

POND · LIFE

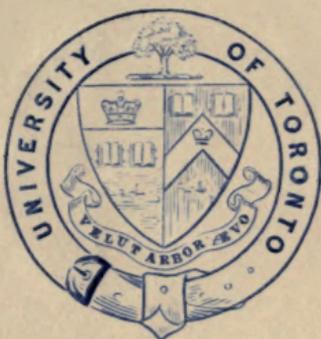
EDWARD · C · ASH, M.R.A.C



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² POND LIFE

By EDWARD C. ASH, M.R.A.C., F.R.M.S.



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INTRODUCTION

THERE are large numbers of people, who unfortunately miss a great many of the good things of this world. They live their lives without knowing anything of the wonders that surround them. There are some keen searchers after knowledge, alive to the fact that time is precious, and there is much to learn—but there are also countless numbers who are so ignorant that they do not realise that there is anything beneath the surface, and they simply live to make the best of their positions, and take interest in nothing in particular. And there are yet a few—one meets such occasionally—that scoff at everything which does not concern them personally.

The reader will, I hope, peruse this introduction carefully, as it may add to his or her pleasure, for a little elementary knowledge is required if the intention is to take an intelligent interest in what follows.

Every living thing, whether plant or animal, whether it be the leaves, flowers, or fruit of the former, or flesh and muscle of the latter, is made of many single cells, and each cell essentially consists of a wall that surrounds it, protoplasm, and a nucleus.

Protoplasm without nucleus cannot exist, nor can the nucleus without protoplasm. And each cell is typically alive—that is to say, it is able to multiply, to make more of its kind. Thus an animal grows larger year by year—the ovule forms the plant.

Living things are roughly divided into (1) single-celled, (2) many-celled things. The single-celled animals are known as Protozoa—many-celled as Metazoa.

When a cell multiplies, the nucleus divides and its parts take

up a position at opposite sides of the cell, a wall is formed, and two cells result. These cells are known as daughter cells.

A single cell may have permanent projections known as cilia (hairs), and may be able to change its shape, by means of temporary elongations—known scientifically as Pseudopodia, or temporary feet. It is wise to remember that single cells are not imperfect, in fact they are far more adapted to their life than some of the many-celled creatures. Nor is there any justification in labelling amoeba and other Protozoa as the beginning of life; for we find that the amoeba, simple as it may be, is dependent for food on organic matter. The organic matter consists of living plants and the remains of decomposed plants and animals.

We can roughly divide pond life into—

Animals	{	large	
		small	
		very small	
		microscopically large	
		”	small
”	minute		

and plants into similar divisions.

For example: the newt would be amongst the large, the water-beetle amongst the small, whilst the water-mite, a creature only just visible, would be classed as the very small. With the aid of the microscope comparatively large animals will be easily examined (such as vorticella), a higher power shows us the amoeba, and a still higher power would give us a clear picture of the smaller diatoms, &c.

Just as the pond inhabitants vary in size so likewise does their habitat. Some live in the mud at the bottom of the pond, others on the lower branches of water-weeds, and many others, again, are usually “at home” nearer to the surface. Our equipment, therefore, must be such that we are able to collect our creatures from any ordinary situation. The pond-hunter needs no expensive appliances for his work; all he requires he can easily procure or make for himself, and if he should wish to save time a very little outlay will buy the necessary equipment.

Of course, just as in every other matter, if the pond-hunter wishes to spend more on his appliances, he can always do so,

but to the writer's mind, the simpler the outfit, "the more the fun." The appliances essentially consist of :

- (1) a drag-net,
- (2) a hand-net,
- (3) several jam jars.

The Hand-net should be made of strong canvas of a small mesh, and should be carefully sewn on to a ring of wire or cane. The sewing is of importance, and as I do not profess to be an expert on needlework, all that I am able to advise, is that it should be done so as to allow no chance of fraying. The finished net should be fastened on to a fairly strong but not too heavy stick.

The Drag-net is a metal or wood frame triangular in shape. The net required is rather larger than for the hand-net. The wooden frame is perhaps of the most use, as by means of holes bored at suitable distances it allows for the attachment of weights when necessary.

Hunting the stag amongst the hills of Somersetshire, or the fox on the level lands of the Midlands, are both arts. Likewise the hunting of a pond with success requires experience, although it may often happen that the first attempts may give good results. But it is only by collecting that the pond-hunter learns where to find the various creatures he requires.

Water is heavy—a gallon weighs 10 lbs.—and foolish is he who must carry a gallon of water several miles to his home in order to procure some minute creatures, which would be equally safe, if not safer, in half a pint or even less.

A very simple way to save carrying water, is by means of a filtering tin or bottle.

A tin with holes punched through the sides, a piece of very fine muslin tightly fastened round the holes, has been found by the writer to be more or less satisfactory.

A still simpler idea is to have a cylinder of copper wire gauze of very fine texture. The latter is so easily carried that it is perhaps one of the best methods to advocate.

It seems hardly necessary to give any details as to methods of using nets. Suffice it to say that the drag-net should be weighted or lightened depending on pond conditions. The net

should be drawn through the water with considerable speed—consideration must be allowed for obstacles, as a net can be very easily destroyed by submerged wood, rocks, &c. On lifting it out care must be taken to allow some of the water to escape, or else the strain occasioned may lead to the tearing of the net; a very sad occurrence, when one is ardent with much work to do. It is advisable when lifting out the net to seize it as near to its contents as possible. The net should then be opened and turned gradually inside out, the contents placed in various bottles in just enough water to allow free movement.

Small pieces of decaying wood, unhealthy discoloured weeds should be placed in other jars (in water), for these are certain to be the homes of various creatures, specially rotifers, and other animalcules that seem to have a depraved taste for decomposing vegetable matter.

Any creature of particular interest should be put with others of a kindly disposition, or the collector may have a similar experience to the writer, who having caught a very large and comparatively rare larva, unfortunately placed it with various smaller creatures, under the mistaken idea that the weakest goes to the wall. But on reaching home, he found his rarity "hanging up by its neck," in the jaws of the larva of a small water-beetle, less than half the size of its victim.

The larvae of water-beetles, when placed in close quarters, are only too ready to make the most of their opportunities, and the other inhabitants are very soon reduced in numbers—care therefore must be taken to place ferocious animals in special jars, and allow them to wreak their vengeance on things for which you have no particular interest. On reaching home, the various creatures should be separated.

POND LIFE

CHAPTER I

MICROSCOPIC WONDERS

THE world as we know it without inquiring below the surface is certainly wonderful, but with the application of scientific knowledge, aided by microscope and hand lens, the whole aspect of "the world" alters ; it becomes even vaster.

The owner of a low-power hand lens finds himself in a fresh world. The small wild flowers of our hedge-rows reveal little-known beauty, and turn into blooms that would eclipse many of our most prized varieties. But the use of a microscope has even a greater effect, and the mycologist enters into a kingdom never even dreamt of by the non-initiated. The low-power lens reveals countless numbers of most beautifully formed animals and plants, very different to those we are accustomed to see. When first using a microscope the thinking man experiences a sensation as if he were committing a sacrilege, for he feels that he is prying into things never meant for human eyes to behold.

One is liable to think that plants are green structures which have nothing else to do than to be eaten by lower animals, or plucked and put into a vase by the higher. Some more enlightened realise that plants are one enormous branch of life, and that those we see every day, and are most familiar with, represent but a very few of the different kinds.

On one occasion, after a lecture on Plant Life, I was asked by a young member of my audience whether plants had brains, and if not how was it that they could do such wonderful things that seemingly require thought.

I mention this incident because it shows that the vegetable kingdom contains large numbers of interesting species, some of which behave in a highly intelligent manner.

As this book is not one dealing with marvels of plant life, excepting those few that live in ponds and streams, we must be satisfied with these, which are none the less interesting because they belong to the microscopic kingdom.

What are plants? and how do they differ from animals? The reader will find that many of the pond life plants have one or more animal characters, while certain animals have plant-like characteristics. Plants and animals vary from each other as follows:—

<i>Plant</i>	<i>Animal</i>
Has greatest surface and least bulk.	Greatest bulk and least surface.
Has no digestive system.	Has a complex digestive system.
Is unable to move.	Has free movement.
Has an external skeleton (cellulose).	Has an internal skeleton.
Lives on simple but highly oxidised compounds.	Lives on complex compounds.
Contains chlorophyll (green colouring matter).	Does not contain chlorophyll.

In the case of the "higher" plants very few have animal characteristics, but many of the algae and certain microscopic plants behave in a very similar way to animals.

Unfortunately for man, the three kingdoms, animal, vegetable, and mineral, were allotted before science had made much headway, and so it stands to reason that there are many things typically members of none of the above kingdoms. When such are classified as plants a feeling of utter astonishment is experienced by those uninitiated in the peculiarities of scientific nomenclature.

To the average mind the majority of these dubious plants are more characteristically animals, but it must be remembered that the ordinary non-scientist does not usually value all the points, but forms his opinion by the things which are most noticeable. It is interesting to know that the appearance of a Desmid moving gracefully, as if drawn by some powerful magnet, across the slide, gives even the average mycologist an impression of animal, although he is fully aware that what he sees is really a plant. Little can it be wondered at, therefore, that the non-hardened mycologist is fully convinced that many plants are "animals," and that the scientist who named them plants was utterly mistaken.

A single-celled plant, so minute that several hundreds could be placed in a pin-prick without crushing; an architect and

craftsman able to build a case from chemical matter held in solution in water—cases of most gorgeous designs, some even able to move by what means no one knows—such is the diatom, one of the most interesting inhabitants of every pond and stream. The owner of a microscope may spend his life studying the cases of these minute plants, for their numbers are legion, and the patterns revealed by the microscope become most interesting, and more beautiful the higher the power of the lenses used.

Each minute plant, the largest being $\frac{1}{50}$ th of an inch in diameter (the average vary from $\frac{1}{1000}$ of an inch to less), builds its siliceous case in the form of a pill-box and lid. And in the security between the two valves (frustules) the tiny plant lives a perfectly secure life—for the cases are so hard that no crushing can damage them. And these strongly-built cases are deeply engraved, so as to form most exquisite designs, unequalled by anything man has devised.

And when one considers that the owner and maker of the case is firstly $\frac{1}{1000}$ of an inch in diameter, secondly a single cell, and lastly a plant, one wonders at the marvels of the universe, and how wonderful even the most insignificant object may be.

Apart from how the plant should be able to make the case, the question arises, How is it that each little cell of the same kind should build a case similar in every detail to others of the same family? Thus we have the round case of the *Heleopelta*, the triangular cases of *Triceratium*, the boat-shaped of *Naviculae*, and countless more.

