

ART. LIV.—*The American Spongilla, a craspedote, flagellate Infusorian*; by H. JAMES-CLARK, A. B., B. S., Prof. Nat. Hist., Kentucky University, Lexington, Ky. (With a Plate).

THE argument of Hæckel, and others, that the Sponges are essentially compound Polypi, is virtually based upon the assumption that the minor (afferent) and major (efferent) ostioles of the former correspond to the mouths of the latter; and that the profusely branching afferent and efferent canals of the Sponges are strictly comparable with similar canals in the polypidom of Halcyonarians; and, by implication, that the cilia-bearing cells of the interior, lining-wall of the Zoöphyte find their homologues in the ciliated, cell-like bodies of the interior chambers of the Porifera. If, now, it should turn out that these last are not altogether mere cell-components of a tissue, but are each, severally, an independent body, although closely connected with others in a common bond, then the attempted parallelism between the two groups must utterly fail of confirmation. The tendency of Carter's later investigations, and our own too, is to show that this is no vain supposition.

For ourselves, we hold that each *ciliated body* of the Sponge is a *cephalic* member (a *cephalid* in this case) of a polycephalic individual.\* We believe, as far as we can understand his undecided, rather hesitating position, Carter's latest decision is, that the Sponge is a community of Amœbous individuals,† and not a polycephalic unit. Yet, whichever view prevails, the tendency is the same, and the Polyp theory is negatived most unquestionably. The incompatibility of the interior organisms of the two groups, above mentioned, is so great that it would seem as idle to elaborate a proof of it, as to attempt the demonstration of an axiom. The question is really circumscribed,

\* See our article on "*Polarity and Polycephalism*," this Journal, January, 1870.

† See Carter, *On Fecundation in the two Volvoes; on Eudorina, Spongilla, &c.* Annals and Magazine Nat. Hist., January, 1859; also for July, 1871, *On new Sponges, &c.*

according to the method of Hæckel, to arguing that, since a system of branching canals in the Sponge reminds one very strongly of the intricate network of passage-ways in the basal parts of certain Polyps, therefore the two are homologous, and bear an identical relation to the rest of the organism. Carter (*On new Sponges, &c.*, Ann. Mag. Nat. Hist., July, 1871) has answered this far-fetched homology with considerable detail in a recent paper; and we do not, therefore, feel called upon to add more to it.

The principal aim of this article is to furnish new material in proof of the polycephalism of the Spongiaë, and particularly in regard to their relation with the *Protozoa Flagellata*. We are highly pleased to find that Carter has lately (ut sup., July, 1871) confirmed our earliest observations\* as to the organization of the collar-bearing monads of *Leucoselenia*, by an investigation of *Grantia compressa*. He has also accepted our interpretation of the horn-like processes of the sponge-cell of *Spongilla alba*; that they are the outlines of a membraneous collar in profile.

We have now to bring forward a fourth example of a *craspedote*, flagellate monad-cephalid in a Sponge. It seems to be a *Spongilla*, but specifically, at least in its monads, it differs from the English forms. For convenience sake, we will call it *Spongilla arachnoidea*, from its resemblance to an irregular spider-web. It lives in fresh water streams and ponds, usually about the bottom of the stems of water-plants, or wherever there is considerable shade; apparently avoiding the light, as we seldom, if ever, found it in open water. In size it varies from a few inches to half a line in diameter: of no definite shape; and has a uniform fuscous or yellowish-brown color; and is wrapped about by a filmy, transparent, colorless envelope ("investing membrane" Carter). The brown color is inherent to the interior mass, in which the groups of monads are imbedded; in fact the latter are themselves as strongly colored by brown granular contents. The "investing membrane" is also slightly tinged with amber color by the large and small spicules which are imbedded in it. Excepting in very small specimens, foreign matter is often so thickly spread over the surface as to obscure the view and seriously interfere with a correct interpretation of the relation of parts. We have been most fortunate in our endeavors with the minuter individuals, which occasionally, we found, would allow a view through and through their entire bulk, and of course left full opportunity for a satisfactory study of the details of special parts, without our resorting to the dissecting needles. Anyone who knows, by experience, the intense contractility of the living sponge, can appreciate the ad-

\* Memoirs Boston Soc. Nat. Hist., vol. i, 1867, "On the Spongia Ciliata as Infusoria Flagellata."

vantage of not being obliged to destroy and sever parts of an organism from their natural relations. Premising thus, that everything has been studied "in place," even to the details of the monads, we shall endeavor to describe this sponge as if it were to be the type for future comparison.

