Family 1. TETRACLADIDÆ.—With the characters of the sub-order. Examples: *Theonella*, Gray (fig. 21 *k*); *Discodermia*, Bocage; **Siphonia*, Parkinson.

Sub-order 2. *RHABDOCREPIDA*.

The desmas are of various forms, produced by the growth of silica over a uniaxial spicule.

Family 1. MEGAMORINIDÆ.—The desmas are comparatively large. Triænes, usually dichotriænes, help to support the ectosome. Microscleres usually spirasters. Examples: *Corallistes*, O.S.; **Hyalotragos*, Zittel; *Lyidium*, O.S.; **Dorydermia*, Zittel.

Family 2. MICROMORINIDÆ.—The desmas are comparatively small. Triænes and microscleres are both absent. Examples: *Azorica*, Crtr.; **Verruclina*, Zittel.

Sub-order 3. *ANOMOCLADINA*.

Desmas with a massive nucleated centrum, from which a variable number of arms (*28*) extend radiately (see fig. 12 *f*). Examples: *Vetulina*, O.S.; **Astylospongia*, Roemer.

Reproduction and Embryology.

Fresh individuals arise by asexual gemmation, both external and internal, by fission, and by true sexual reproduction.

Fission is probably one of the processes by which compound sponges are produced from simple individuals. Artificial fission has been practised with success in the cultivation of commercial sponges for the market. External gemmation has been observed in *Thenea*, *Tethya*, *Polymastia*, and *Oscarella*. A mass of indifferent sponge-cells accumulates at some point beneath the skin, bulges out, drops off, and gives rise to a new individual. Internal gemmation, which results in the formation of a statoblast, is only known to occur in the freshwater *Spongillidæ*. The statoblasts consist of a mass of yolk-bearing mesoderm cells, invested by a capsule, which in *Ephydatia fluviatilis* is composed of an inner cuticle of spongin separated from a similar outer layer by an intermediate zone of amphidisks and interspersed protoplasmic cells. On one side of the capsule is a hilum which leads into the interior.

Their development has recently been studied by Götte, with results that confirm the conclusions of Carter (*3*) and Lieberkühn (*13*). The process commences with an accumulation of amœboid cells within the mesoderm to form a globular cluster; yolk granules develop within them, especially in those that lie nearer the centre. The external cells give rise to the investing capsule; some resemble sponginblasts and secrete the inner and outer horny cuticle; others give rise to the amphidisks and interspersed cells of the middle layer. Under favourable conditions the interior cells creep out through the pore of the capsule, and form a spreading heap, which by subsequent differentiation gives rise to a young *Spongilla*. Since the freshwater sponges can only be regarded as modified descendants of ancient marine species (probably of the family *Halichondridæ*), we may consider the internal gemmules, like the similar statoblasts of the freshwater *Polyzoa*, as special adaptations to a changed mode of life. They appear primarily to serve a protective purpose, ensuring the persistence of the race, since they only appear in extreme climates on the approach of drought, and in cold ones on the approach of winter. As a secondary function they serve for the dispersal of the species; some are light enough to float down a stream, but not too far, so that there is no danger of their being carried to sea; others, which are characterized by large air-chambers, are possibly distributed by the wind.

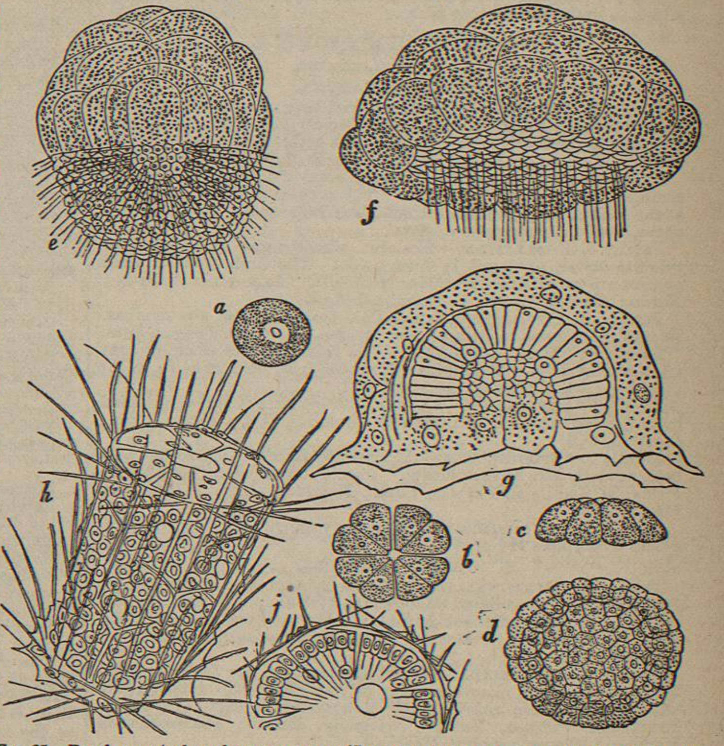

FIG. 25.—Development of a calcareous sponge (*Sycandra raphanus*). *a*, ovum; *b*, *c*, ovum segmented,—*b*, as seen from above, *c*, lateral view; *d*, blastosphere; *e*, amphiblastula; *f*, commencement of the invagination of the flagellated cells of the amphiblastula; *g*, gastrula attached by its oval face; *h*, *j*, young sponge (Ascon stage),—*h*, lateral view, *j*, as seen from above. After Schulze.

