DROPS OF WATER

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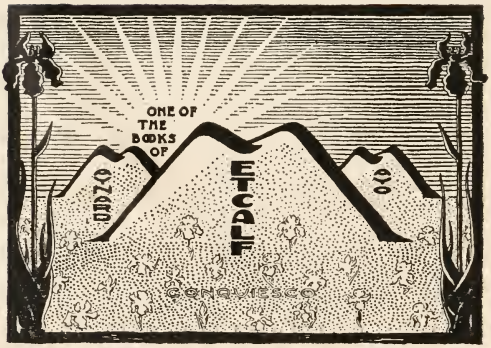

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DROPS OF WATER.

DROPS OF WATER;

THEIR

MARVELLOUS AND BEAUTIFUL INHABITANTS

DISPLAYED BY THE MICROSCOPE.

BY

AGNES CATLOW,

AUTHOR OF 'POPULAR CONCHOLOGY,' 'POPULAR FIELD BOTANY,' &c.

"For Nature here
Wanton'd as in her prime, and played at will
Her virgin fancies."—*Milton.*

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DEDICATION.

THIS slight introduction to one of Nature's inexhaustible sources of wonder and delight, I inscribe to three Sisters, my affectionate friends; who, by their cultivated minds and kind sympathy, have so greatly enhanced my pleasure in the pursuit.

Beaconsfield, March 1851.

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Earth hath its Mountains, lifting high
Their viewless summits to the sky;
Its Plains, that in their boundless maze,
Baffle the eye's far-searching gaze;
And Seas, immeasurably deep,
Which, in their secret holds, do keep
Treasures unknown to human thought,—
Treasures by human hands unsought.
Yet hath nor mountain, plain, nor sea,
In all their vast immensity,
More power to speak, through wondering sense,
Of the great God's omnipotence,
Than one small *drop of water!*—Yes,
Behold its living world! (no less)
Of creatures beautiful and bright,
Disporting 'midst its liquid light.
Some, like to rare and clustering gems;
Like lilies some, with silver stems,
Waving in graceful motion, slow,
(Like measured cadence) to and fro;
Others like fairy bells appear,
Ringing their chimes in fancy's ear;—
And there are serpent-forms, that glide
'Midst tiny banks of moss, or hide
Their glittering coats beneath the leaves
Of mimic boughs,—which Nature weaves

By the same hand of power, that made
For man the mighty forest glade!
But vainly words essay to tell
What things of wondrous beauty dwell
Within these liquid worlds concealed,
Till by some magic spell revealed.
Come, watch the myriads as they pass
In bright review before the glass
Of wizard Science!—then declare
If aught on earth, in sea, or air,
Can with these *Water Drops* compare.—*C. P.*

PREFACE.

Having for several years derived great and increasing pleasure from the use of a good microscope, particularly in the investigation of the minute creatures contained in water, and wishing to extend this pleasure to others, I venture to make public the following pages; for though there are several learned works already on the subject, my experience and observations may be

more genial to the beginner, than the scientific treatises of more able authors. I shall be satisfied if this little work is soon laid aside for those of higher pretension and greater merit; and I refer the advanced student to the volumes by Ehrenberg, Pritchard, and Mantell.

To give an idea of the wonders to be found in this new world, to which I wish to lead the reader, I shall describe one scene amongst the many to be witnessed. My readers must fancy themselves spirits, capable of living in a medium different from our atmosphere, and so pass with me through a wonderful brazen tunnel, with crystal doors at the entrance.

These doors are bright, circular, and thick, of very peculiar construction, having taken much time and labour to bring to perfection. A spirit named Science opens them to all who seek her, and feel induced to enter her domains. At the end of the tunnel we find other portals, much smaller, and more carefully constructed, and two or three in number; when these are opened, we are in the new world spoken of. And now I see your astonishment: your minds are bewildered with the variety of new beings and forms you behold, all gliding and moving about without noise and at perfect ease.

Now let me direct your attention, first, to the

vegetation you see around you; and remark how different it is from our own. Here is a plain covered with a plant which resembles numberless yards of green figured ribbon, in a state of entanglement. If you examine the substance, you find it composed of cells linked together in myriads, each cell containing granules which form the seed; these cells in time break up, the imprisoned grains come forth, and from them arise new plants in countless numbers. Here is another, much thicker, and of a different pattern. Now we come to one, which, instead of being round, like the others, is three-sided. Then look on this—have we anything to compare to it? You

observe it is formed of two half-circular green masses, joined together on the straight side by a narrow band-like tube: you see it has neither root, branch, nor leaf, and yet it is a vegetable.

Now we will turn from the inanimate, to animated beings. That wonderful living creature you see approaching, is worthy of special examination. You exclaim, "This is not a living creature, but a miniature globe, rolling in this new world into which you have introduced us." It has this appearance, certainly; but that it has sense, motion, and will, I think I can convince you, and moreover that it is not *one* being alone, but is formed of hundreds of minute beings, all

enjoying life, and grouped together in this curious manner for mutual support. Let us examine it, and you will then be able to believe the evidence of your own senses. You see before you a hollow globe, formed of a material sufficiently transparent for you to see within it. Now look at the green dots with which it is spotted thickly, but evenly, all over; they are living beings, attached to the inner side of the globe, each having an eye and a double proboscis, which it protrudes from an opening in the transparent case, and by which it has communication with the exterior, and obtains its food. See how actively each moves this instrument, and what

enjoyment they all seem to have; their united efforts also, continuously exerted, turn the globe round, and thus the whole progresses rapidly. Look within the globe, and you cannot fail to observe, towards the centre, other smaller globes, formed exactly like the larger one, being already full of little individuals ready to enter on active life.—Now you perceive the transparent case is ruptured in one spot, and you fear the globe has met with an accident, and will perish. On the contrary, it is the prelude to new life. The orifice becomes larger; the minute globes contained within are making towards the opening: now one has escaped, and now another; those

have entered on an independent existence, and are followed by the rest. But watch the little individuals in the case; you see they are also, many of them, ready to assert their independence, and are leaving their habitation. At last you see the case lies shrivelled, useless;—but I desist; I see you are lost in admiration at only *one* of the creatures of this unknown world to which we have paid a transient visit; we will, therefore, again beg Science to admit us through her brazen tube, and open the crystal portals, that we may pass into our own world; where, though we meet with no creatures of a compound form, no living globes, we find beings like ourselves, who

will, when Nature is more closely and affectionately studied, be lost, like us, in wonder, love, and praise.

Microscopists usually speak of the power of their glasses in diameters, or what is termed, also, linear dimensions; that is, the simple measure across, instead of the compound or superficial measurement: a power of 250 diameters (quite sufficient for all ordinary purposes) has a superficial measurement of 62,500. The size of objects is calculated by parts of an inch; an animalcule may, therefore, be $\frac{1}{30}$, $\frac{1}{140}$, or even $\frac{1}{12000}$ of an inch in size:—this may be ascertained by knowing the diameter of the

field of view in the glass used. Further particulars may be acquired on this subject by referring to works on the microscope.

DROPS OF WATER.

No pursuit in the whole range of learning is more congenial to the human mind than the study of Nature. No one can gaze upon the beauty and complexity of her forms without wishing to dive more deeply into her hidden recesses, and, by investigation, to find out the cause of many wonderful effects constantly brought before the eye. Astronomy may raise our thoughts to the Creator in wonder and astonishment by the magnitude of the stars, and the marvellous wisdom by which they are kept in their course; but "there are miracles of minuteness as well as of magnitude,"

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and, as an old writer expresses himself, "the majesty of God appears no less in small things than in great; and as it exceedeth human sense in the immense greatness of the universe, so also doth it in the smallness of the parts thereof."

The wonderful power of the Creator is as clearly manifested in the formation of the smallest animalcule, as in that of the largest living being; and perhaps the former even excites our admiration in a greater degree, for when we examine, by the aid of "that mighty talisman of wisdom" a microscope, an object which is so small that the unassisted eye cannot discern it, or which the point of the finest needle would destroy in an instant, and find it perfectly beautiful in all its parts, our wonder is the more increased, and the

mind is lost in astonishment at that power which has brought such things to pass. The reflective mind experiences great delight in the investigation of those minute objects, which to the unassisted eye are invisible, but which, by the aid of a good microscope, may be studied at ease; our curiosity, however, is never satisfied, for, though by magnifying an object we find wonders revealed which before were hidden, we know that if our glasses were of a still higher power, we should discover more of the mechanism, and find out the use of many parts, that without this increased aid would remain in uncertainty. As our microscopes will probably never be made sufficiently powerful to show clearly all the minute creatures contained in water, we shall

still remain ignorant of some of them. And this fact forms a parallel case to that relating to the stars; for astronomers have informed us, that, by the increased power of their telescopes, myriads of stars have been discovered, beyond those seen without this powerful aid, and that every year, as the glasses are improved, more and more stars appear: we may, therefore, in viewing the series the other way, imagine with some degree of probability, that water may still teem with life even beyond the reach of the highest powers of our glasses, and we may never be able to say with perfect truth of any drop of water, that it is free from animal or vegetable life. The thought is as overpowering in the one case as in the other, and we should be thankful that, by the aid of

science, such systems are laid open for our investigation and study. Dr. Chalmers, in speaking of these two wonderful instruments, says very impressively—"While the telescope enables us to see a system in every star, the microscope unfolds to us a world in every atom. The one instructs us that this mighty globe, with the whole burthen of its people and its countries, is but a grain of sand in the vast field of immensity; the other, that every atom may harbour the tribes and families of a busy population."

I cannot better commence this slight sketch of some of the minute objects contained in water, than in the words of Professor Jones.—

"Take any drop of water from the stagnant pools around us, from our rivers, from our lakes,

or from the vast ocean itself, and place it under your microscope: you will find therein countless living beings, moving in all directions with considerable swiftness, apparently gifted with sagacity, for they readily elude each other in the active dance they keep up, and, since they never come into rude contact, obviously exercise volition and sensation in guiding their movements. Increase the power of your glasses, and you will soon perceive, inhabiting the same drop, other animals, compared to which, the former were elephantine in their dimensions, equally vivacious and equally gifted. Exhaust the art of the optician, strain your eye to the utmost, until the aching sense refuses to perceive the little quivering movement that indicates the presence of

life, and you will find that you have not exhausted nature in the descending scale. Perfect as our optical instruments now are, we need not be long in convincing ourselves that there are animals around us, so small, that in all probability, perseverance will fail in enabling us accurately to detect their forms, much less fully to understand their organization."

These few pages are almost entirely confined to the description of animalcules* found in water: and as all, or very nearly all, are invisible to the naked eye, no subject can be more interesting than that of these wonderful atoms, which, we

* The word animalcule signifies *little animal*: Infusoria is a term more generally used to designate these little creatures, as they abound in all infusions of animal and vegetable matter.

have every reason to suppose, are by far the most numerous of those beings possessing life. The variety of form, the extraordinary construction, the rapid movement of some, the stationary life of others, and many other peculiarities, will prove subjects of interest and delight to the thinking mind. The one idea that a single drop of water may afford amusement, and excite astonishment for hours, to the investigator, is sufficient proof of the wonderful powers of the Creator in this minute portion of his works. These little creatures prove quite fascinating; and hour after hour will be spent in watching their habits and movements, till the powers of the student are exhausted. A good microscope, in fact, opens a new world to the possessor, a world of beings totally

different from anything we have been accustomed to see; and the substance of which they are composed is in general so transparent, that the internal structure is visible to the eye,—even the act of digestion can be perceived, and the food traced from its entrance at the mouth, to its passage into the internal cavities; the eggs, also, can be seen within the body. These and many other peculiarities have been discovered only by very patient investigation, and several naturalists, both English and foreign, have almost devoted their lives to the study: and let no one say it is a useless one, for whatever can help to prove the power and wisdom with which this world was created, cannot be time thrown away. To those who only use the microscope as an

amusement (and it is a never-ending one) a short time occasionally is well bestowed on one of the most beautiful parts of the creation.

There are upwards of seven hundred species of Infusoria known and described. These are of all shapes and forms, some even assuming a variety in themselves; many possess eyes, others have none; some move so rapidly that the eye cannot follow them, and others are attached to various substances; some have very many stomachs, or internal sacs, and others have only one; others, again, form a compound mass, that is, many individuals live in the same transparent case, and some are so minute that by the aid of the best microscopes they cannot be clearly discerned. But enough has been said to excite the mind, and in-

terest the intelligent reader in the subject, and we will at once proceed to a more detailed history of the peculiarities of Infusoria; premising that one family, the *Desmidieæ*, which was by Ehrenberg considered as belonging to the animal kingdom, has, after much variety of opinion by naturalists, been placed amongst vegetables, and considered as minute forms of Sea-weeds (*Algæ*): these will be described slightly in the sequel.

After the first expense in the purchase of a good microscope, amusement may be constantly obtained at all seasons of the year, without any trouble but that of procuring and selecting water likely to contain animalcules, and they are miraculously abundant everywhere. Many people are disgusted after viewing water through a micro-

scope, and suppose that all water abounds in living creatures, and that, consequently, we drink them in myriads. This is an error: there are none, or very few, in spring water, and, as no one would think of drinking from a ditch, or stagnant pool, where plants abound, there is little to fear. If necessitated to partake of water abounding in life, the person is either ignorant of its state, or the want is so urgent that the thought does not occur; and even should it arise, these delicate transparent little atoms would not be perceived by the taste;—this fear or disgust may therefore be dismissed. Many waters abound in the larvæ of gnats and other insects, and minute creatures of the crustaceous order, but these can generally be seen by the naked eye.

