On the Structure of *Porites*, with Preliminary Notes on the Soft Parts. By Henry M. Bernard, M.A. Cantab., F.L.S.

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(Plate 35.)

In a paper lately read before this Society*, I endeavoured to ascertain the position of *Porites* in the Madreporarian system. A brief sketch of the structure was then given, sufficient to make the rest intelligible. The conclusion arrived at was that *Porites* resulted from a tendency towards very early budding, already noted in the Madreporidæ. This tendency, pushed still further, has produced a genus in which the budding takes place while the skeleton is still immature. In this way, the small size and the shallowness of the calicle, the perforation of the septa, and the reticular nature of the whole skeleton, which may be regarded as retrograde characters, can be reconciled with the presence of a flattened epitheca which, as elsewhere † explained, is characteristic of the highest Madreporarian specialization.

In the present paper I propose to give an account of the structure of *Porites* in greater detail. During the year which has elapsed, my specimens have been examined and re-examined, and new structural details have come to light. One of them, namely, the discovery of the directive plane, and the bilateral symmetry of the calicle, will largely help to rescue the genus from the obscurity to which the smallness of its calicles and the complexity of its reticular skeleton have necessarily condemned it. I have also been able to cut sections of the polyps of a West-Indian form, one of the many from that region with low thick knobbed stems, alive only for a few centimetres at the top. A few brief notes on the first results of the microscopical examination of these are here appended.

The Skeleton.

Wall and Cœnenchyma.—The distinction often drawn between these two ‡ has been due to the absence of any clear conception as to what the wall really is. I have already explained in my last paper how, in the Madreporidæ, the primitive epithecal

* This vol., p. 127.

† Journ. Linn. Soc., Zool. xxvi. p. 495.

‡ Compare, for example, Klunzinger's statement that, in *Porites*, the calicles are united by the walls and not by a cœnenchyma (Corallenthiere, ii. p. 39). The same is repeated by Martin Duncan, Linn. Soc. Journ., Zool. xviii., 1884.

wall became flattened out, and a secondary internal septal wall took its place, the living tissues clothing the whole of this septal wall down to the remains of the epitheca. This wall was primitively built up of the radially arranged laminate septa and their synapticular junctions. Secondary modifications occur, and the stiff radial arrangement of plates joined concentrically together dissolve down and change into a sponge-work in which the primitive elements are only just traceable. We then have a reticular wall which may be thick or thin. When a coral with such a septal wall buds, to form a stock, the reticular walls of parent and bud flow together. *These combined walls form the cœnenchyma.* The cœnenchyma can only be said to be absent when it is reduced to a minimum, *i. e.*, when the calicles are separated by a single perforated plate. But, in reality, no sharp line can be drawn between the many degrees of thickness resulting from the fusion of the walls.

It is true that an apparent distinction exists between the wall and the cœnenchyma in certain cases, but in none will it bear examination. In *Madrepora*, the upper parts of the calicles (when young) project above the cœnenchyma, that is, above the fused basal parts of their walls. But as these calicles get older, the fusion usually rises, till, in the basal or older parts of most Madrepores, the calicles are quite submerged, and the fused walls and the cœnenchyma are one and the same structure *.

* It will be noticed that this description tends to limit the meaning of the word 'cœnenchyma' to the fused outer or costal surfaces of purely septate thecæ. Its component elements, therefore, are septal and synapticular,—one might have said costal and synapticular. But, in these porous thecæ, division of radial structures into septal and costal portions can only be artificial. And it seems to me that the word 'costa' had better be reserved for external ribs which are somewhat more naturally separate from the septa.

If the term 'cœnenchyma' is so limited, it not only excludes such tissues as that in which the calicles of *Galaxea* are embedded, which is epithecate in origin, but also all the stray proliferations of the skeleton which are frequently met with in the Madreporidæ and elsewhere. For instance, in *Alveopora* there can be no costæ at all, the walls between adjoining calicles being morphologically equivalent to interlacing septal spines (Journ. Linn. Soc., Zool. xxvi. p. 495). And yet, in rare cases, on the undersides of stocks, a curious proliferation of the walls sometimes takes place, so that the calicles may be separated by a coarse reticulum almost like a normal cœnenchyma. All such adventitious proliferations of skeleton I propose to call a 'pseudo-cœnenchyma.' They are mostly found in the basal parts of stocks, where normally, as is well known, the basal skeleton merely thickens without forming any additional framework.

In *Montipora* and in *Porites*, the calicle-walls fuse for their whole height, and the fossæ are merely sunk into the common reticular skeleton. In *Montipora* it is impossible to assign definite portions of this reticulum to the individual calicles; but in many *Porites* this can be done, the surface being marked off into polygonal areas, each area being in close contact with those adjoining it, and with its surface often sloping inwards towards the fossa in the centre. Hence it has been stated that *Montipora* has a cœnenchyma, but *Porites* little or no cœnenchyma (Milne-Edwards and Haime *; see also quotation from Klunzinger, *ante*, p. 487, footnote). An extended survey of *Porites* shows that this distinction is quite artificial. On many of the forms with these thick-walled calicles marked off into polygonal areas, these areas become gradually invisible in the older parts of the stock; while forms in which no areas are traceable at all, and in which the calicles are sunk straight into a reticular skeleton as they are in *Montipora*, are quite common. Milne-Edwards suggested that perhaps these latter should be placed in a new genus. This suggestion was carried out by Verrill †, and further emphasized by Klunzinger, who placed *Synaræa*, Verr., at the very end of the Poritidæ, because it alone had a cœnenchyma; whereas, as above stated, calicles marked off into areas and calicles sunk in a level cœnenchyma can frequently be found on one and the same stock ‡.