Both sexual elements may be formed in the same individual, *e.g.*, *Oscarella lobularis*, *Grantia raphanus*, and many others; but even in hermaphrodites one or other element usually occurs to excess in different individuals, so that some are predominantly male and others predominantly female. Polejaeff found only one such male form to 100 female forms in *Grantia raphanus*. In other sponges—*Reniera fertilis*, *Euspongia officinalis*—the sexes are distinct. The ova develop from archæocytes or wandering amœboid cells, which increase in size and acquire a store of reserve nourishment in the form of yolk granules; at first they exhibit lively amœboid movements, but later pass into a resting stage. The cavity of the mesoderm within which they are situated becomes lined by a layer of epithelium, which may not appear, however, till a late stage of segmentation. In *Euspongia officinalis* the ova occur congregated in groups within the mesoderm, thus presenting an early form of ovary. The spermatozoa, which also develop from wandering amœboid cells, are minute bodies with an oval or pear-shaped head and a long vibratile tail (fig. 24 *k*). Each amœboid cell produces a large number of spermatozoa, which occur in spherical clusters or sperm-balls. The heads of the spermatozoa, as in the *Metazoa*, are produced from the nucleus of the mother-cell, the tails from the surrounding protoplasm.

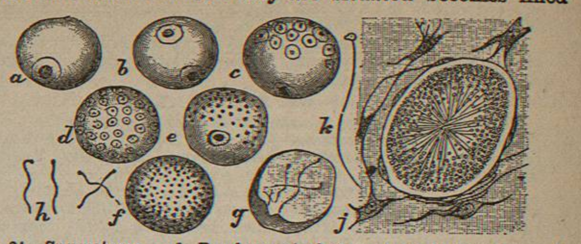

FIG. 24.—Spermatozoa. *a*-*h*, Development of spermatozoa in *Sycandra raphanus*, highly magnified; *h*, mature spermatozoa. After Polejaeff (×792). *j*, A sperm ball in *Oscarella lobularis* (×500); *k*, an isolated mature spermatozoon. After Schulze (×800).

The development in detail is upon two plans. In *Grantia raphanus* (*15*) the nucleus of the mother-cell divides into two (fig. 24 *b*); one of the resulting daughter nuclei undergoes no further change, but with a small quantity of peripheral protoplasm forms a "cover-cell" to the other or primitive sperm nucleus and its associated protoplasm. The sperm nucleus repeatedly divides, wi

out involving the surrounding protoplasm (fig. 24 *c*-*f*). The resulting nuclei at length cease to exhibit a nucleolus, and become directly transformed into the heads of spermatozoa; the tails are appropriated by each head from the common protoplasmic residue. The mother-cell in this case undergoes no increase in volume as development proceeds, and it is not enclosed within an "endothelial" layer. In the second and apparently more usual case (*20*) no "cover-cell" is formed, but the mother-cell divides and subdivides, protoplasm as well as nuclei, till a vast number of minute cells results; the nucleus of each becomes the head of a spermatozoon and the protoplasm its tail. In this case the sperm-ball does increase in bulk: it grows as it develops, and the cavity containing it becomes lined by epithelium, or so-called "endothelium" (fig. 24 *j*). No doubt (*15*) the development of the epithelium stands in direct physiological connexion with the growth of the sperm-ball.

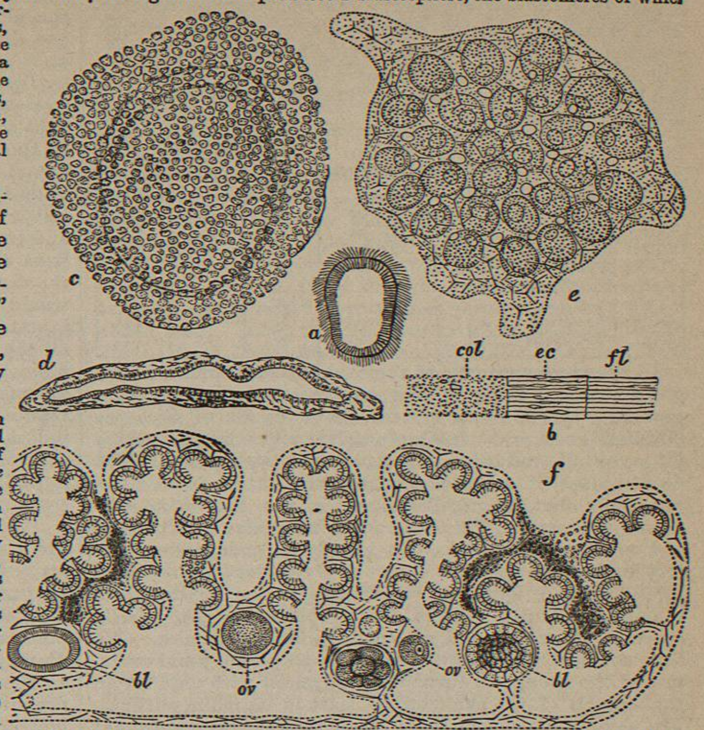

FIG. 26.—Development of a *Demospongia* (*Plakina monolopha*). *a*, planula (the central part should be shaded). *b*, Section through side of planula; *ec*, flagellated cells; *fl*, their flagella; *col*, cœnoblast. *c*, Attached gastrula (the paragaster is formed by fission). *d*, Section across the foregoing. *e*, Young sponge (Rhagon). *f*, Part of a section through fully grown sponge; the attached basal layer is the hypomere; the spongomere is folded so as to produce incurrent and excurrent canals; the canal system is eurypylous; *ov*, ova (a segmented ovum lies between two of them); *bl*, blastospheres. After Schulze.