In all parts of the world, and in most waters where aquatic plants in a healthy state abound, these invisible creatures may be met with, and not only in stagnant pools, but in running streams, and the broad ocean. Among water-plants these little beings find shelter and food; therefore, when water is brought from these localities, some of the vegetation peculiar to the pool, or stream, should be procured at the same time. They swarm amongst duckweed (*Lemna*). Many are found also in clear shallow pools, particularly in the spring. When a pond is observed to have a stratum of dust on the surface, or a thin film, it will generally be found almost entirely composed of living creatures. This dust-like appearance consists nearly exclu-

sively of species of the most beautiful colours, such as *Pandorina, Gonium,* &c. A shining film of various colours is also occasionally seen on standing water: this is composed of Infusoria; a red appearance being often given to water by some species, and by others a yellowish hue. Sheets of water often assume an intense green, from the presence of many of these minute bodies. Lakes have been known to change their colour very mysteriously, and to have caused some alarm in the superstitious; but it is now known to arise from Infusoria, as they are attracted to the surface by the sun in the middle of the day, and descend as that luminary declines;—thus the lake will be clear, morning and evening, and turbid, or of different colours, in the course of

the day. If stalks of flowers are steeped for a few days in water, it will be found to swarm with life; even a few dead leaves, or a bit of dry hay, will produce the same effect. At first monads will appear; these will be succeeded by specimens of the genera *Paramecium*, *Amoeba*, and those of the class *Rotatoria*. I have tried these experiments, and always with success. If the infusion be kept a few weeks (particularly that formed with leaves), one peculiar kind of animalcule will swarm to a most astonishing degree, so that a drop will contain hundreds, so close together that they form quite a crowd, and yet all are in a state of activity, and feeding from the vegetable matter disengaged from the decaying leaves. They are not even confined to these localities, for lakes and rivers, the

fluids found in animals and vegetables, strong acids, and also the briny ocean, are full of these interesting creatures. One kind of phosphorescence, (an appearance which is so often observed by the sea-side and at sea,) is occasioned by some species; and when we remember that this luminosity often extends for miles, we are lost in astonishment at the immensity of their numbers.

And here I may mention the evident use of these wonderful beings. They appear wherever decaying animal or vegetable substances are found in water, and are extremely useful in destroying what would otherwise taint the air with noxious gases and smells. Minute algæ also assist in preserving the purity of the water in which they live; they serve as food, also, to

animals higher in the scale of creation than themselves. Captain Sir James Ross, in his Antarctic Voyage, speaking of a small fish found by him in the South Seas, and stating by what means it and many others are fed, says, "All are eventually nourished and sustained by the minute infusorial animalcules, which we find filling the ocean with an inconceivable multitude of the minutest forms of organic life." We may infer from this, the immense importance of the Infusoria in the scale of existence, for although only remotely supporting the higher animals, yet the want of them would be greatly felt. Ehrenberg* states, that a single drop of water may hold five

* A celebrated Prussian naturalist, who has devoted his life to the microscopic investigation of animalcules and other minute objects.

hundred millions of the smallest animalcules. What, then, can be the population of a lake, or of the ocean!

I have watched specimens of the genera *Floscularia*, *Vorticella*, and *Stentor*, for hours at a time, and they have never ceased to feed on minute portions of animal and vegetable substances, brought to them by the current they are enabled to make in the water; others eagerly pursue their prey, or feed on the decaying vegetable matter floating about: indeed, the appetite of these little creatures seems insatiable. Many genera have a strong chewing apparatus, like a mouth armed with teeth. All seem employed in the same way, though using different methods:—much decaying matter must thus be taken away by

this insatiable, though miniature army, provided for the purpose. They, in their turn, afford sustenance to aquatic insects, which are again preyed on by fishes; and thus food is prepared for more highly organized animals, and lastly for man.

Animalcules have never been observed to rest, or at least to sleep; but this may be partly owing to the light necessarily used in viewing them, which forms an artificial sun-light, exciting their powers of motion: they may rest during darkness, when they cannot be seen by us. Many are only attracted to the surface of the water by the light of the sun, and are difficult to be obtained on a dull day; they are, however, not much affected by cold or heat, for they are procurable in winter

as in summer, though not in such profusion: they are found even under thick ice, and I have frequently broken, in severe frost, the frozen surface of a pond, and, inserting a bottle, have obtained some most interesting kinds. Many of the *Polygastrica* will bear a great degree of cold, even more so than those of the class *Rotatoria*, whose organization is of a higher order.

It has, I believe, been generally observed, that the more simple the organization of animals, the more retentive is the creature of life, and this is the case with these minute beings. The *Rotifer vulgaris* will even bear revivification several times. Dr. Carpenter relates that he tried the experiment six times with twelve specimens, and each time some were perfectly restored to animation.

By allowing the drop of water which held them to evaporate, and at the end of twenty-four hours giving them a fresh supply, he succeeded six times in restoring some of them: at last two only were left, and these unfortunately he lost. Ehrenberg affirms, that if thoroughly desiccated they cannot revive, but that they may remain in a lethargic condition if deprived of water for a certain time only. The same naturalist observes that when an animalcule is frozen with the water, it is surrounded by an exceedingly small portion which is unfrozen, occasioned probably by the animal heat of its body; but, should the cold be so great as to freeze this, the creature dies. Animal heat in such an atom! how marvellous! Yet they will bear a great degree

of heat also. The same naturalist says, that the *Polygastrica* will bear the temperature *gradually* raised to 120° of Fahrenheit, and some even to 200°, but if raised *suddenly* they die at 140°. Now, if we consider that water raised to 212° is boiling, we shall be as much astonished at their powers of enduring heat, as cold. Sir James Ross, in his Antarctic Expedition, found upwards of seventy species of *Polygastrica* with *loricæ*, or siliceous shells, in fragments of ice.

It will, therefore, be seen, that animalcules are obtainable at all seasons, and in every place where there are ponds or pools of water; or they may be procured from water-butts, or by placing leaves, hay, or almost any vegetable substance in a little water, which has been previ-

ously found to have nothing living in it. It has, therefore, been proved, that after the first expense in the cost of a good microscope, and with proper care, so that no repairs are required, the amusement is cheaper than most others; never ending, and never failing in interest.

A few particulars of the formation, and peculiarities of structure, of these wonderful atoms, will now be entered upon.

In the first place, the variety of form is most astonishing, and strikes the observer perhaps more than any other peculiarity. They are of all imaginable shapes, and may be likened to many objects with which we are familiar,—as tops, trumpets, pincushions with pins in ready for use, telescopes, balls, leaves, sticks, threads,

bells, hollow spheres, &c.; there are also others like different kinds of fruit, flowers, fish, eels, and serpents; others, again, are egg-shaped, round, square, three-cornered, oval, spiral, spindle-shaped, star-shaped; besides some representing funnels, cylinders, flasks, and many having an apparatus which perfectly resembles a rapidly-turning wheel. Most of these forms will be noticed hereafter, when the genera and species are more minutely described.

Animalcules have either a soft naked body, or are covered with a kind of siliceous shell, or horny case, which is transparent, and varies much in form; in some instances nearly covering the

* "In some cases it is composed entirely of silica; in others, of lime, with a portion of oxide of iron."—*Pritchard.*

body, in others only forming a shield. This shell is called a *lorica*, and the term *loricated* is used to point out the species having a shell. None are supposed to have internal bones, but their muscles must be of the most complicated construction, to enable them to move easily and rapidly, which many of them do in an astonishing degree. One species (*Vorticella convallaria*) is attached to leaves and stalks, by a transparent thread of some length: this it has the power of suddenly contracting when danger threatens, so that the body is instantaneously removed to a distance. The muscles in this thread-like stalk are so contrived, that it assumes on these occasions a corkscrew or spiral form, and this action brings the body close to the leaf on which it is

fixed; after the lapse of an instant the creature gradually uncoils its stem, and is again employed in procuring food. The muscle that produces this motion (so rapid that it cannot be followed by the eye) is seen within the stalk, with a glass having the power of 250 diameters. There are many equally wonderful displays of muscular power to the one here described.

An eye, which is generally of a red colour, is very visible in some genera, but not to be discerned in others, and probably they are destitute of that organ. By some naturalists it is doubted whether these spots are eyes; but, as animalcules are evidently excited by light, it is more than probable: most of the *Rotatoria* possess them, some species even having three, and one genus

having seven or eight, on each side of the head; but they are less frequent in the first class, though, even there, many species have two and others one. How astonishing that so complicated a structure as the eye should exist in so very diminutive a creature!

Their organs of locomotion, or means of moving through the water, are as varied as their forms. The simplest method is by the aid of a proboscis, which seems to be useful both in obtaining food and in giving motion to the body, the creature using it as a kind of paddle, or oar; in some species there are two of these members. Others, again, have many short ones (called *cilia*) surrounding what may be termed the mouth, and by which they not only bring food to that

orifice by their rapid movement, which creates a current in the water, but the same action propels the body with wonderful speed, so that the eye can scarcely follow it. These cilia, when in motion, have the appearance, to the eye of the spectator, of a rapidly-revolving wheel, and this extraordinary effect is produced in the following way.—Each of these little thread-like members has a rotatory motion, the point describing part of a large circle, and the base (which is seated on a bulb) part of a small one; this motion, when all are seen in action at once, gives the appearance of a turning wheel, because the *apparent* revolution of the whole takes place in the same time as the real rotation of a single one. I know nothing more wonderful than this forma-

tion, and, indeed, it is one of the most interesting spectacles that can be observed by the aid of the microscope. It is supposed by some naturalists to be also the means of respiration. In some genera the cilia are not confined to the opening, but cover the whole body, and by this means they progress rapidly through the water, having a revolving motion, like that of a ball. Some have a gliding movement, similar to the snail or leech; others, again, have a foot, with which they catch hold of substances that come in their way. In many species, also, bristles are attached to the surface of the body, which may act as fins; and some kinds have appendages, curved at their extremities, and serving as hooks to attach the animal to sub-

stances on which it feeds. Some few are motionless, others revolve on the centre, or move by leaps, or undulations; and, in fact, they seem to use every kind of motion that can be conceived.

Infusoria increase more rapidly than other organized beings. In some of the modes of reproduction they resemble animals of a higher order of creation. Very many species lay eggs, which they attach to water-plants; others produce their young alive; but many increase by germs, or buds, growing from their own body, which are separated when sufficiently arrived at maturity; others, again, divide into two or more parts, and each becomes a new animalcule with equal powers. But, perhaps, the most extraordinary is the compound formation of the

Volvocina family, in which many individuals are enclosed in a transparent globe, where they have increased by self-division: as they grow in size the case enlarges also, but continues entire till they have arrived at maturity, when it bursts, and the inhabitants, as they may be called, are set at liberty, each forming in its turn a new globe, and again increasing by self-division. How wonderful are all these peculiarities in beings unseen by the naked eye! These facts must create an eager desire to witness these marvellous atoms ourselves; and those who have a taste for investigation in natural history, will here find ample scope for amusement.

It was formerly supposed that animalcules received their nourishment by absorption through

the skin, as in many kinds mouths could not be discovered; but by feeding them on coloured substances, an internal structure has been observed equally complicated with that of larger animals, and consisting of muscular and nervous systems, all wonderfully suited to their respective wants. As these creatures are for the most part transparent, the being enabled to feed them on coloured substances, such as indigo, sap-green, and carmine, has given naturalists the power of investigating the internal construction, which would have been impossible without this plan. The method is to place a very small portion of the carmine, well rubbed down with a little water, in a drop containing animalcules; they will immediately appear very active, and in a

few seconds the internal sacs will be filled with red colour, whilst the rest of the body will retain its original appearance. The cilia, proboscides, and other appendages will also be much more clearly perceived than without the assistance of the foreign substance. This experiment requires some nicety and care, and the new diet does not seem to injure the animalcules, for, as indigo and sap-green are vegetable, and carmine is an animal production, they probably do not find them disagreeable; but no metallic substance must be used.

It is a wonderful fact, that a drop of water exhibiting to the eye only a few particles of vegetation and sand, may, by the aid of a glass, be found to contain a crowd of animated beings, all beautifully and curiously constructed,

all enjoying life, and providing for their various wants—their beauty so great, that we can scarcely bear to lose sight of them by withdrawing the eye from the microscope; and yet that drop is as nothing in the scale of creation, and we wipe it away with hardly a thought of what it contains, intent on viewing fresh wonders in the next drop we may take up. The educated mind, however, knows that nothing is made in vain, and that even the minute beings under observation have had their influence in maintaining the purity of the water and atmosphere, and thus spreading around, benefits of which the uninstructed are perfectly ignorant.

This introduction will be concluded by a short

account of fossil Infusoria. A fossil animalcule! Is it possible that such minute and delicate bodies can be changed into, and preserved as, fossils? This is really the case, and the following extracts will prove the truth of this remark.—

Ehrenberg says, "The Infusoria, in consequence of their siliceous shells (*loricæ*), form indestructible earths, stone, and rocky masses. With lime and soda we can prepare glass out of invisible animalcules, use them as flints, probably prepare iron from them, and use the mountain-meal, composed of them, as food in hunger."

To prove this marvellous fact, the following interesting extracts are drawn from Pritchard's 'History of Infusoria':—

"The shell-like coverings (*loricæ*) are found in large masses, covering many miles of the earth's surface, and occur, when indurated and mixed with argillaceous and other earths, in the form of siliceous rock, slate, &c. These remains of the primeval inhabitants of our globe are records in the pages of history, penned by Infinite Truth, unbiassed by ignorance and prejudice; and form some of the first-fruits of the effective application of achromatic glasses in our microscopes." "It is hardly possible to take up and examine a dozen flints without discovering species of Infusoria enclosed within them. These may be seen under the microscope, when very thin sections are made."

As flint is used in the manufacture of glass,

the shells of these creatures are thus found coming into use, after the inhabitant has been dead thousands of years. Dr. Mantell remarks, in his 'Thoughts on a Pebble,'—"Investigation has shown that a great proportion of the mass of the (flinty) pebble, is actually composed of the aggregated fossil skeletons of animalcules, so minute as to elude our unassisted vision, but which the magic power of the microscope reveals to us, preserved, like flies in amber, in all their original sharpness of outline and delicacy of structure."