Passing in review the various walls found in *Porites*, we shall see again how impossible it is to separate a group as a new genus merely on account of the great thickness and level tops of their walls.

Thin Membranous Walls.—These walls have very different appearances according as the intrathecal skeleton rises to the level of the wall or sinks down below that level. In the former case we have a surface like that shown in fig. 5, Pl. 35; only here the skeletal elements are somewhat thickened. In these cases it is common to find the edge of the wall incomplete, the calicles communicating freely one with the other. These communications doubtless become perforations as the stock thickens.

In these thin-walled forms the wall itself is composed of a

* Ann. Sci. Nat. 3rd ser., xvi. 1851, p. 24.

† Bulletin Mus. Comp. Zool. i. 1864, p. 42.

‡ For another supposed generic distinction between *Porites* and *Synaræa* ee p. 494 footnote.

single ring of synapticular bars or plates, and these may be arranged either zigzag round the calicle or in straight lines. In the latter case, the lines form the sides of polygons. These straight walls are, I expect, secondary; for, regarding the reticular wall as primitive, the zigzag wall would be the more natural derivative of such a reticulum. The zigzag line is formed by single synapticular bars joining the alternating costal edges of adjacent calicles. All stages of the straightening of this line can be found. It is the straight wall which rises above the surface as a thin membrane-like edge, and, in extreme forms, may give the whole surface an alveolate appearance. The whole intrathecal skeleton may remain deep down in the base of the membranous pits, or septal striæ may slightly thicken the walls and serrate their edges.

Reticular Walls.—Of these there is an immense variety, and again the appearance is very different according as the intrathecal skeleton rises to the level of the wall or is sunk down below that level. They are thick and thin, round-topped or with a sharp median ridge; or again, if the calicle-depressions are cylindrical, the intervening angles may be thick and reticular, while at the points where the calicles touch one another, the wall may be reduced to a single lattice-work. Of the thick walls, we have already referred to the variety in which straight median ridges mark off in polygonal lines the areas belonging to each calicle. These areas may sink inwards funnel-shaped towards their central fossæ. Or, again, they may be quite level. In this case, the median ridge frequently disappears, and we have the cœnenchymatous group (formerly *Synaræa*, Verrill). The most interesting section of these is formed by those in which the thick walls rise up secondarily into ridges or papillæ (fig. 6, Pl. 35), very similar to those found in *Montipora*. This is an interesting case of similar specialization arising under similar conditions. But, in *Montipora*, the thick reticular walls are characteristic of the genus: hence these cœnenchymatous developments on the tops of the walls are far richer and more varied than they are in *Porites*, in which the thick reticular wall is confined to a group only. I have so far found no traces of the 'tuberculate' specialization * of the cœnenchyma which is so widely developed in *Montipora*.

* *Cf.* Brit. Mus. Madrep. iii., Introd. p. 9: also for figures, Ann. & Mag. Nat. Hist. xx. (1897) p. 117, pl. ii.

These secondary cœnenchymatous developments have given rise to some confusion, their morphology not being always clear, especially when the calicles are crowded and the ridges appear as mere upward extensions of the walls. In the 'Challenger' Report on the Reef Corals (xvi., 1886), two new forms, *P. crassa* and *P. latistellata*, Quelch, are described; but, according to the classification there adopted, they should have been placed in the genus *Synaræa*, which was established to contain all the Poritid forms with ridges or papillæ rising from the walls between the calicles. *P. latistellata* was so named because the individual calicles were measured as if these secondary cœnenchymatous ridges were the tops of the walls; and in an allied form, where the ridges ran so as to separate the calicles into short linear series in the bottoms of narrow valleys, such series were thought to be the result of intracalicinal gemmation. This led Mr. Quelch to found a new genus, *Napopora*. Recent acquisitions by the British Museum have supplied us with links sufficient to connect the types of the new genus specifically with *P. latistellata*.

