
Ex-libris
Charles Atwood
Kofoid
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COLLARED MONADS (*Choano-flagellata*).

1, Monosiga fusiformis; 2, Codosiga alloides; 3, C. grossularia: 4, C. umbellata; 5, C cymosa: 6, C. botrytis; 7, Astrosiga disjuncta; 8, A. moniliformis; 9, Salpingæca marina; 10, S. ampulla: 11, S. Steinii; 12, S. napiformis; 13, S. Clarkii; 14, S. vaginicola; 15, S. cornutum; 16, S. tintinnabulum; 17, Lagenæca cuspidata; 18, Polynæca dichotoma—all highly magnified. (*Modified after Saville Kent and Stein.*)

TYPE PROTOZOA.—CLASS INFUSORIA (INFUSORY ANIMALCULES).

Microscopic Animals—One Cause of the Phosphorescence of the Sea and of the Discoloration of Water—The Life in Infusions—Characters of the Infusoria—Example of Ciliate Infusorians—The Slipper Animalcules—Their Construction—The Flagellate Order—Features—*Cercomonas*—The Cilio-flagellate Infusorians—Characters—The Animalcules of the Ponds in Phœnix Park, Dublin—*Melodinium*—*Ceratium*—The Order Tentaculifera—Characters—*Acineta*—Classification—The Ectoplasm—The Endoplasm—Origin of the Cilia, Flagella, and Tentacles—How Infusorians Feed—Action and Function of the Contractile Vesicle—The Nucleus or Endoplast—The Colours of Infusoria—The Coloration of Waters—Trichocysts—Reproduction by Fission, Gemmation, and otherwise—Distribution—TENTACULIFERA—SUCTORIA—ACTINARIA—CILIATA—HOLOTRICHA—Paramecium—Prorodontidæ—Trachelocercidæ—Ichthyophthiriidæ—Colepidæ—Ophryoglenidæ—Pleuronemidæ—Lembidæ—Family Discovered by Leidy—Opalinidæ—HETEROTRICHA—The Largest Infusoria—*Spirostomum ambiguum*—*Condylostoma patens*—*Stentor polymorphus*—PERITRICHA—*Halteria grandinella*—*Urocentrum turbo*—The "Bell" Animalcules—Genera with Vorticella-like Animalcules—HYPOTRICHA—CILIO-FLAGELLATA—FLAGELLATA—*Noctiluca miliaris.*

If a glass tumbler be dipped into a pond or ditch, so as to collect some of the vegetation which is found at the surface and at the sides, besides some clear water, it will invariably be found to contain numerous living things, some of which are just visible to the naked eye, whilst others require a lens or a compound microscope for their detection and examination.

The larger living things are mostly in rapid movement about the water, whilst some cling to the small plants and weed. They are usually small Crustacea, and also the larvæ and active nymphs of insects. Sometimes a water-spider is included in the capture, and frequently small worms are to be seen. Often just visible, and moving here and there, are numerous animals which evidently produce considerable currents in the water, and a lens enables the observer to distinguish that they belong to species of Rotifera of the Vermes.

But the most numerous of the dwellers in the water are either, in a few instances, just visible to the unassisted eye, or are to be seen in countless numbers with the aid of high magnifying powers under the compound microscope. Amœba and Gromia, minute Rhizopoda, may be found on the weed or on the glass which contains the water, and little moving things are visible which the botanists state are of the nature of vegetables, such, for instance, as the globe-like Volvox. But besides Crustacea, Insecta, Vermes, and Rhizopoda, and vegetable organisms, there are thousands of microscopic, or nearly microscopic, animals, which are called Animalculæ, or little animals, and also Infusoria, or animals which live in infusions. Suppose that some sea-water is collected, with a piece of seaweed in it; after a few days a host of those minute microscopic animals will be found in the slime around the weed.

Fig. 1.—INFUSORIA IN THE FIELD OF THE MICROSCOPE.

On a warm summer evening, as darkness closes in, the ripples of the sea become luminous, and flashes of light start from one part of the harbour or coast-line, and stretch far and wide, expanding in ever-widening circles. This particular form of phosphorescence of the sea is due to the presence of myriads of minute animals, which do not belong to any of the groups of animals hitherto described in this work, and which must be ranged amongst the Infusoria. Again, discoloration of fresh and salt water often occurs, and it is found to be produced by crowds of microscopic creatures. In water which is brackish, in water which contains a considerable quantity of salt, in water which may be icy cold or very warm, and in water which is impregnated with fœtid gas and decaying animal and vegetable remains, these simple, active, wandering, or sedentary microscopic creatures, which constitute the lowest forms in the animal kingdom, and which in some instances are separable only in a very arbitrary manner from the simplest and lowest members of the vegetable kingdom of nature, may be found in abundance. Place some of the pond water, deprived of its visibly living and moving things, under a microscope with a low power, or such an one as will magnify about forty times: minute bodies, hitherto invisible, are seen moving rapidly across the field of vision (Fig. 1), sometimes rushing across, so that only an indefinite idea can be gleaned of their shape; or going along more slowly, either steadily or turning over from side to side, and screwing themselves, as it were, forwards. Sometimes a dozen or more will come within the range of vision, and twist and turn in every direction, and suddenly rush off, moving so as not to come in collision. Occasionally a globular-shaped thing will come by and stop, and just as suddenly will leap, as it were, in the water, and go right out of sight. Now and then a great current of water appears to be in motion, near the side of the field of vision, and if the slide holding the water be moved, so as to bring it beneath the eye, some balls, like specks, are seen united to delicate stems. They produce much movement in the water, and are suddenly dragged backwards towards their fixed point. Here and there, settled down and resting on a kind of stem, some pear-shaped things may be seen, with delicate hairs sticking out from their ends. A still higher power of the microscope, which will magnify from 300 to 1,000 times, enables other and smaller creatures to be seen, and renders the minute structures, of the larger, visible and capable of study. Amongst the smaller ones are little bag-shaped things, with one or two hair-like projections—the cilia which keep them in movement—and in places here and there are multitudes of little moving things, mere lines of matter, with an end produced into a hair-like tail or flagellum. These are amongst the simplest of living things, and may be animal or may belong to the lowest plants. The microscope reveals, amongst the larger kinds, that they move in consequence of the vibration, or to-and-fro movement of microscopic cilia, and that the kinds which are stalked can be retracted by the contraction of a granular tissue resembling the simplest form of muscle.

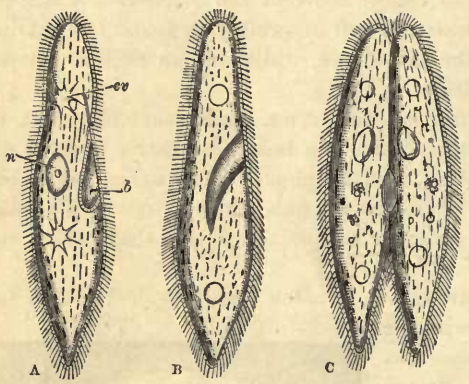

Fig. 2.—PARAMECIUM AURELIA.
A, Lateral, B, ventral surface; C, in conjugation; cv, contractile vesicle; n, nucleus; b, oral aperture.

If lately-collected rain-water is examined in the hope of discovering any of these minute forms of life, disappointment will occur. But if some hay, or any vegetable matter, be allowed to soak in pure water exposed to the air, or if pieces of flesh, brain, blood, or any animal substance, be placed in water, and also exposed for a day or two, a great many species of these animalcules, or Infusoria, the individuals being in vast multitudes, will be distinguishable. Certain kinds of these animalcules are almost invariably to be found in water in which particular vegetable or animal substances have been soaked, and a succession of kinds is often observed to occur as the infusion gets old. The free access of air is requisite for all this, and the hay and animal substances form the food of the minute creatures, whose derivation is not from the minute structures or broken-down tissues of the plant or animal. The air contains the extremely minute spores, or reproductive particles, whence the animalcules spring. There is no spontaneous generation of these animalcules, and no turning of dead animal or vegetable tissue into them. The term Infusoria, or animals of infusion, merely relates to where they are to be found in most instances, but not invariably, and it must be carefully noted that the animalcules are not derived from the infusions. Certain infusions suit particular kinds of Infusoria, and these particular species are to be found in them.

The Infusoria are exceedingly simple in their construction, may be said to be uni-cellular, and are allied, as Protozoa, to the Rhizopoda. There is this distinction, however, that whilst the majority of the Infusoria move actively, and a great number are sedentary, or move during some part of their life-cycle, they rarely have silicious or calcareous tests,* and the pseudopodia, which sometimes exist, never run together as they do in Gromia and Amœba amongst the Rhizopoda. The body is usually soft, and there are one or more contractile vesicles. A nucleus exists, and there are vacuoles which contain food. The outside of the body is ciliated in a great number, has but one or two long cilia in front in others, and one group has no cilia, but tubular processes project from the more or less pear-shaped body, and really act as suckers.

The following are examples of the four great divisions or orders of the Infusoria.

* Haeckel has described some with tests.

Pond water and artificial infusions of hay yield, as a rule, considerable numbers of a rather large animalcule, which may be from $\frac{1}{96}$th to $\frac{1}{120}$th of an inch in length. They are free swimmers and long-bodied, being narrowish and bluntly pointed at one end, and more sharply at the other. They are flat also, and there is a groove in the body extending from the left side of the front part of the body backward and underneath to about the middle. They are about four times as long as broad, and their shape has given them the name of Slipper animalcules (Fig. 2).* They are not quite symmetrical fore-and-aft, and the back and ventral surface can be distinguished. The whole of the body is covered with a fine down of cilia of nearly or quite equal size throughout, which vibrate with considerable rapidity, enabling the animal to move here and there rapidly, to turn round on its axis, to swim backwards and forwards, and even to turn like a screw on its long axis, throwing the under part up and over, to replace the back in its original position. As these animalcules, which have a yellowish-brown tint by transmitted light, move vigorously along, they rush over the field of the microscope and re-enter, and should there be a collection of vegetable mucus, numbers will come together and push in and amongst it, passing here and there, but never brushing up against one another, so as to come into collision. It is evident that they have some power of slightly altering the shape of the body, and that the slit on the underside has to do with the inception of food. The cilia, when the animal is moving or comparatively still, form currents in the water, and those in the neighbourhood of the slit produce whirlpools, down which rush minute particles of food. These pass down the slit, and enter the body at a kind of mouth, and they there come in contact with the soft inner substance composing the animalcule, and sink into it, being surrounded by a drop of water. Several of these morsels of food are to be seen lying in clear spaces filled with water or food vacuoles, and as the whole of the soft internal structure tends to move in an amœboid kind of manner, the vacuoles change their places. This gave rise to the false idea that the Infusoria were many-stomached, or "polygastrica." In this internal substance, or endoplasm, some other things are to be seen. Firstly, there is an oval body with a small dark spot in it, the nucleus or endoplast, and the nucleolus or endoplastule; secondly, there are two spots, one close to either end of the body, which gradually become more visible and transparent, and suddenly shut up and disappear. They are the contractile vesicles, and it is commonly observed that, if the animalcule is subjected to any pressure, these light spots present rays passing from them into the endoplasm, so as to assume a stellate appearance. The opening and closing of these vesicles are very regular. There is a most delicate tissue covering the whole animalcule, and another from which the cilia spring. They are elastic, and appear to be endoplasm in a less watery condition. They form the ectoplasm. Between these layers and the minutely-granular endoplasm is one of exceedingly delicate rod-like bodies arranged point outwards, and they are called trichocysts.

