No. XX.—ON *POLYTREMA* AND SOME ALLIED GENERA. A STUDY OF SOME SEDENTARY FORAMINIFERA BASED MAINLY ON A COLLECTION MADE BY PROF. STANLEY GARDINER IN THE INDIAN OCEAN.

By Sydney J. Hickson, F.R.S., *Professor of Zoology in the University of Manchester.*

(Communicated by Prof. J. Stanley Gardiner, M.A., F.R.S., F.L.S.)

Read 4th May, 1911.

(Plates **30—32** and one Text-Figure.)

I. INTRODUCTION.

Some years ago Professor Stanley Gardiner sent to me a small collection of Stylasterina from the Indian Ocean for investigation and description; but I found included in the consignment some purple and yellow corals which, having a superficial resemblance to some varieties of *Distichopora*, might easily be mistaken for Stylasterina in the process of sorting out the specimens of such a large collection as Prof. Gardiner made in the course of his expedition. Having no special knowledge of the Foraminifera it did not occur to me at once that these large dark red and yellow corals could have any relation to the well-known genus *Polytrema*, but further investigation convinced me that the specimens were identical with or closely allied to the specimens collected in the Gulf of Manaar by Captain Warren and described by Carter (5) as *Polytrema cylindricum*.

Carter's description of his new species was very brief and I found it very difficult to understand the reason for including it in the genus *Polytrema*, as there are many characters, apart from its great size and its colour, in which it differs from the *Polytrema miniaceum* that is found in the Mediterranean Sea and elsewhere and is so well known to zoologists by the researches of many investigators. I endeavoured, therefore, in the first place to clear my mind as to the essential characters of the genus *Polytrema*; but, on reference to the literature, I came across a great difficulty which it took me some time to unravel.

The accounts given of the structure of *Polytrema* by different authors of repute are not consistent, and the inconsistencies cannot be accounted for by any supposition that they are due to gross inaccuracy of observation and description.

Fortunately there is in the Manchester Museum the large and valuable collection of Foraminifera made by Mr E. Halkyard and included in this collection are several specimens of Foraminifera labelled *Polytrema miniaceum*. On making a careful examination of one series of specimens in this collection from the West Indies I found that the structure of the surface corresponds very closely with the description given by Carpenter and is totally different to that given by Max Schultze, Merkel and Lister, but on the other hand the descriptions given by Max Schultze, Merkel and Lister agree quite accurately with the structure I was able to observe on the specimens collected at Nice and from a locality off the Kermadecs in the S. Seas.

This led me to test the provisional hypothesis that the specimens examined by Carpenter and those examined by some of the other observers belong to quite distinct genera. I therefore searched through all the many bottles of Corals, Alcyonaria and other specimens of marine fauna in the laboratory and examined any red patches I could find that had the least resemblance to a *Polytrema*; and I also examined a large number of specimens of the genus in the collections at the British Museum.

The result was to prove conclusively that there are at least two distinct genera of Foraminifera included in the group of specimens which are usually labelled in Museums "*Polytrema miniaceum*" and that these two genera differ from one another by constant and well defined characters. For the form that is certainly common in the Mediterranean Sea but is also widely distributed in other parts of the world I propose to retain the generic name *Polytrema*, for the other genus which does not, so far as my information goes at present, occur in the Mediterranean Sea at all, I propose the new generic name *Homotrema.*

But to return to the specimens identified as *Polytrema cylindricum.* A critical examination of my own specimens proved that their structure was in many respects quite distinct from that of either *Polytrema* or *Homotrema*, and having convinced myself that they are not gross, overgrown or hypertrophied specimens of either of these two genera I propose now to constitute for them a new generic name *Sporadotrema.*

I wish to acknowledge the assistance I have received in the course of this investigation from Mr H. Sidebottom, a well-known authority on the Foraminifera, and from Professor Burrows of the Manchester University whose advice I have followed in the construction of the new generic names.

I am also indebted to the authorities of the Free Public Museum at Liverpool for the loan of the type specimens of *Sporadotrema cylindricum* and to Mr Kirkpatrick for his assistance in my study of the specimens of *Polytrema* in the British Museum.

The very fine set of specimens and preparations of the genus *Polytrema* made by Mr E. Halkyard which was recently presented to the Manchester Museum with the rest of his rich collection of Foraminifera has been of invaluable assistance to me in the study of the genus.

II. DIAGNOSES OF THE THREE GENERA.

1. Polytrema.

The original description of this genus given by Pallas (14) is as follows:

Millepora miniacea—M. pumila subramosa rubra, punctis crebris impressis minutis. Maris Mediterranei, Americani, Indicique Corallia.

Tournefort* committed himself to the view that this coral was the beginning of the true red coral, i.e. *Corallium.* It was Risso, in 1826, who separated it from the genus *Millepora*, but Dujardin, in 1841, first placed it tentatively among the Rhizopoda.

Coming down to more recent times the more important papers on the genus are by Max Schultze (15), Möbius (13), Carter (3) and Merkel (12).

* Mem. Acad. Sci. 1700, p. 35.

The coral may be in the form of small flat encrusting disks on corals, shells and rocks, or in the form of short branching coralline structures rising from a flat and sometimes spreading base. The usual size of the branching forms from the Mediterranean Sea is about 3—4 mm. in height and 4—5 mm. in diameter at the base. The flat encrusting forms are very variable in shape and size, the largest patch from the Mediterranean I have seen is 6 mm. in length but of irregular shape. The specimens from other parts of the world do not seem to grow much larger than the Mediterranean specimens. The greatest height attained by the branched specimens in Möbius' large collection off Mauritius was only 3·5 mm. The finest specimen I have seen came from the Ki Islands in the Malay Archipelago (Plate **30**, fig. 1, Plate **31**, fig. 8), Siboga station 250, 90 metres. It is 7 mm. in height and one branch alone is 6 mm. in length.

The colour is usually pale red, of a tint that has variously been described as "cinnabar," "carmine" or "peach colour," but pale pink and white varieties are known.

There can be no doubt that the genus has a very wide distribution in the tropical and temperate seas. It certainly occurs in the Mediterranean Sea, the Indian Ocean, the Malay Archipelago and the S. Pacific Ocean (Kermadecs, Funafuti, etc.) but I have not yet found any specimens from the W. Indies or from the shores of the American continent.

It is not necessary to describe the structure of *Polytrema* in detail but it may be useful for purposes of comparison with the two allied genera (cf. pp. 447 and 450) to state the principal characters that can be used for distinguishing the genus.

The surface is perforated by two kinds of pores, the larger or pillar pores ("Pfeilerporen" of Merkel) gradually shelving from a diameter of 0·08 mm. to a diameter of 0·03 mm. and the smaller and far more numerous pores or foramina opening abruptly with a diameter of about 0·005 mm. (Plate **32**, fig. 23). Below the surface there is a series of laminae perforated by foramina similar to those of the surface lamina and these laminae are connected together and supported by the hollow pillars (Pfeiler) (Plate **32**, figs. 18 and 27). The walls of the pillars are not perforated by foramina but there may be one or more than one passage ("Lochern" of Merkel) by which the cavities of the pillars are connected with the intralaminar spaces.

2. Homotrema.

It is difficult to determine whether the original specimens described under the names *Millepora miniaceum*, *Polytrema corallina* and *Polytrema miniaceum* by Pallas, Risso and Dujardin belong to this new genus *Homotrema* or to the genus *Polytrema*. Lamarck (10) described his specimens of *Millepora rubra*, some of which came from the "American ocean," as "*sublobata*, poris crebris minutis punctata." I believe these specimens belong to the new genus *Homotrema*. The specimens described by Max Schultze (15) clearly belong to the genus *Polytrema* and it is evident that the specimens described by Carpenter (2) belong to the genus *Homotrema*. Max Schultze's specimens came from the Mediterranean and he states that he examined Carpenter's specimens which came from the South Sea, and although they showed more variation than his, he had no doubt they were the same specific form. Schultze's opinion that the specimens from the two localities are undoubtedly the

same species is difficult to understand when the descriptions given by the two authors are compared.

Carpenter for instance lays stress on the fact that "the surface is always areolated" and "the areolæ are porous while their boundaries are composed of solid shell substance." In describing the internal structure he says that the chambers communicate by large circular pores and smaller orifices. It is noteworthy that he does not state that the walls of the chambers are perforated by foramina nor in the figure does he show any foramina except those at the surface. Carpenter's statement moreover that "sometimes its stalk, instead of branching swells into a globular protuberance" is quite consistent with the view that the form he described was a *Homotrema*. I have not seen any specimens of *Polytrema* for which this statement of the shape could be considered accurate*.

If Max Schultze's account of *Polytrema* be compared with that of Carpenter it will be noticed that on all these important points the two authors are at variance.

Carter (3) evidently examined a large number of specimens which he considered to be *Polytrema miniaceum* from the Mediterranean Sea and from other parts of the world.

His figure 6 of the species appears to me a composite production, the upper part being taken from a true *Polytrema* and the lower part from a *Homotrema*. I have never seen any such combination of the characters of the two genera in any one specimen. Both his figures and his description appear to have been composed from notes taken from the examination of a number of specimens of a mixed collection of the two genera.

The very careful and accurate description of *Polytrema* by Merkel gives absolutely no support to Carter's views.

The coral may be in the form of flat encrusting disks, or of a short erect coralline structure rising from a flat and sometimes spreading base and showing an expanded crown springing from a constricted stalk terminating in a number of short arms or verrucæ (Plate **30**, fig. 2, Plate **31**, fig. 9). The size of the erect forms in my collection is from 5—6·5 mm. in height, 4—6 mm. in diameter across the crown, and 2—3 mm. in diameter across the stalk. The specimens of flat encrusting forms that I have seen are (1) from S. America 12 × 7 mm. and 8 × 8 mm.; (2) from Coin, Peros Banhos Atoll 6 × 8 mm. and 6 × 6 mm. The colour is nearly always red, but the tone of colour is darker and more purplish than is usually the case in *Polytrema*†.

One series of specimens from Coin, Peros Banhos Atoll, was pink, and I have seen

* Pallas, p. 252, wrote "Americana varietas plerumque verrucæ magnæ inæqualis speciem habet, quæ superficie sparsos ramulos exserit." This is remarkable because it would apply admirably to many specimens of *Homotrema* in my collection but not to any specimens of *Polytrema*, and at present there is not any evidence that the genus *Polytrema* occurs on the American coast although *Homotrema* is common.

