

blance between these two comets is greater than was at first supposed, the origin of the unsatisfactory large differences for the mean places having been found out. The elliptic elements, which he has now calculated, give us less reason, then, to doubt the probability of a connection between these two comets. Dr. Ristenpart compares his elements with those of comet Biela at the time of its appearance in 1852, but suggests that more observations must be used in the investigation before an accurate value of the eccentricity, and therefore of the period, can be obtained. The comparison is as follows:—

Comet Perrine 1896.	Comet Biela 1852.
$\tau$ Nov. 24 <sup>h</sup> 7433 B.M.T.	
$\omega$ 163 57 30 <sup>h</sup> 5 <sup>m</sup> } 1897 <sup>o</sup>	223 17
$\Omega$ 246 24 7 <sup>h</sup> 2 <sup>m</sup> }	245 51
$i$ 13 50 41 <sup>h</sup> 1 <sup>m</sup> }	12 33
$\log q$ 0 <sup>h</sup> 046412	9 <sup>h</sup> 9348
$\log e$ 9 <sup>h</sup> 843395	9 <sup>h</sup> 8784
$a$ 3 <sup>h</sup> 676	3 <sup>h</sup> 526
$U$ 7 <sup>h</sup> 047 years	6 <sup>h</sup> 62 years

DOUBLE STAR MEASURES.—Mr. R. G. Aitken communicates to the *Astr. Nachr.*, No. 3395-6, his measurements of double stars during 1895-6 with the 12-inch and 36-inch equatorial telescopes of the Lick Observatory. The majority of the measures were made with the former instrument, but occasionally the 36-inch was used for any crucial test. The selection of objects was restricted; no special search was made for new doubles, and great care was taken to determine the proper quadrant when two stars of nearly equal magnitude were being observed. In the micrometric measurements published, Mr. Aitken gives double weight for observations made with the 36-inch; the position angle is the mean of four or more settings, and the distance that of three double-distances.

The following are some of his remarks on interesting doubles and questionable doubles:—

- OS 65 (Mag. 6.5, 7.0).—Certainly a physical pair, and the plane of the orbit appears to be in the line of sight. Further measures are needed at short intervals.
- H VI 101  $\delta$  Tauri (Mag. 4.0, 9.0).—Distance appears to be slowly increasing.
- $\Sigma$  634 (Mag. 5.0, 8+).—Rectilinear motion. Stars are moving in nearly opposite directions. Distance in 1834 was 34', in 1896, 14'75.
- $\Upsilon$  1222.—Examined this star with the 36-inch powers to 1000. Star apparently single (1896.475). Conditions good. "Strongly suspected close double" by H. Looked for by  $\beta$  in 1876 without success. Probably a mistake on the part of H.
- OS 269 (Mag. 6.5, 7.0).—Companion of this rapid binary has completed more than one revolution since the measures of OS. From measures down to 1891,  $\beta$  finds a period of 48.4 years.
- $\Sigma$  2026 (Mag. 8.9, 9.0).—Undoubted binary. Angular motion should now become more rapid.
- OS 342. 72 Ophiuchi.—With 36-inch powers 1600. Apparently single (1896.488). Powers to 2600. "No certainty of elongation" (1896.513).  
Measured as a close pair by OS and others, but  $\beta$  has always found it single in the last twenty years. Probably the companion is an illusion.
- $\beta$  989  $\alpha$  Pegasi (Mag. 5.0, 5+).—Shortest period of any known binary 11'37 years.

THE CANALS OF MARS.—We have received a communication from Herr M. Teoperberg, of the Hague, in which he submits an explanation of the formation and doubling of the canals on Mars. The idea which he suggests is one that will scarcely recommend itself to astronomers, for, indeed, one assumption cannot reasonably be admitted. The writer supposes a periodical downfall of snow to be the principal agent, taking the undoubted bands as the crests of anticlines, the bases of which may be veiled from the observer by increase of absorption. Such a range, he says, presenting itself as a narrow band, will be doubled if the higher part of the crest be covered with snow. With the advance of the season the snow-covering will extend downwards on the slopes of the ridge, and its margin will at last dip into those strata which escape our observation: the bands will then be lost for a time, reappearing by the inverse process at the next change of season. As another instance of such combinations, he says,

"a synclinal, filled up in winter with snow extending also, but in thinner layers, over the bordering ranges, will present a double band as soon as these more exposed ranges are laid bare by the melting of the snow in summer. They will then change into a single band when the central thicker mass of snow has melted away and replaced either by the dry valley ground or by a drowned *Thalweg*, these recalling the canals *prop. dict.*, differing, however, therefrom by a probably high situation and by the elevated ranges on the sides." Sufficient, however, has been quoted to show that the writer must assume in his hypothesis innumerable ranges of mountains, the highest peaks of which must be singularly placed to give the effect of straight lines or arcs. It is true that horizontal sections of mountains become more simplified the greater the elevation, and that gaps of considerable magnitude would escape observation, but even then the mountainous conditions on Mars would be very extraordinary. If such were the case, the "flashings" would be very much more numerous than they are, and the colour phenomena would probably be different from what observations tell us. The hypothesis of "vegetation" seems still to be the most satisfactory explanation for these curious canal-like markings, although even this cannot satisfy all the observed phenomena.