An extract from another author will prove that chalk abounds also in remains of Infusoria.—"Throughout the chalk beds there are layers of flint,—that is, masses of silex, or flint, of various sizes, from a pea to a man's head, each lying

detached amidst the chalk. Whence this great quantity of a substance, which seems to be characteristic of the chalk formation? The supposition is, that it has been derived mainly from siliceous coverings of animalcules! The remains of many of these minute and humble animals have been discovered in the chalk, some of them being the first animals which yet exist in the species upon earth. It has also been found that the flints invariably include the remains of some sponge, or other humble animal form, the lineaments of which are often beautifully preserved amidst the dark glassy substance, and may be detected by a microscope, if not by the naked eye. Now, if the silex from the coverings of the dead Infusoria, were in solution amidst the settling sub-

stance of the chalk, any decaying sponges, *Alcyonia*, sea-urchins, or other animals placed there, would be sure to collect the particles of the silex around them, and thus be converted into flints." * * * "We refer to beds of greater or less thickness, composed exclusively of the solid remains of animalcules—creatures individually so small, that only a microscope could enable human eyes to see them. Such a rock (called Tripoli) is found at Bilin, in Bohemia,* and at Planitz, in Saxony. It has been used as a powder in some of the arts, for ages, without any suspicion of its being thus composed. But within the last few years M. Ehrenberg, a

* The series of strata forming this polishing slate is about fourteen feet thick.

scientific Prussian, has fully ascertained that it consists simply and wholly of the siliceous coverings of certain minute creatures, some of which belonged to species still to be found in stagnant water. To common perception, the powder of which the rock may be said to consist resembles flour; and in Norway, where it is called Bergmehl (that is, mountain meal), it is actually used in times of famine as food; for which it is not entirely unsuitable, seeing that there is always a per-centage of animal matter left in it, in addition to the siliceous shields.* So extremely small are the creatures of which these rocks form the sepulchre, that, according to M. Ehren-

* Dr. Carpenter says, this earth contains a large proportion of animal matter,—about 80 per cent. of its weight.

berg's calculation, ten millions of millions of individuals might be required to fill the space of a cubic inch. Yet in the smallest of these creatures there have been found several stomachs, besides other organs; and minute as the coverings are, they are variously sculptured or marked, so as to form distinctions of species."

Here may be added, also, the remarks of other authors on this curious subject.—"In Swedish Lapland, under a bed of decayed mosses, forty miles from Degesfors, in Umea Lapmark, is found a stratum of this substance known there by the name of Bergmehl. When examined by the aid of the microscope, it is found to consist almost entirely of the remains of minute organisms. In seasons of scarcity this is made

use of in certain quantities mixed with flour in the manufacture of bread by the poor: not that it contains any nutriment (or, at all events, it possesses it in so small a quantity, as not to be able alone to support life), but on account of its serving to distend the stomach, and thus to prevent the unpleasant sensations attendant on an imperfectly-filled state of that organ." This substance seems also to be occasionally used in China, as is shown by the following statement published in 1839 by M. Laribe, a missionary:—"This earth is only used in seasons of great dearth. One of our Christians, who, at the period of the last famine, fed upon this substance, with five other individuals composing his family, informed me, that when they made use of it,

they bruised it into a very fine powder, mixing three parts with two of rice-powder, or, better, the flour of wheat, to make small cakes, which were seasoned with salt or sugar. Recourse was only had to this in times of great want; and that being over, no one ever dreamed of making use of it as an article of food. Those persons who employed the fossil flour without mixing it with vegetable meal, scarcely ever escaped death." "This mountain meal is principally composed of the flinty coverings of the *Navicula viridis*, *Gallionella sulcata*, and *Gomphonema gemmatum*, all of which are to be found in a living state."

Dr. Carpenter, in his interesting work entitled 'Principles of Physiology,' whilst speaking of fossil animalcules, says, "It is peculiarly inter-

esting to trace such occurrences in progress at the present time. The author has seen water, brought from a lake in the island of St. Vincent, crowded with the shields of races of *Naviculæ* which at present inhabit it; and the mud which is being deposited in abundance at the bottom of the lake, is almost entirely composed of them."

There can be few subjects more interesting to the thinking mind than these details of the living animalcule, and its fossil remains.

> "These viewless beings, to whom
> Each tiny drop is as an ample world, each day
> A life of ecstasy, fulfil their Maker's high behests,
> And, in obeying, find felicity."

An outline of the history, habits, and loca-

lities having now been given, an investigation of the scientific classification, and more lengthy details of the most interesting genera and species, will follow; the reader or student will then be enabled to understand the more learned works of Ehrenberg and Pritchard, whose volumes are so often quoted, and to whom these pages are indebted for many of the descriptions.

The object of this little book is not to treat scientifically of the minute forms mentioned, but only to induce the lover of nature to search into their curious history, and also to prepare the student for more learned works; the classification will not, therefore, be entered upon minutely—a short account only of the great classes into which they are divided will be sufficient. But it must first

be stated, that naturalists have some difficulty, in many cases, in determining whether the minute object under examination belongs to the animal or vegetable world. This appears very extraordinary, but when the following details have been read, and it is found that what seemed to be a plant, has within it certain granules which, when discharged, act like living beings, swimming about, having all the movements of animals, yet at last fixing themselves to a substance, and after a time assuming the appearance again of vegetation, it will be acknowledged that the subject is one of extreme difficulty. Professor Rymer Jones remarks, that the physiologist has many difficulties, "who endeavours to draw the boundary between these two great kingdoms of nature; for

so gradually and imperceptibly do their confines blend, that it is at present utterly out of his power to define exactly where vegetable existence ceases, and animal life begins."

In some of the fresh-water *Confervæ* which form the green slimy patches seen in ponds, the reproductive organs are the little green grains filling the transparent tubes of which the plant is composed. These, when ripe, leave the tubes, and have a very visible, and voluntary movement in the water, so like animal life, that they have in that state been taken for animalcules. But the *Conferva comoides*, growing on the coasts of Picardy and Normandy, and mentioned in a work entitled 'Observations sur les Limites qui séparent le règne végétal du règne animal,' is of

a very remarkable construction, and peculiarly interesting, proving how nearly connected are the two great classes of animals and vegetables. This little plant-like substance is seen at low water, attached to stones, and is in the form of a hair pencil, from half an inch to an inch in length, each thread being finer than a hair, and slightly branched, rounded and compressed: they contain a number of small yellowish bodies, which are first round, then oblong, afterwards more pointed at one end, which becomes transparent. They are packed very closely, but when the cell bursts, they move about in the water in the most amusing manner, and keep up a voluntary, incessant motion for a considerable time. They at last fall down in immense numbers on the stones, and

emit a globule of particles which is supposed to be their fry. This substance lengthens, and branches, and again forms long hair-like threads, similar to those from which it sprang. In the green ditch-laver (*Ulva bullata*, or *minima*), by the aid of the microscope, may be seen a number of green granules,—these, when separate and loose in the water, have a rapid movement, as if chasing each other. In time, two approach, and touch one another, then retreat, touch, and retreat again; then four combine to execute the same movement; and at last, the whole party thus grouped in fours, dance together in seeming confusion. After a time the motion ceases, and they form the new substance known as *Ulva*.*

* Lindley's Botany.

It will be easily imagined, therefore, from this marvellous account, how difficult it must have been to classify and arrange these little atoms, and, consequently, naturalists have differed greatly on the subject. The microscopist will be greatly struck with many minute green objects, of exquisite form, which will be seen lying quietly at the bottom of the water, having no movement, but greatly resembling a seed, or pod. These have been, and still are by some naturalists, supposed to be of an animal nature, from the movement of the granules contained in their substance, but by late writers they are considered vegetables. They will, however, be inserted here, not only from the interest they excite, but from their frequent occurrence in water in which ani-

malcules abound, so that the student may not be at a loss as to their nature when they are met with.

Infusoria are comprised under two great classes, *Polygastrica* and *Rotatoria*; the former being distinguished by appearing to have numerous vessels, or stomachs, for carrying on digestion, and the latter having but one. This is Ehrenberg's method of classifying them; and though Meyen and others think the vessels of the first class are not stomachs, the name must be retained until the fact is ascertained.

After some experience in viewing animalcules with a glass, their general form and outward appearance is sufficient to enable the observer to determine in which class to place them. The *Rotatoria* have usually a foot near the extremity

of the body, and rotatory organs affixed to the head: these, and their higher organization, render them in general distinguishable from the *Polygastrica*. Each of these classes is divided into many families, genera, and species, the different kinds amounting to nearly eight hundred well-ascertained species. This number will probably increase, as our microscopes are improved, and observers multiply. We can understand that the labours of microscopists must have been very great, when we consider the extreme difficulty of watching these minute productions. It frequently happens that a specimen is lost to view after only a very slight inspection, and perhaps another of the same kind is not met with again for days or weeks. I cannot describe the regret

I have felt when having to lose sight of a very interesting specimen, perhaps new to me at the time. After watching it for hours, a period must come when the drop containing it will either evaporate, or an additional drop or two must be mixed with it, and then the probability is that it may never be seen again. If very small, and not fixed to a leaf, this is most likely to happen. The movements of many are also so rapid, and the impossibility of touching them so great, that it is only wonderful we have such correct and minute accounts of these atoms, which are so completely invisible to the naked eye.

As these pages only aspire at being considered an introduction to an interesting study, I shall not enter on a scientific arrangement, further than

that of describing the objects I select in regular succession, according to Ehrenberg's classification, with the exception of the family *Bacillaria*, which I place first, as the species are now considered (at least, the greater part of them) to belong to the vegetable kingdom. I shall suppose four DROPS OF WATER to be under inspection at different times; and though it seldom happens that the objects I have depicted in each drop are found alone at any period, still I have thought this plan not an unnatural one, giving clearly some idea of classification, and preparing the way for more scientific works, when the subject is made a deeper study. The specimens contained in the First Drop are minute Algæ, and other objects nearly allied to them: they are found more particularly in

bog-water, and may be seen in great numbers together. Those contained in the Second Drop are polygastric, and are often found in prodigious numbers in spring, to the exclusion of others. The individuals of the family *Vorticellina* (also *Polygastrica*) will nearly occupy the Third Drop; and their beauty is so great, that they fully attract the attention when present in the field of the microscope. The Fourth Drop will be occupied by the class *Rotatoria*. By this means some of the most striking microscopical objects found in water will have been examined.

DROP I.

I HAVE mentioned in the introductory chapter, that many of the microscopic objects found in water are at present not sufficiently known, to enable naturalists to determine, *beyond dispute*, whether they belong to the animal or vegetable kingdom. Ehrenberg thinks, to the former belong all the genera I am about to describe in this section. Dr. Meyen is of opinion that many of these are decidedly vegetable; and others imagine that all may belong to the latter kingdom. By

botanists, some of them are placed among the minute Algæ; and if colour and general outward appearance alone are considered, connected with the fact, that in most cases they are immoveable, the young student will conclude that the botanist is nearer the truth than those who argue for their animal nature. Still, we must come to no hasty conclusion, for if the learned differ on the subject we must be content to wait for further information; and it is not unlikely that these minute and puzzling atoms may form the connecting link between the two kingdoms. Ehrenberg describes them as polygastric, the body having variable processes, and being covered by a *lorica*, or shell; as undergoing self-division, but most of them being connected together by a thread,

forming chains, or rounded groups. This imperfect division is similar to that described in the family *Vibrionia*, amongst animalcules. These facts caused Ehrenberg to conclude, after patient investigation, that they belong to the animal kingdom. Dr. Meyen, on the contrary, argues for their vegetable nature. The want of actual motion in most of them, is a great point in favour of his opinion; and, regarding the self-division, he affirms that it is very common in the lowest plants, as well as in some of the organs of the higher kinds. The green corpuscles seen within the *Desmidieæ* are similar to those found in the cells of the *Confervæ*, though Ehrenberg considers them as eggs. This group, therefore, may with great reason be looked upon as belonging

to the vegetable kingdom;* but another portion, termed the true *Bacillariæ*, and named *Naviculacea*, after the most interesting genus, have a greater resemblance to animal life, much more spontaneous movement, and currents are also frequently observed on the sides, as if minute cilia existed; still Dr. Meyen classes even these with plants, and observes that they are by no means so free and active as the spores of the Algæ. Notwithstanding some uncertainty respecting the true nature of this family, it is very interesting, and some species are possessed of great beauty.

* Mr. Ralfs's able work on British Desmidieæ appears to set the subject at rest, as regards this section of the family *Bacillaria*; for he particularly mentions that the presence of starch (peculiarly a vegetable production) may be detected in the atoms composing it, by the application of tincture of *iodine*, which turns them of a violet or blue colour.

The first section, the *Desmidieæ*, are a family of microscopic Algæ, distinguished, like most other plants, by their green colour; they are formed of vessels or cells containing a green substance. These cells, or joints, separate either completely or only partially, some genera forming long filaments, by the union of many cells, and others are seen generally only in pairs. I shall describe a few of the most singular in appearance, and those most commonly found.

The genus *Desmidium* is seen as a long, pale green filament, formed of many cells. There are two species. *Desmidium Swartzii* (Plate I. fig. 1) has three edges, forming a triangle when viewed transversely; when many cells are connected together, and the filament is lying

longitudinally under the eye of the observer, a dark line is seen to cross alternately from one side to the other—this is caused by the twisted form of the filament, and the line is the third corner of the triangle. It separates into single joints or cells, and then shows its triangular shape, with the green substance within forming a star of three points. This is a species of common occurrence. *Desmidium quadrangulatum* is more rare, and only seems to differ from the last in the number of sides. There are other genera of these thread-like Algæ, but this is the most striking.

The genus *Micrasterias* contains many singular forms; they are more or less round, and flat, deeply divided into two lobed segments, or cells, and notched or cleft at the edges, some-

times even rayed; the colour is green, but with the edges or rays transparent, forming beautiful objects for the microscope. They will be viewed with great interest, and are so large as to be visible to the eye without the aid of a glass, but only as a small green dot. The mode of increase is very remarkable:—the two segments are united by a narrow band or tube, and this produces two new minute segments, which gradually increase, and separate the two original portions; the young acquire colour, and soon look like the old ones; then the latter are entirely separated, each taking one of the newer formations with it. This singular process is constantly being repeated. *Micrasterias denticulata* (Drop I. fig. 2) is one of the most common found in bog-water: it is

very prettily denticulated at the margin, besides the deeper divisions; and the white edge, and bright green centre, are strikingly beautiful. *M. crenata* is smaller, and less denticulated. *M. rotata* is large, and with two of the divisions cut in a curved line. There are several other species, but they are rare.