Obscure as are the details of this subject, sufficient is known to enable us to make out two chief types of development. One, common amongst the calcareous sponges, and possibly occurring in a single genus (*Gummina*) of the *Micromastictora*, is characterized by what is known as the "amphiblastula" stage; the other, widely spread amongst the *Micromastictora* (*Reniera*, *Desmacidon*, *Euspongia*, *Spongelia*, *Aplysilla*, *Oscarella*), is characterized by a "planula" stage.

The first has been most thoroughly investigated in *Grantia raphanus* by Schulze (*20*). The ovum by repeated segmentation gives rise to a hollow vesicle, the wall of which is formed by a single layer of cells—*blastosphere* (fig. 25 *d*). Eight cells at one pole of the blastosphere now become differentiated from the rest; they remain rounded in form, comparatively large, and become filled with granules (stored nutriment), while the others, rapidly multiplying by division, become small, clear, columnar, and flagellated. By further change the embryo becomes egg-shaped; the granular cells, now increased in number to thirty-two, form the broader end, and the numerous small flagellated cells the smaller end. Of the granular cells sixteen are arranged in an equatorial girdle adjoining the flagellate cells. A blastosphere thus differentiated into two halves composed of different cells is known as an *amphiblastula*. The amphiblastula (fig. 25 *e*) now perforates the maternal tissue, and is borne along an excurrent canal to the oscule, where it is discharged to the exterior and swims about in a whirling lively dance. It then assumes a more spherical form, a change premonitory of the next most remarkable phase of its career. In this the flagellated layer becomes flattened, depressed, and finally invaginated within the hemisphere of granular cells, to the inner face of which it applies itself, thus entirely obliterating the cleavage cavity, but by the same process originating another (the invagination cavity) at its expense (fig. 25 *f*). The two-layered sac thus produced is a *paragastrula*; its outer layer, known as the *epiblast*, gives rise to the ectoderm, the inner layer or hypoblast to the endoderm. The paragastrula next becomes somewhat beehive-shaped, and the mouth of the paragastric cavity is diminished in size by an ingrowth of the granular cells around its margin. The larva now settles mouth downwards on some fixed object, and exchanges a free for a fixed and stationary existence (fig. 25 *g*). The granular cells completely obliterate the original mouth, and grow along their outer edge over the surface of attachment in irregular pseudopodial processes, which secure the young sponge firmly to its seat (fig. 25 *h*). The granular cells now become almost transparent, owing to the exhaustion of the yolk granules, and allow the hypoblast within to be readily seen; a layer of jelly-like material, the rudimentary mesoderm, is also to be discerned between the two layers. The spicules then become visible; slender oxeas appear first, and afterwards tri- and quadri-radiate spicules. The larva now elongates into a somewhat cylindrical form; the distal end flattens; and an oscule opens in its midst. Pores open in the walls; the endodermal cells, which had temporarily lost their flagella, reacquire them, at the same time extending the characteristic collar. In this stage (fig. 25 *h*, *j*) the young sponge corresponds to a true Ascon, no trace of radial tubes being visible; but as they characterize the parent sponge they must arise later, and thus we have clear evidence through ontogeny of the development of a Sycon sponge from an Ascon.

The three most striking features in the history of this larva are, first, the amphiblastula stage; next the invagination of the flagellate cells within the granular, instead of invagination in the reverse order; and third the attachment of the larva by the oral instead of the aboral surface. Should Schulze be correct in deriving the sponges from the *Cœlentera*, it is probable that the reversal of the Cœlenterate history as exemplified in the last two events will furnish an explanation of the remarkable divergencies which distinguish the two phyla. The history of the second or planula type has been thoroughly worked out by Schulze (*20*) in a little incrusting Tetractinellid sponge (*Plakina monolopha*, Schulze). The ovum by regular segmentation produces a blastosphere, the blastomeres of which increase in number by further subdivision till they become converted into hyaline cylindrical flagellated cells (fig. 26 *f*). Thus a blastosphere is produced consisting wholly of similar flagellated cells. It becomes egg-shaped, and, hitherto colourless, assumes a rose-red tint, which is deepest over the smaller end. The larva (now a planula, fig. 26 *a*, by the filling in of the central cavity) escapes from the parent and swims about broad end foremost. In this stage thin sections show that the cleavage cavity is obliterated, its place being occupied by a mass of granular gelatinous material containing nuclei (fig. 26 *b*). In from one to three days after hatching the larva becomes attached. It then spreads out into a convex mass, and a cavity is produced within it by the splitting of the central jelly (fig. 26 *c*, *d*; compare *Eucope* and others amongst the Cœlenterates). This cavity becomes lined by short cylindrical cells (endoderm), while the flagellated cells of the exterior lose their flagella and become converted into pinnacocytes (ectoderm). The gelatinous material left between the two layers now formed acquires the characters of true collenchyme and thus becomes the mesoderm. The endoderm then sends off into the mesoderm, as buds, rounded chambers, which communicate with the paragastric cavity by a wide mouth and with the exterior by small pores (fig. 26 *e*). An oscule is formed later, and the sponge enters upon the Rhagon phase. Subsequent foldings of the sponge-wall give rise to a very simple canal system (fig. 26 *f*). In addition to these two well-ascertained modes of development others have been described which at present appear aberrant. In *Oscarella lobularis*, O.S. (*27*), a curious series of early developmental changes results in the formation of an irregular paragastrula, the walls of which become folded (while still within the parent sponge) in a complex fashion, so as to produce a form in which the incurrent and excurrent canals appear to be already sketched out before the flagellated chambers are differentiated off. In *Spongilla* Götte describes the ectoderm as becoming entirely lost on the attachment of the larva, so that the future sponge proceeds from the endoderm alone. As *Spongilla*, however, is a freshwater form, anomalies in its development (which remind us of those in the development of the freshwater *Hydra*) might almost be expected.