### THE CLASSIFICATION OF MADREPORARIA.

AT present the classification of Madreporarian corals is admitted to be in an unsatisfactory condition. A fair standard of the opinion of the time can be obtained by reference to Prof. Nicholson's "Manual of Palæontology," or to Prof. von Zittel's new "Student's Text-book of Palæontology." One of the most striking features is the insecurity which is now felt about the sub-orders of Milne Edwards and Haime, the *M. Rugosa* = *Tetracoralla* (Haeckel), and the *M. Aporosa* and *Perforata* = *Hexacoralla* (Haeckel). Yet the authorities just named think it best to maintain these sub-orders provisionally.

I propose here to give a short sketch of some work of mine on corals, which was entered at the Royal Society of London in July 1895. It deals with the "Microscopic and Systematic Study of Madreporaria," and covers a rather wide field:—

(1) Numerous sections of the skeleton of living corals are examined and figured, all controversial points with regard to the structure of skeletal parts are exhaustively discussed, and my own views are advanced regarding microscopic structure, and the relation of the soft parts of the polyp to the skeleton.

(2) A comparative account is given of the fossil skeleton in the various families. In this part I have been greatly aided by the results of my special work on corals of Upper Jurassic age, "*Stramberger Korallen*," to be published next month in the *Paläontologische Mittheilungen* (Stuttgart).

(3) The determination of the main evolutionary changes within Madreporaria.

(4) Systematic results.

#### General Microscopy of the Skeleton.

The basal "tabula" or "dissepiment" forming the floor of the calyx presents us with the simplest form of septal structure in Madreporarian corals. Microscopically examined, it proves to be a compact series of calcareous lamellæ, each of which is made up of minute, crystalline, needle-shaped fibres, set perpendicularly to the lamellar surface. The fibro-crystals are oriented in one and the same direction throughout the whole thickness of lamellæ, hence they behave in the same way towards light. The appearance under the microscope is that of long fibres running through the lamellæ, but crossed by a dark and light band in each lamella (Fig. 1). These bands are wavy, not straight in section, and a special group of tiny fibres is present within each "wave." *The solid dimensions of such a fibrous wave-unit or "scale"* (Fig. 2) *of the lamella agrees with those of a single ectodermal cell of the polyp.* The wave-units of the lamellar surface indicate the original cell-units, whose protoplasmic contents have been changed to crystalline fibres. Still, however, some fragments of organic matter and dirt particles usually remain, and their decomposition gives rise to the dark spots and bands which blur the crystalline deposit.

The structure just described for the calcareous floor of the coral calyx repeats itself throughout all parts of the skeletal

tissues. It is the structure characteristic of the Madreporarian skeleton. The endless variety of form, which we find among the skeletal parts, is produced by corresponding varieties in the calicoblastic layers of the polyp. With this difference, that the

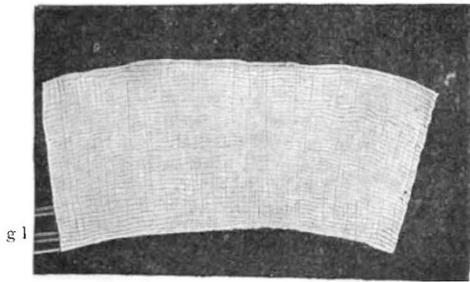


FIG. 1.—*Galaxea dissepimentum*. g.l., growth-lamellæ.

calcareous lamella is, as it were, the "cast" of the ectodermal flesh.

The cell-for-cell equivalence of the skeleton with the outer polypal layers explains why the fine microscopy of fossil and

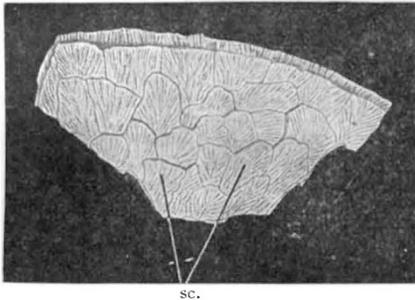


FIG. 2.—Calcareous scales on the surface of a dissepiment (from the conenchyme of *Galaxea*) highly magnified.

recent skeletons may guide the systematist in tracing the affinities between Madreporarian genera and families. I shall next consider the outstanding varieties of form which I recognise in the septa of typical Madreporaria.