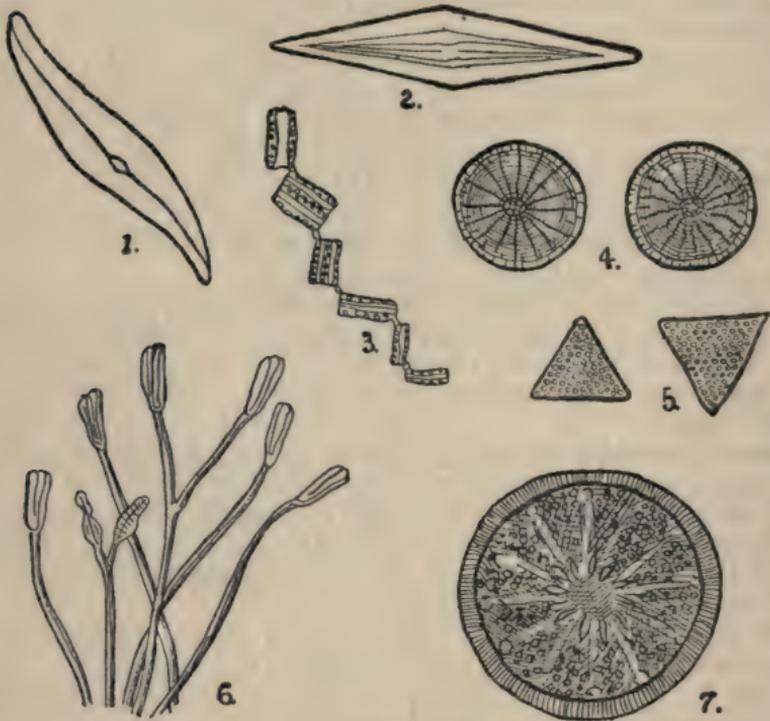
The diatom, like everything else that lives, has one main object in life, and that is that its species will survive.

Diatoms increase as follows: the pill-box forms a new lid, and the lid a new box, but the new part is not so large as the former, and hence the diatom becomes smaller and smaller as the age increases. But a time comes when this minute organism realises that there is even a limit to *smallness*, and then, guided by some uncommon sense (for we can hardly place reasoning power in one cell, and that a plant), it changes its methods of reproducing, and joining on to another of its species, it becomes surrounded by jelly. Then the two diatoms, by a process into which we will not inquire, fuse together to form an individual of sensible proportions.

Some diatoms live singly, and, as before mentioned, can move about at their "own free will." It must be left to the owner of the microscope to feel the sensation occasioned by the movements of these extraordinary plants. Suffice to say, that

seemingly inert diamond or oval-shaped objects, as if prompted by some unseen force, glide out of the field of view, and should they meet with an obstacle, such as another of the same species, the encumbrance and the visitors will often move together, side by side, until one or other alters its direction.

Some species of diatoms live in colonies, a very interesting



DIATOMS

1. *Pleurosigma attenuatum*. 2. *Navicula cuspidata*. 3. *Diatoma vulgare*.
 4. *Arachnoidiscus*. 5. *Triceratium*. 6. *Gomphonema geminatum*.
 7. *Heliopelta*.

example being *Diatoma vulgare*. The members of this colony form a chain, whilst the diatoms *Asterionella formosa* join together so as to represent the "spokes of a wheel."

Another group of great interest is the stalked diatoms, a good example being *G. geminatum*, which reminds one of a wedge fastened on to a stalk by the narrow end.

The wedge secretes a thin stream of gelatinous substance, which soon becomes solid, and acts as the stalk of the organism.

Most beautiful colour effects are often obtained unintentionally. The light is decomposed by the surface of the frustules, and the cases are seen to be iridescent. A diatom slide usually shows similar effects.

Desmids resemble diatoms in the fact that they are single-celled plants. But they have not the same wish, or perhaps power, to build cases. But although lacking in this respect yet they are most beautiful little objects, and any time spent in their study is amply repaid.

"Minute green plants" is perhaps the best description one could give of them, for they contain chlorophyll, the green colouring matter which we know so well in the higher plants. And, as if aware of this fact, Desmids in fine weather are found on the surface of the pond, forming a green film, whilst should the weather be less bright they retire to the bottom, chlorophyll being essential in the decomposition of carbon dioxide for the production of sugar and starch in the presence of sunlight.

During our usual fine hot summer weather, so characteristic of our climate, these little plants appear in such large numbers as to make the water appear green.

Desmids are of all shapes, partly due to the fact that their method of reproduction leads to great alterations in their "physique," and partly due to the large number of species that are in existence.

Perhaps, if one asked the mycologist what he found interesting in Desmids, he would reply, the study of "Cyclosis." Cyclosis is the movement of protoplasm, and this may be most easily studied under the microscope.

But to the average person their methods of reproduction are probably of more interest.

The Desmid, when the instinct prompts it, gradually divides the protoplasm and leaves a vacant space in the centre: a break occurs and two Desmids result. This is not the only way that Desmids increase. The other method is sexual, the former asexual (fission).

In the sexual method, known as conjugation, two Desmids meet, the cell contents mix, and a spore is formed. This spore then forms several Desmids of the same species.

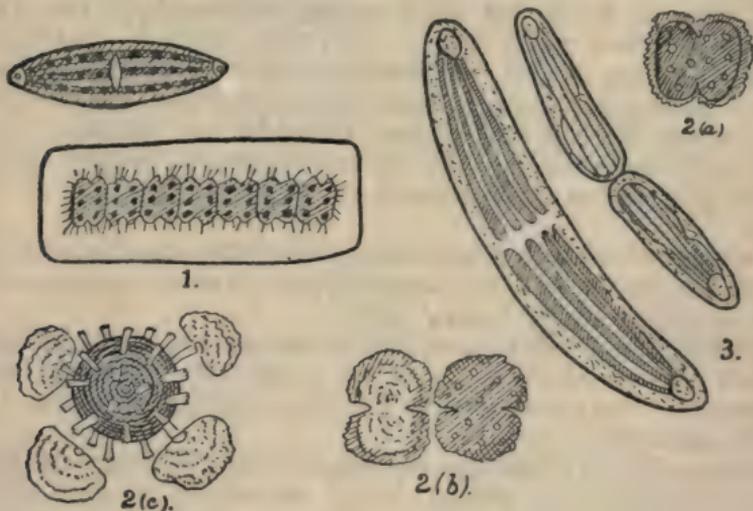
Closterium lunula is one of the most interesting, being comparatively common, and especially easy to study.

The phenomenon of Cyclosis can be easily followed.

Another Desmid of peculiar interest is *Cosmarium botrytis*.

Cosmarium botritis is noticeable for having on its surface many nobbles; these are arranged in rows. The Desmid is

divided into two halves by a waist. When reproduction takes place the "waist" becomes narrower and narrower, and eventually breaks. At the same time another plant undergoes similar changes. A most remarkable phenomenon now takes place. The contents of the half cells of the first Desmid leave their cell walls, and simultaneously the cell walls of the second Desmid are evacuated. The cell contents meet, and very soon are surrounded by a thick wall, covered with peculiar spines. This structure is the spore case, and in it the spores are formed,



DESMIDS

1. *Hyalotheca dissiliens*. 2. *Cosmarium botrytis*, multiplying.
3. *Closterium lunula*, dividing.

and remain dormant until the following spring, depending on when the conjugation took place.

Another most interesting Desmid is *Hyalotheca dissiliens*. In this case we find several Desmids living fastened together in a colony surrounded by gelatinous matter. When conjugation takes place the contents of two neighbouring cells fuse, and a spore case is formed.

Desmids can be easily kept for study. If placed in a watch-glass in water obtained from their natural home, they will not only live, but increase rapidly. Before leaving Desmids, mention must be made of their power of movement. Similar to diatoms, they are able to travel freely, and, so far, no means of

movement have been discovered ; even the highest power lens and the most carefully arranged light effects give no clue to this mystery ; and one can only imagine that it is by means of some most minute hairs, so fine and so transparent that they are ultra-microscopic, or else by some other physical or chemical means, unless we take it for granted that these most interesting "plants" have a means of movement that has no similarity in the higher world.

Volvox globator may be said to resemble a tennis ball $\frac{1}{50}$ th of an inch in diameter ; in fact its behaviour is so much like that of an animal, that it is a moot point as to whether it should not be classified as such.

It is not a single-celled plant as a *Desmid*, but a colony of cells joined together by strands of protoplasm, in the form of a round net, the knots being the individual cells.

Each little cell is furnished with a pair of minute hairs, known as cilia, which are most energetically waved.

It may strike the reader as extraordinary that the *volvox* should move in any direction whatsoever, as we can hardly imagine that each of these minute cells co-operates with the remainder, but it is probably due to their independent action that the *volvox* rolls through the water in such an original way.

Strangely enough, one often notices that inside the *volvox* itself some other creature is living a perfectly free life, seemingly indifferent to its destiny. This rather goes to show that the *volvox* either contains water, or comparatively non-viscid material.

Volvox multiplies by both asexual and sexual methods.

In the case of the asexual, daughter cells are formed similar to the parent, and the juveniles roll over and over inside the parent in a most unfilial manner, and when the adult *volvox* thinks that the joke has gone far enough it breaks open in the gentlest way, and the daughter *volvoxes*, leaving their parent, start on an independent existence.

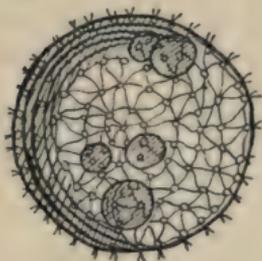
The second method is rather more interesting. Some of the cells become changed in shape, and form respectively *antherozoids* and *oospheres*, and then after a short time the *antherozoid* opens, and a large number of animal-like objects swim out and find their way towards an *oogonium*, into which they hurry. A spore case is then formed, and, as usual, ends the following year in a fresh generation of these most interesting plants.

If there should be doubt that each little cell forming the net is an independent object, one has only to crush a *volvox* under a cover glass to see that such is the case ; for each little

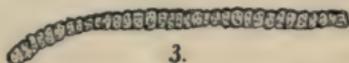
cell will swim independently, as if it were quite an ordinary event to be separated from its relations.

To the amateur mycologist one might say, "Find a volvox and be happy"; for it may be said that there are very few things more beautiful, more original, and more extraordinary than this little plant.

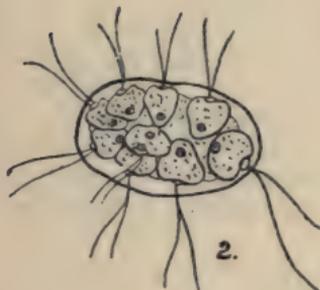
Another of great interest, a member of the family, is *Pandorina morum*. It is very common in many districts, and is



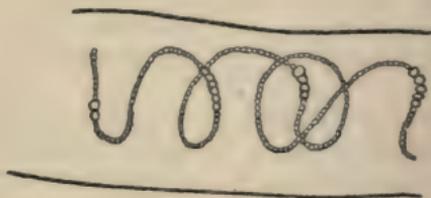
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VOLVOCINEAE

1. *Volvox globator*, showing daughters inside parent. 2. *Pandorina morum*.