† Note on colour. As it is very difficult to express in words the exact difference in colour between these "red" corals I have consulted Mr H. Cadness of the Manchester Municipal School of Art and the suggestion he makes is that the term "apricot red" might apply to the specimens of *Polytrema* from the Mediterranean Sea and "salmon-colour" to the specimens from the West Indies. It is of considerable interest, in this connection, to note that Pallas in his description of *Millepora miniacea* records his observation of a difference in colour between his specimens from the Mediterranean and those from the American sea, the former being in all probability specimens of *Polytrema* and the latter of *Homotrema*. His words are, "Color hujus elegantissimi Corallioli ex Mari Mediterraneo allati, pallide roseus solet, interdum saturatior. Quod in Coralliis Indicis reperitur pulchre cinnabarinum colorem exhibet, saturatissimum vero specimina in Coralliis testisque exesis Maris Americani reperiunda."

some white specimens, but it is probable that all of these were technically dead. The distribution of *Homotrema* is still imperfectly known, but I have seen specimens from the Ki Islands 129 fms. and from Celebes in the Malay Archipelago, from various localities in the Indian Ocean, from the West Indies, and from the Coast of S. America.

In both *Homotrema* and *Polytrema*, as in other sedentary coralline structures, the form of the full grown skeleton is very variable, but the study of a large number of specimens shows that in *Polytrema* the ramification is more complete and the branches longer and more slender than in *Homotrema*. This difference between the genera is not only indicated by Pallas (p. 446 footnote), but also by Lamarck, who by the use of the word "sublobata" instead of "subramosa" suggests that his own specimens of *Millepora rubra* did not branch. In *Homotrema* the larger specimens often assume a mushroom shape, the free end being considerably expanded and giving off short blunt processes, whereas the proximal end is contracted into a relatively slender stalk.

The combination of the two characters of colour and form are frequently sufficient to determine a specimen without the use of any magnifying glass at all. But of course no specimen can be determined with certainty to be a *Polytrema* or a *Homotrema* until its surface characters have been examined by at least a half-inch microscope objective.

The description of the structure of *Homotrema* for comparison with that given for *Polytrema* on p. 445 is as follows.

The surface is marked by clearly defined areolae about 0·1 mm. in diameter perforated by a large number of small foramina, ·001 mm. in diameter. The boundaries of the areolae are solid, and there are no pillar pores. Below the surface there may be seen a number of chambers communicating with one another by large open passages and bounded by solid walls. There are no hollow pillars and no foramina except those on the outer walls of the superficial chambers (Plate **32**, figs. 19, 22, 28).

3. Sporadotrema.

The specimens of this genus that were first discovered were found by Captain Warren in the Gulf of Manaar and described by Carter (5) under the name *Polytrema cylindricum*. By the kindness of the authorities of the Public Museum at Liverpool I have been able to examine the type and co-type specimens. They belong to the "Amirante" facies* of *Sporadotrema* but are very small specimens. The type specimen is 6 mm. in height and 2 mm. in diameter. The illustration of *Polytrema miniaceum* in Brady's Plate CI, fig. 5, of the Challenger "Foraminifera" represents a *Sporadotrema*. There is a specimen of *Sporadotrema* similar in general structure to the "Amirante" facies in the British Museum from the Macclesfield Bank and there is also in the same institution a pink specimen resembling the "Saya de Malha" facies. I have examined the type specimen of Carter's *Polytrema mesentericum* in the British Museum and found that it belongs also to the genus *Sporadotrema*, but it is a distinct species. The type specimen is very much water-worn and the locality from which it came is unknown, but I have found a number of fine specimens in a collection of Alcyonaria made by Professor Haddon in Torres Straits.

* For an explanation of the use of this term see p. 451.

The type species has always the form of branching coralline structures but the degree of ramification varies considerably in the different varieties, the details of which will be related later. Flat encrusting varieties have not been found at present.

One of the chief characters of the genus is undoubtedly the great size which it attains. The largest specimen in the collection is from 70 fathoms of water off Providence Island (Plate **30**, fig. 3)*. It is no less than 27 mm. in height and 28 mm. in expanse. It rises from a base 7 × 5 mm. and the diameter of the short stumpy arms is 5—6 mm. This is truly a giant foraminifer. Selecting three fine specimens of other facies of the genus in Prof. Gardiner's collection I find that a specimen of the "Amirante" facies from 32 fathoms is 10 mm. in height with an expanse of 13 mm., that a specimen of the "Saya de Malha" facies from 29 fathoms is 11 mm. in height with an expanse of 15 mm. and that an orange coloured variety from Cargados is 16 mm. in height with an expanse of 18 mm. All of these specimens are many times larger than the largest known specimens of either *Polytrema* or *Homotrema* and a great deal larger than the type specimen discovered by Capt. Warren. Another very well marked character of the genus is the colour variety. The type specimen from the Gulf of Manaar and the specimens from the Indian Ocean which for convenience sake I call the "Amirante" facies are dark purplish red in colour (Plate **30**, fig. 6). It is darker and more pronounced, "saturatior" as Pallas would have said, than the colour of *Homotrema* and *Polytrema*, but still it is a red colour. The "Saya de Malha" facies is a pale purplish pink (Plate **30**, fig. 4) very different in tone to the pale pink varieties of *Polytrema*, but the specimens of the "Providence" variety are yellow (Plate **30**, fig. 3) and a specimen from Cargados is deep orange, colours which so far as my knowledge goes are quite unknown among the varieties of the other two genera.

But size and colour, although useful as easy guides to identification and valuable as supplementary characters are not by themselves trustworthy characters upon which to base a generic distinction.

A careful examination of the structure of the specimens proves that these specimens possess other and more fundamental characters which justify the conclusion that they constitute a distinct genus.

When the surface of the stem of a *Sporadotrema cylindricum* is examined it is found to be smooth and often porcellanous in texture but perforated by a number of relatively large and scattered foramina (Plate **32**, fig. 21). There are no honeycomb markings nor defined areas of any kind. The foramina are all of the same kind and there is no trace of anything corresponding with the pillar pores of *Polytrema*. The foramina at the surface are very much larger than those of either of the other two genera. In the specimens from Providence island the average size of these apertures is 0·057 mm. in diameter. In *Polytrema* the average size of the external openings of the foramina is 0·005 mm. and in *Homotrema* about 0·001 mm.

When the branches of *Sporadotrema* are examined, the surface may be found to be marked by a pattern of grooves bounding convex areas which correspond with the subjacent chambers (Plate **31**, fig. 15 and Plate **32**, fig. 24). The foramina on

* The specimen drawn in Plate **30**, fig. 3, and photographed in Plate **31**, fig. 10, is smaller than the largest specimen in the collection.

these areas are smaller and more numerous than the foramina on the stalk. At the extremity of an unbroken branch the outlines of the chambers may be even more clearly traced. The terminal chambers seem to be inserted on the edge of the branch like a series of biconvex or irregularly spherical bricks on the top of a chimney. The outer wall is perforated by foramina, the inner wall turned towards the axis of the branch shows two or three large spout-like apertures by which the protoplasm in the cavity of the chamber communicated with the exterior (Plate **31**, fig. 16 and Plate **32**, fig. 24). At the free edge of some of the chambers there is a cock's comb of short tubercles. The axis of the branch sometimes terminates in a veritable forest of siliceous sponge spicules.

The extent to which the outlines of the chambers can be seen on the branches varies a good deal. In the "Providence" facies they can be seen only at the extremities of the branches. In the "Amirante" and "Saya de Malha" facies they may be seen along the whole length of the branches and in some cases on the upper part of the stalk as well (cf. Plate **30**, figs. 3, 4, 6, 7).

When the internal structure of *Sporadotrema* is examined, several points of great interest can be discovered. As in *Homotrema* it is only the outer walls of the chambers that are perforated by foramina, the walls of the chambers turned towards the axis are not perforated by foramina. In some of the larger branches and stems the axis is occupied by almost solid skeleton around which the chambers are arranged, but usually the axis exhibits a number of cavities and irregular spaces communicating with one another by large apertures but bounded by very thick and solid* walls (Plate **32**, fig. 20).

The size of the chambers varies a great deal with the size of the specimen examined and varies also within wide limits in every individual. An average diameter for the chamber of *Sporadotrema* cannot be given in this paper with any approach to mathematical accuracy, but roughly speaking the average diameter of the chambers of the "Providence" facies of *Sporadotrema* is ten times as great as that of the chambers of *Homotrema*.

Another very striking feature of *Sporadotrema* is the thickness of the outer wall on the stem and larger branches. In some of the specimens from Providence the distance between the outer wall of the chambers and the surface of the coral is no less than 2 mm. (Plate **31**, fig. 14). It is this thickness of the outer wall that is responsible in some measure for the smoothness of the surface of the stem and main branches. At the free extremities of the branches where the outer wall is thin the outlines of the chambers can be readily distinguished on the surface, but on the older parts where the wall is thicker all traces of these outlines are lost.

The initial chambers of one megalospheric form of *Sporadotrema* have been discovered. Three of these chambers can be seen in the section (Plate **32**, fig. 29 *ic.*) distinguished from the other chambers of the specimen by their regular shape and by the fact that, although buried in the base of the stalk, their outer walls are clearly perforated by true foramina.

The size of the central chamber is perhaps an important point in the general argument that *Sporadotrema* is distinct from *Polytrema*. At first I was inclined to believe that

* The term "solid" is used only in a relative sense, the whole skeleton is undoubtedly perforated by fine canaliculi as is the skeleton of *Polytrema* according to the researches of Merkel.

these large specimens from the Indian Ocean are merely large or hypertrophied specimens of *Polytrema*, and even after observing the difference in structure between them and *Polytrema* I considered the possibility that they may have passed through either a *Polytrema*-stage or a *Homotrema*-stage.

Two facts seem to render any such view quite untenable. There is a small branch of some dead coral in the collection to which are attached in close proximity a specimen of *Homotrema* 5·25 mm. in height and 5 mm. in diameter at the crown, and a young specimen of *Sporadotrema* 3·25 mm. in height and 1·75 mm. in diameter. Both of these specimens show the surface characters of their respective genera with great distinctness, although the *Sporadotrema* is actually smaller than the *Homotrema*.

In the section of the initial chambers of the specimen of *Sporadotrema* from Providence the central chamber is 0·33 mm. × 0·48 mm. in measurement. In *Polytrema miniaceum* the average diameter of the central chamber of ten specimens is 0·051 mm. according to Lister (11), but the average diameter of eleven specimens in the Halkyard collection I have found to be about 0·075 mm.

The description of the structure of *Sporadotrema* for comparison with that of *Homotrema* and *Polytrema* on pp. 445 and 447 is as follows.

The surface of the stem and, in many cases, of the proximal parts of the branches as well are not marked by areolae at all. The foramina are scattered irregularly on the surface and are of relatively large size. There are no pillar pores. Below the surface there may be seen a number of chambers communicating with one another by large open passages and bounded by solid walls. There are no hollow pillars and no foramina except those on the outer walls of the superficial chambers (Plate **32**, figs. 20, 21 and 26).

