MEMOIRS

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PART III.

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IX. *On the* Spongiæ Ciliatæ *as* Infusoria Flagellata; *or, Observations on the Structure, Animality, and Relationship of* Leucosolenia botryoides, *Bowerbank*.[1] *By* H. James-Clark, A. B., B. S. Professor of Natural History in the Agricultural College of Pennsylvania.

Read June 20, 1866.

I HAVE been engaged, like others, for some time past, endeavoring to clear up the doubt which prevails in the scientific community in regard to the nature of the Sponge. The question has been, is it an animal or is it a plant? Bowerbank, the highest classificatory authority upon this subject, for a long term of years held that it was an animal, but his *bases* for this theory were such that they did not appear to offer a satisfactory means of finally deciding the dispute. The latter remark applies with equal force to the investigations of Lieberkühn. Of later years Carter has made some special investigations in reference to this subject, and in fact he has been the first one to present any thing like decisive proofs of the animality of the Sponge. A few words quoted from his paper, which he published in the "Annals and Magazine of Natural History" for April, 1857, Vol. xx. p. 30, will suffice to show to what extent he has carried his observations. Speaking of the "monociliated sponge-cells of the ampullaceous sac," — which he says was set free by the disintegration of the whole mass of the sponge, — he remarks that "particles . . . . . were thrown [by the flagellum] almost point-blank on its surface and rapidly passed into the interior." Strangely enough, though, as it seems to me now, he does not look upon the intussusception of the particles as a genuine process of swallowing, like that which obtains among the ciliated infusoria, but describes it, in several places, when speaking of the various kinds of sponge-cells, as an enveloping of the food after the manner of *Amœba*. It is plain, therefore, that he does not believe that the "sponge-cells" are endowed with a *mouth*, and, moreover, if I am not mistaken, he attributes to any part of the "cell" the faculty of engulfing food. This interpretation, therefore, would exclude the Sponge from the list of *Flagellata*, notwithstanding the presence of the *flagellum*. That, however, does not weaken the proof as to the animality of this organism, but merely leaves it — as Mr. Carter believes it to be — in the most intimate alliance with the naked *Rhizopoda*; and, as if to confirm this conclusion, the same authority adds, "These monociliated sponge-cells present the contracting vesicle[2] in great activity, but also in variable plurality." I believe, however, that the "variable plu-

[1] A sketch of the contents of this memoir has already been published in the Proceedings of this Society for June 20, 1866; and in the *American Journal of Science* for November, 1866.

[2] Already noticed by him in 1847, in the *Trans. Bombay Med. and Phys. Soc.;* abstract in *Annals Mag. Nat. Hist.*, 1848.

rality" of the contracting vesicles does not alone belong to the *Rhizopoda*, but, as I shall show hereafter,[1] that it is also to be observed among the true *Flagellata;* and I would remark, moreover, that when we consider the close relationship — which I hope to prove in this paper — of the Sponge to the other flagellate, monad-like infusoria, which undoubtedly have a definite oral aperture, we must, if on no other grounds, conclude that it also possesses a true mouth.

Still there would appear to be some who doubt whether, after all, the Sponges are really animals instead of plants, and, moreover, seem to insist that they are neither the one nor the other, but form, with other infusorians — such as *Volvox, Gonium, Pandorina, Euglena,* and other conferva-like bodies — a group by themselves, standing intermediate to, and partaking of the nature of, both animals and plants. This is the group which has been called *Phytozoa,* i. e. plant-animals.

In the midst of this halting decision, I have been, for some years past, working upon a class of infusoria, the knowledge of whose structure fully prepared me not only to recognize the animal nature of the Sponge, but also enabled me to determine to what group of infusoria it belongs. Such a decision, therefore, does not leave any trace of doubt in my mind as to the strictly animal nature of the Sponges. The whole question in dispute hinges upon the determination as to the animal or vegetable nature of the Monad-like, or so-called flagellate infusoria. And here again I would say that it has fallen to my lot to decide, for the first time, that one of the smallest known of the infusoria, the Monad, (*Monas termo,* Ehr?) is an animal. If, now, we can prove this point, the way is perfectly clear through the intermediate forms which lie between the Monad and the Sponge.

Commencing, then, with what I believe to be the *Monas termo* of Ehrenberg, I shall proceed to describe in detail a series of forms — several of which are new, both generically and specifically — which stand in the closest relationship among the lowest embodiments of infusorial life, embracing among them, as I hope to show, the true ciliated sponges, and which, notwithstanding, lead in unobstructed, although varied courses,[2] to the more elevated kinds of *Protozoa,* the true *Infusoria Ciliata.*

§ 1. Monas termo, Ehr?

(Plate IX., figs. 1, 2, 3, 4.)

Upon a slight acquaintance with this infusorian, one would be strongly inclined to identify it with the younger stages of *Anthophysa Mülleri.* Bory. (fig. 49); but a more searching investigation reveals such a number of characters in each which are not to be found in the other that one need not have any hesitation whatever in setting them down as totally diverse organisms. In fact, *Monas* belongs to the uniciliate *Flagellata,* whilst the other genus just mentioned is a biciliate, heteronematous form.

Monas lives in two diverse conditions, of which one is a fixed state (fig. 3), and the other a free and motile stage (figs. 1, 2, 4). During its sedentary life it may be found in great abundance on the old stems of *Myriophyllum, Potamogeton, Ceratophyllum,* and other aquatic, phenogamous plants which inhabit quiet waters, and are more or less thickly covered by a floccose overgrowth of various minute *Confervæ, Diatomaceæ,* etc. In its free state it swims with either a sort of hitching, wriggling motion, or, gliding along smoothly, revolves at an

[1] *Salpingœca marinus,* nov. sp. § 8, and *S. amphoridium,* nov. sp. § 9.

[2] See the preliminary remarks upon *Anthophysa,* § 11.

inconstant but never rapid rate upon its longer axis, of which the flagellum (fig. 2, *fl*), which always precedes it, may be said to be a prolongation. This is the condition in which it is most frequently to be found after it has been kept a few days in an aquarium. It then gathers in swarms about decomposing matter, and thus affords frequent opportunity of seeing its mode of collecting and swallowing its food.

The *form* of the body in a fixed state (fig. 3) may be compared to a flattened heart, of which one summit is prolonged into a broad, conical, transparent beak (*lp*), and at the opposite end the apex is attached to a slender, flexible pedicel (*pd*), which frequently is equal in length to four or five times the antero-posterior diameter of the body. In a free condition (fig. 2) the posterior end is rounded and about as broad as the front, but still it presents the same lateral flattening as the fixed form. The prevailing color is a faint olive or yellowish green.

The *flagellum* (*fl*) is the only cilium-like organ which this creature possesses. It is attached to the front, close to the proximal side of the conical beak (*lp*), and consequently lies in the axial line of the body. In a quiet state, which it most frequently assumes during the fixed condition, it appears like an arcuate bristle, and extends from near its base to its apex in one uniform, slightly but distinctly curved line, and terminates without any very sensible diminution in thickness. The plane of its curve is in direct extension of the plane of the greater diameter of the body, and at the same time passes through the conical beak. During natation the flagellum takes precedence and vibrates with an undulating, whirling motion, which is most especially observable at its tip, and produces by this mode of propulsion the peculiar rolling of the body, which at times lends so much grace to its movements as it glides from place to place. During the fixed state of the body the chief design of the movements of the flagellum is the prehension of food; and this is accomplished by a peculiar, abrupt deflection of the end of this organ toward the *front*, by means of which particles of various kinds are made to impinge upon the region immediately at the proximal side of the base of the broad, conical beak; — a point at which, as will be seen presently, the mouth is situated.

The *mouth* (figs. 3, 4, *m*) lies between the base of the flagellum (*fl*) and the beak, or *lip* (*lp*), as I shall hereafter designate it, from its obvious office, presently to be described. A plane, therefore, drawn through the lip and the base of the flagellum, would also strike the mouth, and moreover form a continuation of that of the greater diameter of the body. This aperture is not visible during its closed state, but its presence has been often and unmistakably determined by seeing the masses of food enter invariably at the point designated above. As already stated, particles are thrown with a sudden jerk, precisely as is done by *Anthophysa Mülleri*, Bory. (figs. 50, 51), and apparently with great precision, directly against the mouth (fig. 4, *m*). If acceptable for food, the flagellum presses its base down upon the morsel, and at the same time the lip is thrown back (fig. 4, *lp*) so as to disclose the mouth, and then bent over the particle as it sinks into the latter. When the lip has obtained a fair hold upon the food, the flagellum withdraws from its incumbent position and returns to its former rigid, watchful condition (fig. 4, *fl*). The process of deglutition is then carried on by the help of the lip alone, which expands laterally until it completely overlies the particle. All this is done quite rapidly, in a few seconds, and then the food glides quickly into the depths of the body, and is enveloped in a digestive vacuole (*d*), whilst the lip assumes its usual conical shape and proportions.

The *contractile vesicle* (figs. 2, 3, 4, *cv*) is a much larger and far more active organ than that of *Anthophysa* (figs. 47, 48, *cv*). If we view the body from its narrower aspect (fig. 2), when it stands so that the lip (*lp*) is nearest the eye, the contractile vesicle (*cv*) appears in profile, on the left broad side, and so close to the surface that it seems to project beyond the general outline of the body. It lies in the anterior third of the broad side just mentioned, and close to the transverse plane which separates that part which contains it from the one upon which the lip is placed. From whichever direction, therefore, one views this organ, it will be seen to stand in an asymmetrical relation to the rest; and as it is preëminently a dominant feature, it may serve, perhaps better than any other, as a starting-point in determining the obliquity of the type of this infusorian, and its perfect consonance in this respect with that of the more obviously spiral forms, such, for instance, as are exemplified by *Dysteria* (figs. 77, 78) and *Pleuronema* (figs. 75, 76). It is so large and conspicuous that its globular form may be readily seen, even through the greatest diameter of the body; and contracts so vigorously and abruptly, at the rate of *six times a minute*, that there seems to be a quite sensible shock over that side of the body in which it is imbedded.

The *reproductive organ* may possibly be represented by the very conspicuous, bright, highly refracting, colorless, oil-like globule (*n*), which is inclosed in a clear vesicle, and appears to be so constantly present in the depths of the posterior third of the body. Its position seems to be invariably on that side of the transverse axial plane which is opposite to that in which the contractile vesicle (*cv*) lies. Nothing further of a positive nature can be said in regard to this body, but we may conjecture that, inasmuch as it cannot well be assigned to any other office, — not even to that of an eye-spot, — it is in all probability an organ of reproduction.

In regard to the *stem* (fig. 3, *pd*), it may be added that although it appears to be of the simplest nature, a mere gossamer thread as it were, it is none the less positive, as a support, than that of *Anthophysa* (figs. 47, 48, 49, *pd*), and must indeed possess a similar self-reliant power in order to keep the body in the same relative position in regard to the object to which it is attached, or to sustain it in an upright attitude at a time when the flagellum is quiet, and there is consequently no other means of preventing the animal from sinking down upon the nearest fixed point.

§ 2. MONAS NEGLECTA, nov. sp.

(Plate IX., figs. 5, 5^a, 5^b, 6.)

To a casual observer this species would appear to be one of the varieties of *Monas termo* of § 1, and I must confess that under an amplification of only five hundred diameters the mistake would be easily made, unless one had become perfectly familiar with the two by prolonged study with a much higher magnifying power. There is, though, a physiological difference which can be observed when all others could scarcely be noted, which is this: the rate of the systole of the contractile vesicle (*cv*) of this species is double that of *Monas termo*. Like the latter it enjoys two diverse conditions of life, namely, a fixed (figs. 5, 5^a, 6) and a free (fig. 5^b) state; frequents the same habitat; progresses with the same means and mode of locomotion, and obtains its food by similar prehensile organs, and swallows it in the same manner.

The *form* of the body is that of an oval, but terminates anteriorly in an obliquely truncate front; or rather one side of the front projects in the form of a low, rounded prominence, which constitutes the *lip* (*lp*). The posterior end is either broadly rounded or very bluntly pointed where the pedicel (*pd*) is attached. The color is either grayish or there is none at all.

The *flagellum* (*fl*) has more of a sigmoid flexure than that of *Monas termo* (figs. 1–4), and about as much as that of *Anthophysa Mülleri*, Bory (figs. 47, 48, *fl*). It arises from the axial point of the front, and extends to about three times the length of the body. The plane of its curve bears the same relation to the mouth and lip as that of *Monas termo*, and it is used in the same manner as a prehensile organ to assist the lip (fig. 6, *lp*), when taking food, and for a propelling apparatus (fig. 5^b, *fl*) as the body whirls along after it during natation.

The *mouth* (fig. 6, *m*) lies in the same relative position as that of *Monas termo*, and receives its food in precisely the same manner, and, by the assistance of the lip (*lp*), with the same degree of rapidity passes it into the body.

The *contractile vesicle* (*cv*) lies on the same side of the plane of the arcuate flagellum (*fl*) as that of *Monas termo*, and at about the same distance from the front, but in an opposite region, and directly in the antero-posterior line with the lip. It is also a more vigorous and larger organ than that of the other *Monas*, and, bulging out (fig. 5^a, *cv*) the body even more strongly during expansion, its systole takes place at double the rate, that is, *twelve times a minute*, and very abruptly.

The *pedicel* (*pd*) sometimes attains to four or five times the length of the body, but most frequently it is not more than half as long as that. It is thin and delicate, but appears to possess considerable rigidity, either in a fully extended state, or when — as appears to be the case sometimes — it is contracted into more or less abrupt curves (fig. 6, *pd*). Its apex (fig. 5^a, pd^1) is attached to the posterior end of the body at a point which is coincident with the longitudinal axis.

§ 3. Bicosœca, nov. gen.[1] (B. gracilipes, nov. sp.)
(Plate IX., figs. 34, 35.)

This genus might be compared to a *Monas* seated in a calyx, and upon a highly muscular, contractile stem.

Bicosœca gracilipes is a marine form, and has thus far been found, although in considerable numbers, only upon *Sertularia cupressina* Linn. It is an excessively minute creature; as may be readily judged by the reader upon referring to the magnifying powers which are laid down in the description of the figures. When first met with it appeared, upon a casual observation, and under a magnifying power of only five hundred diameters, to be an elongate, naked *Monas*, which was kept in a firm position by some invisible power. It soon, however, attracted particular attention to itself by its peculiar, spasmodic, and often repeated retrocession. Upon putting on a power of eight hundred diameters the whole organization was brought out with sufficient clearness to satisfy one upon every point. For the purposes of illustration, however, it was thought best to increase the magnifying power to a still greater extent, and we have, therefore, drawn one figure (fig. 34) to represent this infusorian as it appears when seen under an amplification of about fifteen hundred diameters.

This animal has never been found in a free state, nor in any other than that which is represented in these two figures, (figs. 34, 35). It has an elongate oval body which is enclosed in a deep, vasiform, pedicellated calyx (*c*), to whose bottom it is attached by a slen

[1] βίκος, a vase; οἰκέω, to inhabit.

der, colorless, contractile ligament (r). It usually rests about half way between the top and bottom of the calyx, but is frequently jerked to the bottom (fig. 35) of the vase (c) by means of the ligament just mentioned. The anterior end is truncate, and prolonged into two prehensile organs, one of which is a *flagellum* (fl) and the other a *lip* (lp) similar in position and function to that of the *Monas* described in the previous section. The generally prevailing fuscous tint is interrupted by a transparent, colorless streak (r^1) which extends from the laterally posited base of the flagellum (fl) to the posterior end of the body, where it seems to be prolonged into the contractile ligament (r). It is not a band, however, but a sharply defined furrow, of considerable depth. At the anterior end it is sunk so deeply that it borders closely upon the base of the flagellum, and from that point it gradually shallows until it nearly disappears at the point of junction of the body with the contractile ligament.

