerable distances, as it increases. In each case alike the cylindrical cavities of all the branches open into each other, and there is no true separate central cavity into which they open. The separate branches form exceedingly regular cylinders, and the primary fold is marked on each with perfect regularity. The margin goes off to a round edge, as will be seen in the figure.

The species cannot be at all understood, or even detected, without careful clearing out with the knife and needle; since its very nature, like that of every other species in this section, prevents it ever coming out of the matrix entire by any accidental fracture: beautiful fragments of it are, however, sometimes found.

The species is found in the Upper and Middle Chalk. A form essentially the same and of the same habit is sometimes found in the lower chalk and in the chalk marl and greensand*. In all the specimens from these latter beds which I have seen the thickness of the wall is however much greater, and the diameter of the branches also rather greater than in specimens from the Upper and Middle Chalk, a fact which it is interesting and important to notice as connected with the stratigraphical distribution of these fossils, though I do not conceive these minor characters sufficient to justify, at present at any rate, and until their constancy is fully established, a distinct species or even variety for those lower forms.

Among the Mount Rhanden specimens in the British Museum are individuals identical in general character and habit with the last-named modification of *B. digitatus*.

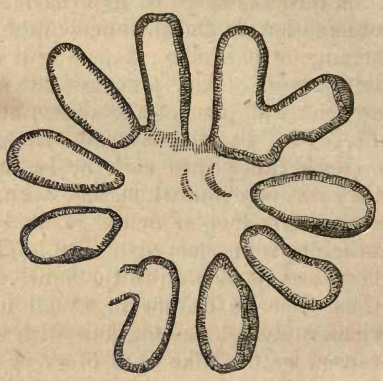
4. *Brachiolites tubulatus*. Pl. XV. fig. 7.

Membrane having a more or less slight, but close, primary fold, without any regular figure: brachial fold in narrow tubes increasing in size and length from the base upwards, and closely ranged round a central cavity; each tube narrowing at the mouth.

* See ante, p. 88.

This form will readily be distinguished from every other not only by the difference in the primary fold from that of any species which approach it in the character of the brachial fold, but in the essential character of that brachial fold itself. The narrowness, in comparison with the length, and the close setting, of the tubes, are together found in no other species. The accompanying figure, which is a transverse section of a specimen of this species, near the top, and just therefore missing the central cavity, could be presented by a similar section of no other species. It seems to me that there is generally no marked distinct opening to the central cavity, but that it is surrounded on all sides by the tubes. In fig. 7 of Pl. XV. the upper part was cut away before it came into my possession, but the wall of the cavity is, in that specimen, rounding inwards, and not expanding.

Fig. Q.



It is important to notice that each brachial fold is distinctly tubular and prominently projecting, and that its termination is slightly contracted, in the present species; two characters in which it essentially differs from *B. labrosus* and *B. fenestratus*, and characters which must obviously have materially affected the access and circulation of the sea-water. The central cavity into which those tubes open is another character to which the last remark strongly applies, and is a character also at once distinguishing this species from *B. fenestratus*.

This species is from the Middle Chalk.

5. *Brachiolites fenestratus*. Pl. XVI. fig. 3.

Membrane simple and without any primary fold: brachial fold in narrow tubes anastomosing and opening into each other in not very regular figure, but in several vertical and horizontal planes, leaving interspaces between them about equal to their own width: each tube rounding at mouth and projecting slightly beyond the plane of the most external range of the anastomosed mass.

The description will at once show wherein this species differs from the last. A single fragment of tube may be mistaken, as the primary fold is not strikingly marked in either, and the size

of the tube is the same in each. But masses of the two cannot be confounded, and the specific distinctions, as noticed in treating of *B. tubulatus*, are very important. It should be further noticed that, in the present species, there is not that variety in the size of the tubes which, as seen in fig. 7. Pl. XV., is found in *B. tubulatus*.

A certain degree of regularity is generally found, on careful observation, in the arrangement of the anastomosing tubes; that arrangement bearing often a near resemblance to regular square lattice-work. This arrangement extends both in the horizontal and vertical plane, as endeavoured to be represented in fig. 3, Pl. XVI. Specimens sometimes attained a large size.