III. ON THE GENERIC AND SPECIFIC NAMES.

There can be no doubt that Pallas, one of the earliest writers on these corals, examined specimens of both the genera *Polytrema* and *Homotrema*. The distinction he draws between the colour of his Mediterranean specimens and the colour of those from the American sea, together with his special description of the form of the American variety, indicate this with sufficient clearness. It is therefore a matter of choice, governed by no special rule of nomenclature, which genus shall retain the original name. It will be doubtless the more convenient plan to assign to the very common Mediterranean foraminifer which has been so well described by Max Schultze and Merkel the generic name *Polytrema*.

In selecting a name for the specimens from the American seas and elsewhere which I have shown to be distinct I have chosen the generic name *Homotrema*, signifying "pores together" (cf. ὁμόσπορος = sown together) with reference to the character that the foramina are confined to defined areas on the surface. For the third genus which is characterised by the fact that the foramina on the surface are relatively few in number and are scattered without reference to any defined areas I propose the generic name *Sporadotrema*.

The questions of the specific names present some difficulties. It is clear that the

name of the Mediterranean form must be *Polytrema miniaceum*, it is also necessary to retain the specific name *cylindricum* for the type specimens of *Sporadotrema* from the Gulf of Manaar originally described by Carter (5) under the name *Polytrema cylindricum*. The specific name of the only species of the genus *Homotrema* should be "*rubrum*" (Lamarck).

But when it comes to a question of subdividing the three genera into a number of specific groups a much more debateable ground is reached.

The three genera described in this paper are sedentary animals and have, in all probability, a very wide geographical distribution. Beginning their lives as free floating organisms they settle down casually on some hard substance at the bottom of the sea and gradually assume a coralline form. The actual environmental conditions to which the individuals are subject during the remainder of their lives vary enormously according to the locality, depth, condition of the tides and the neighbouring benthos of the spot on which they have happened to settle, and these varying conditions undoubtedly exercise a considerable influence in the determination of the actual size, shape and ramification of the full grown individual. It cannot be assumed that the form of a full grown individual is entirely a matter of environmental influence. A comparison of a large number of specimens of *Homotrema* and *Polytrema* must convince any one that there is an underlying hereditary influence controlling to some extent the growth of the individual. It is impossible to determine in any particular example, with any pretence to scientific accuracy, the part played by the environment and the part played by heredity in the determination of shape, and it becomes therefore a matter of judgment, based upon a knowledge of a large number of specimens of each genus, whether a particular specimen or group of specimens should be separated from the others as a distinct species.

In many cases among sedentary animals, a particular form of growth seems to be associated with some particular conditions of the environment such as we see for example in many forms of corals such as *Millepora* and *Madrepora*, and the specimens may be arranged in groups, which are practically discontinuous groups, according to their shape. Detailed examination of the structure of the members of these groups may show no differences of importance correlated with the differences in shape, and it appears to me that to regard such groups as separate species is unsound. Nevertheless it is of importance to be able to give to them group names, in order to be able to record briefly the general influence of the environment on the specimens from a particular locality or depth, and such group names I have in a previous paper (8) called "facies."

As regards the two genera *Polytrema* and *Homotrema* I do not consider that we are in a position to subdivide the two species. I believe that a more detailed comparison of the structure of the S. Pacific, Indian Ocean and Mediterranean forms of *Polytrema* may necessitate the constitution of two or three new species. There are some differences to be observed between the *Polytremas* from the Mediterranean and those from the Indian Ocean, but I am not in a position to state that these differences are constant.

For the present I consider that there is only one species of *Polytrema* (*P. miniaceum* Pallas) and it is convenient to recognise in this species two "facies," the flat plate-like

forms (*repens*) and the branching forms (*ramosum*). The same remarks apply to the genus *Homotrema*. I can recognise in this genus only one species *H. rubrum* and two facies *repens* and *ramosum*.

The question of colour is an important but difficult one. The colour of *Polytrema miniaceum* and the colour of *Homotrema rubrum* are remarkably constant (cf. p. 446). In these species neither yellow nor orange coloured varieties have been observed. White varieties have been recorded by Carter, Brady, etc. I have also met with many white specimens from many different localities, but it appears to me that the white specimens are in all cases "dead" corals and that the whiteness is due to post-mortem discolouration. In the genus *Sporadotrema* on the other hand there is a great range of colour. Yellow, orange, pale pink, red and deep red specimens being known. My own view is that differences in colour, unless associated with differences in form or structure are untrustworthy guides for the separation either of species or facies.

The well known example of *Melitodes chamæleon* should serve as a warning to those inclined to put their trust in colour. But when colour is associated with form and structure it may be used as a valuable supplementary character.

Of the genus *Sporadotrema* I recognise two species, *S. cylindricum* (Carter) which is fully dealt with in this paper and *S. mesentericum* (Carter).

Sporadotrema cylindricum may be conveniently divided into three facies.

Facies Providentiæ. This is a very robust form of great size, the largest specimens being 27 mm. in height, with short branches, yellow to orange in colour, with a very thick outer wall on the stalk and with the chamber outlines obliterated except at the extremities of the branches (Plate **30**, fig. 3).

Facies Amirantiæ. This is a more delicate form, with longer branches than in "Providentiæ," red or orange in colour with the outlines of the chambers well marked on the branches and sometimes on the upper part of the stalk (Plate **30**, figs. 6, 7).

Facies Saya de Malhensis. This is a more delicate form even than "Amirantiæ" with longer and more cylindrical branches, pale pink in colour with the outlines of the chambers usually well marked on the branches, but with the stalk usually remarkably smooth and almost porcellanous in texture (Plate **30**, fig. 4).

There can be no doubt that intermediate forms will be found between these facies but at present the facies Providentiæ is very well defined, the other two being more difficult to distinguish.

Sporadotrema mesentericum (Carter), Plate **30**, fig. 5, Plate **31**, figs. 11 and 12. Syn. *Polytrema mesentericum* Carter (5).

This species was described from a single water-worn specimen now in the British Museum. Carter remarked at the end of his description that "when perfect" it "probably resembled *Polytrema cylindricum*."

Having found in a collection of Alcyonaria made by Professor Haddon in Torres Straits several perfect specimens of this species preserved in spirit, I can confirm Carter's opinion in so far as to include it with his species *P. cylindricum* in the new genus

Sporadotrema, but I believe that the resemblance between the two species is not so close as he anticipated from the examination of his worn specimen.

The description of the species may be amended as follows:

Test composed of more or less erect sinuous laminæ arising from a spreading encrusting base. The free margin is thick and crenated.

Colour, salmon-red.

The surface of the vertical sides is perforated by foramina and exhibits a pattern of lenticular convexities corresponding with the subjacent series of chambers (Plate **31**, fig. 12). In the larger specimens the convexities are obscured in the lower or basal parts of the surface. The internal structure of the laminæ consists of two parallel series of chambers whose outer walls are pierced by foramina. The chambers communicate with each other by wide cylindrical passages. Between the two series of chambers interlocular spaces occur at the free edges but these spaces become closed up with growth of the chamber walls, so that, at and near the base of the lamina there are no interlocular spaces (Plate **32**, fig. 25).

At the edge of the laminæ the upper portions of the chambers are free and exhibit a cock's comb row of short tubes as in *S. cylindricum.*

The larger laminæ in my collection are from 15—20 mm. in length, from 7—8 mm. in height and from 1·5—2 mm. in thickness.

The species differs very noticeably from *S. cylindricum* in shape. The large and perfect specimens in my collection show that it does not break up into branches comparable with the branches of *S. cylindricum.* In some of the larger specimens several laminæ arise from a common spreading base and are united together to form a plexus or labyrinth. I have not, at present, been able to determine whether this is due to concrescence or irregular ramification. Carter's expression that the laminæ are "united mesenterically" is not very clear to me, but it may be intended to signify that the edges of some laminæ are united with the vertical sides of others in the formation of the labyrinth.

Carter correctly describes the colour of his specimen as pinkish red. It was, as already stated, very much water-worn and probably dead when dredged up. The colour may have been as dark in tone as my specimens when it was alive. In the older parts of the laminæ where the outlines of the chambers can no longer be recognised in the surface view, the foramina are 0·7 mm. in length and 0·03 mm. in diameter and are distinctly tabulate (Plate **32**, fig. 25). The chambers vary a good deal in size but are approximately 0·7 mm. in horizontal length and 0·5 mm. in depth.

IV. DISTRIBUTION.

Polytrema miniaceum (Pallas).

Syn. *Millepora miniacea* Pallas 1776.
Polytrema corallina Risso 1826.

The only specimens of this species that I have found in Professor Stanley Gardiner's collection are from Providence (D. 8) 125 fathoms and Coetivy.

The species has a wide distribution in the warm and tropical seas. It certainly occurs in the Mediterranean Sea, the Indian Ocean including the coast of Ceylon, the Malay Archipelago and the South Pacific Ocean. I have no record of it however from the West Indies or from the American coast.

The following species have also been described but subsequently assigned to other genera.

P. balaniforme (Carter 1876) = (*Carpenteria balaniformis* Carter 1877).
P. planum (Carter 1876) = (*Gypsina melobesioides* Carter 1880).
P. utriculare (Carter 1876) = (*Carpenteria utricularis* Carter 1880).
P. cylindricum (Carter 1880) = (*Sporadotrema cylindricum* Hickson).
P. mesentericum (Carter 1880) = (*Sporadotrema mesentericum* Hickson).
Homotrema rubrum. (Lamarck.) New Generic name.

Syn. (*Millepora miniacea* Maris Americani Pallas 1776.)
Millepora rubra Lamarck 1816.
Polytrema rubra Carpenter 1862.

Specimens of this species were found in Professor Stanley Gardiner's collection from the following localities:

Amirante (E. 9) 34 fathoms.
Amirante (E. 12) 32 fathoms.
Providence (D. 4) 50—78 fathoms (Plate **30**, fig. 2).
Providence (D. 4) 78 fathoms.
Providence (D. 11) 50 fathoms.
Coin, Peros Banhos, Surface Reef.

All these specimens with the exception of those from Coin, Peros Banhos, form small coralline growths 3—7 mm. in height, with a spreading knob-like crown 5—6 mm. in greatest diameter, covered with short wart-like protuberances. The stalk and base of attachment are usually but not invariably constricted. Other specimens I have examined belonging to the same genus and probably the same species are from:

The West Indies, Halkyard collection.
Coast of South America, Manchester Museum.
Antigua, Author's collection.
Celebes, Author's collection.
Ki Islands, 129 fathoms, Challenger, British Museum.
Unknown locality, British Museum, 40, 10, 23, 95, 6.
Korean Strait, 40 fathoms, Capt. St John, British Museum.

The specimen described as *Polytrema* by Dakin (6) from Ceylon may be a *Homotrema.* I have at present seen no specimens of the genus from the Mediterranean sea.