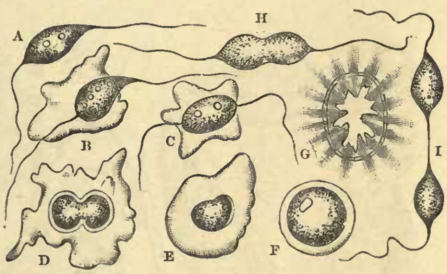

Fig. 3.—CERCOMONAS TYPICA. (*Saville Kent.*)
A, Adult; B–I, different stages in the development. (*After Dallinger and Drysdale.*)

The animalcule evidently respires through its outer ciliated coat, takes in food through the mouth at the bottom of the slit, has several food vacuoles, which finally come near the surface skin, and discharge the undigested matters. As the food, consisting of minute spores and animal and vegetable matters, is digested, the protoplasm of the body is added to, and the circulation and removal of effete matters are in relation to the contractile vesicles.

The creatures languish if the water remains too long without exposure to air, but otherwise their movement appears to be constant. Occasionally two will approach and cling together by their oral or ventral surfaces, and it is occasionally noticed that a large individual contracts midway and finally separates into two. If watch be kept long enough, the animalcules will be noticed to become quiet, to take on a globular form, and to have the ectoplasm dense and non-ciliated. Sooner or later the globe will burst, and a host of minute moving things will come forth, each of which is a young animalcule.

* *Paramecium aurelia.*

This is a common instance of the order of the class Infusoria, called, from the body being more or less covered with cilia, the Infusoria Ciliata.

The highest powers of the microscope, and glasses possessing very perfect defining qualities, are requisite in order that the next type of Infusoria may be seen perfectly. The little creatures are free swimming, and the body is long, egg-shaped more or less, but it has a projection so as to render it more or less spindle-shaped or fusiform. In front, there is a single filament prolonged from the body like a very large cilium, and a longer one, about twice the length of the body, projects behind. These are the flagella. There is a single minute contractile vessel in the body on one side, and the nucleus or endoplast is spherical, and near the centre of the animal. There is no mouth or special aperture for food, and there are no cilia on the soft external part, which barely differs from the inner mass of the minute body or endoplasm. Only measuring from $\frac{1}{2000}$th to $\frac{1}{3500}$th of an inch in length, these minute Infusoria are found in vegetable infusions. They swim freely by means of their long flagella, and also crawl over substances very much after the fashion of Amœbæ. It may happen that one may be seen larger or broader than the others, and, after a while, the observer is repaid by seeing the body

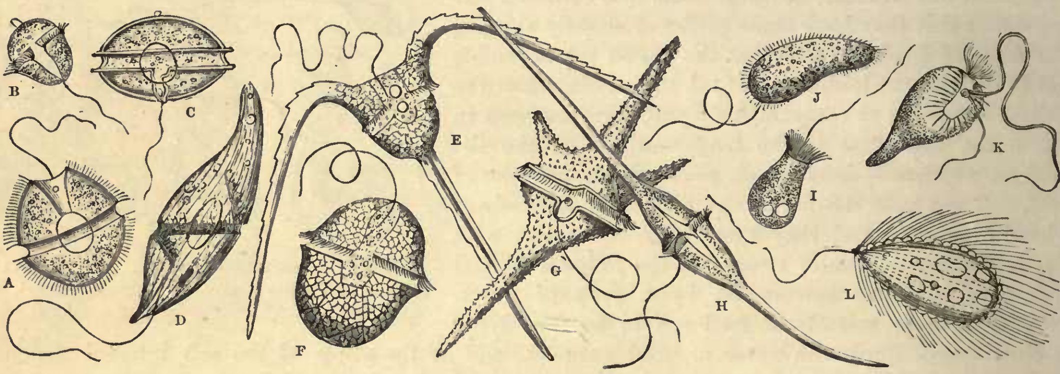

Fig. 4.—GENERA OF CILIO-FLAGELLATE INFUSORIA.

A, Melodinium uberrimum: B, Glenodinium acuminatum: C, Diplopsalis lenticula: D, Gymnodinium spirale; E, Ceratium tripos; F, Peridinium tabulatum; G, Ceratium longicorne; H, C. fusus; I, Stephanomonas locellus; J, Mitophora dubia; K, Heteromastix proteiformis; L, Mallomonas Plosslii.

split down its length, and two creatures swim off, each supplied with a front and rear flagellum. If two come in contact, they join together, like Amœba, and after a while the mass loses its flagella, and a vast number of spores are formed out of the endoplasm. These escape, and gradually form into creatures like those which produced them.

Exceedingly minute particles of food are taken in by the surface of the body at no particular spot, and the undigested matters simply pass through the endoplasm to the outside. This Infusorian is a Cercomonas* (Fig. 3), and is a fair example of the order called the Flagellata. Members of this order are distinguishable—in some instances with difficulty—from moving spores of the lower plants, and indeed it is in this group that the junction of the animal and vegetable kingdoms is to be found. The Flagellata contain very simply-constituted organisms, and some which are less so, and of these last the phosphorescent marine Noctiluca is an example.

Another type of Infusoria combines, as it were, the characters of the ciliated animalcules and those which have a flagellum. The kinds which are associated with it are mostly found in sea water, and in many parts of the globe. A few, however, are to be noticed in fresh water in the United Kingdom. Thus, Professor Allman found enormous multitudes of an Infusorian about $\frac{1}{500}$th to $\frac{1}{1000}$th of an inch long, of a reddish-brown colour, in the ponds in Phœnix Park, Dublin. It had an almost globular body, with a constriction or furrow running round the middle, and a groove passing from this furrow over the body to the top. The whole surface was covered with extremely delicate moving cilia, and a long, slender, active cilium or flagellum was found to be placed on the top in the groove. A large endoplast (nucleus) was in the centre of the animal, and just below the origin of the flagellum was a small, intensely red spot. A contractile vesicle occurs in this type. The brown colour of the ponds in

* *Cercomonas typica.*

1854 was owing to the presence of prodigious numbers of this species of Melodinium* (Fig. 4, A). The tint was sometimes uniformly diffused through the water, and at others was collected in dense clouds, varying from a few to upwards of 100 square yards in extent. Later on, the coloration of the ponds, brought about by the agency of these minute organisms, had much increased in density. By the 9th of July the water was so dark and brown, that a white disc, half an inch in diameter, was invisible when plunged to a depth of from three to six inches; while a copious exit stream, constantly flowing away from the ponds, presented a similar deep brown hue. In many places the animalcules had descended from the surface, and were found congregated in immense masses near the bottom of the water. In these instances they had, for the most part, become quiet; the flagellum and cilia had disappeared, and a kind of transparent tissue had been developed around each one. During the life of these curious animalcules the body divides across, and two individuals are formed; and this proceeds time after time, adding rapidly to the numbers of individuals. Moreover, the encysted state is accompanied by a breaking-up of the internal protoplasm or endoplasm into numberless particles, each of which will grow into a form resembling the parent.

In examining the phosphorescence of the sea, moderately large animalcules of $\frac{1}{90}$th of an inch long are occasionally seen. They are light-emitting, of a yellow colour, and have a remarkable shape and construction. An external coat, transparent but hard, exists, and it covers the soft structures. It is prolonged into a long horn in front and behind, and the body is nearly globular, with a depression around it, and a groove crossing this at right angles. The appearance is very peculiar. Cilia bound the depression, and a very long and delicate flagellum, which moves like the lash of a whip, starts from the groove. The long fore-and-aft projections are quite stiff, and the only mobile parts are the cilia and flagellum. This Infusorian belongs to the same order as the last, and to the genus Ceratium† (Fig. 4, H). They are CILIO-FLAGELLATA.

A very different kind of animalcule must be taken as the example of the next and last order of the Infusoria. If the surface of water-plants in the Birmingham and Stratford Canal, for instance, be observed, a fine Infusorian $\frac{1}{75}$th to $\frac{1}{100}$th of an inch in length may be seen fixed on a long stalk which is straight and stiff. The body, placed at the top, is contained in a cup-like sheath, with a triangular outline, widest where free, and where there is a slit which enables the endoplasm to communicate with the water outside. The endoplasm (finely granular) does not fill the cup, but collects in an egg-shaped mass which has a contractile vesicle, and the nucleus or endoplast is in the form of a band. There are neither cilia nor a flagellum, but a bundle of numerous tentacles exists at both ends of the free end of the cup-shaped sheath, and they are processes of the body. The tentacles have a disc-like top, and do not move so as to enable the animal to swim. They are catchers of prey, and any small animalcule coming in contact with them is stopped, and its delicate tissue is penetrated by their sucker-like disc (Fig. 5)‡. By-and-by the endoplasm of the victim is sucked out of it, and acts as the food of the catcher. The young of these stationary Infusorians are active, and move well and rapidly with the aid of cilia, and thus resemble the Ciliate Infusoria. These Infusoria constitute the order TENTACULIFERA.

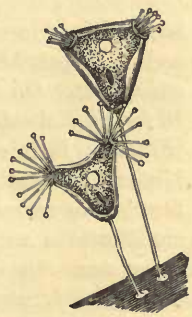

Fig. 5.—ACINETA TUBEROSA, WITH TENTACLES EXPANDED AND CONTRACTED.

There are, then, four great groups or orders of Infusoria typified by the species of the genus Paramecium, Cercomonas, Melodinium, and Acineta, and they constitute the orders Ciliata, Flagellata, Cilio-flagellata, and Tentaculifera.

A host of species, included in numerous genera, is classified under each of these orders, and there is the greatest diversity of shape and of method of life amongst them; but the main features and especial characters of the orders are so definite, that there is no difficulty in classifying any Infusorian, which has attained adult age, in its proper group.

From their great vivacity of movement, their many varieties of cilia, the invariable existence of contractile vesicles, and endoplasts, and sometimes trichocysts, the Ciliata, or the Infusoria which move by and are more or less covered with cilia, strike the observer as of predominant zoological importance. They are clearly more highly organised than the Infusoria which have only flagella. And these last appear to be lower in the animal scale than the creatures which have a few cilia,

* *Melon*, a peach; *dine*, a vortex. † *Ceratium fusus*. ‡ *Acineta tuberosa* (Ehrenberg).

and a flagellum also. The fact that the Tentaculifera are totally unlike the other Infusoria in their adult age is very remarkable; but it is evident that before they attain maturity they resemble the Ciliata. New structures are thus, by evolution, given to the Tentaculifera, and they have considerable affinities with the Rhizopoda. Their adult form is in advance of the ciliate young one, and the order Tentaculifera must stand at the head of the Infusoria. Next come the Ciliata, then the Cilio-flagellata, and, finally, the Flagellata.

Fig. 6.—DENDROSOMA RADIANS. (*After Saville Kent.*)
a, Embryos escaping with cilia; *b*, buds producing embryos like the parent; *st*, stolon.

The Infusoria are uni-cellular, and this is true where there are two or more individuals in close contact, or where a common stem supports the bodies of others, which may be numerous. For in these instances subdivision of the parent has produced the independent creatures. In the Tentaculifera, however, the most highly-organised amongst the Infusoria, in the species called *Dendrosoma radians* (Fig. 6), there is a root common to many trunks which give origin to branchlets terminating in a bundle of tentacles with suckers. This arrangement can hardly be called uni-cellular; there is, however, no actual cell division, and indeed the ordinary idea of the single cell is hardly applicable to this and many other Infusoria.

