results (fig. 17 *h*). The pterocymba is subject to considerable modifications: the prows may be similar (*homoproral*) or dissimilar (*heteroproral*); the pteres may be lamellar or ungual; additional lamellæ (*tropidial pteres*) may be produced by a lateral outgrowth of the keel (fig. 17 *k*); and by growing towards the equator the opposed proral and pleural pteres may conjoin, producing a spicule of two meridional bands (*oocymba*; fig. 17 *l*). A curious group of flesh spicules are the *trichites*. In this group silica, instead of being deposited in concentric coatings around an axial fibre, forms within the scleroblast a sheaf of immeasurably fine fibrillæ or trichites, which may be straight (fig. 17 *m*) or twisted. The trichite sheaf may be regarded as a fibrillated spicule. Trichite sheaves form in some sponges, as *Dragmastra* (*25*), a dense accumulation within the cortex. In Hexactinellid sponges the rays of the aster are limited to six, arranged as in a primitive sexradiate spicule, but divided at the ends into an indefinite number of slender filaments, which may or may not be tylotate, *rosettes* (fig. 17 *t*).

Spongin is a horny substance, most similar to silk in chemical composition, from which it differs in being insoluble in an ammoniacal solution of copper sulphate (cuproso-ammonium sulphate). In *Darwinella aurea*, F. Müller, it occurs in forms somewhat resembling tri-, quadri-, and sex-radiate spicules. But usually the spongin skeleton takes the form of fibres, consisting of a central core of soft granular substance around which the spongin is disposed in concentric layers, forming a hollow cylinder (fig. 23 *b*). The relative diameters of the soft core and of the spongin cylinder differ greatly in different sponges. The fibres branch so as to form antler-like twigs or bushy tree-like growths, or anastomose to form a continuous network, as in the bath sponge (*Euspongia officinalis*). The detailed characters of the network differ with the species, and are useful in classification. In *Ianthella* certain cells (sponginblasts) become included between the successive layers of the spongin cylinder, and their deep violet colour, contrasting with the amber tint of the spongin, renders them very conspicuous.

Union of scleres into a skeleton.

In some sponges the scleres are simply scattered through the mesoderm and do not give rise to a continuous skeleton,—*Corticium*, *Chondrilla*, *Thrombus*. In the *Calcarea* and many silicious sponges they are dispersed through the mesoderm, but so numerously that by the overlapping of their rays a loosely felted skeleton is produced. In the calcareous sponges the spicules are frequently regularly disposed; and in the Sycons in particular a definite arrange-

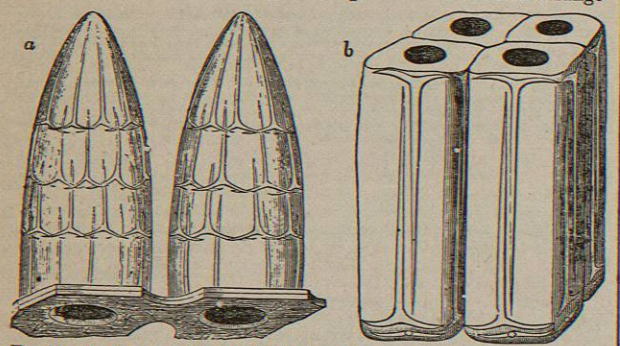

FIG. 18.—Articulate and inarticulate tubar skeletons of calcisponges. *a*, articulate; *b*, inarticulate skeleton. After Haeckel.

ment, on two plans, the *articulate* and *inarticulate*, can be traced in the skeleton of the radial tubes. On the latter plan the triradiate or quadriradiate spicules, the apical rays of which are of considerable length, are arranged in two sets, one having the basal rays lying in the mesoderm of the paragastral wall and the other with the corresponding rays in the dermal mesoderm. The apical rays of each set lie in the mesoderm of the radial tubes parallel to their length, but pointing in opposite directions (fig. 18 *b*). In the articulate division numerous spicules, small in comparison with the size of the radial tubes, form a series of rows round the tubes, their basal rays lying parallel to the paragastric surface and the apical pointing towards the ends of the radial tubes (fig. 18 *a*).

In the *Silicispongia* sheaves of long oxeate spicules radiate from the base of the sponge if of a plate-like form, or from the centre if globular, and extend to the surface. If triænes are present their arms usually extend within the mesoderm immediately below the dermal surface (fig. 19). Single spicules reach from centre to surface only in small sponges. As the sponge increases in size the spicules must either correspondingly lengthen, or fresh spicules must be added, if a continuous skeleton is to be formed. The latter is the plan followed in fact: the additional spicules overlap the ends of those first formed like the fusiform cells in a woody fibre. With the formation of a fibre, often strengthened by spongin or bound together with connective tissue, there appears to be a tendency for the constituent spicules to diminish in size, and the length of each in the most markedly fibrous sponges is insignificant when compared with the length of the fibre. The spicular fibre thus formed may be simple or echinated by spicules either similar to those which form its mass or different. More usually they are different, and generally styles, often spinose about their origin. The spongin which sometimes cements together the spicules of a fibre may progressively increase in quantity and the spicules diminish in number, till a horny fibre containing one or more rows of small oxeas results. In an echinated fibre the axial spicules may disappear and the echinating spicules persist. Finally all spicules may be suppressed and the horny fibre of the Ceratose sponges results. The horny fibres may next acquire the habit of embedding foreign bodies in their substance, though foreign enclosures are not confined to the *Ceratosa* but occur in some *Silicispongiæ* as well. The included foreign bodies may increase in quantity out of all proportion to the horny fibres; and finally the skeleton may consist of them alone, all spongin matter having disappeared.

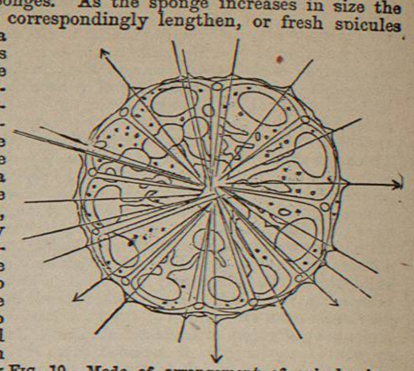

FIG. 19.—Mode of arrangement of spicules in a young Stellettid sponge, *Dragmastra normani*, Soll. After Sollas.

