side, and thus to see down into the short wide œsophagus. Such a view was obtained both by Mr. Busk and myself, and is represented in fig. 9 *b* of my memoir; but MM. Koren and Danielssen seem only to have examined these parts from the side.—I shall of course take the first opportunity of again applying myself to the investigation; and if I find that I have been in error, I shall lose no time in making public my retractation.

P.S. Since writing the above, I have been informed by Dr. Dyster of Tenby, that he has repeatedly verified the most important parts of my observations; viz. the development of embryos, possessing a mouth and ciliated œsophagus, from single ova, which are distinguished as such from the very commencement, by the mode of segmentation and the presence of the directive vesicles.

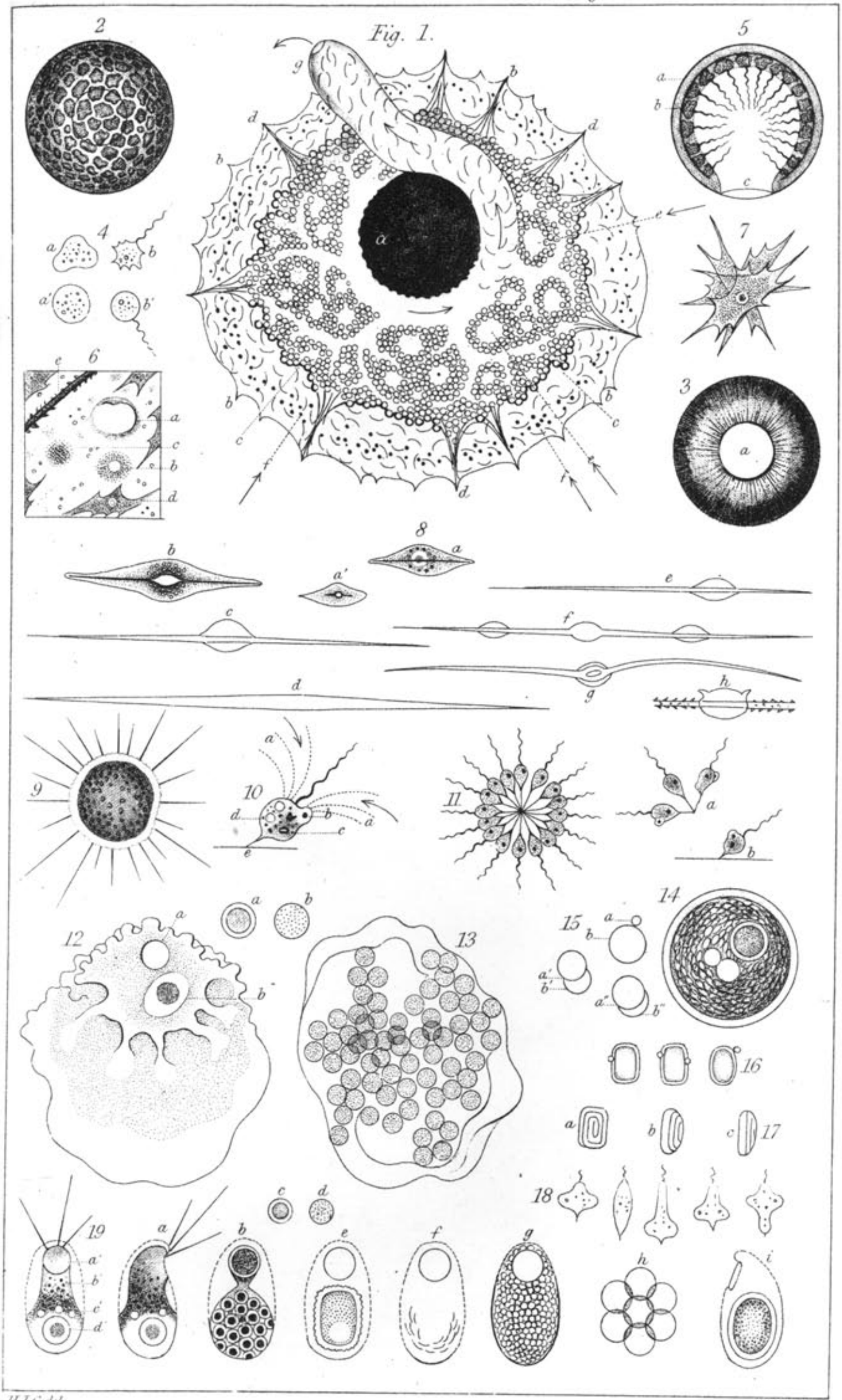
IV.—*On the Ultimate Structure of* Spongilla, *and Additional Notes on Freshwater Infusoria.* By H. J. Carter, Esq., Assistant Surgeon H. C. S., Bombay.

[With a Plate.]

In the "Postscript" to my notes on the organization of Infusoria, dated 10th June last*, it is stated that apertures exist in the investing membrane of *Spongilla,* and that the particles of carmine taken in through them pass into the substance of the sponge-cells. This was added chiefly to correct an assertion made in the body of the paper, that *Spongilla* lived by endosmosis. I also stated that I should recur to these facts more particularly hereafter; but since then, up to within the last month, I have not had an opportunity of again pursuing the subject. I have, however, during this time, succeeded in ascertaining the ultimate structure of *Spongilla,* by following its development from the seed-like body, and this I will now relate.

Those who are acquainted with *Spongilla* are aware, that it is charged towards the base with a number of seed-like bodies of a globular shape, each of which consists of a coriaceous membrane enclosing a number of delicate, transparent, spherical cells, more or less filled with ovules and granular matter, while an incrustation of gelatinous matter, charged with small spicules peculiar to the species, surrounds the exterior of the coriaceous membrane. It has also been shown that at an early period

* Annals, vol. xviii. p. 242.



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of development the spherical, which we shall henceforth call "ovi-bearing," cells are polymorphic—identical, but for the ovules, with the ordinary sponge-cell,—and surrounded by a layer of peculiar cells equally polymorphic, which I have conjectured to be the chief agents engaged in constructing the capsule*. It is desirable also to remember that there are these two kinds of cells in the composition of the seed-like body, because we shall find by and bye that they appear in corresponding parts of the newly developed *Spongilla*. Lastly, the seed-like body presents a hole, which we shall call the "hilum."