The simplest Infusoria belonging to the Flagellata, which have no special spot for the ingestion of food,* have no distinct environing membrane over their soft finely granular protoplasm, and they can assume various shapes for a while. Others belonging to the same group have the outside of the body slightly more solid than the rest. In the Ciliata the presence of an outer membrane is evident, and it is possible to distinguish, on some of them, four layers around the soft semi-fluid central endoplasm. On the outside is a perfectly transparent structureless membrane, and it is a true cuticle. It forms a sheath for the stalk of some Infusorians, and the covers or shields (*lorica*) of others (Fig. 7). It is composed of formed material, and is independent of the nutrition of the animal Under the hyaline outer layer there is, without exception amongst the Ciliata, a firm homogeneous elastic and contractile layer, of which the cilia and their various modifications are the offshoots. They penetrate the outer layer and arise from this inner one. In some, but not all, of the Ciliata, there is a layer beneath this last one, which is more or less fibrillar, and highly contractile. It is the muscular, or myophan layer of Haeckel. In the genus Stentor (p. 367) it is highly developed, and it can be seen, by using high and well-defining powers, in the common Vorticella, in which it forms the central, or contractile, part of the stalk, and a thin layer continuous with this is in the body. The fourth layer is not invariably found, but it has been already noticed in the description of a Paramecium. It produces and holds in place the minute rod-like bodies called trichocysts, which will be noticed farther on. These layers constitute the ectoplasm.

Fig. 7.—TINTINNUS LAGENULA, SHOWING THE LORICA AND THE CROWN OF CILIA.

The endoplasm, situated within the ectoplastic or outer layers, is more or less fluid, granular, and coloured glairy protoplasm. It is tolerably immobile in many Infusoria. In most it is subject to amœboid movements, to a faintly-developed rotatory movement, and to what may be called streaming. In some instances the movement is strong, and resembles that of the cyclosis of plants, as in Vallisneria and Chara. Noctiluca, the phosphorescent flagellate Infusorian, has the endoplasm more or less in the form of a network, with vacuole spaces, and a quantity of granular substance, and this condition is seen in other forms.

* Group *Pantostomata*

The spaces occasionally seen in the endoplasm, and which transmit light more readily than the rest, are called vacuoles; they may exist as spaces filled with water, and usually they contain, besides the water, a greater or less portion of the vegetable or animal matter which has been introduced into the body as food. They must not be confounded with the contractile vesicle. Besides these, there is the nucleus or endoplast, which is surrounded, in part, by the granular semi-fluid endoplasm, and which is also in contact with the deeper layers of the ectoplasm. Colouring matter, diffused or localised, is seen in the endoplasm, and this inner protoplasm produces the minute particles or spores which escape and develop into new individuals.

In all Infusoria, the cilia and their varieties, the flagella and the tentacles are extensions of the substance of the body. In the minute flagellate animalcules the flagellum, which is an elongated whip-like cilium, is an extension of the delicate ectoderm: in the Ciliata the cilia arise from the special layer beneath the hyaline cuticle; and the long suckers of the Tentaculate order are probably extensions of the same tissue. The cilia differing in dimensions and shape in some Infusoria are the minute hair or eyelash-looking vibratile appendages which mainly move their possessors, or produce currents in the water when the Infusorian is fixed. They appear to move actively in one direction, and to return to their original position by their elasticity. The tops move forwards and backwards, and it is noticed in certain species that the ciliary lashing is consecutive in a series, and that it produces the appearance of rotation, as in the Rotifera (pp. 245–9). They are semi-solid and elastic, and they are moved by the contraction of the endoplasm at their base. The vibratile cilia are arranged in bands only, in certain families, and universally in others. Some Infusoria have some cilia which are elongate, flexible, but not movable, and they are then called setæ; and in one interesting genus (*Halteria*) these long hairs are utilised when the animal makes its sudden jumps. Some Ciliate Infusoria have these setæ stout, and placed on the ventral, or under-surface of the body, or at the extreme ends, and then they are called styles. In some instances the ends of the styles are branched or feathered. In a family of the Ciliata, the Oxytrichidæ (p. 371), there are claw or sickle-shaped appendages, which are modified setæ, called hooks, or uncini, and some of the species carry all these remarkable outer structures for the purposes of locomotion and prehension (Fig. 8). The body is, in some Infusoria, furnished with fin-like, thin, vibratile membranous fringes (Fig. 9), and in one important group of the Flagellata the collar of the animalcule, which exactly resembles that of the cell of the sponge, has its protoplasm in streaming movement, which carries the particles coming in contact with the outside over the top to the mouth within. The tentacles of the Tentaculifera resemble the pseudopodia of Rhizopods more or less; some have a disc-shaped sucker at the top, and are hollow, being filled with semi-fluid endoplasm. A spiral fibre is seen on the outside of some tentacles, and in one family there are no terminal suckers.

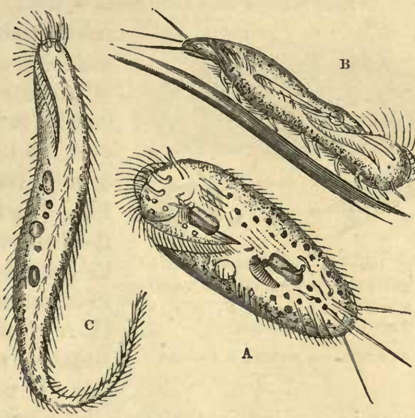

Fig. 8.—A, B, STYLONYCHIA MYTILUS, SHOWING CILIA, STYLES, AND UNCINI; C, EUROLEPTUS. (*After Stein.*)

Whilst some Infusoria take in food at any part of their body, the morsel simply sinking into the soft protoplasm, and carrying with it a small quantity of water, forming thus a vacuole, in others it is carried in the direction of a particular orifice, slit, or tubular cavity, by currents in the water produced by certain cilia. In some species the mouth-opening is always visible, in others it is small, and only visible at the time of the capture of prey, and in a few it is so large that a morsel is often swallowed nearly as large as the captor. The mouth, in the most perfect forms, consists of a passage in the ectoplasm structures, which can dilate, and the lining of which is plaited, folded, and even furnished with a layer of rod-like teeth (Fig. 10). This part is often capable of protrusion, and on opening it leads to the exposed semi-fluid endoplasm, and not to anything like an œsophagus and stomach. The morsel simply sinks into the mass with a little water, and forms a vacuole.

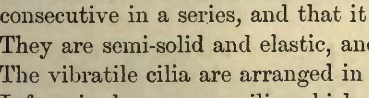

Fig. 9.—LEMBUS VELIFER.

One or more food vacuoles may exist, and as one is formed subsequently to the other, the oldest vacuole is the most deeply imbedded, and if the animalcule be fed with carmine, a number will be noticed forming a series in the endoplasm, and moving with it. Much of the food thus received is digested, and the rest is evacuated in a definite direction, and sometimes through a special opening in the ectoplasm—the anus. In many species, however, the fæcal matters pass out at any point.

When one of the Infusoria is lively and feeding, and is being examined under high powers of the microscope, one or more spots, with a circular or radiating outline, will suddenly appear near the ends of the body. Each begins in a point of greater transparency than the body structure all around it, increases rapidly in diameter, and often assumes a tinge of colour, retaining, however, its transparency. It is a light-transmitting space, with the slightly denser structure of the inside of the animal around it. As the light from the reflecting mirror of the microscope traverses the tissue of the Infusorian at this now enlarged spot, it seems to be unsteady, and this depends upon water passing into this really globular space, which, seen under the microscope, presents the appearance of a circular area (Fig. 11, A, *cv*). It is evident that water flows into this space, which is situated really in the layer immediately over the soft endoplasm; there is no environing membrane to it. Suddenly the circle of light closes in on its centre, and the appearance of a light point amongst the darker surrounding matter suddenly ceases. The tissue closes in on the space, moving in on all sides, and this is done not passively but actively, for in some instances a tremor can be seen to occur over the whole animalcule at the time of the contraction of the space. Moreover, although the space enlarges slowly, it contracts very rapidly, as a rule. If the Infusorian be kept for some time under observation, the absence of food and fresh water will begin to diminish its energies, and it will especially influence the rapidity of the dilatation and subsequent contractions of this space, which is termed a contractile vesicle. The appearance of the light spot is not so frequent; it commences languidly, and enlarges slowly, and finally contracts, or disappears less abruptly than in the instance of the vigorous animal. After a while, the appearance and disappearance of the spot—or, in other words, the dilatation and contraction of the contractile vesicle—become slower and irregular, and they cease with the death of the animal.

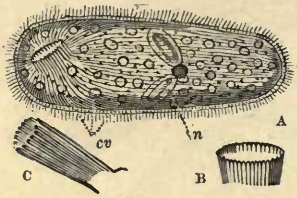

Fig. 10.—A, PRORODON MARGARITIFER; B, PHARYNGEAL ROD-FASCICLE OF P. NIVEUS C, DITTO OF NASSULA.

cv, contractile vesicle; *n*, nucleus.

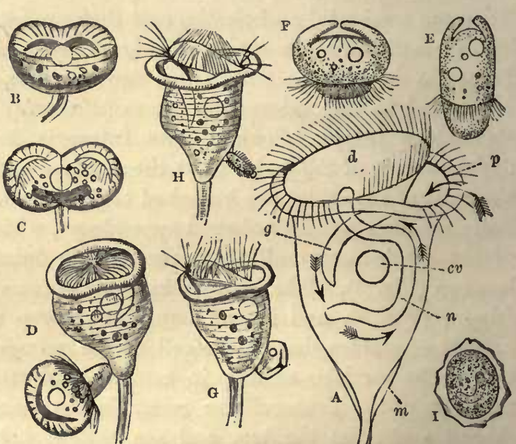

Fig. 11.—A, DIAGRAM OF VORTICELLA NEBULIFERA: B–D, PHASES OF LONGITUDINAL FISSION; E–F, PHASES OF ATTACHMENT, AND G–H, OF INCORPORATION OF FREE EMBRYO OF V. MARINA (*After Greeffe*); I, ENCYSTED STAGE OF V. MICROSTOMA.

d, disc; *p*, peristome; *g*, gullet; *cv*, contractile vesicle; *n*, nucleus; *m*, muscular coat. The arrows denote the course of circulation of food particles.

More than one contractile vesicle may exist in the same species, and their position in the body, although generally well defined, is not invariably in the same spot. Usually, the vesicles are nearer the ends of the body than the central part, and when they are fully dilated they occupy not only a portion of the body hitherto filled with endoplasm, but come close under the outer and denser tissue. In the instances where the contractile vesicle presents the appearance, under the microscope, of a circular space, no movement can be seen, in the vast majority of observations, to extend from it into the endoplasm during the active contraction or dilatation. The water contained in the vesicle must go somewhere, and must be derived either from within the body or from without, or perhaps from both directions. Occasionally, however, a very indistinct movement can be seen radiating, as it were, amongst the granular, or almost homogeneous protoplasm of the animal, subsequent to an active contraction of the space. No visible movement accompanies the infilling. There are many Infusoria, such as the species of Paramecium, in which the contractile vesicle, when fully expanded, is not limited by a definite circle of endoplasm, but has rays, or tubular passages, tapering outwards around it (Fig. 2, *cv*). The passages are numerous, and may be seen to ramify at their extreme ends, and they are weak spots in the cortical layer over the more fluid endoplasm, extending far and wide from the vesicle. These passages transmit light more readily than the protoplasm in which they are placed, and it therefore occurs that, as water fills them, and they increase in diameter and length, they are nearly as light-transmitting as the main space with which they are continuous. They become largest just before the contraction of the vesicle, and they sometimes do not disappear until after its contraction. It is evident that the watery contents of the passages are pressed upon by the contraction of the surrounding protoplasm, and that this water and that of the space penetrate, during contraction, into this environing substance. Movement may be noticed under the outer tissue, here and there, within and along the lines of the passages. More or less defined communications exist between the outside water and the contractile vesicles through the ectoplasm, and the vesicle receives pure water from without, and collects and expels the impure water from within the animal. It is evident that the function of the contractile vesicle is of great importance to the animal, and it may relate to the elimination or removal of certain soluble matters resembling the urinary secretions. It may also relate to an internal circulation of water.