We are thus reminded of those heteronematous *flagellata*, like *Anisonema* (figs. 65–69), whose bodies are so conspicuously sulcated in a longitudinal direction; and the apparent continuation of the retractor ligament (fig. 34, r) with this furrow (r^1) heightens the impression, by its resemblance to the highly muscular, trailing lash (figs. 65–69, fl^2) of that genus. One could hardly be accused of unduly straining a point in homology if he were to consider the furrow (fig. 34, r^1) in question as merely a greatly prolonged ostial notch, and the retractor (r) as a trailing lash, which originated at the greatest possible distance from the other, its proboscidal companion (fl).

The *lip* (lp) is a more prominent organ than that of *Monas.* It has a conical shape, and is about twice as long as its greatest breadth. It is so hyaline as to readily escape notice until it is fully recognized. It is situated at the edge of the truncate front opposite to that from which the flagellum arises, and therefore leaves a considerable space between the latter and itself. Within this broad space the simple mouth (m) is situated.

The *flagellum* (fl) is the most active of the prehensile organs, and the only vibratory, filamentous body which this animalcule possesses. In length it is about three times that of the body, or a little more, and projects far beyond the rim of the vase (c). It is a curious fact that while in *Monas* and *Anthophysa* the lip and flagellum lie closely together, they stand far apart in *Bicosœca.* The flagellum is not an undulatory, vibrating organ, in the common sense of the term, but usually supports itself in a rigid condition, except at the tip, which is kept in nearly constant motion, incurvating with frequent jerks, and tossing floating particles toward the mouth. Its distal two thirds is quite strongly curved, but not so much as to be absolutely falcate; and at its basal third it is moderately arcuated in the opposite direction, so that the whole flagellum has a slightly sigmoid flexure. The plane of this curve is such as to strike the mouth and lip when carried out in that direction. The diameter of this organ is about equal from tip to base, excepting a slight thickening at the latter point. The only times that the flagellum abandons its rigid deportment is either when it is assisting the lip to seize the food, or during the spasmodic retrocession of the body. In the latter case it is abruptly retracted and coiled (fig. 35, fl) transversely within the calyx (c) close down to the truncate front of the body. When the latter slowly pushes forward from the bottom of its dormitory, the flagellum as deliberately uncoils, and at first vibrates with a rapid wriggle, but finally assumes its former sigmoid curve and rigid deportment.

The *mouth* (m), as has already been mentioned incidentally, lies in the middle of the truncate front, and consequently faces toward the aperture of the calyx (c). Food is brought to it by means of the flagellum (*fl*); and the latter and the lip (*lp*) force it into the oral aperture exactly in the same way as has been described in regard to *Monas*.

The *contractile vesicle* (*cv*) is a single globular organ, which lies on the corresponding side of the body with that of *Monas*, and just in front of the middle. In full diastole its diameter equals one third of that of the body. Both the systole and diastole are very slow.

The *calyx* (*c*) is about twice as long as the body which it encloses, and between four and five times its own average diameter. It has the form of a very deep, slender urn, with a rounded bottom, slightly contracted waist, and a very delicate, scarcely reverted, truncate rim. It is so hyaline and faint that it almost defies any magnifying power below that of eight hundred diameters. The pedicel (*pd*) which supports it is at least twice as long, of uniform diameter throughout, and very slender, in fact not much thicker than the flagellum. It is attached (pd^1) to the bottom of the calyx exactly opposite to the point from which the contractile ligament (*r*) arises, but, unlike the latter, it appears to be totally incapable of contraction.

§ 4. Bicosœca lacustris, nov. sp.

(Plate IX., figs. 33, 33^a, 33^b, 33^c.)

This species lives in quiet streams and lakes, attached to filamentous *Algæ*, and is quite common, especially on old specimens of *Zygnema*. It is tinged throughout with a yellowish color, which seems to add a good deal to the difficulty of distinguishing its various parts. When protruded (fig. 33) it occupies the anterior half of the calyx (*c*) and projects a little beyond its edge, and consequently its retractor ligament (*r*) stretches over the whole posterior half of the dormitory. The shape is rather elliptical than elongate-oval, but it varies more or less between these two forms, and seems to have the latter shape in the largest individuals. Posteriorly the body is rounded, but its broadest region is about the middle, and from thence it tapers considerably to a truncate front, and ends on one side in a laterally projecting *flagellum* (*fl*), and on the opposite side in a long incurved *lip* (*lp*).

The longitudinal furrow (r^1) which is so conspicuous in *B. gracilipes* is much narrower in this species and not so deep, yet it holds exactly the same relations to the base of the flagellum (*fl*), and the contractile ligament (*r*). After a number of observations upon the frequent and sudden retraction of the body to the bottom of its calyx, during which in every instance that side along which the furrow (fig. 33^c, r^1) runs was contracted much more than the opposite one, I feel quite confident that this sulcus is the seat of a highly contractile band, and moreover that it is continuous with the posterior retractor ligament (*r*). The latter is very slender and thread-like, and is attached to the posterior end of the body on one side (see fig. 33^a, *r*) of its axial line, and has very much the appearance of being a free continuation of a ligament in the furrow just mentioned. The *lip* is nearly twice as long in proportion to the breadth of the front as that of *B. gracilipes*, and has an incurved, digitate form (figs. 33, 33^a, *lp*).

The *flagellum* (*fl*) is the most remarkable and distinguishing feature of this species, when contrasted with *B. gracilipes*, on account of the wide angle at which it diverges from the longitudinal axis of the body; for whilst in the latter it deviates but little from parallelism with the axial line, in the former it arises at an angle of from forty to forty-five degrees (fig. 33^a, *fl*) with the same line. At its base it curves away from the lip, but for the remaining four fifths it bends with a long arch in the opposite direction, but not so much as to bring its tip in a line with the body. It is therefore altogether eccentric, but yet its curve lies in the same plane relatively to the mouth and lip as that of its marine congener. Its length is about two and a half times greater than that of the body, and it scarcely, if at all, tapers from one end to the other. It usually is held in a rigid attitude, except at the tip, which is always kept in a rapidly gyrating state, accompanied frequently by spasmodic incurvatures, when floating particles are thrown by it toward the mouth (*m*). Its flexibility is exhibited during the frequent spasmodic retrocessions of the body (fig. 33[c]) in the same way as in the other species, and the like remark applies to its action when assisting the lip to force the food into the mouth.

The *mouth* (*m*) opens in a slight hollow which lies between the base of the flagellum on one side and the lip on the other, and therefore is concentric with the longitudinal axis of the body. It very readily takes in quite large particles (fig. 33, *m*) of food, with the aid of the incurvating lip (*lp*) and the flagellum (*fl*), and immediately encloses them in a digestive vacuole, or, more properly speaking, a hyaline envelope, within which they revolve for a while with considerable rapidity. The *anus* (fig. 33, *a*) lies in the same hollow as the mouth, but further up on the base of the lip. That it is distinct from the mouth was frequently demonstrated by the collection of large globular masses in the base of the lip, and sometimes further up, and their subsequent exit thereabouts.

The *two contractile vesicles* (*cv*, *cv*,) form another very strong mark of distinction, since they are not only double the number of that of *B. gracilipes*, but are also situated at the extreme posterior end of the body. They are quite conspicuous, and appear to lie right and left of the plane which passes through the lip, flagellum, and furrow. The systole of each alternates with the other, and occurs from five to six times in a minute, but with nothing remarkable in its action, unless it be that it operates more moderately than in *Monas*.

The *calyx* (*c*) has, in its fully developed condition, about the same shape and proportions as that of the marine form (figs. 34, 35), but like the body, it is much larger. In its younger stages (figs. 33[a], 33[b], 33[c] *c*, c^1,) its aperture (c^1) almost closes when the body is retracted (fig. 33[c]), and during the protrusion of the latter its rim (fig. 33[a], c^1) embraces it very closely; so that on the whole the calicle has an elongate ovate shape, with a narrowed, truncate, smooth margin. During the undeveloped stages of the calyx, the *pedicel* (*pd*) is less than half its length, and from that it varies down to little (figs. 33[a], 33[c], *pd*) or nothing; but when the former is full grown (fig. 33, *c*), the latter (*pd*) is at least half as long as it. It is more slender than that of *B. gracilipes*, and like the latter is attached to the base of the calyx opposite the insertion of the retractor ligament (*r*).

§ 5. Codonœca, nov. gen.[1] (C. costata, nov. sp.)

(Plate IX., fig. 36.)

Of all the calyculate *Flagellata*, the species before us is perhaps by far the most beautiful, both in physiognomy and proportions. It is a marine form, and was found with *Bicosœca gracilipes*. Generically it differs from *Bicosœca* (§§ 3 and 4) in having neither a basal, retractor muscle, nor lip, nor lateral longitudinal furrow, and by the attachment of its single flagellum (*fl*) to the central point of the front. From *Salpingœca* (§§ 7, 8, and 9) it differs principally in not possessing a projecting collar or rim about the anterior end, but, as in

[1] κώδων, a bell; οἰκέω, to inhabit.

that genus, the body is not attached to the calyx by any visible means. It cannot be a Dinobryon, since that, as Claparède has already shown, has but a single contractile vesicle, and moreover it is situated near the anterior end of the body, and just behind a red eye-spot. Dinobryon has a slightly notched, asymmetrical front; in fact, it is a calyculated *Euglenian.* The general tint of the body of *Codonœca costata* is a dingy yellow, whilst the calyx (c) is colorless, and excessively transparent. The shape of the body is oblong, rounded posteriorly, and slightly pointed in front, where the flagellum (fl) is attached. Its posterior half nearly fills the basal third (c^2) of the calyx.

The *flagellum* (fl) has not that rigid carriage which is so characteristic of that of *Bicosœca* (§§ 3 and 4) and *Anthophysa* (§ 11), but is a truly vibratile organ. It is kept in an almost constant state of rapid agitation, and projects at the same time far beyond the rim (c^1) of the calyx. It is by no means easy to detect, even with a power of eight hundred diameters, not only because it is seldom at rest, but on account of its excessive delicacy; yet when it does stop its vibrations, its character and proportions can be unequivocally demonstrated under the proper circumstances of illumination and adjustment. It is about twice as long as the body, and has a decided, although not rapid taper at its distal termination.

The *mouth* remains yet to be discovered. There can be no doubt, however, that it is an aperture of no very small extent, or at least that it is capable of considerable distension, inasmuch as we find quite large angular particles within the body. That it is terminal rather than lateral, is probable from the similar position of this organ in the not very distantly allied genus *Codosiga* (§ 6).

The two *contractile vesicles* (cv, cv) are situated midway between the front and hind ends of the body, and at two nearly opposite points. They are of moderate size, yet not so large as those of *Codosiga* (§ 6), which they resemble, but exhibit a much feebler action than the latter.

The *calyx* (c, c^1, c^2), or carapace so called, has an ovate-campanulate outline, but is divided, by a constriction, into two regions. One of these, the basal (c^2) or posterior third, is about one half as wide as the remaining two thirds (c), and possesses an ovate-obconical form, which tapers abruptly into the pedicel (pd). The anterior two thirds (c) arises from the sharp constriction with a strong swell, or bulging, and then, narrowing a little, terminates with a truncate aperture (c^1); so that on the whole this portion may be compared, in shape and proportions, to a claret-glass. This region is peculiar moreover in being longitudinally banded or sulcated by about twenty furrows, which terminate at the rim in as many notches, that alternate with a like number of distinct scallops. Of these two regions the basal one is quite distinct, although perfectly hyaline; but the banded part is much fainter, and requires a careful adjustment of the light in order to bring it out clearly. The *pedicel* (pd) is moderately slender, colorless, at least as long as the calyx, and of a uniform thickness from base to top.

§ 6. CODOSIGA, nov. gen.[1] (C. PULCHERRIMUS, nov. sp.)

(Plate IX., figs. 7–27.)

This infusorian is as eminently a compound flagellifer as *Anthophysa* (§ 11); and although not a heteronematous form, like the latter, it bears a very striking general resemblance to

[1] κώδων, a bell; σίγαω, to be silent.

it; as one may see by comparing figures 8 and 47 with each other. It also frequents the same habitat as *Anthophysa*, where it is quite abundant, and readily recognized, when one has become familiar with it, even under as low a magnifying power as two hundred diameters. The greater number of individuals are found attached singly (figs. 9 and 24[a]) or in twos to a slender peduncle (*pd*); but often three or four constitute a colony. A group of these monads, seated on their short pedicels (fig. 8 pd^2), and the latter arising from a nearly common point at the end of a long, slender peduncle (fig. 8 *pd*), might be designated, in botanical parlance, as umbellate. Very seldom are more than four or five bodies assembled in one colony, but occasionally as many as eight (fig. 7) are united in a single umbel. They bear the same remarkable relation to each other and to the main stem (*pd*) that we find in *Anthophysa*, that is to say, the arcuate flagellum (*fl*) of every member of the group curves backwards towards the base of the common peduncle (*pd*); and consequently the rest of the organism of each one holds a corresponding position. When there are but three or four in a colony the longer axis of each monad usually diverges at an angle of not more than thirty or thirty-five degrees from the axis of the main stem, but when the number is greater the divergence is also greater, and frequently amounts to seventy or eighty degrees. Oftentimes it will be observed that several of a group of bodies are attached in pairs (figs. 21, 22) to the pedicels, instead of each being possessed of a support of its own. This, as will be explained more fully under the head of *fissigemmation*, arises from an incompleteness of the self-division of which the pairs are the several resultants; and it will be noticed also that they are smaller than those which arise singly from the common peduncle.

The usual *form* of the body is an oblique oval (figs. 25, 26, 27,) which is twice as long as it is broad; but in old individuals, which are about to undergo self-division, the shape is very broadly oval (fig. 24[a]), and its one-sidedness is not very conspicuous. The same may be said of specimens which have lived for a while in stale water, and have lost nearly all their yellow color (fig. 24). Posteriorly it tapers, more or less abruptly, into the pedicel (figs. 25, 26, 27, pd^2); but anteriorly it is slightly constricted (b^2) a short distance behind the front, and thence projects in the form of a low, truncate cone (fig. 24[a] *fr*). From the constriction (b^2) there projects, in direct continuation of the epidermis of the body proper, a very high *membranous, campanuliform collar* (b, b^1), presenting, on the whole, an appearance as if the body were seated in the lower half of a deep, urceolate calyx. That this collar is not the upper portion of an urceolus in any sense of the term may be demonstrated in two ways, at least. In the first place, it is highly flexible and retractile; as it occasionally shows itself to be, either by narrowing its aperture almost to absolute closure (fig. 24, *b*), or by reducing its height to a small fraction of its greatest altitude, — as seen in fig. 27, *b*,— and then extending itself again, within a few seconds, by a direct protrusion, (fig. 26, *b*) to its original proportions (fig. 25, *b*). In the second place, it divides longitudinally, like the rest of the body when self-division occurs (figs. 11–22), a process in which no genuine calicle was ever known to be concerned. In an adult state (figs. 8, 11, 24[a], 25) it is slightly constricted by a gradual incurvature extending from the base (fig. 24[a], b^2) to the distal margin (b^1); but frequently, and apparently always just before self-division takes place, its sides bulge slightly outward (fig. 11, *b*). Taking all these things into consideration, therefore, it is perfectly clear that this infusorian is not a calyculate form, but one of those mimetic shapes which occasionally deceive the eye and puzzle the observer, until he becomes familiar with their various phases of growth and development.