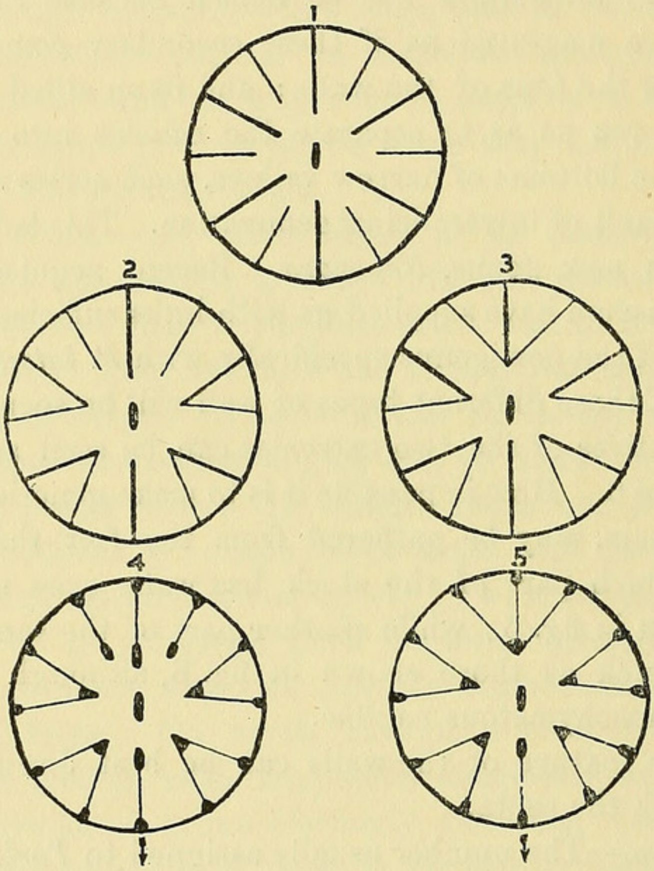
A few of these different types of wall will be seen in Plate 35. Representatives of the two extremes can be seen and compared in figs. 5 and 6. How impossible it is to make generic distinctions between them, may be gathered from the fact that specimens occur in which part of the stock has walls even thinner than those shown in fig. 5; while another part of the same stock has walls as thick as those shown in fig. 6, although without the special cœnenchymatous papillæ.

The finer texture of the walls can be best discussed in connection with the septa.

The Septa.—The number usually assigned to *Porites* is twelve, and it seems quite possible to separate *Porites* from *Goniopora* mainly on this point, *Goniopora* having typically 24. Dr. Verrill ascribed "12, sometimes 12 to 20, rarely 24" septa to *Porites*; but I have found it better to class every Poritid with more than 12 septa in the genus *Goniopora*, as Dana proposed. Mr. Quelch, again, claimed 24 septa for *Porites* (Chall. Rep. xvi.), on account of his species *P. mirabilis*, in which calicles occur with 3 cycles of septa. These, however, are obviously the large double calicles, one or two of which can be found on almost any stock and must be regarded as abnormalities. One is seen in fig. 5, Pl. 35.

With regard to the development of the septa in *Porites* no comprehensive survey has ever yet been attempted. Milne-Edwards and Haime described them as usually hardly distinct from the pali.* I give, in the accompanying diagrams, a series of their more important variations. These are found so intimately linked together, more than one being observable on the same stock, that no generic distinctions can possibly be built upon them.

1. Twelve distinct septa end freely and separately round the fossa.



Diagrams showing the principal variations in the septal and palic formulæ in *Porites*.

Slight swellings of their inner edges may or may not indicate a disposition to form pali. They may or may not be distinguishable into two cycles. Forms with such septa, of which the best known example is *P. astræoides*, Lamarck, were grouped into a separate genus † *Neoporites* by Duchassaing and Michelotti. But the disposition to form pali and also to pass into the condition shown in fig. 2 renders it impossible to admit any such distinction.

* Ann. Sci. Nat. 3rd ser., xvi. 1851, p. 25.

† Or 'subgenus,' Pourtalès, Bull. Mus. Comp. Zool. iv. 1871, p. 85.

2. The septa meet and fuse, and *always in the way shown*, two pairs on each side of a line passing through two opposite septa, the significance of which will be seen presently.

3. The fusion of septa goes still further, and, in addition to the two pairs, a triplet is formed (fig. 3). Pl. **35.** figs. 5 and 6 show these fusions fairly clearly, and probably careful study might make them out on some of the other figures, but they can naturally be best seen in forms in which the upper edges of the septa are nearly on a level with the walls. I have never found any other fusions of septa but these. And here we may note that we obviously have the directive plane in the line passing through this triplet and the columellar tubercle. The calicle is divided into two symmetrical halves; and whether the two cycles of septa are distinguishable or not in size and development, we can always now ascertain which are the primaries and which the secondaries.

4 & 5. The septa which are best developed in fig. 1 become usually poorly developed in figs. 4 and 5 (diagr.), and their upper edges are interrupted. A portion, frequently only a granule, shows near the wall, and another portion appears as a palus at the tip of each septum. I propose to call the peripheral portions of the septal edges, the septal granules. Their variations are found to supply new and valuable taxonomic characters.

In these figures, the spaces between the septal granules and the pali are exaggerated, the figures not being intended to be more than diagrams.

We now come to the pali, which are so very characteristic of the genus, but on the arrangements of which no light has hitherto been shed.

The Pali.—These structures, though well shown in one of the earliest figures of *Porites* *, attracted no attention till Dana described them in his 'Zoophytes' †. He speaks of an inner and an outer ring of points, and adds that sometimes one of the inner unites with two of the outer to form a V-shaped palus. Since that time, the pali have always been treated as features of taxonomic importance, but nothing could be said about them than that their numbers were 5, 6 or more, and that they were large and prominent or the opposite, and occasionally V-shaped.

* Ellis & Solander, 'Zoophytes,' 1786, pl. 47. fig. 2.

† P. 550.

Reference to the digrams shows that they occur in a definite order, and that, in their development, they are closely associated with the fusions of the septa.