Probably in no other single group is the doctrine of homoplasy enunciated by Lankester more tellingly illustrated than in the sponges. The independent development of similar types of canal system in different groups, sometimes within the limits of a single family, is a remarkable fact. In the following table the sign × shows independent evolution of similar types of canal system in different groups:—

	Ascon.	Sycon.	Rhagon.		
			Eurypylous.	Aphodal.	Diplodal.
Class *Calcarea*	×	×	×	...	...
Order *Halisarcina*	...	×	×	...	...
Order *Monaxona*	...	...	×	×	...
Order *Ceratosa*	...	×	×	×	×
Sub-order *Microsclerophora*	...	...	×	×	×
Order *Choristida*	...	...	×	×	...
Family *Tetillidæ*	...	...	×	×	...

In the gross anatomy of the canal system similar homoplasy obtains; thus, to cite one case amongst many, a peculiar type of canal system characteristic of *Siphonia* (Lithistid) occurs also in *Emploca* (Hexactinellid), *Schmidtia* (Monaxonid), and other apparently unrelated genera. The development of a cortex has likewise taken place independently, but on parallel lines, in the *Syconidæ*, *Leuconidæ*, *Monaxona*, *Tetillidæ*, and *Stellettidæ*. Calcareous and silicious spicules have evidently an independent history, and yet all the chief forms of the former are repeated in the latter. Quite as remarkable is the similarity of the independently evolved horny spicules of *Darwinella aurea* to the quadri- and sex-radiate silicious spicules. We have now sufficient knowledge of the morphology and evolution of the sponge to furnish the physicist with data for an explanation of the skeleton, at least in its main outlines. The obvious conclusion from this is that variation does not depend upon accident, but on the operation of physical laws as mechanical in their action here as in the mineral world. Another important consequence follows: if homoplasy—*i.e.*, the independent evolution of similar structures—is of such certain and quite common occurrence in the case of the sponges, it is also to be looked for in other groups, and polyphylitic origin, so far from being improbable, is as likely an occurrence as monophylitic origin.

Physiology and Ætiology.

Under the head of "physiology" we have almost a blank. At present we do not even know what cells of the sponge are primarily concerned in the ingestion of food. If a living sponge, such as *Spongilla*, be fed with carmine for a few minutes, then immersed in dilute osmic acid, and examined in thin sections, its flagellated chambers are found to be all marked out as red circular patches, and a closer investigation shows that the choanocytes, and they alone, have ingested the carmine. In this way we confirm the earlier observations of Carter made by teasing carmine-fed sponges. This might be thought to decide the question; but, though it effectually disposes of Polejaeff's argument that the choanocytes do not ingest nutriment because mechanical disadvantages (conceived *a priori*) make it impossible, it has not proved a final solution. Von Lendenfeld, by feeding sponges such as *Aplysilla* with carmine for a longer interval—a quarter of an hour—finds that amœboid cells crowd about the sides and particularly the floor of the subdermal cavities, and are soon loaded with carmine granules; after a time they wander away to the flagellated chambers and there cast out into the excurrent canals the carmine they have absorbed, apparently in an altered state. On the other hand, the choanocytes, though they at first absorb the carmine, soon thrust it out, apparently in an unaltered state. Hence Von Lendenfeld concludes that it is the epithelium of the subdermal cavities which is charged with the function of ingestion, and that the amœboid cells subsequently digest and distribute it, and finally cast out the worthless residues. There may be much truth in this view, but it requires to be supported by further evidence. (1) Sufficient proof is not adduced to show that the carmine granules expelled from the amœboid cells are really more decomposed than those rejected by the choanocytes. (2) There is at present no proof that carmine is a food, or that if it is sponges will readily feed upon it. In either case one would expect the amœboid cells to play the part which they perform in other organisms and to remove as soon as possible useless or irritant matter from the surface which it encumbers; at the same time the choanocytes, not having found the food to their liking, would naturally eject it. (3) If the choanocytes do not ingest food, how does the Ascon feed, since in this sponge all the pinnacocytes are external? It is, however, a very noticeable fact that, as the organization of a sponge increases in complexity, the choanocytal layers become reduced in volume relative to the whole bulk of the individual; and it is quite possible that as histological differentiation proceeds it may be accompanied by physiological differentiation which relieves the choanocytes to some extent of the ingestive part of their labours.