This phenomenon is most singularly exemplified by the creature before us now, in its almost indistinguishable resemblance to a genuine calyculate Flagellifer (*Salpingœca marinus*, figs. 28–32[a]) which abounds in our marine waters. This similarity arises chiefly from the fact that the urceolus (figs. 28–32, *c*) of the latter has an oval shape like the body of the former, and is constricted so closely at its aperture (c^1) as to present the appearance of being continuous with the high campanuliform collar (*b*) which projects from the front. Usually, however, the body proper of this animal (*Salpingœca marinus*, nov. sp.) lies loosely within, and considerably withdrawn (fig. 28) from, the parietes of its calyx; but occasionally, in older specimens, it completely fills (fig. 31) its sheath, and then it is next to impossible to distinguish it, in this respect, from a *Codosiga*. In a sessile, fresh-water species of *Salpingœca*, of the urceolate type (*S. amphoridium*, figs. 37–37[d]), the *resemblance* to *Codosiga* is almost as strong, but the *difference* is as equally marked.

The *flagellum* (figs. 8, etc., *fl*) is the only prehensile organ which *Codosiga* possesses. It arises from the middle of the low truncate cone (*fr*), which constitutes the front, and consequently within the campanulate collar (*b*); reminding one of the curvate *style* of a labiate, monopetalous flower. It is usually rigid, excepting at the tip, which is constantly occupied in throwing particles of various kinds toward the mouth (*m*) by vigorous, spasmodic incurvations, or jerks. At its basal half it is slightly curved toward the longer side of the body, but gradually reverses the arc and, assuming a much stronger bend in the opposite direction, terminates abruptly, and far beyond the edge (b^1) of the collar, with about the same thickness as at its base. It is a very conspicuous organ, and therefore its whole sigmoid length may be studied with any amount of detail that could be wished for. The plane of this sigmoid curve is a direct continuation of that which passes through the opposing longer and shorter curves of the obliquely oval body. Calling to mind now what has been said in regard to the direction of the curve of the flagellum of the respective individuals of the colony, it will be seen that if these planes are projected inwardly and downwardly, at the same time passing along the pedicels (fig. 8, pd^2) of each body, they will all meet at the main stem (*pd*).

Besides being used as an organ of prehension, the *flagellum* is occasionally devoted to other purposes; for instance, to act as a scavenger by whirling in a gyratory manner, and thus clearing the area, within the collar, of fæcal matters which have been ejected from the anus at a point near to, or perhaps coincident with, the mouth (*m*). At other times it acts as an organ of propulsion during the act of natation (fig. 23), when one of the resultants of self-division breaks loose from the colony and seeks another point to settle down upon and secrete its stem. During this wandering life of the monad it swims — at times very rapidly — with its basal end (fig. 23) preceding it in the direction of its course, and the *flagellum* (*fl*) following behind, and vibrating in rapid undulatory and gyratory curves, as if it were the screw propeller of some subaqueous vessel.

That the *mouth* (figs. 23, 24, 24[a], *m*) is situated near the base of the flagellum (*fl*) is rendered certain by the fact that particles of food are thrown by that organ directly against the area (*fr*) upon which it is based, and are taken within the body somewhere in that region; but, on account of the minute size of these morsels, and the rapidity with which they are swallowed, it has not been possible to determine precisely at what point The position of the *anus*, which, as I have already suggested, may possibly be coincident with the mouth, is easily determined, even to the narrowest limits, as the fæcal matter is discharged in large, highly refractile pellets (fig. 24[a], *d*), close to the base of the flagellum. The digestive vacuoles are quite conspicuous, and frequently very large; but they never have been observed to be so numerous as to obscure the view of the interior of the body.

The *contractile vesicles* (*cv cv*) are two quite conspicuous globular organs, which lie close to the surface, and in the posterior third of opposite sides of the body. Occasionally *three* (fig. 10, *cv*) of these vesicles are found together, but it has always been evident at such a time that the body was preparing for fissigemmation (figs. 9, 10), and that the increase in number of these organs arose from the fact that one of them had already undergone self-division. In another genus (*Salpingœca. S. marinus*, nov. sp. figs. 28, 29, 30) no less than *four* contractile vesicles (*cv*) have been observed to arise from two, under the same circumstances.

The systole of each vesicle of *Codosiga* occurs regularly once in half a minute, and usually that of one alternating with that of the other. Both the systole and the diastole proceed very deliberately, each, however, not occupying more than a few seconds. During the interval between the end of the diastole and the beginning of the systole the vesicles have a rather irregular, indefinite, spheroidal outline, but just at the moment of systole they assume a sharply defined and perfectly globular shape, and raise the surface of the body into a quite perceptible bulge. During this momentary expansion a vesicle equals at least half the greatest diameter of the body.

The *reproductive organ* — if we are not mistaken in our interpretation — is seated at the posterior end of the body, behind the contractile vesicles. It is a globular, highly transparent body (figs. 23, 24, *n*), and sometimes almost fills the space on each side of it. That it is solid, and not a mere vacuole, appears conclusive from its resilient action after being indented by the expansion of the contractile vesicles. It should be mentioned that this body was not observed in the fresh specimens which were collected in December, but appeared to be constant in some stale examples which had been kept on hand for two or three months.

The *peduncle* (fig. 8, *pd*), or main support of the colony, and the pedicels (pd^2) or immediate bearers of the individuals, share in the general gamboge yellow color of the latter, and also in their vitality. The latter statement has been verified fully in regard to the pedicels, by seeing them split down to their bases after the body proper has undergone self-division; and in regard to the peduncle, although only one observation was made, and the splitting was followed in its slow course downward for only a short distance, it was evident, from its much more than usual thickness, and the presence of a distinct median furrow which extended to its very base, that it eventually would divide into two stems. The length of the peduncle varies from a mere disc, when it begins to develop from the base of some newly settled monad, to five or six times the length of an individual. It always carries a single body until it is at least three or four times its length (figs. 9, 24, 24[a]), and frequently much longer; but in the latter case it was sometimes observed to arise from the falling away of one of the resultants immediately after self-division occurred. It has a uniform thickness, or occasionally the slightest possible taper, from base to apex; and appears to be solid and homogeneous in texture. It is apparently inflexible, and even when carrying a single body is united to it at a sharp angle with the longer axis of the latter (fig. 24[a]).

Fissigemmation. This is the only process of reproduction which has been observed. Several instances of this kind were partially followed through in an incidental way, and two complete courses were carefully noted and drawn within a half hour of each other. The set of figures 13, 15, 17, 19, 21, relate to one individual, and figures 11, 12, 14, 16, 18, 20, 22 to another belonging to the same colony. The rate of progress of the former when the drawings were made was not noted, but that of the latter set was observed in four out of six of the intervals which occurred between the phases which the figures represent, and during the progressive steps of the latter it was carefully recorded which of the successive stages of the former filled the intervals between those of the latter; so that it can be said, in the strictest sense, that all of the figures of both sets of observations represent the phases which were distinctly marked in the second series. In this way the fullest illustration possible was obtained, and no point was left unexplained. The whole time occupied by the process in the second series was *forty minutes*. It has already been mentioned, when describing the form of the collar, that it assumes a bulging, campanulate outline (fig. 11, *b*) as a preparatory, preliminary act in fissigemmation. In addition to this it should be stated that it widens inordinately at the distal end, so as to exceed, by one third, its normal breadth; but before it finally settles itself into this shape and proportions it contracts and expands its diameter by a peculiar sort of vibrating motion, and passes through a series of changes of form which vary from funnel-shape to a narrower cylindrical outline, or from either of these to a broader cylindrical proportion, such for instance as figures 9 and 10 — representing the same individual — exemplify. This would appear also to be the time when the contractile vesicles divide, for at no other period were they observed to be more than two in number, as they are represented in figures 9 and 10 (*cv*).

Immediately after this preparatory sign was discovered, — the time being noted at 12.55 P. M., — the flagellum became unusually conspicuous, and much thicker, and moreover it lost its sigmoid flexure and assumed a perfectly straight carriage, with the slightest possible tremulous, vibratory motion. Within a very few minutes after this the flagellum began to shorten as if retracting, — reminding one of the running down of a cotton thread in the flame of a candle, — and in one minute's time it became reduced (fig. 12, *fl*) to a length which was somewhat less than half the height of the collar (*b*), and then it rapidly disappeared, and left no trace of its former position. During this process the body shortened and became broader (fig. 12), in the same direction that the plane of the arc of the flagellum formerly trended in, and consequently the contractile vesicles (*cv*) were more widely separated; and, the front (*fr*) also having become proportionately extended laterally, the base of the collar (*b*) was also increased in diameter until it almost equalled that of the distal end, so that, as a whole, it was almost cylindrical.

In less than fifteen minutes after the preparatory stage was observed, the collar had become cylindrical (fig. 13, *b*) by a combined action of the base and distal end, which consisted in a narrowing of the latter and a broadening of the former.

It was not until 1.15 P. M. that a decided mark of incipient self-division became evident in the guise of a narrow, slight furrow (fig. 14, *e*), which extended, medianly, from the front to over half way toward the posterior end of the body. By this time the body had broadened until it was wider than long, and the collar (*b*) — having followed this expansion at its basal portion whilst its upper extreme had contracted a little — had assumed the form of a high, truncate cone.

In two or three minutes after this the body had become distinctly indented (fig. 15, e^1) at the anterior termination of the furrow (fig. 15, *e*), and the latter had grown longer and more distinct, whilst the collar (*b*) had approximated more closely in shape to a perfect cone.

In another minute or two the anterior indentation (fig. 16, e^1) had become so deep and broad that the body presented a cordate outline when seen from its broader aspect, whilst the furrow (e) appeared to extend to its base, and the distal end of the collar (b) had so nearly closed up as to give that body an almost complete conical form, with a slightly collapsed periphery.

From this moment the process of reduction ceased, and soon after the cone-shaped collar began to expand (fig. 17, b). Consentaneously with this, the anterior indentation (e^1) had become sharper and deeper, and, — with the lateral median furrow (e) of each of the opposing broad flanks of the infusorian acting in combination with it, — had split the body about half way to its base. The most remarkable phenomenon observable at this time was what occurred at the rounded ends of the two half separated bodies of the new pair of individuals. This was no more nor less than the incipient development of the flagellum, which proceeded in this wise. At each of the rounded ends just mentioned a slight commotion appeared, resembling the molecular vibrations of a granule, and then there arose quite rapidly a sharp and distinct filamentous outgrowth (*fl*), which kept itself in a constant state of narrow vibrations, or a sort of shivering.

By 1.23 P. M. the newly born flagella (fig. 18, *fl*) had risen to half the height of the collar (b), and still remained in a shivering condition, whilst the body had divided almost to its base, and the collar had broadened to a widely terminating, truncate cone.

In about a minute more the dividing process had risen into the collar and split it (fig. 19, e^2) upwards for one quarter of its height, and the still tremulous flagella (*fl*) were slightly longer than in the last phase.

By 1.26 P. M. the body was divided (fig. 20) to its posterior termination, and the fissuration (e^2) of the collar (b) had reached half way to the distal edge, and was further sketched out, as it were, by two opposing shallow, longitudinal furrows which extended to the margin. At this period the collar was broader at the still undivided portion than below, so that on the whole it had a very wide campanuliform shape, or rather, — since the divided portion was rolled inwards at the opposing edges, — was like two slightly flaring broad funnels, merged into each other at their broader ends. The flagella (*fl*) also had developed considerably, and extended a short distance beyond the collar; and the front end of the body, from the middle of which the flagellum arises, had assumed the low, truncate, conical shape of the adult form.

From this time onward the division did not appear to go forward so rapidly, and the new bodies seemed to be more particularly occupied in shaping themselves into the characteristic form of the adult. The collar, however, was not long in dividing itself up to its margin (fig. 21), but still the two cylindrical halves (b, b) did not separate at their extremes as soon as the fissation reached that point.

At 1.35 P. M. the self-division was completed (fig. 22) as far as the body proper was concerned, and had extended a short way down the pedicel (pd^2). The margins of the two collars (b) seemed merely to lie in contact, and each collar had a slightly funnel-shaped outline, and was considerably more elevated in proportion to its diameter than in the adult form. The flagellum (*fl*) was nearly as long as that of the full-grown body, but yet had neither the sigmoid curve of the latter nor its stout and rigid aspect, but was much more delicate, and in fact still exhibited a slight, tremulous motion. The two contractile vesicles (*cv*) of each body were as distinct as those of the adult, and had the same proportionate size and relative position.

In a very few minutes the two resultants were totally separated and divergent from each other at a sharp angle, and in less than half an hour after the last time noted they had assumed the proportions of the other members of the colony. Shortly after the investigation of the phase just described, the last stages of self-division of another body, belonging to the same colony, were observed, and thus the group, which within two hours before consisted of five individuals, was increased to eight (fig. 7). It seems to be a rare occurrence that so many bodies remain long together, since it very seldom happens that more than four or five (fig. 8) are found in a colony; and now and then, in such instances, I have seen an individual drop off and swim away. When we meet with them settled down upon some point, amidst others which have scarcely any stem, and those which are seated on very short peduncles, it becomes perfectly clear that they are there for the purpose of secreting a new support from the posterior end.

§ 7. Salpingœca,[1] nov. gen. (S. gracilis, nov. sp.)

(Plate IX., figs. 38, 39.)

The difference between this genus and *Codonœca* has already been pointed out. It might well be compared to a stemless *Codosiga* (§ 6) enveloped in a sheath. I have met with three quite diverse species of this genus, of which that under present consideration and another (*S. amphoridium*, nov. sp. § 9) are fresh-water denizens, and the third (*C. marinus*, nov. sp. § 8) is a marine inhabitant. *S. gracilis* (figs. 38, 39) was found upon only one occasion, and then in an old aquarium, which could not be said to be in a perfectly healthy condition, although its contents were by no means putrid.

The *body* is yellow and has a cylindrical shape, about four times longer than broad, narrowed and rounded behind, and rounded-truncate in front. Like *Codosiga* it bears a filmy, membranous, colorless collar (b), which is attached to the extreme edge of the frontal area (fr), and arises to a height which is equal to two thirds the length of the body. The outline of the collar is cylindrical, as a general thing, and truncate at the distal end, but still is subjected to various degrees of momentary change. Unless it be by means of the vibrations of the flagellum, there is no other immediate agent which can be supposed to move the body up and down in its sheath. There is no visible movement in itself, like creeping, to be observed, and moreover the body progresses so quickly, when changing its place in the calyx, that it becomes evident that it is not due to any reptant mode of transposition. When withdrawn (fig. 38) into the basal, tapering portion of its calyx, the collar (b) does not extend beyond the rim (c^1) of the latter, but on the other hand the body occasionally moves so far in the opposite direction (fig. 39) that nearly the whole of the collar (b) projects outside of the dormitory.

The *flagellum* is a delicate filament, which arises from the axial point of the front and projects a short distance beyond the edge of the collar. It presents a constantly undulating aspect, and vibrates from base to tip.