Sporadotrema cylindricum (Carter). New Generic name.

Syn. *Polytrema cylindricum* Carter 1880.

It is convenient to divide this species into three "facies."

S. cylindricum, facies Providentiæ.

Providence (D. 7) 70 fathoms. Several large specimens (Plate **30**, fig. 3).

S. cylindricum, facies Amirantiæ.

Amirante (E 1) 29 fathoms, 2 specimens.
Amirante (E 2) 29 fathoms.
Amirante (E 9) 34 fathoms (Plate **30**, fig. 6).
Amirante (E 12) 32 fathoms.
Amirante (E 13) 20—22 fathoms.

All the above are salmon colour.

Saya de Malha (C 1) 150 fathoms.
Saya de Malha (C 16) 26 fathoms, 2 small specimens (Plate **30**, fig. 7).
Providence (D. 4. 10. 05) 50—78 fathoms.
Cargados Carajos (B 9) 30 fathoms.

The above are orange coloured.

The type of the species is red in colour and belongs to the "Amirante" facies. It came from the Gulf of Manaar. In the British Museum there is an orange coloured specimen of the Amirante facies from the Macclesfield bank.

S. cylindricum, facies Saya de Malhensis.

Saya de Malha (C 16) 26 fathoms.
Saya de Malha (C 19) 29 fathoms (Plate **30**, fig. 4).
Providence (D. 4) 78 fathoms.

In the British Museum there is a specimen of this facies, locality unknown.

Sporadotrema mesentericum (Carter).

This species is found in Torres Straits (Plate **30**, fig. 5).

V. SOME NOTES ON STRUCTURE.

The siliceous spicules. All the specimens of the three genera I have examined have the habit of picking up and incorporating the siliceous spicules of sponges. This habit is not peculiar to these genera but occurs in other genera, such as *Carpenteria*; and it is probably comparable with the habit of picking up sand grains and other foreign bodies by the arenaceous Foraminifera, as in some cases I have found grains of sand and the frustules of Diatoms (*Coscinodiscus*, etc.) enclosed in the chambers. Lister (11) speaks of the sponge spicules taken up by *Polytrema* as "a temporary scaffolding for the support of the extended pseudopodia, in advance of the proper wall." The number of sponge spicules seen in different specimens varies very considerably. In many specimens of *Sporadotrema* the spicules are so numerous that the free edges may be said to bristle with them, in others only a few scattered spicules may be observed. (Some of the spicules may be faintly seen in Plate **31**, fig. 16.) In the chambers broken fragments of siliceous spicules are invariably found but in the solid calcareous walls of the chambers and particularly in the central hard core of the larger specimens of *Sporadotrema* very few spicules can be found. It is difficult to

believe that any of the spicules that are seen at the free edges are cast off when they have served the purpose of a "temporary support for the extended pseudopodia" because the greater number of them are firmly fixed into the solid calcareous skeleton and cannot be withdrawn by pulling hard with a pair of forceps. Nevertheless there are far fewer spicules in the calcareous substance, at a little distance from the free edges, than one would expect to find if it is a fact that they remain unchanged as a matrix for the deposit of the calcium carbonate. I am forced to the conclusion that in the process of the deposition of the calcareous skeleton many of these siliceous spicules are dissolved. If there is not some solution of the silex it is very difficult to account for the numerous fragments of spicules that occur in the intralocular protoplasm. The spicules are taken up whole at the ends of the branches and so far as I can observe at the ends of the branches only. No spicules or fragments of spicules can be seen in the foramina that perforate the sides of the main stem, base or branches. The fragments of spicules in the chambers therefore must be derived from spicules taken up when those chambers were first formed and at the growing points, or possibly passed down to them with the flow of protoplasm from other chambers at the growing points. At the growing points however all the spicules seem to be perfect, at least they are much longer than the diameter of the chambers and very much longer than most of the fragments of spicules found in the older chambers. The sponge spicules must therefore either be forcibly broken or partly dissolved after they are incorporated into the substance of the organism and it seems to me that the view that they are partly dissolved is the more reasonable of the two.

It is difficult to account for the presence of the spicules in these Foraminifera. They are quite constant in their occurrence and consequently it seems probable that they play some essential part in the physiological processes of the species. The regularity of their arrangement and the fact that, usually, very few other foreign bodies than the monaxon siliceous spicules of sponges are found, show that they are not picked up at random but selected from the mud in the neighbourhood and deliberately placed in position.

That they are of foreign origin there can be no reasonable doubt. The sponges from which they collect their spicules must live in the neighbourhood of the Polytremids, or the Polytremids must live in a region where sponge spicules play an important part in the formation of the sand or mud. Not infrequently the sponges cover a part of the Foraminifer or, in some cases, completely overwhelm it. This is a special danger to which the Polytremidæ and some other calcareous organisms are exposed. Forty years ago there was an interesting discussion on the origin of the siliceous spicules in these Foraminifera. Gray (7) and Carpenter (2) maintained that both the siliceous spicules and the calcareous skeleton are the products of the same organism, Max Schultze (15) and Carter (3) on the other hand strongly opposed these views and maintained that the siliceous spicules are of foreign origin. The controversy would be of little more than academic interest in these days were it not for the fact that in a recent paper Kirkpatrick (9) has suggested that *Merlia*, which he considers to be a sponge, does actually secrete siliceous spicules and a calcareous chambered shell. Having had an opportunity of examining the structure of specimens of *Merlia* and arrived at different conclusions to those of Kirkpatrick I will postpone the discussion of this question to a subsequent paper.

The structure of the shell. In comparing the three genera, attention may be called to the relative hardness and density of the skeleton. In *Sporadotrema* and particularly in the "Providentiæ" facies of the genus and in *S. mesentericum* the skeleton as a whole is very hard and rigid. This hardness of the skeleton may be expressed by the use of Carter's words "Consistence stony." In *Polytrema* on the other hand the consistence of the skeleton is very brittle. It may be easily crushed into fragments between the finger and thumb. In *Homotrema* the consistence of the skeleton is intermediate between that of *Sporadotrema* and *Polytrema*.

This difference in consistence is due to the difference in structure of the three genera. The structure of the branches of *Polytrema* is very difficult to understand when taken by itself. The structure of the branches of *Homotrema* and *Sporadotrema* seem to me to throw light upon it and render its understanding more easy. If the growing end of a branch of a *Sporadotrema* is examined it will be found to consist of a circle of more or less biconvex or almost spherical chambers arranged on edge at the tip of the branch. The convex surface facing outwards of each of these chambers is perforated by foramina, the convex surface facing inwards is not perforated by foramina (Text-fig. A). The free edge of each chamber is produced into three or four tubular processes sometimes arranged like the points of a cock's comb (Plate **31**, figs. 15 and 16). In well-preserved specimens one or more of these tubes has a trumpet-shaped mouth the lips of which are the beginnings of a new chamber. Tubular processes similar to those at the edge are sometimes situated on the inner convex surface. Surrounded by these terminal chambers there is an interlocular space (Text-fig. A *i*).

The structure of the branches of *Polytrema* is far more difficult to understand, and the descriptions given of it by Schultze, Möbius and Merkel are not consistent. After careful observation of several specimens from different parts of the world I am quite convinced that there is a wide range of structure of these parts and that a new series of investigations based on the study of a large number of specimens is very desirable. There can be no doubt that zoologists who have given their attention to the Foraminifera have been inclined to "lump" all the Polytremidæ into one species. I believe that when the detailed structure is more carefully examined there will be a swing of the pendulum and the genus *Polytrema* will be split into a large number of species.

However, I will in this statement refer only to one or two points upon which there is inconsistency of statement in the descriptions of previous writers and then describe what I believe to be the structure of the growing point of specimens of *Polytrema miniaceum* from the Mediterranean.

Möbius describes in the branches of specimens of *Polytrema* he obtained in Mauritius a central canal (eine centrale Kammer) around which the chambers are arranged spirally or in circles. Merkel denies the existence of a true central canal but describes excentric canals and spaces opening to the exterior with imperforate walls (Scheidewände) formed by the fusion of the pillar walls. Lister writes of "axial spaces" which open widely at the ends of the branches.

The spaces with imperforate walls, sometimes opening to the exterior at the end of the branches, can be clearly distinguished in some specimens (Text-fig. B *i*); but in a very

large number of specimens they do not occur at all and the presence of centric or excentric canals is certainly not an essential feature of the structure of the branches of the genus *Polytrema* or of its species *P. miniaceum.* The statement that the branches of *Polytrema* consist of 3—4 joints (gliederartigen Abschnitten) made by Merkel and confirmed by a good figure, is not of general application. I have examined a very large number of specimens from the Mediterranean Sea and from other localities and I have not yet been fortunate enough to discover a single one that corresponds with this description. The chambers of the arm of a *Polytrema* are very variable in shape and size and they communicate freely with their neighbours of the same row or stratum. Their outlines are indicated only by the pillars (Text-fig. B *P*). At the free end of a branch there may be seen a variable number of openings. In the diagrammatic text-illustration B, I have shown four such openings. Of these three may be regarded as homologous with the