Both this species and the last are very beautiful fossils when they can be obtained in any degree of perfectness. This however is extremely difficult, owing to the small branching arms of which each is made up. The inquirer may, unless great care is bestowed, and very cautious dissection made, easily mistake for them some of the markings often found on accidental fracture of chalk and flint, and on the outsides of flints, and which are really caused by *B. foliaceus* or other of the sinuous species. Oblique fractures take very indeterminate forms.

This species is found in the Chalk Marl and Upper Greensand. I have never seen a specimen from any higher beds.

6. *Brachiolites labrosus.* Pl. XVI. fig. 4.

Membrane having a slight and irregular primary fold: brachial fold variously winding and irregularly anastomosing, thus forming irregular but wide sinuous cavities opening into each other, with slightly projecting wide and irregular openings having entire and rounded margins: mass compact, broad and wide; rising to a moderate height, and subglobose in form.

The description will at once enable the inquirer to distinguish this very marked form from every other. The character of the primary fold resembles that of *Ventriculites impressus*. It is not nearly so close as in *B. tubulatus*, but much closer than is usual in *B. protensus*. The mouths of the cavities rarely open, as in *B. fenestratus*, by a regular cylindrical tube, but are very often elongated or irregular, and more or less constricted near the middle. The margin, however, is in every case entire, and generally spreads outwards, thick and lip-like, whence the name. The figure exhibits these peculiarities, but the size of the plate did not allow space for the representation of an entire specimen.

This species is found in the Chalk Marl and in the Upper Greensand. I have seen it from no higher beds.

7. *Brachiolites protensus.* Pl. XVI. fig. 5.

Membrane having a slight and irregular primary fold: brachial fold in large sinuous tubular masses frequently anastomosing and opening into each other, and with occasional, but irregular, large interstices: mass very irregular and usually spreading horizontally.

This species will perhaps be best understood if the inquirer conceives a number of the arms of *B. digitatus* to be more or less contorted instead of straight, and to anastomose and open into each other instead of always being distinct from each other at all other points than their bases. The tubular folds of *B. protensus* project from the mass not very prominently, but still conspicuously and in every direction. The primary fold differs however, as will be seen both by the description and figure, most essentially from that of *B. digitatus*.

The habit of the mass is the very reverse of being compact like *B. labrosus*; it may best be described as *sprawling*, whence the name; its tendency being usually to horizontal rather than perpendicular extension: it does not seem to have had any inclination to assume the globose or any other definite general figure. The mouths of the tubes tend to expand as in *B. labrosus*, while in *B. digitatus* their tendency, where not simply straight, is rather to contract as in *B. tubulatus*.

This species is from the Lower Chalk and Chalk Marl.

I have thus laid before the reader the result of an investigation which has engaged most of the leisure hours of some years. I am too conscious of the disadvantages under which I labour, and the want of qualifications which I possess, to anticipate otherwise than much criticism as to the results of that investigation and the execution of my task. I would only request the reader to remember that the field was an entirely untrodden one and the task a new one,—"a task of no little difficulty in the accomplishment, and one that may fairly entitle him who enters upon it to expect to meet with indulgence*."

I have endeavoured to show the existence, in one, at least, of the great geological epochs, of a widely extended class of animals whose nature,—if the existence of a few of the forms was vaguely known before,—was totally unknown, as also was their structure and all that constitutes the knowledge of an organic being. I have exhibited a structure as remarkable as it is novel. I have shown the extraordinary variety of forms which that structure assumes,—a variety in which one Law of Unity, however, still

* Farre, ut ante, p. 387.

prevails. Numberless illustrations of design and adaptation have forced themselves upon attention in the course of the investigation, and more might have been suggested had it not been feared that the allusion would appear obtrusive.

It cannot be supposed that the forms which have been here described constitute all that existed of this family even in the cretaceous seas. In my own collection are a few individuals as to whose specific identity I have some doubt, but as to which I would wait for further means of observation rather than rashly increase the number of species. Doubtless, now that the structure has been described, and figures and descriptions of such numerous forms been given, some attention will be directed to the subject and other forms be found. From the great extent of the materials on which these observations have been made, it may, however, without presumption, be conceived that the principal typical forms are here included, and that any which may hereafter be clearly ascertained will range themselves easily in one or other of the groups whose characters, general and special, have been here determined.