*General plan.*—The whole individual sponge is endowed with a double envelope (fig. 1 *a, a'*, *c, d*), the outer and inner parts of which are directly continuous into each other at many points. The outer division (*a, a'*) lies at a considerable distance from the monadigerous mass (*g*), and is, as it were, suspended on the points of the larger, far-projecting spicules (*e*); just as a tent canvas is supported on the ends of poles. The inner division (*c*) closely embraces the monadigerous mass like an epidermis, and even plunges between the hollow groups of monads, forming to them a basis of support. The outer and inner divisions are continuous with each other at many points, as stated just now, but only where the larger spicules project. There the envelope (*d*) runs along the spicules, completely embracing them, as if in a sheath, from their tips to their bases, where they rest on the brown mass of monads. In brief, we might say that the sponge is covered with a miniature colonnade, whose ceiling is the outer division of the envelope, the pillars are the bundles of spicules, and the floor is tapestried by the inner division, which about the pillars hangs from the ceiling in lofty folds. The continuity of the outer division of the envelope is broken by numerous, round or oval openings, of various and frequently changing sizes, sometimes very large, which allow a free ingress of the water to the space just beneath. These are the *afferent ostioles* (*os*), through and into which a constant current of floating particles may be seen moving with considerable vivacity. Here and there, scattered at wide distances, finger-like, hollow processes from the outer division arise singly, and at various angles. Each is terminated by a large aperture, the *efferent ostiole*, from which a current of water and floating matter emerges with more or less spasmodic irregularity. The smaller individuals, from half a line to half an inch in diameter, possess only one such ostiole; and those an inch in diameter seldom have more than two or three like conduits; but they are very large, sometimes a quarter of an inch in length when fully extended, and of the proportions and taper of the human forefinger.

Plunging the focus of the objective to the floor of the colonnade, the inner division (*c*) there is found to be pierced by much more numerous openings (*i*), but far smaller in diameter, and quite methodically arranged, each one corresponding to and overlying a hollow group of monads (*h*). The outer division is further embellished with irregularly scattered minute

spicules ( $e^1$ ), which lie imbedded in the cytoblastema, parallel with the surface of the envelope, and occasionally crossing each other at various angles. To complete this general sketch, we will state more definitely the relation of the constituents of the monadigerous mass. There are essentially but two elements here; namely, the inner division ( $c$ ) of the investing membrane, and the groups of monads ( $h$ ) which are imbedded in it, below its surface. In a fully expanded individual these groups seldom lie so closely as to touch each other. They vary considerably in size and are usually globular or spheroidal, and form a single *stratum*, with rather narrow interspaces ( $c^1$ ) between them.

It seems proper here, at least for the sake of precision, that the *cytoblastematous basis*, in which the monad groups are imbedded, should be considered apart from the epithelium-like, inner ( $c$ ) investing membrane which overlies it, although the two are essentially one; the epithelioid membrane, by prolonging itself between (at  $c^1$ ) and beneath the groups, forming for them a continuous foundation. In this light, then, we shall speak of the monadigerous mass as consisting of three elements, namely, the inner investing membrane proper, the group of monads, and the *cytoblastematous basis*. This *basis* seems to constitute a large part of the bulk of the body, since it occupies all of the interior space beneath the monad groups. In specimens which grow over flat surfaces in depressed patches, or around stems of plants, it forms a relatively thin layer; but where the body stands out an irregularly rounded mass, sometimes an inch in diameter, the cytoblastematous basis fills up the interior, in enormous proportion to the bulk of the monad layer.