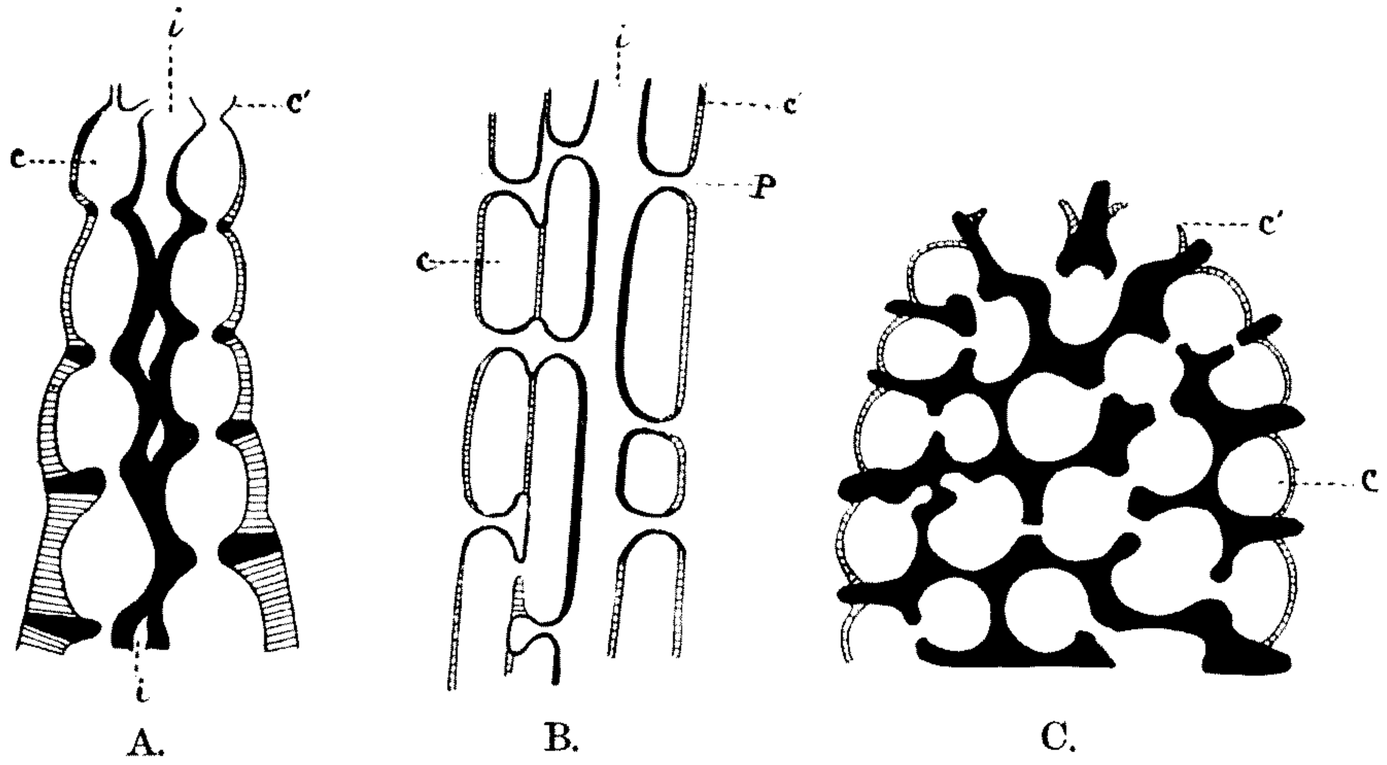


Fig. 1. Diagrams to illustrate the structure of the growing points of A. *Sporadotrema*, B. *Polytrema*, C. *Homotrema*, *c'* incomplete chambers, *c* completed chambers, *i* interlocular spaces, *P* pillar pores of *Polytrema.*

openings of incompleted chambers and the fourth (*i*) as the opening of an interlocular canal or space. The incompleted chambers have walls perforated by foramina on the sides that are free and external as in *Sporadotrema*, but unlike *Sporadotrema* the walls separating one chamber from another that lies internal to it are also perforated by foramina.

The wall of a chamber that separates it from an interlocular space is imperforate.

At the growing point of a *Sporadotrema* (text-illustration A) there is, as a rule, only one circle of chambers enclosing an irregular interlocular space. In *Polytrema* on the other hand there may be a cluster of chambers, two, three or more deep on one side, and one or two deep on the other, enclosing an excentric or possibly in some cases a centric interlocular space. The pillars *P* represent the distal and proximal sides of chambers of a row and their cavities are really interlocular spaces which may be continuous with the walls of the deep seated interlocular canals.

The characteristic feature of the branch of a *Polytrema* is that the chambers appear to be very irregular in outline and this is due to fusion of neighbouring chambers which

may be explained as an expansion of the communicating passages which are seen in *Sporadotrema* and *Homotrema.*

In *Homotrema* (text-illustration C) there are apparently no interlocular spaces. In a vertical section through one of the verrucæ a cluster of chambers may be seen, communicating with one another by large irregular passages. All these chambers, except those at the surface, have solid walls which are not perforated by foramina. The chambers at the surface exhibit a convex outer wall perforated by foramina. At the apex of each verruca a few chambers, with incomplete outer walls, can always be seen.

The foramina. When a specimen of *Sporadotrema* is decalcified and stained, one of the most noteworthy features to be seen is a series of approximately parallel moniliform tubes which break up into branches at the inner end before terminating in a perforated membrane on the outer wall of a chamber and open by a single large aperture at the surface (Plate **32**, fig. 32).

These tubes line the foramina, as can be seen in a stained section of hard and soft parts together, and they are of a chitinous texture. Similar chitinous tubes have been described and figured for *Polytrema* by Merkel and Möbius, but whereas in *Sporadotrema* the tubes may be as much as 2 mm. in length, in *Polytrema* they are rarely more than ·02 mm. in length. In *Polytrema* the tubes are usually simple, but as Merkel has correctly pointed out they sometimes divide at their inner ends. In *Sporadotrema* they are simple only in the region of the terminal chambers; but, on the branches and stems they always divide into a considerable number of smaller tubes which terminate in the chambers. In the figures I have drawn only three or four of these secondary tubes—that is the number that can be seen in a thin vertical section—but there must be actually nine or ten branches springing from each of the main foraminal tubes.

In many of the tubes there may be seen a few or in some cases several chitinous plates stretching transversely across the tubes and these plates have all the appearance of the tabulæ of a tabulate coral except in texture. In the specimen of *Sporadotrema mesentericum* that I have examined these tabulæ seem to be more pronounced than in the other species and, as shown in Plate **32**, fig. 25, the foraminal tubes in this species have the appearance of being regularly tabulate.

Two important questions naturally arise concerning these tabulæ: (1) Are they complete tabulæ, that is to say, do they completely occlude the foramen? (2) Are they supported in any way by calcareous tabulæ?

To the first of these questions it is difficult to give a definite answer. In nearly all the good sections I have examined of decalcified sections and of ground sections of the hard parts they seem to be perforated, but it is still quite possible that in some cases they do completely close the passage. With such delicate structures as these are, it is always difficult to determine the extent of the damage done either by the process of decalcification or of grinding.

To the second question the answer is that in *Sporadotrema mesentericum* there are certainly narrow projecting shelves of calcareous substance supporting the chitinous tabulæ (Plate **32**, fig. 33), and it is probable that they also occur in some of the older foramina in *S. cylindricum* as well.

In *Carpenteria* the chitinous tubes were shown by Möbius (13) to be marked by transverse lines, and these lines probably represent ring-shaped thickenings of the chitin.

In *Polytrema* they are shown to be marked by a series of rings (see Plate **32**, fig. 31, copied from Merkel (12)).

In *Sporadotrema* (fig. 32) they are usually moniliform and frequently marked by a series of ring thickenings. These facts alone, which are easily demonstrable, point to the conclusion that the growth in thickness of the outer wall is not continuous but marked by a series of intermittent stages of activity, and it is at each of these stages of activity that the narrow calcareous shelves are or may be formed.

VI. LITERATURE.

1. Brady, H. B. Foraminifera. Challenger Reports, Vol. ix. 1884.
2. Carpenter, W. B. and Jones, Rupert. Introduction to the study of the Foraminifera. Roy. Society, 1862.
3. Carter, H. J. On the Polytremata. Ann. N. H. Ser. 4, xvii. 1876, p. 185.
4. Carter, H. J. On the locality of *Carpenteria balaniformis*. Ann. N. H. Ser. 4, xix. 1877, p. 209.
5. Carter, H. J. Report on Specimens dredged up from the Gulf of Manaar. Ann. N. H. Ser. 5, v. 1880, p. 437.
6. Dakin, J. W. Foraminifera. Ceylon Pearl Fisheries, Vol. v. 1906, p. 240.
7. Gray, J. E. On *Carpenteria* and *Dujardinia*. Proc. Zool. Soc. xxvi. 1858.
8. Hickson, S. J. Report on the genus *Millepora*. Willey's Zoological Results. Pt ii. Cambridge, 1899.
9. Kirkpatrick, R. A sponge with a siliceous and calcareous skeleton. Nature, May 19, 1910.
10. Lamarck, B. P. Animaux sans Vertèbres, 1816, p. 202.
11. Lister, J. J. Foraminifera in "A treatise on Zoology" by Sir E. Ray Lankester, Part i. Fasc. 2, 1903, p. 120.
12. Merkel, F. Beiträge zur Kenntnis des Baues von *Polytrema*. Zeit. f. wiss. Zool. lxvii. 1900.
13. Möbius, K. Beiträge zur Meeresfauna der Insel Mauritius. Berlin, 1880.
14. Pallas, P. S. Elenchus Zoophytorum, 1776, p. 251, and in Elenchus Zoophytorum. German translation by Wilkens and Herbst, 1787, Part i. p. 321.
15. Schultze, Max. On *Polytrema miniaceum*. Wiegmann's Archiv, 1863, p. 81. Translated by W. S. Dallas, Ann. N. H. Ser. 3, xii. 1863, p. 409—423, pl. 7.

EXPLANATION OF THE PLATES.

PLATE 30.

Fig. 1. *Polytrema miniaceum.* A specimen from 90 metres off Ki Islands × 4½ diameters, showing the characteristic pale pink (or apricot red) colour.

Fig. 2. *Homotrema rubrum* from Providence 50—78 fathoms × 4½ diameters, showing a darker (salmon colour) red tint.

Fig. 3. *Sporadotrema cylindricum*, fac. Providentiæ; from Providence 70 fathoms × 2 diameters, showing the characteristic orange yellow colour.

Fig. 4. *Sporadotrema cylindricum*, fac. Saya de Malhensis. Saya de Malha 29 fathoms × 2 diameters, showing the pale pink colour.

Fig. 5. *Sporadotrema mesentericum* from Torres Straits × 2 diameters, showing the characteristic dark red colour.

Fig. 6. *Sporadotrema cylindricum*, fac. Amirantiæ. Amirante 34 fathoms × 2 diameters, showing a darker red colour than (in Fig. 4) fac. Saya de Malhensis.

Fig. 7. *Sporadotrema cylindricum*, fac. Amirantiæ. Saya de Malha 26 fathoms × 1½ diameters. This is an orange coloured variety of the facies.

PLATE 31.

Fig. 8. *Polytrema miniaceum.* A specimen from 90 metres off Ki Islands (Siboga Expedition) × 4½ diameters, showing the branching method of growth.

Fig. 9. *Homotrema rubrum* from Providence 50—78 fathoms × 4½ diameters, showing the characteristic solid and tuberculate method of growth.

Fig. 10. *Sporadotrema cylindricum*, fac. Providentiæ; from Providence 70 fathoms × 2 diameters. Note that the magnification of this is much less than that of Figs. 8 and 9.

Fig. 11. *Sporadotrema mesentericum* (Carter) from Torres Straits (Haddon coll.) × 2 diameters.

Fig. 12. *Sporadotrema mesentericum* from Torres Straits × 2 diameters. Side view showing the convex surfaces marking the outlines of the chambers.

Fig. 13. *Sporadotrema cylindricum*, fac. Saya de Malhensis. Saya de Malha 29 fathoms × 2 diameters.

Fig. 14. Transverse section through a stem of *Sporadotrema cylindricum*, fac. Providentiæ × 5 diameters, showing the thick outer wall perforated by the foramina, and the ring of chambers surrounding a more solid core. Pl. **32**, fig. 20.