Many other obscure fossils are found in the chalk, either generally unknown or distinguished by names which impart little idea of vitality to the objects to which they have been attached,—a vitality which it is sought in vain to realize by any descriptions which have hitherto been published. To a more particular examination of some of these, the attention of such readers as have followed with any interest the present inquiry into the structure, affinities and forms of the Ventriculidæ, may, at a future day, be perhaps invited.

EXPLANATION OF PLATES, AND INDEX.

[The Plates are numbered as they were published in the 'Annals and Magazine of Natural History.']

Pl. VII. (all in flint except figs. 1, 2, 3, 9 and 12).

Fig. 1. Transverse section of *Cephalites longitudinalis*, pp. 17 & 73.
— 2. Transverse section of *C. alternans*, pp. 17 & 75.
— 3. Oblique section of *C. bullatus*, p. 76.
— 4. Vertical section of *Ventriculites*, showing base of body lodged and ensheathed in the root: the upper part showing the fold of the membrane, p. 16.
— 5 & 6. Vertical and transverse sections of the same specimen showing body lodged and ensheathed in the root, p. 19, & see p. 97, note.
— 7. Root seen externally ensheathing body, p. 19.
— 8. Intimate structure of the Ventriculidæ highly magnified, showing square and octahedral structure, p. 21.
— 9. Cast in chalk of this structure, p. 23.
— 10. The octahedral structure very highly magnified, p. 22.
— 11. The dermis or underskin, pp. 23 & 31.
— 12. The epidermis or polyp-skin, pp. 23 & 31. This specimen is broken away at the upper part, showing traces of the structure below.
— 13. The polyp-cells: vertical section highly magnified, pp. 36 & 37.
— 14. The mode of addition of fibre, p. 21.

Pl. VIII. (all in chalk except fig. 7).

Figs. 4 & 5. Casts showing the places of processes, p. 32.
— 6. Polyp-cells highly magnified, p. 36.
— 7. Root-fibre encrusted with chalcedony, p. 25.
— 1. *Ventriculites simplex*, p. 55.
— 2 & 3. *Ventriculites impressus*, p. 56.
N.B. For *Ventriculites quincuncialis* see Pl. VII. fig. 7, & p. 58.

Pl. XIII. (all in chalk, except fig. 6, which is in flint).

Fig. 1. *Ventriculites muricatus*, p. 61.
— 2. *Ventriculites tessellatus*, p. 62.
— 3 & 4. Different sections of *V. tessellatus*, p. 62.
— 5. *Ventriculites cavatus*, p. 63.
— 6. *Ventriculites striatus*, p. 63.
— 7. *Ventriculites mammillaris*, p. 64.
N.B. For *Ventriculites latiplicatus* see fig. D, p. 66.
— 8. *Ventriculites decurrens*, p. 66.
— 9. Variety *tenuiplicatus*, p. 66.
— 10. *Ventriculites radiatus*, p. 69.
— 11. Section of *V. quincuncialis*, p. 59.
— 12. Section of *V. muricatus*, p. 61.
— 13. Plaits of *V. striatus*, pp. 63, 65.
— 14. Plaits of *V. mammillaris*, p. 65.
— 15. Plaits of *V. radiatus*, p. 67.
N.B. For *Ventriculites bicomplicatus* see fig. E, p. 70.

Pl. XIV. (all in chalk).

Fig. 1. *Cephalites longitudinalis*, p. 73.
— 2. *Cephalites guttatus*, p. 74.
— 3. *Cephalites paradoxus*, p. 75.

Figs. 4 & 5. Outer and inner surfaces of *Cephalites alternans*, p. 75.
— 6. *Cephalites bullatus*, p. 76.
— 7. Section of *Cephalites bullatus*, p. 76.
— 8. *Cephalites retrusus* (moulded from a cast in flint), p. 77.
— 9. *Cephalites catenifer*, p. 78.
— 10. *Cephalites compressus*, p. 80.
— 11. *Cephalites capitatus*, p. 81.
— 12. *Cephalites campanulatus*, p. 82.
— 13. Vertical section of *Cephalites campanulatus*, p. 84.
— 14. Piece of the matrix from inside of *C. catenifer*, showing projecting parts, which filled the depressions in the living animal, broken away, p. 79.
— 15. Transverse section of fold of membrane of *C. catenifer*, p. 79.
— 16. Plaits of *C. catenifer*, p. 79.