Æti ogy

The origin of the sponges is to be sought for among the choanoflagellate *Infusoria*; and Savile Kent has described a colonial form of this group which is suggestively similar to a sponge. Its differences, however, are as marked as its resemblances, and have been sufficiently pointed out by Schulze (*23*). Kent has called this form *Protospongia*, a name already made use of, and fortunately, as the organism is not in any sense a true sponge; the present writer proposes, therefore, to call it *Savillia*, in honour of its discoverer. It consists of choanoflagellate *Infusoria* (see PROTOZOA, vol. xix. p. 858, fig. XXI., 15), half projecting from and half embedded in a structureless jelly or blastema, within which other cells of an amœboid character and reproductive function are immersed. Professor Haddon arrives at the generalization that conjugation amongst the *Protozoa* always takes place between individuals of the same order: flagellate cells conjugate with flagellate, amœboid with amœboid, but never with flagellate; while in true sexual reproduction the conjugation occurs between two individual cells in different stages of their life cycle: a flagellate cell conjugates with a resting amœboid cell. Now *Savillia* would appear to be extremely near such a true sexual process, since the simultaneous coexistence of cells in two different stages of life and within easy reach of each other—a necessary preliminary, one would think, to the union—has already been brought about. That coalescence between two different histological elements should result in products similarly histologically differentiated (compare amphiblastula stage of *Calcarea*) has in it a certain fitness, which, however, has still to be explained. The mode by which an organism like *Savillia* might become transformed into an Ascon cannot be suggestively outlined with any satisfactory results till our knowledge of the embryology of sponges is more advanced. The minute characters of the flagellate cells of the amphiblastula and other sponge larvæ are still a subject for research. They often possess a neck or collum; but the existence of a frill or collar is disputed. Kent asserts that it is present in several embryos which he figures; and Barrois makes the same assertion in respect to the larva of *Oscarella*, and illustrates his description with a figure. On the other hand, Schulze and Marshall both

deny its existence, and the former attributes Kent's observations to error. One constant character they do possess: they are provided with flagella at some stage of their existence, but never with cilia. Ciliated cells, indeed, are unknown amongst the sponges, and, when pinnacocytes exceptionally acquire vibratile filaments, as in *Oscarella* and other sponges, these are invariably flagella, never cilia. An Ascon stage having been reached at some point in the history of the sponges, the Sycon tubes and Rhagon chambers would arise from it by the active proliferation of choanocytes about regularly distributed centres, possibly as a result of generous feeding. Vosmaer recognized as the physiological cause of Sycon an extension of the choanocytal layer. Polejaeff, relying on Von Lendenfeld's experiments, which seem to prove that it is the pinnacocytes and not the choanocytes which are concerned in the ingestion of nutriment, argues that, as in Sycon the pinnacocytal layer is increased relatively to the choanocytal, we have in this a true explanation of the transition. The existence of *Homoderma*, Lfd., however, shows that in the first stage there was not a replacement of choanocytes by pinnacocytes, but that this was a secondary change, following the development of radial tubes, and therefore cannot be relied upon to explain them. The radial tubes having been formed by a proliferation of choanocytal cells, the reduction of those lining the paragastric cavity to pinnacocytes would follow in consequence of the poisonous character of the water delivered from the radial tubes to the central cavity, since this water not only parts with its dissolved oxygen to the choanocytes it first encounters, but receives from them in exchange urea, carbonic acid, and fæcal residues. The development of subdermal cavities is explicable on Von Lendenfeld's hypothesis.

Distribution.

Distribution in space.

Our knowledge of this subject is at present but fragmentary; we await fuller information in the remaining reports on the sponges obtained by the "Challenger." The sponges are widely distributed through existing seas, and freshwater forms are found in the rivers and lakes of all continents except Australia, and in numerous islands, including New Zealand. Many genera and several species are cosmopolitan, and so are most orders.

As instances of the same species occurring in widely remote localities we take the following from Polejaeff:—*Sycon arcticum* is found at the Bermudas and in the Philippine Islands, as also are *Leuconia multiformis* and *Leucilla uter*; *Sycon raphanus* occurs at Tristan da Cunha and the Philippines; *Heteropegma nodus-gordii* and *Leuconia dura* at the Bermudas and Torres Straits. We do not know, however, whether these species are isolated in their distribution or connected by intermediate localities. Of the *Calcarea* about eighty-one species have been obtained from the Atlantic, twenty-two from the Pacific, and twenty-two from the Indian Ocean; but these numbers no doubt depend largely on the extent to which the several oceans have been investigated, for the largest number of species has been found in the ocean nearest home. Schulze states that the *Hexactinellida* brought home by the "Challenger" were obtained at seventeen Atlantic stations, twenty-seven Pacific, and nineteen in the South Seas. In the last the number of species was greatest, in the Atlantic least. They flourish best on a bottom of diatomaceous mud. The *Calcarea* and *Ceratosa* are most abundant in shallow water and down to 40 fathoms, but they descend to from 400 to 450 fathoms. The *Hexactinellida* are most numerous over continental depths, *i.e.*, 100 to 200 fathoms; but they extend downwards to over 2500 fathoms and upwards into shallow water (10 to 20 fathoms). The *Lithistida* are not such deep-water forms as the *Hexactinellida*, being most numerous from 10 to 150 fathoms. Only one or two species have been dredged from depths greater than 400 fathoms, and none from 1000 fathoms. The *Choristida* range from shallow water to abyssal depths. A characteristic deep-sea Choristid genus is *Thenea*, Gray (= *Wyville Thompsonia*, Wright; *Dorvillia*, Kent). This is most frequently dredged from depths of from 1000 to 2000 fathoms; but it extends to 2700 fathoms on the one hand and to 100 on the other.