The rhythm of the dilatation and contraction is very remarkable, and Saville Kent states that "the time occupied between the consecutive pulsations of this organ is found, under normal conditions, to present a constant average among individuals of the same species, varying from a few seconds only in certain forms, to over sixty or even one hundred seconds in other types."

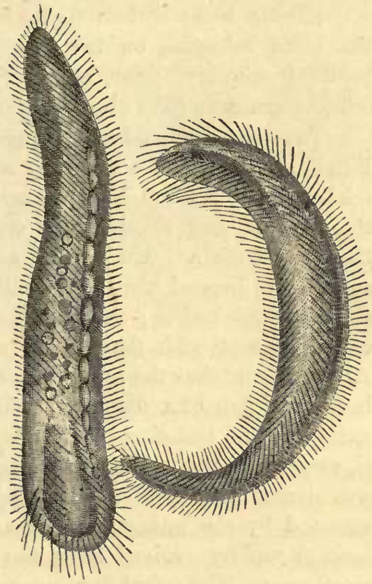

Fig. 12.—CONDYLOSTOMA PATENS, SHOWING MONILIFORM ENDOPLAST.

The nucleus or endoplast with its contents resembles, in some Infusoria, that of the simplest vegetable cell. In its simplest form, noticed in some of the Flagellata, the endoplast is more or less spheroidal, and may or may not contain a nucleolus or endoplastule. Saville Kent has given an admirable *résumé* of the knowledge which has been accumulating regarding these structures, and he notices that the first step towards complexity is in the genus Euglena and its allies, in which the endoplast becomes ovate in outline. A sausage shape is assumed in some Ciliata, and its ribbon shape in Vorticella has long been known. In some of the Tentaculifera the nucleus is branched, and in some Ciliata, such as *Condylostoma patens* (Fig. 12), it presents a necklace appearance, and in others the swellings are widely separated by narrow processes. More than one endoplast exists in the Oxytrichidæ, one being in front and the other behind the centre of the body; and in some species of Opalina the endoplasts are numerous. In its more complex forms the endoplast is enclosed within a very delicate transparent membrane. The nucleolus or endoplastule is sunken within the substance of the endoplast in some forms; it is attached to the inside of the membrane of the endoplast in others, and on the outside in a few Infusoria.

Two or three endoplastules exist in some, and in Vorticella they are granular fragments, one or more of which become enclosed within each of the segmental portions into which the endoplast becomes separated, during the process of internal budding, which will be noticed farther on. The endoplast is in contact with the softer internal substance of the Infusoria (the endoplasm), and also with the inner part of the cortical structures or ectoplasm.

The Infusoria are usually more or less coloured, and the Flagellata, with rare exceptions, have a small brilliant crimson spot at one end of the body; in one genus there are two of the spots. Amongst the Ciliata the red spot is rarely seen, and one genus has a black one; but the Tentaculifera do not have these pigment spots. Formerly they were considered to have to do with vision, but this is an error, and the common term "eye spot," is therefore incorrect. Diffused colouring matter tints most Infusoria, and the smallest animalcules or monads belonging to the Flagellata have a pale glaucous or fluorescent hue, and Saville Kent notices that this is visible under high magnifying powers. It is probably due to reflected and not to transmitted light. Most of the Flagellata are coloured, and the species of one great group, the Euglenidæ, are of a brilliant green, the colour being diffused in the endoplasm. The colour is identical with that of the lower plants, containing chlorophyll, and it is remarkable that this green tint should turn to red. Thus in *Astasia sanguinea* the green colour, which gives a tint to the water in which the myriads of the animalcules swim, is suddenly turned to red, accounting for old and new traditions regarding the turning of fresh waters into blood. Ray Lankester has shown that in the genus Stentor the green matter, like that of *Hydra viridis* and *Spongilla*, is a chlorophylloid substance similar to that of plants. One Stentor, however, has a blue colouring matter which is produced by a special chemical combination called Stentorin. Quite as many Infusoria have a diffused pale amber to deep olive colour as green, and most of the Tentaculifera and Cilio-flagellata have these dull colours.

Saville Kent notices that some of the Flagellata differ from the majority by the presence of the olive colouring on two lateral bands on the body. In the Ciliata, a Leucophrys is of a brilliant crimson colour, and a Nassula has numerous violet granules in its endoplasm. Minute crimson granules have also been noticed in the contractile tissue of the stalk of Vorticella.

In some Euglenidæ, there are bodies in the green endoplasm which are of a starchy nature. Finally, there are the accessory structures of the cortical part of some of the Infusoria or the trichocysts. As has been already noticed (p. 355), they are visible in *Paramecium aurelia*, in the form of very slender rods crowded together in a layer, their points looking outwards beneath the outer cuticle. Under the action of weak acetic acid, these trichocysts force through the cuticle and beyond the cilia. Ellis, an Englishman, writing more than a century since, discovered these curious bodies; and Allman, in 1855, established their true nature, and assimilated it to a certain extent with that of the nematocysts of the Corals. But there are essential distinctions. Allman found that the minute fusiform rods, under external irritation, become suddenly transformed into long hair-like filaments, which projected from the whole surface. By carefully crushing examples, and isolating the trichocysts in their unaltered condition and in their fusiform shape (that is, swollen in the middle, and narrow at each end), it was found that after a few seconds the shape was altered with a jerk, as if some previous state of tension were relieved. A spheroidal shape was assumed by the hitherto fusiform rod. Then, in a few seconds, a spiral filament was observed to become rapidly evolved from the sphere, apparently through the rupture of a previously confining membrane. The spiral fibre unwound, and became straight and rigid. In their most extended state, these bodies were found to consist of a long rigid spiculum-like half, sharp at one end, and continued at the other into a very filiform part, which is bent more or less. Probably they have a noxious influence on minute living things.

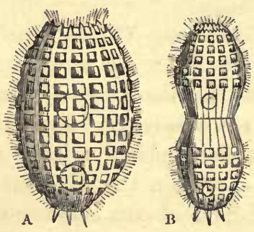

Fig 13.—COLEPS HIRTUS. (*After S. Kent.*)
A, Showing ornamentation; B, transverse fission.

Some Infusoria appear to retain the same shape under all kinds of circumstances; others enlarge laterally or longitudinally, and even twist, as they move here and there or endeavour to get in between substances, but they speedily return to their normal figure. Such irregular changes of shape as are seen in the Amœboids are not often found in the Infusoria, but a very different appearance is presented by some during active motion and feeding and during quiescence.

Nothing is more common than to see many Ciliated Infusoria moving along with the shape of their bodies altered by the presence of a greater or less central constriction, and if one of them is watched, it will be seen to separate, into a front and a hinder part, and each will become a separate individual (Fig. 13). Division also occurs lengthwise. It has been computed that, in the instance of *Stylonychia mytilus* (p. 371), no less than a million of independent beings were derived from repeated fission of a single individual in the course of ten days. When Infusoria form colonies, they arise from the repeated binary subdivision of the first stock, and in some instances masses result, slime-like, many feet in extent (*Epistylis grandis*, p. 370). In the majority of species, the division is across the body, and in others in a longitudinal direction, especially in the

Vorticellidæ. In the Stentors and some other genera the fission is oblique. The endoplast divides in every instance, and part remains with each individual, and the other organs, such as the mouth, anus, and contractile vesicle, are developed where they are wanting.

Some Infusoria increase by a process resembling budding, and in this process, the important endoplast contributes a little process which accompanies the protrusion of the body membrane to form the bud. In Noctiluca (p. 374) the protoplasm beneath the cuticle becomes broken up into nodular fragments, which are protruded upon the external surface, and are finally liberated as very minute bodies resembling monads, and these grow into adult Noctilucæ.

In some instances the young grow within the body of the parent, but only at the expense of the endoplast. Portions of this separate and become embryos, which escape with their cilia, and either resemble the parent or grow into its shape as in the Tentaculifera.

Another method of reproduction is when the Infusoria become quiescent; a delicate covering is then formed over the body, and the quiet and encysted creatures have their internal tissue broken up into myriads of minute particles, which escape, and finally assume the shape and destiny of the parent. It is found that sometimes an intermediate amœbiform condition occurs (Fig. 14).

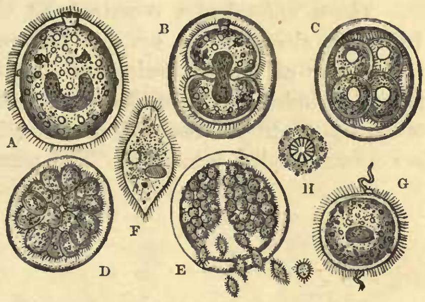

Fig. 14.—ICHTHYOPHTHIRIUS MULTIFILIIS. (*After Fouquet.*)

A, Adult; B–G, different stages of development (E, escape of young); H, oral apparatus.

Infusoria also reproduce after a process which somewhat resembles the conjugation in Algæ amongst plants. Swimming, or fixed by a common stalk, two animalcules come in contact by their oral surfaces, and remain united for a limited period. They swim about, and exist as one, and in the Flagellata the flagella are withdrawn, and amœbiform processes are cast forth. In other instances the junction of different individuals, one often larger than the other, persists. Under both circumstances the reproductive energy of the couple is intensified. How, is a matter of debate, but late microscopical researches by Bütschli and Englemann show that during the process the original endoplast in both animalcules breaks up into a number of fragmentary portions, and becomes lost among the endoplasm. By-and-by a new endoplast is constructed through the gradual assemblage and union with each other of fragmentary particles, and the new endoplast is common to both of the animalcules when the conjugation is complete and lasting, as in Vorticella (Fig. 11); while two or more, according to the normal number, are reproduced where the conjugation is transient as in Paramecium (Fig. 2). Bütschli denies that embryos are subsequently developed from the endoplasts, and he considers that the conjugation is a mere vital stimulant to the decaying energies of the animalcule. Before passing on to a short classification of the Infusoria, it is necessary to mention that they have a most extraordinary distribution. Some families inhabit salt water, others fresh; some species live in running water, others in stagnant pools. Many species are parasitic on, and others within, other Infusoria, and many groups of Invertebrata and Vertebrata. Many are only found in animal, others in vegetable, infusions. One group is mouthless and essentially endoparasitic. The Opalinidæ inhabit the alimentary canals of insects, frogs, toads, and the aquatic Annelida. Some Ciliata inhabit the stomachs of ruminants, some live in the human gut. Others live fixed to fish, or crawl about the Hydra. The Flagellata are found in fresh and salt water, and are often parasitic, and some inhabit human urine. In searching for ordinary and well-known forms, the surface of pure and coloured fresh waters, and the leaves of the plants, should be examined, and the waters of bogs and the sea-shore yield many new forms. The artificial production of Infusoria, by infusing hay, meat, &c., depends on the existence of the germs in the air, in the water, and collected about the plants.

ORDER TENTACULIFERA (*Huxley*).