Pl. XV. (all in chalk, except fig. 6, which is flint).

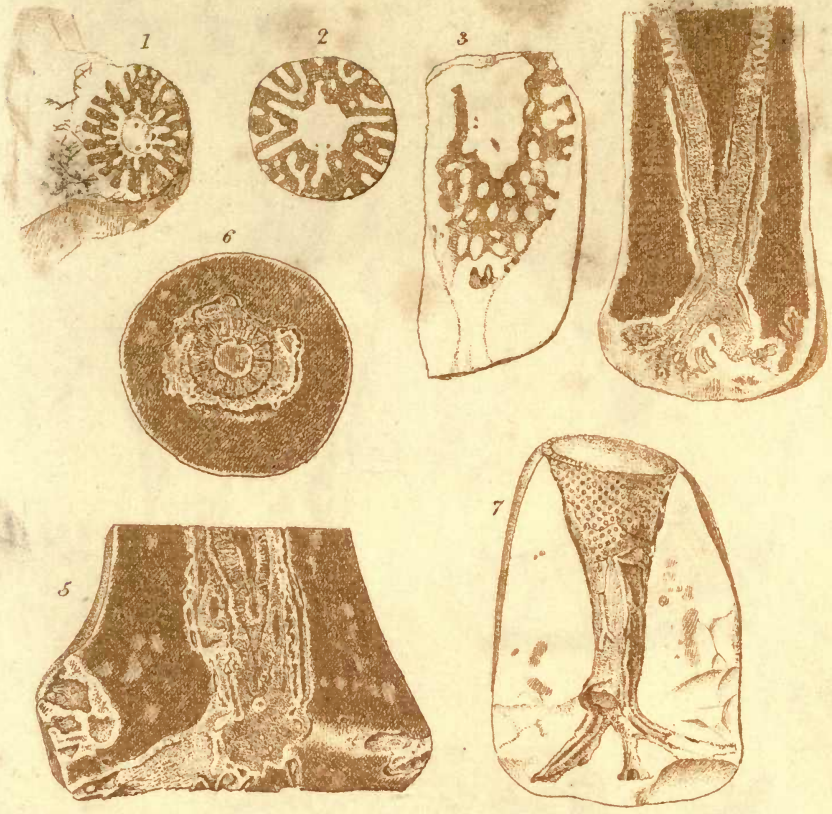
Fig. 1. *Cephalites constrictus*, p. 84.
— 2. *Cephalites perforatus*, p. 86.
— 3. *Brachiolites tuberosus*, p. 89.
— 4. *Brachiolites elegans*, p. 90.
— 5. *Brachiolites convolutus*. The specimen has been vertically divided and one-half cleared out, thus showing the convolutions and the interior, p. 90.
N.B. For *Brachiolites angularis* see fig. O, p. 92.
— 6. *Brachiolites racemosus*: the right-hand portion shows the form of the arms as seen on outside of flint; the left-hand portion shows the root and longitudinal sections of several arms, p. 99.
— 7. *Brachiolites tubulatus*, p. 101.

Pl. XVI. (all in chalk).

Fig. 1. *Brachiolites foliaceus*: the lower part showing the outside, the upper part a vertical section, p. 99.
— 2. *Brachiolites digitatus*, p. 100.
— 3. *Brachiolites fenestratus*, p. 102.
— 4. *Brachiolites labrosus*, p. 103.
— 5. *Brachiolites protensus*, p. 104.

ERRATUM.