Until about 1876 one of the chief obstacles to the interpretation of fossil sponges arose from a singular mineral replacement which most of them have undergone, leading to the substitution of calcite for the silica of which their skeletons were originally composed. This change was demonstrated by Zittel (*35*) and Sollas (*24*), and, though it was at first pronounced impossible, owing to objections founded on the chemical nature of silica, it has since become generally recognized. These observers also showed that the fossil sponges do not belong to extinct types, but are assignable to existing orders. Zittel in addition subjected large collections to a careful analysis and marshalled them into orders with remarkable success. Since then several palæontologists have worked at the subject,—Počta, Dunikowski, and Hinde (*7*), who has published a *Catalogue*—which is much more than a catalogue—of the sponges preserved in the British Museum. The result of their labours is in general terms as follows. Fossil sponges are chiefly such as from the coarseness or consistency of their skeletons would be capable of preservation in a mineralized state. Thus the majority are *Hexactinellida*, chiefly *Dictyonina*; *Tetractinellida*, chiefly *Lithistida*; and *Calcarea*, chiefly *Leuconaria*. Monaxonid sponges rarely occur; the most ancient is *Climacospongia*, Hinde, found in Silurian rocks. A very common Halichondroid sponge of this group (*Pharetrospongia strahani*, Soll.) occurs in the Cambridge greensand; it owes its preservation to the collection of its small oxeate spicules into dense fibres. The *Choristida*, though not so common as the Lithistids, are commoner than the Monaxonids, particularly in Mesozoic strata.

The distribution of fossil sponges in the stratified systems may be summarized as follows. CALCAREA.—*Homocœla*, none. *Heterocœla*, a Syconid, in the Jurassic system. Numerous *Leuconaria* from the Devonian upwards. MYXOSPONGIÆ.—None; not fitted for preservation. HEXACTINELLIDA.—*Lyssacina*, from the Lower Cambrian upwards. *Dictyonina*, commencing in the Silurian; most numerous in the Mesozoic group; still existing. MONAXONIDA.—*Monaxona*, from the Silurian upwards. *Ceratosa*, none; few are fitted for preservation. TETRACTINELLIDA.—*Choristida*, from the Carboniferous upwards; most numerous in the Cretaceous system. *Lithistida*, from the Silurian upwards; most numerous in the Mesozoic group. In ancient times the Hexactinellids and Lithistids seem not to have been so comparatively uncommon in shallow water as they are at the present day. Thus, in the Lower Jurassic strata of the south-west of England we find Dictyonine Hexactinellids, Lithistids, and Leuconarian *Calcarea* associated together in a shelly breccia and in company with littoral shells, such as *Patella* and *Trochus*. Several Palæozoic Hexactinellids actually occur in a fine-grained sandstone. Of the Chalk, which is the great mine of fossil sponges, we must speak with caution, owing to the insufficient evidence as to the depth at which it was deposited.

As shown by *Protospongia*, the phylum of the sponges was in existence in very early Cambrian times, and probably much earlier. Before the end of the Silurian period its main branches had spread themselves out, and, developing fresh shoots since then, they have extended to the present day. Of the offshoots none of higher value than families are known to have become extinct, and of these decayed branches there are very few. The existence in modern seas of the *Asconidæ*, which must surely have branched off very near the base of the stem, is another curious instance of the persistence of simple types, which would thus appear not to be so vastly worse off in the struggle for existence than their more highly organized descendants.

Bibliography.—A fairly complete list of works on sponges published before 1882 will be found in Vosmaer's article "Poriferæ," in Bronn's *Klassen und Ordnungen*, vol. ii. D'Arcy Thompson's *Catalogue of Papers on Protozoa and Cœlenterata*, a still more complete list, extends to 1884.

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Commerce.

Distribution.

When the living matter is removed from a Ceratose sponge a network of elastic horny fibres, the skeleton of the animal, remains behind. This is the sponge of commerce. Of such sponges the softest, finest in texture, and most valued is the Turkey or Levant sponge, *Euspongia officinalis*, Lin. The other two varieties are the *Hippospongia equina*, O. Schmidt, and the Zimocca sponge, *Euspongia zimocca*, O.S., which is not so soft as the others (see p. 423 above). All three species are found at from 2 to 100 fathoms along the whole Mediterranean coast, including its bays, gulfs, and islands, except the western half of its northern shores as far as Venice and the Balearic Isles, Corsica, Sardinia, and Sicily. Bath sponges occur around the shores of the Bahamas, and less abundantly on the north coast of Cuba. They are of several kinds, one not distinguishable from the fine Levant sponge; others, the "yellow" and "hardhead" varieties, resemble the Zimocca sponge; and of horse sponges there appear to be several varieties, such as the "lamb's-wool" and the "velvet" sponge (*Hippospongia gossypina* and *H. meandriformis*). The fine bath sponge occurs on the shores of Australia (Torres Straits, the west coast, and Port Phillip on the south coast). A sponge eminently adapted for bathing purposes (*Coscinoderma lanuginosum*, Crtr.; *Euspongia mathewsii*, Lfd.), but not yet brought into the market, occurs about the South Caroline Islands, where it is actually in use, and at Port Phillip in Australia. The fine bath sponge occurs in the North Pacific, South Atlantic, and Indian Oceans, so that its distribution is world-wide.