*Septal Forms.*

Bearing in mind the origin of the radial or septal fold as an invagination of the embryonic "basal plate" of the polyp, it will readily be understood that there are two opposite calicoblastic surfaces in the radial invagination instead of one surface, as in the tabula or dissepiment. Fibrous lamellæ are formed along the entire external surface of the fold. If the invagination is conical, or nearly so, naturally so is the skeletal deposit which it lays down; if smooth, the deposit is smooth. Such is the deposit of the "septal spine," which we see projecting inwards from the wall in many Palæozoic corals, and may still find in several species of Madrepora and other living corals. The lamellæ are formed in the septal spine around a central axis, and as the fibro-crystals are oriented rectangularly in the lamellæ, they radiate out from this axis.

Considerable notice has been taken in current literature of the central part of the spine and of its analogue in the flat septum, called the "dark line" or "primary septum." I find that the opacity of the "dark line" or "axis" is due to the same cause as the "dark bands," or closely-strewn "dark points," which occur in the fibro-crystalline deposit in the tabula, dissepiment, or any skeletal part. The organic cell-remnants are, however, massed together in the axial portion of a conical or oblong fold, and the "dark points" therefore appear more prominently in sections of septal spines and septa than in sections of a one-sided structure like the dissepiment. There is a further observation. Several of the first few layers laid down by the adjacent surfaces of a septal fold are in many cases less completely calcified than the next in age. Apparently skeletal deposit accumulates more rapidly at the septal edges

than lower down on the septal sides, but the crystalline changes in the cell are less complete. While I regard the presence of disintegrating carbon products as the original cause of the "dark line," it is well known that the "line" may ultimately assume various appearances due to secondary changes (see Hinde, "On Septastrea," *Q. J. G. S.*, 1888), or may be represented by a hollow space.

If the septal invagination is long instead of round in shape, it stretches through a certain radial length in the calyx, and the calcareous deposit takes the form of a *flattish septal plate* in consequence. The lamellæ are symmetrical on either side of the "dark line," which indicates the axis or median plane of the fold. We are familiar with microscopic transverse sections of flat, plano-symmetric septa in Palæozoic Zaphrentids, as well as in our own Turbinolids. The septal spine and the plano-symmetric septum are the two most primitive forms of septal deposit, and sometimes the flat septum passes at its inner edge into spinate prolongations.

We now come to more elaborate forms. The *striated septum* (Fig. 3) develops within the flaps of a septal fold, which, in-

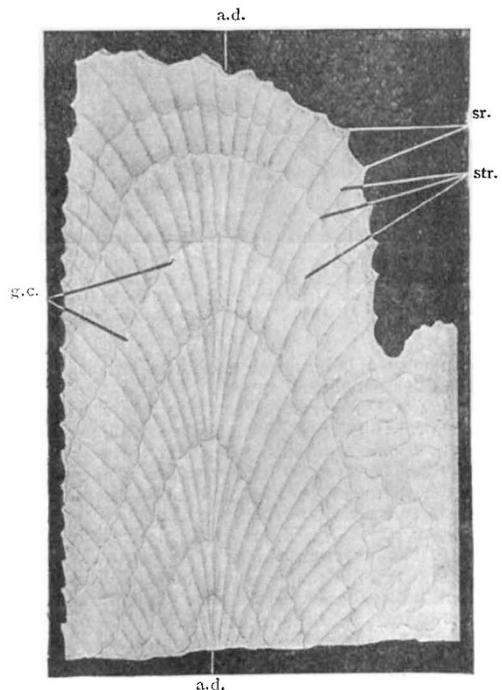


FIG. 3.—Striated septum of *Galaxea*. The striæ diverge fan-like from an "area of divergence" (a.d.); g.c. = growth-curve.

stead of being smooth, is thrown into a regular system of pleats, and has a goffered edge. The surfaces of the calcareous lamellæ are consequently marked by striæ (str.) and grooves, and the striæ taper to fine serræ (sr.) at the edge of the septum. In microscopic transverse sections of striated septa, the fibro-crystals radiate out from "dark points," better called "centres of calcification," which form a row in the median plane (Fig. 4). Each "centre" represents in cross-section the long axis of a stria, or pair of striæ, according as the striæ are alternate or opposite on the two surfaces of the septum. A number of wave-units of the lamellæ are arranged around each axis, hence the unit-bunches of fibres, though minute in themselves, combine to form a relatively large, radiating bunch to which I have given the name of "fascicle." It passes obliquely upwards and outwards through the series of lamellæ and gives rise to a slight eminence or "granulation" where it emerges at the surface. Striated septa occur in Stylinidæ, Oculinidæ, some Turbinolidæ, &c.; they are composed entirely of fascicles bisymmetrically arranged on either side of median axes.