At *page* 17, *line* 16, a reference is made to Pl. VII. by mistake for Pl. VIII.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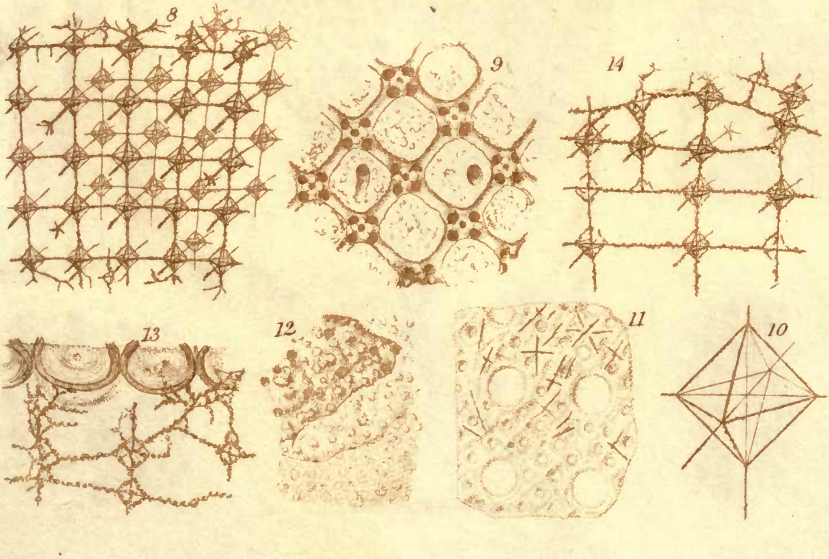
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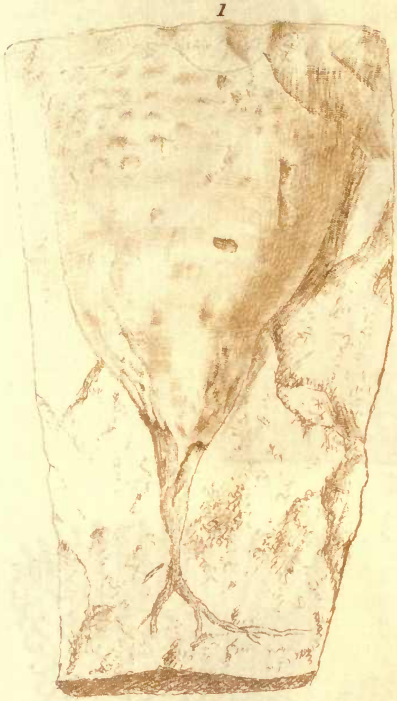

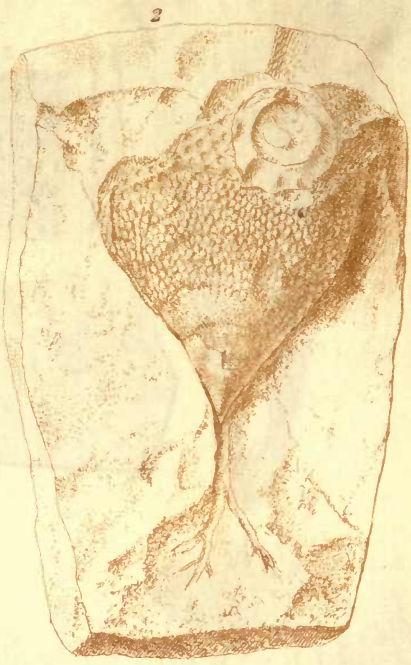

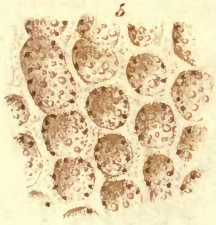

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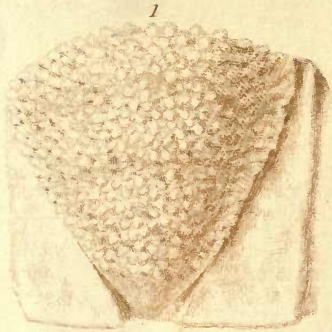