Passing over the cases of those *Porites* with septa arranged as in fig. 1 (p. 492), and each with a slight paliform swelling, and therefore with traces of 12 pali, the number is limited to eight as shown in fig. 4. Of these eight, the four which arise at the points where the septa meet in pairs are usually much larger than the rest (Pl. 35. fig. 1). They may be very large indeed as compared with those arising from single septa. When the large palus is formed by the fusion of the three septa, as shown in fig. 5 (diagr.), we have, with the four large ones at the points of fusion of the pairs, five large pali. Whenever we have a ring of five large pali, we know where and how they arise, viz., at the five points in which the septa fuse (see many of the rings of pali, Plate 35. figs. 3 & 6). Among these will be seen many in which there is a small extra palus, making five principal pali and one minute palus. The last is that on the directive septum, which remains single as shown in fig. 5 (diagram).

In Plate 35. fig. 6, it is easy to see the large pali arising from the points of fusion of the septa, and here and there having the V-shape described by Dana. But this arises not from the fusion of granules, as the great American naturalist believed, but from the fact that the fusing septa are slightly exsert *.

As the pali will have to figure in all future specific descriptions, it is necessary to name them. I propose therefore to call those which arise at the points of fusion of the four pairs, the four '*Principals*.' The directive palus which often takes part in the triple fusion may be called the '*Directive principal*.' The rest may be called *Supplementaries*, and we have a directive supplementary and two lateral supplementaries; one or both of these last-named may fuse with the directive principal.

It should be noted that no palic formula seems to be constant throughout all the calices of a stock. When describing the formula of any species of *Porites*, all that is meant is that there is apparent in the colony a tendency to produce that particular formula.

Having now described the septa and the pali, we may return

* This prominence of the pali and septa in many of the *Porites* with developed cœnenchymas was thought to be another generic distinction of *Synaræa*, but the point is an unimportant one.

to the finer texture of the walls which are built out of these septa, with their synapticular junctions.

It is quite correct to say of *Porites* that the stiff radial and concentric symmetry of septa and synapticulæ which characterizes the typical Madrepore is here melted down into a reticulum; a reticulum more loose because of the perforate and incomplete character of the septa.

We find, however, interesting variations in this respect. Not a few *Porites* still show traces of the stiff radial septa radiating outwards on the top of the walls as so many short ridges, *e. g.*, slightly seen in fig. 4, Pl. 35. These sometimes run from calicle to calicle, but are always slight and never approach the fine systems of parallel striæ which are so well developed over the whole cœnenchyma in *Madrepora* and *Turbinaria*, as unmistakable evidence of the part which the laminate septa (or costæ) play in the construction of the walls.

The first stage of dissolution is probably that in which the vertical elements persist as trabeculæ or upright threads which end above the surface as granules. This is the most common condition of the surface of *Porites*. The connection between the walls can then be seen from the fact that the wall granules are only a repetition of those seen within the calicle—septal granules and pali.

Not infrequently the horizontal elements become flattened flakes, so that the vertical section shows tiers of floors supported by short pillars.

The last stage is that in which both vertical and horizontal elements melt down entirely into either a sponge-work, or into a system of flakes mostly lying horizontally. In these cases we do not usually find the surface covered with granules, they are present only so far as the vertical elements, the tips of which constitute these surface-granules, continue to be developed as pillars.

The Columellar Tangle and Tubercle.—The base of the calicle in *Porites* always fills up sooner or later with a mass of reticular tissue, as emphasized by Dana*. This tissue may be conveniently called the Columellar Tangle. The most symmetrical manner in which this can develop is as a regular ring joining the septa and pali. It rises to various heights. It may be very simple and

* Zoophytes, 1848, p. 117.

open, or else, especially in cases where the horizontal elements are flaky, it may appear solid. I have never seen the columellar tangle as such protuberant or convex in *Porites*.

And here it is worth noting that there appears to be some trace of dimorphism in the calicles of a stock, while in some the centre of the columellar tangle fills up with cross bars, in others the latter remains a deep open pit. These two forms on one and the same stock are so frequent, that they suggest some definite physiological significance (*cf. infra*).

The tubercle which rises from the columellar tangle but is absent when the centre is hollow, is, as above noted, often found flattened in the directive plane and here and there joined to one of the directive pali. It is the equivalent of the directive keel seen bisecting the columellar tangles in many *Turbinaria*. It appears as if, in the earliest stages of budding, the directive septa met straight across the calicle, and that this columellar tubercle is the remains of the connecting link. This conclusion commends itself from the fact that a close study of columellar tangles, as in *Turbinaria*, where they are specially well developed, shows that they are primitively built up of the usually curled lower edges of the septa.

These comparisons help to confirm my view of the relationship of *Porites* to the Madreporids. In the case of *Madrepora*, the directive plane in the buds falls in with the radial symmetry of the parent, and might almost be regarded as coincident with that of one of its costæ. In *Turbinaria* although, in large stocks, the directive keels point almost all ways, yet, near the margins, they are often seen all pointing towards the growing edge. I have been fortunate enough to see this phenomenon in a thin explanate *Porites* (fig. 4, Pl. 35). In this figure the great majority of the directives point nearly uniformly up and down, that is, in the line of growth. If we refer to the diagrams, the direction of growth runs out between the four principal pali as indicated by the arrow (diag. 4 & 5, p. 492).