CYANOPHYCEAE

3. *Oscillatoria tenuis*. 4. *Nostoc*.

often mistaken for *Volvox globator* by the amateur. It is composed of a few large green cells, noticeable for a red spot nearest to the broad side. Each cell has a pair of long cilia, and the entire colony is surrounded by a gelatinous envelope, through which the cilia protrude. Their method of reproduction is rather different to that of volvox. The cells break out of their envelope, and swim freely until two of them meet; these then join together and spores are formed.

Things are not always what they seem, and many ardent pond-hunters have thrown *Nostoc* back into the pond without more than a cursory glance. A little lump of greenish-blue jelly is all one finds. This minute lump of jelly, likened by some to partially boiled tapioca, is the bulwarks of a colony of *Nostoc* securely hidden in the centre. Under the microscope the jelly is seen to be occupied by long chain-like objects, the links of which are of various sizes and shapes. Some of the chains are composed of small round cells, others of large square-shaped cells. The former are the young *Nostocs*, the latter the mature. The chains may increase in length, or else portions of the threads break away and swim slowly until, finding a suitable spot, they settle and secrete a gelatinous substance that entirely covers them ; thus fresh colonies are formed. But *Nostoc* has yet another method of propagating its species—by spores.

One of the most fascinating micro-plants is *Oscillatoria tenuis*—not because its conduct is of great interest, but on account of its peculiar manner of swinging to and fro like a pendulum. This oscillation is most captivating, and the writer has found it a most difficult matter to leave the microscope, even at meal times, when *Oscillatoria tenuis* is under focus. For this plant sways backwards and forwards untiringly, as if there was nothing else to do but to swing itself to sleep.

When the feeling prompts it, *Oscillatoria tenuis* swims very slowly to a fresh situation, and there, anchoring, continues its pendulum behaviour. Sometimes two or more of these plants will remain close together, and then the effect is even more surprising, for they interfere with each other's free movements, and seem to push and struggle more like animals than plants.

Perhaps the most popular aquatic plant is *Spirogyra*, one of the most beautiful objects to be found abundantly everywhere. Its size makes it particularly easy to study, and the vividly green spirals, so rich in colour, when properly lighted, form a picture that once seen is not readily forgotten. At first sight it is so typically an ordinary plant, that its subsequent behaviour produces a feeling of great astonishment. One examines it carefully, and comes to the conclusion that it is a most beautiful filamentous weed. On placing some in the live box, and examining it at intervals, the mycologist begins to doubt his powers of observation, and wonders whether the heat from the reflector is the cause of what he sees. For lo and behold ! two pieces of the weed are seen to be approaching each other, and then each begins to swell at a particular point, forming lateral protuberances, which increase in size until that

from the one and that from the other meet. In the meantime the contents of the cells have altered, have massed together into a smaller space. Then the walls of two touching protuberances break, and the contents of the one cell passes across and joins that of the other. The "spore" thus formed eventually elaborates a fresh filament. Spirogyra is visible to the naked eye; it will be seen as a fine green thread-like weed often on the surface of the water.

This book is not intended to deal with plants alone, or else we might have made further inquiries into the life histories of many more interesting species. The reader will doubtless come to the conclusion that plants are greatly misunderstood, and that they are not so hopelessly inert as one might expect.

We are still in a world of Lilliputians: amongst the extraordinary plants, so very different to those we are familiar with, equally original animals live their lives, uninterrupted by modern civilisation. The motor, electric tram, and other complicated machines have made no difference to their lives, and except for circumstances of pond interest, they have altered little as time passed on.

The higher animals have been affected by modern conditions: the lion and tiger, the rook, and other wild birds have learnt what man is, have realised his danger, they have become accustomed to his manners and habits.

But the microscopic inhabitants of the pond have never seen man, and they can have no idea of his appearance, for their world is so vast that one shudders with the idea of what it must be. For the merest spot of water is a veritable lake to these minute creatures, which swim to and fro, passing over each other, and becoming lost in the depth of a "sheet of water" practically non-existing on a microscopic slide.

And man ignorantly wanders about, all-important in himself, and only too willing to form the opinion that everything was made for his particular benefit, and that all animals work by instinct, and have no hopes, no ideas—in fact nothing but the power to live.

And the mycologist, as he watches these little specks of life, vibrating with energetic movement, hurrying and scurrying to and fro, so busy in their lives, so eager to accomplish some object of which he has no knowledge, thinks perhaps of many a man, living a life of nothings—doing nothing, finishing nothing, never eager, never agile, except when it comes to a matter of games.

And then the humour of the situation comes to him, for he

is looking into a world of such small creatures that they are invisible except by the aid of the microscope, and these minute specks are perfectly equipped for their existence, and do not even know of this all-important semi-artificial product, which lives in the bliss of "Top of the Tree."

"Oh!" I can hear the reader remark. "What! does this pond-hunting enthusiast consider a microscopic quantity above man?" And the answer is "No." But to the writer's mind man is only one of the many fine creatures in this world, but he, unfortunately, owing to ignorance of his surroundings, thinks he is "the only one." And oh, for the pathos of such ignorance, for even a pond contains countless numbers of perfect creatures, and the largest pond is only a minute speck compared with the universe.

And as all the actions of the most intelligent creatures are labelled with that hopelessly inaccurate and childish title "Instinct," what can the actions of the Lilliputians into whose lives we are now to inquire be put down to? A nothingness? For we find that certain minute animalcules hunt in pairs—single-celled creatures for all that. Why should we think that the Deity has only given man the power to make the best of his surroundings (which he so seldom does), whilst all other things should exist, and no more?

As time goes on, and we become more enlightened, such ideas will be ridiculed by everyone, and we will learn that it is part of our duty to try and understand things, and not to imagine that all the wonders of this world were made for the particular purpose of being destroyed in the most expeditious manner.

So, returning to our pond life, we will study a few of the wonderfully adapted creatures known as Infusoria.

If we place a small quantity of hay in a jar of water certain small animals make their appearance after a very few days.

One of the first to appear is the amoeba. Amoeba Proteus is $\frac{1}{20}$ th to $\frac{1}{100}$ th of an inch in diameter.

Under the microscope this minute lump of jelly-like substance will be seen to wander aimlessly this way and that by producing temporary projections. Should, however, a current be produced the amoeba will be seen to work its way against it, and show every sign of unwillingness to float with the stream.

Although mouthless, and free from a digestive system, yet the amoeba feeds like every other living thing. It is interesting to see one obtaining a meal. The weird little cell, by altering its shape, wanders about until it touches a Desmid or

other speck of organic matter. Gradually the sides of the amoeba elongate until the prey is literally engulfed, the Desmid being deposited in the centre of a lump of protoplasm. When the victim has been digested, the amoeba opens and wanders away, leaving the remains of its meal behind it.

A time comes when the amoeba, having lived a happy life, becomes fat, and then the single-celled creature forms a waist, which becomes more fashionable until, having reached a minimum, it breaks, and two amoebas crawl in different directions.

The amoeba reacts to certain stimuli; electric currents, &c., show various effects.

It is most active in temperatures of about 100° F., and may be killed by poisons or excessive heating.

The famous Leucocyte or Phagocyte (white blood corpuscle), which inhabits the veins and arteries of the higher animals, is similar to the amoeba, wandering along when emergency calls, by means of "temporary feet." The amoeba may be found inhabiting the mud at the bottom of the pond, and can usually be easily discovered under a fairly low-power lens.

Under adverse conditions, such as when the pond dries up during a drought, the amoeba forms a case or cyst, and thus encysted remains dormant until conditions are again favourable. It may happen that the encysted amoeba is carried by the wind to another pond. Thus micro-life appears in fresh situations.

Certain of the Infusoria have cilia, and are known as Ciliata.

Stylonychia mytilus is a comparatively large protozoon, and will be seen swimming about in a most characteristic manner. It is a broadly oval organism with cilia along its sides. The mouth is very large, and the cilia with which it is furnished are most energetically waved, proving that at all events *Stylonychia* has an appreciable appetite.

This little creature, like many others, deserves that its name should be inscribed upon marble, as an example of energy, for the animalcule seems to be well stored with this quality, and free from any signs of fatigue. It is continually darting to and fro, as if the forward or backward movement resulted in the stretching of an elastic band, which suddenly becoming taut drew the creature back, whether it wished to come or not. Sometimes it crawls, at other times it travels by leaps and bounds, but usually the dart-like movement is its mode of progression.

It is most interesting to study *Stylonychia*, although it needs much patience, as it continually leaves the field of focus at the critical moment.

One of the largest of the Ciliata is *Paramecium*. It is just visible to the naked eye, as a minute white speck.

Like many others of the Protozoa, it is able to change its shape when occasion needs, but it does so only temporarily, for it very soon regains its usual form when it has passed the obstacle. Its body is covered with short, hair-like cilia, which it uses in swimming. Its mouth, known as the vestibule, is a cone-shaped depression, furnished with long cilia, by means of which very minute particles of organic matter are washed in. When *Paramecium* is interfered with or wishes to obtain living food, it shoots out long threads, from certain special organs known as "trichocysts." These threads, in some way or other, have a paralysing effect upon the victim.

Multiplication occurs by conjugation. Two individuals fasten together, and their protoplasm becomes continuous through their mouths. The nuclei then undergo changes, after which the creatures separate. And curiously enough, no sooner has this occurred than both *Paramecium* divide into two, thereby forming four young ones of the same kind.

Paramecium is popularly known as the Slipper Animalcule, because it to some extent resembles such an article. A bedroom slipper, that has seen much wear, and is thereby out of shape, is perhaps rather like the creature.

Trachelocerca Olor, or the Swan Animalcule, is one of the most charming of all the Protozoa to be found in a pond.