In the Lithistid sponges a skeleton is produced by the articulation of desmas into a network. The rays of the desmas (figs. 12 *f*, 13 *s*, 14 *e*) terminate in apophyses, which apply themselves to some part of adjacent desmas, either to the centrum, shaft, arms, or similar apophyses, and then, growing round them like a saddle on a horse's back, clasp them firmly without anchylosis. Thus they give rise to a rigid network, in conjunction with which fibres composed of rhabdus spicules may exist. In the *Hexactinellida* both spicular felts and fibres occur, and in one division (*Dictyonina*) a rigid network is produced, not, however, by a mere clasping of apophyses, but by a true fusion. The rays of adjacent spicules overlap and a common investment of silica grows over them.

Histology.

Ectoderm.

The ectoderm usually consists of simple pavement epithelial cells (*pinnacocytes*), the margins of which can be readily rendered visible by treatment with silver nitrate, best by Harmer's method.[1] The nucleus and nucleolus are usually visible in preparations made from spirit specimens, the nucleus being often readily recognizable by its characteristic bulging beyond the general surface. In some sponges (*Thecaphora*) the epithelium may be replaced locally by columnar epithelium, and the cells of both pavement and columnar epithelium may bear flagella (*Aplysilla violacea*, *Oscarella lobularis*). The endoderm presents the same characters as the ectoderm, except in the Ascons and the flagellated chambers of all other sponges, where it is formed of collared flagellated cells or *choanocytes*,—cells with a nearly spherical body in which a nucleus and nucleolus can be distinguished and one or more contractile vacuoles. The endoderm extends distally in a cylindrical neck or *collum*, which terminates in a long flagellum surrounded by a delicate protoplasmic frill or collar (fig. 21 *g*). In *Tetractinellida*, and probably in many other sponges—certainly in some—the collars of contiguous choanocytes coalesce at their margins so as to produce a fenestrated membrane, which forms a second inner lining to the flagellated chamber (fig. 20, ii.). The presence of this membrane enables us readily to distinguish the excurrent from the incurrent face of the chamber, since its convex surface is always turned towards the prosopyle. In sponges with an aphodal canal system the flagellated chambers usually pass gradually into the aphodal canal, but the incurrent canal enters abruptly. This abrupt termination of the incurrent canal appears to mark the termination of the ectoderm and the commencement of the endoderm. The flagellated chambers differ greatly in size in different sponges, and evidently manifest a tendency to become smaller as the canal system increases in complexity; thus Sycon are always larger than Rhagon chambers, and eurypylous than aphodal Rhagon chambers. In most sponges except the Ascons the mesoderm is largely developed, and in many it undergoes a highly complex histological differentiation. In its commonest and simplest form it consists of a clear, colourless, gelatinous matrix in which irregularly branching stellate cells or connective tissue corpuscles are embedded; these may be termed *collencytes* (fig. 21 *a*) and the tissue *collenchyme*. In the higher sponges (*Geodia*, *Stelletta*) it consists of small polygonal granular cells either closely contiguous or separated by a very small quantity of structureless jelly, and in this form may be termed *sarcenchyme* (fig. 20). Collenchyme does not originate through the transformation of sarcenchyme, as one might expect, for it precedes the latter in development. Schulze (*20*), who has compared collenchyme to the gelatinous tissue which forms the chief part of the umbrella of "jelly-fish," describes it as becoming granular immediately in the neighbourhood of the flagellated chambers in the bath sponge, the granules becoming more numerous in sponges in which the canal system acquires a higher differentiation, till at length the collencytes are concealed by them. According to this view, sarcenchyme would appear to originate from a densely granular collenchyme. Amœboid wandering cells or *archæocytes* (fig. 22) are scattered through the matrix of the collenchyme. They evidently serve very different purposes: some appear to act as carriers of nourishment or as scavengers of useless or irritant foreign matter; others may possibly contribute to the formation of higher tissues, some certainly becoming converted into sexual products. Their parentage and early history are unknown.

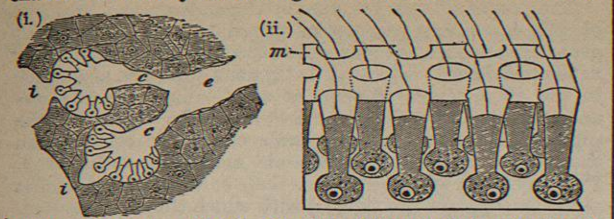

FIG. 20.—Choanocytes with coalesced collars. (i.) Longitudinal section through two flagellated chambers of *Anthastra communis*, Soll.; *i*, prosopyles; *c*, aphodal canals leading from the flagellated chambers; *e*, excurrent canal; the tissue surrounding the chambers is sarcenchyme (×360). (ii.) Diagram showing the fenestrated membrane (*m*) produced by coalesced collars of choanocytes. After Sollas, "*Challenger*" *Report*.