Whether these directive planes, when found twisted all ways on a stock, indicate special relationships between adjacent individuals of the colony it is impossible to say. I should be inclined to think that the individual as such is submerged except in *Madrepora*, and that the buds come from the common cœnosarc.

Before leaving this columellar tubercle, I would draw attention to the fact that I have inserted it in all the diagrams as a permanent feature of the skeleton. While I believe it to have been a primitive element of importance, it is not now universally developed. I have already mentioned those scattered calicles which occur on most stocks in which the fossa is a deep pit, but, apart from these, we find in very deep calicles that the pali and the columellar tubercle are sometimes wanting. There can be little doubt that there is some correlation between the depth of the calicle and the development of pali. The same phenomenon occurs also in *Goniopora*. Stocks occur in which great variation exists in the depths of the calicles; for instance fig. 2, Pl. 35, is taken from one side of a stock in which the calicles on the opposite side are much deeper and show only the faintest traces of pali.

It is not surprising, then, that it is just in the deeper calicles with all septa free, as is shown in diagram 1, that the columellar tubercle is most frequently absent, and the pali often only slightly traceable as faint swellings. But cases are not wanting in which, while the septa are free and the pali hardly traceable, the columellar tubercle is well developed: I have found this in some West Indian species. The combination is interesting, because a *Porites* without pali but with a columellar tubercle exists in the Berlin Museum, and was named by Ehrenberg *P. punctata*. Milne-Edwards & Haime first suggested a new generic name for it, and called it *Stylaræa Mülleri*. But these authors suppressed this name the same year and reverted to Ehrenberg's *P. punctata*. In recent years, however, Dr. Klunzinger* has again revived the genus, re-naming the original specimen *Stylaræa punctata*, and placing it next to *Porites*. I find it necessary to add this genus *Stylaræa* to the list of apparently needless genera given in my previous paper. For, not only is there nothing specially startling in the absence of pali and the presence of the columellar tubercle, but, among the many other variations presented by *Porites*, we actually have specimens in which the columellar tubercle is well developed while the pali are here and there only faintly traceable. As against the advisability of making a new genus on the original specimen of Ehrenberg, I should like to point out that it is so small that, as Ehrenberg suggested, it might easily be a young form in which adult conditions are not yet fully developed. I have frequently observed that young, and perhaps very rapidly

* Corallenthiere, ii. 1879, which see for other references.

growing stocks have characters very unlike those of the larger stocks close to which they are growing, and from which it is probable, though not always certain, that they have been derived.

Growth-forms.—Very young colonies consisting of a small mass of reticulum filling up an epithecal saucer are frequently met with. I have, however, never met with one in which the parent calicle was still recognizable. Such, however, must of course be postulated. The appearance, in cases in which the wall is reticular, is almost indistinguishable from that shown by young Montipores (see figs. 1 & 2, Ann. & Mag. N. H. (6) xx. pl. ii.). I have not found any young colonies of forms with membranous walls. A knowledge of the early colonies would be very desirable: considering the ease with which, in a large stock, one type of calicle passes into a very different type, we might expect them to vary considerably from the adult.

The budding of shallow, saucer-like calicles from the sides of other shallow calicles is not likely to be very plastic. But among other causes of form-variation, we may note the local thickening of the walls. When this is very irregular and confined to small groups of calicles, it leads to the formation of bosses and knobs from which branches are easily developed. In this way purely branching forms many have been evolved, but the branches are for the most part thick and coarse; elegantly branching forms are rare.

Considerable variation occurs as to the depth to which the colony descends in branching forms. We find all extremes: merely the tips for a centimetre or two may be alive, or the living layer may extend right down to the base of the stock, twenty centimetres or more.

As reef-builders, this genus of Stony Corals has long been famous. It is a conspicuous component of the outermost edge of the reef where the surf is most violent. The unfavourable conditions of existence at such spots may supply us with a clue to the dwarfing of the polyps, this having resulted in the building-up of almost solid coral-masses. Hence again, though branching forms are fairly numerous, they are insignificant as compared with the rounded masses of almost solid coral-rock (often many feet in diameter) which are most frequently met with. In the West Indies, we read of thick tangles of branching Porites spreading over the surface, but the branches are coarse, thick and matted together.

Dana thought that there were no foliate forms, the nearest being the sublamellate growths due to the fusion of the branches. There are, however, a few thin explanate forms which approach the foliate condition. But there is certainly no rich foliation such as we find in the foliate group of the *Turbinariæ* and, only in lesser degree, in the Montipores.

The various growth-forms pass so gradually into each other that it is only possible to group them in series. I place the explanate forms, which admit of being described separately, as the first division. The second consists of those explanate and encrusting forms which throw up lobes and columns; these vary imperceptibly in two directions: (*a*) into columns, and (*b*) into branching forms, both without encrusting bases. The third group consists of glomerate forms beginning (*a*) with those with edges expanding while the centre thickens, and may either, by continuous growth or by fresh relays, form great hemispherical masses, and ending (*b*) with those in which the stock develops at once as a rounded mass. These again are often difficult to distinguish from one another: and hard and fast distinctions are impossible.

Some Preliminary Notes on the Soft Parts.