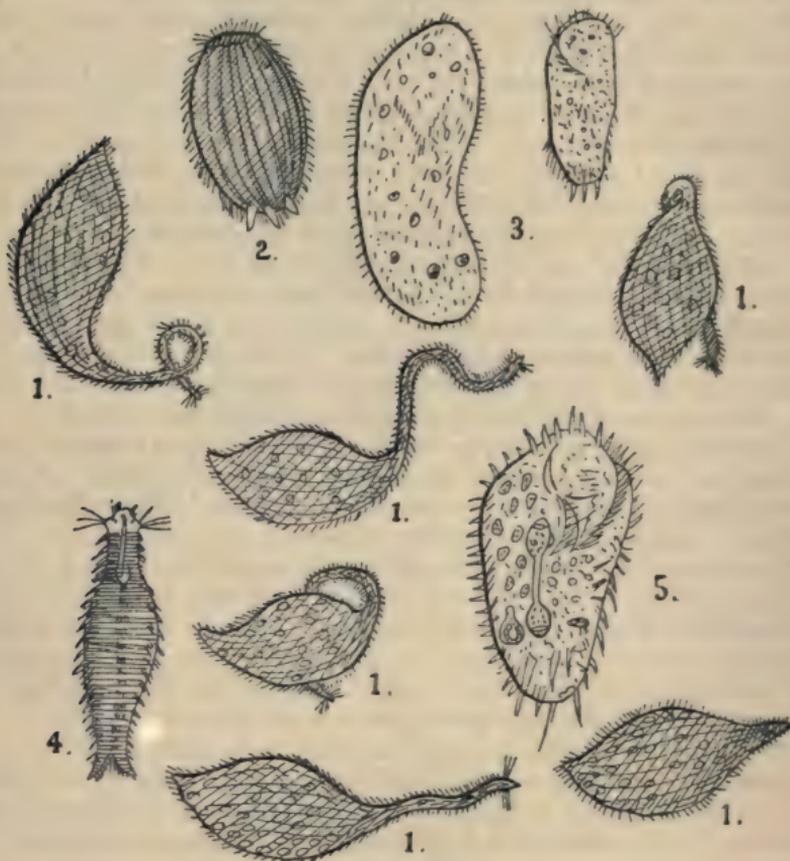
Its title it certainly well deserves, for it has the extraordinary power of forming a swan-like neck of surprising flexibility when required, or I might better say of reducing its neck to a short, stumpy growth when occasion needs.

At times it will rest in one spot, its neck writhing so gracefully that it reminds one of the artistic arm play of the well-known Maud Allan style of dancing, except that the minute creature is the essence of gracefulness, each movement rounded off with a perfectness that the dancer can never attain.

And if we have the opportunity of watching this minute animal at play, gracefully twisting its neck into all sorts of inconceivable evolutions, we begin to wonder if there is anything new in this world of ours.

It is hard to describe the movement of that neck, so supple, and so lithe, that one expects any moment that it will break with the effort to form the necessary curve, and when *Trachelocerca Olor* becomes active in search of food one realises the value of the play. We are all aware that unless in practice we soon become unfit, and to be an expert at rapid and yet comfortable movement every muscle must be exercised. And

the minute animal, although a single cell, seems to understand that this rule also applies to it. When searching for food its neck moves with wonderful rapidity, darting in and out, twisting here and there, shortening, lengthening, just like the



INFUSORIA

1. Swan-necked Animalcule. 2. *Coleps hirtus*, or Barrel Animalcule
3. *Paramecium*. 4. *Choetonotus larius*. 5. *Stylonychia mytilus*.

imaginary snake should do, and then suddenly its body becomes lengthened, and it swims rapidly to another spot.

Strangely enough, we find that *Trachelocerca Olor* believes in co-operation, and so usually has a companion. But whether this is really a matter of agreement, or whether it is the result of mere chance, it is difficult to say.

From personal experience I have never seen two of these

strange little creatures in any way assisting one another, although usually if the mycologist has the good fortune to find one, a second soon makes its appearance.

It is interesting to know that *Trachlocerca Olor* was one of the first Protozoa to be discovered.

Coleps hirtus—known as the Barrel Animalcule—is not only interesting but highly useful. For it is one of the micro-scavengers, and spends most of its life clearing away the dead and decomposing remains of the unfortunate inhabitants of ponds and streams.

Coleps hirtus sometimes rolls along in a characteristically barrel-like fashion, but usually it swims to and fro, resting for a considerable time between each movement.

It multiplies by producing a waist until it resembles a diabolo. Fission takes place, and two *Coleps hirtus* are produced.

Choetonotus larus is always in a hurry, and characteristically minds its own business. This is the impression it leaves on one's mind, as it bustles along, stops for nothing, and seems to have every intention of reaching its destination wherever it may be. Should it meet an obstacle, and find its effort to push through unsuccessful, it turns and hurries off again, possibly in exactly the opposite direction, but seemingly with the same determination of eventually getting "there."

It is a queer-looking little creature, partly on account of the cilia just behind the head, that resemble to some extent side whiskers.

Choetonotus larus is a member of a family known as *Gastroricha*, of which there are very many species. Some have eyes, others as far as can be seen are eyeless. Their food usually consists of decaying organic matter, but occasionally they attack creatures larger than themselves, and once having made a wound savagely feast on the escaping cell contents (protoplasm).

Choetonotus larus is probably a hermaphrodite (male and female in one), but so far only one sex has been determined. Females carrying eggs have been seen to lay them amongst aquatic weeds, where they remain, prevented from slipping off by the roughness of their deeply engraved shells.

The *Gastroricha*, although to some extent resembling *Infusoria*, are classified with the rotifers amongst the worms.

THE BELL ANIMALCULES

Some of the queerest little animals are members of this family. The best known is the "Vorticella." Each little creature consists of a cup, or bell, and a stalk, the latter able to contract and expand in the manner of a coiled spring.

The movement is aided by a muscle fibre, which passes down the stalk. The mouth of the bell is surrounded by cilia, and these producing aquatic currents, all sorts and conditions of things are washed into the cavity.

Similarly to most of the microscopic pond inhabitants, vorticella are always busy. They uncoil, rising slowly until their stalks are fully stretched; for some few seconds the cilia wave lustily, and then with a suddenness and surprising rapidity they recoil.

It would seem that the vorticella practically immediately regret their action, for the very next moment they very gradually unwind, the bell opens, and the cilia are very soon most actively engaged. When they recoil the cilia are withdrawn, and the bell takes the form of a ball.

Vorticella multiplies by dividing longitudinally, and on examining a colony several individuals are certain to be in different stages of this function. When fission is complete one of the individuals remains in the stalk, whilst the other swims away and starts life "on its own."

Vorticella also multiplies by conjugation. When this is about to occur, one or more of the individual bells divides rapidly into many small vorticella, and these, breaking away from the stalk, swim to a mature individual.

The smaller vorticella is absorbed by the larger. It is interesting to know that if different parentage is prevented (that is to say, the vorticella is forced to multiply with relations), after a short while they become degenerated.

It is really most surprising how rapidly colonies of vorticella appear, become numerous, and disappear.

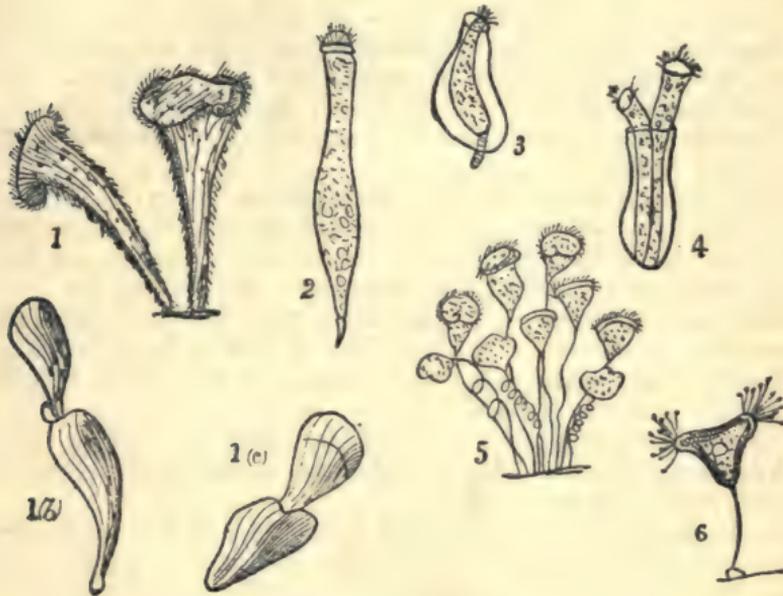
One may find that the aquarium is well stocked with these creatures—in fact that weeds, broken sticks, and even snails are covered with them, and within a very few days one may search high and low, and not find a single colony.

In the aquarium a colony of vorticella can be seen with the naked eye, as white fur, on stems of weeds, &c.

There are many kinds of bell animalcules—some grow as bunches on one stalk, others are in a tree-like colony with

many branches, each ending in a single bell; and their behaviour is characteristic of their kind.

In some cases the whole colony is fastened on one single stalk, and contracts in sections when occasion needs, for each part of the colony acts in conjunction with any single member of that particular group. In others the main stalk contracts, so that all the branches are drawn down together,



BELL ANIMALCULES

1. *Stentor polymorphus*. 1 (b) and (c). Free swimming and multiplying.
2. *Ophrydium versatile*. 3. *Corthurnia imberbis*. 4. *Vagincola*. 5. *Vorticella*.

SUCTORIA

6. *Acineta*.

whilst in the case of *Epistylis* the main stalk does not alter, but each individual contracts singly.

Sometimes a blundering free swimming rotifer, or the most exasperating nematode worm, is the cause of the sudden retirement of a single member, a part or the entire colony depending on the kind, but it often happens that these bell animalcules seem totally indifferent to interruption, for the writer has frequently seen a colony of *vorticella* pushed into a different position by some unscrupulous interloper, and

yet continuing to feed, seemingly totally indifferent to their visitor.

But usually, they are most sensitive to touch, and will remain in retirement some little time, if very violently interfered with.

Whilst some bell animalcules live more or less independently, others again are surrounded by a jelly-like substance.

Ophrydium is often found as a lump of jelly $\frac{1}{4}$ th of an inch in diameter. Under the microscope it will be seen to be the home of many hundreds of vorticella-like creatures. Each minute animal is able to withdraw or extend in search of food, whenever it may wish to, perfectly independent of the remaining colonists.

Although most of the bell animalcules seem to prefer a social life to a solitary one, a few species are the exceptions, and live quite independently, the most beautiful of these being *Cothurnia*, *Umbellula*, *Vaginicola*, and others.

Two very interesting experiments may be performed with these little creatures. If a solution of iodine be added to the slide of living vorticella, the nuclei of the cells will immediately take the stain.

Vorticella feeding may be watched, and the course of the food followed, by allowing a very small quantity of Indian ink to run under the cover glass.

The little specks of black will be caught in the vortex, and taken in by the animalcule, but after some attempt to digest them, the Indian ink particles are returned to the water.

SUCTORIA

The Suctoria contain some most curious little animals—a good example being the *Acineta*. Each little creature, less than $\frac{1}{100}$ th of an inch in length, stands on a hardened stalk, which terminates in a triangular cup-like structure. Out of the corner of the cup, arms are thrust, each arm ending in a little knob. In some species the arms are able to open into tubes, through which the food is drawn.