Euastrum somewhat resembles the last genus, but the species are more oblong in form, and have circular protuberances on the surface. They are attractive, also, from their size. *Euastrum oblongum* (Drop I. fig. 3) is common in pools: the form of it is much longer than broad, with five or six prominences. *Euastrum insigne* is smaller, has the segments inflated at the base, and tapering into the form of a neck, with the end a little

dilated; the prominences are arranged two on each segment. There are more than a dozen species of this genus known.

In the genus *Cosmarium* the segments are more or less round, and neither dentated nor rayed at the edge. *Cosmarium margaritiferum* (Drop I. fig. 4) is rather abundant; there are more than thirty species known.

Xanthidium greatly resembles the last, but is armed with spines, and has a circular projection near the centre of each segment. *Xanthidium armatum* (Drop I. fig. 5) has short thick spines, placed in pairs round the edge of each segment, each spine having several points, and occasionally some scattered on the disc. This species is often found in masses, floating in the water of shallow

pools. *Xanthidium aculeatum* has the spines simple, shaped like a horn, and numerous; other species have them longer, and but few in number.

The genus *Arthrodesmus* has the segments entire, with a single spine on each side; the two segments, joined by a very narrow band, are broader than long, and smooth. There are often four united together. *Arthrodesmus convergens* (Drop I. fig. 6) has the spines of its segments curved towards each other. *A. incus* has the spines diverging outwardly, and the ends truncated.

The genus *Staurastrum* has a great variety of species, amounting to about forty. They are mostly of minute size, and differ but slightly at

first view from the last genus. The segments are broader than long, and in many species elongated into a process. This is of a more angular form than *Arthrodesmus*. *S. cuspidatum* (Drop I. fig. 7) will serve as an example.

Closterium is a very interesting and striking genus. Many of the species are large, and all of a deep green colour; the form also is very graceful, the two valves are elongated, narrow, curved, and often of the form of a crescent, the union of the two being marked in the middle by a pale line, but there is no constriction there, as in the former genera, and there are neither spines, nor prominences of any kind. In some species there are lighter green dots arranged down the length, or scattered about, and in most may be perceived,

near the ends, with a high magnifying power, a transparent spot, containing minute granules in constant motion. Some species are smooth, others striated—but this is rarely seen, excepting when the case is emptied of its green matter. The method of increase is very similar to that described in other genera, but differs in some degree. The pale line in the centre becomes double, the intermediate portion gradually increases, and then another transverse line becomes visible in its centre; when mature, complete separation takes place there, and two *Closteria* are formed. The species are above twenty. *C. acerosum* (Drop I. fig. 8) is a very pretty object, bright green, and very slender in form; *C. moniliferum* rather crescent-shaped, with a

line of transparent dots down the middle; *C. Dianæ* (Drop I. fig. 9) is quite crescent-shaped, small and slender; *C. setaceum* (Drop I. fig. 10) is perhaps the most beautiful—it is very slender in the centre, the ends tapering into long beaks, and rather curved, which give it an elegant form. These specimens will be sufficient to make the reader or microscopist familiar with the genus.

Spirotænia greatly resembles *Closterium* in size and general form, but is easily distinguished by the green matter forming a spiral line from one extremity to the other; there is no mark of division in the centre, and the ends are round.

Occasionally may be seen very minute bundles of green objects, like little faggots;—these

belong to the genus *Ankistrodesmus*, and there is but one species, *falcatus*.

The next genus, *Pediastrum*, is composed of many species, all being more or less like a star; they are formed of several little cells, four or more united together either in a single or double circle: they are very curious, and soon attract notice. I shall only give two species, which I have myself seen repeatedly—*P. pertusum* (Drop I. fig. 11) and *P. Napoleonis* (Drop I. fig. 12): the figures show their extraordinary forms more clearly than any words.

Scenedesmus comprises little objects composed of from two to ten minute cells, arranged in a row, instead of in a circle, as in the last genus. *S. quadricaudata* (Drop I. fig. 13) is common.

This slight sketch of the *Desmidieæ* will suffice to call the attention to an interesting and wonderful family of minute objects, only discernible by the microscope, and therefore unknown to the greater number even of those who interest themselves in botany. If this brief account should excite the curiosity of the lovers of nature to make deeper researches, the valuable work by Mr. Ralfs is recommended as the most useful to assist the student;—much information has been derived from it for these pages.

Naviculacea.—I shall not again repeat the opinions of naturalists, or the disputes as to the nature of this branch of the family *Bacillaria*, but merely name the most interesting of the genera. *Navicula* is so called from its shape, all

the individuals being more or less in the form of a little boat,—and their quiet gliding motion increases the resemblance. The bright colours, or delicate transparent appearance of the lorica, make these little objects also very attractive; and I have watched a number of them moving in different directions with great pleasure, for their pace is so slow and gentle that all their habits may be noted. They appear to me to have decidedly a will of their own, and to avoid dangers or obstacles in their path, just as many of those animalcules do which are decidedly considered as belonging to the animal kingdom; and yet, as Dr. Meyen says they are by no means so free and active as the spores of the Algæ, we are again puzzled. When watched with attention,

they are found to glide slowly along at the bottom of the water, in a straight line, though occasionally a little slightly zigzag, as if to avoid the roughness of the glass; then, when anything obstructs their path, they do not go round it, but immediately turn back on almost the same track, without turning the body, and this motion I have seen a specimen keep up for some time: a little tap on the glass will arrest their progress, and then they immediately reverse their motion. When, however, they meet with a substance which may afford them food, they stop, and either glide under or about it. They appear to have cilia at the sides, for I have often observed small substances propelled along the body of the creature, and even running backwards and forwards several

times, as if the *Navicula* might be extracting food from it. I do not know a prettier sight for the observer, than a drop of water containing several of these curious little creatures of different colours and shapes, gliding in various directions, and all actively engaged in their pursuits. Ehrenberg describes about forty species, some found in salt water, some in fresh, and others fossil. They are seen single, and in pairs, but never in chains, or bands, like the rest of this division of the family. They are generally broader in the middle than at the ends: some have the two ends very sharp, others are more blunt, and one or two are more round than long; a few have the ends curved different ways. Some are green, some brown or red, and others almost

transparent; a few, also, are of a golden yellow. *N. viridis* (Drop I. fig. 14), *N. amphisbæna* (fig. 15), and *N. acus* (fig. 16), are frequently seen.

The genus *Bacillaria*, from which the family derives its name, is composed of bodies of singular construction. They seem originally to form connected lines, but, when mature, separate generally only in part, forming zigzag chains: in this state they move slightly, and one marine species, *B. paradoxa*, when separated from its companions, moves quickly like a *Navicula*. *B. vulgaris* (Drop I. fig. 17) is by many botanists looked upon as a vegetable, and named *Diatoma flocculosum*: it is found both in fresh and salt water, and has a straight lorica three or four times as long as broad; and when seen sideways it is in

the form of a spindle. *B. cuneata* (Drop I. fig. 18) is of wonderful construction—each individual is wedge-shaped, and they still preserve the straight ribbon or chain-like form, by being placed alternately the broad and narrow end together. These chains of the *Bacillaria* are free and floating; as well as those of the next genus, *Fragilaria*, specimens of which are frequently seen to rise in the water, and turn round; the individuals also, when separated, move forward gently. They may be distinguished from *Navicula* by being square at the ends, instead of pointed, and having two openings instead of one. In *F. grandis* there are as many as thirty individuals found linked together. *F. rhabdosoma* (Drop I. fig. 19) is very slender, and the bands

drop to pieces very easily, and then the individuals creep about. The last genus of this division is *Meridion,* the separate individuals of which are wedge-shaped, but, unlike the *Bacillaria cuneata* mentioned above, they are arranged with all the small ends placed together, so that the band is not straight, but forms a spiral, if many are linked together; if there are but few, then a circle, or part of a circle, may be formed: *M. vernale* is the species usually seen. How marvellous are all these variations, when we consider the minute size of the objects!

The next section of the *Bacillaria* family is called *Echinellea,* and the genera are distinguished from those of the other divisions, by being attached at one extremity to weeds, &c.

They may be seen of various forms, some single, others in groups; some long and narrow, others wedge-shaped, and occasionally they grow one on the other. The individuals of one genus, *Gomphonema*, form quite a little tree: each one is wedge-shaped, and at certain periods becomes detached, and creeps about, but it is not known whether it forms another stalk; it is found attached to *Lemna*. Those of the genus *Echinella* form a cluster like a fan, and this is caused by the body dividing, but not the stalk, so that the individuals, being wedge-shaped, as they lie side by side, have a fan-like form. These are principally found in the sea, attached to sea-weeds and mollusca; but two are found in fresh water.

The fourth section consists of curious little

bodies, found principally in the sea, and too complicated to admit of description here; but I must mention the genus *Acineta*, which has been added to the *Bacillariæ*. It may be frequently noticed on the stalks of *Lemna*, and, being extremely pretty, shall be described. The body is affixed by a short stalk, is small, and round or bell-shaped, with numerous rays projecting from it in various directions, each appearing to have a slight knob at the end; these rays do not vibrate, but are said to be retractile. This I have not observed, for I never could trace movement in any part of this singular little being. It is nearly transparent, very small, and may be almost compared to a pin-cushion with pins in it ready for use, as the knobbed rays

are of some length. In *Acineta mystacina* these rays are arranged in two bundles; in *A. tuberosa* they are fewer in number. This little object shows the amusing variety of forms found in this minute portion of the creation; and though the specimens seen in this drop of water are some of them of an uncertain character, they have yet considerable beauty and interest, and will not fail to reward the student who diligently searches for them.

DROP II.

It has been remarked before, that the class *Polygastrica* derives its name from the globular vessels, seen through the transparent body of the animalcule, being supposed to be numerous digestive sacs.* In forty-eight species, eyes are perceptible, and the colour is red, with the exception of one species, in which it is black. They have no feet, but their locomotive organs consist of vibratory cilia, which are in constant rapid

* The name is from two Greek words, signifying *many stomachs.*

1. [illegible]
2. Dix[illegible] [illegible].
3. Trochilomonas [illegible].
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]
10. Euglena [illegible].
11. [illegible]
12. [illegible]

motion, and by which they move in various ways, some gliding slowly, others rapidly, some again darting from place to place, and many having a rolling motion: indeed, their modes of progression are almost as various as their forms. The methods of reproduction are principally three:—by eggs, which is the most common; by self-division of the body; and by the growth of buds, or gemmules, upon the parent. They increase at a most rapid rate, by each of these methods. I have watched the self-division frequently, and more particularly in the *Vorticella convallaria*, as that interesting animalcule is attached to weeds, so that its movements can be noted with great certainty. I shall describe the process when I more particularly mention that species. There

are as many genera loricated as illoricated in this class. The *Polygastrica* are found in all parts of the world, both in fresh and in salt water.

The first family into which this class is divided is named *Monadina*, containing creatures of the most minute forms, and only interesting to the unscientific observer on that account; most of the individuals requiring very patient investigation, and high magnifying powers, before their movements and habits can be sufficiently understood to be minutely described. It has been discovered, however, that some of the genera possess eyes, and most of them cilia; some only have a proboscis, and others again a tail; none are enclosed in a lorica, and they increase by self-division into two or four parts, each becoming a perfect individual.

The genus *Monas* is represented in Drop II. by the species *M. crepusculum* (fig. 1), and is curious as being the smallest of known living beings. It feeds on decaying substances, and may be observed in considerable numbers, as a minute colourless speck, moving very rapidly, by the aid of a proboscis, and enjoying its transitory life in the society of its kind. Another species is of a deep red, and abounds in salt-marshes on the shores of the Mediterranean, to which it imparts a red colour. The *M. crepusculum* cannot be seen without the aid of a glass magnifying 300 diameters.

The individuals of the genus *Uvella* cluster together so as to form a mass like a mulberry. The species *U. glaucoma* is found in stagnant water. Ehrenberg was able to see, within the

body of this minute creature, some green Monads which it had eaten, and by which it was proved not to be herbivorous. With a magnifying power of 800, eggs may be discerned. The genus *Polytoma* abounds in water where animal matter is found. It has a double whip-shaped proboscis; as the body increases in size, it has a wrinkled appearance, and at last self-divides into numerous individuals. *Polytoma uvella* is the only species: it is colourless and of an oblong form. *Microglena* is characterized as being the first to possess an eye—in other respects it resembles the *Monad*: it is found amongst slimy water-plants. A great portion of the green matter found on stagnant water is formed by individuals of the genus *Glenomorum*; they cluster

occasionally, and possess a single red eye, and a double hair-like proboscis. *G. tingens* is oblong, of a beautiful green colour, and the proboscis is only half the length of its body. *Doxococcus ruber* (Drop II. fig. 2) is a pretty lively little animalcule, having a peculiar rolling motion; of globular form, and possessing neither tail nor eye; the colour is a brownish-red; *D. pulvisculus* is green; and *D. inequalis*, irregularly round, transparent, and covered with green spots. These interesting little creatures will be readily distinguished by their globular form, bright colours, and singular motion, and add greatly to the beauty of the animated scene, which they often diversify. Occasionally they are found in considerable numbers, and then they appear to keep

up a merry dance amongst themselves, advancing and retreating, or gliding past each other with the most graceful movements. These are the most interesting genera of the family *Monadina*.

The family *Cryptomonadina* is distinguished by the individuals having a *lorica*, or shell, which in some is found to be indestructible by fire. It is either of a box or pitcher shape, and the animals sometimes have more than one proboscis.

The first genus, *Cryptomonas*, has some of the individuals green, others brown, and they may be known from the genus *Doxococcus* by observing that when the little creature is stopped in its rotatory motion by anything in its path, it leaps back suddenly. The individuals of the genus *Prorocentrum* are only found in the sea, and help

to form the luminous appearance which is so frequently observed in the ocean. How marvellous that these little atoms, which require a magnifying power of 300, to be discerned, should produce this extraordinary light! The lorica of the only species, *P. micans*, is pointed at the extremity, oval in shape, and compressed. The creature has no eye, but a proboscis, and cells can be seen in the interior of the body. It is of a yellowish waxy colour, similar to all the luminous Infusoria. *Lagenella euchlora* has a lorica shaped like a bottle with a neck, and is of a beautiful green colour, but quite clear, and having a bright red eye. It is found in fresh water, with Conferva. *Cryptoglena conica* has a shield-like lorica, which folds inwardly at the sides, two proboscides, and

an eye, and is of a bright green colour: it moves briskly, but springs back when obstructed. *Trachelomonas volvocina* (Drop II. fig. 3) is distinguished by the lorica being spherical, and the proboscis very long and slender; it is green or brown, but has a red ring on the circumference, which is seen whichever way it turns. Another, *T. cylindrica*, is of a beautiful green, with a purple circle and red eye.