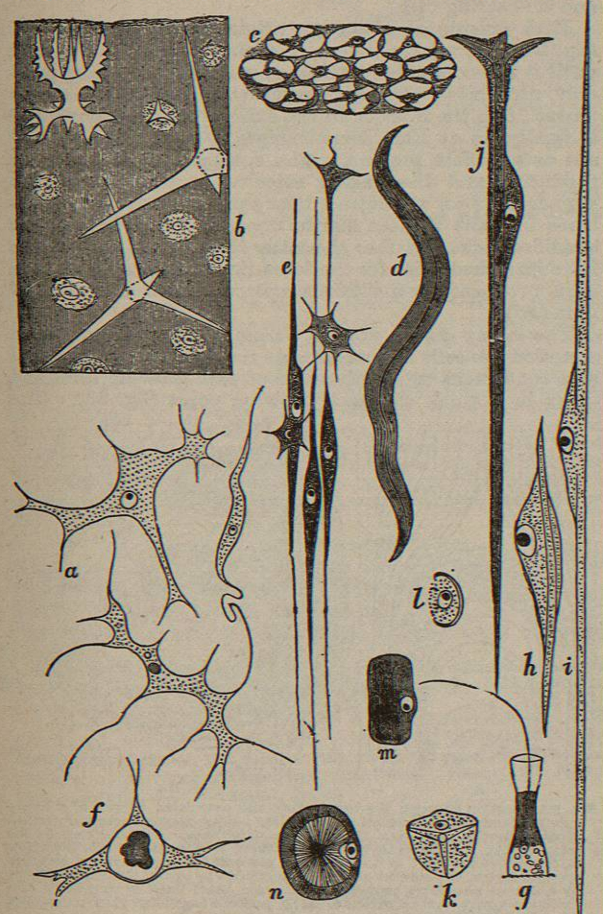

FIG. 21.—Histological elements. *a*, collencytes, from *Thenea muricata*; *b*, chondrenchyme, from cortex of *Corticium candelabrum* (the unshaded bodies are microscleres); *c*, cystenchyme, from *Pachymatisma johnstoni* (partly diagrammatic); *d*, desmacyte, from *Dragmastra normani*; *e*, myocytes in connexion with collencytes, from *Cinachyra barbata*; *f*, thesocyte, from *Thenea muricata*; *g*, choanocyte, from *Sycandra raphanus*; *h*-*n*, scleroblasts—*h*, of a young oxea, from an embryo of *Craniella cranium*; *i*, of a fully grown oxea, from an adult *C. cranium*; *j*, orthotriæne, with associated scleroblast from *Stelletta*; *k*, of a tetracladine desma, from *Theonella swinhoei*; *l*, of a sigmaspire, from *Craniella cranium*; *m*, of an orthodragma, from *Disyringa dissimilis*; *n*, of a sterraster, from *Geodia barretti*. Figs. *b* and *g* after Schulze, the others after Sollas.

A tissue (*cystenchyme*) which in some respects resembles certain forms of vegetable parenchyme occurs in some sponges, particularly *Geodinidæ* and other *Tetractinellida*. It consists of closely adjacent large oval cells, with thin well-defined walls and fluid contents. Somewhere about the middle of the cell is the nucleus with its nucleolus, supported by protoplasm, which extends from it in fine threads to the inner side of the wall, where it spreads out in a thin investing film (fig. 21 *c*). Cystenchyme very commonly forms a layer just below the skin of some *Geodinidæ*, particularly of *Pachymatisma*, and, as on teasing the cortex of this sponge a large number of refringent fluid globules immiscible with water are set free, it is just possible that it is sometimes a fatty tissue, and if so the contained oil must be soluble in alcohol, for alcoholic preparations show no trace of it. A tissue resembling cartilage, *chondrenchyme*, occurs in *Corticidæ* (fig. 21 *b*).

Connective-tissue cells or *desmacytes* are present in most sponges; they are usually long fusiform bodies, consisting of a clear, colourless, often minutely fibrillated sheath, surrounding a highly refringent axial fibre, which stains deeply with reagents (fig. 21 *d*). In other cases the desmacyte is simply a fusiform granular cell, with a nucleus in the interior and a fibrillated appearance towards the ends. The desmacytes are gathered together, their ends overlapping, into fibrous strands or felted sheets, which in the ectosome of some sponges may acquire a considerable thickness, often constituting the greater part of the cortex. The spicules of the sponge often furnish them with a surface of attachment, especially in the *Geodinidæ*, where each sterraster of the cortex is united to its neighbours by desmacytes, in the manner shown in fig. 10.

Contractile fibre cells or *myocytes* occur in all the higher sponges. They appear to be of more than one kind. Most usually they are fine granular fusiform cells with long filiform terminations, and with an enclosed nucleus and nucleolus (fig. 21 *e*). In the majority of sponges both excurrent and incurrent canals are constricted at intervals

[1] S. F. Harmer, "On a Method for the Silver Staining of Marine Objects," *Mitth. Zoolog. Station zu Neapel*, 1884, p. 445.

by transverse diaphragms or *vela*, which contain myocytes concentrically and sometimes radiately arranged. The excessive development of myocytes in such a velum gives rise to muscular sphincters such as those which close the chones of many corticate sponges, such as *Pachymatisma*. In this sponge, which occurs on the British shores, the function of the oscular sphincters can be readily demonstrated, since irritation of the margin of the oscule is invariably followed after a short interval by a slow closure of the sphincter.

Supposed sense-cells or *æsthacytes* (fig. 22) were first observed by Stewart and have since been described by Von Lendenfeld (*12*). According to the latter, they are spindle-shaped cells, 0·01 mm. long by 0·002 thick; the distal end projects beyond the ectodermal epithelium in a fine hair or palpocil; the body is granular and contains a large oval nucleus; and the inner end is produced into fine threads, which extend into the collenchyme and are supposed—though this is not proved—to become continuous with large multiradiate collencytes, which Von Lendenfeld regards as multipolar ganglion cells (fig. 22).

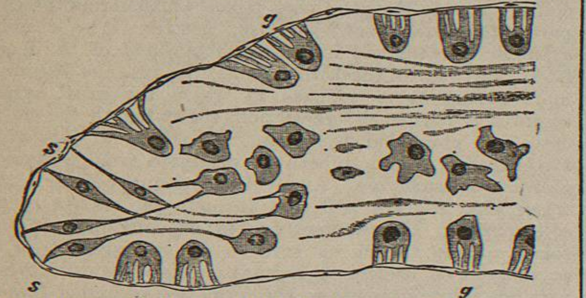

FIG. 22.—Transverse section through the edge of a pore in *Dendrilla cavernosa*, Lfd.; cells in the middle to the right, archæocytes; fusiform cells on each side of them, myocytes; *g*, above and below these, with processes terminating against the epithelium, gland cells; fusiform cells terminating against the epithelium at *s*, æsthacytes; at their inner ends these are continuous with ganglion cells. After Von Lendenfeld (× 800).

More recently he has described an arrangement of these cells curiously suggestive of a sense-organ. Numerous æsthacytes are collected over a small area, and at their inner ends pass into a granular mass of cells with well-marked nuclei, but with boundaries not so evident; these he regards as ganglion cells. From the sides of the ganglion other slender fusiform cells, which Von Lendenfeld regards as nerves, pass into the mesoderm, running tangentially beneath the skin. The inner end of the ganglion is in communication with a membrane formed of fusiform cells which Von Lendenfeld regards as muscular. If his observations and inferences are confirmed, it is obvious that we have here a complete apparatus for the conversion of external impressions into muscular movements.

In most sponges a direct connexion can be traced by means of their branching processes between the collencytes of the mesoderm and the cells of the ectodermal and endodermal epithelium and the choanocytes of the flagellated chambers. As the collencytes are also united amongst themselves, they place the various histological constituents of the sponge in true protoplasmic continuity. Hence we may with considerable probability regard the collencytes as furnishing a means for the transmission of impulses: in other words, we may attribute to them a rudimentary nervous function. In this case the modification of some of the collencytes in communication with the ectoderm might readily follow and special æsthacytes arise. Fusiform collencytes perpendicular to the ectoderm, and with one end touching it, are common in a variety of sponges; but it is difficult to trace the inner end into connexion with the stellate collencytes, so that precisely in those cases in which it would be most interesting to find such a connexion absolute proof of it is wanting.

