former, very large, so that the peculiar contents of the nuclei are bounded by a proportionally delicate sheath.

Near these moving Amœbæ tolerably large cysts are frequently found; they undoubtedly take part in the reproductive process of these organisms. The cysts (fig. 26 d) are always quite round, with a tolerably delicate sheath lying close to the contents. The diameter is somewhat variable, usually about 0·03—0·04 mm., and in one case 0·007 mm. The protoplasmic body contained in the sheath always consists in part of a very clear and quite homogeneous protoplasm, and in part of a very finely granular protoplasm. Inside the cyst a number of nuclei are invariably found, they are of the same nature as the smaller nuclei in the ordinary Amœba condition. The author has counted 11, 19, and occasionally 25 or even 30 small nuclei. The size of these nuclei varies somewhat in one and the same cyst, so that the measurements taken vary between 0·003—0·008 mm. The investigations which have been as yet made do not afford any clear evidence of the relationship of the single to the multi-nucleated condition.

On the MORPHOLOGY *and* SYSTEMATIC POSITION *of the* SPONGIDA. By F. M. BALFOUR, M.A., Fellow of Trinity College, Cambridge.

PROFESSOR SCHULZE's[1] last memoir on the development of Calcareous Sponges, confirms and enlarges Metschnikoff's[2] earlier observations, and gives us at last a fairly complete history of the development of one form of Calcareous Sponge. The facts which have been thus established have suggested to me a view of the morphology and systematic position of the Spongida, somewhat different to that now usually entertained. In bringing forward this view, I would have it understood that it does not claim to be more than a mere suggestion, which if it serves no other function may, perhaps, be of use in stimulating research.

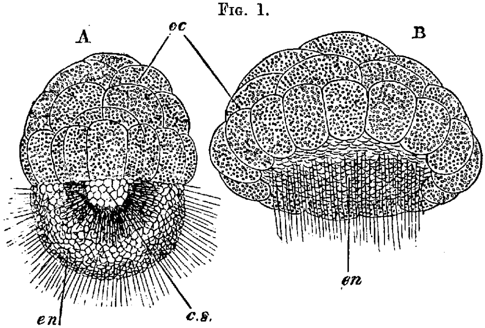
To render clear what I have to say, I commence with a very brief statement of the facts which may be considered as established with reference to the development of *Sycandra raphanus*

[1] "Untersuchungen über d. Bau u. d. Entwickelung der Spongien," 'Zeit. f. wiss. Zool.,' Bd. xxxi, 1878.

[2] "Zur Entwickelungsgeschichte der Kalkschwamme," 'Zeit. f. wiss Zool.,' Bd. xxiv, 1874.

the form which was studied by both Metschnikoff and Schulze. The segmentation of the ovum, though in many ways remarkable, is of no importance for my present purpose, and I take up the development at the close of the segmentation, while the embryo is still encapsuled in the parental tissues. It is at this stage lens-shaped, with a central segmentation cavity. An equatorial plane divides it into two parts, which have equal shares in bounding the segmentation cavity. One of these halves is formed of about thirty-two large, round, granular cells, the other of a larger number of ciliated clear columnar cells. While the embryo is still encapsuled a partial invagination of the granular cells takes place, reducing the segmentation cavity to a mere slit; this invagination is, however, quite temporary and unimportant, and on the embryo becoming free, which shortly takes place, no trace of it is visible; but, on the contrary, the segmentation cavity becomes larger, and the granular cells project very much more prominently than in the encapsuled state.

Fig. 1.

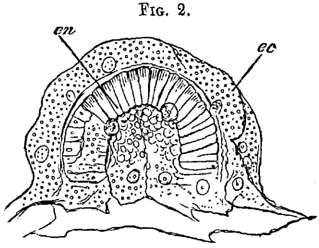


Two free stages in the development of *Sycandra raphanus* (copied from Schulze).

A. Amphiblastula stage; B, a later stage after the ciliated cells have commenced to become invaginated; *cs.* segmentation cavity; *ec.* granular cells which will form the ectoderm; *en.* ciliated-cells which become invaginated to form the entoderm.