In the diagram of *Porites* which I sketched in my former paper*, in order to compare the structure of the skeleton upon its flattened epitheca with that of a Madreporid, the porous septa were purposely drawn very low. The diagram represents only an ideal parent calicle of a *Porites*. As a matter of fact, while, in very many forms, the calicle-depression is like that there shown, the underlying reticular skeleton occupied by the soft tissues is very much deeper.

In sections of dried *Porites*, the staining of the living tissues penetrates some 3–4 mm. beneath the surface, and, if a piece be decalcified, the soft parts are left as a fleshy reticulum of nearly even thickness (3–4 mm.), from the surface of which the polyps project. The enteric cavities of the compound stock are simply a network of fine canals.

On decalcifying a fragment of *P. recta* (?) from Jamaica, beneath the fleshy rind was found a cloudy mass of hyphæ, threads of which had run up through the skeletal reticulum into

* This vol., p. 135, fig. 1.

the septa and pali. These threads kept the hyphal mass attached to the rind after the skeleton was dissolved away. Several different kinds of fungoid growths can be distinguished, many presenting appearances so interesting that the whole will be submitted to specialists in that branch of study, in the hope that some new biological facts will be forthcoming.

Further, in the clear spaces left by the decalcified skeleton, are sections of an organism which is almost certainly a ciliate Infusorian. These are essentially like those figured by Moore of *Spirostomum* (Journ. Linn. Soc., Zool. xxiv. pl. 27),—an open angular network with staining granules at the nodes, the cilia not staining and passing out through a thin, deeply staining membrane which, in sections, is broken up by the cilia into a row of dots. How Infusoria live in the apparently solid coral I do not know. It is, however, worth recording that one not infrequently finds the thinnest skeletal framework completely hollowed out by a system of thin-walled tubes, so that it is in reality not solid. I have never hitherto found any clue to this phenomenon. The discovery of a large Infusorian in the spaces of a Porites-section which are, in life, occupied by skeletal bars, adds another to the organisms, Sponges, and Fungi, to whose agency the excavations above mentioned might possibly be due.

There seems to be great variation in the shapes of the polyps, both contracted and protruded, judging from the published figures. But it is very doubtful how far any value can be attached to these variations.

Nevertheless some of these differences should be noted. Lesueur *, who first figured the polyps of *Porites*, shows three different kinds in a species called by him "*P. astrœoides*," possessing a large disc, and short round tentacles each with a distal black point. Duchassaing † also figures a *Porites* without name, with large convex disc and short, slightly knobbed tentacles each with a black distal point. This so far agrees with the above-mentioned figure of Lesueur. Agassiz ‡, on the other hand, gives five figures of polyps of "*P. astrœoides*," viz., a young one, in which no tentacles are yet seen, and four adults in which the arrangement of the parts are not at all clear. The ring of lobes drawn round the mouth can hardly be the tentacles, while

* Mém. Mus. Paris, vi., 1820.

† Coraliaires des Antilles, Suppl. 1864, pl. viii. fig. 2.

‡ Florida Reef, 1880, pl. xvi.

the peripheral fringe looks very like the mesenterial furrows which run down the sides of most *Porites*. The escape of a planula is shown.

The other two polyps figured by Lesueur, *P. recta* and "*P. clavaria*" (non Lamarck), have much smaller discs and short tentacles inclined to be pointed. Dana figures the polyps of *P. levis* as contracted down flush with the surface, the external mesenterial furrows radiating like spokes round the ring of knobs representing the contracted tentacles. The disc is fairly large and only furrowed by six mesenteries, whereas in most of the figures referred to, at least in which any furrowing of the disc is at all marked, the disc is furrowed by the full number of mesenteries. This is the case also in the figures of the long polyps of "*P. furcata*" given by Agassiz, in which the tentacles are thin, fusiform, and pointed. Saville Kent, in his 'Great Barrier Reef,' figures the polyps of three Australian species, with thin, cylindrical tentacles about as long as the diameter of the disc, each tentacle ending in a distinct spherical knob. The only specimen examined by myself which I would provisionally classify with *P. recta*, Lesueur, has rather a narrow column which suddenly enlarges to carry the twelve tentacles, which stand erect and short, stout and round-topped; the disc was rather small.

Agassiz (*l. c.*) first figured the nematocysts, or rather the coiled threads of the nematocysts. On my sections these occur chiefly in small groups raised into hemispherical batteries. One large battery occurs at the tip of each tentacle, and a row of smaller batteries runs down its inner face. The stinging-threads were all I could see, and they were mostly coiled in more or less conical spirals, the cones pointing inwards, and each beneath what appears to be a small round aperture on the covering membrane of the battery. Between these batteries the ectoderm was largely composed of slime-cells.

In addition to these small ectodermal stinging-threads, the cavity of the polyp contains great numbers of long, membranous sacs some 40 μ in length, each with a long coiled thread; the coil is never a regular spiral, and the membranous sac is often collapsed upon the thread. No nucleus or communication with the exterior could be found, the bodies being loosely attached to the endoderm in great numbers in the tentacles, but also, though in smaller numbers, on the mesenteries. Examined with a very high power, the thread, which was as thick as the whole coil of the ordinary nematocyst (*i. e.* about 2 μ), appeared to have spiral lines running round it, and, when cut across, I saw it on more than one occasion hexagonal with the sides inwardly curved. While it is fairly safe to assume that these are defensive weapons *, more extended researches with better preserved material would be necessary to throw light on their structure and to discover their origin and the nature of their contents and method of discharge.