Having thus briefly alluded to the constituent parts of the seed-like body, let us now pursue the development of *Spongilla* from it. This takes place in the following order: viz. 1st. The contents issue through the hilum under the form of a gelatinous mass, in which the ovi-bearing cells and their contents appear to be imbedded *entire*. 2ndly. The spicules begin to be developed, and with them is formed a delicate pellicle, which not only encloses the new *Spongilla*, but also the seed-like body: to this pellicle we shall give the name of "investing membrane;" this becomes separated by an interval (which we shall designate the "cavity" of the investing membrane) from the gelatinous mass containing the ovi-bearing cells, which we shall term the "parenchyma." 3rdly. Apertures are developed in the investing membrane, and a system of afferent and efferent canals in the parenchyma; the afferent canals commencing in many large apertures and afterwards communicating with each other, and the efferent canals commencing in *ramusculi* which end in a single tubular vent. In this period also the spicular structure is formed and arranged. 4thly. The ovi-bearing cells are developed into spherical ampullaceous sacs, communicating with the afferent canals; and the afferent and efferent currents are established. We will now follow this more in detail.

First Period.—Three or four days after the seed-like body (which has never been allowed to get dry †) has been placed in clear water, a white substance like cotton is seen to have issued from the lower part of it. This, when examined, is found to present a flat, transparent border, so abounding in (indolently contracting) vesicles of different sizes, that it looks like an areolar structure. I wish particularly to call attention to this point,

* Annals, vol. xviii. pl. 6. figs. 41, 42.

† For this purpose it is best to place a piece of *Spongilla*, charged with the seed-like bodies, in a basin of water, where it will soon get putrid; but this does not matter: the seed-like bodies still retain their vitality, and will throw out the young *Spongilla* much more quickly than if taken fresh from the living mass. Those which I have used for these experiments belong to *Spongilla alba*, H. J. C., which was taken from the tank a year since.

because it resembles the vacuolar state of the protoplasm in the early development of the cell of the Characeæ, and probably of vegetable structures generally. The margin of this border is more or less irregular and digitated, from the polymorphic substance of which it is composed; while further in may be seen the ovi-bearing cells in the denser gelatinous matter, with their ovules already somewhat diminished in size. The spicules have also begun to appear.

Second Period.—We may commence with the formation of the spicules, which is so rapid, that they come into view almost simultaneously with the issue of the substance of the seed-like body.

Spicules.—These appear to be formed in sponge-cells of a peculiar kind, one of which is confined to the parenchyma, viz. that which forms the large smooth spicule, and the other to the seed-like bodies and the investing membrane, viz. that which forms the small spiniferous spicule characteristic of the species. Of the former I can state nothing, except that it appears to be filled with ovules like the ovi-bearing cell, while the latter is characterized by the absence of ovules, a uniform granular composition, and the presence of a nucleus (Pl. I. fig. 7).

At the earliest period that a spicule becomes visible it appears under a hair-like form of immeasurable thinness, and enclosed in a sponge-cell of a spindle-shape, which has assumed this figure to accommodate it. The nucleus of the cell is now seen in its centre, and the spicule, about $\frac{1}{400}$th of an inch in length, lying across it (fig. 8 *a*′). After a few hours the spicule becomes much larger and longer, and the sponge-cell still more extended to retain it within its substance; it also presents a glairy, ovate globule in its centre, through which its shaft passes, not in the line of the longitudinal axis, but on one side of it, so that the globule looks as if it were appended to it (fig. 8 *a*, *b*, *c*). When, however, the spicule is arrested at this stage of its development and denuded of the sponge-substance, that part which in the sponge-cell appeared to be a glairy, refractive globule, is found to be merely an inflation of the outer wall of the spicule, for the shaft of the spicule, slightly diminished in size, may then plainly be seen to pass through it in the manner before mentioned, and to present the longitudinal canal in its inside. In this state neither undiluted nitric acid nor a saturated solution of caustic potash produces any change in it, so that it may fairly be assumed to be of the same composition as the rest of the spicule.

By degrees, as the spicule is enlarged, the inflation is also proportionally increased in size, and disappears only when the spicule is fully formed (fig. 8 *d*). The normal state of the inflation appears to be single and in the centre of the spicule, but it may be situated on any part of the shaft, or present in variable plurality (*e, f, g*).

In my notes on the organization of the Infusoria I have stated* that the spicule grows from a hair-like extension projecting from either side of a glairy globule, which now is found to be nothing but an inflation, probably filled with refractive fluid. However, as we see that the spicule grows by layers deposited on the original one, which, therefore, forms the longitudinal canal, and that, when it is fully formed, the inflation is no longer visible, at the same time that the inflated portion is continuous with the outermost layer of the spicule while the latter is growing, it does not seem improbable that the first layer does arise from the linear extension of a globule, and that every succeeding layer is formed in the same way; (hence, as there will be more layers in the centre than at the circumference, the spicule assumes a pointed form at each extremity); the inflation subsiding with the extension of each layer, until the final one leaves no inflation at all, and the spicule assumes its ultimate form. The original form of the spicule, therefore, appears to determine its ultimate one, and the spiniferous character of this will therefore depend on the greater or less tendency in all the layers to assume this figure, whatever it may be (fig. 8 *h*). Whether the spicule is developed throughout by the same sponge-cell, or whether, after it very much exceeds in area any of the sponge-cells, which is always the case with the large spicule, a plurality are engaged in its ultimate development, or whether it continues to grow in the intercellular substance until it has reached its largest size, I am ignorant; but I have ascertained, by a series of observations and measurements, that it does not grow after having become denuded of the sponge-substance.

Again, I am not certain that the inflation, though extremely common, is always concomitant, or even necessary in the formation of the spicule, for many present no trace of it in any stage of their development, from the time they are first visible to that in which they have attained their largest size.

Long before the spicules are formed, however, they are transported from place to place by the sponge-cells individually, and when too large for this, are twisted and turned and grouped together by the general mass, to meet the requirements of the case, with as much instinct as that which characterizes the arrangement of the bits of stick in an ant-hill; while they appear never to become finally fixed until the substance in which they may be imbedded has altogether lost its vitality.

Investing Membrane.—As the sponge-substance accumulates vertically, the flat transparent border seems to disappear by

* Annals, vol. xviii. p. 118.

being raised with the pellicular covering of the *Spongilla* generally, until it presents a considerable angle of elevation at the circumference; while the parenchyma, either by contraction within, or by forcing outwards bundles of its large smooth spicules, here and there separates itself from the pellicular covering, and thus both the investing membrane and its cavity are formed (Pl. I. fig. 1 *b, b, b*). The investing membrane, now supported in its position by these bundles of spicules (*d, d, d*), and kept on the stretch by the small spiniferous spicules which are scattered through its substance, presents two objects well worthy of description, viz. the peculiar cell to which I have before alluded, and a number of apertures (*f, f*).