The larva, after it has left the parental tissues, has an oval form and is transversely divided into two areas (fig. 1, A). One of these areas is formed of the elongated, clear, ciliated cells, with a small amount of pigment near the inner ends (*en*), and the other and larger area of the thirty-two granular cells already mentioned (*ec*). Fifteen or sixteen of these are arranged as a special ring on the border of the clear cells. In the centre of the embryo is a segmentation cavity (*cs*) which lies between the granular and the clear cells, but is mainly bounded by the vaulted inner surface of the latter. This stage is known as the amphiblastula stage. After the larva has for some time enjoyed a free existence, a remarkable series of changes takes place, which result in the invagination of the half of it formed of the clear cells, and form a prelude to the permanent attachment of the larva. The entire process of invagination is completed in about half an hour. The whole embryo first becomes flattened, but especially the ciliated half which gradually becomes less prominent (fig. 1, B), and still later the cells composing it undergo a true process of invagination. As a result of this invagination the segmentation cavity is obliterated and the larva assumes a compressed plano-convex form with a central gastrula cavity, and a blastopore in the middle of the flattened surface. The two layers of the gastrula may now be spoken of as ectoderm and entoderm. The blastopore becomes gradually narrowed by the growth over it of the outer row of granular cells. When it has become very small the attachment of the larva takes place by the flat surface where the blastopore is situated. It is effected by protoplasmic processes of the outer ring of ectoderm cells, which, together with the other ectoderm cells, now become amœboid. At the same time they become clearer and permit a view of the interior of the gastrula. Between the ectoderm cells and the entoderm cells which line the gastrula cavity there arises a hyaline structureless layer, which is more closely attached to the ectoderm than to the entoderm, and is probably derived from the former. A view of the gastrula stage after the larva has become fixed is given in fig. 2.

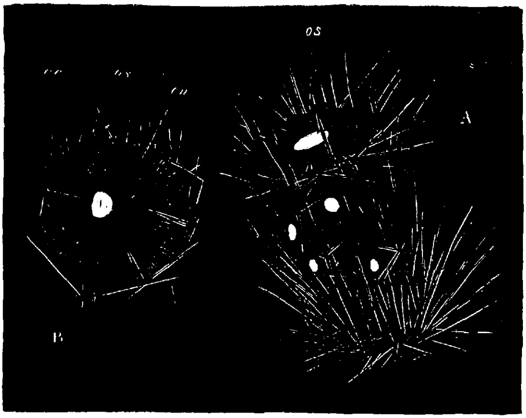
FIG. 2.



Fixed Gastrula stage of *Sycandra raphanus* (copied from Schulze). The figure shows the amœboid ectoderm cells (*ec*) derived from the granular cells of the earlier stage, and the columnar entoderm cells, lining the gastrula cavity, derived from the ciliated cells of the earlier stage. The larva is fixed by the amœboid cells on the side on which the blastopore is situated.

After invagination the cilia of the entoderm cells can no longer be seen, and are probably absorbed, and their disappearance is nearly coincident with the complete obliteration of the blastopore, an event which takes place shortly after the attachment of the larva. After the formation of the structureless layer between the ectoderm and entoderm, calcareous spicules make their apppearance in it as delicate unbranched rods pointed at both extremities. The larva when once fixed rapidly grows in length and assumes a cylindrical form (fig. 3, A). The sides of the cylinder are beset with calcareous spicules which project beyond the surface, and in addition to the unbranched forms, spicules are developed with three and four rays as well as some with a blunt extremity and serrated edge. The extremity of the cylinder opposite the attached surface is flattened, and though surrounded by a ring of four-rayed spicules is itself free from them. At this extremity a small perforation is formed leading into the gastric cavity which rapidly increases in size and forms an exhalent osculum (*os*). A series of inhalent apertures are also formed at the sides of the cylinder.

FIG. 3.



The young of *Sycandra raphanus* shortly after the development of the *Spicula* (copied from Schulze).

A. View from the side; B, view from the free extremity; *os.* osculum; *ec.* ectoderm; *en.* entoderm composed of collared ciliated cells. The terminal osculum and lateral pores are represented as oval white spaces.

The relative times of appearance of the single osculum and smaller apertures is not constant for the different larvæ. On the central gastrula cavity of the sponge becoming placed in communication with the external water, the entoderm cells lining it become ciliated afresh (fig. 3, B, *en*) and develop the peculiar collar characteristic of the entoderm cells of the Spongida. When this stage of development is reached we have a fully developed sponge of the type made known by Hæckel as Olynthus.

Till the complete development of other forms of Spongida has been worked out it is not possible to feel sure how far the phenomena observable in Sycandra hold good in all cases. Quite recently the Russian embryologist, M. Ganin,[1] has given an account, without illustrations, of the development of *Spongilla fluviatilis,* which does not appear reconcilable with that of Sycandra. Considering the difficulties of observation it appears better to assume for this and some other descriptions that the observations are in error rather than that there is a fundamental want of uniformity in development amongst the Spongida.

The first point in the development of Sycandra which deserves notice is the character of the free swimming larva. The peculiar larval form, with one half of the body composed of amœboid granular cells, and the other of clear ciliated cells is nearly constant amongst the Calcispongiæ, and widely distributed in a somewhat modified condition amongst the Fibrospongiæ and Myxospongiæ. Does this larva retain the characters of an ancestral type of the Spongida, and if so what does its form mean? It is, of course, possible that it has no ancestral meaning but has been secondarily acquired; I prefer myself to think that this is not the case, more especially as it appears to me that the characters of the larva may be plausibly explained by regarding it as a transitional form between the Protozoa and Metazoa. According to this view the larva is to be considered as a colony of Protozoa, one half of the individuals of which have become differentiated into nutritive forms, and the other half into locomotor and respiratory forms. The granular amœboid cells represent the nutritive forms, and the ciliated cells represent the locomotor and respiratory forms. That the passage from the Protozoa to the Metazoa may have been effected by such a differentiation is not improbable on *à priori* grounds, and fits in very well with the condition of the free swimming larva of Spongida, though another and perhaps equally plausible suggestion as to this passage has been put forward by my friend Professor Lankester.[2]

[1] "Zur Entwickelung d. Spongilla fluviatilis," 'Zoologischer Anzeiger,' vol. i, No. 9, 1878.