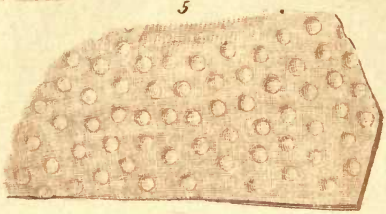

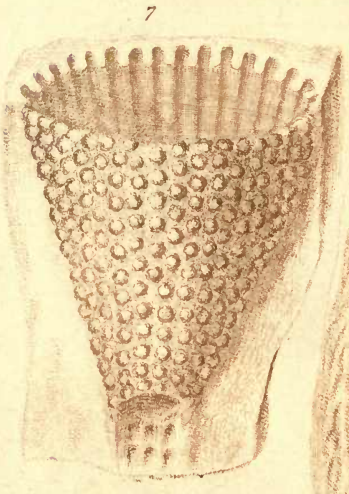

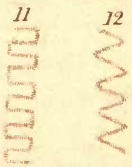

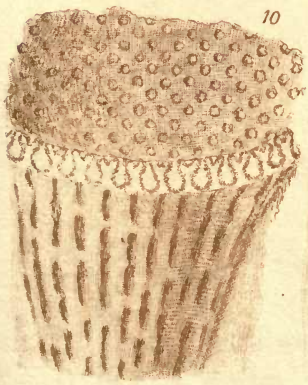

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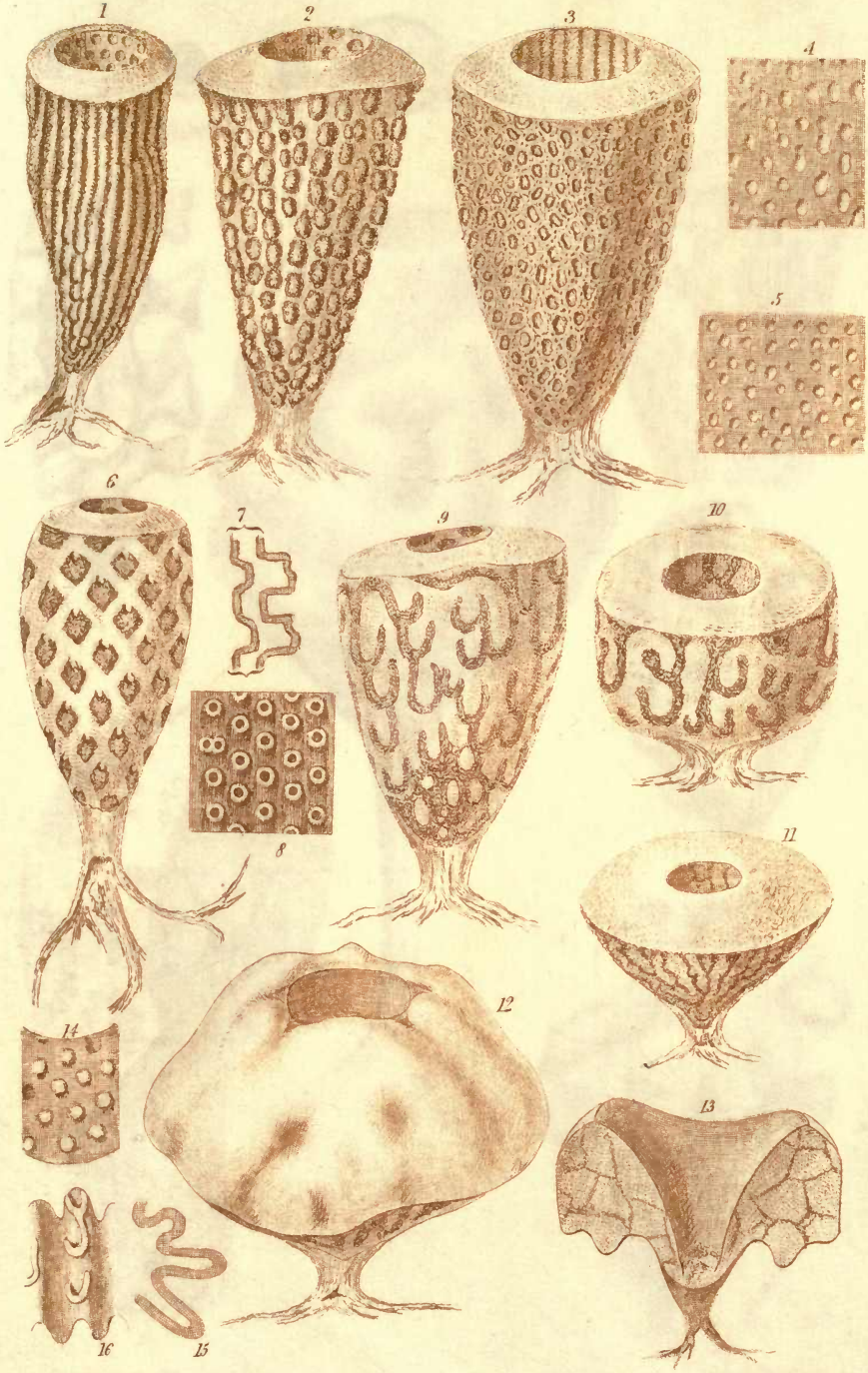