The family *Volvocina* contains many very wonderful genera and species, equalled by none among these minute creatures. They are of a compound form, and live as it were in masses. This is caused by their method of self-division, which takes place, not by the body simply dividing into two, but into many parts, and each

of these parts seeming to form a perfect individual though joined to the rest, and all enclosed in a transparent envelope, which expands in size as the individuals approach maturity, and at last opening sets them all at liberty. This marvellous structure will be described under each genus, as they differ in form and construction.

The first genus, *Gyges*, consists of very inactive creatures: very slight motion of the body only has been perceived, and they are, therefore, not so interesting as many others. The lorica is transparent, and the enclosed parts of a green colour.

The genus *Pandorina* is one of the most beautiful for observation by the microscopist. The transparent globular body encloses numerous rather dark green animalcules, each pro-

vided with a proboscis about twice the length of the body, protruding from the circumference of the globe, and busily engaged in moving the mass, and at the same time gaining food. The whole has much the appearance of a mulberry, whence the name of the English species, *P. morum* (Drop II. fig. 4), which is found amongst Conferva and Lemna. The regular rolling motion of this beautiful creature adds greatly to the delight of the spectator: this movement is not very rapid, so that it can be watched with ease. I once witnessed the disruption of the transparent case, and the escape of the numerous individuals: some of these had already the wrinkled appearance produced by the preparation for self-division. The globe, as I watched it, seemed to have lost its

rigidity, and each individual was busily engaged in working its way out. I was first attracted by seeing the mass lying without motion, except that the green bodies within were moving rapidly, and by degrees each made its escape after some exertion, and swam away. It was a curious and interesting sight.

Though not surpassing the last in beauty, the genus *Gonium* is highly interesting, from its surprising form and construction. It is compound, and consists of sixteen individuals, each of a round form, having two proboscides, and six cords or tubes which connect it with those surrounding it; the lorica is transparent, and the sixteen individuals are arranged in regular order, four in the centre and three on each side, re-

sembling "the jewels in the breast-plate of the Jewish high priest." The colour is bright green, so that both form and colour contribute to the beauty of the whole. The four central individuals are generally larger than their external companions, and sometimes the clusters appear irregular, from some of the individuals having arrived at maturity, and become separated from the rest. If they are all of the same size, the cluster is seen to divide into four, each having four of the animalcules, and these again form fresh clusters like the original. I have two or three times observed that one of the individuals, before disconnecting itself from the rest, had divided into sixteen distinct bodies, forming a perfect compound mass, though the size was extremely minute.

When swimming gently in the water, they occasionally turn on the edge, when it will be clearly seen that the individuals are arranged on a plane. This structure is highly wonderful, and is a proof of the extraordinary variety displayed in the works of nature. The species I have described, *G. pectorale* (Drop II. fig. 5), is found in clear water both salt and fresh: it is abundant in some waters both in spring and autumn;—in water procured in October I have seen them swarm in great numbers, and of all sizes. It is a beautiful sight to watch the quick movement of perhaps a dozen specimens at once in the field of the microscope. There are four other species differing slightly from the above, but one, *G. glaucum*, has as many as sixty-four animalcules within its lorica.

The genus *Syncrypta* is distinguished by having two loricas, one small one to each individual, and the other common to the whole cluster, enclosing them in its transparent folds. The long proboscis of each protrudes from the envelope, and gives the globe the appearance of being covered with hairs; neither an eye nor tail has been perceived. There is one species only, *S. volvox*: the shape of the individuals is oval, and of a green colour, with whitish rays in the centre, forming a pretty berry-like cluster when united.

The beautiful creatures composing the genus *Synura* are met with in clear waters containing Lemna, often in prodigious numbers, so that the field of the microscope will exhibit six or eight at once, all rolling about with the greatest ease and

apparent enjoyment. Now and then they stop at a portion of decaying vegetation, and appear to be taking a slight repast, but as the mass forms a ball, how each individual comes equally into contact with the food is difficult to determine; it is probable, however, that the principal part of their sustenance is floating in the water, and therefore they procure it even when moving. The whole cluster seems to be moved as with one mind, for I have watched them repeatedly, and they move and turn as if all was under the direction of one individual, and yet they are a compound mass, formed of very many animalcules. Each has an oblong yellowish body with a tail, which is attached to the bottom of a cell in the general envelope. Into these compartments they

can withdraw, and can also stretch themselves out to a considerable length when actively employed. *S. uvella* (Drop II. fig. 6), the only species, has the form of a mulberry, and I have watched the individuals when arrived at maturity separating from each other, and at last leaving nothing but the shrivelled remains of their former habitation: it is a most interesting genus, and is fortunately not scarce. To show what astonishing powers these little creatures possess, I will relate a circumstance I witnessed. A large cluster had evidently been injured by pressure, so that half of its members appeared to be mis-shapen and dead. The living end was actively employed in turning round, and for some time I could not comprehend what this action denoted;

but at last, to my surprise, I found it had twisted itself off from the rest, and it soon swam away, presenting the appearance of a perfect cluster. The mutilated part left behind remained quite still, though I watched it for some time, and I have no doubt the members were dead.

Each animalcule of the cluster, in the genus *Uroglena*, has an oblong yellow body, an eye and a tail: by the latter it is fixed to its own particular envelope, and it radiates from the centre. The common globe-like lorica, or mantle, covers them all, but the proboscis projects beyond, and gives the appearance of hairs in constant motion. *U. volvox* is the only species, and is found in turf-water.

The only species of the genus *Eudorina* is

E. elegans (Drop II. fig. 7), and it deserves its name, for there can scarcely be imagined a more elegant creature. It seems to have a property different from the other members of this family—that of casting off the globular lorica, and forming a new one; probably it has not the power of expanding to suit the growth of the congregated animalcules within it; self-division taking place whilst the clustered portion is retained. The individuals have no tail, but possess a sparkling red eye, and a vibratory proboscis: the body is green, from about fifteen to fifty of these little creatures are assembled under the same transparent covering, presenting a most beautiful appearance. They are often in great numbers, but so exceedingly delicate, that it is difficult to preserve

them for any time; Pritchard says, that "whenever it is attempted to retain them in large quantities, the second day will generally exhibit a thick mass of dead ones at the bottom of the vessel. When a few only remain alive, if the water be poured away, and the creatures removed into a vessel of clear water, they will live for weeks." They are most abundant in the spring of the year.

A green matter is often observed on ponds and other places, which at a first glance might be taken for a minute weed in great quantities, but if examined with care, it will be found entirely formed of the animalcule belonging to the genus *Chlamidomonas pulvisculus*, so named from its forming a dust-like stratum on the surface. They are often in vast quantities, and when they

die, the bodies float, and give the surface of the water a green coating. They are compound, like the rest of the family, but there are never more than eight individuals in the lorica. Each has a beautiful red eye, which is seen even after death, and a double proboscis, but no tail.

Sphærosira volvox is the only species of the next genus. It is distinguished by possessing a pale green globular body, an eye, and a single proboscis, but no tail. It divides in an irregular manner, within the large transparent globe which covers the whole; for it is often found, that some of the young are simple, others already in clusters, and some oblong. They are found generally in clear water, or turf-water, and are often as large as those of

the next genus, from which they differ principally by having a single proboscis.

The *Volvox* is one of the most lovely of these interesting atoms, and attains comparatively so large a size, that its construction is easily discerned, and in the spring may be found in clear water in great numbers, having a rolling motion, slow and very graceful. The hollow transparent globe contains some hundreds of single animalcules, attached to the inner surface, each of a small size and green colour, having a red eye and a double proboscis, which they protrude through an opening in the lorica, so as to give its surface the appearance of being covered with moving hairs. The shell of each individual is in the form of a bell, and it is said they have the

power of leaving it when full grown, though they are attached to each other by six cords, or tubes. Besides these numerous minute creatures, the globe often contains many globes like itself, of a small size and green colour. Sometimes as many as eight may be observed. The species *V. globator* (Drop II. fig. 8) is the most common, and is found in the spring and summer in shallow pools of clear water: the largest globes measure $\frac{1}{30}$ of an inch, and the smallest about $\frac{1}{350}$; *Volvox aureus* has the enclosed globes of a golden colour, and the individuals green; and *V. stellatus*, as the name implies, has the animalcules of an angular shape, and the young globes contained in the large one, are stellated also.

Very little is known of the organization of the

family *Vibrionia*, for the minute beings which form it are very difficult to examine, on account of their small size, many of them being invisible to microscopes of low power. If it were not for the circumstance of their linking together, so as to form threads, they would escape our observation. Sometimes two or three individuals only, form the chain or thread, at others a greater number, and from this circumstance it is supposed that they are originally separate, and only join together for mutual support, or that it is caused by the imperfect method of self-division. One genus, *Bacterium*, has a tremulous motion, but looks like a very fine stiff thread: it requires a power of more than 500, to see the individuals of which it consists. The genus *Vibrio* is more

flexible, and the chains move like a snake: I have seen vast numbers in water, in which a few leaves had been steeped. In another genus, *Spirillum*, the threads resemble a corkscrew, and have a brisk, lively motion; they are found in stagnant water. Some other genera are too obscure to mention.

The family *Astasiæa* has the power of changing the form of the body at pleasure. The eye, in all the genera, is very conspicuous, excepting in the genus *Astasia*, in which the species have no eyes. *A. hæmatodes* (Drop II. fig. 9) contracts and dilates itself in a curious way; it is first green, and afterwards becomes of a blood-red colour. Even these little creatures have been a cause of terror to the superstitious, for they in-

crease at an astonishing rate, and, assuming a blood-red colour, give a tinge to waters, for which the ignorant cannot account. It has a spindle-shaped body. *A. pusilla* occurs in myriads, so as to form occasionally quite a stratum on the surface of the water: it has no colour. *A. nivalis* is found in snow in Switzerland.

Most of the species of the genus *Euglena* are beautiful objects, the bright colours rendering them very attractive. *E. sanguinea* (Drop II. fig. 10) is of a spindle shape, the head rounded, tail short, proboscis long: the colour varies—some may be found quite green, which seem to be the young ones, others mixed red and green, and others quite red. *E. viridis* is green, except the head and tail—these are white,

and the eye is red. I have seen this species in such numbers, that there appeared a perfect swarm, though the water was obtained as late in the year as October, their elegant form and bright colours rendering it a beautiful sight. *E. pyrum* is dark green, pear-shaped, and swims rather swiftly. *E. pleuronectes* is like a small green leaf with a short stalk: it is flat. *E. longicauda* has the power of twisting its body into a spiral form, and is also somewhat leaf-shaped. This is an elegant animalcule, the form very curious, and the colour sparkling green; the tail is as long as the body, and, though colourless, is very conspicuous. When two or three are moving gently near each other, they form a very pretty scene. *E. acus* has a slender body, with

a pointed tail; the head and tail have no colour, but the body is bright green, and the eye brilliant red; it is a beautiful species, not only from its bright colours, but from the elegance of its form, and its mode of swimming; when stationary, it frequently changes its shape. There are several other species, but those mentioned are the most common: I have found them all in pond-water.

A little creature, attaching itself to other bodies by a foot-stalk, and frequently found on *Rotatoria* and the crustaceous creatures allied to the water-flea, is called *Colacium.* I have seen it covering the stalks of the *Vorticella convallaria,* so as to give the whole the appearance of a minute branch of green leaves. The species

C. vesiculosum has a very short foot-stalk, the body bright green, and of an oval form; currents are seen near the fore part of the body, when coloured particles are introduced into the water, so that there is, probably, a vibratory proboscis. *C. stentorinum* is more cylindrical in form.

The genus *Distigma* is formed of individuals which neither swim nor produce currents, but they creep at the bottom of water, and change their form in a curious manner: they appear to have delicate black eyes. *D. tenax* is the largest, and it contracts and dilates very visibly; the colour is yellowish. *D. viride* has green granules within. Both are found amongst Lemna and Conferva.

The family *Dinobryonia* differs from the last in

having a lorica, which has the form of a little pitcher; the body still retains the power of changing its shape at will. One genus, *Dinobryon*, possesses more beauty than many others among these interesting creatures. *D. sertularia* (Drop II. fig. 11) is more like the flowering spike of some grasses than anything else to which I can compare it, except, perhaps, a branch of coral: the little creature resembles the *Euglena*, mentioned before, but is of a pale yellow, and has the power of stretching itself out, and also assuming a globular form within its lorica. It has a red eye, and a long proboscis which assists not only in propelling itself through the water, but also the others to which it is attached. Each individual lorica seems to have sprouted from the one below, till

at last there is formed quite a little spike, or shrub, of these delicate loricas, and the elegant inhabitant. It is so extremely transparent that it requires very nice adjustment of both instrument and light, to see it well;—it is lost sight of by the smallest alteration of the focus, but, when fully seen, is an exquisite object. It is not attached, but moves slowly in the water, turning gently round. I have occasionally met with bog-water abounding in this delicate creature: the groups differ in size, some having only two or three collected together, others formed of a dozen, and then nothing can exceed the beauty of this compound mass. It is found principally in the spring.

The family *Amœbæa* consists of one genus,

Amœba. This singular animalcule has neither foot, eye, nor proboscis; it appears like a transparent bladder, and has the power of putting out at all parts of the body processes which help it to creep slowly—these it contracts and dilates continually, so that it is constantly changing its form; this renders all the species very interesting objects for the microscope. *A. princeps* (Drop II. fig. 12) is of a pale yellow colour, and its manner of progression is very amusing to watch. It puts out a portion of its body which appears quite transparent for an instant, and then the granules with which the body is full, run forward into it and fill it; at the same time other portions undergo the same extension, and thus it moves slowly along. The protruded parts

of the body do not seem to be always the same, but to arise from any part at the will of this singular creature. *A. verrucosa* is smaller, and with shorter and more blunt processes. *A. diffluens* has no colour, and *A. radiosa* expands its processes in the form of a star, though when at rest it looks like a lump of jelly.