[2] "Notes on Embryology and Classification." This Journal, Vol. XVII,

While the above view seems fairly satisfactory for the free swimming stage of the larval Sponge there arises in the subsequent development a difficulty which appears at first sight fatal to it. This difficulty is the invagination of the ciliated cells instead of the granular ones. If the granular cells represent the nutritive individuals of the colony, they and not the ciliated cells ought most certainly to give rise to the lining of the gastrula cavity, according to the generally accepted views of the morphology of the Spongida. The suggestion which I would venture to put forward in explanation of this paradox involves a completely new view of the nature and functions of the germinal layers of adult Sponges.

It is as follows:—When the free swimming ancestor of the Spongida became fixed, the ciliated cells by which its movements used to be effected must have to a great extent become functionless. At the same time the amœboid nutritive cells would need to expose as large a surface as possible. In these two considerations there may, perhaps, be found a sufficient explanation of the invagination of the ciliated cells, and the growth of the amœboid cells over them. Though respiration was, no doubt, mainly effected by the ciliated cells, it is improbable that it was completely localized in them, but the continuation of their function was provided for by the formation of an osculum and pores. The ciliated collared cells which line the ciliated chambers, or in some cases the radial tubes, are undoubtedly derived from the invaginated cells, and if there is any truth in the above suggestion, the collared cells in the adult Sponge must be mainly respiratory and not digestive in function, while the normal epithelial cells which cover the surface of the sponge, and in most cases line the greater part of the passages through its substance, must carry on the digestion.[1] If the reverse is the case the whole theory falls to the ground. It has not, so far as I know, been definitely made out where the digestion is carried on. Lieberkühn would appear to hold the view that the amœboid lining cells of the passages are mainly concerned with digestion, while Carter holds that digestion is carried on by the collared cells of the ciliated chambers.

1877. It seems not impossible, if the speculations in this paper have any foundation that while the views here put forward as to the passage from the Protozoon to the Metazoon condition may hold true for the Spongida, some other mode of passage may have taken place in the case of the other Metazoa.

[1] That the flat cells which line the greater part of the passages of most Sponges are really derived from ectodermic invaginations appears to me clearly proved by Schulze's and Barrois' observations on the young fixed stages of Halisarca. Ganin appears, however, to maintain a contrary view for Spongilla.

If it is eventually proved by actual experiments on the nutrition of Sponges, that digestion is carried on by the general cells lining the passages, and not by the ciliated cells, it is clear that neither the ectoderm nor entoderm of Sponges will correspond with the similarly named layers in the Cœlenterata and the Metozoa. The invaginated entoderm will be the respiratory layer and the ectoderm the digestive and sensory layer; the sensory function being probably mainly localised in the epithelium on the surface, and the digestive one in the epithelium lining the passages. Such a fundamental difference in the germinal layers between the Spongida and the other Metazoa, would necessarily involve the creation of a special division of the Metozoa for the reception of the former group.

FLAGELLATED ORGANISMS *in the* BLOOD *of* HEALTHY RATS.[1]

By TIMOTHY RICHARDS LEWIS, M.B.

IT will be recollected that it is one of the fundamental tenets of M. Pasteur's creed that neither microscopic organisms nor their germs are ever found in the blood of an animal in health. Doubtless our conception of what implies good health may differ, and especially so when it is the health of an animal, and not of a person, that may be the subject of debate. If it be maintained that an animal affected with either epiphytes or entophytes, with epizoa or entozoa, is not in the enjoyment of full health, then there can be but few perfectly healthy animals. The organs of some animals are almost never absolutely free from parasites. It would nevertheless be scarcely justifiable to pronounce such animals as diseased in the ordinary sense.

So much being admitted, it is scarcely possible that this portion of M. Pasteur's doctrine can be correct. For some years past I have taken considerable interest in this matter, and my attention was drawn to it in a special manner in May last year, by my having been directed by the Government to make inquiries regarding the spirillum of Bombay-fever. Whilst doing this I had occasion to examine the blood of a considerable number of animals, and eventually (July, 1877) detected organisms in

[1] This chapter forms a portion of a paper on "The Microscopic Organisms found in the Blood of Man and Animals," which will shortly be published in the 'Fourteenth Annual Report of the Sanitary Commissioner with the Government of India.' Another portion of this paper, "The Nematoid Hæmatozoa of Man," will appear in the next number of this Journal.—ED.