The cells of the investing membrane are characterized by their uniformly granular composition and colourless appearance. They are nucleated, possess the contracting vesicle singly or in plurality, and are spread over the membrane in such numbers, that it seems to be almost entirely composed of them; while they are of such extreme thinness, and drawn out into such long digitated forms, that they present a foliated arrangement not unlike a compressed layer of multifidous leaves, ever moving and changing their shapes (figs. 6 *d* & 7). This is, as I have before stated, the same kind of cell as that which forms the cortical layer of the seed-like body at a very early period; and, as will be seen hereafter, is further characterized by not enclosing any carmine when the other cells become charged with it.

The apertures, on the other hand, are circular or elliptical holes in the investing membrane among (in ?) these cells. They seldom exceed $\frac{1}{700}$th of an inch in diameter, have a clean, thin margin, which in one part presents a slight tubercular enlargement, and are generally surrounded by some minute colourless granules; while they have the remarkable property of closing or dilating like the pupil of the eye, but generally with extreme tardiness instead of the velocity observed in the latter (fig. 6 *a*). The tubercle looks very like the nucleus of a sponge-cell, and, when the aperture is contracted, the granules may be seen to be enclosed in a circumscribed form, which, together with the presence of one or more contracting vesicles, gives the whole very much the appearance of one of the sponge-cells peculiar to the investing membrane. Through the apertures the particles of food and other substances suspended in the surrounding water are admitted into the cavity of the investing membrane, preparatory to passing into the parenchyma, in the manner which will be presently mentioned*.

* These are the apertures to which I alluded in the postscript mentioned. Mr. Bowerbank also discovered them about the same time in

Independently of all these structures, together with an innumerable number of minute contracting vesicles, the investing membrane is so transparent, that every part of its cavity can be seen as clearly as if there were no membrane at all.

Parenchyma.—This consists of a mass of gelatinous substance (Pl. I. fig. 1 *c, c*), in which are imbedded the smooth spicules and ovi-bearing cells, and through which pass the afferent and efferent canals.

Ovi-bearing cells.—The ovi-bearing cells do not burst and allow their contents to become indiscriminately scattered through the gelatinous mass in which they are imbedded, but each becomes developed separately and entire in the following way, viz. the ovules and granules of the ovi-bearing cell subside into a granular mass by the former losing their defined shape and passing into small monociliated and unciliated sponge-cells; this mass then becomes spread over the interior surface of the ovi-bearing cell, leaving a cavity in the centre, into which the cilia of the monociliated sponge-cells dip and keep up an undulating motion; meanwhile an aperture becomes developed in one part of the cell which communicates with the adjoining afferent canal, and thus the ovi-bearing cell passes into an ampullaceous, spherical sac. The cilia may be now seen undulating in the interior; and if the *Spongilla* is fed with carmine, this colouring matter will not only be observed to be entirely confined to the ampullaceous sacs, but when the *Spongilla* is torn to pieces and placed under a microscope, particles of the carmine will be found in the interior of the monociliated as well as in that of the unciliated sponge-cells (figs. 2, 3, 4, 5); proving that of such cells the ampullaceous sac is partly composed.

This sac then must be regarded as the animal of *Spongilla*, as much as the Polype-cell is regarded as the animal of the *Polype*, and the whole mass of *Spongilla* as analogous to a Polypidom.

Sometimes an isolated ovi-bearing sponge-cell which has escaped from the general mass, may be seen to have undergone the same development by itself in the watch-glass; but in this case there appears to be no aperture, for particles of carmine brought into contact with it indicate no currents about its exterior, while, within, the cilia may be undulating as actively and as evidently as if it were *in situ*. Another proof also of the absence of an aperture is, that under this condition the ampullaceous sac encloses the particles of carmine which are in contact with its exterior, after the manner of *Amœba*.

England, and mentioned the fact at the British Association (Athenæum, 30th August, 1856). His paper in the Quart. Journ. Microscop. Science I have not yet seen.

I have stated that the contents of the ovi-bearing cell during development become spread over its inner surface, but at the same time I think it questionable whether this cell becomes revivified, or whether it is not ultimately cast off after a new one has been formed.

In proportion as the ampullaceous sac experiences a want of nourishment after it has been fully developed in the watch-glass, so it gets thin, and, becoming more translucent, not only allows its aperture to be better seen, but presents an indistinct meridional lineation, which, radiating from around the aperture, meets at the opposite pole of the sac, thus giving the former an appearance not unlike the pupil of the eye (fig. 3 *a*); but though at one time it is larger and at another smaller, and not unfrequently of an irregular circular form, yet its changes are so gradual, that I have seldom, except when carmine has been added and taken into this sac, been able to see any alteration in its size or form for an hour together. When the aperture is in focus, the opposite point of the sac is invisible.

Afferent Canals.—The afferent canals consist of a number of channels which open by large apertures into the parenchyma from the cavity of the investing membrane, and then, freely anastomosing, form an areolated cavernous structure, throughout which the particles admitted into the cavity of the investing membrane subsequently circulate, and are finally received into the ampullaceous sacs which open into them (fig. 1 *e*, *e*).

Efferent Canals.—The efferent canals, on the other hand, begin by radicles in the interstices of the cavernous structure, among the ampullaceous sponge-cells (with the cavities of which, however, they do not communicate, nor with the afferent canals, as will be seen hereafter), and, growing into large branches, at length terminate in a single tube. This tube extends beyond the periphery of the *Spongilla*, and ends in a mammilliform point, in the centre of which is a single contracted aperture (Pl. I. fig. 1 *g*).

Thus we have the structure and composition of the portion of *Spongilla* developed from the seed-like body. Let us now direct our attention to its functions, which are easily elicited by placing a little carmine in the water, and watching the particles as they pass through its substance.

No sooner has the carmine reached the exterior of the investing membrane, than its particles are rapidly drawn in through its apertures, not vortically but directly, and, traversing its cavity, or the interval which exists between the investing membrane and parenchyma, in different directions, are thence drawn in through the apertures of the latter, and finally into the ampullaceous sacs, where they remain a quarter of an hour or more, until they are thrown off and find their exit through the efferent system of canals.

During their course we observe, that on arriving near the ampullaceous sacs, they are rapidly drawn aside, and for the most part pass into their cavities; and by seeking for those favourably situated for such observations, that is, at the circumference of the parenchyma, we not only see that this takes place at one point only, but also, frequently, that at this part of the sac there is the circular aperture mentioned, and that they pass in through this aperture; further, after a certain time, we observe, that the particles of carmine which have accumulated round the inner surface of the sac, are gradually thrown off from its circumference, and, falling into the efferent system of canals, are thus carried away and finally ejected.