#### ORGANOGRAPHY.

*The Investing Membrane.*—The *investing membrane* (fig. 1,  $a$ ,  $a^1$ ,  $c$ ,  $d$ ), consists essentially of two histiological elements, namely, a very diffuse *cytoblastema* ( $a^1$ ) and irregularly disposed cells ( $b$ ,  $b^1$ ,  $b^2$ ) scattered through it. The intercellular *cytoblastema* forms a very thin layer ( $a^1$ ) between the cells ( $b$ ); but where the latter are imbedded in it, its outer and inner faces are as wide apart as the considerable depth of the cells demand; and thus it happens that the membrane (both the outer and the inner divisions) presents in profile ( $a^1$ ,  $c$ ,  $d$ ) such an irregular thickness. The *cytoblastema* ( $a^1$ ) is colorless, hyaline, and apparently homogeneous under a low power; but, when magnified to about four hundred diameters, it displays a very finely granular aspect. It occupies wide intervals between the cells, certainly more than one-half, and fully three-fifths of the whole area of the membrane. Its apparent extent, in a general view, is even more

than that, owing to the extreme transparency of the cells, and their consequent inconspicuousness. That the cytoblastema, notwithstanding its low undeveloped state, is the true contractile element in this membrane, there can scarcely be a doubt, when we consider both its wide spread preponderance, and its relative continuity, as contrasted with the scattered, disconnected condition of the cells ( $b^2$ ) which are imbedded in it. Sometimes it is barely possible to discover even the trace of a cell on the border of an afferent ostiole ( $os$ ), and in that case we must infer, inevitably, that it is cytoblastema which opens and closes the aperture. We find it, too, embracing the extreme tips of the larger spiculæ, where the cells utterly fail to appear.

The *cell-element* ( $b$ ) of this membrane is also in a lowly condition; only partially developed. There is no *cell-wall*. What may appear to be a wall is really the thin stratum of cytoblastema ( $a^1$ ) overlying the distal and proximal faces of the cell. This is our conclusion after the most critical scrutiny, with a carefully-corrected objective. Were it not, indeed, for the usually constant presence of a distinct nucleus ( $n$ ) in each cell, we would be strongly inclined to look upon it as merely a dense collection of coarser granules than are generally diffused through the cytoblastemic layer. The irregular and jagged outline, and the caudate projections of the cells ( $b^2$ ) also tend to tempt one to the latter view. The cell element in this case, then, corresponds only to what is usually considered the cell contents, and a nucleus. The contents are composed of coarse and fine grey granules, which at times are quite conspicuous, but most frequently are so transparent and slightly refractive as to appear, collectively, unless specially focussed upon, as a faint blotch in the investing membrane. This renders it all the more difficult to trace the outline of the cell, and particularly where it throws out irregular, caudate prolongations, to blend with those of other cells. We have been able to detect but one layer of cells in this membrane\* when it is well stretched out. The depth of the cells, as may be seen in a sectional profile view ( $b$ ), is about equal to their breadth, and their length is from one-half more than to twice their breadth; but frequently they are as broad as long. They stand in no particular relation to the ostioles; and, as stated above, sometimes scarcely touch their border. The *nucleus* ( $n$ ) may be readily detected by its peculiar, strong refraction, and its considerable superiority in size over the granules. Its bright refractiveness in this connection reminded us of a contractile vesicle, but, although suspecting it of such a function, we could detect no change other than might be produced by the varying length and breadth of the cell, and the

\* Carter figures two or three cells overlying each other in *Spongilla alba*. Ann. Mag. Nat. Hist., July, 1857, Pl. 1, fig. 7.

shifting of the relative position of the coarse granules. In the *inner division* (*c*) of the investing membrane the cells are usually smaller than those in the outer division, but differ in no respect, otherwise, neither in form nor arrangement. They lie flat on their sides in the cytoblastemous layer; but, except in profile, they are most difficult to discover on account of the underlying brown mass of monad-groups and granular interstitial substance.

Although we have been unable to discover any distinct cell elements in the cytoblastematous mass immediately around and beneath the monad groups, neither have we found it possible to distinguish it from the cytoblastema lying on the surface; and since the continuity between the two is unbroken, we must, perforce, consider them as one. The underlying portion of the cytoblastematous mass, however, is characterized by irregularly scattered, moderately coarse, brown granules (*c*<sup>1</sup>). These serve very well as a dark frame or setting to the monad-chambers (*h*), and by contrast brings them out more strongly.

*The Monad-cephalids*.—We now proceed to describe the most essential feature of this animal, the *monads*. They are the characterizing, the dominating element, in reference to which the whole organism is contrived and constructed. They are not cells; they are the *heads* of a polycephalic individual, and consequently correspond functionally to the tentaculated heads of Polypi, and not to their interior epithelial cells. We must first describe what we call the monad-chamber.