The internal tissues were much disorganized (1) by the symbiotic algæ and (2) by the great quantities of slime. The former were large, very numerous, and often found dividing. They occurred in greatest numbers in the extensible or projecting parts of the polyp, that is, doubtless, where the light can reach them, although they also occur scattered among the cœnosarcal canals. The slime seemed to have filled the internal cavity with a network of darkly staining strands, quite different from the bright carmine of the ectoderm-cells of the gullet.

Among the fragments of the cœnosarc which appear in the sections separated by the clear spaces left by the decalcified skeleton, the interseptal loculi can be made out by their radial arrangement, and by the presence of the mesenteries, which are here correspondingly narrowed. Different conditions would doubtless be found in other forms in which the intrathecal skeleton did not rise to the level of the walls.

Small as this contribution to the subject is, my work on the sections having been unexpectedly interrupted, it is enough to show the desirability of an extended study of the soft parts of different species of the genus.

EXPLANATION OF PLATE 35.

The six photographs here reproduced are from negatives kindly lent, for the illustration of this paper only, by the Trustees of the Natural History Museum. All are enlarged five times.

Fig. 1. *Porites* with full number of pali typically arranged ; the directives point in all directions.

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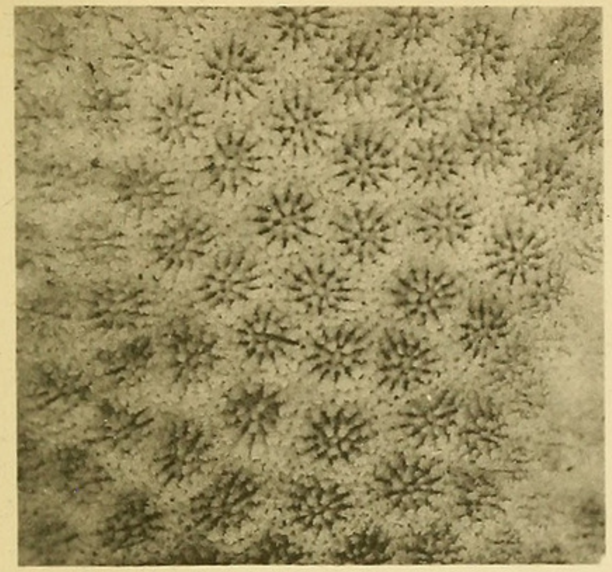
* At the suggestion of my friend Prof. Howes, I have compared these organs with figures of large cells with thick, coiled threads given by Weymouth Reid (Phil. Trans. 1894, B) for the skin of the Eel, and Goodrich (Q. J. M. Sci. xxxix.) for the cœlomic corpuscle of the Oligochæte *Enchytræus*. As Prof. Howes points out, these latter seem to be curious modifications of ordinary slime secretions. While I can trace only slight structural resemblance between these cells and those described above and *Porites*, the fact that here again they are associated with immense numbers of slime-cells suggests a line of enquiry which might be followed up.



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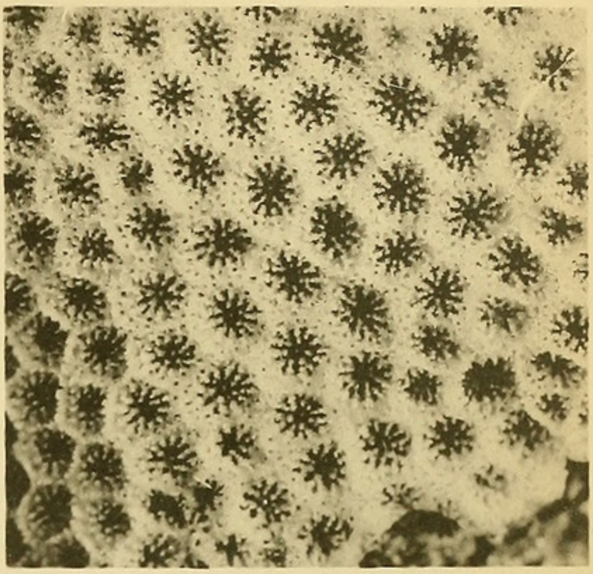

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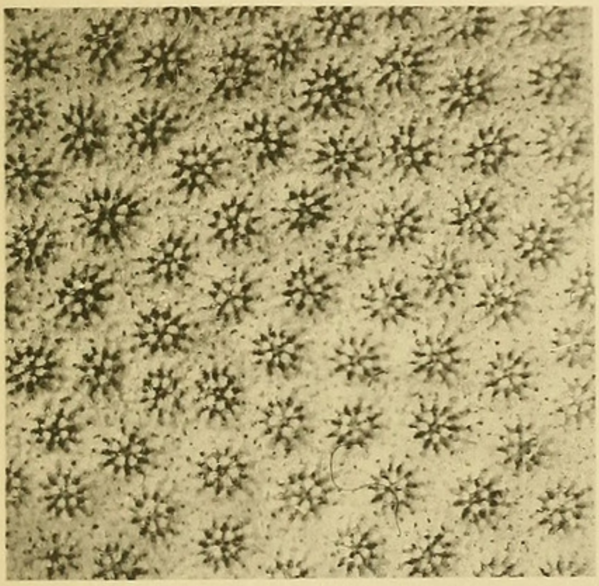