The family *Arcellina* differs from the last in having a lorica of a pitcher- or dish-shape, and moves by the soft processes protruded beyond it. The first genus is *Difflugia,* which has the processes cleft into several parts, and the body enclosed in an opake lorica. *D. proteiformis* (Drop II. fig. 13) is of a globular or oval form, the lorica encrusted with minute grains of sand: the transparent processes are often as many as ten in

number; it is found amongst Conferva, as well as the next genus, *Arcella*, which differs in form, being flatter, and the surface not covered with sand. *A. aculeata* has spines upon its surface, and a large opening. *A. vulgaris* has the lorica round, and covered with rows of minute granules, and *A. dentata* is of a hemispherical form, and has the margin dentated. The last genus of this family, *Cyphidium*, has only one dilated process; the lorica is pitcher-shaped, with protuberances upon it, which give it a square form: the process by which it moves may be termed a foot, and resembles the body of the genus *Amœba*. *Cyphidium aureolum* is the only species.

DROP III.

The objects contained in the drop under consideration are of a different character to those in the last. Many of them have very lively movements, others are attached, but at the same time full of life and motion. One family, the *Vorticellina*, will be found highly interesting, and, most of them being fixed to weeds, they are more easily examined than many others. Two small and insignificant families are arranged before it in the classification. The family


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Cyclidina contains animalcules having no lorica and no eyes; bristles, or cilia, are the organs used in locomotion. The genus *Cyclidium* has a compressed body, and the cilia are placed in a single circular row. *C. glaucoma* is abundant in the spring, and may be known by its oblong body, the ring of cilia, and its peculiar movement, which is generally quick; but frequently the little creature stops, and then springs suddenly to another spot, with a light, graceful motion. The family *Peridinæa* possesses a lorica, and probably eyes, and the cilia are in the form of a crown. Some of the genera have a delicate proboscis, in addition to the cilia; they are, however, insignificant in size, and I shall pass them over, to give more space to the next family.

The individuals of the family *Vorticellina* form one of the most interesting groups. Some are free, others are attached either singly or many together, forming little tree-like masses, where each individual may be likened to a leaf: this is caused by their imperfect self-division. They have no lorica, but numerous cilia arranged in various ways—in some genera they cover the body all over, and in others they merely surround the mouth, or form a wreath. Eyes have not been observed, but they have some quick mode of knowing when danger approaches, and shun it very rapidly. The mode of increase is by self-division, either by the body completely dividing into two separate individuals, and becoming perfectly independent of each other, or by the body

dividing, but the two remaining attached by a stalk; they also increase by buds issuing from the sides of the parent body.

The first genus of this wonderful family is called *Stentor*; the animalcules are free, in the form of a trumpet, and of considerable size, as they may be seen without a microscope, floating as specks in the water. I have found the black species so numerous in some waters as to give the appearance of a black powder having been spilled on the surface. All the species are active, lively creatures, and extremely amusing to watch. They adhere, when feeding, by the pointed extremity of the body to a leaf or stalk, and stretch themselves into the form of a trumpet, expanding at the larger end where the mouth lies, and

where a wreath of large cilia are in constant vibration, enabling them to draw within the body the food they require: this consists of Monads, and various little creatures; and as most of the species are transparent, the digestive cells may be plainly seen filling gradually with these unfortunate little beings. *Stentors* increase by self-division longitudinally, and also by eggs. *S. Müller*i is white, transparent, and large. *S. Roeselii* (Drop III. fig. 1) is equal in size, but rather more yellow in colour. They both contract, when swimming, into the form of an oblong ball, but when fixed, stretch out considerably; when two or three are attached near each other, and all have their mouth-cilia at work, the current they form in the water is quite extraordinary,

and very interesting: small cilia cover the whole of the body. *S. polymorphus* has green masses within, supposed to be eggs. *S. igneus* is yellow, or rather red, and is smaller than the rest. *S. niger* is very dark in colour, and does not stretch out to so complete a trumpet-shape as the rest: it swims rapidly, and is very abundant in the spring, making the surface of the water quite black in patches. *S. cæruleus* has the ova blue, which may be seen through its transparent body.

The genus *Trichodina* has no cilia on the surface, but a wreath of them at one end of the conical body. *Urocentrum* has no cilia except a wreath. *U. turbo* has a transparent, three-sided body, and a short tail: it is found amongst Lemna and other weeds.

The genus *Vorticella* is one of the most interesting amongst the Infusoria. The species *V. convallaria* (Drop III. fig. 2) is the most common, has a bell-shaped body, is perfectly transparent, and attached by a flexible stalk of considerable length to weeds, &c., so that it can be watched with great ease; and a more amusing sight cannot be met with, than a number of these beautiful beings grouped together, all busily engaged in procuring food by the aid of their cilia, which they keep in constant motion, thus producing a strong current in the water, and drawing into their mouths small atoms upon which they feed. When any object alarms them, they immediately contract the strong muscle, which, with a power of 250 diameters, may be

seen within the stalk: this motion carries the body instantaneously to a considerable distance; after a short time it uncoils again, and the animalcule renews its occupation. This stalk, which is about five times longer than its body, is a marvellous structure:—the muscle within, at the will of the animal, can contract into many coils, so suddenly that the eye cannot follow the motion, though the effect is seen by the removal of the body to a distance;—the uncoiling is not so sudden, and much more graceful. *Vorticellæ* group themselves together in hundreds, when the scene is very animated, first one and then another contracting; and often the whole party recede at once, as if animated by the same will, then they expand again, and the same scene is

displayed; the current in the water, formed by the group, causing numerous little animalcules and vegetable productions to whirl about in a curious way. This current may be observed more clearly still, if a small portion of carmine or indigo be placed in the water, at the same time the animalcules will be found to eat it in vast quantities, the stomach cells becoming coloured either red or blue. They increase rapidly by three different methods. Though the act of depositing eggs has not been perceived, still young ones appear in vast numbers attached near the old ones to the same substance, and gradually increasing in size. A full-grown one will frequently be seen to have a double appearance, and if this is watched, a

fissure will soon be perceived—two bells will be formed, and in time one will twist itself off, and, swimming freely about for a period, at last fix itself, and form a stalk. One extraordinary circumstance has been witnessed by those who have watched minutely—that the lower portion of what may be called the new being, and which was attached to the stalk, now becomes the mouth, and is surrounded with cilia, whilst the upper part closes and produces the stalk. I have frequently observed a circle of cilia in active motion on the lower part of the newly-formed bell, even before it had left its parent, but have never been so fortunate as to observe what follows. When this newly-formed creature is swimming about, it might be, and has been, taken

for a new genus. Besides this extraordinary method of increase, buds have been perceived on the sides of the bells, which gradually increase in size, and form new individuals. By these various means their numbers augment astonishingly, and this increase may be watched, if a stalk of duckweed or other substance to which a few are attached, be put by itself in a small vessel of water, and examined by the microscope every day. I have often selected a small group, and keeping it in a vessel alone, have observed them increase to several hundreds in the course of a short time. They fall from their stalks and die, if deprived of air, for I have more than once kept a number under a glass cover, for twenty-four hours, and found half lying dead in

heaps at the bottom, and in double that time all had perished. This species is found principally on duckweed. *V. campanula* is larger than *V. convallaria*, and rather brown in colour: it has a bell-shaped body, but truncated in front. The single animalcules may be discerned without a glass; and a mass of them appears like a bluish matter attached to water-plants. There are several other species, all differing slightly from those mentioned, but having the same general appearance and habits.

The next genus is *Carchesium*, and it differs from the last in its imperfect mode of self-division. There is one main stalk, which has the power of being contracted in coils, like that of the last genus; but it is branched, and each

division bears a bell. *C. polypinum* (Drop III. fig. 3) has a bell-shaped body of a white colour, and in size is equal to the *Vorticella convallaria.* These groups are particularly beautiful, and the actions very amusing to watch. Each individual bell has the power of contracting slightly, and drawing in its cilia, but the long stalk is only common to the whole number; how they agree to contract that, it is difficult to say, and yet they are constantly repeating this movement, and again stretching themselves out in the most elegant manner.

The genus *Epistylis* has a stiff, inflexible, hollow stalk, which is generally branched, like the last genus. *E. plicatilis* has a forked stem, the bell-shaped body has rather a yellow

cast, and, when contracted, has a folded appearance. *E. anastatica* has an oval-shaped body, and does not form folds when contracted: it is often found on the shells of small mollusca. *E. digitalis* is small, but much branched, and is often abundant on the body of the *Cyclops quadricornis*, where it appears to be indifferent to the rapid movement of that active creature, whose passage through the water one would suppose must destroy the life of so delicate a being. *E. grandis* has not an erect stalk, but it is often of great length, even as much as several feet: it looks like blue slime to the naked eye. *E. nutans* has the body drooping when the cilia contract, though it is upright when they are expanded. It is curious to see this little crea-

ture suddenly fall into a drooping posture when danger approaches, as if its minute stalk had a joint near where it is attached to the main stem; after the lapse of a moment, it again rises, and renews its search for food. *E. parasitica* is small and solitary. There are several other species.

The species of the genus *Opercularia* have a stiff stalk, and much branched; but the bells, or little bodies, are of different shapes and sizes. The genus *Zoothamnium* has a flexible stalk, and the bodies of different forms. *Z. arbuscula* is much divided, forming objects like beautiful little trees, or plumes of feathers. Most of these curious genera of the family *Vorticellina* may be seen with ease by the aid of a good microscope, and will amply reward the patient investigator by the

pleasure derivable from watching the habits and peculiarities of these extraordinary and beautiful little beings.

In the next family, *Ophrydina*, I shall only mention two genera—*Vaginicola* and *Cothurnia*. *Vaginicola crystallina* (Drop III. fig. 4) has a transparent, crystalline, pitcher-shaped lorica, fixed to the stalks of duckweed; the body is bright green, from the granules with which it is filled, and often appears double: it expands slowly as if afraid, and protruding from its lorica, it then unfolds its cilia for a short time, but again suddenly retires. *V. decumbens* has the lorica flat on the stalk or leaf—not erect, like the last. *Cothurnia imberbis* (Drop III. fig. 5) has the transparent lorica round at the bottom,

and supported by a short stiff stalk: the body is yellow;—often attached in numbers to the *Cyclops quadricornis.*

We now come to a part of the classification where the families and genera are exceedingly difficult to describe; I shall only, therefore, mention a few of the most striking, leaving the student to refer to works of greater science when the excited curiosity is anxious to be satisfied. The little creatures are of higher organization than those described before, and many of them much larger. They are all more or less bladder-shaped, the body generally covered with delicate cilia, some possessing loricas, and others none; some, bristle-like appendages, and a few having long necks; they either swim about or creep on

plants. One genus is named the swan-neck animalcule, from the extreme length of that part in some of the species; indeed, they may be called all neck, for the body is small comparatively, and they are more frequently seen with the neck alone projecting from the edge of a leaf. *Trachelocerca olor* (Drop III. fig. 6) has a spindle-shaped body, with a very long flexible neck, dilated at the end, where the mouth is situated. The animal creeps at the bottom of the water, or on the leaves, and is constantly moving its graceful neck in all directions amongst the weeds: when two or three are feeding close together, it is curious to watch the actions of this flexible member.

Another singular creature, somewhat similar

in form to the last, though differing in many essential particulars, is the *Trachelius anas*: it has what at first sight might be taken for a neck, but the mouth not being placed at the end, it cannot be so considered. The mouth is at the base of this long appendage, and may be seen occasionally whilst the long process is waving about; this, and the cilia on the body, are the organs by which it moves.

Bursaria truncatella (Drop III. fig. 7) is another marvellous being, large, and easily discernible by the naked eye; found in water where there are decayed beech-leaves. It is oval in form, truncated in front, and having a simple row of cilia there, but the body is entirely covered with small ones disposed in rows. It

glides about in a quiet manner, between the portions of vegetable matter, and appears to have the power of compressing its body to suit the size of the passage. The internal cells are very transparent, and I have seen *Rotiferæ* and other small animalcules lying within, as if only just swallowed. Having procured some water which contained a large number of these creatures, I had an opportunity of making observations about their death, which I do not see mentioned by naturalists:—whilst watching a very fine one, I perceived that a part of its body seemed to be separating from it, particularly the contents of the internal cells; this continued for some time, until at last the whole body had dispersed, and was lying on the surface of the

water in minute portions; but the most marvellous part of the proceeding was, that the cilia continued to vibrate the whole time, not only as long as the body was partially hanging together, but each little portion, as it floated away from the larger mass of the body, had considerable motion in it from the action of the cilia, and this continued for full five minutes, or perhaps more, after each portion had separated from the main body. The animalcule itself remained turning slowly round during the process; and the motion only ceased when all was dispersed. I witnessed this curious fact many times before I discovered what may be considered the reason of this extraordinary dispersion: I believe it to have been caused by the evaporation

of the water, as its death always seemed to take place after the drop had been under the microscope a certain time, and though there was still sufficient water remaining for the body to move within it, with some freedom, there might not be enough for its comfort and life. I caused the death of many specimens, before this idea occurred to me, and I have not met with anything similar to it, except once, in the case of a *Stentor*, which I saw disperse in the same extraordinary way. That the bodies of these little creatures should be dissipated in the water *after* death is not surprising, but that they should commence breaking up during life,—at least, that the cilia should retain so much muscular power when separated from the body,—is won-

derful. The more we watch these little creatures, the more we find to admire and interest us.

I must mention the *Paramecium aurelia* (Drop III. fig. 8), because it is found sometimes so very abundant in stagnant water. I have seen it in such numbers in one drop, that the little creatures were almost close together, and yet all gliding about in seeming enjoyment: they were in water in which I had steeped a few leaves for some weeks. They have an oval cylindrical body, and have short cilia placed in long lines, those near the mouth rather longer. The digestive cells are very numerous; and it is stated that these little creatures have the sense of taste, for if a mixture of carmine and indigo be put into the water, some will take only one substance,

and some the other—and this can be seen by the colour in the stomach-cells.