It would have been satisfactory to have seen the particles pass in through the aperture while the latter was uppermost or undermost, and in the focus of the microscope (Pl. I. fig. 3 *a*)*, but this I could never do, perhaps from the rapidity with which they are whirled into the interior; but when the aperture happens to be on one side of the sac, the particles may be seen to pass through it into the interior, and generally to adhere to the first part with which they come into contact, when they are instantly enclosed by the sponge-cell on which they impinge. Again, the aperture would not appear to be the only part of the exterior of the ampullaceous sac which is in communication with the afferent canal, but a much larger portion is bathed by the afferent fluid, for particles of carmine may be seen to adhere to the external surface of this sac as well as to be carried into it; and the latter seems to be more the case as the sac becomes altered from want of nourishment, after having reached its maximum of development under the circumstances mentioned.

If now we clear the watch-glass of all superfluous carmine by dipping it in clean water, and again place it under the microscope, the facts to which I have before alluded will become perfectly evident, viz. that the colouring matter is wholly confined to the ampullaceous sacs, and that the sponge-cells of the investing membrane do not contain a single particle; while, by tearing the *Spongilla* to pieces, it will be found as much in the bodies of the monociliated as in those of the unciliated sponge-cells. Thus the component parts of the ampullaceous sac are easily demonstrated. One point, however, remains to be proved,

* This aperture corresponds in every respect, except the presence of the tubercle, with the aperture of the investing membrane; but I never could entirely satisfy myself that the latter was not a contracting vesicle, until I saw the particles of carmine pass in through it.

namely, that there is no direct communication between the afferent canals, or the ampullaceous sacs, and the efferent canals. This is easily effected by placing a little carmine in the water, and observing the moment of its entry through the apertures of the investing membrane and that of its exit through the efferent tube, when the interval will be found to vary; but as it is seldom less than a quarter of an hour, this is quite sufficient to show that there is no direct communication between these cavities; while the mode of enclosing the particles by the small sponge-cells being known to be like that of the *Amœba*, their having been seen to throw them off at the circumference of the ampullaceous sac, when they are immediately carried away by a current passing through the canal into which they are thrown, is still further corroborative of the fact; but, indeed, it requires no corroboration, for when the sacs are only one layer deep, it can be seen.

We have now to consider by what power the particles are drawn into the ampullaceous sacs, and how a constant current through the *Spongilla* is maintained—questions which we can only hope to answer by a study of the organs of *Spongilla* individually; and fortunately, as far as the first inquiry goes, this is much aided by the change which takes place in the new *Spongilla* a few days after it has been developed.

The same difficulty which exists in maintaining life in the Infusoria, viz. the want of proper nourishment, is experienced with respect to the young *Spongilla*, and hence, sooner or later, it becomes starved; but frequently, just before this takes place, the whole community of sponge-cells, more or less, separate, dissolve partnership, so to speak, leave their habitation, and issue forth into the watch-glass to seek independent existences respectively for themselves. At this time the ampullaceous sac may be seen entire, but reduced to an actinophorous form (Pl. I. fig. 9), and presenting a single nucleus, while in other instances the community of this sac have separated, and its monociliated and unciliated sponge-cells are also seen spread about the watch-glass; also groups of much smaller monociliated cells like those called *Uvella* by Ehrenberg; and lastly, the characteristic sponge-cell of the investing membrane.

The one, however, which interests us most here, is the monociliated sponge-cell of the ampullaceous sac (that which I once supposed to be the *androspore*), and this may be seen attached by a pedicular elongation of its substance to the watch-glass on one side, and with its single cilium undulating on the other (fig. 10). We have it now, then, exactly in the position for ascertaining the direction of the currents of the latter, and these, when a little carmine is added, are found to be towards the body on either side of the cilium, by which the particles may be seen to be thrown almost point-blank on its surface, and at the same time caught up (by apparently adhering to it, or by a process thrown out by it as in *Actinophrys Sol* (*b*)) and rapidly passed into the interior. Hence we may easily conceive the united effort of all the ciliated sponge-cells in the ampullaceous sac being sufficient to produce a considerable current into its interior, and thus to catch the particles which are passing through the afferent canals.

The other question, viz. that of the afferent and efferent currents, is not so easily solved, but still the monociliated sponge-cell supplies data for at least speculation on that point. I have already shown, in my notes on the organization of the Infusoria, that the vesicula or contracting vesicle is an excretory organ, and that it discharges itself from the surface in many Infusoria, especially in the naked Rhizopoda, to which the sponge-cell is most intimately allied; and it so happens, that not only do these monociliated sponge-cells present the contracting vesicle in great activity, but also in variable plurality, so that with those of the other sponge-cells lining the cavity of the ampullaceous sac, a continual and rapid discharge of water must be kept up; which, when we remember that it is the character of this organ to discharge itself from the surface, and find that when the ampullaceous sac leaves the parenchyma it becomes nothing more than a large sponge-cell, gives us, I think, pretty good reason to infer that these organs discharge their watery contents into the efferent system of canals; and, when we consider the powerful organ which the contracting vesicles of all the ampullaceous cells together must form for effecting this function, it does not seem unreasonable, in connexion with the following facts, to conclude that the currents, both afferent and efferent, of the sponge may be produced in this way.

It might be supposed, from what has been stated respecting the course of the particles of carmine through *Spongilla*, that the afferent and efferent currents never cease as long as it is alive; but such is not the case under some circumstances, for although no difference is appreciable when only a small quantity of carmine has been taken in, yet when there is an abundance in the water, and the ampullaceous sacs become apparently filled with it, not only do these sacs one after another seem to close their apertures and refuse admittance to any more, but the whole investing membrane becomes drawn towards the parenchyma, its apertures all become closed, and the tubular vent of the efferent system retracted, and its aperture also closed, so that there is a total cessation of all active motion in the *Spongilla*; and this may continue for more than an hour, when the vent is seen to project itself as gradually as it became contracted, the investing membrane to resume its original position, and the apertures in both to open and admit and emit their currents respectively as before; but now, the latter brings away the refuse of the carmine which has been and is still being thrown off into the efferent canals. In fact, the *Spongilla*, having been fed to satiety, appears thus to shut itself up for a time for the purpose of digestion, and then to open to throw off the refuse.

Again, it sometimes happens that one of the large branches of the efferent system bursts and gives rise to an efferent current before the tubular vent resumes its original dimensions and opens its aperture, by which two efferent currents are subsequently established, for the abnormal one does not close when the normal one becomes opened. Hence we have a further indication of pressure on the contents of this system, which will hardly derive explanation from anything but a force exerted by the contracting vesicles in the way mentioned; the conditions of the fluid in the afferent and efferent canals hardly holding out a sufficient difference in composition or density to account for this by endosmosis.