The colour of sponges usually depends on the presence of cells containing granules of pigment; though dispersed generally through the mesoderm, these cells are most richly developed in the ectosome. Pigment granules also occur in the choanocytes of some sponges,—*Oscarella lobularis* and *Aplysina aerophoba*, for instance. In the latter the pigment undergoes a remarkable change of colour when the sponge is exposed to the air, and finally fades away. In many cases sponges borrow their colours from parasitic algæ (*Oscillatoria* and *Nostoc*) with which they are infested. The colours of sponge-pigments are very various. They have been examined by Krukenberg and Merejknovsky. Zoonerythin, a red pigment of the lipochrome series, is one of the most widely diffused; it is regarded as having a respiratory function. Reserve cells or *thesocytes* (fig. 21 *f*) have been described in several sponges as well as amylin and oil-bearing cells.

Each spicule of a sponge originates in a single cell (fig. 21 *h-n*), within which it probably remains enclosed until it has completed its full growth; the cell then probably atrophies. During its growth the spicule slowly passes from the interior to the exterior of the sponge, and is finally (in at least some sponges, *Geodia*, *Stelletta*) cast out as an effete product. The sponge is thus constantly producing and disengaging spicules; and in this way we may account for the extraordinary profusion of these structures in some modern marine deposits and in the ancient stratified rocks. Within the latter these deciduous spicules have furnished silica for the formation of flints, which have been produced by a silicious replacement of carbonate of lime (*26*). Scleroblasts

The horny fibres of the *Ceratosa* are produced as a secretion of cells known as *sponginblasts*, which surround as a continuous mantle the sides of each growing fibre, and cover in a thick cap each growing point (fig. 23). The

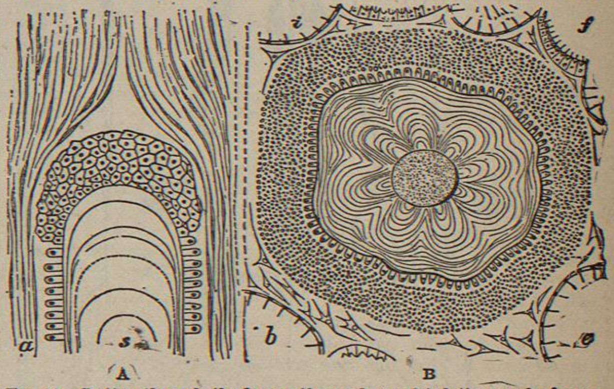

FIG. 23.—Section through the horny fibre and associated tissues of a horny sponge (*Dendrilla*). A, longitudinal section; *s*, layers of spongin, surrounded at the sides by the lateral mantle of sponginblasts, and at the ends by the terminal cap. A desmachymatous sheath, *a*, surrounds the whole (×150). B, transverse section; in the centre is the soft core, surrounded by wavy spongin layers, the outermost being surrounded by sponginblasts, and these by a fibrous sheath; *i*, part of an incurrent canal lined by flagellated epithelium; *e*, part of an excurrent canal; *f*, part of a flagellated chamber (×150). After Von Lendenfeld.

lateral sponginblasts are elongated radially to the fibre; the terminal cells are polygonal and depressed. The latter give rise to the soft granular core and the former to the spongin-walls of the fibre. Cells similar to the lateral sponginblasts, and regarded as homologous with them, occur in a single layer just below the outer epithelium of some horny sponges (*Aplysilla* and *Dendrilla*), and under certain circumstances secrete a large quantity of slimy mucus (*11*).

Classification.

The phylum *Parazoa* or *Spongiæ* consists of two main branches, as follows:—

Branch A.—*MEGAMASTICTORA.*

Class CALCAREA, Grant.
Order 1.—*Homocœla*, Pol.
Order 2.—*Heterocœla*, Pol.

Branch B.—*MICROMASTICTORA.*

Class I.—MYXOSPONGIÆ, Haeckel.
Order 1.—*Halisarcina.*
Order 2.—*Chondrosina.*

Class II.—SILICISPONGIÆ.
Sub-class i.—HEXACTINELLIDA, O. Schmidt.
Order 1.—*Lyssacina*, Zittel.
Order 2.—*Dictyonina*, Zittel.
Sub-class ii.—DEMOSPONGIÆ, Sollas.
Tribe *a*.—**Monaxonida.**
Order 1.—*Monaxona.*
Order 2.—*Ceratosa*, Grant.
Tribe *b*.—**Tetractinellida**, Marshall.
Order 1.—*Choristida*, Sollas.
Order 2.—*Lithistida*, O.S.

By the possession of both sexual elements and a complex histological structure, and in the character of their embryological development, the sponges are clearly separated from the *Protozoa*; on the other hand, the choanoflagellate character of the endoderm, which it retains in the flagellated chambers throughout the group without a single exception, as clearly marks them off from the *Metazoa*. They may therefore be regarded as a separate phylum derived from the choanoflagellate *Infusoria*, but pursuing for a certain distance a course of development parallel with that of the *Metazoa*.

Different views have been propounded by other authors. Savile Kent regards the sponges as *Protozoa* (*10*); Balfour suggested that they branched off from the Metazoan phylum at a point below the *Cœlentera*, and considered them as intermediate between *Protozoa* and *Metazoa*; Schulze regards them as derived from a simple ancestral form of *Cœlentera* (*23*); Marshall advocates the view that they are degraded forms derived from Cœlenterates which were already in possession of tentacles and mesenteric pouches (*14*).

Subdivision in groups. As a phylum the *Spongiæ* are certainly divisible into two branches, one including the *Calcarea* and the other the remaining sponges, which Vosmaer has termed *Non-Calcarea*, and others *Plethospongiæ*. Since, however, the choanocytes of the *Calcarea* are usually, if not universally, larger than those of other sponges, we may make use of this difference in our nomenclature, and distinguish one branch as the *Megamastictora* (μαστίκτωρ, "scourger") and the other as the *Micromastictora*.

Branch A.—*MEGAMASTICTORA.*

Sponges in which the choanocytes are of comparatively large size, 0·005 to 0·009 mm. in diameter (Haeckel, *6*).

Class **CALCAREA.**

Calcarea. *Megamastictora* in which the skeleton is composed of calcareous spicules.

Order 1. HOMOCŒLA.—*Calcarea* in which the endoderm consists wholly of choanocytes. Examples: *Leucosolenia*, Bwk.; *Homoderma*, Lfd.