It is a further step in complication of structure to pass from the striated septum to the roughly-granulate, ridged, spiniform-toothed septum which one sees in many Astræidæ, e.g. *Mussa*. Each broad ridge that passes downwards from a single spiniform

tooth of the edge bears on it a number of striæ, sometimes veiled superficially by the granulations, but always apparent after polishing the surface. This simply means that the septal fold in *Mussa* is thrown into a few very wide, deep pleats, corresponding with the broad ridges of the septal surface, and then that each wide pleat falls into a system of smaller, pitted pleats. Transverse and longitudinal sections show a departure from the

row of fascicles (Fig. 6) added along the growing septal edge, indicates a single period of growth in the existence of the polyp. I have, therefore, applied the term of "growth-segment" to signify one such addition made to the height of the septum; the term "trabecular part" to a pair or group of fascicles; and I define the term "trabecula" as a series of "trabecular parts" laid down during successive growth-periods of the polyp.

In the case of most Turbinolids the basal deposit laid down during a growth-period is in the form of a few more lamellæ added, without any spacial interruption, to the lamellæ of the previous growth-period. In the case of tall *Astræids*, *Stylinids*, &c., the basal deposit of each growth-period forms a new calycinal floor. And the space between any one calycinal floor and its predecessor corresponds to one growth-segment of the septum. This is a most important relation, and is one which I find also holds good for the synapticate form of base. The "true synapticate" in *Fungia* and its allies would thus be homologous with a basal dissepiment, and is probably an acquired feature in them, modified from a more primitive dissepimental base. Certainly one finds that dissepiments dwindle or even disappear in these synapticate types. The question arises of the possible advantage to the polyp of the synapticate in place of the dissepimental floor. The advantage is, at least, two-fold: (1) mechanical, as a support equally strong, although proportionally lighter; (2) physiological, as a means of extending the internal coelenteric space by the canalicular elongations, which are supported between synapticate.

The septum of the *Eupsammidæ* is, as in the *Fungidæ*, frequently porous, and the interseptal loculi are bridged by the coalescence of septal ends, by pseudosynapticate, or by true synapticate. The pores of the *Eupsammid* septum, however, may occur not only between the adjacent "trabecular parts"

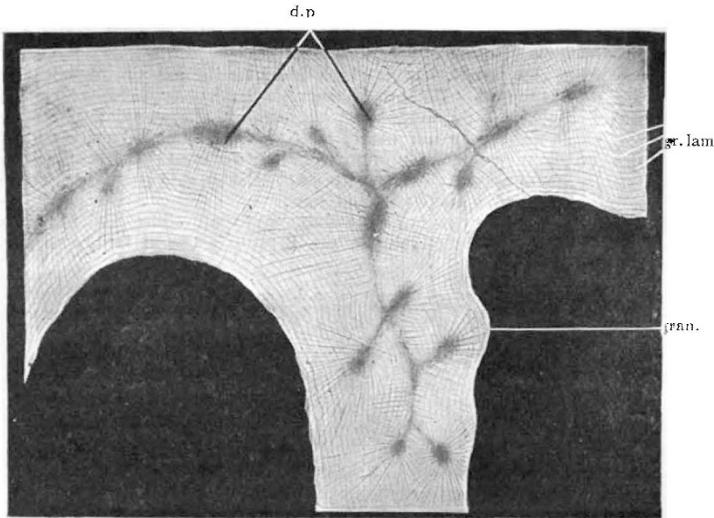


FIG. 4.—Transverse section of part of septum and wall, showing the radiating lines of structure passing out from the "dark points," and also the wavy cross-lines corresponding to successive "growth-lamellæ" (high power); gran. = granulation.

strict bisymmetry of fibres and uniform distribution of axes observed in the striated septum.

The septum of *Heliastrea* presents a further variation of the *Mussa* scheme. In microscopic transverse sections (Fig. 5), the fascicles are especially closely grouped in the middle, bulging part of a ridge, and are there arranged almost circularly; while, at the narrower ends of the ridge, the fascicles are further apart and are set bisymmetrically.