An example of this order has been noticed already, and it explains the characters of the group. They are animalcules inhabiting either salt or fresh water, and many are parasitic on and within other

Invertebrata. They have tentacle-like processes, derived from the cuticle or from the endoplasm, or from both of these parts. The body contains an endoplast and one or more contractile vesicles. They increase by division across or longitudinally, and also by budding, which may be external or internal. Some of the young (embryos), on escaping from the parent, are ciliated, and the cilia may be arranged over the whole body, or in the form of a wreath around the body, or only on the under surface. With growth the state changes, and the cilia are lost. Others resemble the parent. The adults have neither cilia nor flagella. The majority of species are sedentary. The Tentaculifera are divided into two sub-orders, in one (the Suctoria) the tentacles are wholly or partially suctorial in their office, and in the other (the Actinaria) they are not suctorial but merely adhesive. One family of the first sub-order has one or two tentacles only, and another (the Acineta) has many tentacles, and some of the genera have the body without, and others with a lorica or a more or less covering sheath. *Acineta tuberosa* has the tentacles in bundles, which protrude through the transparent lorica, and the endoplasm can be seen within. It is a salt water form, and measures from $\frac{1}{300}$th to $\frac{1}{500}$th of an inch in length (Fig. 5).

These animalcules remain with their tentacles extended, and other freely-swimming minute Infusoria are stopped by the suckers at their tips. The endoplasm of the victim passes into the hollow of the tentacle and mixes with the soft tissue of the body of the Acineta. A third family includes the genus Dendrocometes, which settles on *Gammarus pulex*, and has rather flexible tentacles slightly branched at their extremities. Its embryos, which escape from the parent, are ciliated underneath only. The next family includes branching Acinetans, with many tentacles, a host of individuals apparently arising from a common stem. But the tops of the ramified stem are really not separate individuals, and the whole mass must be looked upon as one (Fig. 6).

Some embryos with tentacles are produced from the ends of stems (Fig. 6, *b*), and those which are ciliated are derived from the thicker parts of the stem (Fig. 6, *a*).

The endoplast is ribbon-like, and is much contorted in the stolon and band parts of the main stem, and is continued as a band into the branchlets.

The next sub-order (the Actinaria) have the tentacles simple or ray-like, as in the family Ephalotidæ, or represented by one or more retractile organs, which resemble a proboscis with or without cirri. The genus Ophryodendron (Fig. 15) is the type of the last, and the species are very extraordinary looking things. The animalcules may be solitary or in a little group, and then one has a long proboscis, and the others are more or less vermiform or flask-shaped, with a delicate tubular ending. The prey is caught on the proboscis, and gradually withdrawn into the body. They inhabit salt water, or fix on to the polyparies of Hydrozoa, or on to Crustacea. The embryos are ciliated.

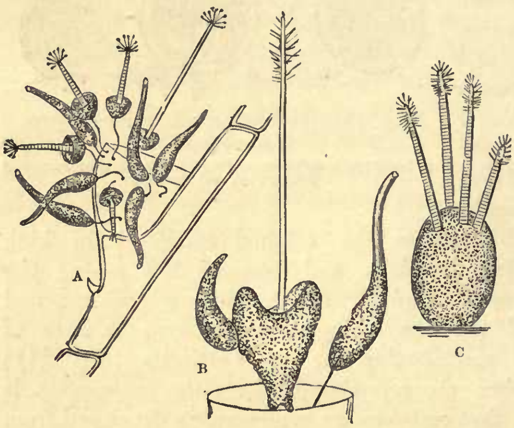

Fig. 15.—A, OPHRYODENDRON PEDICELLATUM ON A PLUMULARIA STEM (THE ELONGATE FORMS ARE THE VERMIFORM BODIES); B, MORE HIGHLY MAGNIFIED; C, O. MULTICAPITATUM. (*After Saville Kent.*)

ORDER CILIATA.

In this order the animalcules are more or less covered with vibratile cilia, some of which may be modified into setæ, styles, and hooks or uncini. A well-developed oral and anal aperture is mostly present.

The example (*Paramecium aurelia*) already given of this order brings these important characters before the mind. The order is divided into four sub-orders, of which the first is the Holotricha, or the Animalcules, which are closely covered all over with cilia, and usually furnished with trichocysts. Paramecium is the example of the first family of the sub-order (Fig. 2).

The Prorodontidæ are the second family, and they are ovate or cylindrical, and the oral aperture is at one end or at the side. The canal (pharynx) leading from the mouth to the endoplasm is bounded by rod-like teeth, which are well seen in the genus Prorodon (Fig. 10).

The species *Enchelys farcimen*, which is found in stagnant water, and is from $\frac{1}{430}$th to $\frac{1}{1000}$th of an inch in length, has the oral cilia larger than the others, and the cuticle of the bag-shaped body and changeable-shaped body is soft (Fig. 16).

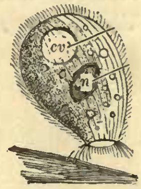

Fig. 16.—ENCHELYS FARCIMEN.
cv, Contractile vesicle: n, nucleus or endoplast.

The flask-shaped, long-necked forms, with cilia over the whole body, and the mouth at the end, constitute the family Trachelocercidæ. *Trachelocerca olor* has a body $\frac{1}{140}$th of an inch in length, and lives in pond water. Its long neck and body obliquely striated with cilia, the several contractile vesicles, and its double endoplast, are all characteristic (Fig. 17).

The family Ichthyophthiriidæ has the oral orifice in the midst of an adhesive disc, and the cilia of the oral region are setose and radiate internally. The species of the only genus is parasitic on trout and salmon and the loach. The contractile vesicles in the sub-globose or ovate body are numerous, and its endoplast is curved. Length, $\frac{1}{150}$th of an inch (Fig. 14).

The family Colepidæ contains ovate-shaped animalcules which have an indurated cuticle, and the oral aperture terminal. *Coleps hirtus* is a good example, and it will be noticed that the surface is furrowed, so as to present the appearance of being divided into numerous equal quadrangular spaces. These are indurated, and the intervening furrows are soft and ciliated. The mouth is at one end, and the cilia near it are larger than the others, and the anus is at the opposite end. These Colepidæ divide transversely, and *Coleps hirtus*, which is from $\frac{1}{400}$th to $\frac{1}{500}$th of an inch long, has three spinous processes at its nether end. It is a common species, living in pond water amongst confervæ. It is a voracious animalcule, and it may be seen in numbers in the neighbourhood of any dead animal or vegetable matters. These it takes in with its cilia, which form currents mouthwards, and it may distend its body considerably (Fig. 13).

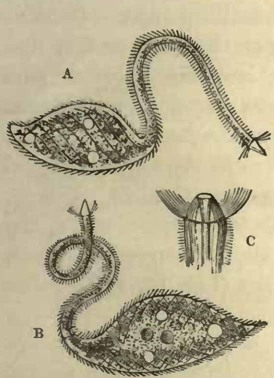

Fig. 17.—A, B, TRACHELOCERCA OLOR.
C, cilia of the mouth

During the process of natural fission, the extremities retain their usual aspect, but the newly-developed central area, where separation is to occur, is smooth, and thus, after division, one part of each Coleps is smooth, and the other like that of the parent.

There is a group of four families of these Holotricha which is characterised by the presence of a portion of the cuticle or ectoplasm formed into a flap, which may or may not vibrate. The Ophryoglenidæ have the oral aperture situated at the bottom of a distinct depression in the body, within which is a vibratile flap or membrane. The genus Ophryoglena has the family character, and the genus Trichoda resembles an Enchelys in shape, but the mouth is led to by an ovate furrow, and from its inner wall starts a vibratile flap. This genus is common in putrid infusions with the Enchelys already mentioned. A second family (the Pleuronemidæ) has the membrane extending in front of the oral furrow in a hood-like manner, and it is not vibratile. The third family (the Lembidæ) has long, vigorously-swimming, worm-shaped animalcules, and the membrane forms a long crest-like border to that furrowed part of the under surface of the body which extends from the front, backwards, to the oral aperture. It has large cilia along its inner border. *Lembus velifer* has a long spike-shaped body, narrow in front, thicker behind, where the contractile vesicle is seen, and the body is covered with long cilia. Beneath, in front, is the large membraniform expansion like a fin, broadest in front. The front part of the body is elastic, and can change its shape, and the hinder part is rounded. They increase by cross and longitudinal division (Fig. 9).

The last family of the group has been discovered by Leidy, and its species are most extraordinary looking things, and lead very remarkable lives. They are freely moving, but rarely swimming animalcules, their movements being chiefly of a twisting and writhing kind. The shape is more or less elongate and spindle-shaped, and the cuticle is entirely ciliate. Sometimes there are undulating membranes on it. They occur as parasites within the intestine of the American White Ant (*Termes flavipes*). Leidy found some white ants which had their intestines, as seen through their translucent abdomen, considerably distended with a brown substance, which consisted mainly of these parasites, decayed wood, and the filaments of one of the Algæ. *Trichonomorpha agilis* (Fig. 18) has the cilia various in length, forming three or four distinct sets, and one of them is very long. The body is more or less separable into a smaller ovate head-like portion and a larger and inflated body. The oral aperture is indistinct, and is a rounded pore at the summit of the head, whence there passes backwards a tube to the endoplasm of the posterior part. There is a granular nucleus in the centre, but no contractile vesicle has been observed. The movements consist of an incessant retraction or shortening and bending to and fro of the head-like anterior region, accompanied by the rapid waving and swelling outwards of the long cilia. It is very possible that these animals may belong to another class of animals altogether.

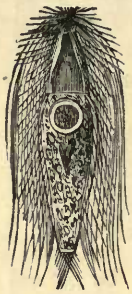

Fig. 18.—TRICHONOMORPHA AGILIS. (*Leidy*)

The last group of the Holotrichous Ciliata contains one family, the Opalinidæ, whose species are parasitic within the intestines of Amphibia and Invertebrata. The genus Opalina is very characteristic, and its species are mouthless, free-swimming, and they may be ovate or elongate in shape. The cilia cover the cuticle throughout, and this is striated. There are no extraordinary organs of prehension, and the spherical or oval endoplast is single in young individuals. It breaks up by repeated divisions, as growth proceeds, into innumerable minute rounded bodies, each having a clear peripheral zone and endoplastule. There is no contractile vesicle. *Opalina ranarum*, $\frac{1}{30}$th to $\frac{1}{45}$th of an inch long, is found in the intestines and rectum of the common frog and toad. Its body is usually ovate, flattened, evenly rounded posteriorly, and the anterior part is bluntly pointed. The minute embryos contained in cysts (Fig. 19, G) are found in the rectum and excreta of frogs in the early part of the year. They get into the water where tadpoles are developing, and are eaten by them. The cyst has its wall broken or dissolved in the digestive canal of the tadpole, and the embryo is set free. At this stage the young Opalina is long, egg-shaped, covered with cilia, and has a large endoplast and a number of corpuscles in the endoplasm (Fig. 19, H). After a short interval, the body becomes longer, slightly curved in front, and the endoplast becomes divided into two or four equal spheroidal portions (Fig. 19, I). After a while the pointed end becomes rounded, and the normal shape is attained (Fig. 19, A). When fully grown the animalcule begins to increase in numbers by fission, and the first division takes place obliquely (Fig. 19, B), so that one individual has a pointed posterior end, and the other a rounded-off one. The separated moieties subdivide over and over again, first obliquely and then transversely (Fig. 19, C, D), until at last the pieces are not more than $\frac{1}{500}$th to $\frac{1}{700}$th of an inch in length. These are long, oval in shape (Fig. 19, F), and soon become languid in their movements, and contract to a spherical shape, diminishing in bulk and becoming encysted. The endoplasts included in the animal at the encystment unite in one, after the swallowing by the tadpole, and this one is carried out with the young free-swimmer.