Order 2. HETEROCŒLA.—*Calcarea* in which the endoderm is differentiated into pinnacocytes, which line the paragastric cavity and excurrent canals, and choanocytes, which are restricted to special recesses (radial tubes or flagellated chambers). Examples: *Sycon*, O.S.; *Grantia*, Fl.; *Leuconia*, Bwk.

Branch B.—*MICROMASTICTORA.*

(*Non-Calcarea*, Vosmaer; *Plethospongiæ*, Sollas.) Sponges in which the choanocytes are comparatively small, 0·003 mm. in diameter.

Class I. **MYXOSPONGIÆ.**

Micromastictora in which a skeleton or scleres are absent.

Order 1. HALISARCINA.—*Myxospongiæ* in which the canal system is simple, with simple or branched Sycon or eurypylous Rhagon chambers. An ectosome sometimes and a cortex always absent. Examples: *Halisarca*, Duj.; *Oscarella*, Vosm.; *Bajalus*, Lfd.

Order 2. CHONDROSINA.—*Myxospongiæ* in which the canal system is complicated, with diplodal Rhagon chambers and a well-developed cortex. Example: *Chondrosia*, O.S.

The *Halisarcina* are evidently survivals from an ancient and primitive type. The simplicity of the canal system is opposed to the view that they are degraded forms; we may therefore regard the absence of scleres as a persistent primary and not a secondary acquired character. They are as interesting, therefore, from one point of view (absence of scleres) as the Ascons are from another (undifferentiated endoderm). With the *Chondrosina* the case is different; they differ only from *Chondrilla* and its allies by the absence of asters; these differ only from the *Tethyidæ* by the absence of strongyloxeas; and we may very reasonably assume that in these three groups we have a series due to loss of characters, the *Chondrillæ* being reduced *Tethyidæ* and the *Chondrosina* reduced *Chondrillæ*. Still, as Huxley has well remarked, "classification should express not assumptions but facts"; and therefore till we are in possession of more direct evidence it will be well to exclude the *Chondrosina* from the *Silicispongiæ*.

Class II. **SILICISPONGIÆ.**

Micromastictora possessing a skeleton or scleres which are not calcareous.

Sub-class i. **HEXACTINELLIDA.**

Silicispongiæ characterized by sexradiate silicious spicules. Canal system usually simple, with Sycon chambers. Sponge differentiated into ecto-, choano-, and endo-some.

Order 1. LYSSACINA.—*Hexactinellida* in which the skeleton is formed of separate spicules, or, if united, then by a subsequent not a contemporaneous deposit of silica. Examples: *Euplectella*, Owen; *Asconema*, S. Kent; *Hyalonema*, Gray; *Rossella*, Crtr.

Order 2. DICTYONINA.—*Hexactinellida* in which sexradiate spicules are cemented together by a silicious deposit into a continuous network *pari passu* with their formation. Examples: *Farrea*, Bwk.; *Eurete*, Marshall; *Aphrocallistes*, Gray; *Myliusia*, Gray; *Dactylocalyx*, Stutchbury.

The *Hexactinellida* are a very sharply defined group, impressed with marked archaic features. No other *Silicispongiæ* possess, so far as is known, so simple a syconate canal system. The oldest known fossil sponge is a member of the *Lyssacina* (*7* and *24*), viz., *Protospongia*, Salter, from the Menevian beds, Lower Cambrian, St David's Head, Wales. The group is almost world-wide in distribution, chiefly affecting deep water, from 100 to 300 fathoms, but often extending into abyssal depths; occasionally, however, though rarely, it frequents shallow water (*Cystispongia superstes* dredged off Yucatan in 18 fathoms).

Sub-class ii. **DEMOSPONGIÆ.**

Silicispongiæ in which sexradiate spicules are absent *Demospongiæ.*

Tribe *a*. *MONAXONIDA.*

Demospongiæ in which the skeleton consists either of silicious spicules which are not quadriradiate, or of horny scleres or included foreign bodies, or of one or more of these constituents in conjunction.

Order 1. MONAXONA.—The skeleton is characterized by either uniaxial or polyaxial spicules. Examples: *Amorphina*, O. S. ("crumb of bread" sponge); *Spongilla*, Lmk. ("freshwater" sponge); *Chalina*, Bwk.; *Tethya*, Lmk.

Order 2. CERATOSA.—The skeleton consists of horny scleres which never include "proper" spicules, or of introduced foreign bodies, or of both these in conjunction. Examples: *Darwinella*, F. Müller; *Euspongia*, Bronn (the "bath" sponge).

Tribe *b*. *TETRACTINELLIDA.*

Demospongiæ possessing quadriradiate or triæne spicules or Lithistid scleres (desmas).

Order 1. CHORISTIDA.—*Tetractinellida* with quadriradiate or triæne spicules, which are never articulated together into a rigid network. Examples: *Tetilla*, O.S.; *Thenea*, Gray; *Geodia*, Lmk.; *Dercitus*, Gray.

Order 2. LITHISTIDA.—*Tetractinellida* with branching scleres (desmas), which may or may not be modified tetrad spicules, articulated together to form a rigid skeleton. Triæne spicules may or may not be present in addition. Examples: *Theonella*, Gray; *Corallistes*, O.S.; *Azorica*, Crtr.; *Vetulina*, O.S.