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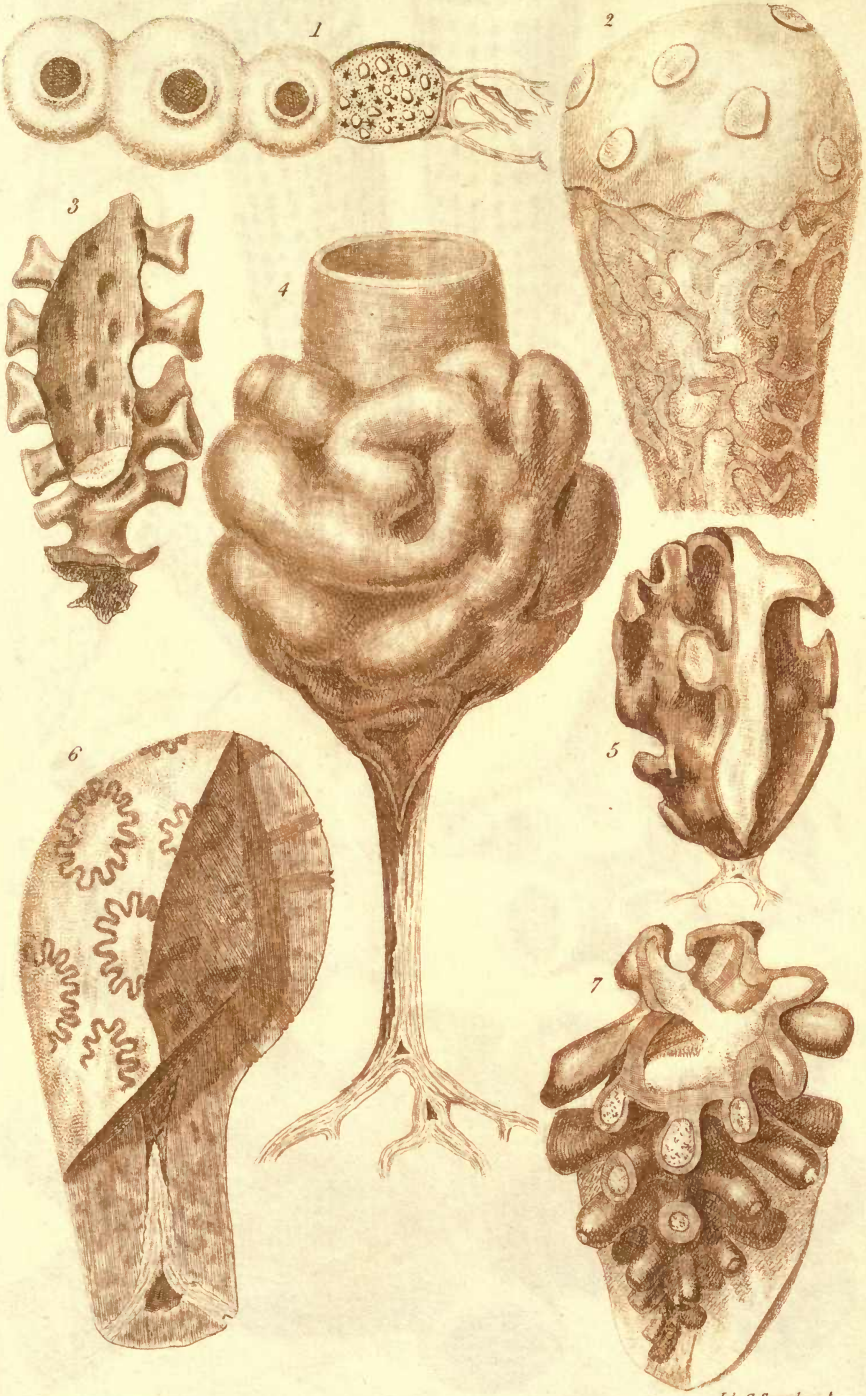