The *monad-chambers* (fig. 1, *h*; fig. 2; fig. 4) are deep, spherical hollows which form the receptacles of the groups of monads (*j*). They are mere cavities, and have no lining wall.\* They may be easily recognized, in young specimens, as clear, more or less circular, areas scattered in pretty close proximity to each other over the "cytoblastemic mass." Each chamber has a single, small, circular aperture (*i*) which perforates the inner (*c*) investing membrane, and allows egress into the circulatory apartment (*f*). The aperture (*i*) varies in size at times, and may, even, be completely closed. We have never seen it open wider than one-third the diameter of the chamber, and very rarely more than one fifth as wide. That it is a true perforation, and not a clear spot, may be demonstrated by bringing a chamber into profile, so that its aperture (fig. 4, *i*) lies on the extreme border, and then an actual break in the continuity of the investing membrane becomes evident.

\*The hollow groups of monads were originally described by Carter (Ann. Mag. Nat. Hist., July, 1857) as lining an hypothecated vesicle, which he named the "ampullaceous sac." He has since (Ann. Mag., Jan., 1859) revoked that view and adopted another. We believe him to be, excepting the inferred "ampullaceous sac," in the main, right in his first interpretation; but as our species are different we cannot speak definitely.

Entering this aperture we do not meet with any obstacle for a little distance around it; there is a clear open space (fig. 4); but pressing onward beyond that, either to the right or the left or directly forward, the cavity appears filled by a collection of vibrating bodies. They seem to be arranged radiatingly from and about the center. Close inspection, however, modifies this view, and it turns out that they are based upon the periphery of the chamber, and converge toward its center, where is a small unoccupied space. We presently recognize these converging bodies to be *craspedote, flagellate monads* (*j*), so closely packed together, side by side, as to form a continuous *stratum* (figs. 2 and 4) over the whole concave face of the chamber, excepting immediately about the aperture. Every feature of the monad is strongly marked; even the cylindrical collar is so heavy and conspicuous that its outlines may be seen with as low a power as two hundred diameters. We have studied these bodies with an  $\frac{1}{8}$ th-inch objective, and found it not at all difficult to focus down upon the details of their organization, without pressing upon or even touching the specimen.

These monads are in every general essential identical with those which we originally found in *Leucoselenia*, and like those, also, recently described by Carter (Ann. Mag. Nat. Hist., July, 1871), in *Grantia compressa*. They are attached to the concave face of the chamber by their posterior end (fig. 4, *j*); and the anterior extremity, with its flagellum (fig. 3, *l*) and collar (*k*), projects freely into the open space, and toward the center of the apartment. When fully expanded, the length of the body and collar together is about one-third, or a little more, of the diameter of the chamber; so that nearly one-third of the latter is unoccupied at the center, except by the tips of the flagella converging from every direction. As the monads lie touching each other on every side (fig. 2), they mutually flatten their bodies, sometimes so much as to give them a strong polygonal outline; or, when the whole mass is expanded, they scarcely impress each other, and therefore retain a rounded contour. By plunging the focus so as to look into the aperture of a chamber, down upon the monads at the bottom (fig. 2) of it, an end view of each cephalid is obtained. From this point the foreshortened cylindrical collar looks like a strong, dark circle (fig. 3<sup>a</sup>, *k*), which retains its conspicuousness as we plunge down further, even to the base, where it is attached to the body (*j*). The outline of the latter is considerably without the "dark circle," the two being concentric to each other. At the same time we see in the center of the dark circle a black spot (*l*) which may, also, be focussed up and down upon, and hence it is inferred to be a continuous line foreshortened. Other views (fig. 3, *l*) confirm this, and show that it is a single *flagellum*.

The monads are so transparent, and the organization so distinct, that the collar and flagellum may be seen clearly from an opposite point of view, looking directly through the body of the cephalid. This, too, is the best position from which to study the *contractile vesicles*.

A sectional, profile view of a group (fig. 4), to be obtained by plunging the focus half way through a chamber, serves best to disclose the manner in which the posterior ends (*j*) of the monads are affixed to the concave face of their receptacle: and we, also, here obtain a strictly profile aspect of a monad. Figure 3 is such a view, representing a single cephalid, under a much higher power than in figures 2 or 4. An excellent and least obstructed side-view, but not strictly a profile, is to be had by focussing upon the monads immediately about the aperture of the chamber. Here we look directly into the door-way, or through the bordering, transparent epithelioid membrane which it penetrates.