Next, in some *Astræid* types, and conspicuously in the family of *Fungidæ*, similar large ridges are present, but they are elliptical, squarish, or roundish in shape, indicating a still closer bundling together of the fascicles. As a fact, the fascicles radiate out around a common ridge-axis, although the individuality of the fascicles is still maintained. This is proved

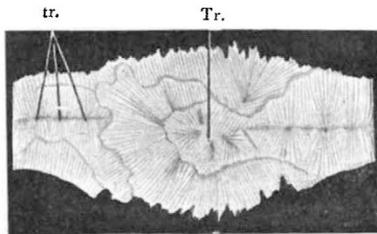


FIG. 5.—Thick central portion of a septal ridge of *Heliastrea* formed by a radio-symmetric trabecula (*Tr.*); and the thinner lateral wings of the same ridge passing into corresponding furrows—only bi-symmetric trabeculae (*tr.*) are present in these (magnified 70 times).

by the distinctness of emergent ends of fascicles in the thinner septa, and also by the inherent structure of parallel-set striæ. In thick septa, however, the emergent ends of fascicles coalesce to form the characteristic large granulations. These are the granulations, composite in structure, which give rise to "pseudosynapticate" (Pratz), inasmuch as their large size enables those at the same horizon on adjacent septal surfaces to coalesce across the interseptal loculus.

Thus I have passed from a bisymmetric to a radio-symmetric arrangement of fascicles in septa. Throughout all these septal types, certain definite laws of growth can be observed. Each

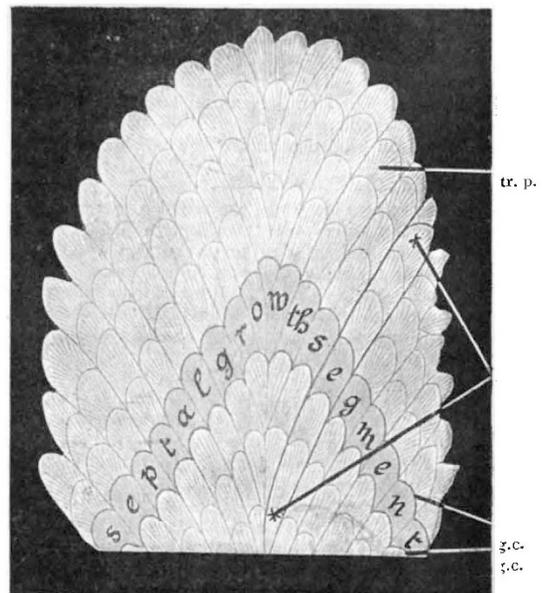


FIG. 6.—Radial structure composed of a "septal" wing and a "costal" wing. The trabeculae diverge right and left from an "area of divergence" between the two wings. The single trabecula marked "tr." is composed of seven trabecular parts (*tr. p.*) representing seven successive growth-periods. The trabecular parts between any two growth-curves (*g.c.*) form a "septal growth-segment," and represent one growth-period (diagrammatic).

of a growth-segment, but also between the successive "trabecular parts" in any one trabecula. Hence it is possible for a "trabecular part" to be absolutely free from its neighbours in

the same radial line—to be, in short, a *free septal spine set in the calyx*, as in the case of Palæozoic Cystiphyllids. The Triassic genera Stylophyllum and Stylophyllopsis show this same feature, also several Jurassic genera, e.g. Epistreptophyllum and Dermosmia, and there is no doubt that we have here an important structural feature in a living coral family which can be traced back to a feature characteristic of certain Palæozoic genera.

The Eupsammids were associated by Edwards and Haime with the Madreporidæ (sub-ord. M. Perforata). But the septal structure is very different. My sections prove that Turbinaria and Madrepora possess *compact septa* of a strictly bisymmetric type like those of Turbinolids, Oculinids, Stylinids. Porites again, the type of the other "Perforate" family of Edwards and Haime, has a porous septum composed of radio-symmetric trabeculæ. The crystalline structure of the trabeculæ in the Poritidæ distinguishes them essentially from the Fungidæ. The homology of the so-called synapticula is also in my estimation different in Porites. I regard it as having the character of an *inter-trabecular, interseptal spine*. It does not replace dissegmental deposit, and appears to be an *inherited feature*, not an acquired modification.

Reasoning now upon the foundation of the micro-structure of septa, I would draw the following conclusions respecting the classificatory system of Madreporaria.