Fig. 15. *Sporadotrema cylindricum*, fac. Saya de Malhensis. A terminal branch × 9 diameters. To show the outlines of the chambers clearly marked at the extremity where they are superimposed, becoming less clearly marked as the walls thickened and quite obliterated at the base of the branches and below.

Fig. 16. *Sporadotrema cylindricum.* View of the same specimen as in fig. 15, to show the free edge. The spout-like openings of the terminal chambers may be seen and also the scaffolding of spicules which support the growth of the terminal chambers.

Fig. 17. Vertical section through *Polytrema cylindricum*, fac. Providentiæ × 6⅔ diameters, showing the arrangement of the chambers in the stem and in one of the branches.

PLATE 32.

Fig. 18. Transverse section of a thick branch of a *Polytrema*, showing four concentric circles of chambers. × 100 diameters. *p.* pillar pores.

Fig. 19. Transverse section of one of the verrucose processes of a *Homotrema*, showing that the outer wall (*O*) of the outer circle of chambers alone are foraminate. The other chambers composing the process are not arranged in definite circles, have imperforate walls but communicate with one another by large open passages. × 100 diameters.

Fig. 20. Transverse section through the base of a branch of *Sporadotrema*, showing a single circle of chambers with very thick and continuous outer walls perforated by foramina (*f*). Within the circle of chambers there is a core of calcium carbonate perforated by interlocular passages (*i*). × 6 diameters. Compare this drawing with the photographs on Plate **31**, figs. 14 and 17.

Fig. 21. Surface view of a portion of a stem of *Sporadotrema*, showing the irregular arrangement of the foramina (*cc*). × 50 diameters.

Fig. 22. Surface view of a portion of a *Homotrema*, showing the areolæ (*A*) perforated by foramina and bounded by solid walls. × 50 diameters.

Fig. 23. Surface view of a portion of a *Polytrema*, showing the pillar pores (*P*) and the foramina perforating all the other parts of the surface (*f*). × 50 diameters.

Fig. 24. Drawing of a growing point of a specimen of *Sporadotrema cylindricum*, fac. Amirantiæ, showing the young chambers (*cc*) at the edge with a cock's comb row of short tubes (*T*) opening freely on the distal margin. × circa 9 diameters. Compare this drawing with the photographs on Plate **31**, figs. 15 and 16.

Fig. 25. Vertical section through a lamina of *Sporadotrema mesentericum* to show the tabulæ in the foramina (*f*). These tabulæ are probably never quite complete but perforated in the centre by a pore (compare fig. 33). × 20 diameters.

Fig. 26. Transverse section of a part of a branch of *Sporadotrema* to show the relation of the foramina to the chambers (*c*, *c*). × circa 18 diameters.

Fig. 27. Transverse section of a part of a branch of *Polytrema* to show the relation of the pillar pores (*P*) to the chambers (*c*) and the interlocular spaces (*i*). × circa 200 diameters.

Fig. 28. Transverse section of a part of a branch of *Homotrema* to show the perforated outer walls of the external chambers and the passages which establish communication between the chambers. × circa 200 diameters.

Fig. 29. Vertical section through the base of the stem of *Sporadotrema cylindricum*, fac. Amirantiæ, showing three of the initial chambers (*i.c*). These chambers can be recognised by their regular oval shape and by the foramina which perforate their walls. Camera drawing × 10 diameters.

Fig. 30. Chitinous tubes lining the foramina of *Carpenteria raphidodendron*. Copied from Möbius (13). Plate VI, fig. 3. × 150 diameters.

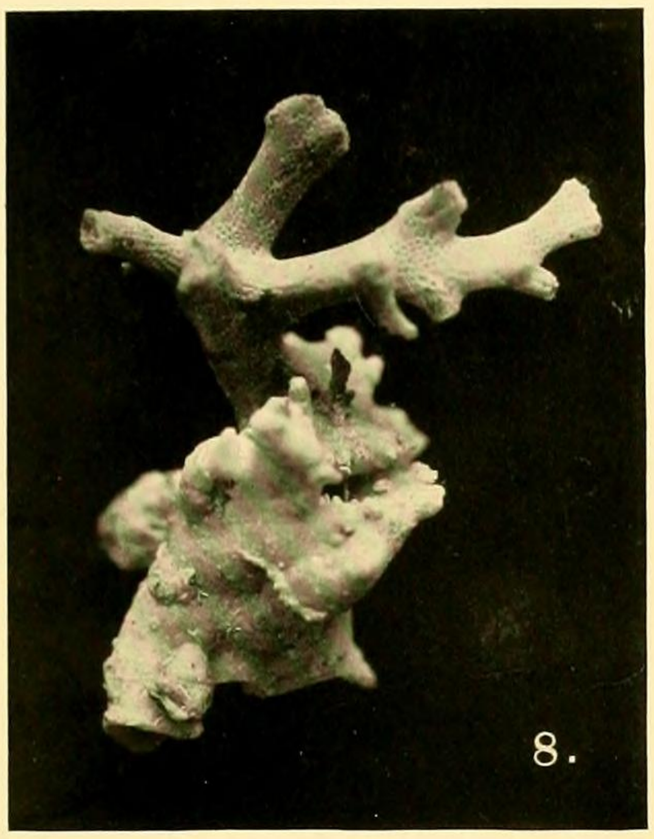
Fig. 31. Chitinous tubes lining the foramina of *Polytrema miniaceum*. Copied from Merkel (12). × 580 diameters.

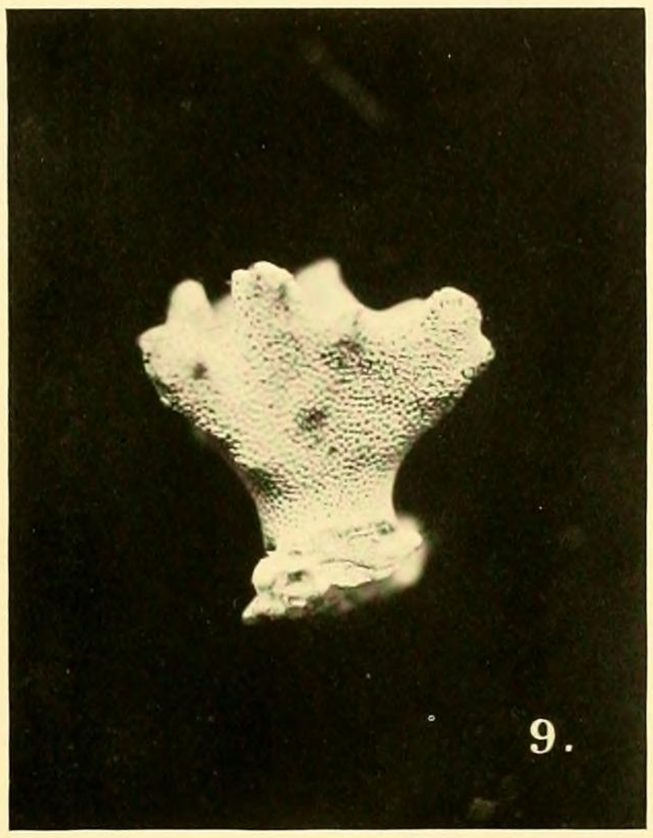
Fig. 32. Chitinous tubes lining the foramina of *Sporadotrema*. × 150 diameters.

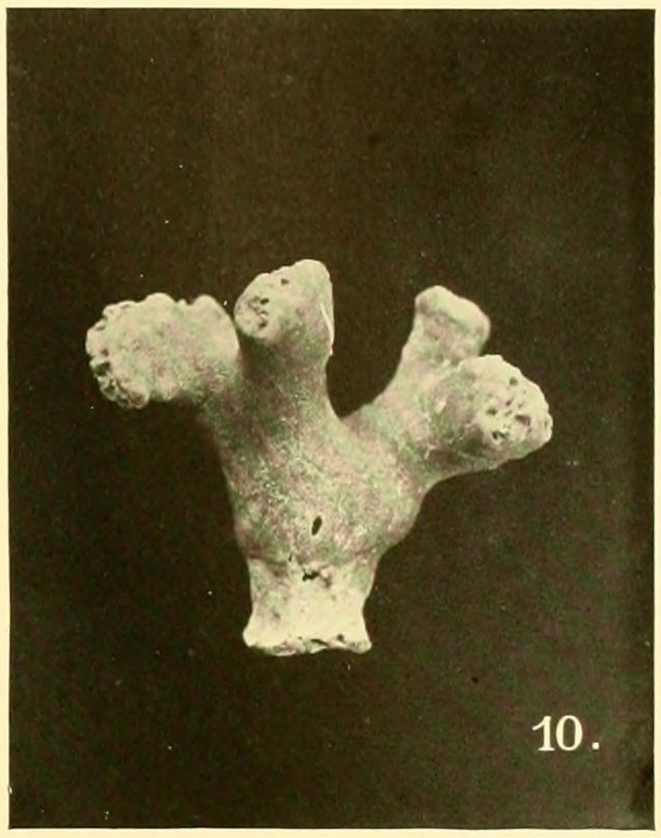
Fig. 33. One of the joints in a foramen of *Sporadotrema*, very much enlarged, to show the narrow shelf-like tabula.

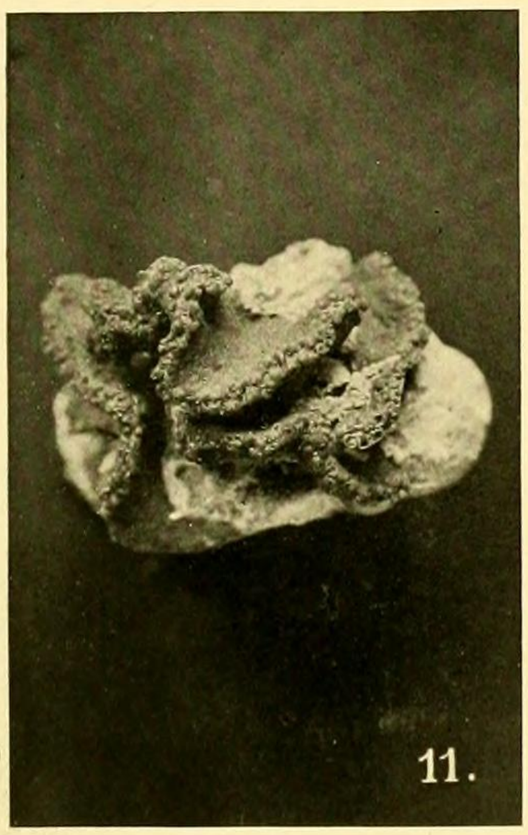
1. POLYTREMA. 2. HOMOTREMA. 3–7 SPORADOTREMA.