The body, proper (fig. 3, *j*), of a cephalid is a little shorter than it is broad; on the whole spheroidal in shape. Its posterior end is broadly rounded, and so is its anterior extremity. In front arises a cylindrical, membranous "collar" (*k*), which tapers slightly and projects forward to a distance equal to considerable more than twice the length of the body. Its diameter is not more than two-thirds, or even less than that of the body. Although colorless, and homogeneous, it is remarkably conspicuous on account of the thickness of the membrane of which it is composed. Near its open extremity it is more transparent and less obvious than toward its basal attachment.

The *flagellum* (*l*) arises from the center of the anterior end of the body, in the midst of the area which is surrounded by the membranous cylinder (*k*), and without tapering extends a little farther than the open end of the latter. It vibrates usually throughout its length, but is most active near its tip. We have never seen it assume a rigid, arcuate position, as in some other species of monads. It is particularly remarkable for its want of transparency, and looks like a black thread more than any vibrating cilium that we have ever met with. Its action, at times, is rather that of a strong wriggle than a vibration.

The *contractile vesicles* (*v*).—The body of the monad is distinctly marked by a coarse, scattered, brown granulation, with two or three rather large, clear spots, at a considerable distance from each other, but always close to the periphery. These clear areas are the *contractile vesicles* (*v*). They do not occupy any particular place in the body, although they, usually, are not in front. The systole and diastole are extremely slow, but very distinct, if sufficient patience is summoned to watch them fixedly, and without interruption. The last third of the systole is

abrupt, and then only does the vesicle appear to contract suddenly; whereas by watching it through a complete circuit of diastole and systole, one learns that its function is, on the whole, performed very slowly. This very abrupt movement, quite happily, may serve to rebut any such objection as that the otherwise tardy action is merely the result of protoplasmic contraction of the body, as in certain Palmellate Zoöspores. Their immovable position, as regards the body contents, is another item of rebutting evidence.

The *Spiculæ* (fig. 1, *e*, *e'*) are very slender, slightly curved, needle-shaped bodies, gradually tapering to a sharp point at each end. They have a bright amber color, and a rather dark, strongly refractive outline. From tip to tip they are slightly roughened by irregularly scattered, low, but acute prominences or knobs. There are two kinds of spicules, large and small, but they differ in no other respect. The larger (*e*) are from four to six times longer and thicker than the smaller ones. They occur in bundles of two, three or four; and act as props to hold up the outer investing membrane, as described in the early part of this article. They seldom arise perpendicularly from the monadigerous mass, but more or less obliquely; and, in forming bundles, stand across each other like stacked arms. We seldom found spicules penetrating the monadigerous mass far beyond the epithelioid, inner investing membrane. They evidently belong, universally, to the investing membrane, and assist it in forming a framework in which the inner mass is suspended. The *smaller spicules* (*e'*) are strictly confined to the outer division (*a*) of the investing membrane, and lie there on their sides, completely immersed in its thickness. They are scattered irregularly and sparsely about, and frequently cross each other at varying angles. We observe no nearer approach to a methodical arrangement among either the large or the small spicules; yet their very irregularity, being after a kind, and constant in that kind, may be recognized in some sense as methodical.

*General considerations.*—Seeing the secluded position of the monad-cephalids, deeply ensconced in little chambers below the general surface of the circulatory apartment, it is not directly evident that their *flagella* have any agency in keeping up the inflow and outflow of currents through the afferent and efferent ostioles. Nowhere else are vibrating or non-vibrating cilia or cilia-like bodies to be met with than in the monad chambers. And since the efferent ostioles are irregularly interspersed among the much more numerous afferent ostioles, we cannot conceive how the flagella in any way could influence currents to move in a particular direction, from the smaller apertures toward the larger ones. They no doubt keep up a direct flow