The *mouth*, we are obliged to presume, as we did in regard to *Codosiga*, lies somewhere about the base of the flagellum. Abundant digestive vacuoles were observed, as well as loose particles of food, in various parts of the body; but at no time were we so fortunate as to see the introception of nutritive material, or the ejection of fæcal matter.

[1] σάλπιγξ, a trumpet; οἰκέω, to inhabit.

The *contractile vesicles* (*cv*) are two in number. They lie between the second and posterior thirds of the body, usually on opposite sides, and close to the surface. In aspect and rate of systole they resemble those of *Codosiga pulcherrimus*, but they are a little smaller in proportion to the size of the animalcule. Sometimes the protean changes of the body are so extensive as to throw the two vesicles into line with each other in an antero-posterior direction, but they hold this position only temporarily, and soon return to their normal relations.

The *calyx* (c, c^1, c^2) has the general shape and proportions of a champagne glass, and appears to be hollow to the very bottom (c^2) of its pedicel-like, inferior third. Anteriorly it is truncate, smooth, and flares (c^1) quite strongly. About the middle it bulges very sensibly, and thence tapers gradually into a slender posterior third (c^2), but expands again slightly as it terminates upon its place of attachment. It is colorless, excessively transparent, and exhibits considerable flexibility under the movements of the body; apparently having the consistency of a mere film.

§ 8. Salpingœca marinus, nov. sp.

(Plate IX., figs. 28–32[a].)

The remarkable generic resemblance of this species to *Codosiga* has already (p. 315) been commented upon. It is very common, especially upon the marine Hydro-Medusa, *Dynamena pumila*. Lamx., but is so excessively minute, and withal so transparent, excepting the body proper, that under a magnifying power of five hundred diameters it appears to the casual observer like a mere globular speck. It was discovered when searching after specimens of *Codonœca costata* with a power of eight hundred diameters. Although sometimes met with in groups of forty or fifty, it always appeared single. In its general aspect it may be compared to an oval flask which is supported by a slender stem (*pd*), and has a broad funnel inserted in its mouth. Upon close inspection we find that the funnel (*b*) is a direct projection from the body which hangs freely within the flask (c, c^1,), and is in no way connected with the latter.

The *body* proper has a dark fuscous color, and consequently is quite conspicuous. It is mainly oval in shape, but is constricted anteriorly into a short thick neck (*i*) which terminates in a truncate front. It hangs quite loosely within the calicle (*c*), and usually at a considerable distance from its parietes, but at the mouth (figs. 31, 32, c^1) of the latter the neck (*i*) presses so closely against it as to seem, without the most careful scrutiny, to form a continuation with it. Occasionally, however, the neck narrows and retreats from the aperture of the calicle to that degree which allows a clear and unmistakable view (fig. 32) of the relations of the former to the latter.

The *collar* (*b*), which has just now been likened to a funnel set in the mouth of the flask-shaped calyx, is most frequently seen in a very broadly expanded state (fig. 28, *b*); in outline resembling a low, obtuse-angled, truncate cone inverted upon the front of the body. It arises from the extreme circular margin of the head (*i*), and, widening to about twice the equatorial diameter of the calyx (*c*), terminates in a smooth edge at an altitude which is hardly equal to one quarter of the width of its distal expanse. It is hyaline, and so extremely thin and filmy as to require the most careful manipulation of the light, even with so high a power as eight hundred diameters, in order to define its boundaries clearly. Its plasticity is even more marvellous than that of *Codosiga;* at least it is exhibited over a far wider lateral range than in the latter, and with equal rapidity in its changes. In a few seconds it narrows from its greatest expanse to the proportions of an obverted, acute-angled cone (fig. 29, *b*), and at the same time assumes an altitude which is equal to the length of the body; and then, within an equally short period, it contracts into the form of a cylinder (fig. 30, *b*) whose height more than equals that of the calyx. These changes are carried on with the same peculiar vibrations as were noted in regard to *Codosiga*, reminding one of the glimmering outlines of the prongs of a tuning-fork when vibrating. When observed with a poorly defining lens, I can readily see that this phenomenon might be mistaken for the cone of light produced by the gyratory vibrations of a single filament, or for the bright *lumen* of a circular row of vibrating cilia. As regards the former category it may be said that the flagellum is far more conspicuous than the collar, and may be seen clearly projecting in the line of the axis of the body, and vibrating after a manner of its own. As for the latter supposed case, one might be inclined to dismiss it without any scruple, upon the simple assumption that no flagellate infusorian can bear numerous cilia, were it not that I call to mind my own discovery of a flagellated animalcule (*Heteromastix*, figs. 70–74) of the heteronematous form, which is at the same time abundantly ciliated. I have, therefore, taken all possible pains to ascertain that this "*collar*" (figs. 28–32, *b*) is a genuine membrane, and not the similitude of one.

Occasionally individuals (fig. 32) were seen which bore an inverted conical collar (*b*), that remained — at least for a time — at an expansion and altitude equal to the breadth and height of the calyx (*c*). These were among the largest specimens found, and almost or altogether filled the calyx. Rarely were examples found which crowded the calyx so fully as to seem to bulge it out laterally. Figure 31 represents such an instance, in which the aperture (c^1) of the calyx is absolutely inseparable from the head, excepting that, knowing that it is not really continuous, one recognizes the line of demarcation by the abrupt change in the thickness of the seemingly uninterrupted membrane. This case is also remarkable, inasmuch as it at the same time furnishes us with an example of an enormously large, bulging, campanulate collar, nearly as broad as the most common and normally permanent form (fig. 28), and yet higher than it is wide. In all probability, judging from appearances, which in every respect remind one of the preparatory steps of fissigemmation of *Codosiga pulcherrimus*, this individual is soon about to undergo self-division. Unfortunately the drawing was made at a time when the impending process could not be watched.

The *flagellum* (*fl*) is as highly flexible as that of *S. gracilis*, and very active throughout its length. It is attached to a more or less elevated axial prominence in the middle of the frontal area, and extends to a length which is, at most, not more than one third greater than that of the body.

Regarding the *digestive organs* nothing can be said, excepting that dark irregular pellets and loose foreign material were abundant enough, and so irregularly scattered that they could not be looked upon otherwise than as nutritive matter.

The *contractile vesicles* (*cv*) are two or three globular bodies, which in appearance, position, relative size, and rate of systole, may be compared with those of *Codosiga pulcherrimus*. On one occasion (fig. 30), they amounted to four (*cv*) in number, and were arranged in pairs, one above the other.

The *calyx* (*c*, c^1) usually has the form of a Florence flask, but with a very short, thick neck, which flares (c^1) slightly at the aperture. It sometimes, however, is slightly pointed at its base where it joins the pedicel (*pd*). When not filled by the head (fig. 32, *i*) of the animalcule, the neck and the sharp margin (c^1) of its aperture may be clearly distinguished from the collar (*b*) which rises just above them; but very frequently this discrimination is attended with a good deal of difficulty, because when the body presses closely at this point it overlaps the margin in question, and obscures it. The pedicel (*pd*) is not much longer than the calyx, and joins the latter with little or no expansion. It is colorless like the calyx, moderately slender, of a uniform diameter from top to bottom, and appears to be solid and homogeneous in texture. Figure 32^a represents one of three bodies which were found in the midst of several living animals of this species, and which had every appearance of being the deserted calicles of the same, with a collapsed aperture. In the next species (*S. amphoridium*) the deserted calicles (fig. 37, *c*) were found so numerous among those which were occupied, and moreover retaining the shape of the latter so perfectly, that there could be no doubt that the calyx is not only a separate organism apart from the body-wall, but also may be as readily vacated as that of *Cothurnia* or *Vaginicola*.

§ 9. Salpingœca amphoridium, nov. sp.

(Plate IX., figs. 37–37^d.)

Although this species bears a strong resemblance to *S. marinus* (§ 8), there are several prominent points of difference between the two. *S. amphoridium* is a fresh-water form, and appears especially to frequent old specimens of *Zygnema* and other filamentous *Algæ*. It is very common in such places, and lives in more or less crowded groups. Excepting the main part of the body it is very transparent, but not so faint as *S. marinus*. It varies much in size, even down to half that of fig. 37^a. Like its marine congener it always occurs single, and never with a trace of a pedicel to the calyx (c, c^1). As a compensation for this, if one may use the expression, it has a long neck, which is frequently seen bending from side to side (fig. 37^b, *i*) with a gentle motion, and apparently in search of something.

The *body* is gray or greenish yellow in color, which fades in the neck (*i*) and disappears altogether in the collar (*b*). In its general aspect the body, with its collar, might be compared to a wine-glass with a long stem and a globose pedestal. The globose part is the posterior half of the body, and the stem is its neck, or anterior half, which tapers rapidly from the main part to one quarter or one fifth its diameter, and then gradually widens to nearly double that thickness at its front, where the collar is set on. The *front* is truncate, or rises into a low cone, upon which the flagellum (*fl*) is based. The posterior half of the body usually fills the bottom of the calyx (*c*), but the rest and the neck (*i*) stand off from it at a very appreciable distance. In this respect there is a marked difference between this species and *S. marinus* (§ 8). In the latter we might say that the body is suspended from the aperture of the urceolus, but in the former it rests on the bottom of the calicle. Not infrequently, however, the whole body of this species lies loosely within its calyx (fig. 37).

The *collar* (*b*) is an excessively hyaline, filmy membrane, whose distal margin (b^1) is so extremely delicate as to almost defy detection with the highest powers. In the latter respect it is a more difficult object of research than that of *S. marinus*. Generally speaking it may be described as obconical, but with greatly varying degrees of width. In this relation it agrees perfectly with that of *S. marinus*, and therefore need not be redescribed here. At its greatest height it equals that of the body, and always terminates in a smooth edge. Its plasticity is also equal to that of the marine species. In one instance, when the animal was disturbed by a predaceous Rotifer, its whole body quickly retracted, and the collar totally disappeared, as if melted down with great rapidity; but soon after protruded slowly, at first with a broad base (fig. 37^d, *b*), and then rapidly narrowed at the latter point and assumed its usual proportions.

The *flagellum* (*fl*) differs from that of *S. marinus*, both in proportions and deportment. It is usually rigid and projects considerably beyond the collar when the latter is at its greatest height. It has a decided arcuate figure, with a uniform thickness throughout, excepting near the base, which tapers rapidly from the low cone in the middle of the front. Its apex moves with quite gentle, spasmodic twitches, and the whole becomes flexible (fig. 37^b, *fl*) when fæces are ejected, or some undesirable particle enters the area within the collar.

The *mouth* was not actually seen; but that it exists somewhere about the base of the flagellum was sufficiently demonstrated by seeing minute particles of food thrown by the latter organ against the front, and rapidly disappear there. The *anus* (fig. 37, *a*) certainly opens within the same area, as particles of considerable size were seen to make their exit at the base of the flagellum. No digestive vacuoles were noticed, although the body was often found filled with food.

The *contractile vesicles* (*cv*) usually amount to three or four, and rarely to five in number; or there are two very large ones, which occupy nearly the whole breadth of the body (fig. 37^a). They occur in all parts of the body except its neck, and beat with a sluggish systole about at the same rate as those of *Codosiga* (§ 6).

The *calyx* (*c*, c^1) has very much the same proportions as the body over which it is fitted as if upon a mould. Its posterior half (*c*) is globular, and is attached at its hindermost, axial termination to the point of support. Although hundreds of specimens of this species were observed, not one of them had a pedicel. The anterior half tapers, like the thick neck of an urn, from the posterior one to one third its diameter, and then rapidly widens and terminates with a flaring, smooth-edged aperture (c^1), which is about twice as wide as its narrowest portion. The margin usually is exceeded by the projecting head, so that the former may be seen quite readily as a distinct ring behind the circular edge of the front from which the collar rises. The empty calicles (fig. 37^c) were found very frequently, and so nearly identical in form with those of the living body that they must have possessed considerable rigidity. That they are, however, to a certain degree flexible and plastic, was shown on one occasion when the body and neck suddenly retracted and swelled laterally (fig. 37^d) to an extent which was considerably beyond the usual breadth of the calyx and its neck, and then returned to its former shape and proportions.

§ 10. Leucosolenia (Grantia) botryoides, Bowerbank.

(Plate IX., figs. 40–44. Plate X., fig. 64.)

If I were now to describe merely the congregated monads of this compound animal without giving it a name, any one who had already become acquainted with the structure of *Codosiga* (§ 6) would set down the first as a colonial, massive form of the latter. In fact, a glance at a figure of a free swimming individual (fig. 23) of *Codosiga*, in one of its numerous attitudes, and then a momentary inspection of the monad (figs. 42, 43, 44) of this sponge would almost induce one to believe that the two belonged to the same genus, nay, even to the same species, as far as the representations referred to are concerned.

In the introductory section of this memoir I have already discussed the theory of Carter as to the alliance of Sponges with Rhizopods; and I will therefore only state here my firm conviction that the true, ciliated *Spongiæ* are not *Rhizopoda* in any sense whatever, nor even closely related to them, but are genuine, compound, *flagellate Protozoa;* and are most intimately allied to such genera as *Monas* (§§ 1, 2), *Bicosœca* (§§ 3, 4), *Codonœca* (§ 5), *Codosiga* (§ 6), and *Salpingœca* (§§ 7, 8, 9). What are the special relationships of the numerous genera of Sponges, I am not prepared to say; yet in regard to *Leucosolenia botryoides,* there can be no doubt that it is very closely allied to *Codosiga* and *Salpingœca,* but to which one more than to the other would be difficult to determine. *Codosiga* (§ 6) is a compound form like *Leucosolenia,* and its individuals are united by a common, branching support, which has been shown, by the changes which it passed through during fissigemmation, to be as fully alive as the glairy, spicule-secreting cytoblastema of the Sponge. *Salpingœca* (§§ 7, 8, 9), on the other hand, is a single monad, but excretes around it an envelope, or *calyx,* into which the body is sunken in the same way that the monads (fig. 41, *md*) of the Sponge are imbedded in the surface of their common dormitory. Inasmuch, however, as the calyx is probably an excretion rather than a secretion, and appears as inanimate as that of *Cothurnia, Vaginicola,* and other *Vorticellidæ,* it is more comparable to the *spiculæ* (*sp*) than to the *cytoblastema* of Sponges. If one may draw an inference from the above considerations, it does not seem at all improbable that hereafter we shall find that the monads of the different genera of Sponges resemble the various genera of single and branching Flagellata, and then we will be able to divide the former into such family groups as *Monadoidæ, Bicosœcoidæ, Codosigoidæ, Anthophysoidæ,* &c. &c.

Leucosolenia botryoides, Bowerbank, occurs on our sea-shore among the groups of *Dynamena, Sertularia,* &c., and may be readily recognized by its ivory-white color. The colony is an elongate mass, and seldom exceeds more than an inch or an inch and a half in length, and resembles an irregular group of slender, contorted spines or forked horns (fig. 40), which vary in thickness from one thirtieth to one sixteenth of an inch in diameter. At the tip of each horn is an aperture — the so-called excurrent orifice — large enough to be seen by the unassisted eye. The whole mass is so transparent that not only the currents in the interior, but even the vibrating flagella and the pulsation of the contractile vesicles may be seen with a strong light. The exterior consists of an excessively hyaline, cytoblastematous layer, with scarcely, if any trace of organization of a cell-like character in it. Within this layer, or immediately beneath it, but certainly not in the monadigerous stratum, the faint yellow *spicula* (fig. 64, *sp*, sp^1) are imbedded in systematic order, and overlap each other irregularly in two or three layers. They present two diverse forms, namely, a simple aciculate shape (sp^1), and a stellato-tri-radiate (*sp*) one. The rays of the latter are slender, tapering frequently to a bifid termination, divergent at equal angles from each other, and lie in the same plane. Without exception they are all arranged with one ray — often longer than the others — projecting backwards, *i. e.,* away from the excurrent orifice, and the other two extending symmetrically right and left, and obliquely transverse to the longer axis of the branch. In this manner they are disposed in a sort of net-work over the whole colony, even close up to the excurrent orifices; and as the aciculate spicula lie parallel with the rays of the other kind, there are consequently no projecting spines specially devoted to guarding the entrance to these apertures.