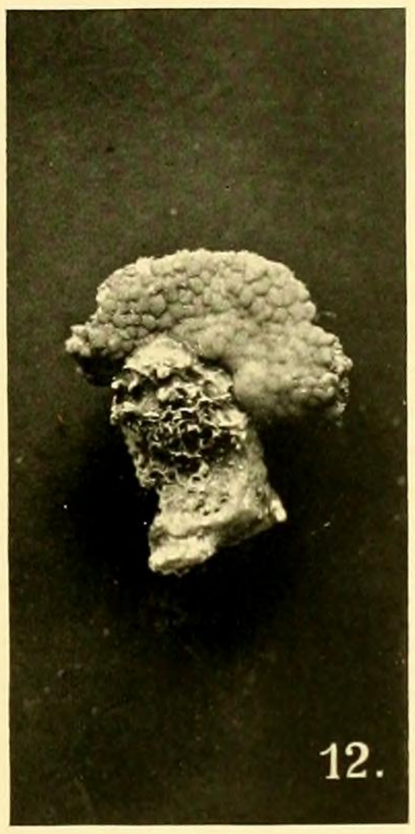
E. Wilson, del. et lith. Cambridge.


8.

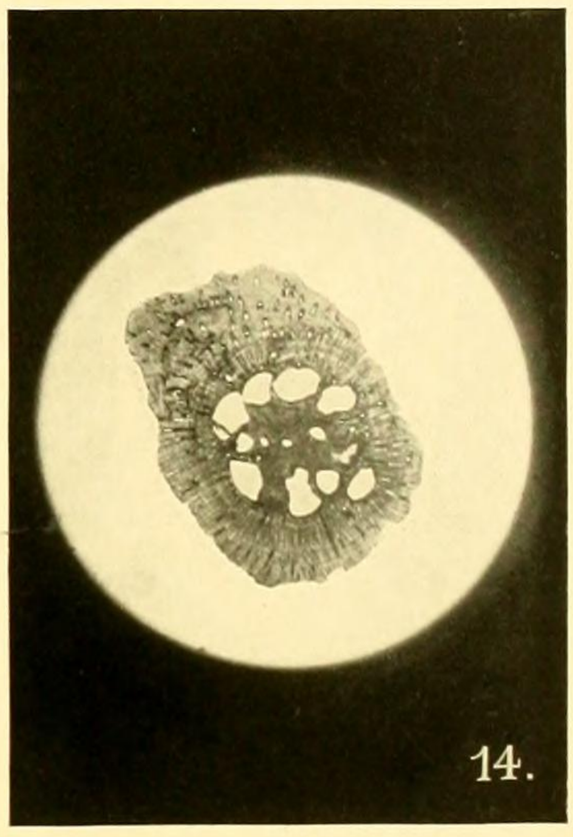

9.

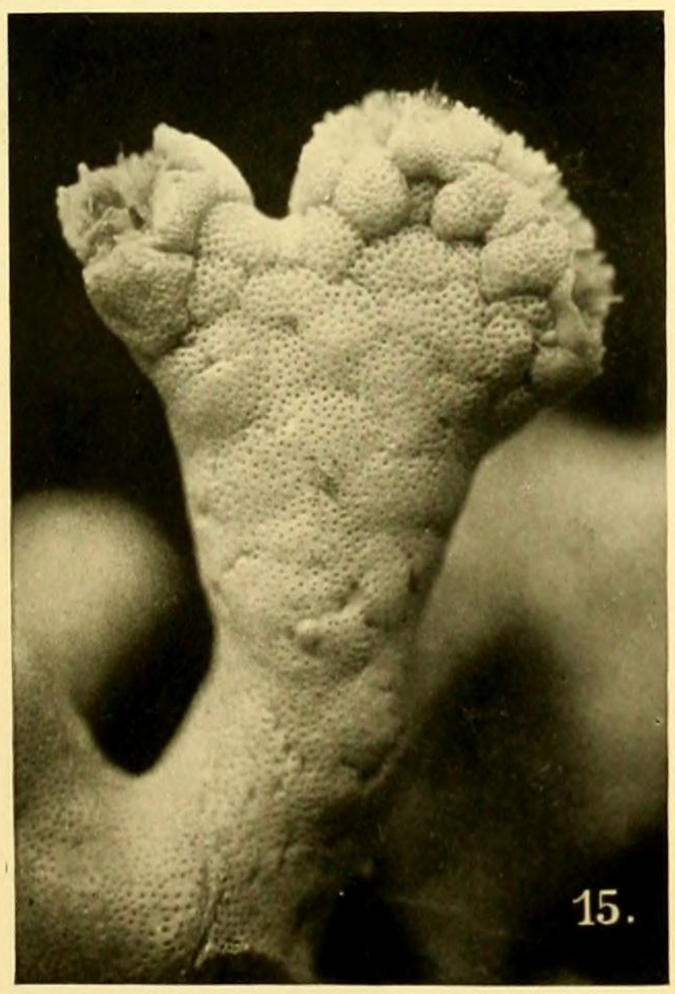

10.


11.

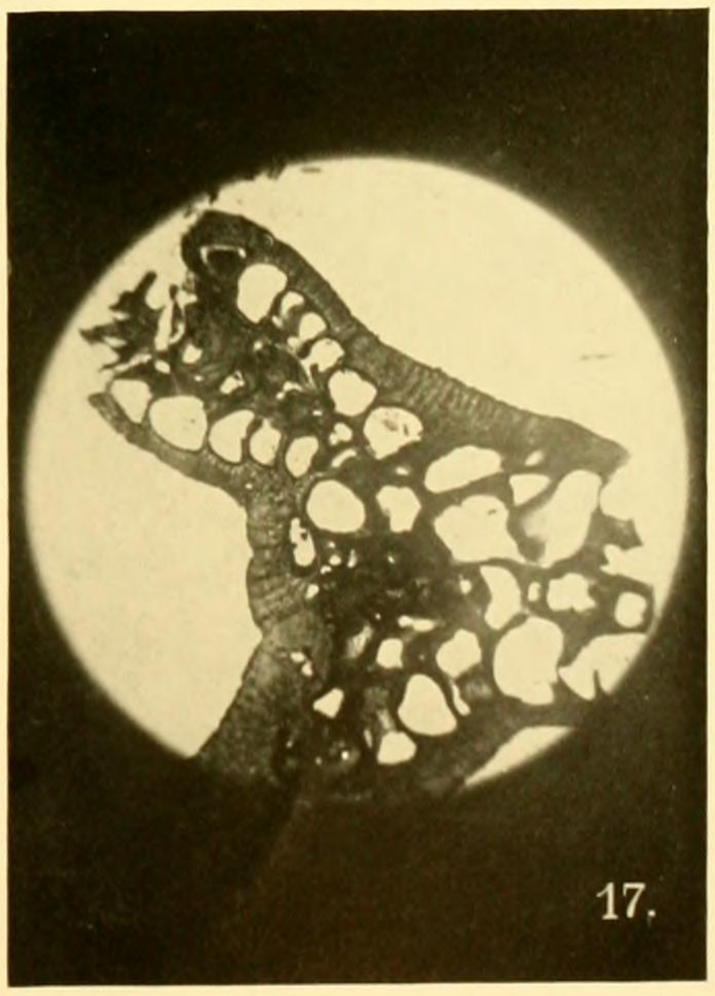

12.


13.

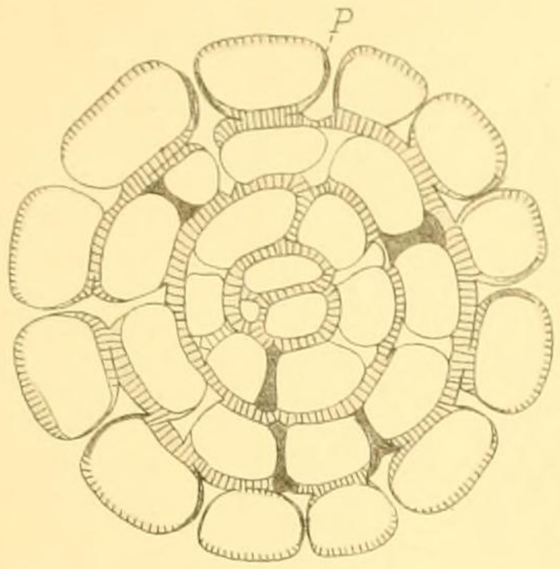

14.


15.

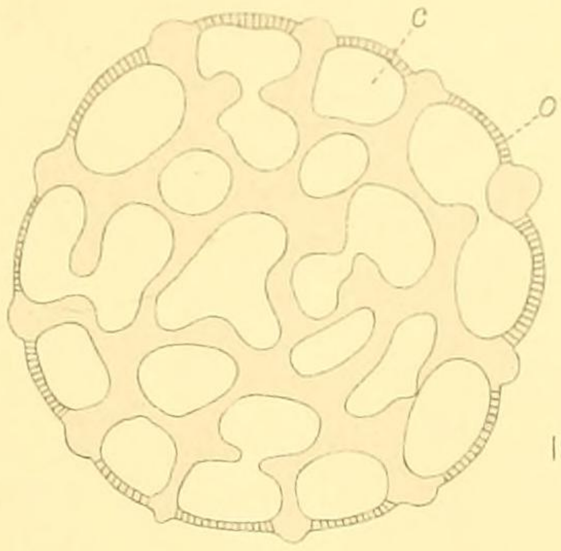

16.


17.

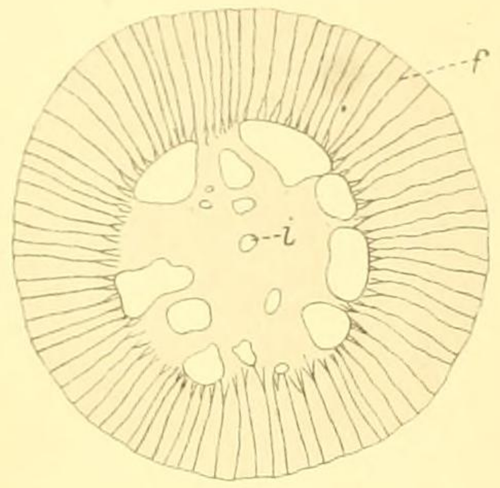
8. Polytrema × $4\frac{1}{2}$. 9. Homotrema × $4\frac{1}{2}$. 10. Sporadotrema × 2.
11—17. Sporadotrema, various magnifications.