Should an unfortunate creature, such as a small rotifer, come into contact with one of these tentacles, its doom is sealed, for the other suckers bend over towards the victim. Gradually the fluid portions of the rotifer are sucked out, until nothing but the solid portions remain.

By what power the *Acineta* is able to hold its prey, is

difficult to say. The life history is of interest on account of the fact that the members of the Suctorina start life as free swimmers, resembling the Ciliata.

Gradually the young mature, until eventually they become similar fixed objects to their parents. Hence we may say the Acinetaria were probably evolved from the Ciliata some far bygone day.

A little animal, fastened to a stem or leaf, resembling a model post-horn, swinging gently from side to side, will often be found, when searching for microscopic pond creatures. Or a green, pear-shaped animal may swim with a peculiar roll across the slide, turning over and over until it passes out of the field of view. Perchance two such creatures, fastened one above the other, may make an appearance.

Stentors, like most other micro-pond animals, multiply, and so should one be found it is more than likely that others will shortly be discovered.

Stentor Polymorphus is a green little creature, and although able to swim often settles on a favourable spot and produces a temporary foot.

Thus a colony is founded, which increases until a large number of individuals are closely packed on the same weed. Occasionally a member of the colony will liberate itself and swim by means of the cilia with which its body is covered to a fresh spot, and there start a new colony. From the writer's personal experience it would seem that Stentor Polymorphus is free swimming during certain seasons, and usually sedentary during others.

The animal itself will be easily recognised by the illustrations. Illustration No. 1(b) shows Stentor Polymorphus multiplying by division, but it is interesting to know that sexual reproduction also takes place, in which case two stentors join together. Strangely enough, whilst in the act of dividing, the stentor swims actively, changing its shape, contracting and expanding, as if perfecting normal.

The trumpet shape of the individual, the peculiar twist of the opening of the funnel, and the size of the creature does not allow any confusion in its identity; for it in no way resembles vorticella, nor can it be mistaken for a rotifer.

Free-swimming stentors, especially whilst engaged in division, are most interesting to watch, whilst a group of settled stentors, viewed with a dark background, is certainly a beautiful picture.

Stentor Niger or the Black Stentor is a free swimmer. It is a smaller creature than Polymorphus, and not so well dis-

tributed as the latter. *Stentor Niger* does not surround itself with a case. *Stentor Coeruleus* is scarlet in colour, *Stentor Igneus* blue.

The stentors are the largest of the Ciliata. The colouring pigment in the Blue Stentor has been named by Lancaster blue stentorin.

CHAPTER II

AQUATIC CRUSTACEANS

"GIVE a dog a bad name and hang him" is very true in the world in which we live, and the reader, particularly if a member of the gentler sex, will probably leave this chapter unread. For the flea is an animal barred from conversation.

Its existence is ignored by those free from its presence, whilst he or she chosen by the interesting little animal as a food supply is belabelled as uncleanly.

But the water-flea is no relation to "the flea we don't know." It is a harmless, interesting little creature, far too busy in its own sphere of life to interfere indirectly or directly with the all-important man and his subordinates.

One may notice occasionally, particularly on a warm summer day, that certain parts of the pond are reddish or whitish colour. This colour on closer examination will be found to be the result of large numbers of water-fleas congregated in that particular district. These creatures are members of Cladocera, a sub-order of the Branchiopoda, a division of the crustaceans, and are characterised in that their breathing organs are attached to their limbs (Branchius poda=leaf-footed). There are several species of water-fleas, some small, others comparatively large. Some live in running water, others prefer the most stagnant pool, whilst yet another species inhabits water so saturated with salt that no other creature could possibly live there. A few that live at a great depth or in underground water are eyeless.

The British Cladocera are divided into eight families, all more or less resembling the *Daphnia*.

Each little creature is surrounded by a case, known as the carapace, which varies both in size and in shape in different families. In some the carapace is large and entirely encloses the creature; in others it is small, and in the case of *Gymnometra* it is large when the creature is carrying its eggs, but

shrinks when not required for this purpose. The headpiece of the carapace often forms a prominent curved beak, giving the animal a most curious appearance.

The food of these little crustaceans is various; usually it consists of decomposing organic matter. *Apus*, a species of Phyllopora now thought to be extinct, has been seen to attack tadpoles, whilst *Daphnia*, being less of a gourmand, is satisfied with a diet of mud.

The limbs, of which there are never more than four pairs in the Cladocera, are in certain species most beautiful objects, those of the female *Simocephalus* being adorned with hairs, resembling the most perfect feathers, of microscopic size. When the creature is swimming the carapace is usually open, but should the water-flea wish to rest the "shell" acts as an anchor by gripping the weed.

Leptodora hyalina and *Daphnia Pulex* are two of the largest British species, and are therefore of particular interest as they afford examples for study.

Daphnia Pulex can be readily recognised by its size and prominent beak. Owing to the transparency of both carapace and body, one is able to watch natural functions with perfect ease. The heart, a peculiar cleft organ, will be seen to be actively "beating." The digestive tract can be examined from end to end (not a very great distance) and in certain species the young, which remain inside the maternal carapace until mature, can be seen to have inside their little carapaces a yet younger generation.

Fortunately for the water-flea and its admirers, asexual reproduction is constant. The male is a very rare creature, and only appears in meagre numbers at particular times. In fact he may be labelled as a rarity. He resembles the female, but is much smaller. Water-fleas produce two kinds of eggs, winter and summer eggs. The former, which are fertilised eggs, are produced on the approach of cold weather or other critical periods.

The carapace of the female becomes thickened, and the eggs, either one or two, are enclosed therein. The creature then moults, and the discarded carapace containing the eggs rests on the mud until conditions are more favourable. These winter eggs are most hardy in structure, and can resist freezing and drying with impunity.

The carapace and eggs, which are very light, may be blown by the wind from a dried-up pond, or carried by birds or other animals to fresh water. Hence water-fleas often make a sudden appearance in water where they have not previously been found.

When food is plentiful and other conditions favourable, large numbers of unfertilised eggs are produced, which hatch shortly after being laid.

Before we leave the water-fleas mention must be made of their characteristic single eye. At a very early period in the babyhood of the creature two eyes were present, but these before long fused together, and were surrounded by special tissue. Certain species of the Phyllopora have two eyes, whilst in others the eye resembles that of the Cladocera (water-fleas)

CYCLOPS

Cyclops, the one-eyed giant of Greek mythology, has a worthy namesake in the personality of Cyclops, the one-eyed crustacean. In size the latter is far from being a giant, but on the contrary is a tiny pear-shaped, creature. Its one eye, the result of two fused together, is the only thing that bears any resemblance whatsoever to the mythological character.

There are several species of cyclops, similar in appearance but differing in size and colour. They are all pear-shaped with long antennæ, and a single medial eye. They have four pairs of legs, each pair being fastened together by a transverse muscle, so that the leg on one side and its fellow on the other move together. Hence the creature is driven through the water in a peculiar dart-like manner.

The male, which is rarer and smaller than the female, is easily differentiated from the gentler sex by the absence of encumbrances. The female cyclops carries one or two egg-bags, fastened to her abdomen; each bag contains fifty or sixty eggs. The young, when hatched, in no way resembles its parents. It is a peculiar little creature, typically a larva of the crustacean. As soon as it enters the world it leads an independent life, driving itself through the water by an occasional powerful stroke. It is so minute that it is practically invisible, and could be mistaken for a tiny speck of dust.

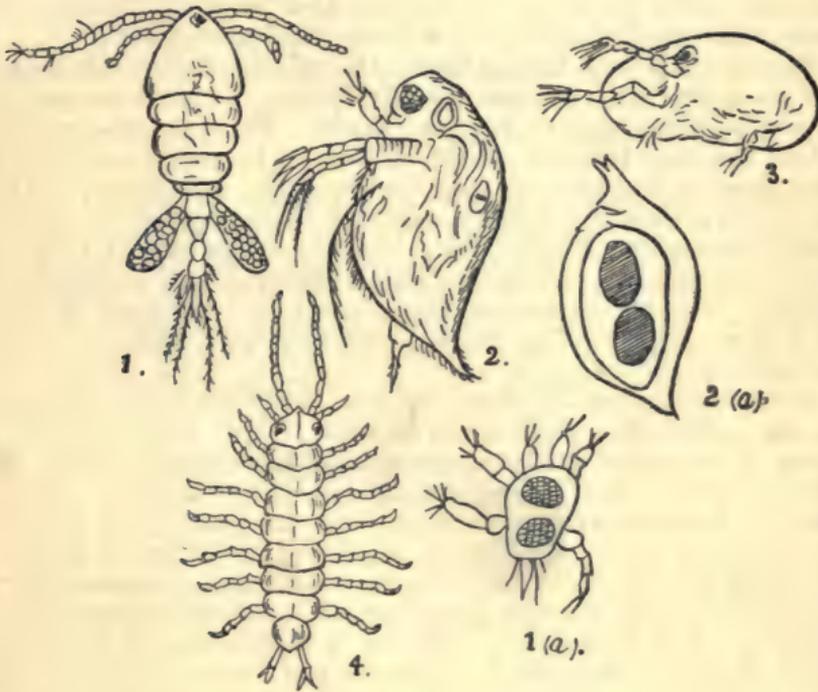
The larva undergoes a series of changes, and eventually takes the form of the adult cyclops. On one occasion I found a black cyclops carrying her egg-bags. In two days her colour had noticeably changed—was in fact less dark—and on the seventh day the eggs hatched.

The female's colour, which at the beginning of the week had been black, was now of lightest brown. She was swimming to and fro in a most weird manner, head downwards, antennæ spread out as if intently searching the neighbourhood for her

youngsters. After much trouble, several members of the family and the mother were placed in the live box. But unfortunately before the writer had the opportunity of witnessing a meeting, an accident occurred, and her ladyship had disappeared.

How the change of colour had occurred was easily explained when the water in which the cyclops had been living was examined. Two skins, one dark coloured, and the other lighter, were found; on the former were the remains of the egg-bags.

The life of the cyclops is not all pleasure. Many inhabitants



CRUSTACEANS

1. Cyclops, the one-eyed crustacean. 1 (a). Young cyclops. 2. Water flea.
2 (a). Egg-bag of water-flea. 3. Cypris. 4. Asellus aquaticus.

of the pond, especially the larva of dragon-flies, are partial to a diet of "shell-fish." The cyclops are also infested with colonies of bell animalcules—sometimes completely covered with numbers of these creatures—while certain rotifers, knowing cyclops to be a capable carrier, may nearly always be found

busily at work perched on various parts of the crustacean's body.

The eggs of cyclops are not dependent on the body heat of the mother in order to hatch, for eggs separated from the parent hatch in due course.