The *ostioles* (fig. 64, *o*), or incurrent channels, are very numerous, there being at least two, and often three, opposite every interstice of the spicula. They are very small, but quite conspicuous, especially at their inner ends, where they plunge through the monadigerous layer (*md*). They afford great assistance whilst studying the contractile vesicles, and the action of the flagella, since they enable one to get a freer view of the monads, in an undisturbed state, than where they are observed through all the tissues. It should be mentioned, however, in this connection, that the profile view (fig. 41) of the monads was obtained by making an actual section of one of the younger branches and allowing it to revive and expand in a fresh supply of sea-water.

The *monadigerous layer* (figs. 41, 64, *md*) lines the cavity of the body; and it is by the combined action of the vibrating flagella (*fl*) of the monads that currents of water and floating particles are kept up. This layer is composed of monadiform animalcules (*md*), packed closely side by side in a vast colony, which extends over the whole length and breadth of the general mass. In this respect we are reminded of the similar arrangement of the individuals of that floating ascidian *Pyrosoma.* These monads crowd so closely upon each other that their sides are mutually compressed, and they thus form a sort of irregular, polygonated pavement (fig. 64, *md*). They all lie with the anterior end (*fr*) turned inwardly, and projecting into the general cavity, and the posterior extremity imbedded in the cytoblastematous external, general envelope.

The *body* of a monad is yellow when seen by transmitted light, and in general terms may be designated as broadly oval, with the longer axis extending antero-posteriorly. Behind it is broadly rounded; at the sides lightly indented and irregularly polygonal by mutual contact with others; and extended in front into a delicate, membranous, circular collar (b, b^1), which might be compared to a transverse section of a tube which is about as long as it is broad. This *collar* is capable of variations in form, like that of *Codosiga* (§ 6) and *Salpingœca* (§§ 7, 8, 9), at one moment assuming a truncate conical shape (figs. 43, 44, *b*), and in the next instant expanding its distal margin into a distinct flare (fig. 42, *b*) which is at least two thirds as wide as the body; or, finally, it retracts altogether and disappears for a while, but eventually reappears, and expands to its fullest dimensions.[1]

The *flagellum* (*fl*) is the only prehensile organ which the monad possesses. It arises from the middle of the frontal area and extends to a great length, at least five or six times as long as the body, with scarcely any diminution in thickness. It is a comparatively thick filament, and quite conspicuous; on which account it is so easily seen through the whole mass of the colony. It usually vibrates with considerable vigor from base to tip, but occasionally assumes the quiescent state, and arcuate form so eminently characteristic of that of *Codosiga* (§ 6), *Bicosœca* (§ 3), and others.

1 In this connection it may be well to mention the latest decision of Carter in regard to the structure of the monociliated sponge-cell. In the Annals and Magazine of Natural History, Vol. xx. 1857, Pl. 1, figs. 10, 11, this cell is represented as an oval body, with a single ciliary appendage; but in a subsequent communication to the same periodical (Vol. iii. 1859, p. 14, Pl. 1, figs. 12, 13, 14,) a partial recantation seems to be made, and the cell in question is figured with "two spines or ear-like points projecting backwards, one on each side of the root of the cilium." If now we suppose these "*two spines*," to be the right and left profiles of a membranous, cylindrical collar, such as I have described in *Leucosolenia*, then it follows that the monociliated sponge-cell of *Spongilla* is like that of the former. That Carter did not always find these "two spines," may be explained by the fact that the membranous collar, as I am inclined to believe the "spines" to be, was retracted; since I have frequently observed this to happen in the case of *Leucosolenia*, when it was disturbed.

The *mouth* is the only organ which has not been actually observed, although its position has been inferred, not only from the otherwise similar structure of the monad of this creature to that of *Codosiga* (§ 6), but because currents of floating particles are constantly whirled in by the flagella and made to impinge upon the area within the collar. In addition to this it may be added that more or less numerous coarse and fine particles (fig. 44, *d*) are always present, and scattered irregularly about the interior of the monads, apparently under various degrees of digestive decomposition.

The *contractile vesicles* (*cv*) are two in number, and lie near each other, at or about the middle of the body. When fully expanded they are from one fifth to one fourth the diameter of the monad, and have a perfectly globular shape. In appearance, and manner and rate of systole and diastole they resemble those of *Codosiga* so closely that the former might be substituted for the latter with scarcely a chance for a detection of the change. As the rate of systole of each vesicle, which is once in half a minute, was observed directly through the undisturbed layers of the colony, and moreover at the edge of the ostioles, there need be no hesitation in accepting the record as that of the normal measure of pulsation.

§ 11. Anthophysa Mülleri, Bory.

(Plate X., figs. 47–63.)

A description of this infusorian — but without illustrations — has already been sent for publication to the "American Journal of Science," and will appear in its September number. In order to carry out the object of this memoir to its fullest extent, I propose here to make quite large extracts from this paper, and also to add a number of figures, both for the better understanding of the character of the animal, and for the sake of comparison with others, which are illustrated in the accompanying plates.

The mononematous *Flagellata* which are described in the foregoing pages (§§ 1–10), are connected with the heteronematous forms through two diverse lines; or rather they are closely allied to two different types of *diversiflagellate* infusoria, of which *Anthophysa* is an example of one type, and *Anisonema* (§ 13) a representative of the other; both of the *flagella* of the former being proboscidiform, and of the latter, one being gubernaculiform and the other proboscidiform. The intimate alliance of *Anthophysa* with *Monas* may be best expressed by saying that the former is a *Monas* modified by the addition of a comparatively minute *cilium* which is affixed to the head near the *flagellum*.

Anthophysa Mülleri, Bory (Epistylis? vegetans, Ehr.) is quite common among fresh-water plants, such as *Myriophyllum*, *Ceratophyllum*, and *Utricularia*, and adheres to their filiform leaves like an irregular, floccose, brownish deposit.

"Under a low magnifying power this floccose matter appears to consist of clusters of very jagged, irregularly branching and contorted, semi-transparent, intertwined stems and projecting, tapering, and flexible twigs (*pd*). Each of the tips of the latter sustains a single, more or less globose mass of spindle-shaped bodies (*md*), which radiate from a common centre of attachment, and are kept in a constant agitation by the spasmodic jerks of a long, stout, usually rigid, arcuate filament (*fl*), with which the free end of each one is endowed. The whole bristling mass revolves alternately from right to left, and from left to right; whirling upon its slender pivot with such a degree of freedom that one might almost suspect that it merely rested upon it, and had no truer adhesion to it than the juggler's top to the end of the *baton* upon which it spins. The largest of these twirling groups contains as many as fifty fusiform bodies, but most frequently not more than half that number are grouped together; and from this they vary in decreasing numbers down to only one or two (fig. 48), upon each filamentous twig. In the last instances the bodies are comparatively quiet, scarcely moving out of focus at each spasmodic twitch of the arcuate filament. On this account, and because they offer an unobstructed view, the latter are by far the most available as objects for the investigation of their internal organization."

"The relationship of the individual monads to the whole colony must, however, be studied where they are more numerously congregated; since, as will be shown presently, each monad sustains a definite relation to every other one, and to the twig to which it is attached."

"*Form, &c.* — The adult monads (figs. 47, 48, *md*) have a truncate fusiform shape, and are slightly, but quite appreciably flattened on two opposite sides; so that in an end view they appear to be broadly oval transversely. The attached end tapers gradually to a point; and on this account it is difficult to determine where the body ends and the twig begins. All of the members of a group radiate from a common point of attachment, to which they adhere by their tapering filamentous ends (fig. 48, pd^1). The free end is truncate, but one corner of it — as if in continuation of the line along which the opposite flattened sides meet — projects in the form of a rather blunt triangular beak (*lp*). At the inner edge of the base of this beak lies the mouth (*m*), to which the former — as frequent observation has proved — acts as a lip or prehensile organ when food is taken into the body. The prevailing tint is a more or less uniform light gamboge, without the least trace of an eye-spot of any color."

"A most singular uniformity prevails in the arrangement of the several members of a group. Each monad (*md*) is attached to its mooring in such a position that its flattened sides lie parallelwise with those of its nearest neighbor; and the beak (*lp*) projects from that corner of the head which is most distant from the twig (*pd*). To give a full idea of the peculiarity of this arrangement it must be stated here that the rigid, arcuate, spasmodically twitching filament (*fl*) mentioned above, is attached close to the mouth (*m*), and invariably curves away from the beak, and consequently always toward the pedicel (*pd*) of the colony."

"*Prehensile organs.* — The only motile organs which this animalcule possesses are preëminently prehensile in character; and their apparent appropriation for the office of propulsion, when a colony breaks loose from its attachment, I can scarcely doubt is an accidental one, inasmuch as the arcuate cilium continues its spasmodic twitching without any apparent deviation from its usual mode of action."

"There are two cilia, of very unequal size, attached to the truncate end of the body. The larger one of these has already been mentioned casually, as a *rigid, arcuate filament* (*fl*). It does not taper, but has a uniform thickness from base to tip, and is about half again as long as the body. It arises near the base of the triangular beak (*lp*), but appears to be separated from the latter by the intervening mouth (*m*). When quiet it appears like a bristle, and projects in a line with the longer axis of the body; at the base bending slightly toward the beak, and then sweeping off in a moderate but distinct curve in the opposite direction, so that on the whole it presents a long-drawn-out sigmoid flexure. The plane of this curve lies in strict parallelism with the plane of the greater diameter of the body; in fact it may be said to be a direct continuation of it. It does not appear to have the character of a *flagellum*, except when assisting the smaller cilium (fl^1) to convey the food to the mouth, and then it lays aside its rigid deportment and assumes all the flexibility and wavy vibration of the prehensile organ of an *Astasia*."

"*The smaller cilium* (fl^1) is an excessively faint body, and almost defies the detective powers of the highest objectives. This is partly due to its almost incessant activity; for when it is quiet, or nearly so — which happens when food is passing into the mouth, — it becomes comparatively quite conspicuous under a one eighth of an inch objective. It is scarcely as long as the greater diameter of the truncate end of the body. It arises close to the base of the larger cilium (fl), but whether on the right or left, or nearer or more distant from the mouth than the latter, cannot be said positively. Most frequently it was observed to be flexed in the same direction as its companion; and occasionally it seemed to be quite evident that it was attached nearer to the mouth than the latter. It is highly flexible, and vibrates with great rapidity in what appears to be a gyratory manner."

"*The Mouth.* — This organ is never visible except when food is passing through it (figs. 50, 51, *m*). It then may be seen that it lies close to the beak, which acts as a sort of lip by curving over the introcepted particles as they pass into the body. The mouth is highly distensible; at times allowing particles as wide as two thirds the greater diameter of the body to pass in without any apparent extra effort (fig. 51, *m*). It seems undeniable that it possesses discriminative powers in regard to the quality of its food. This one may readily judge of for himself, by seeing the unerring precision with which the particles of floating matter are thrown, by the spasmodic incurvature of the larger flagellum, against the mouth, where, if they are not swallowed, they are detained but for an instant by the smaller cilium, quickly adjudged to be worthless, and then thrown off with a twirl of the organ which held them in temporary abeyance. If, however, the captured morsel proves to be agreeable, the larger cilium (fig. 47, fl) assists the operations of the smaller one (fl^1), and the lip, by abruptly bending itself at its point of attachment and laying its basal part across the food, presses it into the mouth, while the terminal portion is kept in a constant wavy vibration, and curved toward the posterior end of the body. This is usually done in three or four seconds, and then the cilia return to their usual positions, while the introcepted edible passes toward the centre of the body, and is there immediately enclosed in a digestive vacuole (fig. 51, *d*). For a while the food dances about in this vacuole with a very lively motion, but finally it subsides into quietude."

"*The contractile vesicle* (*cv*). — There is a two-fold difficulty in discovering the presence of this organ. In the first place it is comparatively quite small, and secondly, it pulsates so slowly that it is very rarely possible to see it contract twice in succession between any two of the abrupt, lateral deviations of the body, which the spasmodic twitchings of the arcuate flagellum produce. On this account it has not been possible to determine the precise rate of its systole and diastole. It seems to contract from three to four times a minute. It lies near the surface, about half way between the two ends of the body, and nearly midway between the two extremes of its greater diameter. At the completion of its *diastole* it has a circular outline, and appears like a clear, colorless vesicle in the midst of the yellowish tissue of the body. Upon contraction it disappears, and leaves no trace of its presence. The *systole* progresses slowly, as in *Anisonema* (*A. sulcatum*, Duj. ? and *A. nov. sp.* [*A. concavum*, § 13]), *Cyclidium* (*C. nov. sp.*), and *Phacus pleuronectes*, Duj.; and in this respect contrasts strongly with the same process in *Heteromita fusiformis*, Jas.-Clk., *Astasia tricophora*, Clap. (§ 12), and *Cryptomonas (C. nov. sp.)*, in which the last half of the systole is very abrupt and marked."

"*The stem.* — In addition to what has already been said of the general appearance of this part of the organism, it may be added that the older and basal portions (fig. 63) of the branches are flat, and have a distinct longitudinal, irregular striation; to all appearances made up of the older, laterally agglutinated twigs. The youngest, terminal portions (fig. 47, *pd*) of the branches which, under the name of twigs, have been described in this paper as the immediate supporters of the colonies of monads, are evidently tubular (fig. 62). They appear to be as flexible as a spider's thread, and are usually quite irregular in outline, and in the calibre of the canal which permeates them. The wall of these tubular twigs is quite thick, and is alike rough on the exterior and interior faces. The substance within the tubes appears homogeneous, but whether it is solid or fluid could not be determined. The oldest part of the stems is of a reddish-brown color, but as they taper off into branchlets they gradually assume a gamboge color, and finally terminate in scarcely colored twigs."

"*Reproduction* by fissigemmation (figs. 52–61), is the only method of propagating individuals which I have observed. As a preliminary to this process the monad gradually loses its fusiform shape, and assumes at first an oval contour, and finally becomes globular (fig. 52). During this transition both of the prehensile cilia (*fl*, fl^1) become much more conspicuous than usual, and the body develops a closely fitting hyaline envelope (*h*) about it; thus passing into a sort of encysted state. The contractile vesicle (*cv*), however, does not seem to cease its pulsations during this period, and moreover it becomes quite conspicuous. This arises mostly from the fact that the body is in a nearly quiet state, and allows the observer to obtain a prolonged and undisturbed view of it. Unfortunately the rate of the pulsations of this organ was not ascertained when the following observations were made, because the whole time was occupied in watching aud drawing the various and rapidly changing phases of self-division."