Thus we find *Spongilla* (for I have ascertained that the same structure exists in the large masses as in the small ones) composed of a number of stomachal sacs imbedded in a gelatinous substance permeated with spicules for its support, and an apparatus for bringing them food, as well as one for conveying away the refuse, while the nutriment which is abstracted by the process of digestion common to Rhizopodous cells (*e.g. Amœba*) no doubt passes through the intercellular gelatinous substance into the general development of the mass; and if right in comparing the ampullaceous sacs to the stomachal cavities of the simplest Polypes, are we not further justified in drawing a resemblance also between the ciliated sponge-cells and those which line the stomach of *Cordylophora**, of *Otostoma*†, and many of Ehrenberg's *Allotreta* together with those in the stomach of the *Rotatoria* and *Planariæ*‡, which are evidently biliary organs, also having cilia floating in the cavity which receives the food?

Lastly, it is perfectly evident that each monociliated sponge-cell possesses a large granule (Pl. I. fig. 10 *c*), which is of a greenish colour, and that the assemblage of these cells in the interior of the ampullaceous sac produces the assemblage of granules which are seen in it; also that these granules, when the ampullaceous sac becomes individualized and assumes an actinophorous form, represent the "granules" which I have described as a part of the internal contents of the Rhizopoda (fig. 9).

* See Prof. Allman in Phil. Trans. 1853, p. 370.

† Annals, vol. xvii. p. 117. ‡ *Idem*, vol. xviii. pl. 7. fig. 92.

May we not infer from this that these indicate the presence of similar cells in the interior of *Amœba*, &c.? If this should be the case, and that they are homologous with the liver-cells of the *Planariæ*, then I shall have been right in my original conjecture that the "granules" are the homologues of the "spherical cells*."

It is proper to notice here, also, the affinities which *Spongilla* has to the vegetable kingdom. I have already alluded to the resemblance between it and the cell of the Characeæ at an early period, when both are filled with vacuoles; nor is the plurality of the contracting vesicle in the Rhizopoda generally, when matured, a less striking instance of the transition of the vesicula or contracting vesicle in the more animal Infusoria, into the passive vacuoles of the vegetable protoplasm. The nucleus of the Rhizopoda is typical of that which exists in the vegetable cell. Similar "granules" are also seen in motion at the extremity of the root-cell of *Chara*, in the "fixed protoplasm†;" and at present no difference can be shown between the molecular protoplasm in each; while as regards the production of starch, that is so common in every specimen of *Spongilla* that is met with, more particularly at the end of the season, that its presence is no novelty whatever. The mode of taking nourishment is different, but I have already stated that when the protoplasm leaves the cell of *Spirogyra*‡, and even before its exit, it encloses nutrient matter after the manner of *Amœba*. For the last year, some plants of *Chara*, which I reared from the nucules, and have grown in a glass jar, have only been kept vigorous by dead grasshoppers, which every now and then, when the *Chara* begins to grow lighter in colour and meagre in appearance, have, by being thrown into the water, restored it to its former condition §. So that the same elements, under different circumstances, are thus made subservient to the same purposes. Hence the sponge-cell appears to be but a naked condition of the vegetable cell, and thus to become the first, or among the first, of animal organisms.

I would here also recur to the forms which the substance of *Spongilla* assumes when, under the dread of starvation, it leaves

* Annals, vol. xviii. p. 125.

† *Idem*, vol. xix. pl. 3. fig. 2*f*.

‡ *Idem*, vol. xix. p. 259.

§ In this instance I have noticed, that the moment the plants become robust, they cease to bear fruit; while, when they become impoverished, they throw forth nucules,—the physiology of which appears to be evident: viz. so long as there is plenty of nourishment to build up more structure for ultimately making more propagative germs, this alone occupies the instinct of the plant; but the moment the nourishment ceases, the instinctive fear of failing in the propagative department causes the plant to turn its attention to preserve itself by forming seeds.

its habitation; not more to particularize these forms than to show how closely they resemble those of the protoplasm of *Spirogyra,* when under similar circumstances it also leaves its natural habitation or cell-wall and seeks for food elsewhere. The smallest is that which resembles *Uvella,* Ehr. This consists of a number of minute, monociliated, flask-shaped cells, which adhere by their pointed extremities respectively to a common centre point, whence the whole assumes a globular form (Pl. I. fig. 11 *a, b*). They are about $\frac{1}{3733}$rd of an inch in diameter, polymorphic, and present the granule and contracting vesicles like the monociliated sponge-cell of the ampullaceous sac; they also enclose particles of food, and on separating from each other, attach themselves by a prolongation of the body to the watch-glass (*b*), so that they are but a miniature type of the ciliated sponge-cell. The latter, again, which I have already described, loses its cilium a day or two after it has come out into the watch-glass, and assumes an actinophorous form, becoming at last encapsuled; previous, however, to losing the cilium, it progresses with the latter in front, and not behind, as when it is set free by tearing up a piece of the *Spongilla.* The ampullaceous sac, whilst remaining entire, also assumes an actinophorous form, loses all appearance of cilia internally, and encloses food after the manner of *Amœba.* All these figures are so like those assumed by the protoplasm of *Spirogyra** when it breaks up and undergoes the changes to which I have alluded, that no doubt can be entertained of both organisms being Rhizopoda at this period.

Of the sense of feeling in *Spongilla,* I have had no manifestations beyond the instinctive acts to which I have alluded, and that wonderful power of opening an aperture through itself, which the sponge-cell of the investing membrane apparently possesses; but in *Amœba Princeps,* which is a closely allied organism, I once saw the surface contract and become puckered several times successively, on being pinched by a rotatory animalcule (*Diglena*), an experiment which this animalcule performed for me so satisfactorily, that I have no longer any doubt about the matter.

The "swarm-spore" described by M. N. Lieberkuhn†, which appears to me to be a ciliated form of the seed-like body, and the same as the "gemmule" described by Dr. Grant, I have not yet been able to see; nor have I been able to see his "spermatozoa-like bodies," unless the *Uvella*-form just mentioned be them.

The formation of the seed-like body, however, now that we

* Annals, vol. xix. p. 259. † *Idem,* vol. xvii. p. 407, 1856.

know the structure of the ampullaceous sacs, seems very intelligible; for we have only to conceive an enlargement of the small sponge-cells lining its interior, with the addition of ovules to them respectively, and the spicule-bearing sponge-cells of the cortical substance supplying the spicular crust to the exterior, to have a globular capsule thus composed, with a hilum precisely like the seed-like body; a conjecture which seems to derive support from the fact, that in some instances, when *Spongilla* is beginning to experience the want of nourishment, these sacs, small as they are, assume a defined, rigid, spherical form, from their pellicle becoming hardened and encrusted with extremely minute spicules.

Additional Notes on the Freshwater Infusoria in the Island of Bombay.