Another crustacean that frequently falls victim to the pond-hunter is Cypris. It resembles a minute brown mussel about the size of a clover seed. On a close examination the likeness to the mollusc increases. For Cypris lives in a bivalve shell—a shell that opens on one side only in the prescribed manner. And when the little brown shell opens two long antennae adorned with hairs are projected, and without further ado away goes the little creature with surprising rapidity.

Strange as it may seem, the male Cypris has never been found, and so reproduction must nearly always be parthenogenical. Cypris lays her eggs on aquatic plants. Weisman was successful in keeping females of Cypris for eight years, and during that time they produced eggs continually. An animal similar to Cypris is *Condona reptans*, which is characterised by a longer and more curved shell, lighter in colour, and also by its antennae, which are minus the hair appendages so noticeable in Cypris. A glass jar containing a teeming population of these little creatures as well as *Daphnia* and *Cyclops* is indeed a "thing worth having."

Every pond-hunter, every eater of watercress, knows *Gammarus pulex*—the fresh-water shrimp. This little animal, a giant if compared with cyclops, a Lilliputian when placed side by side with a lobster, is common in every stream. Leaves, dead and decomposing, decaying animal matter, in fact all refuse, is its happy hunting-ground, and there *Pulex* plays to its heart's content. But hunger, or at least the satisfying of it, is the reason for its presence amongst the decomposing matter. For *Pulex* is a scavenger, and is only too glad to clear away by the destructive process of eating anything that is suitable. The water-shrimp is not a fad, and is only too pleased to eat healthy and fresh weeds when occasion needs.

The males and females at certain seasons will be found swimming together, the male holding his spouse by the neck, by an enormous claw. The eggs are carried by the mother in her front legs, which form a brood-pouch. The young, which resemble their parents, but are redder in colour, on hatching remain with the mother until dispersed.

Asellus aquaticus—the water hog or louse—is far less active than *Pulex*, in fact it will be found creeping sluggishly on the mud or weeds, slowly as if fearing danger. Like the latter, it

is a good scavenger, and should be useful in a badly-managed aquarium.

Unfortunately both *Gammarus pulex* and *Asellus aquaticus* find a stagnant-water aquarium unpleasant, and soon die. It is difficult to understand the cause of death, for the writer kept a large number of freshwater shrimps in a jam jar with few casualties, whilst those in the aquarium have died in a very short time. The depth of water cannot be the cause. *Asellus aquaticus* was found to inhabit the abysmal regions of Lake Geneva at a depth of 130 feet.

CHAPTER III

INSECTS

ALL insects have what is termed a "life cycle," that is, they usually undergo various transformations ere they become like their parents. Everyone is familiar with the caterpillar, the queer and sometimes beautiful creature found enjoying life in the vegetable kingdom, and most people have seen a chrysalis at some time or other. Well! These are two stages in the life cycle of the butterfly or moth, which consists of:

The egg,
The caterpillar or larva,
The chrysalis or pupa,
And the adult butterfly or moth as the case may be.

These transformations are what all self-respecting insects ought to go through, but some do not. We find that several kinds hatch into larva (caterpillar) and subsequently change into the adults without becoming a pupa (chrysalis); whilst again the young springtail is similar on hatching to the parent practically in all respects, except size, thus missing the larva and pupa stages. The above points are of importance, or else the reader will be less able to understand what follows. In short, if the life history is "complete," an insect egg hatches into a larva. The larva feeds and eventually changes into a pupa; in the meanwhile it eats and sleeps, but gradually alterations are taking place in its form and structure, and eventually the pupa case is torn open and the perfectly-formed insect makes its *début*.

Some species of the following families spend their entire lives

or often their younger days in water, and can be recognised by the points mentioned :

- | | |
|---|---|
| (1) The Neuroptera (dragon-flies, may-flies, caddis-flies, &c.) | Two pairs of membraneous wings (lacelike). |
| (2) The Lepidoptera (moths) . . . | Two pairs of wings covered with scales. |
| (3) The Diptera (gnats, corethra, &c.) | One pair of membraneous wings, one pair of degenerate wings (halters, little rods with knobbed ends). |
| (4) The Coleoptera (beetles) . . . | One pair of membraneous wings, one pair of hardened wings known as elytra. |
| (5) The Hemiptera (bugs) . . . | One pair of membraneous wings, one pair of wings partly hardened. |
| (6) Aptera (springtails). . . . | No wings at all. |

WATER-BEETLES

Water-beetles are common inhabitants of all ponds and streams. How contaminated and foul the water, or how large or small the pond may be, makes little difference to the aquatic Coleoptera as long as they are able to find the food they require. The eggs are laid under water, the young larva hatch and live in the same environment, but the pupa stage is nearly always passed out of water.

The aquatic beetles belong to three main groups :

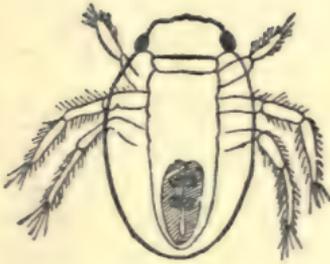
<i>Characteristics</i>	<i>Habits</i>
Hydradephaga, long antennae .	Carnivorous and vegetarian.
Hydrophilidae, shorter antennae.	Vegetarian and seldom carnivorous.
Gyrinidæ, very short, broad antennae (live on water surface)	Carnivorous and vegetarian.

THE HYDRADEPHAGA

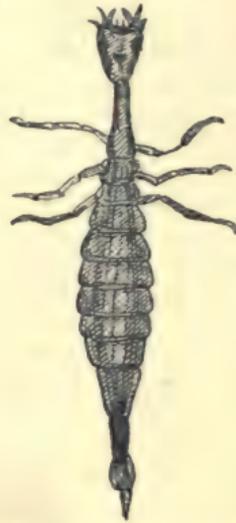
The largest of this family is the well-known *Dytiscus*, the giant amongst British beetles. Although very savage, *Dytiscus* only kills when it actually requires food. It swims slowly, searching systematically for some unwary creature. A tadpole may be resting amongst the weeds, and disturbed, blunder into the beetle's "arms." In a moment it is seized; swim how it may, there is no chance to escape, although the victim, if large and strong, may drag its captor some distance. If *Dytiscus*

should be hungry it will hang on, to its victim with a tenacity worthy of a bulldog. In fact the beetle can be lifted out of the aquarium and swung round and round without relinquishing its hold.

The male and female *Dytiscus*, though of the same size, are readily distinguished from each other: the former having two disc-like structures on its front legs, which are absent in the female. These discs secrete a sticky, gummy material, with which the male holds the female. This sticky substance is sometimes the cause of a most unenviable position, as the male beetle finds itself stuck to stones, and other objects. The un-



Young *Corixa* (one hour old).



Larva of *Ascilius sulcatus*.

fortunate creature takes some time to get free, and no sooner is this done than it resettles, and the trouble starts again. Thus a beetle may be continually sticking to various objects, much against its wish. The wing-cases—elytra—which are the first pair of wings hardened, not only protect the membranous wings, but also act as an air reservoir. For the water-beetle is unable to live on aerated water, and depends entirely on the atmosphere for its supply, and so we will notice that the insect comes to the surface at frequent intervals, and extrudes the end of its abdomen, drawing back the elytra, so as to facilitate the entrance of air, and then, with a supply imprisoned beneath the wing-cases, it swims slowly away and remains below until the store is exhausted. *Dytiscus* lays her eggs in clefts made in

the stems of water-weeds. The eggs hatch into peculiar larvae very different to the parents. The body is brown and segmented, and the usual three pairs of legs are present: the head, joined to the body by a narrow neck, is broad and flat with cruel curved fangs (mandibles), and on the last segment of the creature's body two fringed tubes are borne, which contain the spiracles and supply the larva with air.

Similarly to the adult, it must rise to the surface to extrude the end of its abdomen. The creature is well adapted to the life it leads, for its colour makes it difficult to notice, especially when resting on the mud. It obtains food not by chase but by stealth, and concealed by its colour waits until a tadpole or other creature touches it. Then its prey is savagely seized and held in the sickle jaws, through the fine canals of which the liquid portions are drawn up, for the larva, although possessing a mouth, is unable to use it. The young *Dytiscus* has an insatiable appetite, and so has no sooner dispensed with one victim than it is ready and eager for another. Worms, tadpoles, fishes, newts, larva of its own kind, large or small, full-grown water-beetles, all are slaughtered. For some time the youngster kills and grows, having frequently to change its skin as its size increases, until it reaches the maximum of $1\frac{1}{2}$ inches.

Although no longer so agile, its savagery has by no means diminished. The hand of the owner, so bravely lowered into the aquarium, if it should be placed within seeing distance of the larva, is not there on a future occasion. For the *Dytiscus* is a mass of ferocity, eager for the blood of anything that comes its way: nor is it afraid to protect itself by any means. Eventually it becomes less active, and slowly swims to the side of the pond, in order to leave the water for pupating. It buries itself in the mud, and here, in a sanctuary safe from its enemies, rests whilst the wonderful changes that are to make it into the beetle are undergone.

And one fine day the pupa case is ruptured, and the perfect insect brushes the earth aside, and finds its way back into the pond where its larvahood was spent. The adult, although a carnivorous beast, dearly loving a tadpole or worm, can if necessary live happily on vegetable matter, and being by no means a faddist, enjoys freshly dead or living creatures, or even decomposing organic matter. In habits it is much altered. As larva it waited ready to pounce on some unfortunate visitor—but when adult it swims sedately until it finds what it requires.

Ascius sulcatus is a beetle very similar to *Dytiscus*. Its

larva might also be mistaken for that of the latter, except for its long, tapering neck. It has the habit of slowly approaching its victim until near enough to make an attack. Then with indomitable spirit the larva clings on to its capture, large though it may be, hard though it may struggle, and shakes it in a similar manner as a terrier does a rat. Very soon the victim becomes less active, and death approaches. During the struggle the blood of the unfortunate has been gradually, but continually, passing up the sickle-shaped mandibles into the ever-ready stomach.

Whilst the members of the *Hydradephaga* lay their eggs in the stems and on the leaves of water-weeds, the *Hydrophilides* nearly always make an egg cocoon, in which the precious eggs are safely deposited. *Hydrophilus Piceus* is the largest of this family. The female forms a ball-shaped cocoon of closely woven silk, anchors it to some well-submerged object by a tiny silken rope, and eventually the eggs, which number about fifty or so, hatch into minute larvae. Although, as previously mentioned, the adult is practically a vegetarian, yet her larvae are as voracious as the young of *Dytiscus*, and savagely slaughter the unfortunate inhabitants of the pond irrespective of size and kind. When so engaged they have the peculiarity of bending over in order to use their own backs as a table on which to demolish their victim.