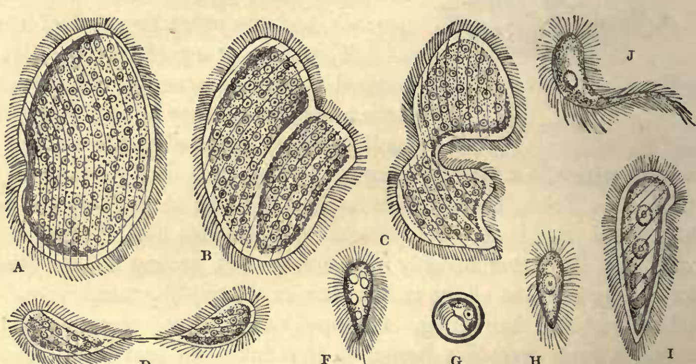

Fig. 19.—OPALINA RANARUM. (*After Zeller and Englemann.*)
A. Adult. B. Oblique division. C. Transverse fission. D. Fission. F. Last stage before encystment. G, H, I, J, Stages of growth of young.

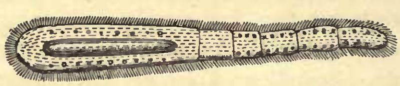

Fig. 20.—ANOPLOPHRYA PROLIFERA. (*After Claparède and Lachmann.*)

Another genus of the Opalinidæ is Anoplophrya, and its species are parasitic within the intestinal organs of many Invertebrata. The type is *Anoplophrya prolifera* (Fig. 20), which is found in the intestinal cavities of various marine Annelids on the Norwegian coast. It is mouthless, long, widest in front, striated longitudinally, and ciliated along the striæ. The endoplast is in the axis, is long and sub-cylindrical, and the contractile vesicles are numerous, and in two long rows. These animalcules increase by several divisions across the body, and their length is $\frac{1}{20}$th of an inch.

SUB-ORDER HETEROTRICHA.

These Ciliata are free swimming or attached, naked or loricate, and the cilia form two widely distinct systems; those of the general surface being short, and those of the oral region large and like cirri. These oral cilia are either linear in their arrangement, or form more or less spiral or circular series. The cortical layers are well developed, and sometimes contain parallel muscular fibrillæ.

The largest Infusoria are amongst this sub-order, which may be divided into a family, the Bursariadæ (Fig. 21), which has the cilia near the mouth confined to the left border of the mouth groove, and into six other families which have the mouth cilia in a spiral or circular series round the aperture. The first family of this second group has free-swimming animalcules, and the fringe of cilia around the oral aperture is confined to the ventral surface, and the anal orifice is behind and at the end. *Spirostomum ambiguum* is the type of the family, and is one of the largest animalcules, measuring $\frac{1}{6}$th to $\frac{1}{8}$th of an inch in length, and being visible to the naked eye, "gleaming," Saville Kent remarks, "like golden threads in the sunlight" (Fig. 22).

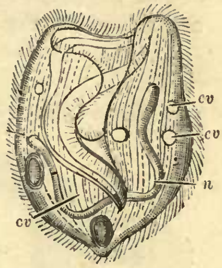

Fig. 21. — BURSARIA TRUNCATELLA. (*After Stein.*)
cv, Contractile vesicle; *n*, endoplast curved.

When they are placed in clean water off the duckweed on which they like to move, the body is long and filiform, has a tendency to twist itself and untwist, and the eye is struck by the long contractile vesicle which occupies much of the hinder part of the body, and by the endoplast, which is long and moniliform. The slit for the mouth is surrounded by cilia.

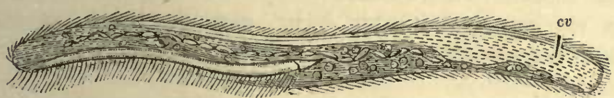

Fig. 22.—SPIROSTOMUM AMBIGUUM. (*After Stein.*)
cv, contractile vesicle.

Another member of the family is *Condylostoma patens*, found in sea water, and $\frac{1}{48}$th to $\frac{1}{72}$nd of an inch in length. Its endoplast is moniliform and long, and the anterior border of the body is rounded off, and flat in front, and the mouth groove is an angular excavation occupying much of the ventral surface. There is an undulating membrane extending over the whole length of the right side of the peristome border. The contractile vesicle is canal-like, and breaks up into minor spaces (Fig. 12).

A most important family has the trumpet-shaped animalcules in it, which are usually found adherent by their narrow bases, and often freely swimming. The broad trumpet opening of these Stentoridæ is the region around the mouth, and the left-hand extremity is turned in spirally, forming a funnel-shaped groove which leads to the mouth. The right-hand limb is usually raised higher than the opposite one, and all the cilia around the mouth are large and strong. The cilia of the rest of the surface are small, and arranged in regular longitudinal rows, and there are occasional setæ. The endoplast is canal-like, and the contractile vesicle is an anterior circular dilatation, which gives off an annular branch that underlies the circumference of the peristome.

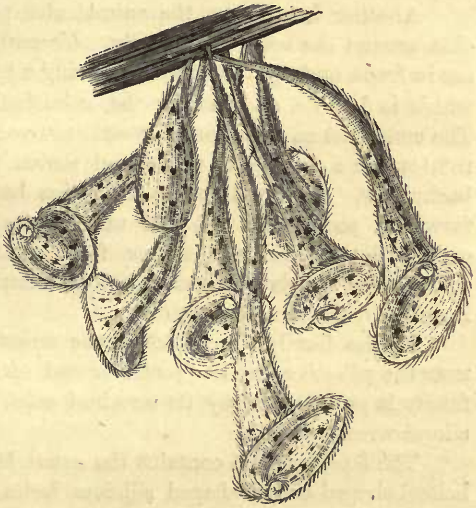

Fig. 23.—STENTOR POLYMORPHUS.

Stentor polymorphus (Fig. 23) is a large form, and the colour is produced by the presence of rich green chlorophyll granules. Its endoplast is moniliform, and the whole trumpet is $\frac{1}{20}$th of an inch long. It lives in groups, and the stems of all are immersed in a mucus which they secrete and hold on by. When swimming the shape is altered, and may be pear-shaped or top-shaped, and they fix themselves at pleasure. They increase in numbers by oblique fission, and a rudimentary mouth fringe appears, and only in the part of the body which will require it after division. They live in standing water among living and dead vegetation. One of the genus has blue colouring matter, and another, in addition to its green chlorophyll, has spots of a brilliant scarlet, and a third is black. The species of the genus Folliculina secretes a lorica, and the peristome opening occupies the end of the projecting part of the animalcule (Fig. 24). *Tintinnus lagenula* is a type of a family of this sub-order (Fig. 7).

SUB-ORDER PERITRICHA.

These Ciliata have the body smooth, except where there is a circular or spiral wreath of cilia in front. Sometimes there is a second encircling wreath which may be at the posterior part of the body, or at the middle. When the anterior circlet of cilia assumes a spiral form the right limb of the part around the mouth is mostly band-like and long. These animalcules may be free swimming or attached in colonies, and in this case often forming branching growths. They multiply by transverse and longitudinal fission, and by conjugation.

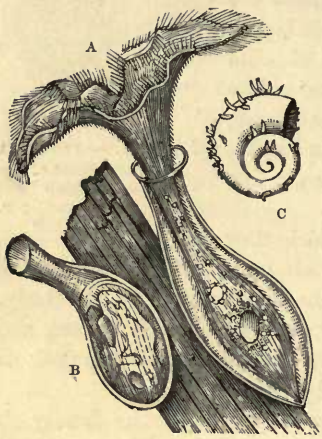

Fig. 24.—FOLLICULINA AMPULLA. (*Modified after Stein.*)
A, Protruding from, and B, contracted in lorica; C, Spirorbis shell with animalcules attached.

This very important sub-order is well divided into those families which are free swimming, and those which are sedentary or attached.

There are seven families of free swimmers, and in the first, containing the genus Torquatella, the cilia around the mouth are replaced by a vibratile collar. The second family has the animalcules protected by a silicious covering or lorica, and the third has no lorica, and there are retractile tentacules with the fringe of cilia in the front.

Halteria grandinella (Fig. 25) is the type of the fourth family, and is a free-swimming globular animalcule, and it has the oral aperture at one end, and associated with a spiral or sub-circular wreath of large cirrate cilia. There is a zone of long hair-like setæ around the body equatorially, and they enable the creature to jump in a most extraordinary manner. They roll themselves about, and suddenly leap backwards on to one side. There is a contractile vesicle and a spherical endoplast. The length is from $\frac{1}{860}$th to $\frac{1}{1500}$th of an inch, and it inhabits pond water.

Another family has the animalcules pear-shaped; the mouth is lateral, and there is a fringe of cilia around the body equatorially. *Urocentrum turbo* (Fig. 26) is the example, and the zones of cilia are in front, and equatorially, there being a terminal style, which is flexible, and enables the animalcule to adhere. The endoplast and contractile vesicle are very visible. It rotates like a top in the water, and moves forwards and backwards, and fixes itself, and spins backwards and forwards, so as to twist and untwist its stalk. The contractile vesicle has two or four sinuses, and the coutraction expels the water visibly externally. They increase by transverse division.

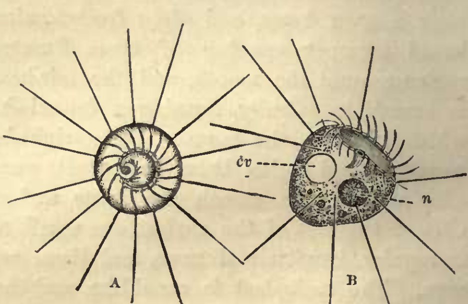

Fig. 25.—HALTERIA GRANDINELLA.
A, Ventral, B, lateral, aspect; *cv*, contractile vesicle; *n*, nucleus.

In the family Urceolaridæ the wreath of cilia is near the adhesive disc-like posterior end, and the seventh family is peculiarised by its terminal setæ, and a spinal adoral wreath of cilia.

The family which contains the genus Dictyocysta is characterised by the possession of a beautiful helmet-shaped or bell-shaped silicious lorica, which is usually perforated so as to resemble a fine lacework. The species are from salt waters, are free swimmers in the Mediterranean and south-west coast of England. In their tests they closely resemble Polycistinæ.

The family Vorticellidæ comprehends the Peritricha which are fixed during the greater part of their lives, and which are only temporarily free swimming. These are the "Bell Animalcules" which form colonies, and the commonest of which have their stalks contracting, often in a corkscrew shape, the end of the bell being provided with a circle of long active cilia. Occasionally they may be seen freely swimming, and then there is a second circlet of cilia at the tail end; but they soon settle down, become attached, and grow a stalk, the lower circlet of cilia disappearing. Very often the group of these stalked Vorticellidæ are so large that they are visible to the naked eye, and hence they were amongst the first animalculæ described. There are numerous genera, arranged in sub-families, and some have no stalk and others have it, and they may be solitary or social, arranged in branching groups on a common stem or immersed in mucus. The animalcules are highly contractile, and vary in shape from that of a long egg to sub-cylindrical, or a long or broad bell shape (Fig. 11). The free end of the bell consists of an outer raised border, sometimes but not always ciliated, and this closes the opening like a sphincter when the animalcule shuts up. As it reopens this peristome is seen to environ a spiral membrane with a circle of cilia on its free surface, and this projects beyond the peristome and the cilia produce very forcible currents in the water. On one side the circle is incomplete, and leads to a furrow which is often prolonged backwards on the body to a canal-like opening to the mouth. The movements of the cilia cause the particles of food to take the direction of this furrow, which has often a long solitary cilium at its free end. The spiral part, or disc, can be protruded or retracted. The endoplast is band-like and large, and the contractile vesicle is single, spherical, and is placed close to the anal aperture, which is distinct near the furrow. The stalk, when it exists in its highest degree of perfection, has an outer cuticle continuous with that of the body, and an inner spiral tissue more or less longitudinally fibrous, which is continuous with the myophan layer of the hinder part of the bell. Contraction produces spiral winding of the stem in some species, and a slow unwinding happens subsequently.