The methods employed to get sponges from the bottom of the sea, where they grow attached to rocks, stones, and other objects, depend on the depths from which they are to be brought. In comparatively shallow water they may be loosened and hooked up by a harpoon; at greater depths, down to 30 or 40 fathoms, they are dived for; and at depths of from 50 to 100 fathoms they are dredged with a net. The method of harpooning was the earliest practised, and is still carried on in probably its most primitive form by the Dalmatian fishermen. Small boats are used, manned by a single harpooner with a boy to steer; when, however, the expedition is to extend over night the crew is doubled. The harpoon is a five-pronged fork with a long wooden handle, and if this is not long enough another harpoon is lashed on to it. The Greek fishers use a large boat furnished with two or three smaller ones, from which the actual harpooning is carried on; the crew numbers seven or eight. One of the chief difficulties is to see the bottom distinctly through a troubled surface. The Dalmatian fishers throw a smooth stone dipped in oil a yard or so in front of the boat; the stone scatters drops of oil as it flies and so makes a smooth track for the "look-out." The Greeks use a zinc-plate cylinder about 1½ feet long and 1 foot wide, closed at the lower end by a plate of glass, which is immersed below the surface of the sea; on looking through this the bottom may be clearly seen even in 30 fathoms. This plan is also adopted in the Bahamas, where harpooning carried on after the Greek system gives employment to over 5000 men and boys.

The primitive method of diving with no other apparatus than a slab of stone to serve as a sinker and a cord to communicate with the surface is still practised in the Mediterranean. The diver carries a net round his neck to hold the sponges. On reaching the bottom he hastily snatches up whatever sponge he sees. After staying down as long as he is able—an interval which varies from two to at the most three minutes—he tugs violently at the cord and is rapidly drawn up. On entering the boat from depths of 25 fathoms he quickly recovers from the effects of his plunge after a few powerful respirations; but after working at depths of 30 to 40 fathoms or more he reaches the surface in a swooning state. At the beginning of the season blood usually flows from the mouth and nose after a descent; this is regarded as a symptom of good condition; should it be wanting the diver will scarcely venture a second plunge for the rest of the season. The work is severe, and frequently the diver returns empty-handed to the boat. Diving is usually carried on in the summer months; in winter it is too cold, at all events without a diving-dress. The ordinary diver's dress with pumping apparatus is largely used by the Greeks. The diving is carried on from a ship manned by eight or nine men, including one, or rarely two, divers. At a depth of from 10 to 15 fathoms the diver can remain under for an hour, at greater depths up to 20 fathoms only a few minutes; the consequences of a longer stay are palsy of the lower extremities, stricture, and other complaints. Dredging is chiefly carried on along the west coast of Asia Minor, principally in winter after the autumn storms have torn up the seaweeds covering the bottom. The mouth of the dredge is 6 yards wide and 1 yard high; the net is made of camel-hair cords of the thickness of a finger, with meshes 4 inches square. It is drawn along the bottom by a tow-line attached to the bowsprit of a sailing vessel or hauled in from the shore.

Cultivation.

Prompted by a suggestion made by Oscar Schmidt, that sponges might be artificially propagated from cuttings, the Italian Government supplied funds for experiments to determine the feasibility of cultivating sponges as an industrial pursuit. A station was established on the island of Lesina, off the Dalmatian coast, and experiments were carried on there for six years (1867-72) under the superintendence of Von Buccich. The results were on the whole successful, but all expectations of creating a new source of income for the sponge-fishers of Dalmatia were defeated by the hostility of the fishers themselves.

The details of the method of sponge-farming as practised by Von Buccich are briefly as follows. The selected specimens, which should be obtained in as uninjured a state as possible, are placed on a board moistened with sea water and cut with a knife or fine saw into pieces about 1 inch square, care being taken to preserve the outer skin as intact as possible. The operation is best performed in winter, as exposure to the air is then far less fatal than in summer. The sponge cuttings are then trepanned and skewered on bamboo rods; the rods, each bearing three cuttings, are secured in an upright position between two parallel boards, which are then sunk to the bottom of the sea and weighted with stones. In choosing a spot for the sponge-farm the mouths of rivers and proximity to submarine springs must be avoided; mud in this case, as in that of reef-building

corals, is fatal. A favourable situation is a sheltered bay with a rocky bottom overgrown with green seaweed and freshened by gentle waves and currents. So favoured, the cuttings grow to a sponge two or three times their original size in one year, and at the end of five to seven years are large enough for the market. Similar experiments with similar results have more recently been carried on in Florida. The chief drawback to successful sponge-farming would appear to be the long interval which the cultivator has to wait for his first crop.