This large sub-class embraces the great majority of existing sponges. Its external boundaries are fairly well defined, its internal divisions much less so, as its various orders and families pass into each other at many points of contact. Although there does not appear to be much resemblance between a Lithistid sponge, such as *Theonella*, a Monaxonid such as *Amorphina*, and an ordinary "bath" sponge (*Euspongia*), yet between these extremes a long series of intermediate forms exists, so nicely graduated as to render their disruption into groups by no means an easy task. If the delimitation of orders is difficult, that of genera is often impossible, so that they are reduced to assemblages depending on the tact or taste of the author. Thus Polejaeff states that with a single exception "none of the genera of *Ceratosa* are separable by absolute characters." The chief spicules of *Monaxona* are uniaxial, often accompanied by characteristic microscleres. Although distinguished as a group by the absence of quadriradiate or triæne spicules, two exceptions are known in which these occur (*Tricentrion*, Ehlers, and *Acarnus*, Gray); these, however, present unusual characters which suggest an independent origin. The canal system of *Monaxona* has not yet been fully investigated; it appears usually to follow the eurypylous Rhagon type, but the aphodal is not unknown. The *Ceratosa* contain all sponges with a horny skeleton, except those in which the horny fibres are cored or spined with silicious spicules secreted by the sponge ("proper" spicules); these are arbitrarily assigned to the *Monaxona*. There is convenience in this proceeding, for horny matter is widely disseminated throughout the *Demospongiæ*, occurring even in the *Lithistida*, and it frequently serves to cement the oxeate spicules of the *Monaxona* into a fibre, without at the same time forming a preponderant part of the skeleton. It would be wellnigh impossible to say where the line should be drawn between a fibre composed of spicules cemented by spongin and one consisting of spongin with embedded spicules, while there is comparatively no difficulty in distinguishing between fibres containing spicules and fibres devoid of them. That the distinction, however, is entirely artificial is shown by the fact that, after spicules have disappeared from the horny fibre, they may still persist in the mesoderm; thus Von Lendenfeld announces the discovery of microscleres (cymba) in an Aplysillid sponge and of strongyles in a *Cacospongia*, both horny sponges. (A form intermediate between this Aplysillid and the *Desmacidonidæ* would appear to be *Toxochalina*, Ridley.) The *Ceratosa* frequently enclose sand, *Foraminifera*, deciduous spicules of other sponges and of compound Ascidians, and other foreign bodies within the horny fibres of their skeleton; they also sometimes attach this material, probably by a secretion of spongin, to their outer surface, and thus invest themselves in a thick protective crust. In some *Ceratosa* no other skeleton than that provided by foreign enclosures is present. The canal system is syconate or eurypylous in the simpler forms and diplodal in the higher. The *Monaxonida* make their earliest appearance in the Silurian rocks (*Climacospongia*, Hinde), and are now found in all seas at all depths. The only sponges inhabiting fresh water belong to this group. The *Tetractinellida* adhere to the *Monaxonida* at more than one point, and one of these groups has probably been a fruitful parent to the other, but which is offspring and which parent is still a subject for discussion. The *Choristida* in its simplest forms presents a eurypylous Rhagon system, in the higher an aphodal system. It is in this group that the most highly complex cortex is met with; in the *Geodinidæ*, for instance, it consists usually of at least five distinct layers. Thus, proceeding outwards, next to the choanosome is a layer of thickly felted desmachyme, passing into collenchyme on its inner face; then follows a thick stratum of sterrasters united together by desmacytes; this is succeeded by a layer of cystenchyme or other tissue of variable thickness; external to this is a single layer of small granular cells and associated dermal asters; and finally, the surface is invested by a layer of pavement epithelium. The *Lithistida*, like the *Ceratosa*, are possibly of polyphylitic origin; in one group (*Tetracladina*) the articulated scleres are evidently modified calthrops spicules (see fig. 14 *e*), and associated with them are free triænes, which support the dermis and resemble precisely the triænes of the *Choristida*. In another group (*Rhabdocrepida*) the scleres are moulded on a Monaxonid base (see fig. 13 *q-s*); but, associated with them, triænes sometimes occur similar to those of the *Tetracladina*. Both these groups are in all probability derived from the *Choristida*, and a distinct passage can be traced from the Tetraclad ose to the Rhabdocrepid group. In the *Rhabdocrepida* we find forms without triænes; these may possibly be degenerate forms. The third group of Lithistids is derived from the *Rhabdocrepida*, the Anomocladine desma being derivable from the Rhabdocrepid by a shortening of the main axis into a centrum. The thick centrum, from which the arms, variable in number, originate, is hollowed out by a cavity, which appears during life to have been occupied by a large nucleus, like that of a scleroblast, and it is quite conceivable that the scleroblast, which in the Tetracladine Lithistids lies in an angle between the arms, may have become enclosed in an overgrowth of silica, from which additional arms were produced. The constancy with which spicules in other sponges maintain their independence is very striking. When once a persistent character like this is disturbed, excessive variability may be predicted, as in the Anomocladine scleres.

The classification of the sponges into families is shown in the following scheme.

Class *CALCAREA*.

Order 1. **Homocœla**, Pol.

Family 1. Asconidæ, Hk.—*Homocœla* which are simple or composite, but never develop radial tubes. Examples: *Ascetta*, Hk. (fig. 1); *Leucosolenia*, Bwk.

Family 2. Homodermidæ, Lfd.—*Homocœla* with radial tubes. Example: *Homoderma*, Lfd. (figs. 3, 4).

Order 2. **Heterocœla**, Pol.

Tribe *a*. †Syconaria.[1]

The flagellated chambers are either radial tubes or cylindrical sacs.

Family 1. Syconidæ.—The radial tubes open directly into the paragastric cavity.

Sub-family *a*. **Syconina.**—The radial tubes are free for their whole length, or at least distally. Examples: *Sycetta*, Hk.; *Sycon*, O.S.

Sub-family *b*. **Uteina**, Lfd.—The radial tubes are simple and entirely united. The ectosome is differentiated from the choanosome and sometimes develops into a cortex. Examples: *Grantissa*, Lfd.; *Ute*, O.S. (fig. 5); *Sycortusa*, Hk.; *Amphoriscus*, Pol.

Sub-family *c*. **Grantina**, Lfd.—The radial tubes are branched. The incurrent canal system is consequently complicated. An ectosome is present. Examples: *Grantia*, Fl.; *Heteropegma*, Pol. (fig. 4); *Anamaxilla*, Pol.

Family 2. Sylleibidæ, Lfd.—The choanosome is folded. The flagellated chambers (which are partly rhagose in *Vosmaeria*) communicate with the paragastric cavity by excurrent canals. Examples: *Polejna*, Lfd. (fig. 6); *Vosmaeria*, Lfd.

Family 3. Teichonellidæ, Carter.—Composite *Sylleibidæ* with the oscules and pores occurring on different parts of the surface. Example: *Teichonella*, Crtr.

Tribe *b*. †Leuconaria.

The canal system belongs to the eurypylous Rhagon type.

Family 1. Leuconidæ, Hk.—The outer surface is not differentiated into osculiferous and poriferous areas. Examples: *Leucetta*, Hk.; *Leucaltis*, Hk.; *Leucortis*, Hk.

Family 2. Eilhardidæ, Pol.—Composite *Leuconaria*, with the outer surface differentiated into special osculiferous and poriferous areas. Example: *Eilhardia*, Pol.

The arrangement adopted above is founded on Von Lendenfeld's revision (*11*) of the classification propounded by Polejaeff (*16*), who in a masterly survey has thrown an unexpected light on the structure and inter-relationships of a group which Haeckel has rendered famous. It should not be overlooked that Vosmaer (*31*) had previously explained the structure of the Leucones. However erroneous in detail, Haeckel's views are confirmed in their broad outlines, and it was with true insight that he pronounced the *Calcarea* to offer one of the most luminous expositions of the evolutional theory. In this single group the development in general of the canal system of the sponges is revealed from its starting-point in the simple Ascon to its almost completed stage in the Leucon, with a completeness that leaves little further to be hoped for, unless it be the requisite physiological explanation.