of matter into the sunken chambers, but the current comes from the inner depths of the circulatory apartment, and far away from the ostioles. In this way only a turbulence of floating matter is sustained, but the general, great current is due to a far different cause. We conceive that the contraction and expansion of the body-mass in general, modified by the alternate opening and closing of the afferent and efferent ostioles, is the true motive power in this phenomenon. We have observed, often, that the outer division of the investing membrane is not kept at a uniform distance from the central, monadigerous mass; at one place it will be found to be close to its inner division, so that the circulatory apartment is very shallow there, while at another point the two divisions of the membrane are widely separated, and the circulatory apartment is very deep; and between the shallow and the deep apartments a curtain is drawn, more or less completely, extending from one pillar-like bundle of spicules to another. Each of these temporarily enclosed portions of the general apartment, it is plain now (although our actual observation on this point is very defective), may contract or expand without disturbing the contents of any other. Such an apartment with its afferent ostioles closed, may be contracting and forcing a current out at its efferent ostiole, while a neighboring apartment may have its efferent ostiole closed, and expanding, draw in current through its open afferent ostioles.

We regret that we have not the means, in this locality, for completing these researches. Our specimens were gathered, and studied on the spot where they lived, in the western part of Massachusetts, several hundred miles away from our present residence. Unfortunately we put off the attempt to feed the sponge with colored matter until we had completed other methods of investigation, and then we were prevented, by circumstances, from carrying out our designs.

In regard to the afferent and efferent canals, seen by Carter (Ann. Mag. Nat. Hist., 1857, *ut sup.*) in the monadigerous mass ("*parenchyma*" Carter), we have not met with any trace of them in the species described in this article. It is possible that they may exist in the oldest and largest individuals, but as we worked, only, on very small and transparent specimens, our direct observations, in this respect, strictly apply to the latter. It is more likely that ours is a different genus from the *Spongilla* of Carter, in favor of which we cite the curious fact that each aperture, in the inner division (not mentioned by Carter) of the investing membrane, exactly overlies and is inseparable from the entrance to a monad-chamber ("*ampullaceous sac*;" *partim*, Carter); so that whatever enters these chambers must go out by the same way that it came in; not out into a system of

branching canals, burrowed in the monadigerous mass, but into the great circulatory apartment.

*Spongilla arachnoidea* Jas-Cl.

DESCRIPTION OF FIGURES OF PLATE II.

The following letters apply to identical parts in all of the figures. *a*, Investing membrane; outer division.—*a'*, Sectional profile of the cytotlastema of *a*.—*b*, Cells in the thickness of *a*.—*b'*, Cells (like those at *b*) about the spicules (*e*).—*b''*, Cells of the investing membrane, with their nucleus; a surface view.—*b'''*, Temporary junction (by contact only) of the outer (*a*) and inner (*c*) divisions of the investing membrane.—*c*, Investing membrane; epithelioid inner division, in sectional profile.—*c'*, Interspaces between monad-chambers.—*d*, Junction of the divisions of the investing membrane along the spicules.—*e*, Larger spicules.—*e'*, Smaller spicules.—*f*, Circulatory apartment.—*g*, Monadigerous mass.—*h*, Monad-chambers and monad groups.—*i*, Aperture of *h*.—*j*, Monads, or the body proper in figs. 3 and 3*a*.—*k*, Cylindrical collar of *j*.—*l*, *Flagellum*.—*n*, Nucleus.—*os*, Minor ostioles.—*v*, Contractile vesicles.—

Fig. 1. Magnified 320 diameters. Part of a very young *Spongilla*, of an oblate spheroidal form, and about  $\frac{1}{5}$  of an inch in diameter. On the right is presented a face view of the investing membrane and the underlying monadigerous mass, On the left the focus is so adapted as to be fixed on a face-view of the monad-mass, and at the same time on a sectional profile of the investing membrane at *a'*, *b'*, *c*, and *d*.

Fig. 2. Magnified 780 diameters. Interior of a monad-chamber, seen through the aperture; the monads appear in end view, and crowded together side by side like a pavement work.

Fig. 3. Magnified 1,600 diameters. A single monad, as seen in profile in the monad-chamber. Only two contractile vesicles were present in this specimen. The cylindrical collar (*k*) is extended to its utmost.

Fig. 3*a*. Magnified 1,600 diameters. Foreshortened, front view of a monad; the body (*j*) in the distance; the hollow cylinder (*k*) projecting toward the observer like a dark hoop, and the *flagellum* (*l*) in the center appearing as a black spot.

Fig. 4. Magnified 780 diameters. Sectional view of a monad-chamber, bringing the aperture (*i*) into profile, as well as the monads which lie at the same level; thus showing their convergence about the central open space.