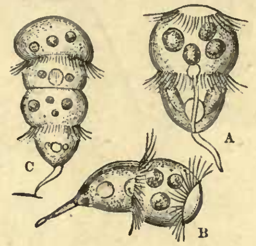

Fig. 26.—A, B, UROCENTRUM TURBO; C, TRANSVERSE FISSION.

The animalcules rarely divide by transverse and usually by longitudinal fission, which takes place through the endoplast and contractile vesicle. The offshoot grows a circle of cilia close to the stalk, which does not divide, and after a while it escapes as a free swimmer. In some species there is a free-swimming and small animalcule, which finally settles on the side of one of the larger fixed individuals, and either penetration occurs or the contents of the smaller pass into the larger. The endoplast subsequently develops a host of germs, which escape and become like the parents with growth.

In the sub-family Vorticellina the animalcules are naked, long, without a stem, and are sessile on substances; some have a distinct sucker, by which they cling on, mostly to moving invertebrata and sometimes to weeds in fresh water. One of the genera (Spirochona) has solitary individuals, and the peristome is developed into a spiral funnel, and in Stylochona there is a rigid pedicle or stem instead of a sucker at the tail end. Then there is a genus with all the characters of the genus Vorticella, but the stem is rigid and uncontractile, and the animals are solitary; and in the genus Pyxidium the solitary animalcules have a rigid stem and a ciliary disc projecting beyond the peristome. These forms lead up to Vorticella as a genus, which is the type of the family. *Vorticella nebulifera* (Fig. 27) is common in ponds attached to duckweed or other water plants, and is a very beautiful object under the microscope. The bell-shaped body of each individual is about $\frac{1}{300}$th of an inch in length, and is attached to a long

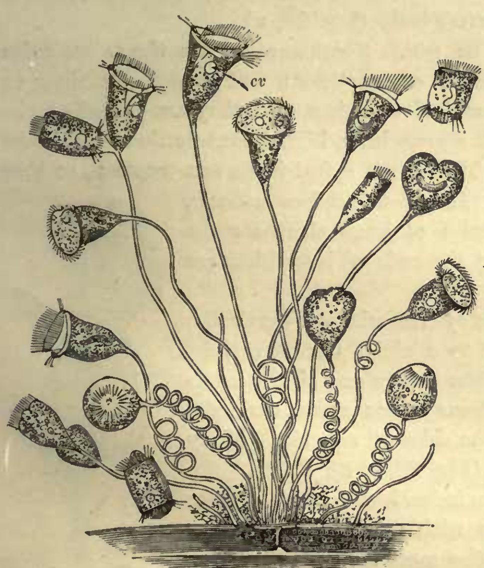

Fig. 27.—VORTICELLA NEBULIFERA.
cv, Contractile vesicle.

flexible stem, which is for a while extended to the utmost, the cilia of the disc and peristome being in full action. Suddenly the stem contracts, becomes spiral, and the body closes slightly and bends on its stalk. Then the oral end opens, the cilia move again, and the stalk is drawn out to the utmost. This goes on very irregularly in a colony of a score or more of individuals, so that whilst some are contracted others are in full play. The currents in the water, produced by the ciliary fringes, are considerable and move much disintegrated matter into the oral grooves. The phenomena of fission and conjugation may be seen in the same colony at the same time, and every now and then a bud moves off by means of its hinder circle of cilia.

Fig. 28.—A, ZOOTHAMNIUM NIVEUM (*Saville Kent*); B, SINGLE ANIMALCULE, MORE HIGHLY MAGNIFIED; C, EPISTYLIS UMBILICATA; D, BRANCHLET OF CARCHESIUM POLYPINUM; E, AN EPISTYLIS GROWING ON A CYCLOPS.

In the genus Carchesium, which belongs to this group, a host of animalcules are on branchlets springing from a common stem. Usually the bell-shaped bodies are on one side of their branchlet, and each one has a stem continuous with the branch and main stem. A muscular tissue resembling that of Vorticella is in the stem and its prolongations, but it is discontinuous, so that each body can contract without the others, and each branchlet can do the same irrespectively of others, and the whole may contract with the primary stem and form a small globular mulberry-looking mass.

The species live in fresh and sometimes in salt water, and the whole colony originates in the fission of one individual and its stalk, and is fully developed by the successive longitudinal fissions of body after body (Fig. 28, D).

The genus Zoothamnium has the animalcules like those of Vorticella, but often dissimilar in shape and of two sizes, and they are placed at the end of a branching, highly contractile stem. The internal muscle of the stem is continuous throughout. This is not spiral in its construction, so that the stem never forms a spiral during its contraction. In *Zoothamnium niveum*, which is a salt-water form, there are spherical animalcules of large size near the bases of the primary branches, and the smaller ones at the ends of branchlets are long bell-shaped (Fig. 28, A, B).

Fig. 29.—PYXICOLA PYXIDIFORMIS.

Another genus, Epistylis, with its animalcules closely resembling Vorticella, has them attached in numbers to a rigid, uncontractible, branching, tree-like stem, and the bodies are of the same size throughout. *Epistylis flavicans* forms slimy encrustations on water plants and on the sides of aquaria. Many species settle on small crustacea (Fig. 28, C, E).

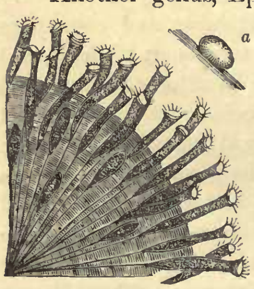

Fig. 30.—OPHRYDIUM EICHHORNII. (*After Saville Kent.*) *a, O. sessile*, natural size.

The next sub-family includes animalcules which excrete hard sheaths as loricæ and live within them. The genus Pyxicola, whose species live for the most part in salt water, has an erect lorica or a stem of attachment, and a horny plate on the body beneath the border of the peristome. This closes in the top of the lorica when the animal retreats. They inhabit fresh and brackish water (Fig. 29).

The last sub-family, the Ophrydinæ, contains Vorticella-like animalcules which excrete and inhabit a soft mucilaginous sheath or mass which may contain many.

Ophrydium Eichhornii (Fig. 30) is an example, and it forms attached gelatinous masses in which are numerous individuals, each with its slender pedicle. The body is long and narrow, and the whole is very elastic. They live in fresh water, attached to Anacharis, and about a hundred may be in a mass measuring $\frac{1}{80}$th of an inch. They increase by transverse as well as by longitudinal fission.

SUB-ORDER HYPOTRICHA.

These animalcules are free swimming, and the locomotive cilia are confined to the inferior or ventral surface, and are often modified into setæ and hooks. The superior surface is either smooth, or has some immobile setæ on it. The mouth and anus are ventral. Saville Kent subdivides this group into six families and forty-two genera. *Chlamydodon mnemosyne* is the type of one family, and it has a short, kidney-shaped body, the front being wide and the dorsal surface convex, and the ventral having a striated border. The cilia are the most conspicuous anteriorly. and they project as a fringe. The oral aperture has a bundle of rods in its membrane. The endoplast is single and ovate, and there are many contractile vesicles. It inhabits salt water (Fig. 31).

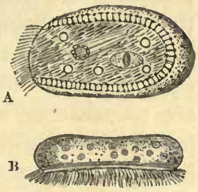

Fig. 31.—CHLAMYDODON MNEMOSYNE.
A, Under, B, side view.

Another family, the Dysteriidæ, mostly inhabit salt water, and these free swimmers are mostly provided with a lorica either single or made up of two joined or detached valves like a small crustacean. The cilia are on the lower surface and the oral aperture leads to a canal, or pharynx, with a horny tube, or rods. The animalcules have a conspicuous tail-like style, or a group of setæ.

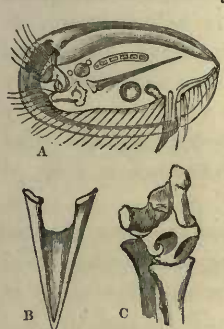

Fig. 32.—DYSTERIA ARMATA. (*After Huxley.*)
A, Left side; B, C, pharyngeal apparatus.

Dysteria armata, a salt-water form, $\frac{1}{250}$th to $\frac{1}{350}$th of an inch in length, is remarkable for the anatomy of the pharynx. The oral fossa has a curved rod which terminates in fork-like teeth, and which is lost in the walls of the fossa. Then comes the armature of the pharynx, which consists of two portions—an anterior rounded mass in opposition with a much elongated styliform posterior portion. These animalcules live in swarms among the confervoid Algæ which coat the shells of limpets and periwinkles (Fig. 32).

The family Peritromidæ has the ventral surface finely ciliate, and there is a curve of powerful cirri around or near the mouth, and the pharynx is unarmed.

A host of flexible or persistent in shape animalcules, with front, ventral, and rear styles, and hooks and setæ at the margin, belong to the Oxytrichidæ. The common *Stylonychia mytilus* is an admirable example. It has a hard covering, or lorica, and the neighbourhood of the mouth has a great curve of long cilia on an undulating membrane. There are usually eight styles in front, five claw-like hooks on the ventral surface, and five straight anal styles. The marginal setæ form a border, and there are three long tail-like setæ. There are two endoplasts, sometimes divided, and a contractile vesicle. It inhabits fresh water, and the largest are $\frac{1}{72}$nd of an inch long (Fig. 8).

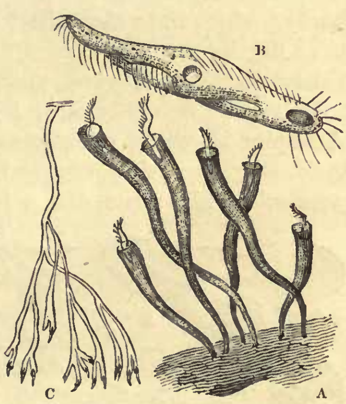

Fig. 33.—STICHOTRICHA REMEX. (*After Hudson.*)
A, Animals in tubes; B, free animalcule; C, diagram of *Schizosiphon.*

Another species (*Stichotricha remex*, Fig. 33) has the cilia of the apex of the peristomial border very long, and the body is lanceolate, and inhabits a slender, brown tube, three or four times as long as the body, which projects from it with a twist.

Fig. 34.—EUPLOTES CHARON.

Closely allied to these dwellers in separate tubes is a species (*Schizosiphon socialis*) which forms colonies that build up a branching tube. Another of this great family is *Uroleptus piscis*, and it is remarkable for its attenuated end, two endoplasts, and great curved ciliated peristome.

A family of the Hypotricha has no setæ along the margin, or they are rudimentary, but there is a lorica, and there are ventral and anal styles, or else hooks. In *Euplotes* *charon* the dorsal surface of the body is ribbed, as it were, and there are seven frontal and three ventral styles, besides five posterior strong setæ (Fig. 34).

ORDER CILIO-FLAGELLATA.