As there are some parts of my "Notes" on the organization of the Infusoria* which require correction, alteration, and further explanation respectively, I take this opportunity of communicating the observations necessary for this purpose, and at the same time of supplying additional matter, which will render them more complete.

Vesicula.—At p. 129 it was stated that the existence of the vesicula "in *Astasia*, *Anisonema* (Duj.), and *Euglena* can only be determined by inference." Since then I have seen the hyaline vesicle, supposed to be the vesicula, empty itself in all three of these organisms, but more particularly in *Euglena viridis*, and a description of the process, which is peculiar, in this species will serve for all the rest. (Pl. I. fig. 14.) It has been already stated, that in *Anisonema* the vesicula seemed to alter in size and shape without completely contracting, which is more or less the case with all this class of animalcules, and appears to arise from the presence of a single sinus in connexion with the vesicula, as will be seen by the following description of the mode in which this function is performed.

In *Euglena viridis* the single sinus, which is attached to the side of the vesicula, after having become filled, pours its contents into the latter; the vesicula, thus distended, is now pressed upon by the gradual refilling of the sinus, and thus its contents also become evacuated. Hence we never witness that sudden contraction of the vesicula which is so common in other Infusoria, at the same time that it often appears double in *Astasia* and *Anisonema* (where it is more evident than in *Euglena*, owing to the absence of colouring matter), from both sinus and vesicula being more or less distended together (fig. 15).

* Annals, vol. xviii. p. 115, 1856.

The only way in which this process can be well seen is, by getting specimens of *Euglena viridis* which are turning red, filled with ovules and about to become capsuled, or which have been just burst from their capsules. These, which at this time are spherical, if placed in water under a light piece of glass, and the water partly abstracted by bibulous paper, will, by the pressure of the glass, assume a compressed circular form, in the centre of which the vesicula and its sinus may be observed in full operation, and be deliberately watched for some time, or until the infusorium dies (fig. 14).

Besides *Polytoma Uvella*, and *Chlamidomonas*, as before mentioned (*loc. cit.*), the vesicula has been seen and described by Mr. G. Busk in *Volvox Globator**, and having myself also seen it in the *Thecamonads*, besides several species of *Euglenæ*, while it would appear that Cohn has observed it in the swarm-cells of *Confervæ*, its existence throughout this class of Infusoria seems thus to be established.

At p. 128 it is stated respecting the vesicula—"in *Euglypha* I have not been able to recognize it;" but since then I have seen it frequently; it is situated in plurality just in front of the nucleus, as in *Euglypha pleurostoma*, H. J. C. (fig. 19 *c*).

Ovules.—At p. 224 I have stated, respecting the "ovules" of Infusoria, that "they occur in *Euglypha alveolata*, Duj., congregated round the hyaline capsule of the nucleus, from forty to fifty in number," &c. I have also observed this in another species, viz. the one just mentioned, for which I propose the name "*E. pleurostoma*"; and the same kind of development described in the "larger variety" of *E. alveolata*, p. 227, figs. 32, 33, as well (fig. 19, *e*, *i*). *E. pleurostoma* is very like Ehrenberg's *Difflugia Enchelys* and Dujardin's *Trinema acinus*, but not being identical with the figure given of the former, and though often presenting three radiated prolongations of the diaphane like the latter, but by no means constantly, it becomes necessary to give it a name. It is just possible hereafter that all three may be found to be the same, but even then it would be well to retain the term "*Euglypha*," because *E. pleurostoma* is essentially of this genus; the only differences between it and *E. alveolata* being the lateral position of the mouth and the circular figure of the scales in the former.

At p. 231, figs. 39, &c., under the head of "Impregnation," it is stated that many of the ovules of *Spongilla*, when pressed out from the seed-like body, have a small granule or cell "in different degrees of connexion with them, from simple approximation to almost undistinguishable incorporation;" the same is the case with the ovules of *Euglena viridis* (fig. 16).

* Quart. Journal Microscop. Science, vol. i. p. 35.

At p. 234, under the head of "Development of the ovules," it is stated that the same process as that which takes place in the development of the ovule of *Spongilla* "appears to take place in the ovules of *Euglena*," and this, to a certain extent, may be really the case; but as the ultimate forms of the two organisms are different, so there must be a point at which their developmental appearances begin to differ. This, in the ovule of *Euglena viridis*, consists in the evolution of a spiral structure, which, when fully formed, appears to spring out in opposite directions, and thus, with the diaphane, afford that means of vermicular progression which *Euglena* always presents when void of, or with only an injured or imperfect cilium (fig. 17 *a, b, c*).

I infer this from the following circumstances: first, that in a watch-glass, where a number of the ovules of *Euglena viridis* had been placed for observation, about a hundred small *Euglenæ virides*, closely corresponding in size with the largest ovules, made their appearance, elongating and contracting themselves incessantly for several days, without moving far from the place in which they appeared to have been developed (on account of the imperfect state of their cilium), and, being without chlorophyll, presenting exactly the same appearances as fully-developed individuals in the same condition (fig. 18). Secondly, from the ovules which remained on the sides of the basin from which those in the watch-glass were taken, presenting, after a while, a spiral line on both the flat sides of the compressed ovule, which apparently, from its resiliency, caused these sides to become prominent and obtusely conical; thus indicating an advance of development in these also as well as in most of those in the watch-glass, which was arrested, probably, from want of proper nourishment (fig. 17).

Now when we consider that the cells of *Euglenæ*, which we have called ovules, do not present any signs of an amyloid composition when treated with iodine, that the existence of the spiral line proves them not to be mere oil-globules, while the cell of *Euglena* ultimately developes a spiral structure in its substance, as I have particularly pointed out in *Crumenula texta*, Duj.*, and a number of minute *Euglenæ virides* made their appearance among a group of ovules of this organism, carefully set apart in a vessel for development; there can, I think, be very little doubt that these cells, which are common in all the family, are in reality their ovules.

In the same page it is stated, that "instances however do occur where the ovules gain a cilium within the cell," &c. I doubt now if these are developments of the *ovules*, but rather products of the other development which I have shown to take

* Annals, vol. xviii. pl. 6. fig. 60 *a, b, c*.

place in *Euglena**, and consider analogous to, if not the same as, that described in the Characeæ and in *Spirogyra* (*loc. cit.*).

It should be remembered that in obtaining the ovules of *Euglena viridis* for development, they should not be forced out of the organism, but swept off the sides of the vessel an hour or two after the *Euglenæ*, together with some of the water in which they have been living, have been collected and set aside for settlement.

I have also met with another species of *Amœba* undergoing ovular development, viz. *A. verrucosa*, Ehr. (fig. 12), precisely like that which I have already described; the *Amœba* perishing as the ovules are developed, and ending in becoming a mere ovisac (fig. 13).