After the sponge has been taken from the sea, it is exposed to the air till signs of decomposition set in, and then without delay either beaten with a thick stick or trodden by the feet in a stream of flowing water till the skin and other soft tissues are completely removed. If this process is postponed for only a few hours after the sponge has been exposed a whole day to the air it is almost impossible to completely purify it. After cleaning it is hung up in the air to dry, and then with others finally pressed into bales. If not completely dried before packing the sponges "heat," orange yellow spots appearing on the parts attacked. The only remedy for this is to unpack the bale and remove the affected sponges. The orange-coloured spots produced by this "pest," or "cholera" as the Levant fishermen term it, must not be confounded with the brownish red colour which many sponges naturally possess, especially near their base. The sponges on reaching the wholesale houses are cut to a symmetrical shape and further cleaned. The light-coloured sponges often seen in chemists' shops have been bleached by chemical means which impair their durability. Sponges are sold by weight; sand is used as an "adulteration."

It is difficult to obtain recent statistics as to the extent of the sponge trade; the following table gives a summary of the sponges sold in Trieste, the great European sponge market, in the year 1871:—

Description of Sponge.	For Export.		For Home Consumption.	
	Value in £	Mean price per pound.	Value in £	Mean price per pound.
Horse sponge..........	£60,000	6s.	£4400	6s.
Zimocca sponge	20,000	6s.	550	6s.
Fine Levant sponge....	20,000	14s.	950	14s.
Fine Dalmatian sponge	2,000	8s.	..	..

(W. J. S.)

SPONSOR. The presence of some suitable sponsor or sponsors to give the answers required and undertake the vows involved would seem to be almost essential to the right administration of the sacrament of baptism, in the case of infants at least. In this aspect, however, as in many others, the early history of the development of the rite of baptism remains obscure. The Greek word for the person undertaking this function is ἀνάδοχος, to which the Latin *susceptor* is equivalent. The word "sponsor" in this ecclesiastical sense occurs for the first time, but incidentally only, and as if it were already long familiar, in Tertullian's treatise *De Baptismo* (c. 18), where, arguing that in certain circumstances baptism may conveniently be postponed, especially in the case of little children, he asks, "For why is it necessary that the sponsors likewise should be thrust into danger, who both themselves by reason of mortality may fail to fulfil their promises, and may also be disappointed by the development of an evil disposition [in those for whom they become sponsors]?" There is nothing to make it unlikely that the sponsors here alluded to may have been in many cases the actual parents, and even in the 5th century it was not felt to be inappropriate that they should be so; Augustine, indeed, in one passage appears to speak of it as a matter of course that parents should bring their children and answer for them "tanquam fidejussores" (*Epist. . . . ad Bonif.*, 98). The comparatively early appearance, however, of such names as *compatres, commatres, propatres, promatres, patrini, matrinæ* is of itself sufficient evidence, not only that the sponsorial relationship had come to be regarded as a very close one, but also that it was not usually assumed by the natural parents. How very close it was held to be is shown by the Justinianian prohibition of marriage between godparents and godchildren. On the other hand, the anciently allowable practice of parents becoming sponsors for their own children seems to have lingered until the 9th century, when it was at last formally prohibited by the council of Mainz (813). For a long time there was no fixed rule as to the necessary or allowable number of sponsors, and sometimes the number actually assumed was large. By the council of Trent, however, it was decreed that one only, or at most two, these not being of the same sex, should be permitted. The rubric of the Church of England according to which "there shall be for every male child to be baptized two godfathers and one godmother, and for every female one godfather and two godmothers," is not older than 1561; in the *Catechism* the child is taught to say that he received his name from his "godfathers and godmothers." At the Reformation the Lutheran churches retained godfathers and godmothers, but the Reformed churches reverted to what they believed to be the more primitive rule, that in ordinary circumstances this function should be undertaken by a child's proper parents. All churches, it may be added, of course demand of sponsors that they be in full communion. In the Church of Rome priests, monks, and nuns are disqualified from being sponsors, either "because it might involve their entanglement in worldly affairs," or more probably because every relationship of fatherhood or motherhood is felt to be in their case inappropriate.

SPONTINI, Gasparo Luigi Pacifico (1774-1851), dramatic composer, was born at Majolati (Ancona) in Italy, 14th November 1774, and educated at the Conservatorio de' Turchini at Naples under Sala, Tritto, and Salieri. After producing some successful operas at Rome, Florence, Naples, and Palermo, he settled in 1803 at Paris. His reception in the French capital was anything but flattering. His first comic opera, *Julie*, proved a failure; his second, *La Petite Maison*, was hissed. Undaunted by these misfortunes, he abandoned the light and somewhat frivolous style of his earlier works, and in *Milton*, a one-act opera produced in 1804, achieved a real success. Spontini henceforth aimed at a very high ideal, and during the remainder of his life strove so earnestly to reach it that he frequently remodelled his passages five or six times before permitting them to be performed in public, and wearied his singers by introducing new improvements at every rehearsal. His first masterpiece was *La Vestale*, completed in 1805, but kept from the stage through the opposition of a jealous clique until 15th December 1807, when it was produced at the Académie, and at once took rank with the finest works of its class. The composer's second opera, *Ferdinand Cortez*, was received with equal enthusiasm in 1809; but his third, *Olympia*, was much less warmly welcomed in 1819.

Spontini had been appointed in 1810 director of the Italian opera; but his quarrelsome and grasping disposition led to his summary dismissal in 1812, and, though reinstated in 1814, he voluntarily resigned his post soon afterwards. He was in fact very ill fitted to act as director; yet on 28th May 1820, five months after the failure of *Olympia*, he settled in Berlin by invitation of Frederick William III., commissioned to superintend all