Their life history is similar to that of the *Dytiscus*, the larva eventually pupating into the adult, a beautiful large bronze-coloured beetle of a harmless disposition. *Helochares*, another member of the *Hydrophilidae*, although forming a cocoon, does not leave the eggs to hatch as *H. Piceus*, but fastens the egg-bag to her abdomen, and carries it about until the eggs hatch. Each little egg is white, and the eyes of the future larva can be clearly seen within. The mother uses her hind legs to hold the bag, taking all care to prevent injuring it, or losing her family. The eggs hatch into very minute larvae of exceedingly savage dispositions, that bite and snap from the very moment of hatching.

As in the case of all other young water-beetles, cannibalism is not only thought of but runs rampant, and the minute beetles slaughter one another with perfect indifference. The contrast between the parents and the offspring is extraordinary, particularly in this case, for the adult *Helochares* is of a gentle and quiet disposition, wandering over the leaves of water-plants, partially surrounded by an air-bubble that gives it a silver-like appearance, whilst her children are as savage as the parents are docile—in fact, so much so that

they open and close their mandibles from the very moment of birth.

The "whirligigs" are members of the Gyrinidae. They are metallic-like little beetles of shiny appearance and oval in shape. Their name implies their habits, for they are always whirling about on the surface of the water—rushing round and round at a great pace, often as if engaged in a game of catch with others of their kind: should danger threaten, the Gyrinidae dart beneath the water and hide in the mud until satisfied that all is safe, and then reappearing continue their interrupted pastime.

Nature has treated few creatures more kindly than the Gyrinidae: their shape, the well-rounded elytra, the peculiar arrangement of their eyes, that allows perfect vision of the air above and the water below, give them a superiority over most other creatures. When the sun is shining these fine little beetles skimming to and fro on the water-film resemble highly-polished steel bullets.

In the spring the females lay their eggs on water-plants. After a few days the eggs hatch into very curious little creatures of charming appearance. Although so fragile they, like the larva of *Dytiscus* and *Hydrophilus*, are carnivorous, and spend their youth destroying and feeding upon all that comes their way. Eventually they climb out of the water and wrap themselves in a cocoon to pupate. After three or four weeks the little metallic beetles make their appearance and re-enter the water. Needless to mention, the Gyrinidae are good fliers, and during the summer, attracted by the light, often enter open windows, and mistaking the tablecloth with its cups and plates for a pond, fly down, landing in all sorts of unconventional positions, often on their backs, on which they rapidly spin round and round in a most astonishing manner.

In its natural element, either on the surface of or in the water below, *Gyrinus* has few if any equals: but on land its powers of progression are sadly at fault. During our childhood two short words were constantly used—"Don't touch"; and the gentle reader will, I am sure, forgive me for repeating the old adage, for water-beetles when frightened are able to produce a foetid-smelling liquid so nauseating that one more than regrets having fingered the creatures.

Although water-bugs are not the obnoxious animals their name would imply, yet we cannot be surprised that bugs are universally disliked, for no other family of insects has played or will play such havoc to man's crops as the bugs. The water-Hemiptera (*Hydrocorisa*) are, however, perfectly harmless,

except to the other pond inhabitants, but to these unfortunates they are a cause of continual anxiety.

Firstly, the scorpions lie concealed in the mud or amongst the vegetation, and make sudden unexpected snatches—then *Corixa*, and *Notonecta*, the water-boatman, spend their time hunting all that comes their way.

Nepa Cinerea, the water-scorpion, is the largest aquatic bug found in our country. The creature, if judged by its appearance, would be considered decidedly uninteresting. In colour and shape it resembles a small brown leaf, and to make this similarity yet more complete, its thinness is such that, until it strolls majestically from amongst the weeds, it is difficult to believe that it is really an animal. Its flattened body is terminated by a thin tube which divides readily into two parts longitudinally. When air is required the insect pushes it through the water-film, but sometimes *Nepa* will save itself a journey by utilising the bubbles of oxygen produced by plants beneath the surface.

Nepa, like all other insects, has three pairs of legs: the front pair are not used for walking as one might suppose, and except for brushing aside the weeds through which the insect is progressing, they are only used for capturing its prey. We might roughly say that the front pair of legs serve as hands, and good ones too. The unfortunate tadpole that incautiously approaches is seized, and without more ado is drawn towards the ever-ready beak, however violently it may struggle.

Even the caddis-worm, so well protected from enemies, falls a prey to *Nepa*. The latter seizes the caddis case and holds it in the most affectionate manner, and then by carefully moving it along until the small end is in a convenient position, forces one of those most useful front legs into the case, similarly as the fisherman uses a blunt pin. Then gradually the unfortunate caddis-worm nears the entrance of its case, but the scorpion knows its work too well, and cautiously shifting the case the leg is pushed in and the larva driven from its shelter. No sooner has its head appeared, than *Nepa* slowly but carefully drives its sharp beak into the soft portion of its victim, just behind the head. The case falls on to the mud below, and *Nepa* holds the owner in its embrace, and gradually sucks out the juices. The coal-black eyes of the murderer, so prominent and yet so small, are typically cruel.

The female *Nepa* lays her eggs on water-plants: each egg is adorned with seven filaments, which are thought to collect air for the embryo inside. The larvae are similar to the adult in appearance, but have neither the long breathing-tube nor

wings. The latter gradually make an appearance as the age of the larva increases, whilst the small stumpy tail is replaced by the tube as in the adult.

When *Nepa*'s "elytra" are expanded, and the membranous wings beneath exposed, it seems no longer so repulsive a creature: the sides of its abdomen are brightly coloured.

Water-scorpions seldom remain long in the aquarium unless it be covered: on the approach of winter they hibernate, and only return to "active" life the following spring.

Although *Ranatra Linearis* lives a life very similar to *Nepa*, yet its appearance is vastly different: its body is long and very slender. The head, similarly to *Nepa*, has a prominent sharp beak, and the bead-like eyes are conspicuously placed on the sides of its head. If these two water-scorpions were compared *R. Linearis* would receive premier honours for agility, fragility, and savage disposition, but all the same it is practically as sluggish as sluggish can be.

When walking *R. Linearis* lifts itself up on its long legs, thus giving the appearance of walking on stilts. Should it leave the water it experiences a great deal of difficulty in breaking the water-film. Its efforts are most amusing to the biped onlooker, for the water-film is no easy thing to crack, and the insect is so light and fragile, that everything seems to be against the success of the undertaking.

But water-bugs are not all of so sluggish a disposition as *Nepa* and *Ranatra*. *Notonecta* or the water-boatman is very common in certain districts and equally rare in others. Its size depends on its age, but its appearance is similar whether old or young, and as one might expect from its astonishing name it resembles a boat, for its back is deeply keeled whilst the underside of its body is flat. Thus *Notonecta* adds to the similarity by swimming continually on its back. Its front legs, which are never used for swimming, are held beneath its head, ready to seize any little or large creature that it may meet with; for size has no dimming effect on *Notonecta*'s courage should it be hungry. The front pair are also useful to hold on to the weeds on which *Notonecta* is settled. The third pair are used for swimming only, and are very long and fringed with hairs.

By means of well-timed, powerful strokes the little miniature vivan't boat is driven through the water. The second or middle pair seem to be useful either to aid *Notonecta* whilst swimming or to assist in holding on to the weeds when resting. But *Notonecta*, although settled, is far from asleep. In fact the oars, held well out, are gently paddling, and its sharp,

prominent eyes keep careful watch. The water-boatman has a very low specific gravity, and therefore must cling on to weeds or sticks in order to remain below. Sometimes the little creature will be seen to dart down into the mud, and often seizing a quantity rise through the water for a moment, and then after dropping the mud dart down again. This behaviour may be repeated for some time. *Notonecta* is not feeding, nor is it attempting to alter the bed of the pond, but the fact is that it wished to remain below, and seizing some loose or light matter of low specific gravity rises with it. For a moment the water-boatman does not realise that it is rising, but on doing so wastes little time in throwing away the encumbrance.

At intervals, when its air supply is exhausted, *Notonecta* rises to the surface, and extrudes its abdomen. Sometimes on reaching the water-film the little creature will actually walk on the underside without breaking it in a most curious manner. On fine days it will rest just beneath the water-film, as if enjoying the warmth of the sun.

The boatman seizes its prey with its front legs, and holding it thus above it sucks out its juices by means of its sharp beak until nothing but the skin and solid parts remain.

This sharp beak the creature is an adept master of, as the following incident will show.

An ardent pond-hunter on one memorable occasion placed a matchbox containing a large water-boatman in his pocket. Later, having to resort to his handkerchief, he placed his hand in his pocket. But *Notonecta*, which had escaped from the matchbox, probably mistaking the action, "pinched" him. The sudden pain was too much for the pond-hunter's feelings or language. In a moment off came his coat and out came Mr. *Notonecta*.

The *Corixidae* are often mistaken by the novice for *Notonecta*, but it can easily be seen that they only bear a very casual likeness to each other. The adults are brown or green marked with yellow spots. The back is flat, not keeled as in *Notonecta*, and *Corixa* swims back uppermost. The female lays her eggs singly on water-plants. The young hatch into queer little creatures very similar in appearance to their parents, except that the wings are only rudimentary.

Like *Notonecta*, *Corixa* is exceedingly savage. The female, some eight days after conjugation, lays her eggs, which are brown cased structures in shape resembling turnips, and each one is fastened separately by a minute stalk to the stem of a weed: gradually these eggs become more swollen, until four weeks later the top of the case cleaves open, and the young

Corixa makes its escape. At first they are practically transparent, except for their yolk-bag and their eyes.

Gradually the little creatures become more and more opaque, and darker in colour: their wings appear, and they mature.

CHAPTER IV

INSECTS (*continued*)

THE may-fly has many admirers. To the fisherman it is the only Diptera worth thinking about, to the naturalist it stands pre-eminently as one of the most beautiful if not the finest fly of our country. But probably it is best known to the majority of people, neither fisherman nor naturalists, as a pathetic example of the seemingly unfairness of nature to some of her children.

Swammerdam tells that one species, "*Palingenia longicauda*," lives only for five hours, and that "the flies may be seen in the air for three days together. Those which appear on the first day die the same evening, and the same thing happens on the second and third days." Also that "the eggs are passed into the water, and are there fertilised by the male" (a mildly incorrect statement). He continues "that the eggs hatch into a crowd of minute worms, each with six legs." Certainly, to say the least, very queer creatures. Reaumur is more accurate; he gives us a vivid picture of a rise of flies in 1738.

De Geer's observations are more reliable. Taking the trouble to watch may-fly under natural conditions, he saw what everyone may see, if patience allows, the fertilisation of the female, thus totally upsetting the "fishy" theory advanced by Swammerdam.