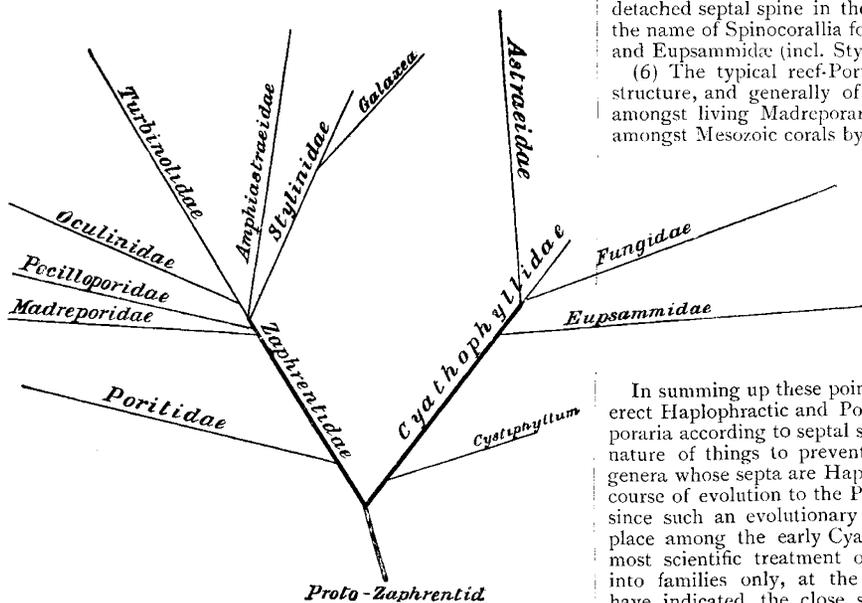


FIG. 7.—Phylogenetic diagram of Madreporaria.

(1) Septal structure affords a strong reason in favour of the abolition of the sub-orders Tetracoralla and Hexacoralla, since all the known septal types amongst Tetracoralla are also prevalent in Hexacoralla.

(2) Septal structure also disannuls the groups of M. Aporosa and M. Perforata. Madrepora and Turbinaria, typical genera of the group of M. Perforata, possess compact septa, whose structure is the same as the septa of certain typical genera belonging to the M. Aporosa. Again, similarity of septal structure characterises compact-septate and poro-septate types of Fungidæ; while one and the same specimen may have some of its septa compact, others porous.

(3) The two sub-families, Astræinæ and Eusmilinæ, hitherto recognised in the family of Astræidæ, have quite different types of septal structure. I would remove the genera of the Eusmilinæ to various other families, e.g. Euphyllia and allied genera to the Turbinolidæ; Amphiatraea and allied genera to a new family of Amphiatraeidae; Stylinæ, Galaxea, &c., to a family Stylinidæ.

(4) The fundamental similarity in the septal type of the families, Madreporidæ (excl. Eupsammidæ, E. H.), Pocilloporidæ (among which I would include Stylophora and its allies), Oculinidæ, Stylinidæ, Amphiatraeidae, Turbinolidæ, and the Zaphrentidæ among Palæozoic corals indicates a probable

common ancestral line. The septal type is very simple, and shows bisymmetry of design. I give it the name of *Haplophractic*. Other considerations concerning the relations of septum and wall, and the general habit of growth, indicate a closer affinity of the colony-building families, Madreporidæ, Pocilloporidæ, Oculinidæ, Stylinidæ; they form a natural group which I call *Cœnenchymata*. While the remaining three families with the Haplophractic septal type are characterised by a strong wall, retaining in part or wholly its primitive character as the inner lining of the epitheca. They may be termed *Murocorallia*.

(5) The fundamental similarity in the septal type of the Astræidæ, Fungidæ, and the typical Cyathophyllidæ, the Eupsammidæ, and Cystiphyllidæ, indicates an ancestral relationship of these families with one another. Their septal type is characterised by complications due to the many pleatings of the septal invagination. I call it *Polaplophractic*, in contradistinction to *Haplophractic*, and it will be remembered that the radio-symmetric trabecula attains here its full perfection, and that the septa are frequently porous. The families Cyathophyllidæ, Astræidæ (excl. Eusmilinæ), Fungidæ, are characterised by the pre-eminence of the *septum* and *septo-costa* in the calyx, and the regularity in the trabecular structure. They may be allied, therefore, under the name of *Septocorallia*. On the other hand, the irregularity of the trabeculæ, and the occurrence of the detached septal spine in the radial structure, make me choose the name of *Spinocorallia* for the allied families of Cystiphyllidæ and Eupsammidæ (incl. Stylophyllinæ).