When first formed, the ovules, which are spherical, consist of a hyaline capsule enclosing a sphere of glairy, refractive fluid, like that of the ovules of *Spongilla* and *Euglena* (fig. 13 *a*); but as they begin to develope, this glairy matter becomes transformed into a granuliferous mucus which is spread over the inner surface of the capsule (fig. 13 *b*); and finally the granules present motion, whether of themselves or by aid of the mucus in which they are imbedded, I am ignorant, for thus far only have I seen the development; but I am inclined to think the next stage consists in the whole ovule becoming polymorphic, like the ovule of *Spongilla*. This *Amœba* appears to me—for I have watched the development of a group for many months together—to be the adult of my *A. quadrilineata*, and therefore the latter is not a new species. The formation and development of the ovules took place in April, and the organism appears to require at least nine months to come to maturity.

At p. 236 I have stated that I had observed "*Vorticellæ* developed singly from *Acineta*." This was from inference. I have since been able to follow the gemmules thrown off from the *Acineta*-form of *Vorticellæ* through their subsequent development, and in no case have seen them take on any other form than that of *Acineta*. The young gemmule at the moment of its exit is, as Stein has stated, exactly like the bud on *Vorticella*, but when pursued to its resting-place, I have always found it end in becoming an *Acineta*; so that this is not a true instance of alternation of generation. Others, viz. Drs. Lachmann† and Cienkowski‡, have arrived at the same facts; and these gentlemen also doubt the transformation of *Vorticella* into *Acineta*. Time will prove whether they or Professor Stein are right in this also; in the meanwhile I incline to side with the latter.

* Annals, vol. xvii. pl. 9. figs. 11–14. † *Idem*, vol. xix. p. 235, 1857.
‡ Quart. Journal Microscop. Science, No. 18. p. 96, 1857.

In the same page it is also stated, that the sudden contractile movement "of *Glenodinum* unites *Euglenæ* indirectly to *Vorticellæ.*" I now find that this is not the case, as the "movement" is not one of the whole body, or of the body at all, but of the cilium, which, floating posteriorly, like that of *Anisonema sulcata* and *Heteromita ovata* (Duj.), &c., every now and then fixes itself by its sucker-like extremity, and thus suddenly checks the progression of the organism. Whether the long cilium is also used for progression, or whether this is performed by the aid of the "minute vibratile cilia" noticed and figured by Dr. Allman*, I am ignorant; but there does not appear to be a second large cilium for this purpose, as in the animalcules just mentioned.

Chara.—At p. 237, pl. 7. figs. 93–98, in the additional matter which I have given respecting the development of monads from the cell-contents of the Characeæ, it is stated that they are derived from the nuclei which are found free in the protoplasm and in the rhizopodous or polymorphic cells which exist in it (fig. 93 *a*); the nuclei becoming granular (94 *d*, 96 *b*), and the granules finally passing into monads; and this may still take place; but for the most part it now appears to me that it is the old protoplasm which becomes divided up into monads, after having first abstracted the starch from the dead chlorophyll and converted it into oil, the oil then appearing in a granular form enclosed within the monads; hence the origin of the "granules" (94 *d*, 96 *b*, 98 *a*) mentioned at p. 238.

In the same page I have alluded to the "mulberry-shape of the plasma," which we must now consider as the protoplasm (96 *a*, 97 *a*, 98 *b*). This derives explanation, I think, from the tendency of the protoplasm to assume an actinophorous form, and the radii at the time the pellicula covering them is about to become hardened, not being entirely retracted, but remaining in the pouch-like form which produces the mammillated or mulberry-surface mentioned. That this does take place is frequently evidenced by the whole surface remaining actinophorous; and indeed it is only an instance of the way in which the peculiar forms of many structures are produced, viz. by the hardening of the pellicula upon the shape assumed by the protoplasm. It is therefore not difficult to conceive, when the protoplasm and oil are subdivided into monads inside this mulberry-shaped capsule, how the "granules," which are in fact oil-globules surrounded by protoplasm, should get into these pouches (98 *a*).

As regards, therefore, impregnation or ovular development being connected with this process, we now see that both are out of the question; but still we have to account for the disappear-

* Quart. Journal Microscop Science, vol. iii. p. 24. pl. 3. fig. 9, &c.

ance of the "nuclei." These, however, might also secrete a pellicula round themselves, and undergo the same kind of division as the protoplasm, for they are endowed with a considerable degree of contractile power, though not so active as that of the protoplasm. Certain it is, that cells containing no nucleus, as well as a cell containing one or more, will each produce a litter of monads.

These additional observations on the development of monads from the cell-contents of the Characeæ will be better understood after perusing the abstract of my paper entitled "Transformation of the Vegetable Protoplasm into *Actinophrys*," to which I have already alluded*.

EXPLANATION OF PLATE I.

Fig. 1. *Spongilla alba*, growing from the seed-like body: *a*, seed-like body; *b, b, b, b*, investing membrane charged with small spiniferous spicules; *c, c*, parenchyma, consisting chiefly of globular, ampullaceous sacs (8 to 10-5600ths of an inch in diameter), and large, smooth spicules; *d, d, d*, bundles of smooth spicules supporting the investing membrane; *e, e*, openings of the afferent canals; *f, f*, dark points representing the apertures of the investing membrane; *g*, tubular vent of the efferent system of canals.
N.B.—All the parts of this figure have been drawn upon the same scale, in order that their relative proportions might be preserved as much as possible.

Fig. 2. Fundus of ampullaceous sac, representing the arrangement of the sponge-cells in its substance; the white or transparent lines indicating the intercellular substance; the central circle, which cannot be seen in the same focus, pointing out the position of the aperture on the opposite side. Sac $\frac{1}{560}$th of an inch in diameter; aperture or mouth $\frac{1}{1400}$th of an inch in diameter. This figure is too elaborate: the sponge-cells should have been a little fewer and larger.

Fig. 3. Aperture or mouth of ampullaceous sac, showing the faint radiating lines which appear when the sac is beginning to waste from want of nourishment.

Fig. 4. Sponge-cells of the ampullaceous sac, as seen after the *Spongilla* has been torn to pieces: *a*, unciliated, *b*, monociliated forms (active or secondary); *a'*, *b'*, passive, spherical or primary, forms of ditto. Unciliated cell from 2 to 3-5600ths of an inch; monociliated cell from 1 to 2-5600ths of an inch in diameter.

Fig. 5. Ideal section of an ampullaceous sac: *a*, diaphane, or cortical layer (the existence of which is inferred, partly from the isolated sac, fig. 9, presenting something of the kind); *b*, monociliated sponge-cells with their cilia projecting into the interior; *c*, aperture. In this state this sac may sometimes be seen isolated, but with the aperture closed, though the cilia are still undulating interiorly.