Class *MYXOSPONGIÆ*.

Order 1. **Halisarcina.**

Family 1. Halisarcidæ, Lfd.—The flagellated chambers are syconate. Examples: *Halisarca*, Duj. (with branched chambers); *Bajalus*, Lfd. (with simple chambers).

Family 2. Oscarellidæ, Lfd.—The flagellated chambers are eurypylous and rhagose. Example: *Oscarella*, Vosm.

Order 2. **Chondrosina.**

Family 1. Chondrosiidæ.—With the characters of the order. Example: *Chondrosia*, O.S.

Class *SILICISPONGIÆ*.

Sub-class I. HEXACTINELLIDA.

Order 1. †**Lyssacina.**

Family 1. Euplectellidæ.—The spicules of the dermal membrane are "daggers" (fig. 15 *a*). Examples: *Euplectella*, Owen; *Holascus*, E. Sch.; *Habrodictyum*, W.T.

Family 2. Asconematidæ.—The dermal spicules are "pinnuli" (fig. 15 *b*, *c*). Examples: *Asconema*, S. Kent; *Sympagella*, O.S.; *Caulophæus*, Schulze.

Family 3. Hyalonematidæ.—The dermal spicules are pinnuli and amphidisks (fig. 15 *d*). Example: *Hyalonema*, Gray.

Family 4. †Rosselidæ.—The dermal spicules are gomphi, stauri (fig. 15 *f*), and oxeas. Examples: *Rossella*, Crtr.; *Crateromorpha*, Gray; *Aulochona*, E. Sch.

Family 5. *Receptaculidæ, Hinde.—The distal ray of the dermal spicules is expanded horizontally into a polygonal plate. Example: **Receptaculites*, Defr.

Order 2. †**Dictyonina.**

Sub-order 1. *UNCINITARIA*.

Uncinate spicules are present.

Tribe *a*. Clavularia.

Clavulæ (fig. 16 *c*) are present.

Family 1. Farreidæ.—Characters those of the tribe. Example: *Farrea*, Bwk.

Tribe *b*. Scopularia.

The dermal spicules are scopulariæ (fig. 16 *b*).

Family 1. †Euretidæ.—Branched anastomosing tubes, or goblet-shaped, with lateral outlets. Examples: *Eurete*, Marshall; *Periphragella*, Marshall; *Lefroyella*, Schulze.

Family 2. †Mellittonidæ.—Tubular or goblet-shaped, with honeycomb-like walls. Example: *Aphrocallistes*, Gray.

[1] An * indicates that the group is only known in the fossil state, a † that it is both recent and fossil.

Family 3. †Chonelasmatidæ.—Flat or beaker-shaped; straight funnel-shaped canals perforating the wall perpendicularly and opening laterally on each side. Example: *Chonelasma*, Schulze.

Family 4. †Volvulinidæ.—Tubular, goblet-shaped, or massive; crooked canals more or less irregular in their course. Examples: *Volvulina*, Schulze: *Fieldingia*, S. Kent.

Family 5. Sclerothamnidæ.—Arborescent body; perforated at the ends and sides by round narrow radiating canals. Example: *Sclerothamnus*, Marshall.

Sub-order 2. *INERMIA*.

Dictyonina without uncinati, clavulæ, or scopulariæ.

Family 1. †Myliusidæ.—Depressed cup-shaped; a complex folding of the wall produces lateral excurrent tubes. Example: *Myliusia*, Gray.

Family 2. †Dactylocalycidæ.—Goblet-shaped or pateriform, with a thick wall consisting of numerous parallel anastomosing tubes, of uniform breadth, which terminate at the same level within and without. Examples: *Dactylocalyx*, Gray; *Scleroplegma*, O.S.; *Margaritella*, O.S.

Family 3. †Euryplegmatidæ.—Goblet-shaped or resembling ear-shaped saucers; the wall deeply folded longitudinally so as to produce a number of dichotomously branched canals or covered-in grooves. Example: *Euryplegma*, Schulze.

Family 4. †Aulocystidæ.—Of massive rounded form, with an axial cavity; wall consisting of a system of obscurely radiating anastomosing tubes and intervening inter-canals; both inter-canals and the external terminations of the tubes are covered by a thin membrane, which is perforated by slit-like openings over the lumina of the tubes, and thus assumes a sieve-like character. Examples: *Aulocystis*, Schulze; *Cystispongia*, Roemer.

This arrangement of the *Hexactinellida* is taken from the latest work on the subject, Schulze's *Preliminary Report on the "Challenger" Hexactinellida*. The reference of fossil forms to the families here instituted is rendered difficult by the disappearance of the requisite "guiding" spicules in the process of mineralization. A revision of the fossil families to bring them into harmony with the recent has certainly been rendered necessary, but this is too large a task to undertake in this place.

Sub-class II. DEMOSPONGIÆ.

Tribe *a*. Monaxonida.

Order 1. **Monaxona.**

Family 1. Tethyidæ.—Skeleton consisting of radiately arranged strongyloxeas (except in the genus *Chondrilla*, which is without megascleres) and large spherasters. The ectosome is a thick fibrous cortex. Example: *Tethya*, Lmk.; *Chondrilla*, O.S.

Family 2. Polymastidæ.—Skeleton consisting of styles radiately arranged and cortical tylostyles. The oscules in many cases open at the ends of long papillæ. Examples: *Polymastia*, Bwk.; *Thecaphora*, O.S.; *Trichostemma*, Sars.

Family 3. Suberitidæ.—Skeleton consisting of strongylate or tylotate styles, arranged to form a felt. The flesh spicules when present are usually microrabds or spirasters. Examples: *Suberites*, Nardo; *Cliona*, Grant; *Poterion*, Schlegel.

Family 4. Desmacidonidæ.—The flesh spicules are cymbas. Examples: *Esperella*, Vosm.; *Desmacidon*, Bwk.; *Cladorhiza*, Sars.

Family 5. †Halichondridæ.—The flesh spicules when present are never cymbas. Examples: *Halichondria*, Fl.; *Reniera*, O.S.; *Chalina*, Bwk.; **Pharetrospongia*, Soll.