"After the body assumes a globular shape, as above mentioned, both the larger and smaller cilium seem to be undergoing a change, and become indistinct in outline. Presently two larger flagella (fig. 53, *fl*) burst upon the view, apparently by the longitudinal splitting of the previously single one of the same kind, and rapidly separate from each other by the broadening of the body, leaving between them the smaller cilium. The latter at this time appears much thicker than usual, and seems to be composed of two closely approximated, parallel threads (fl^1). By this time the contractile vesicle has also divided into two, which lie closely side by side."

"At this moment the time noted in one series of observations was 2.30 P.M. By 2.35 P.M. (fig. 54), the larger flagella (*fl*) had separated still farther, and the smaller cilium had split into two (fl^1) very conspicuous filaments; as yet, however, attached to a common point of the body. From this time forth to the completion of the process of fissigemmation, all of the cilia kept up a slow vibration, in which they undulated from base to tip with a sort of snake-like motion. By 2.45 P.M. (fig. 55), the body had become quite appreciably broader than long; the contractile vesicles (*cv*) were widely separated, and the smaller cilia had left between them a considerable space, and each one had approximated quite near to the base of a larger flagellum. At 2.50 P.M. (fig. 56), the body had become nearly twice as broad as long, and the space (c^1) between the two pairs of cilia was nearly twice as great as in the last phase, and considerably depressed in the middle, so that the body had a broadly cordate outline. By 2.52 P.M. (fig. 57), the posterior end of the body — at a point a little to one side of the spot where it was attached to the pedicel — was also slightly indented, so that in outline it presented a guitar-shaped figure, each rounded half of which bore a pair of unequal cilia, and contained a contractile vesicle. In one minute more the contraction had increased to such an extent that the body was divided about half way through (fig. 58). By 2.54 P.M. (fig. 59), the animal had a dumb-bell shape, and the pedicel (*pd*) was attached to one of the segments near the point of constriction. Still the process went on very rapidly, and by 2.55 P.M. (fig. 60), the new bodies were widely separated, but still attached to each other by a mere thread. At 3 P.M. (fig. 61), the body which was attached to the pedicel was left alone, and its companion swam away to seek a new attachment, and build up its stem."

"To the last moment the hyaline envelope remained about the segments, and in fact so long afterward that time and circumstances did not allow me to ascertain its final disposition. I would remark, however, that when the ovate bodies of the half-grown monads (fig. 49) are contracted temporarily into a globular shape, they appear identical — excepting that they lack the hyaline envelope — with these recently fissated forms. In all probability, therefore, the latter lose their envelope and assume the shape of the former."

"As to the development of the stem, I think it quite certain that it grows out from the posterior end of the body. The best proof of this is that I have frequently found a monad — especially in the condition of the one which I described above as breaking loose from its companion — nearly sessile upon a clean spot, and attached by a very short, faint, film-like thread. From this size upward I have no difficulty in finding abundant examples as gradually increasing in diameter as they did in length; thus furnishing a pretty strong evidence that the stem grows under the influence of its own innate powers, and is not therefore a deposit emanating from the body of the monad, except, perhaps, as far as it may be nourished by a fluid circulating within its hollow core."

§ 12. Astasia tricophora, Clap.

(Plate IX., figs. 45, 46).

The transition from the mononematous *Monas*, *Codosiga*, *Leucosolenia*, &c., to those heteronematous *Flagellata* which possess at the same time a proboscidiform and a gubernacliform *flagellum* is most aptly exemplified by that curious mimetic combination of *Amœba* and *Anisonema* known as *Astasia tricophora*, Clap. (*Trachelius tricophorus*, Ehr.). At first sight it appears to be capable of all the abrupt retrogressive motions and short turnings of an *Anisonema* (figs. 65–69), without being endowed with a similar means of locomotion. One is not long, however, in discovering the homologue of the *trail* (fl^2) or rudder (*gubernaclum*) of the latter in the posterior, abdominal, triangular prolongation (fig. 45, fl^2) of the body of the former. That this is the true interpretation of the prolongation, is warranted not only by the use to which it is put, as a sort of *point d'appui* during the amœboid retroversions of the body, but also by its persistent form whilst the animal is contorted into a shapeless, writhing mass. In the midst of the paucity of distinctive topography, we are also furnished by this organ, if I may so call it, with a basis of ready discrimination between the practically ventral and dorsal sides of the body; for, although it may not lie strictly in the central line of progress during reptation, — nor could we expect to find it there upon being referred to its homological relation to the asymmetrically attached *gubernaclum* of *Anisonema*, — it none the less belongs to the reptant side of the animal, and as it were, controls its motions, and acts as a keel upon which the posterior end of the body vibrates and reels from side to side. Finally, in reference to this point, it may be added, that this species does not swim, properly speaking, nor has it the character of the revolving natant forms, such as Dujardin separated from the *Astasia* of Ehrenberg, and described under the name of *Peranema*.

For the sake of accumulating and multiplying diagnostic characters, that shall serve us hereafter as discriminative points in determining the classificatory relations of *Flagellata*, it is most desirable that every critical study of one of these forms should be carefully recorded, even to the minutest details. On this account, therefore, and particularly in the present connection, notwithstanding that this species is so frequently met with, and apparently so well known, it will not be out of place here to describe it anew; especially as some of the features presented for the consideration of naturalists are not in accordance with the interpretation put upon them by previous observers.

The *body* of this animalcule is colorless, but frequently has a slight yellowish or reddish tinge, which is derived by diffusion from the granular contents of the interior. The only legitimate color present lies in the very faint red eye-spot (*s*). The form is variable from elongate ovate to cylindrical, with a gentle taper, at the anterior third, into a narrow, truncate-emarginate head. Posteriorly the dorsal region is rounded, but on the ventral face a broad, triangular prolongation (fl^2) — already spoken of as the homologue of the *gubernaclum* of the reptant *Heteronemata* — extends backward beyond the outline of the *dorsum*. The exact relation of this prolongation to the axis of the body is not to be determined beyond a doubt, because of the constantly shifting attitude of the animal; at one moment the *gubernaclum* (fl^2) is on the left, and then at the next instant it appears on the right of the mesial line, or follows for a while between these two points, according as the body keels over more or less from one side to the other, or balances itself in a median position. It appears most frequently, however, to be unilateral.

The amœboid contortions (fig. 46) of the body have already been mentioned, but I would add that this is only a resemblance, a mere suggestion, if one may use the term, of the mode of locomotion of *Amœba*; for it is not, as in the latter, an actual *flowing out* of a glairy mass into protean, reptant processes, but an exceedingly variable *puckering*, and always accompanied by a longitudinal contraction of the body; the one being evidently necessary to the other. If I may carry out the niceness of distinction further, I should say that whilst *Amœba* is contractile and plastic, *Astasia* is retractile and flexible.

The *flagellum* (*fl*) also, by its subterminal attachment to the head, carries out the typical plan of the reptant *Heteronemata*. It is based strictly on the ventral side of the front, descending from the latter with such an abrupt turn forward that it appears, without close observation, to be a mere tapering prolongation of this region. Yet it is neither related to the body in the latter sense, nor an extension of it from any point of view, but is as strictly an appendage as any form of vibratile cilia,[1] and alike as incapable of contraction. It is so

[1] As my views in regard to the relation of vibratile cilia to underlying cells may not be fully understood in this allusion, I would refer to my published opinion of this subject, in a note appended to some remarks upon *Actinophrys*, in the *Proceedings of the Boston Society of Natural History*, for September, 1863, p. 283, and republished in the *Annals and Magazine of Natural History*, for December, 1864.

stout and thick that one need not be surprised to find Ehrenberg, in the absence of a knowledge of the structure of this animalcule, mistaking the scarcely tapering *flagellum* for the frontal prolongation of a *Trachelius.* Usually it is about half again longer than the body, but that of very large animals often greatly exceeds this proportion. Its mode of action, as a propulsive organ, is not like that most frequently exhibited by the *flagella* of the truly natant *Flagellata,* for whilst in the latter case the vibrations pass along the whole length of the *cilium,* in the former they are confined to its distal end, and moreover they seem to be different in character; since instead of simply undulating in a more or less restricted plane, the *flagellum* twirls at the tip rather after the manner of a revolving helix.

This method of progression is singularly modified by a rhombic meniscoid species of *Cyclidium,* Duj. (non Ehr.), whose *flagellum* during reptation projects — from a deeply subterminal point of the convex side of the body — without flexure almost to its tip, and then simply bends with frequent and vigorous strokes in the form of a hook, which it applies sidewise against the surface over which the creature is passing, and drags it after it, tilted over on one of its flanks, in a hitching, sidelong manner.

As a tactile organ, and for the purposes of prehension, the *flagellum* appears, by its great flexibility and vigorous action, to be eminently capable. Feeling about it with all the apparent expectation of finally meeting with something, the animalcule keeps its proboscis in a constant quiver, lashing it backward and forward in the meanwhile, or thrusting it along its flanks and then abruptly withdrawing it, very much after the manner of a *Lachrymaria.* When a particle of food is brought near the mouth (*m*), it is, as it were, coaxed into it by the light pulsations of the *flagellum,* apparently assisted by the movements of the buccal margin.

The *eye-spot* (*s*), so-called, naturally comes under consideration in connection with the tactile organ. It is a very minute circular body, apparently about as broad as the diameter of the *flagellum,* which lies a short distance behind the end of the head and just in front of the mouth (*m*). Frequently, from its excessive faintness, and light red color, it appears to be absent. but under careful scrutiny it may always be detected. The tendency which prevails to undervalue the importance of this body because it is present in an apparently similar position in the zoöspores of *Algæ,* no doubt hinders our advancement in the knowledge of its true character and function. Whether it is an organ of vision of any grade, or even a sensorial centre of any kind, can only be brought within the range of probability. Its constant presence demands attention, and should excite inquiry on that ground alone; but when, moreover, we find it in a position which corresponds to that in which the chief sensorial centres are usually situated, no mere resemblance to something else should divert us into a train of fancies about the homologies of the red oil globules of the zoöspores of *Algæ,* whilst the main point at issue is left in obscurity.

If we cannot add any thing further that is positive in regard to this organ, it will be well at least to attract attention to it in relation to its homologue in other *Flagellata.* In *Phacus pleuronectes,* Duj., it is not a uniform red spot, but seems to be divided into two regions, one of which is lunate in shape and of a bright red color, and projects forward from the upper side of the other like an appendage; whilst the main part is more deeply seated in the dorsum, and consists of a colorless, but quite conspicuous, irregularly circular disc, about as broad as the contractile vesicle, which it partially overlies. In this case one might, with a fair show of reasonableness, suggest that the red portion alone is the true eye-spot, and that the colorless disc is a sensorial centre, not only for the former but also for the *flagellum*, which arises close to it, on the ventral side. When we recall instances of the presence of a similar disc, which is unaccompanied by a red spot, in certain species of uniflagellate, natant *Flagellata* (*Peranema?* Duj.), and mark how long it is persistent after the body has fallen to pieces for the lack of fresh water, one cannot but feel that its superior consistency is a fair warrant for the belief that it is at least an important organ, and that, seeing the very faint color of that of *Astasia trichophora*, the absence of all tint does not necessarily exclude it from the category of visual organs. On the other hand, it might be justly questioned whether even the deepest colored spots are at all sensitive to light; and the only answer would be, that analogy renders it highly probable that they are.

The *mouth* (*m*) is a very marked feature when contrasted with that of other *flagellifers*. It is usually to be observed in a closed state (fig. 46, *m*), when it may be recognized as a short, dark, sharply defined double line trending lengthwise with the body, and situated on the ventral side, a short distance behind the base of the *flagellum*, and just in front of the contractile vesicle. When open it has a more or less broad oblong shape, and is more conspicuous than when closed. During the introception of food it is quite active, but whether for the purpose of mastication, or merely to manœuvre the incoming particles, cannot be said positively, although it is probably with the latter design. The peculiar knobbed, particolored aspect of the body is due to the almost invariably present large, highly refracting, red and yellow granules in the general cavity.

The *contractile vesicle* (*cv*) is situated just behind the mouth, but near the dorsal side of the body. At full diastole it is globular, and its diameter is one third of the breadth of the region in which it is situated. The systole is abrupt, and appears to be complete; and the diastole is slow, seeming to occupy all of the intervening time between the systoles. The rate of systole was not ascertained with sufficient accuracy to be recorded, but I should judge it to be not more than four or five times a minute.

The *reproductive organ* (*n*) is probably represented by a very large, light, oval mass which nearly fills the middle of the body. It has a decided outline, and, with the exception of a rather large, central, nucleiform body, its contents are homogeneous.

§ 13. Anisonema (A. concavum, nov. sp.)

(Plate X., figs. 65–69.)

Among all the heteronematous gubernaclifers, *Anisonema* possesses the highest degree of differentiation in its flagella (fl, fl^2); for whilst in *Heteromita* and *Heteronema* these organs are comparatively more like each other, and arise from a nearly common point, as in the *Homoionemata*, in the former genus they exhibit a greater diversity of character, and also originate from more widely separated regions. These are particularly observable in the species before us now, and are certainly more valuable diagnostic characters than the presence of an uncontractile integument by which to distinguish it from its congeners. The habitat of this animalcule is among tangled masses of confervoid *Algæ* in ponds and ditches, where decaying substances are most abundant. Upon these it moves with a more or less uneven pace; at one time gliding over a smooth surface with scarcely a perceptible effort, and at another progressing with a laborious, hitching gait, and lashing its *gubernaculum* (fl^2) about, and swinging its body from side to side, with frequent jerks, in its effort to pass over some obstacle.

The *body* is colorless, and enclosed in an uncontractile, smooth integument. It has an asymmetrically ovate shape, rounded behind, and rapidly narrowed anteriorly into an oblique, truncate conical front. Dorsally it is convex (figs. 67, 68), but ventrally, *i. e.*, on the reptant side, it is concave on the right and in the middle, and so strongly incurved on the left, that its sharp edge (t) reaches nearly to the median line. Beneath this inrolled border the enclosed space (fig. 68, t^1) projects into the left side like a longitudinal, covered way. In front it is very deep, but from that point going backward it narrows gradually, and finally, with the inrolled edge, fades out at the posterior third of the body.

The *two flagella* ($fl\ fl^2$) are as widely diverse in character and function as any two similar organs in the whole group of *Protozoa*. The anterior one (fl) is, strictly speaking, the prehensile organ, as well as the main propulsory agent. It is quite delicate, and tapers gradually, from its subterminal base within the longitudinal covered way, to an extremely fine tip. In point of length it varies from one half to two thirds longer than the body. It is always carried in an extended position in front, and vibrates very actively, especially during reptation.

The posterior flagellar organ, or *gubernaclum* (fl^2), is from three to four times the length of the body, and arises far from the front, in the deepest part of the covered way (fig. 68, t^1), and immediately beneath the contractile vesicle (cv). It is therefore attached quite near to the left margin of the body, and between the anterior and middle thirds. Its base, which is applied very obliquely to its point of attachment, is quite broad, but it narrows rapidly into a uniformly, but scarcely tapering lash, which always projects forward more or less, and then curves backward and extends to a long distance behind. During reptation over smooth surfaces it lies along the abdominal, median line, and trails behind in long gentle undulations. Although it never vibrates, it frequently lashes about, and applies itself against obstacles on the right and left, or even in front, and acts as a prop upon which the body is thrown from one side or the other, according to varying circumstances. That it is contractile would seem incontestible upon observing the sudden jerk with which it sometimes draws the body back toward its distal end; but I am pretty well convinced, from a careful study of this movement, that, although this organ may be to a slight degree *resilient*, it is not truly contractile, but rather *flexible*, and exhibits its muscular power by bending itself into coils or zigzags. Occasionally specimens are met with which have an additional pair of flagella (fig. 69, fl^3), of a more delicate kind, attached near the others. That these originate as a preliminary step to fissigemmation, although that phenomenon was not witnessed in this case, there can be scarcely a doubt, inasmuch as it accords perfectly with what has been observed in *Anthophysa* (p. 329).