(6) The typical reef-Poritids hold, by reason of their septal structure, and generally of their skeleton, an isolated position amongst living Madreporaria. A similar position is occupied amongst Mesozoic corals by the Triassic family of Spongimorphidæ. It seems likely that these two are ancestrally related; but I have not been able to do more than suggest a possible Palæozoic ally in the Theciidæ. Provisionally, I give the name of *Porosa* to the Poritids and Spongimorphids, in reference to the porous network of trabecular parts which makes up the entire skeleton.

In summing up these points, I may say it is not my intention to erect Haplophractic and Polaplophractic sub-orders of Madreporaria according to septal structure, since I know nothing in the nature of things to prevent the more advanced of the living genera whose septa are Haplophractic in type, to attain in the course of evolution to the Polaplophractic type. All the more, since such an evolutionary change seems actually to have taken place among the early Cyathophyllids. In my estimation, the most scientific treatment of Madreporaria is to classify them into families only, at the same time bearing in mind, as I have indicated, the close similarities existing between certain groups of families. My plan of Madreporarian ancestry is represented in the accompanying diagram, and is more fully carried out in a phylogenetic "scheme" of genera given in the complete work (*Phil. Trans. R.S., vol. clxxxvii. (1896) p. 331*).

I have purposely devoted the greater part of the space in this account to septal structure; other points can be merely indicated. The wall displays all the structural types just described for septa. The structure of the "wall" in fossil genera has an important bearing on questions concerning the "Randplatte." (I translate this term as "edge-zone.") It can be observed, for example, that in the early corals *the wall is the inner lining of the epitheca*, and the epitheca there extends up to the very lip of the calyx. The wall is therefore, like the tabula, primitively a one-sided structure. Both are laid down by continuous parts of the polypal ectoderm, and are skeletal forms homologous with the primitive inner lining of the embryonic basal skeletal plate. There cannot, therefore, have been any edge-zone of polypal flesh outside the calycinal wall of these early corals. Indication of an edge-zone is given when the wall in fossil genera is seen to rise up above the epithecal mantle at the edge of the calyx. It is then a two-sided structure developing within a fold, as in the case of septa. But the two flaps of the wall-fold may be quite different in length, as is testified by the varying position—central or excentric—taken by the "dark line" or fold-axis in the wall. This incoming of the edge-zone in corals took place at different times, and only in some genera; in others there has never been an edge-zone, so far as fossil evidence goes.

Speaking generally, I regard coenenchyme as an elaboration or extension of mural and mucrostate structures, formed above or within the epitheca.

I have above referred exclusively to the kind of wall which has been termed a "eutheca" (Fig. 8) or "true theca." Dr. Ortmann has defined it as a wall having distinct centres of calcification independent of these in the septa. In the case of

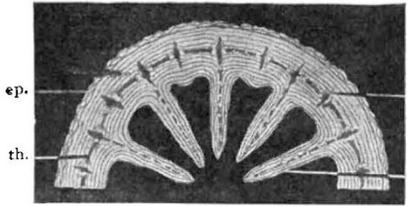


FIG. 8.—*Eutheca*. Transverse section showing the structural relations of *s.*=septa, *c.*=costa, *th.*=theca, and *ep.*=epitheca, in a typical Turbinolid. The section is cut some little distance below the calycinal edge.

the primitive one-sided wall, I would remark that the layers are often so smooth, that no particularly marked ring of "centres" is seen next the epitheca.

The "pseudotheca" (Fig. 9) is defined as a "false wall" formed by lateral thickening of the septa, with or without the participation of basal structures. I find that "pseudothecal" thickening is a very general characteristic in the families with

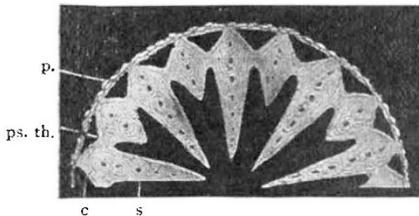


FIG. 9.—*Pseudotheca*. Transverse section showing the structural relations between *s.*=septum, *c.*=costa, *ps.th.*=pseudotheca, and *ep.*=epitheca. All grades occur between a position of the pseudotheca very near the centre and very remote from it, until it may be almost coalescent with the epitheca; the costa is respectively longer or shorter.

Pollaplophractic septa. Two walls, *i.e.* both pseudotheca and eutheca, were present temporarily or permanently in many fossil colonial genera belonging to Cyathophyllidae, Stylinidae, Amphistræidae, but, as a rule, the permanent presence of a pseudotheca is correlated with retrogression or absence of the primitive walling of the epitheca, and even the epitheca itself, around individual calyces.