Family 6. Ectyonidæ.—The skeleton consists of fibres echinated by projecting spicules. Examples: *Plocamia*, O.S.; *Ectyon*, Gray; *Clathria*, O.S.

Family 7. †Spongillidæ.—*Halichondridæ* which are reproduced both sexually and by statoblasts. Habitat freshwater. Examples: *Spongilla*, Lmk.; *Ephydatia*, Lmk.; *Parmula*, Crtr.; *Potamolepis*, Marshall.[1]

The foregoing classification is purely provisional; the group requires a complete revision.

Order 2. **Ceratosa.**

Family 1. Darwinellidæ.—Canal system of the eurypylous Rhagon type. Flagellated chambers, pouch-shaped, large; the surrounding collenchyme not granular. Horny fibres with a thick core. Examples: *Darwinella*, Fritz Müller; *Aplysilla*, F.E.S.; *Ianthella*, Gray.

Family 2. Spongelidæ.—Canal system as in the *Darwinellidæ*, but the flagellated chambers more or less spherical. Horny fibres with a thin core, and usually containing foreign enclosures. Examples: *Velinea*, Vosm.; *Spongelia*, Nardo; *Psammoclema*, Marshall; *Psammopemma*, Marshall.

Family 3. Spongidæ.—Canal system aphodal. Chambers small and spherical; surrounding collenchyme granular. Fibres with a thin core. Examples: *Euspongia*, Bronn; *Coscinoderma*, Crtr.; *Phyllospongia*, Ehlers.

Family 4. Aplysinidæ.—Canal system diplodal; collenchyme surrounding the flagellated chambers densely granular. Fibres with a thick core. Examples: *Luffaria*, Duch. and Mich.; *Verongia*, Bwk.; *Aplysina*, Nardo.

The species of sponge in common use are three,—*Euspongia officinalis* (Linn.), the fine Turkey or Levant sponge; *E. zimocca* (O.S.), the hard Zimocca sponge; and *Hippospongia equina* (O.S.), the horse sponge or common bath sponge. The genus *Euspongia* is distinguished by the regular development of the skeletal network throughout the body, its narrow meshes, scarcely or not at all visible to the naked eye, and the regular radiate arrangement of its chief fibres. *Hippospongia* is distinguished by the thinness of its fibres and the labyrinthic character of the choanosome beneath the skin. As a consequence its chief fibres have no regular radiate arrangement. The species of *Euspongia* are distinguished as follows. In *E. officinalis* the chief fibres are of different thicknesses, irregularly swollen at intervals, without exception cored by sand grains; in *E. zimocca* they are thinner, more regular, and almost free from sand. In *E. officinalis*, again, the uniting fibres are soft, thin, and elastic; whilst in *E. zimocca* they are denser and thicker, to which difference the latter sponge owes its characteristic hardness. Finally, the skeleton of *E. officinalis* is of a lighter colour than that of *E. zimocca*. The common bath sponge (*Hippospongia equina*) has almost always a thick cake-like form; but its specific characters are not yet further defined.

Tribe *b*. Tetractinellida.

Order 1. **Choristida.**

Sub-order 1. *SIGMATOPHORA*.

The microsclere is a sigmaspire.

Family 1. Tetillidæ.—The characteristic megasclere is a protriæne. Canal system in the lower forms eurypylous, in the higher aphodal. The ectosome in the simpler forms is a dermal membrane, in the higher a highly differentiated cortex. Examples: *Tetilla*, O.S.; *Craniella*, O.S. (fig. 21 *h*, *l*).

Family 2. Samidæ.—The characteristic megasclere is an amphitriæne. Example: *Samus*, Gray.

Sub-order 2. *ASTEROPHORA*.

The microsclere is an aster.

Group 1. Spirastrosa.—A spiraster is usually present.

Family 1. Theneidæ, Carter.—The flesh spicule is a spiraster. Canal system eurypylous. Ectosome not differentiated to form a cortex. Examples: *Thenea*, Gray (fig. 21 *a*, *f*); *Pœcillastra* (*Normania*), Bwk.

Family 2. †Pachastrellidæ.—Canal system eurypylous in the lower, aphodal in the higher forms. Examples: *Plakortis*, F.E.S.; *Dercitus*, Gray.

Group 2. Euastrosa.—Spirasters are absent.

Family 1. †Stellettidæ.—Canal system aphodal, but approaching the eurypylous in the lower forms. The cortex chiefly consists of collenchyme in the lower forms; in the higher it is highly differentiated. Example: *Stelletta*, O.S. (fig. 11); *Ancorina*, O.S.; *Myriastra*, Soll.

Family 2. Tethyidæ.—Although this family has been placed in the *Monaxonida*, this seems to be its more natural position.

Group 3. Sterrastrosa.—A sterraster is present, usually in addition to a simple aster.

Family 1. †Geodinidæ.—The megascleres are partly triænes. Canal system always aphodal. Cortex highly differentiated. Examples: *Geodia*, Lmk. (fig. 21 *n*); *Pachymatisma*, Bwk. (fig. 21 *c*); *Cydonium*, Müller (fig. 10); *Erylus*, Gray.

Family 2. Placospongidæ.—The megasclere is a tylostyle. Triænes are absent. Example: *Placospongia*, Gray.

Sub-order 3. *MICROSCLEROPHORA*.

Microscleres only are present.

Family 1. Plakinidæ, Schulze.—Canal system very simple, belonging to eurypylous Rhagon type. Characteristic spicules candelabra. Examples: *Plakina*, F.E.S. (fig. 26).

Family 2. Corticidæ.—Canal system aphodal or diplodal. Mesoderm a collenchyme crowded with oval granular cells; the spicules either candelabra, amphitriænes, or triænes irregularly dispersed in it. Example: *Corticium*, O.S. (figs. 9, 21 *b*).

Family 3. Thrombidæ.—Canal system diplodal. Spicules trichotriænes. Example: *Thrombus*, Soll.

The *Pachastrellidæ* or the *Corticidæ* are probably the families from which the Tetracladine Lithistids have been derived. In the *Tetillidæ* the characteristic microsclere may occasionally fail, but there is never any difficulty in identifying the sponge in this case, as the triænes are of a very characteristic form: the arms of the protriænes are slender, simple, and directed very much forwards, making a very large angle with the shaft. Microscleres, having the form of little globules, are sometimes present with the sigmaspires.

Order 2. **Lithistida**, O.S.

Sub-order 1. *TETRACLADINA*, Zittel.

The desmas are modified calthrops spicules.

[1] Freshwater sponges without statoblasts are excluded from this family, and left for distribution amongst allied marine genera.