The last genus I shall mention in the class *Polygastrica* is *Euplotes*, a genus with which observers soon become familiar, not only from the beauty of the species, but from the peculiar movement of these little creatures. They are of an oval form, very transparent, and brightly coloured with spots of green and red; they have cilia, and are furnished also with what are called setæ, and styles; these are hair-like appendages variously situated, which, by their quick motions, enable the animalcule to move most rapidly through the water; they also dart back suddenly, and, turning round, again advance to the place where they were gaining food: this back-

ward and forward motion is frequently repeated, and occasions them to be easily recognized. They make a powerful current with the cilia near the mouth. *Euplotes charon* (Drop III. fig. 9) is, I think, the most common, and is found in infusions. *E. patella* is larger, more round in form, and abounds most where duck-weed is growing. There are several species of this interesting genus found in sea-water.

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. Polyarthra [illegible]
7. [illegible]
8. [illegible]
9. Mesogloia [illegible]
10. [illegible]
11. [illegible]
12. Arthrocyrtis [illegible]
13. [illegible]
14. [illegible]
15. [illegible]
16. [illegible]

DROP IV.

The animalcules comprised under the class *Rotatoria* are of a higher organization than those already mentioned; the body is of a more definite form (not changing its shape, or dividing spontaneously, as is the case with many of the *Polygastrica*), having but one digestive cell, in the form of a tubular alimentary canal, being provided with a rotatory organ, and in general a single foot, or process, by which it clings to substances in the water. Of the cilia, and their

wonderful construction, I have spoken in the introductory chapter;—by their means a whirlpool is caused in the water, smaller creatures are drawn into it, and swallowed by the mouth; this apparatus forms, also, their means of locomotion, and in many genera the swimming is very rapid. These delicate cilia can be withdrawn at pleasure, and covered securely by the rest of the body. The gullet contains a set of sharp teeth, which grind down the food very rapidly, and which may be seen constantly in action whilst the animalcule is feeding. The foot—or tail, as it is sometimes termed—is in many genera of very wonderful construction; it is formed so as to enable the little creature to make it long or short at pleasure, by one part sliding within another, on the same con-

struction as the tube of a telescope. It is very interesting to watch this exquisite mechanism, and to observe how wonderfully all the parts are adapted to each other. The *Actinurus Neptunius* shows this formation in the greatest perfection. Other genera have a disc at the extremity, like the leech, by which they hold very tightly; and many have one or more toe-like divisions.

The *Rotatoria* are reproduced by eggs, either hatched within the parent body before exclusion, or fixed to weeds and other objects floating in the water. Some few genera attach the eggs to their bodies, and carry them about for some time, appearing not to be in the least inconvenienced. The number of eyes varies in the different genera: they are generally red. As the *Rotatoria* are

large, comparatively speaking, a glass magnifying 250 diameters is quite sufficient to see them with perfect ease. I shall only describe a few of the most common genera, referring the student to Ehrenberg's or Pritchard's excellent works, where each species is minutely described, and as ably illustrated as means will allow.

One of the first genera of the *Rotatoria*, though it will not be the first to attract the attention, is a creature somewhat resembling a long narrow fish with a forked tail. The *Ichthydium podura* has a transparent, colourless body, long, and constricted so as to form a head; it swims rapidly, but is generally seen creeping: the tail is formed of two parts, like a pair of pincers.

The next genus, *Chætonotus*, is more common,

and peculiar, having its body clothed with hairs, the form also resembling in some degree that of a caterpillar: it is generally seen creeping on the stalks of duckweed, and occasionally swimming with considerable ease. *C. larus* is the most plentiful species, and particularly abundant in muddy water.

The genus *Floscularia*, though consisting of species always attached to water-plants, and therefore less lively than most of the *Rotatoria*, is very beautiful, and highly interesting. The individuals each dwell in a transparent case, which is affixed to plants, and the body is attached by a slender foot to the base, having the power of expanding or contracting itself at pleasure. When contracted, it is shorter than the cell, but, if

watched, will be found gradually to expand, and to stretch itself far beyond the edge of the case, and then to unfold its curious, rotatory organ, which is divided into six lobes, each provided with many cilia. A current is then observed in the water, though the cilia are not seen to move; small objects are drawn into the mouth very rapidly, and swallowed, to be ground down by the chewing apparatus, which may be observed constantly at work. When danger approaches, the creature contracts suddenly, and is safe within the case in an instant; this protective case is so exceedingly transparent, that even the brightest light will fail to render it visible, unless it is partially covered with loose matter which has been drifted to it by the water; or it may

be seen, when this is not the case, by colouring the water with carmine. The presence of eggs, also, near the body of the parent, shows that there is a case, though it may not be visible to the eye. *F. ornata* (Drop IV. fig. 1) is the most common species: it has longer cilia than *F. proboscidea,* but no proboscis. The mode of increase is by eggs, which are deposited within the case, and are of considerable size, and of an oval form: I have seen four or five within the transparent covering of the old one, and once witnessed the young animalcule hatching. The two red eyes are very distinctly visible when the little creature is nearly ready to burst the shell; and on one occasion, observing that these eyes were more conspicuous than I had previously seen them, I watched very

attentively, and at last had the pleasure of seeing the young one escape first into the case of the parent, and from thence into the water, where, though so small, it was conspicuous from the bright red eyes; but it swam so rapidly, that I could with difficulty follow it; and at last it was lost among the surrounding weeds, which seemed to form a wide world for the little creature. After a short life of freedom it attaches itself like its parent, and forms a case. In some waters these interesting and beautiful creatures abound. I have counted between thirty and forty specimens on one stalk of duckweed, in all stages of growth:—those of middle age are bright and clear, the case nearly invisible and containing no eggs, the body slim, and very elegant in

form; the old ones have the case large, covered with extraneous matter, and with as many as five eggs clearly seen within it,—the body larger, of a more plump form, much coloured, and capable of stretching out, when feeding, to a very considerable length.

There are other genera of attached *Rotatoria*, which I will slightly describe, but that above mentioned is the one most generally seen. *Stephanoceros Eichhornii* is a very wonderful creature, and of considerable size, but unfortunately very rare. The case is so transparent, that it is rarely seen unless the water is coloured with paint: it is larger than that of the *Floscularia ornata*, and Dr. Mantell describes it as "attached like a collar round the body at the upper margin,

near the base of the rotators; so that its border becomes inflected when the animal shrinks down towards the bottom of the case." The rotators here spoken of are five deep lobes of the rotatory organ, each having fifteen circular rows of cilia one above the other, up to the points; these lobes, or arms, the animal spreads out when it emerges from its case, and occasionally uses them as a "prehensile instrument." They are extremely beautiful and curious, and in a constant state of activity, frequently shrinking into the case, and again emerging and displaying the beautiful form of the lobes. Dr. Mantell once saw one he was watching, capture a *Stentor* by the aid of these arms, but he does not say whether it was eaten. They seem principally to

feed on Monads, and other small creatures. The eggs are retained within the case till they are hatched. The *Stephanoceros* has one eye, which is very conspicuous in the young state.

The *Limnias* has only two lobes to its rotatory organ, and the case, though at first white, becomes of a brown colour, and is often covered with other substances which adhere to it. The rotatory organ of the *Limnias ceratophylli* (Drop IV. fig. 2) has a singular appearance when the creature is feeding ;—the cilia surrounding the lobes are very short, and, when vibrating very rapidly, have the appearance of a moving band of light round the edge, which is very deceptive to the eye, and the mind can scarcely conceive that the effect is produced by so simple a cause as small

vibratory cilia; below this apparatus are seen the grinding jaws in motion. The animal frequently bends its body, first to one side, and then to the other, as if it were looking over its dark case for prey; and at that time are seen several processes, which form part of the body. The *Melicerta*, another genus of stationary *Rotatoria*, has four lobes: the case has a granulated appearance, and is of a brownish-red colour.

Of the free genera of this class, a few species, more highly interesting and more common than the rest, can be alone described.

Microcodon clavus (Drop IV. fig. 3) is a beautiful little animalcule, being in shape like a bell, with a long undivided foot, which it has the power of bending at right angles to its body; the rota-

tory organs are shaped like the figure eight, and have bundles of bristles projecting beyond; it seems to have a small red eye. It is a lively little creature, and extremely difficult to observe with accuracy.

Notommata longiseta (Drop IV. fig 4) is of a very curious construction and appearance, and easily known by its long double tail, which is often more than three times the length of its body; the two portions are needle-shaped, one longer than the other, and slightly curved: the body is small and cylindrical, the rotatory organs numerous, and not conspicuous. It is an active creature, and has the power of leaping, or at least changing its position suddenly, for I never observed that this action gave it much onward

movement; it seems more frequently to turn round only, and is probably assisted in this action by the long stiff forked tail, or foot. It appears to feed on other species of *Rotatoria*, as well as the smaller *Polygastrica*.

Synchæta pectinata (Drop IV. fig. 5) is a beautiful animalcule, but very difficult to watch, from its quick motions, and the transparency of its body. It occasionally, however, fixes its short forked tail, and then twirls round rapidly for some time, vibrating its numerous rotatory organs, and drawing towards it many objects in the water. Between the clusters of ciliated organs, are strong bristles, which are easily seen when the creature is thus comparatively quiet. The body is short, tapering towards the short

pointed tail, but very broad at the head, which has two shoulder-like appendages, giving it a peculiar look, and rendering it, with other circumstances, easily distinguished. It has a large red eye. Altogether, this is an interesting specimen, but from its liveliness rather tantalizing, for it may be followed for a considerable time before it remains sufficiently tranquil for any of its peculiarities to be noted. Another species, found in the Baltic, produces a phosphorescent light, observed by Dr. Michaelis.

Scaridium longicaudum has a long foot, twice the length of the body, and seemingly jointed in the middle. It is divided at the extremity into two toes: with the aid of this curious appendage, the animalcule has the power of leaping

or springing very quickly, not to a great distance, but changing its place, and half turning round at the same time. It has one eye, and a compound rotatory organ, armed with a hooked bristle; the body is oblong. This is an interesting object, and found in the summer, though not very commonly.

Another leaping animalcule, the *Polyarthra trigla* (Drop IV. fig. 6), is of very singular construction. The body is almost square, and on each side are six strong narrow fins, or bristles, which enable it to swim quickly, or leap suddenly. It carries its eggs attached to the outside of the body. The small polygastric animalcule, the *Colacium*, mentioned at page 107, is often found infesting both its body and fins, and yet

its progress through the water does not seem to be impeded.

Rattulus lunaris (Drop IV. fig. 7) is one of the smallest of the *Rotatoria,* but often seen in turfy pools, and soon distinguished by its diminutive size and curved body; the foot is short, and curved also.

The genera mentioned from *Notommata* to *Rattulus* have no lorica.

The individuals of the next family are clothed with a lorica; some of the genera are common, and interesting. *Lepadella ovalis* (Drop IV. fig. 8) is often seen in immense numbers in stagnant water, and is a pretty and lively animalcule, though said not to possess eyes; it guides itself, however, with unerring precision,

and, if deficient in sight, has other senses of equal value. The lorica is flattened, and of an oval form; the small foot divided at the end, and moving about in every direction. It appears to fix the foot on some substance in the water, and then to move the body rapidly on every side, as if in search of prey; the small rotatory organs are in constant motion.

Mastigocerca carinata (Drop IV. fig. 9) is one of the most elegant of these interesting creatures: its oval body, with a crest on the back, seems to take a variety of shapes as it spins round in the water; its long needle-like tail is straight when swimming in one direction, at others bent at right angles to the body whilst it is stopping to examine food. It does not swim so

rapidly as many others, and thus is more easily examined: its rotatory organ is small, and divided into four parts; it has one eye, and the body is so transparent that the internal parts are easily seen, giving colour and seeming solidity to this otherwise fragile-looking creature. The crested and raised part of the lorica on the back, is very curious, but the use of it is doubtful; other genera have a lorica of similar construction.

Euchlanis triquetra is of large size and singular form, but is unfortunately rare, and only found in turf-water. The lorica is very transparent, and three-sided, the crest on the back, and the rather sharp flattened sides, forming, when seen endways, a perfect triangle; the tail is divided into two sharp points, and proceeds

from the under side of the lorica, not from the end of the body. The rotatory organs are divided into several bundles.

Salpina mucronata (Drop IV. fig. 10) is common, but not less interesting on that account. It is smaller than the last, but of sufficiently large size to render it easy to watch its movements. It is lively, but often attaches itself by its forked tail to weeds, for some time, when busy in procuring food; indeed, it is, I think, particularly voracious, for I have watched a specimen seemingly thus employed, for two hours at a time. In my opinion, this animalcule feeds on vegetable substances almost entirely, for I have frequently seen it clearing away the green pulp from the stalks of duckweed, and leaving

transparent spots, which before were opake. The three-sided rather rough lorica is of very curious form; the under side is flatly rounded, the back crested, the sides also project, and the space between is hollowed out; at the end, where the head is placed, it has four points, or horns, and at the base only three, where the two-forked tail projects. It has a compound rotatory organ, which it withdraws completely into the lorica when alarmed. The red eye and toothed jaws are easily discerned, the latter moving very rapidly when the creature is feeding. The eggs are large, frequently found attached to weeds, and so transparent that the young are visible within; these, when nearly arrived at maturity, produce a vibratory motion, easily seen. This animalcule

is found principally among duckweed, and is pretty numerous in spring and summer.

Metopidia lepadella greatly resembles the genus *Lepadella* mentioned before, being flat, oval, and having a forked foot, but it has two red eyes. It is very transparent, particularly the sides; is lively, and not uncommon.

The *Stephanops lamellaris* is a very pretty creature, and is easily known by its head having a kind of hood extended over it, which is transparent, and cannot be withdrawn within the lorica, but probably serves as a defence to the delicate cilia. Its swift movement renders it difficult to observe; and before I had seen the little creature actually withdraw its cilia, I imagined the hood was an appearance only,

caused by the rapid movement of the cilia and the swift motion through the water, but repeated observation undeceived me.