The *mouth* has not been demonstrated to a certainty, by actually seeing food pass into it, but an approximative determination was reached by observing particles of matter, which were brought down by the prehensile *flagellum* (fl), pass into the body somewhere near the front, and apparently within the compass of the covered way.

The *anus* (figs. 65, 66, a) was adjudged to be at the posterior end of the animal, by noticing, in a couple of instances only, a clear, more or less irregular, rounded mass in this region, and its final disappearance while under observation; but the substance was so transparent that it was not possible to decide positively whether it made its exit upon the dorsal or the ventral side.

The *contractile vesicle* (*cv*) is a comparatively large organ, with a rounded contour when in full diastole, and quite faint and inconspicuous. It lies above the base of the *gubernaculum* (fl^2), the expanded base of the latter appearing at times to form a part of it, and by its movements — causing an alternation in light and shade — tends to mislead one into the belief that the systole is very irregular. A careful adjustment of the lens, however, reveals the true pulsation, and shows that the systole has a very slow rate.

§ 14. Heteromastix, Jas.–Clk.[1] (H. proteiformis, Jas.–Clk.)

(Plate X., figs. 70, 71, 72, 73, 74.)

I shall not describe this infusorian in the same systematic manner that has been adopted in treating of previous genera, because I do not know much about its internal organization; but in order that the direct alliance of the *Flagellata* with the *Ciliata* may be illustrated in this memoir in its strongest light, and inasmuch as *Heteromastix* is by far the best example of such a transition between the two above-mentioned orders, I shall take the liberty of quoting what I have already published in regard to it in another place.[2]

"Here is an infusorian (figs. 70–74), from fresh water, which, although it has a pretty strong resemblance to *Euglena*, heightened by the presence of a red eye-spot (*s*), will be found, upon investigation, to possess some additional and decidedly different characters. In the first place, it has two vibrating lashes ($fl\, fl^2$), which differ remarkably among themselves both in position and character. One of them is always carried in front like a sort of proboscis (*fl*), and in fact, it seems to have the office of such an organ, like that of an elephant, to feel and to take hold of objects. I must confess that I was struck with astonishment at the apparent intelligence with which the infusorian extended and twisted and turned and felt about with this extraordinary organ. Never did an elephant seem to use his trunk with more thoughtfulness. With like control did the animal also use the other lash (fl^2), always keeping it turned back along the body; so that it formed a kind of movable keel, when the little creature glided along in its watery element, or was used to sway it from side to side, or oftentimes to raise it up on its tail by forming a prop, as we see it in this other figure (fig. 73.)

"The motory or propelling power, on the other hand, is restricted, at least in the greatest measure, to another kind of vibratile cilia. These are very short, and are crowded together in great numbers (*cl*) in a broad furrow or depression (*f*), which extends over half the length of the body, along its inferior, middle line. When the body is turned over, and the anterior end retracted and swelled out sideways, the furrow (fig. 73, *f*) becomes quite conspicuous, and the extent of the group of minor cilia (*cl*) is easily ascertained. They are very minute and in constant motion, propelling the body backward and forward, up and down, to the right or left, according as it is steered by the trailing lash (fl^2) which extends along its length. Thus it is, that, although similar in form, a diversity of functions is laid upon these three kinds of cilia that amounts to the most marked specialization, through the simplest means; in fact, so simple that the eye cannot detect them in any form beside that of pro-

[1] ἕτερος, dissimilar. μάστιξ, a lash. This genus was originally described in my published volume of Lowell Lectures. *Mind in Nature*, p. 146, fig. 88.

[2] See note 1.

portion and position, and certainly not in the intimate structure of these bodies. The whole body, too, possesses a flexibility and extensibility scarcely inferior to its cilia; at one moment it is darting through the water, sharp as a lance at both ends, and at the next it is as round as a ball, or worming its way through tortuous passages with every possible degree of flexure short of actually tying itself into a knot."

It would be difficult to say now whether *Heteromastix* belongs to the *Flagellata* rather than to the *Ciliata*, or *vice versa*. The structure, position, and peculiar mode of action of its flagella recall *Anisonema* (§ 13) most vividly to mind, but, on the other hand, the group of cilia (*cl*) in the obliquely longitudinal furrow (*f*), in close proximity to, and evidently acting more or less as allies with the flagella (fl, fl^2), find their parallel in the "proboscis-like lash" (fig. 75, *fl*), and vestibular cilia (*cl*) in the oblique buccal furrow of *Pleuronema* (§ 16), and *Dysteria* (§ 15). How closely allied the two latter are to the former is not the immediate question here; it is, are they related at all? We think there can be no hesitation in replying in the affirmative; but in order that the reader may have the proof before his eyes, I think it will not be out of place, in this memoir, to introduce some of the undoubted *Ciliata* which possess at the same time organs that are as truly flagellate in character as are the flagella of *Anisonema, Astasia*, etc., etc. The genus *Dysteria* shall be our first example.

§ 15. Dysteria, Huxley. (D. proræfrons, Jas.–Clk.[1])

(Plate X., figs. 77, 78.)

This species "is an infusorian between two leaves or flexible shells (v, v^1), of unequal width, which are united by a sort of hinge along the left border and gaping to a more than equal extent along the right side, where the upper one (v) far overhangs the other (v^1, bk) throughout the whole length of its free edge. The broader or dorsal shell (v) is convex toward the eye, and the whole organization lies within its concavity, whilst the narrower one (bk, v^1) is flat, simply covering the body, and as a natural consequence does not include any part of it. The open space between them is endowed with a row of closely-set, large, vibratile cilia (*cl*), which differ in size according to their position; those in front being by far the longest, and those along the side scarcely more than half as long; and in addition there is one (*fl*) which, from its great size, has more of the character of a proboscis, or prehensory flagellum, and is attached nearly at the extreme anterior border of the row" (*cl*).

"It is not an easy matter in this case to determine how much of the one-sided, cilia-bordered furrow corresponds to the disc or vestibule of *Epistylis, Stentor, Paramecium*, or *Pleuronema;* nor does it affect the question of the degree of obliquity of the conformation of this animal, so long as we see that, whatever it may be, either wholly or in part a vestibule, it is at least extremely oblique, and that it is not possible to view it from any point but that the body appears asymmetrical in relation to it."

"The most striking peculiarity of this creature is its habit of swinging around on a pivot (fl^2), which consists of an ovate or lancet-shaped appendage, of considerable dimensions, that projects from near the posterior end of the body, and in the line of the row of cilia. The pivot possesses perfect flexibility at its base, so that the animal can move over a considerable distance backward and forward without disturbing the point. Most of the time it keeps the flat side down when gyrating around its place of attachment; but now and then

[1] See *Mind in Nature*, ut sup. p. 171, fig. 100.

it turns upon its right edge, and performs its eccentric rotations about the appendage. This is the habit which, as I said before, has impressed some observers with its similarity to the Rotifera. In connection with this, too, it happens that the creature possesses a pair of jaw-like, or rather pincer-like bodies (m^1) which lie near the entrance to the mouth, and occasionally open and shut like a pair of forceps, just as similar bodies known as the jaws of Rotifers do, whilst food is passing between them. Excepting the passage between these jaws, there is not the least trace of an intestine, nor of any definite cavity devoted to digestion. The food occupies the whole length and breadth of the body, under the same circumstances as are observable in *Parameeium*, *Pleuronema*, *Stentor*, etc.

"The contractile vesicles are two (*cv*, *cv*) quite small globular bodies, one of which is situated just to the right of the jaws (m^1) and the other close to the base of the pivot (fl^2); and although they contract very slowly, not oftener than once in four or five minutes, they evince every characteristic, in action and physiognomy, of true infusorian, pulsating vesicles. The large colorless reproductive organ (n) singularly exemplifies in itself the one-sidedness of the animal by its conformation to the shape of the body. One side of it is convex, and, like the rest of the organization, projects into the concavity of the larger shell, whilst the other face is flat and, as it were, moulded upon the plane shell. It forms a very conspicuous object just to the left of the jaws, and might easily be mistaken at first glance for a contractile vesicle, especially as the true representatives of that organ are so very inconspicuous both in regard to their size and actions.

"Now in all the organization of this animal there is nothing which is not strictly infusorian in character. The jaw-like bodies (m^1) are not confined to this alone, for there are quite a number of others which possess a similar apparatus at or near the mouth. Chilodon has a complete circle of straight rods around the mouth. As for the pivot (fl^2), it is nothing but a kind of stem, such as exists on a larger scale in *Stentor*, or is more peculiarly specialized in the pedestals of *Epistylis*, *Zoothamnium*, or *Podophrya*; and, as counter to what we see in these last, I would state that there are certain of the Vorticellians, closely related to *Epistylis*, which have no stem whatever, and swim about as freely as *Dysteria*."

§ 16. Pleuronema, Duj. (P. instabilis,[1] Jas.-Clk.)

(Plate X., figs. 75, 76.)

This infusorian bears such a strong resemblance to *Heteromastix* (§ 14) in some of its external features, that it seems as if it might more properly have succeeded the latter in the illustration of my subject; but mere resemblances do not always indicate relationship, and in the case of *Pleuronema*, in particular, this is most true, for it is decidedly a far more highly organized animalcule than *Dysteria*, as we shall see by what I shall now quote from an already published description.[2]

"What I wish now to show in the *Pleuronema* is the triple, or I might say even the quadruple diversity of the vibrating cilia, or in other words, a quadruple specialization of one type of organs, by their manifold offices ranking their possessors above those of their class which attain to a less degree of complicity in this respect. The most prominent of these cilia are those which are arranged in longitudinal rows (fig. 75, cl^1) over nearly the whole extent of the body, and which most frequently are seen in a quiet state, projecting far out

[1] See *Mind in Nature*, ut sup. p. 148, fig. 90. [2] See note 1.

from the surface like so many fine, rigid bristles. In fact, the motions of this animal are so lightning-like in rapidity that I have never seen this form of cilia except when the body was in a quiet state; and therefore I judge that, as they do not move then, they are the principal organs of locomotion. There is on the right side a group of much more heavily built cilia (*cl*), which project from the oblique furrow in which the mouth (*m*) is set. They are more particularly devoted to producing currents in which the particles of food may be brought to the mouth.

"We see, also, projecting from the forward end of the oblique furrow, and near the anterior edge of the mouth (*m*), one of those proboscis-like lashes (*fl*) [a *flagellum*] which are so characteristic of the lower, ciliate [flagellate] infusoria; but yet it would not seem to have the same office as in the latter, since it is usually held in this position, apparently as rigid as if it were a wire; and only now and then does it move, by a sudden jerk, and disappears in the oblique furrow; probably acting there in concert with the other cilia in the introduction of food into the mouth. The fourth and last kind of cilia of which I have to speak, consists of two excessively faint, very long, and quite large, bristle-like filaments (sl, sl^1), which project from each end of the body. The straight one (*sl*) always precedes when the creature is in motion, and the curved one (sl^1) is attached a little to the left of the posterior end of the body. Both are always rigid when the animal is not in motion, — but yet there can be no doubt that they are flexible, for at times they disappear suddenly, and probably are bent under the body. What their office is I cannot say, but conjecture, from their resemblance to what are called the saltatory bristles of other infusorians, that they are used as accessory means of sudden propulsion, or leaping, — a habit which seems to be the most frequent mode of leaving any point at which the creature has fairly come to a stand-still.

"The contractile vesicle (*cv*) lies close to the forward end of the body, and corresponds in activity to the vivacity of the motions of the latter. It contracts every ten seconds, and with more vigor than any other that I know of. It is very conspicuous, as it is two thirds of the time in an expanded state; and disappears and reappears like the sudden closing and opening of a large eye.

"I have already indicated the position of the mouth (*m*) as being near the broader, anterior end of the oblique furrow, but again speak of it here in order to make the description of the digestive system complete. From the mouth (*m*) the food passes directly into the general cavity without going through any throat, and most frequently combines in large masses (*d*).

"The presence of a reproductive organ (*n*), which we find here in the form of a clear, colorless, globular body, when added to all the other systems which I have mentioned, puts this animal in the condition of a fully organized, ciliated infusorian; and would seem to give us full warrant for believing it to be the culmination of a progressive development, whose tendency is to pass through such forms of animate organization as we have just been tracing in the successively more and more complicated creatures whose images are before us."

Description of the Figures of Plates IX. and X.

The corresponding parts in the figures are lettered alike, excepting when otherwise stated in the description ot any particular illustration.

a, anus. — *b*, membranous collar; b^1, edge of *b*; b^2, base of *b*. — *bk*, the beaks of the valve of *Dysteria*. — *c*, calyx; c^1, aperture of *c*; c^2, lower half of *c*. — *cl*, cl^1, vibratile cilia. — *cv*, contractile vesicle. — *d*, digestive vacuole, or ingested food. — *e*, furrow in fissigemmation ; e^1, anterior end of *e* ; e^2, prolongation of *e*, e^1. — *f*, broad sulcus, (in *Heteromastix*). — *fl*, flagellum ; fl^1, minor flagellum ; fl^2, *gubernaclum*. — *fr*, frontal area. — *i*, neck, or anterior half of body. — *lp*, lip. — *m*, mouth ; m^1, jaws. — *md*, monads of the Sponge, etc. — *n*, reproductive organ. — *o*, ostioles. — *pd*, pedicel ; pd^1, top of *pd* ; pd^2, forks of *pd*. — *r*, retractor muscle ; r^1, furrow in which *r* is imbedded, and attached. — *s*, eye-spot. — *sl*, sl^1, saltatory cilia. — *sp*, triradiate spicula, sp^1, aciculate spicula. — *t*, margin of the inrolled side of *Anisonema* ; t^1, the deep furrow or covered way behind *t*. — *v*, broader valve of *Dysteria* ; v^1, the narrower valve.

Explanation of Plate IX.

Figs. 1–4. *Monas termo*, Ehr.? Fig. 1, a group of free monads. 500 diam. Fig. 2, a free monad seen from the narrower side, with the lip (*lp*) next the observer, and the contractile vesicle (*cv*) in profile. 950 diam. Fig. 3, an attached form seen from the broad side. 1200 diam. Fig. 4, a free monad in the act of swallowing a large morsel of food. 950 diam.

Figs. 5, 5^a, 5^b, 6. *Monas neglecta*, n. sp. Fig. 5, broad-side view of a pedicellated monad. 950 diam. Fig. 5^a, a posterior view showing the axial attachment of the pedicel (pd^1) and the contractile vesicle (*cv*) in profile, and the flagellum (*fl*) in the distance. 950 diam. Fig. 5^b, a free monad in the act of swimming. 950 diam. Fig. 6, an attached form, contorted in the act of swallowing a large morsel of food. 950 diam.