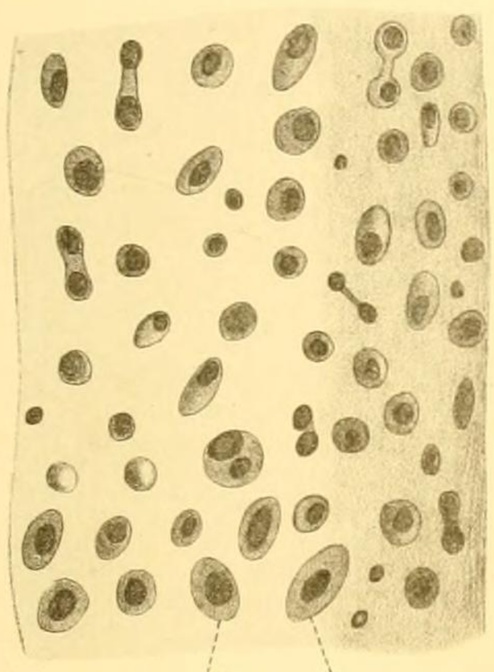
18



19

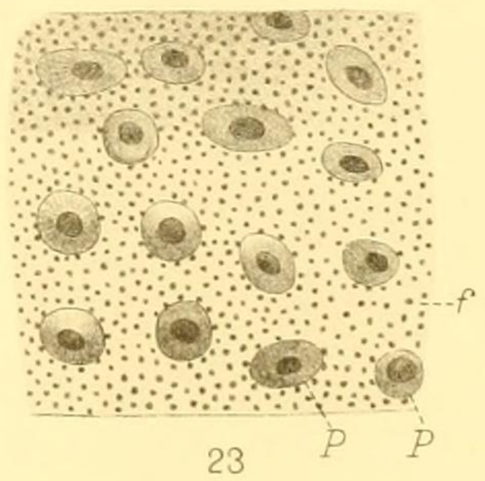


20

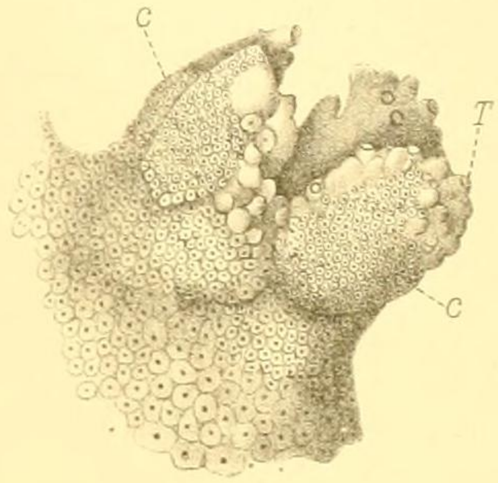


21

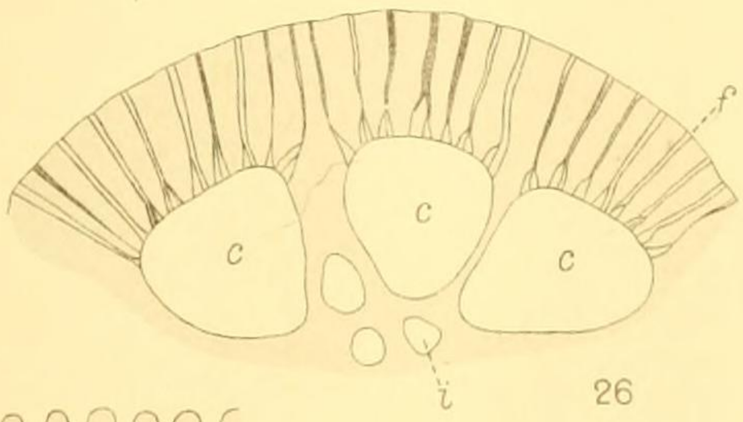
22



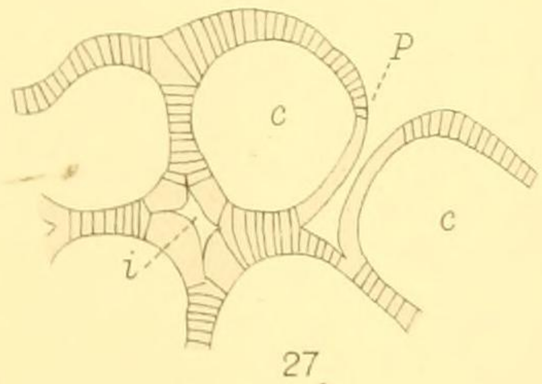
23



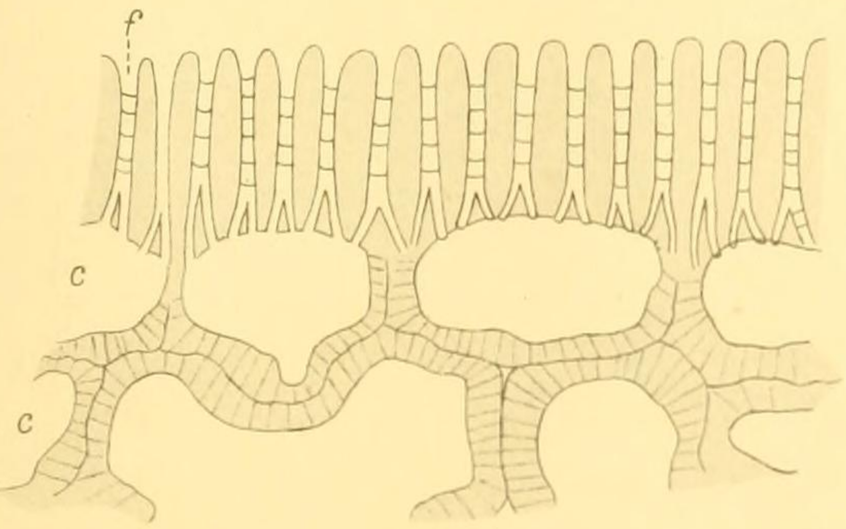
24



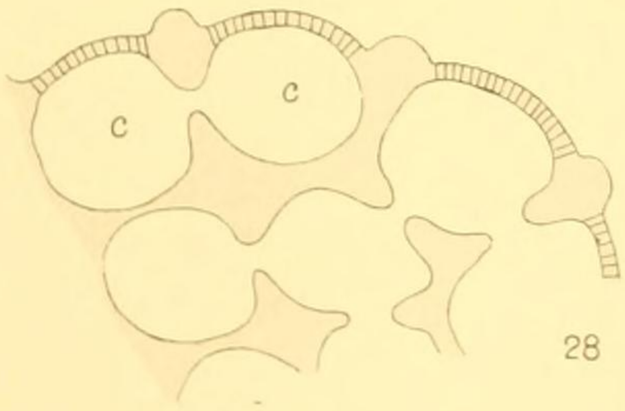
26



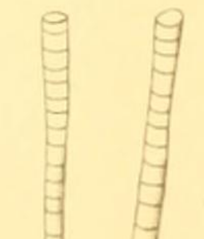
27.



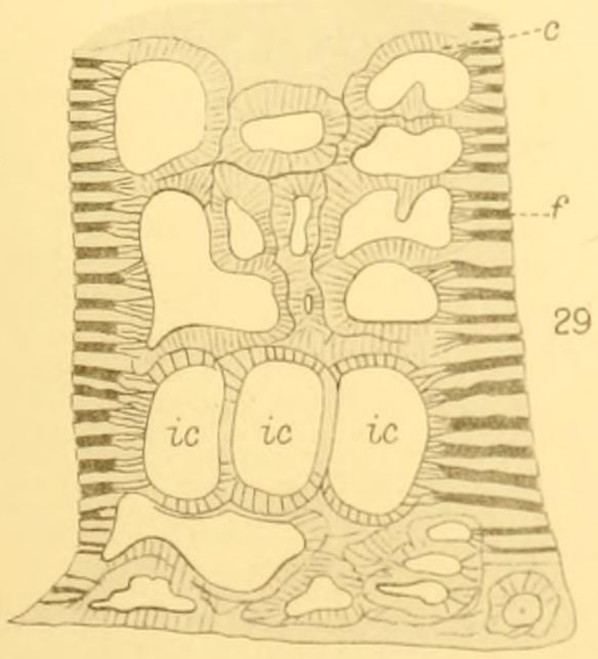
25



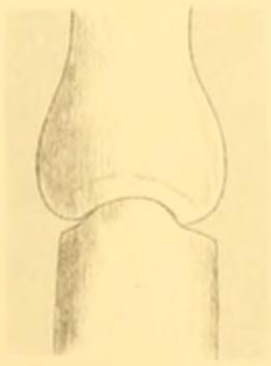
28



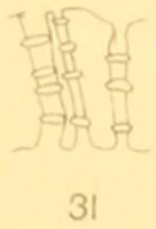
30



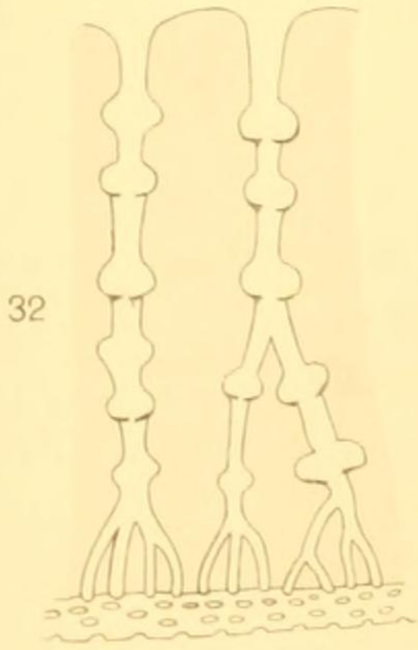
29



33



31



32

2nd Ser. ZOOLOGY.] [VOL. XIV. PART 3.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE PERCY SLADEN TRUST EXPEDITION

TO

THE INDIAN OCEAN IN 1905,

UNDER THE LEADERSHIP OF

MR J. STANLEY GARDINER.

VOLUME III.

REPORTS Nos. 13—20 of this volume; Nos. 51—58 of the whole series.

LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY JOHN CLAY, M.A. AT THE UNIVERSITY PRESS, CAMBRIDGE.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

September 1911.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

SECOND SERIES—VOLUME XIV.

ZOOLOGY.

THE PERCY SLADEN TRUST EXPEDITION

TO

THE INDIAN OCEAN IN 1905,

UNDER THE LEADERSHIP OF

MR J. STANLEY GARDINER, M.A.

VOL. III.

LONDON:

PRINTED AT THE CAMBRIDGE UNIVERSITY PRESS.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON HOUSE;

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

1910—1912.

REPORTS

OF THE

PERCY SLADEN TRUST EXPEDITION

TO

THE INDIAN OCEAN IN 1905,

UNDER THE LEADERSHIP OF

MR J. STANLEY GARDINER, M.A.

VOLUME THE THIRD

[BEING THE FOURTEENTH VOLUME OF THE SECOND SERIES, ZOOLOGY, OF THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.]

LONDON:

PRINTED AT THE CAMBRIDGE UNIVERSITY PRESS.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON HOUSE;

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

1910—1912.

CONTENTS.

PART I.—NOVEMBER, 1910.

PART II.—JULY, 1911.

PART III.—SEPTEMBER, 1911.

PART IV.—MARCH, 1912.