The individuals of the family next under consideration are not cased in a lorica, and are very peculiar, from the form being more or less spindle-shaped, and from their having the power of sliding some portions of the body within each other, like the tubes of a telescope, so that it is either long or short at the will of the creature. This construction is very wonderful, when we consider the mechanism and muscular power required to effect it. *Actinurus Neptunius* is the most striking example of this peculiarity. The genera are as follows :—

The *Callidina elegans* is found in bog-water,

and in water in which oak-leaves or bark has been steeped. It is of an elegant spindle-form when stretched out, the rotatory organs small, the foot forked, and having also processes above; the body is very transparent, and the jaws can be distinctly seen engaged in grinding down the food. At first sight it greatly resembles the following genus, but the rotatory organs and want of eyes distinguish it.

Rotifer vulgaris (Drop IV. fig. 11).—This interesting animalcule was one of the earliest, discovered by the aid of the microscope. It was first described by Leeuwenhoek about 150 years ago, and has never since ceased to be a favourite with those possessing microscopes. It is easily obtained in spring and summer, being abundant

in most waters where decaying vegetables are found; or a store of them may be kept in a jar by following a plan which has been mentioned to me by one interested in the subject. "Fill a three- or four-gallon jug with rain-water (not butt-water), which will serve for a year or two to keep a half-pint mug at the same level (with water from the jug). Into the mug put a few sage-leaves tied together, and when they are not to be obtained, in winter, a little bundle of hay about the size of the joint of a finger will answer as well. When the sage-leaves decay and sink, put in a fresh supply; the *Rotifer vulgaris* will always be found at the surface near the sage-leaves; and when dirt forms at the sides of the mug, if a small portion of it be taken up with

the water, the animal will adhere to it by its tail, and display its wheels. I kept them in the same mug for ten years." This transparent creature is fusiform, or spindle-shaped, tapering gradually to the foot when expanded, but when contracted it is thick, and the head and tail disappear within the body; the joints are not visible when the creature is expanded, but when contracting, their curious conformation is seen, and the method of sliding one within the other clearly observable. The foot, or tail, has six processes, placed two and two at the joints. The upper extremity of the body has a pair of wheels, distinct from each other, and of very wonderful construction; when the wreaths of cilia which form them are in full motion, they produce strong currents

in the water; and small particles of food are brought within reach of the mouth, and swallowed rapidly, to be ground up by the powerful jaws placed below. There are two red eyes, and a long process, which is considered as the respiratory tube; these form what may be termed the head, and they can all be withdrawn at pleasure. The mode of progression is by swimming rapidly, with the wheels expanded, and body and tail stretched out, or, when moving on weeds, &c., by using first the head and then the tail, so as to form a kind of step;—when feeding, it attaches itself by the tail, and, expanding its wheels, seems to be happily and busily employed. It is an amusing sight to watch the current thus made, particularly if a

little paint be put into the water; but I can imagine no sensation more wretched to those unfortunate little creatures, that come within the vortex caused by these powerful wheels, if they are aware to what it leads: they are often whirled round many times, before they either enter the mouth, or are so happy as to be refused by the monster. I have seen them repeatedly, when beyond the influence of the current, fall down, as if spent with fatigue or fright. The eggs of the *Rotifer* can be seen distinctly in different stages of maturity within the body, and even the wheels of the young ones have been seen in motion by some observers. This species increases most rapidly; from one individual a million may be produced in ten days. They are

found both in sea-water and in infusions, as well as in water which abounds in plants; and they have been observed in the cells of *Sphagnum obtusifolium*, which is a kind of moss, with whitish leaves, growing in bogs and swampy places. Rœper says, that the cells have openings into the water, so that the animalcule may creep in, but he also relates that he has found them in the cells of parts of the plant not exposed to the water. If the cells of the *Sphagnum* are open at times, I can easily imagine that the *Rotifer* will creep in, for my own observation nearly proves that they will occupy any small cavity, where they perhaps may feel that they may feed in safety. I founded my opinion upon the following facts, which I observed last spring

frequently. I flattered myself for some time that I had discovered a new species, but after repeated observation, I came to the conclusion that it was in all probability the *R. vulgaris*, or a species of *Philodina* living as I may say in retirement. It appeared to me, that these specimens had placed themselves in the empty cases of the *Floscularia*, but they were invariably so much covered with extraneous deposit, that I could not decide the matter satisfactorily. The wheels, jaws, and respiratory tube alone, were visible beyond the edge; and as it expanded and contracted within the case, in a similar manner to the *Floscularia*, I at first thought it was, like that animalcule, attached to, and the architect of, the case; but as I never saw any of the specimens

leave the snug retreat in which they had fixed themselves, even though I watched many examples, I still somewhat doubt, especially as there were no specimens of *R. vulgaris* swimming about. These specimens might prove to be species of *Philodina*, though I think those animalcules, as well as the *Rotifer*, have never been observed to form cases.

I have mentioned the tenacity of life in this animalcule, in the Introduction, and would advise the experiment to be tried by all interested in the truth. An instance of revivification of an equally small creature may be mentioned. The disease in corn, called ear-cockle, or blight, is caused by a very minute eel-like animal, which fills the seed, and remains dormant for some years, until the

grain is opened and placed in water, then thousands of these minute creatures make their appearance, and after some time revive, and swim about. I have tried this with corn four years old; there is, therefore, nothing unlikely in the statement that the *Rotifer* may revive after being apparently dried for a length of time.

Actinurus Neptunius (Drop IV. fig. 12).—This extraordinary and elegant creature greatly resembles the *Rotifer vulgaris*, but is easily distinguished by the extreme length and wonderful formation of its tail, which, when at the full stretch, has a most striking appearance. The joints shut one within the other, like the tube of a telescope, and this action the animalcule is constantly repeating when searching for food: it fixes the tail

to some substance, and then stretches it and the body out to an immense extent, displaying its rotatory organs, and feeding for an instant, it then contracts, and pursues the same course in a contrary direction. The body is more slender than the *Rotifer*; it has two eyes, and the chewing apparatus is very distinctly seen. The tail has three points, or toes, and two little horns attached to one of the joints: these expand, when the parts are stretched out, but as this form would prevent the joint above that to which they are attached, sliding over them, they have the power of lying flat, and the tube closes without any impediment. This interesting animalcule is not so common as the individuals of the last genus, though frequently found with them.

Philodina erythrophthalma is another slender-bodied animalcule, with a tail resembling the *Rotifer*, and two wheels as rotatory organs: it is found in vegetable infusions. *P. roseola* is flesh-coloured: Ehrenberg says that this species lays its eggs in heaps, and remains with the young for some time, forming one family. *P. aculeata* is distinguished by having soft spines upon the body, which give it a remarkable look; the respiratory tube has a thickened end.

We now come to the last family into which these little creatures are divided; it is called *Brachionæa*, and consists of several genera, containing species of great beauty. They have a lorica somewhat resembling the shell of a tortoise; the rotatory organs are divided into more

than two parts, though the two at the sides seem more particularly used as active organs. One genus, *Anuræa*, has no tail or foot, the others have a powerful instrument of this kind; three of the genera carry their eggs attached to the outside of the body, giving them a very curious appearance, but seeming not to impede their progress through the water.

Noteus quadricornis (Drop IV. fig. 13) is a very fine and interesting animalcule, of considerable size, and, being broad and flat, soon attracts the eye. The lorica is nearly round, much flattened, rough, and on one side seems divided into compartments; it has also two spines near the tail, and four at the head; the whole very transparent, allowing the body to be seen within. There

is no eye. The head is formed of a two-wheeled organ, and a ciliated part divided into three lobes; with these the creature forms a strong current in the water, drawing towards it many small objects floating past, and occasionally selecting one, which then enters the mouth, where the jaws are ready to receive it. I have frequently seen it swallow small *Polygastrica*, one after the other, very rapidly. The tail, which is thick and very powerful, projects from the lorica, between the two spines at the base: it grasps a stalk with this forked tail, and then, raising the body, extends its wheels, and feeds with avidity. It occasionally jerks the body backwards and forwards with great force, still holding by the tail, as if it were greatly excited, showing the strength of its

muscles, and its health and vigour. It is frequently seen with eggs attached to the body, and is often found in water where decayed leaves and Algæ are abundant.

Anuræa squamula (Drop IV. fig. 15).—There are many species of this genus, but they are all known by being without a tail or foot, and most of them carry their eggs attached to the body; they possess an eye, and swim very rapidly. The lorica of the species *squamula* is smooth, rounded at the base, having horns in front, rather flat when seen sideways, and slightly curved: it has usually one egg of considerable size attached. *A. stipitata* has the lorica nearly square, with six spines in front, and one at the base, which might be taken for a tail, but it is quite rigid.

The genus *Brachionus* has a lorica like a tortoise-shell, and both front and base are spined; in some species it is smooth, in others rough. The rotatory organs are double, and the tail or foot is forked; the eggs are attached, and sometimes as many as ten are thus carried about. It has a single eye. *B. polyacanthus* (Drop IV. fig. 14) is one of the most common. It has a smooth lorica, with two very long spines and three short ones at the base, the upper part having many; the wheels do not extend much beyond the edge of the lorica: the tail is strong, and powerfully grasps any substance in the water. *B. militaris* has the lorica rough, four spines at the base, and twelve long ones at the upper end. *B. urceolaris* is often seen in vast numbers in

fresh and brackish water: it has a smooth lorica, round at the base, and six short spines in front; it is nearly as large as *Noteus quadricornis*. *B. rubens* is similar in shape, but the body is reddish.

Pterodina patina (Drop IV. fig. 16).—This is one of the most delicate, beautiful, and transparent of these lovely little beings. When viewed with a magnifying power of 250 diameters, it appears about the size of a sixpence, the lorica nearly round, and having no processes like the other genera of this family: it is exceedingly flat, and so transparent that, with the exception of some parts of the body, it is difficult to see this animalcule if the water is very clear. The rotatory organ is double, forming two wheels; the tail, or foot, is thick, rather clumsy, and furnished

with a disc at the end, by which it holds to substances: it proceeds from near the centre of the under surface of the lorica, and is clearly seen when the creature turns on its side, which it does frequently in swimming. It has two eyes. When alarmed, it withdraws its wheels into the case, as well as the tail, nearly, and lies quite still for a moment, soon, however, becoming active again, and then nothing can be more interesting than the quiet movement and elegant appearance of this animalcule. It is not common, but found sparingly in summer, principally among Lemna; I once found it as early as February, but in small numbers. *P. elliptica* has a lorica of an elliptical form. *P. clypeata* is found in sea-water: it has an oblong lorica,

shaped somewhat like a vase, and smaller than the other species.

Many other creatures of small size, besides Infusoria, will of course be met with in water, but they will soon be recognized as belonging to other classes of the animal kingdom. Several long, worm-like creatures, are the larvæ of the gnat and midge, or perhaps those of the dragon-fly or Tipula. There are several species, also, of *Vibrio,* which will soon be distinguished if the one found in sour paste is known. Then there is a pretty and very lively little creature frequently seen where duckweed abounds, the *Lyncius sphæricus.* It is enclosed in a round, transparent shell, the only projection being a beak, and the

occasional protrusion of a foot; the eyes are black: it feeds on animalcules, and pursues its prey with great activity. The *Cyclops quadricornis*, or water-flea, is larger than the *Lyncius*, and has branching horns, or arms: it is very transparent, and the lungs may be seen clearly in motion: it has but one eye. In some species, of which there are several abounding in stagnant pools, the eggs are enclosed in a membrane, and attached to the outside of the body. The *Cypris* is another curious creature, often found in great numbers: the body is enclosed in a kind of horny bivalve shell, which is not transparent; horns, or arms, are occasionally protruded from an opening, by the action of which it moves quickly. Their shells are found in myriads in

a fossil state. The *Amymone satyra* may be observed in clear water, and is a beautiful object for the microscope: it is rather oval in shape, with four legs, two antennæ, and one bright red eye, the whole body tinged with yellow, and very transparent; it moves quickly, but in jerks. These are a few only of the interesting objects which may be observed in water, besides animalcules.

I have now described as many genera and species of these exceedingly beautiful little beings, as the young student will probably be able to find in the course of several seasons; but with diligent search, and frequent use of the microscope, nearly all these may be seen, and admired,

in any neighbourhood, particularly as water may be conveyed (with care) even from a distance. I believe it is considered safer to fill the bottle in which the water is carried *full* to the cork, as the motion is then trifling, for the shaking of a half-filled bottle kills all the delicate kinds. When a drop of water, tolerably full of life, is placed under the microscope, all seems confusion to the inexperienced eye, the varied forms and rapid movements cause bewilderment in the mind of those who really wish to make a study of the names, habits, and peculiarities of these living atoms; but after some use of the glass this feeling subsides, and some *one* specimen attracts the attention, its shape is remembered, reference is made to the illustrations, and there some

species similar in form will probably be traced; then, by referring to the description, the name of the genus or species may be found, with its characteristics and habits. A species, when once impressed thoroughly on the mind, and its name remembered, soon ceases to attract attention, however frequently it may pass, if the eye is fixed on an animalcule which is new to the observer; thus the confusion is soon lessened, and each drop at last produces so many old friends, that we have leisure to watch their movements, and be amused with their varied habits of life, and extraordinary modes of obtaining food. To those fond of watching the sports and movements of creatures of a larger growth, these little atoms will be never-failing sources of amusement; and

even should the observer only seek to wile away an hour, the objects are always novel and full of interest; but to those who delight in examining the wonderful works of creation, there can be no greater source of pleasure than the possession of a good microscope, and the power of beholding minute beings, all of which are so totally dissimilar to those seen without this assistance. The gift of a microscope to a young inquiring mind, may, therefore, prove one of the purest sources of quiet pleasure, and lead to the cultivation of a taste for natural history in general, in the study of which so many hours may be profitably spent, which would, perhaps, otherwise be wasted in trifling or idle amusements. Allow me, then, to press this fascinating pursuit, not only on those who

are already lovers of Nature, but on those who are seeking for amusement and occupation. I can promise with some confidence that they will at all events not meet with disappointment, and will with more probability discover that a never-failing source of delight and interest has been opened to them,—a new and almost unknown region, peopled with minute beings whose beauty cannot be surpassed or described;—

> Where, even in a water drop,
> These wondrous creatures revel, filling up
> The seeming void of nature; even as planets,
> By the naked eye unseen, perfect
> The glorious firmament.

ALPHABETICAL LIST

OF

GENERA AND SPECIES.

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