Fig. 6. Portion of investing membrane illustrative of its apertures: *a*, aperture fully dilated, showing the tubercle in its margin (nucleus of

* Annals, vol. xix. p. 259, 1857.

the cell in which the aperture is situated?); *b*, aperture half-closed; *c*, wholly closed; *d*, characteristic sponge-cell of investing membrane; *e*, portion of a spiniferous spicule.

Fig. 7. Group of sponge-cells of the investing membrane illustrating their arrangement *in situ*.

Fig. 8. Figures illustrative of the development of the spicule: *a*, nucleated sponge-cell bearing a spicule $\frac{1}{400}$th of an inch in length, and of extreme thinness; *a'*, sponge-cell bearing a still younger spicule, $\frac{1}{1400}$th of an inch in length, on which is seen the inflation; *b*, ditto, with the spicule more advanced; *c*, spicule still more advanced, showing the passage of the shaft through the inflation, thus proving that the latter is the outer layer of the spicule, and that the spicule is formed of layers deposited from within outwards; *d*, fully-developed smooth spicule; *e*, *f*, *g*, varieties in the position and number of the inflations, and in the development of the shaft, which are endless; *h*, central portion of a spiniferous spicule, showing two spines projecting from the inflation.

Fig. 9. Isolated ampullaceous sac ($\frac{1}{700}$th of an inch in diameter), which, having left the parent mass of *Spongilla*, has become amœbous and actinophorous, presenting a cortical transparent portion (the diaphane) externally, and the sarcode charged with granules internally.

Fig. 10. Monociliated sponge-cell, after the constituent cells of the mass of *Spongilla* have separated to seek an independent existence for themselves: *a*, *a*, dotted lines showing the movement of the surrounding particles of carmine in the direction of the arrows; *b*, a particle caught up and enclosed by a projection of the cell, as in *Actinophrys Sol*; *c*, "granule;" *d*, contracting vesicles; *e*, pedicle of attachment, which can be withdrawn at will. Cell from 2 to 4-5600ths of an inch in diameter.

Fig. 11. Section of a spherical group of the *Uvella*-form of sponge-cells seen under similar circumstances (group $\frac{1}{700}$th of an inch in diameter): *a*, isolated group of three polymorphic cells; *b*, fixed isolated on eproducing the same kind of currents with its cilium, &c., as fig. 10 ($\frac{1}{3733}$rd of an inch in diameter).

Fig. 12. *Amœba verrucosa*, Ehr., $\frac{1}{224}$th of an inch in diameter: *a*, vesicula; *b*, nucleus. This Rhizopod generally contains a large portion of *Oscillatoria* or a rotiferous animalcule for food, which has been left out here for clearness. One of its characteristic features is the elliptical form of the capsule of the nucleus or "nuclear utricle," while the nucleus ("nucleolus") is spherical, and frequently presents vacuoles.

Fig. 13. The same, transformed into an ovisac partly filled with spherical ovules in the granuliferous stage of development. Ovisac or effete animal $\frac{1}{136}$th of an inch in length; ovule $\frac{1}{1366}$th of an inch in diameter: *a*, early or nucleated form of the ovule; *b*, in granuliferous stage of development.

Fig. 14. *Euglena viridis*, filled with ovules; compressed vertically; presenting the granular, capsuled nucleus, and the vesicula with its sinus.

Fig. 15. Three figures to show how the fluid is expelled from the vesicula: *a*, undistended state of sinus after it has just filled *b*, the vesicula; *a'*, sinus again becoming distended, and pressing out the contents of *b'*, the vesicula; *a''*, fully-distended state of the sinus which has thus nearly emptied *b''*, the vesicula, preparatory to again discharging its contents into the latter.

Fig. 16. Ovules of *Euglena viridis* (2 to 2·5-5600ths of an inch long), presenting the "granule" on their circumference, like those of *Spongilla*. (See 'Annals,' vol. xviii. pl. 6. fig. 39, &c.)

Fig. 17. Ditto in supposed process of development, presenting a spiral line: *a*, view of flat surface; *b*, half-view of ditto; *c*, marginal view, showing the projection of the ovule in the direction of the axis of the spire.

Fig. 18. Young colourless specimens of *Euglena* (2 to 3-5600ths of an inch in diameter, which made their appearance in the watch-glass wherein the ovules of *E. viridis* had been placed for development.

Fig. 19. *Euglypha pleurostoma*, H. J. C. (*nov. sp.*?), $\frac{1}{500}$th of an inch long: *a'*, mouth with projection of tentaculiform prolongations of the body; *b'*, body; *c'*, vesiculæ or contracting vesicles; *d'*, nucleus. *a*, lateral view of ditto; *b*, ditto partly filled with ovules; *c*, early state of ovule, $\frac{1}{2800}$th inch in diameter; *d*, subsequent or granuliferous stage of development of ditto; *e*, development similar to that described and figured in *Euglypha alveolata*, in which there appears to be a secondary test developed round a capsule containing granules (see Annals, vol. xviii. pl. 5. figs. 32, 33); *f*, empty test containing supernumerary scales; *g*, ditto, covered with scales *in situ* (scale $\frac{1}{5600}$th inch in diameter); *h*, form and arrangement of the scales; *i*, lateral view of figure *e*, but with secondary test more elliptical.

V.—*Notice of the Animal of* Turbo Sarmaticus *and other Mollusca from the Cape.* By ARTHUR ADAMS, F.L.S. &c.

To the Editors of the Annals of Natural History.

Cape of Good Hope, April 11, 1857.

GENTLEMEN,

Dr. Gray having formed a genus out of the *Turbo Sarmaticus*, on account chiefly of its singular operculum, I was particularly anxious to observe the animal. Making a little excursion therefore to Millar's Point, a wild and rocky spot, I succeeded, after long search, in discovering the haunts of the animal. At low-water, and in fissures in the far-out rocks abounding with green sea-weed, and adhering to the sides of the granite masses where the sea breaks, the *Turbo Sarmaticus* may be found. It is timid, slow-moving, and difficult to observe. The colour is green, spotted and marbled with white, and finely reticulate with dark green. The margin of the mantle is thickened, and just within the edge a dark-green band reposes on the dark-coloured zone on the inside of the outer lip. The rachis of the lingual membrane (a specimen of which I have submitted to the examination of Dr. Gray) has a series of five nearly equal, square teeth, outside of which is a quadridentate, lateral tooth flanked by numerous slender uncini. The upper jaw, composed of two long, cartilaginous pieces, is protected at the tip by a horny