#### *Evolution in the general Architecture of the Calyx.*

The internal construction of the calyx has altered very considerably during the history of the Madreporaria. Originally, the Madreporarian calyx was shallow, with low septa ribbing the walls and base, and from one to four grooves (fossulae) in the wall and base. Now, it has become typically deep-cupped, the septa are relatively higher and more ornate, centrally a columellar "style" rises upwards, or the septal ends meet irregularly in a columellar mesh-work, and instead of one to four special grooves, it is as if the whole base of the cup were grooved and deepened. These changes I take to be correlated, and to have been initiated by an increase in the number of mesenteries bearing reproductive organs, and increase in the demand for space in which to accommodate and protect these organs in the calyx. It is generally presumed that the primitive fossulae were pits for the accommodation of a very few mesenteries specialised for reproduction. Whereas now all, or nearly all of the mesenteries in living corals can exert this function. The multiplication of reproductive organs in any species is, we may safely argue, an advantage to it in propagating its kind; certainly it is a change which has proved successful in all Madreporarian families adopting it. The Cyathophyllids were the most precocious of the Palaeozoic corals in modifying their calyx; and I attribute to this fact the marvellous rapidity with which their descendants, the families

of Astræidae and Fungidae, spread over early Mesozoic seas. To this day these families are probably the richest in genera and species.

The change in the architecture of the calyx was effected by a gradual modification of existing skeletal structures. The "tabula" degenerated or was changed to "columella"; it was only retained in its primitive form in the calyces of polyps which have never specially multiplied the number of their mesenteries, but have held their place owing to some other advantageous resource, *e.g.* coenosarc. These are comparatively few.

The wall-lining of the epitheca was modified as I have indicated above. The septa were modified, giving rise to pseudothecæ inside the calyx, a valuable means for the support of mesenteries. In living families, the complicate Pollaplophractic type of septum goes hand in hand with much pleating and greater muscular vigour of the mesenteries. There can be little doubt that higher musculature and sensibility of mesenteries aids reproduction, hence these correlated features in septa and mesenteries were probably adaptations to this end. The synapical base is another modification closely associated with the mesenteries, occurring as an occasional correlate in types with Pollaplophractic septa and a much-pleated aboral polypal surface.

In short, by comparison with well-known facts in the anatomy of living Madreporaria, it becomes clear that all the important changes which have taken place in the history of the group, are secondary features correlative with change in the mesenteries. There is also good evidence that the change in the mesenteries has assisted the polyp's powers of propagation. We need look no further for an explanation of the "hastening" in the stages of cyclical development of mesenteries or septa. The history of the embryo summarises that of the race; tetrameral symmetry is now for the most part an evanescent phase in embryonic development. On this point, any evidence I have gathered from Mesozoic corals only corroborates the published views of Prof. Quélch and Dr. Ortmann against a subdivision of Madreporaria into Tetracoralla (Rugosa) and Hexacoralla, and helps to still more emphatically knit continuity into the thread of Madreporarian descent from Palaeozoic to recent time. Even now the change to radial symmetry of the polyp is often incomplete, and will be while there still are "directive" mesenteries.

In conclusion, I claim in this work to have shown that the great impulse of evolution—*viz.* the successful continuation of the race—is the agent to whose steady working the main changes in Madreporaria may be traced. I claim to have vindicated this position by demonstrating the same structural unit in the simplest and the most complicate skeletal structures known in Madreporaria through all ages, by finding in all skeletal parts one and the same fibrous equivalent of the living, lime-forming, unit cell, and by tracing a correlated series of modifications which primitive forms have undergone in response to the need of safeguarding the race.

MARIA M. OGLIVIE.

#### *THE POSITION AND WORK OF THE CENTRAL TECHNICAL COLLEGE.*

THE Report of the Special Committee appointed by the Governors of the City and Guilds of London Institute, at the instance of the Court of Assistants of the Mercers' Company, to inquire into the expenditure of the Central Technical College as compared with results, has just been published. The Committee comprised not merely representative members of the City Companies, but present and past Presidents of the Royal Society, the Institution of Civil Engineers, the Chemical Society, and other societies interested in the advancement of knowledge, so that its opinion may be regarded as that of the scientific public. Sir John Donnelly was elected chairman of the Committee.

The volume runs into eighty pages, and deals with (1) building and equipment, (2) current expenses, (3) cost of the College per student and comparison with other colleges, (4) methods of administration and control over expenditure. We are glad to give it prominence, first, because the Central Technical College is not supported as a commercial concern to make money, but to provide, at small cost, a sound education in the applications of the principles of science to industry; and secondly, because the members of the teaching-staff are earnest and enthusiastic in their efforts to carry out the scheme formulated some years ago, when the estimates of the cost of the College were drawn up by Huxley and others.