The animalcules of this order are readily distinguished by their bodies being more or less ciliated, and by their having a long lash-like flagellum. The mouth is usually distinct. Saville Kent divides them into four families and sixteen genera, and the individuals are occasionally very numerous, producing the phosphorescent condition of the sea, and discolouring fresh and salt water. Most of the Cilio-flagellata, a type of which has already been noticed (pp. 356-7), are small, $\frac{1}{500}$th of an inch being the greatest length, but amongst the genus Ceratium there are some large forms, some reaching $\frac{1}{72}$th of an inch in length. They are found in fresh and in salt water; and, so far as is known, none are parasitic or sedentary; but during one of the reproductive phases encystment occurs, and a period of quiescence precedes the escape of the young. They are active swimmers as a rule, the lash-like flagellum (in rare instances there are two) enabling rapid and irregular motion easy, and the cilia produce ordinary movement. Fission occurs, but the reproductive phenomena have not been observed satisfactorily. Some of the Cilio-flagellata are naked, and others have a shell, or horny cuirass, which may be smooth or ornamented, and often prolonged into horn-like processes. Some of these loricæ have been preserved in the strata of the chalk, and are referred to the genus Ceratium. The general character of the group having been given already, it is only necessary to observe that the family Peridinidæ contains ten genera. In all there is a distinct ciliary girdle, and one flagellum. In a doubtful genus there are two of these organs. In some of the genera the ciliary girdle is central, in others eccentric, and in one it is terminal. Some genera have a cuirass, and many others are naked. Melodinium, already noticed (p. 356), is an example of a naked, and Ceratium of a cuirassed and horned genus. Peridinium has no horn-like processes, and the cuirass is facetted (Fig. 4, A–H).

The second family* has one vibratile flagellum, and one which is trailed, and the body changes in shape, like Amœba; and the third family† has the body clothed with long setose cilia, and a terminal flagellum, the body shape being persistent. A fourth family has a wreath-like crest or collar of cilia, and in the midst a flagellum, which may or may not be retractile;‡ and the last family,§ which links the order with that of the Ciliata, has a more or less perfect ciliary covering, and a flagellum. The colours differ, and there may or may not be a red spot in these families. Yellow, light-brown, green, pink, reddish-brown, vermilion, are common colours; and usually the endoplasm is transparent, and holds coloured matters in suspension. *Peridinium splendor-maris* of Naples is highly phosphorescent, and *P. sanguineum,* of salt-water pools and the sea-shore of India, is green when young, and with growth a number of oil globules is secreted within, and the green colour disappears, and a bright red tint comes on, just before encystment. The red colour of patches of the sea is due to this form, in many instances, and it is noteworthy that the presence of these animalcules renders water very disagreeable.

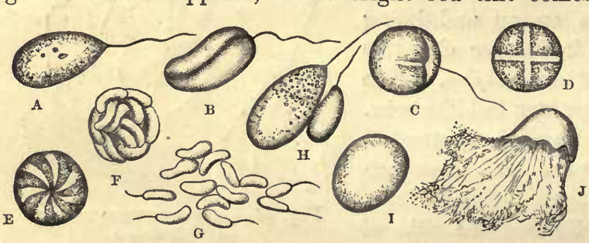

Fig. 35.—MONAS DALLINGERI. (*Saville Kent.*)
A, B, Adult: C, about to encyst; D, E, F, encystment—formation of spores which are liberated as monads; G, H, conjugation: I, encystment from conjugation; J, bursting of and liberation of spores (small).

ORDER FLAGELLATA.

These animalcules, generally very minute, have one or more long slender flagella; there are in some instances pseudopodia. The mouth may be doubtfully present, and food may be taken in at one spot, or anywhere. One or more contractile vesicles are almost invariably present. They increase by fission, or by breaking up of the endoplasm in the encysted state.

This definition explains how difficult it is to limit the lower Flagellata. It is possible that many of the so-called Flagellata are stages of plants, and indeed it seems impossible to draw a hard and

* *Heteromastigidæ* (Fig. 4, K). † *Mallomonadidæ* (Fig. 4, L). ‡ *Stephanomonadidæ* (Fig. 4, I).
§ *Trichonemidæ* (Fig. 4, J).

fast line where the animal and vegetable kingdoms branch off. Saville Kent has paid much attention to the order, and his descriptions and classification are excellent.

The Flagellata may be divided into three sub-orders: in the first there is no defined mouth, and the food may be taken in by any part of the body, and in the second the food is received in the

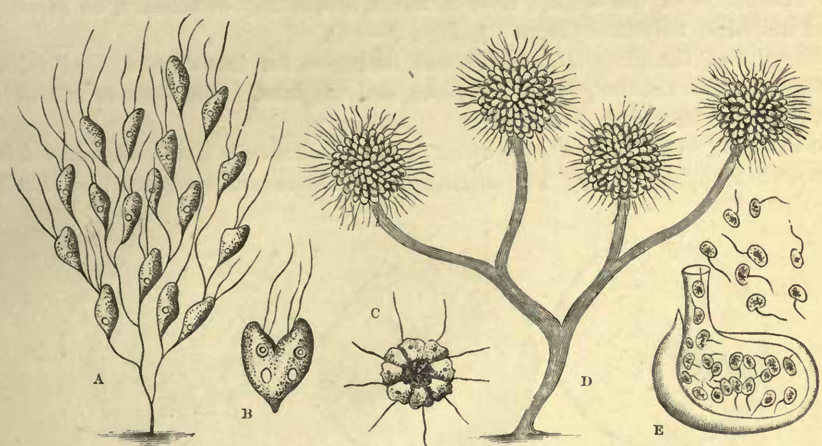

Fig. 36.—A, CLADONEMA LAXA. (*After Saville Kent.*) B, ANIMALCULE DIVIDING; C, ANTHOPHYSA VEGETANS, SWIMMING CLUSTER; D, ANTHOPHYSA VEGETANS, SHORT BRANCHING COLONY; E, SPOROCYST LIBERATING GERMS.

anterior region. A true opening for food exists in the third, which have a non-ciliated body with a flagellum. The sections of the first sub-order are the Trypanosomata, membranous organisms found in the blood of frogs and toads; the Rhizo-flagellata, which have amœbiform bodies and a flagellum; the Radio-flagellata, with or without a lorica, having a flagellum, and ray-like pseudopodia; and the Flagellata-Pantostomata proper, which have a flagellum and the food incepted anywhere. A host of genera belong to this sub-order and Monas may be represented by

Monas Dallingeri, $\frac{1}{4000}$th of an inch in length. It has one flagellum, which is flexible when young, and rigid towards the base in old specimens (Fig. 35).

Cercomonas has a caudal filament besides a flagellum (*Cercomonas typica*, Fig. 3).

The genus Cladonema, as the name implies, has a branching form, and the ovate bodies are attached to thread-like pedicles. There are two flagella (Fig. 36, A, B).

Anthophysa, a genus belonging to the same family, has small individuals $\frac{1}{3500}$th to $\frac{1}{4000}$th of an inch in length, and is in the form of clusters of fifty or sixty bodies at the ends of branching horny pedicles. These have contractile vesicles (Fig. 36, C, D).

Rhipidodendron splendidum (Fig. 37) is in masses, $\frac{1}{75}$th of an inch long, and has its bodies with two flagella. These are in a branching mass, like a fan in shape.

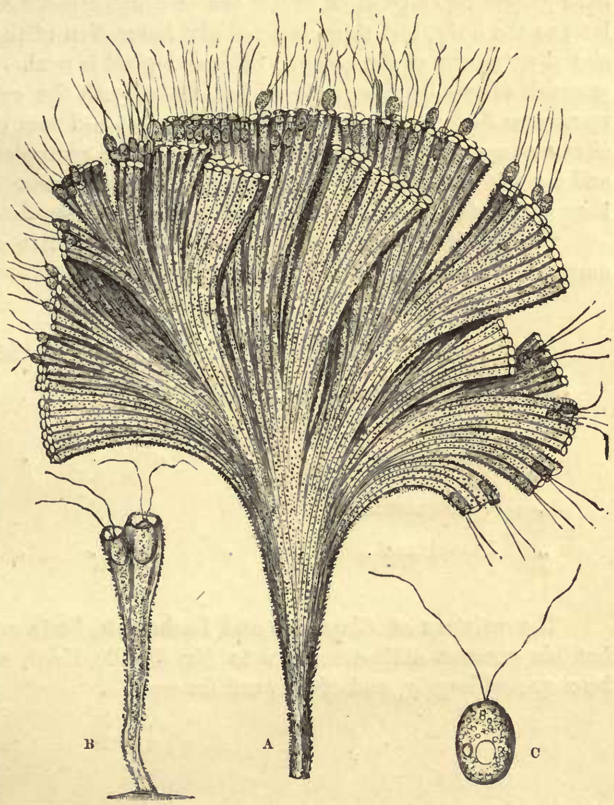

Fig. 37.—RHIPIDODENDRON SPLENDIDUM.
A, Colony; B, animalcule bifurcating; C, isolated monad.

The second sub-order comprehends Saville Kent's division of the collared monads (*Choano-flagellata*), with individuals varying from $\frac{1}{1000}$th to $\frac{1}{3000}$th of an inch in length, and some of which resemble the collared cells of sponges. It consists of three families. In the first the animalcules are naked, and either attached or free; the genera Monosiga, Codosiga, and Astrosiga are examples (Plate 72, Figs. 1—8). The forms of the second have a lorica, which may be solitary, as in Salpingæca and Lagenæca, and united in Polynæca (Plate 72, Figs. 9—18).

In the sub-order of the Flagellata, with a definite region for inception of food (Eustomata), the most interesting examples are the genera Noctiluca and Euglena. The first is one of the greatest producers of the phosphorescence of the sea.

Noctiluca miliaris, from $\frac{1}{20}$th to $\frac{1}{80}$th of an inch in diameter, is peach-shaped, and has a distinct meridional groove to its hyaline body. The mouth fossa is at one end of the groove, and has on one side a

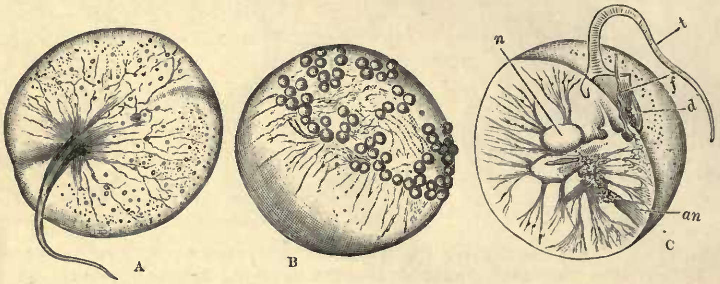

Fig. 38.—A, NOCTILUCA MILIARIS; B, SAME WITH BUDS (*from Photograph after Brooks*); C, IN SECTION. (*After Huxley.*)
n, nucleus; *f*, flagellum; *t*, tentacle; *d*, denticle; *an*, anus.

hard projecting ridge, close to one end of which arises the flagellum. Close by arises a tentacle about as long as the body, and there is a rod-like induration of the cuticle, extending in a straight line from the aboral extremity of the groove. The endoplast is oval. They exist in countless multitudes, and their greenish-silvery light is produced just underneath the cuticle in irregular flashes. They increase by transverse fission, accompanied by encystment and loss of the flagellum and tentacle. Under certain circumstances, the endoplast breaks up, and the protoplasmic contents of the cyst collect in one spot and form by division into many minute nodular masses. These cause the cuticle to rise, and finally they penetrate it and develop flagella. They become detached and swim as germs (Fig. 38).

Conjugation is also observed. The Noctilucæ live on minute floating Algæ, which may be seen amongst the vacuoles of the irregular endoplasm.

CLASSIFICATION.—CLASS INFUSORIA.

Order	Tentaculifera	Sub-order	Suctoria. Actinaria.
,,	Ciliata	,,	Holotricha. Heterotricha. Peritricha. Hypotricha.
,,	Cilio-flagellata.		
,,	Flagellata	,,	Pantostomata. Choano-flagellata. Eustomata.

The writings of Claparède and Lachmann, Stein and Huxley, have been used by the author; but his greatest obligations are to Mr. Saville Kent, whose excellent Manual of the Infusoria has been quoted largely, and often word for word.

P. Martin Duncan.