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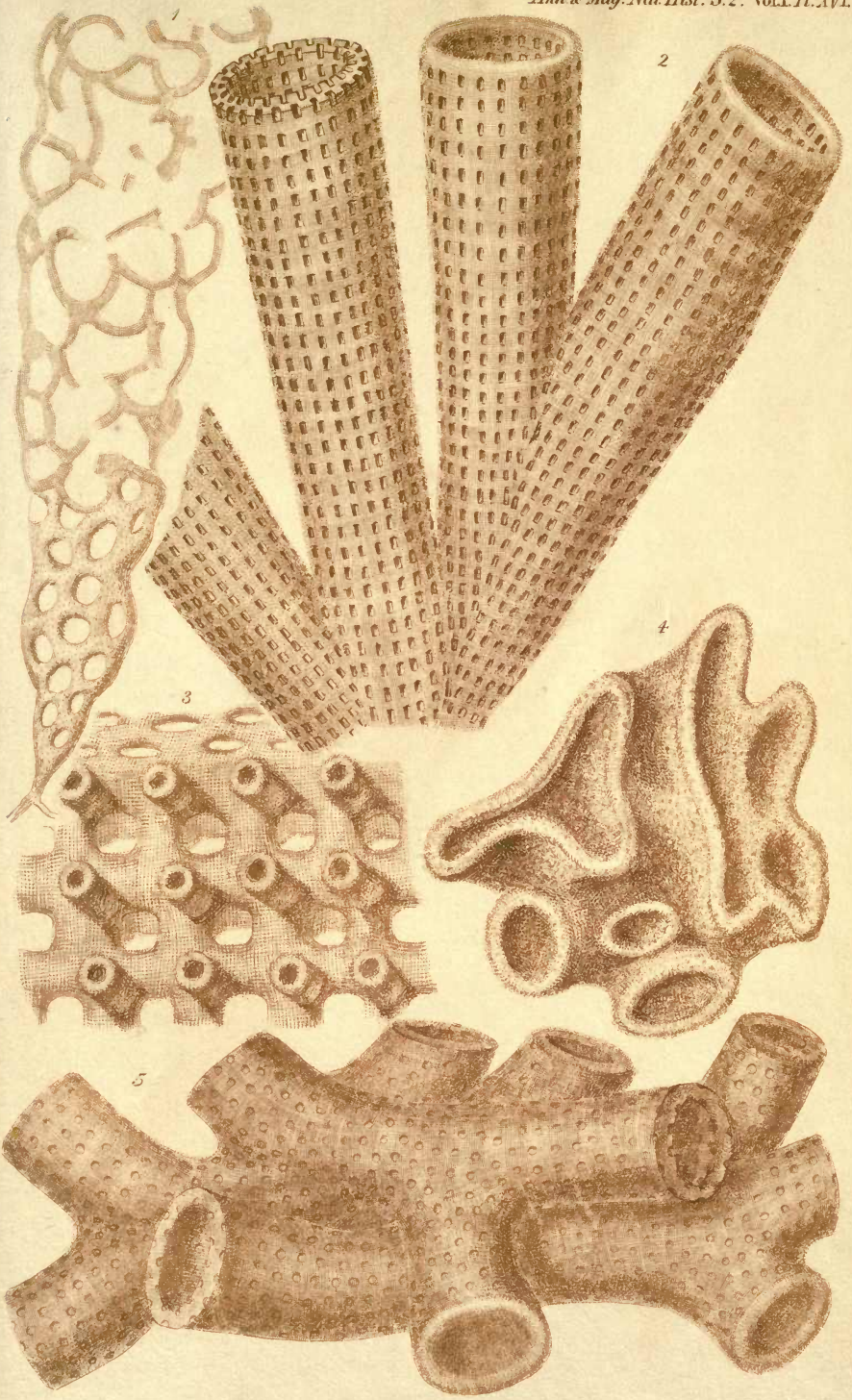

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