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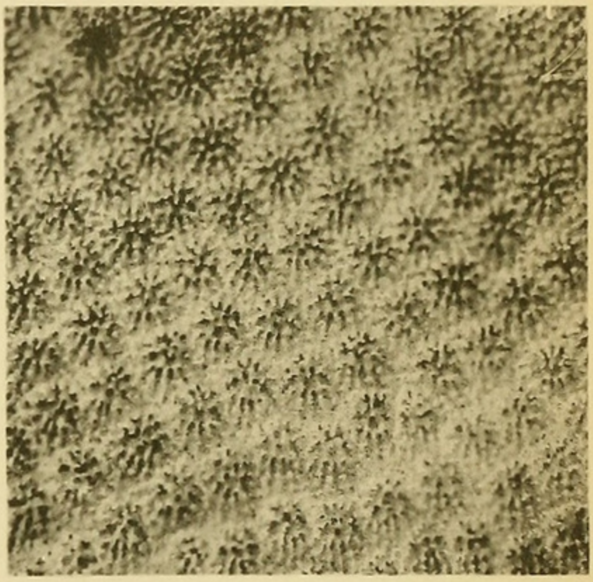

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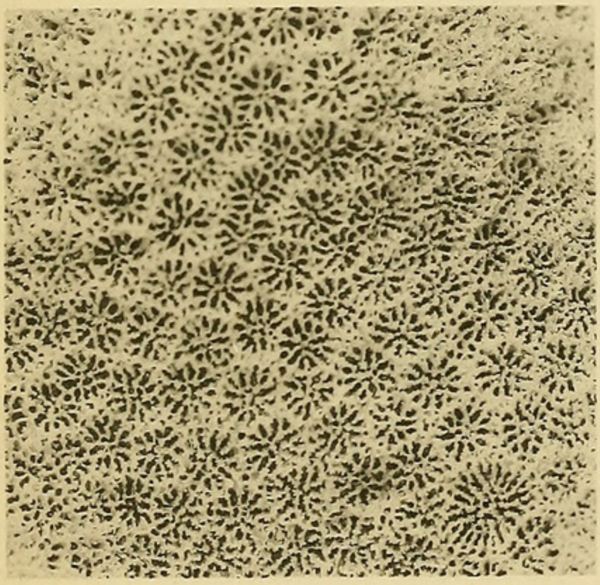

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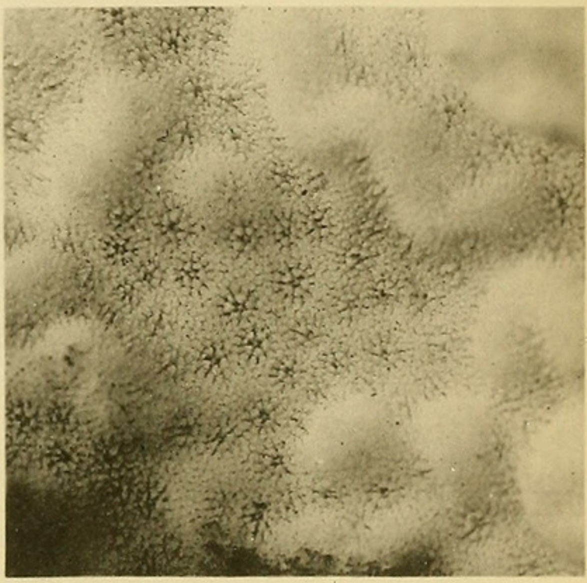

6

THE STRUCTURE OF PORITES.

Fig. 2. The form referred to on p. 488; on one side of the specimen the pali are developed, and on the other the calicles are deep and the pali quite obscured as a definite system.

Fig. 3. A form with the more usual ring of five pali. Traces of the others and of the columellar tubercle can be seen.

Fig. 4. A leaf-like specimen of *P. exilis*, Gardiner, showing the directives all pointing in the direction of growth (towards the top edge of the figure).

Fig. 5. A form with thin wavy walls and showing a double calicle; the columellar tangle rises to the surface, and here and there unites the pali in a ring.

Fig. 6. A cœnenchymatous form, the cœnenchyma rising into rounded ridges and papillæ; the pali are slightly exsert and are often slightly V-shaped. In a few cases the directive principal and its adjacent lateral supplementaries can be seen forming a very blunt broad arrow (the triple fusion mentioned on p. 490).

The Air-bladder and its Connection with the Auditory Organ in *Notopterus borneensis*. By Prof. T. W. Bridge, Sc.D., F.L.S., Mason University College, Birmingham.

[Read 21st December, 1899.]

(Plates 36 & 37.)

Contents.

I. Introduction.

While recently dissecting the air-bladder and associated structures in a specimen of *Notopterus borneensis*, Bleeker, certain features were noticed in which this species differed from *Notopterus Pallasii*, C. & V., as described by Cuvier and Valenciennes (4. pp. 139–141). How far the differences observed are due to