Figs. 7–27. *Codosiga pulcherrimus*, n. sp. Fig. 7, a colony of eight monads, drawn within an hour after the fissigemmation of three of its members. 150 diam. Fig. 8, a group of five, in a bird's-eye view. 500 diam. Fig. 9, a single monad, with three contractile vesicles (*cv*). The dotted lines indicate the degree of the lateral vibrative expansion of the membranous collar (*b*). 950 diam. Fig. 10, the same as fig. 9, preparing to undergo fissigemmation ; the body is contracted and widened, and the collar (*b*) broadened. Figs. 11–22, to illustrate the process of *fissigemmation*. 750 diam. For particulars see the text (p. 316). Fig. 23, a free monad in the act of swimming ; the vibrating flagellum (*fl*) acting as a propulsory agent, and following in the rear. 950 diam. Fig. 24, a single, pedicellated monad from old, stale water ; the membranous collar (*b*) contracted into a cone, and the flagellum (*fl*) vibrating rapidly. 950 diam. Fig. 24^a, a very large pedicellated form, just before *fissigemmation* begins ; the body partially contracted, and the collar (*b*) vibrating. The peculiar sigmoid curve of the flagellum (*fl*) is well shown here. 950 diam. Figs. 25, 26, 27, showing the different degrees of contraction of the membranous collar (*b*) of the same individual. In fig. 25, the *flagellum* (*fl*) is vibrating rapidly, just at the moment when the collar (*b*) has returned to its usual form and attitude. 750 diam.

Figs. 28–32^a. *Salpingœca marinus*, n. sp. Figs. 28, 29, 30, the same individual in different states of expansion. 1900 diam. Fig. 31, the body completely filling the calyx, so that the latter is scarcely distinguishable, except at its mouth (c^1). 1900 diam. Fig. 32, showing the calyx as a distinct envelope considerably separated from the body at the bottom (*c*) and at the aperture (c^1). 1900 diam. Fig. 32^a, an empty calyx closed. 1900 diam.

Figs. 33, 33^a, 33^b, 33^c. *Bicosœca lacustris*, n. sp. Fig. 33, an adult, with the lip (*lp*) nearest the eye, the flagellum (*fl*) in the background, and the longitudinal furrow seen through the body. The flagellum (*fl*) is uncoiling just as the body emerges from the bottom of the calyx (*c*). 950 diam. Fig. 33^a, a young animal in profile, showing the peculiar attitude and curve of the flagellum (*fl*), the narrow aperture (c^1) of the calyx (*c*), and the unilateral attachment of the retractor muscle (*r*). The pedicel (*pd*) is just beginning to develop. 950 diam. Fig. 33^b, a young form partially emerged from the bottom of the calyx (*c*), the latter contracted at the mouth (c^1) and the flagellum (*fl*) forcing its way through, as is usual, in a loop. 950 diam. Fig. 33^c, the same as fig. 33^a, retracted to the bottom of the calyx (*c*) and the aperture (c^1) of the latter nearly closed. 950 diam.

Figs. 34, 35. *Bicosœca gracilipes*, n. sp. Fig. 34, the longitudinal furrow (r^1) and the flagellum (*fl*) next the eye ; the lip (*lp*) in the background. 1900 diam. Fig. 35, the body retracted to the bottom of the calyx (*c*), and the flagellum beginning to uncoil. 950 diam.

Fig. 36. *Codonœca costata*, n. sp. The body seated in the bottom of the pedicellated calyx (*c*). 950 diam.

Figs. 37, 37^a, 37^b, 37^c, 37^d. *Salpingœca amphoridium*, n. sp. All magnified 950 diameters. Fig. 37, an individual suspended freely in its calyx (*c*, c^1). The dotted lines indicate the attitude which the collar (*b*) assumed for a while during the observation upon this specimen. A particle of fœcal matter has just left the anus (*a*). Fig. 37^a, the lower part of the calyx filled by the body, the upper part (c^1) free from the neck (*i*) of the animal, and the membranous collar unusually narrowed. Fig. 37^b, the calyx mostly filled by the body, the head (*i*) bent to one side, and the flagellum (*fl*) in the act of expelling a particle of undesirable matter. Fig. 37^c, an empty calyx, slightly contracted in dimensions. Fig. 37^d, the body contracted and filling the calyx, and the membranous collar (*b*) partially retracted.

Figs. 38, 39. *Salpingœca gracilis*, n. sp. 950 diam. Fig. 38, the body retracted within the calyx (c, c^1). Fig. 39, the same as fig. 38, partially protruded from the calyx.

Figs. 40–44. *Leucosolenia* (*Grantia*) *botryoides*, Bowrbk. Fig. 40, a colony of sponge; natural size. Fig. 41, view of a profile section of the monadigerous layer; the monads (*md*) closely packed together, side by side, with the membranous collar (b) and the flagellum (*fl*) projecting into the general cavity of the colony. 950 diam. Figs 42, 43, 44, isolated monads with the membranous collar (b) in various attitudes. 950 diam. See also fig. 64.

Figs. 45, 46. *Astasia tricophora*, Clap. Fig. 45, a dorsal view, the mouth seen through the head, and the *guber naclum* (fl^2) in the background. 500 diam. Fig. 46, the body in an amœboid, contorted state. 500 diam.

Explanation of Plate X.

Figs. 47–63. *Anthophysa Mülleri*, Bory. Fig. 47, a colony of adults attached to a single tubular branchlet or pedicel (*pd*). One of the monads is in the act of passing a morsel into its mouth (m). 950 diam. Fig. 48, a pair of adults, seen in profile. 950 diam. Fig. 49, a pair of young monads; one in profile and the other presenting its narrow side. 950 diam. Figs. 50 and 51, different attitudes of the same monad as the one in profile in fig. 49, during the introception of food. 950 diam. Figs. 52–61, to illustrate the process of fissigemmation. 950 diam. Fig. 62, a piece of a tubular branchlet like fig. 47, (*pd*). 1900 diam. Fig. 63, a piece of a flat branch from an old part of the colony. 950 diam.

Fig. 64. *Leucosolenia botryoides*, Bowrbk. A portion of the monadigerous layer (*md*) seen through the spiculiferous stratum, with the spicula next the eye. 500 diam.

Figs. 65–69. *Anisonema concava*, n. sp. All magnified 500 diameters. Fig. 65, a dorsal view, the inrolled margin (t) seen through the body. Fig. 66, a ventral view of fig. 65, the base of the gubernaclum (fl^2) covered by the inrolled edge (t). Fig. 67, a profile view of the right side of the body, showing its concavo-convex character. Fig. 68, an end view, to show the lateral extent of the covered way from which the *gubernaclum* (fl^2) and the anterior flagellum (*fl*) spring. Fig. 69, a ventral view of an animal which possesses two extra flagella (fl^3). It is probably in the incipient stage of fissigemmation.

Figs. 70–74. *Heteromastix proteiformis*, Jas.–Clk. All the figures are magnified 500 diameters. Fig. 70, profile view of the right side of a fully extended animal, the gubernaclum (fl^2) trailing beneath. Fig. 71, the same as fig. 70, in a partially contracted state. Fig. 72, an individual seen directly from below, with its anterior end strongly retracted and broadened. Fig. 73, an animal partially contracted and propped up on its tail by its flagella (fl, fl^2), and exposing its ventral, ciliated furrow (f) to full view. Fig. 74, an end view of the head, with the group of cilia (*cl*) on the lower side.

Figs. 75, 76. *Pleuronema instabilis*, Jas.–Clk. Fig. 75, a dorsal (ventral, homologically speaking,) view. 1000 diam. Fig. 76, an end view of the head; the contractile vesicle (*cv*) in the foreground, and the flagellum (*fl*) in the distance. A part of the ventral side is destitute of cilia. 500 diam.

Figs. 77, 78. *Dysteria proræfrons*, Jas.–Clk. Fig. 77, a view of the dorsal (homologically the ventral,) side, the broader valve (v) next the eye, and the narrower, three-beaked valve (v^1, *bk*) in the extreme distance. 600 diam. Fig. 78, a fore-shortened view of the body as it appears when turned up on its right edge; the head next the observer, and the pivot (fl^2) in the distance. 600 diam.

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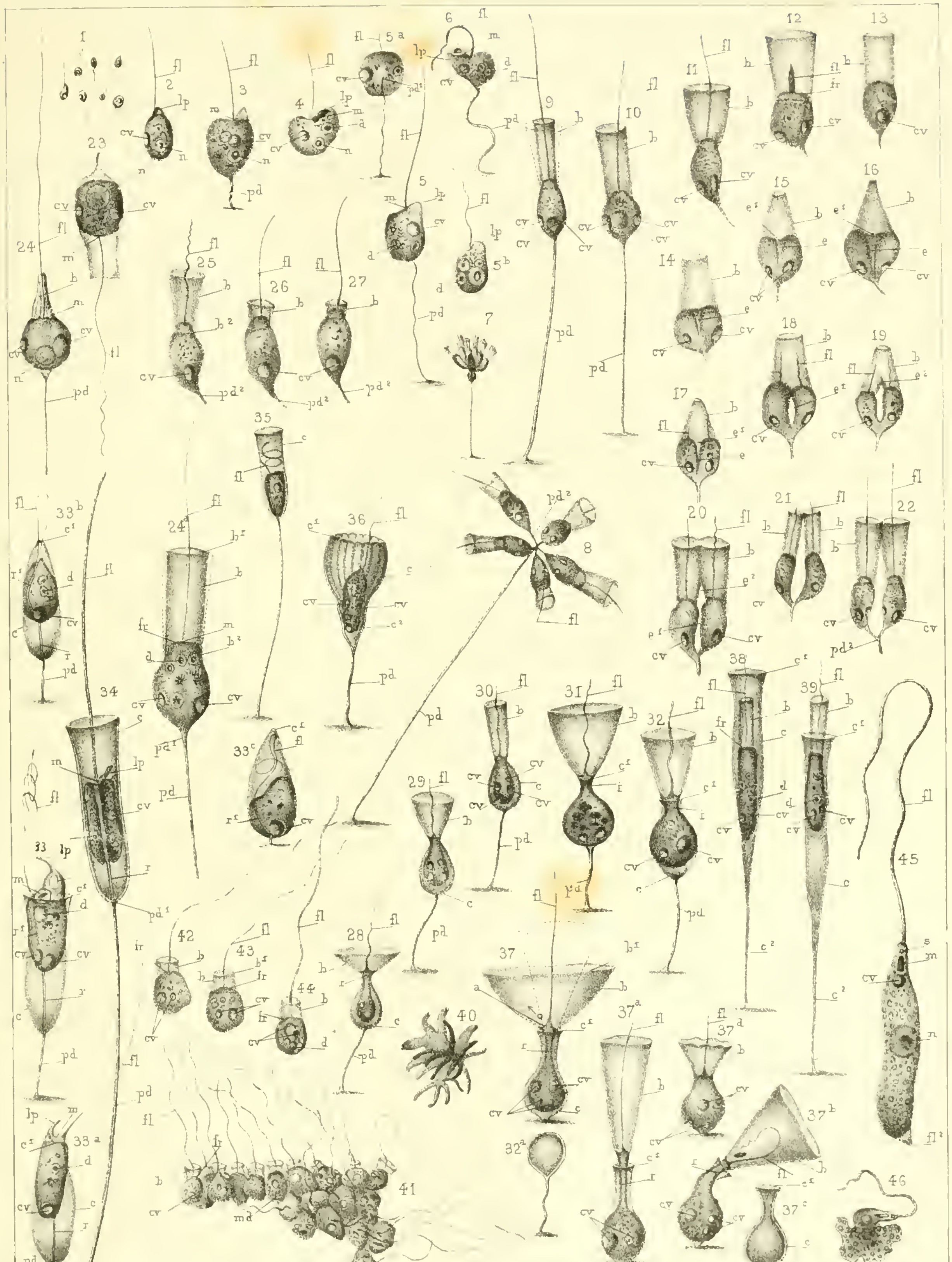

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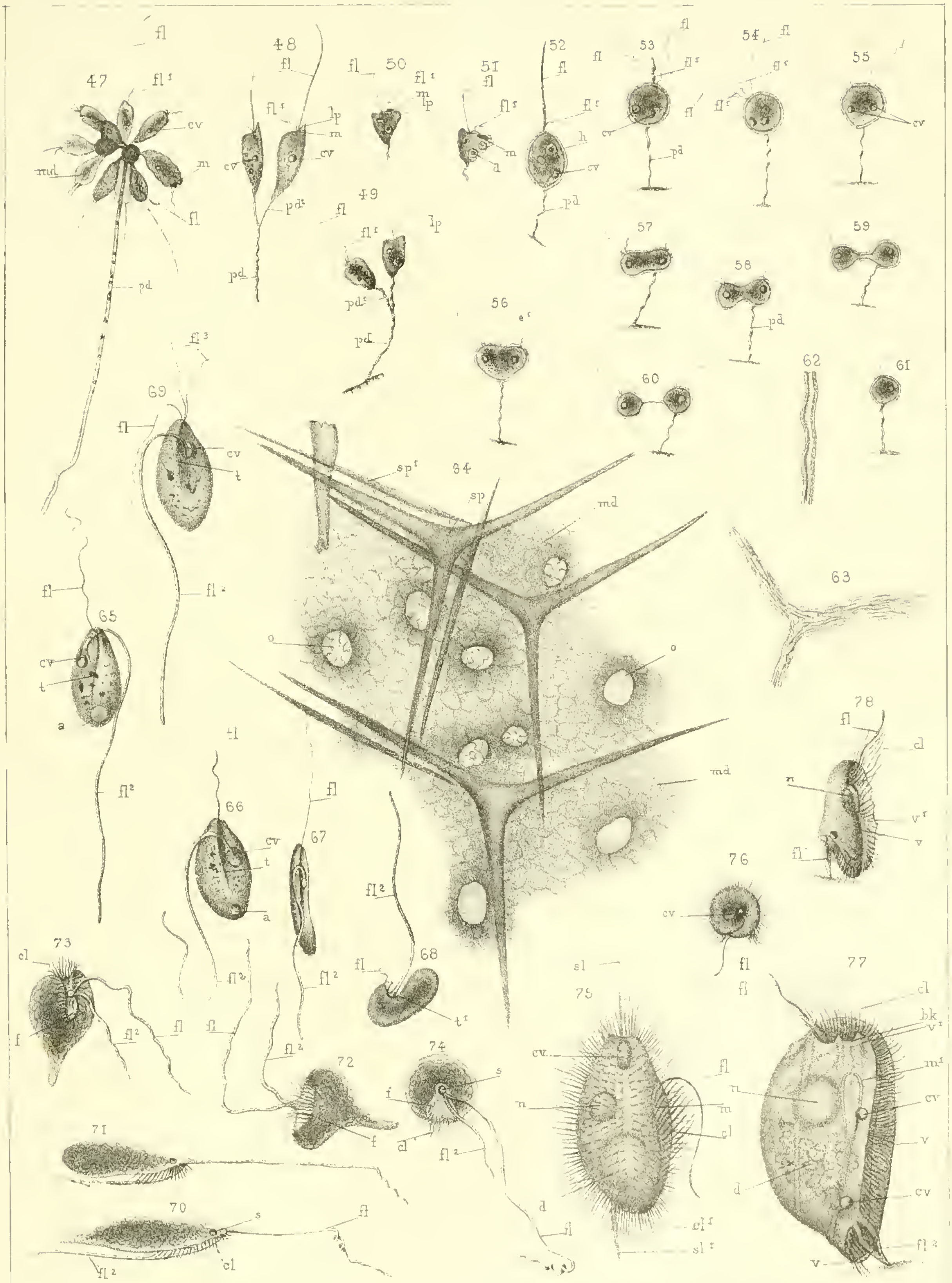

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