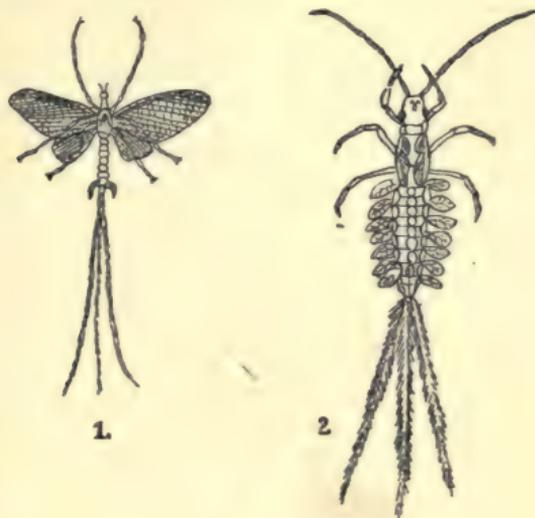
The Ephemera are partly pitied without cause, as they are not shorter-lived than the average insect. Let us rather be sorry that so beautiful a creation is seen for so short a time and by so few.

The adult may-flies, especially those termed by fishermen "drakes" (*E. danica* and *E. vulgata*), are some of the most fairy-like little objects to be imagined.

May-flies have usually two pairs of wings, one pair large, the second pair very small indeed, or totally absent, depending on the species. Like the other members of their family, the venation of the lace wings is most delicate and graceful. The

slender body of the insect is terminated by two or three very fine tails. The body of the female is usually thicker than that of the male. The legs are long, the front pair being so carried as to resemble antennae. In certain species the legs of the male are more than usually long, and often very original in shape. In most varieties we find that the female is by far the stronger (if size means strength), and seems more adapted to "this work-a-day world" than her mate, who is by far the more beautiful creature of the two.

The eyes of the male are larger than those of the females,



MAY-FLIES

1. Adult.

2. Nymph.

and in certain species (*Cloeon*) the compound eyes of the former are most extraordinary structures, being divided into two kinds, one pair situated on pillars, the other pair placed on the side of the head in the normal position. As if not satisfied with two sets of compound eyes, *Cloeon* has also three single eyes, thus making a total of seven. Some naturalists believe that the compound eyes are especially adapted for observing movement. If this be so, we can hardly imagine what the may-fly with two sets of compound eyes must see, especially during the dance of which further mention will be made.

The male insect differs from the female in having a pair of claspers at the end of its body.

Although the mature may-flies have a well-developed digestive tract, yet unfortunately they have no mouth, and are therefore totally unable to obtain food of any description from the moment of leaving the water until they die. That an animal should be so perfect in every detail, and lack so essential a thing as a mouth, is most surprising.

As the may-fly is more generally known as the adult, and seldom in the form of the larva, we will study the life cycle of the insect from maturity. One of the original and most fascinating sights is a swarm of may-flies dancing: rising by means of their wings to a certain height, soaring downwards with tails outspread, rising and sinking over and over again. Occasionally a larger may-fly makes an appearance, but not stopping to join the dancing males, flies rapidly, as if on urgent business, through the dancing throng. But she has not passed unnoticed, for some of the dancers have seen her. An exciting chase follows, the hunters and hunted dodging and twisting in the air with surprising agility, until one of the pursuers manages to seize her by means of his front legs and the claspers terminating his abdomen, and thus fastened together the couple fly to a convenient wall, and after some few minutes separate, the male to return to the dance, the female to find a suitable spot to lay her eggs. She flies along until she reaches a stream and settles on the water. There on the water-film she rests, quivering gently; and gradually the eggs sink, some in groups and some singly, until hundreds and hundreds of eggs are laid. The work is now complete, and as if aware of this fact, she makes little attempt to rise, but lies on the water-film until death intervenes. Often the females fly in a wrong direction, and are forced to lay their eggs in places totally unsuitable for that purpose. It is said that some species of may-fly creep down the stems of water-plants, and lay their eggs on stones and sticks beneath the surface. The young when first hatched are as larvules, and are similar to the nymphs or "adult larvae" except in that the gills are not so fully formed, nor are the rudimentary wings in existence. Gradually the wings become more and more complete. Sir John Lubbock tells us that the metamorphosis in the case of Cloeon is one of twenty or more moults, each producing a slight difference in the appearances and structures of the larvule.

The may-fly nymph is certainly a strange little creature, and although not beautiful is most fascinating, especially when seen vibrating its leaf-like gills in order to produce changes of water, and thus assist respiration. Similarly to the adult

may-fly the larva has two or three tails known as "caudal setae." In the adult these seem to be merely ornamental, but in the larva they assist in breathing, and are important organs.

Under the microscope the setae will be found to be fringed with minute hairs, and if the creature is alive the blood circulation will be seen. Strangely enough, the blood is allowed to escape from the vessel into the setae through small holes in the former.

The larvae of some species of may-fly live in ponds, others prefer fast-running streams, and rest tightly pressed against the stones, thus escaping the full force of the current. Some, again, dig holes into the banks, and thus obtain shelter.

Beatis fluminum is perhaps one of the commonest of the may-flies that inhabit the fast-running, clear streams so typical of hilly districts. It is a strange little creature, so curiously shaped as to resemble a small but flattened lobster. The gills are not fastened on to its back as in most other species, but are attached to its sides. The limbs are broad, the head large and semicircular. Pressed closely against the stone, *Beatis fluminum* vibrates its leaf-like gills and shows a great unwillingness to move unless forced to do so. Then, with a suddenness that easily baffles its would-be captor, the larva rises and runs rapidly, and taking advantage of the nearest cover disappears. *Beatis* is carnivorous, and preys upon smaller aquatic creatures.

Another species very often found in fast-running streams is *Ephemerella*. This little animal has the common sense or common instinct to cover its body with mud, thus deluding both its enemies and the small creatures on which it feeds. It will be interesting to followers of Isaac Walton that the larvae of the "drakes" *Ephemera vulgata* and *E. danica* live in burrows in the banks of rivers and streams. Their food consists of finely-divided organic débris. They seem to prefer streams in which clay forms a noticeable part of the banks. May-fly larvae, as far as it is known, all live a life similar in general details, although differing to some extent in their habits.

The day eventually comes when the larvae which have escaped their numerous enemies—fishes, water-beetles, and carnivorous members of their own order—leave the water. It may have been one, two, or perhaps three years since the larvule first made its appearance, and now the day has come when hundreds of thousands of larvae rises slowly towards the surface. Each skin opens along the back, the head gradually

pushes its way through the opening, and then the insect rapidly draws its body out of the case and flies into the air. Although the fly seems perfectly mature, yet it has one more transformation to accomplish, for it is still shrouded in a thin, transparent skin. But the insect seems to have little patience for this operation, and often whilst casting this skin flies into the air, carrying remnants of its garment with it. It is a time of great excitement; each little insect is only too eager to escape into the air above. The warmth of the day, the sun and blue sky, all add to the pleasure of the moment. The adventures of their long life in the cool waters below are forgotten, and now they are soaring in the free air, seemingly overjoyed at the beauty of their surroundings. One wonders that the may-flies do not hesitate, or stop to try their wings before trusting to the element they have no knowledge of.

Poor little may-fly! apart from the shortness of your life your lot is not a happy one, for everything eats you. To the fish you are the food of all foods, the meal of the year. Birds, bats, mice, and even snails are only too willing to digest your frail body. Seagulls and terns join the swallows and other insectivorous birds in your downfall. And it is a wonder that you are not long ago a thing of the past, a thing remembered but as an emblem of beauty.

Those most responsible for the future of the race have by far the greater risks to run. They fly to the water to lay their eggs: a "phewop" and one is gone: phewop—another vanishes, and the fish feed and feed, until they are gorged with fly. And not far distant the males dance to and fro in the twilight, soaring and kiting, unaware of the fate overtaking their mates and of the doom awaiting them. Gradually they become weaker and weaker.

A few days later the scene of so much beauty and grace is horribly blank. The lover of nature stands at the spot where he has witnessed the may-fly dance, and feels as if he were in the city of the dead. For they are all gone—not a single one remains—he may search for miles without success. Yet only a short while ago the air was full of these beautiful insects, and all along for miles the males were dancing above the hedges. No wonder that the story of the may-fly impressed both Greeks and Romans, and that even to-day in these highly artificial times the poor little may-fly obtains sympathy.

Taking into consideration all the facts of the case, the frailty and short life of the adult, the paucity of the females,

the countless enemies that surround them, one wonders more and more that may-flies were not long ago extinct. Strangely enough, the may-fly in prehistoric times, long before man started to break in the world, was similar in appearance to the present creature. For in the Devonian and Carboniferous rocks splendid fossil may-flies have been found, certainly astonishing when one considers the frailty of the creature.

CADDIS-FLIES

Perhaps one of the most curious and interesting Diptera that spend part of their life in water are Caddis-flies. The adult insect so much resembles a moth that it is often mistaken for such and passed unnoticed. Caddis-flies are not only common in numbers but also numerous in species; for in Great Britain some 150 different species have been found, and it is more than likely that there are still many more to be discovered.

The adults are characterised in that their wings are covered to a greater or less extent with hair, and that the second pair of wings, which were so diminutive in the may-fly, are in their case larger than the front pair. The antennae, which in the may-fly were short, are usually conspicuously long. In fact it in no way resembles the Ephemera, either in its appearance when adult, or as a larva, or during its life history. Yet strangely enough many a fly-fisherman thinks that the caddis larva is the young of the may-fly.

The female lays her eggs in the water, whilst resting on the surface. It is, however, said that she will occasionally go beneath the surface, so as to fasten them to chosen spots. She has sometimes been seen carrying the eggs before laying them. The eggs, which number over a hundred, are surrounded by a jelly-like substance, which swells by taking in water. The young after hatching remain for a few days in their "jelly home," and have no sooner left it than they seek what instinct prompts, in the way of building material—it may be grains of sand, sticks, leaves, or even the shells of molluscs with their living occupants.

The case may be built of stones, and supports in the form of long sticks afterwards added. The caddis-worm may choose to build its case so as to resemble a basket-like structure—or perhaps, better still, to resemble, as Butler remarks, a number of needles in a partly finished stocking. Some species cut

leaves into long, narrow pieces and entwine these spirally in a similar manner to a puttie.

Some tusk-shaped cases are made of most minute grains of sand. So carefully are these tiny grains of silica chosen, and so accurately are they fastened together, that it is hard to believe the mosaic can be the work of an insect. Some larvae prefer well-soaked, partly-decayed leaves, and arrange them so as to produce a huge structure of flattened appearance. In fact caddis-worms, depending on the species, use practically everything of suitable specific gravity. Cases composed entirely of seeds, sticks, leaves, stones, stems of plants are frequently found. In fact, as the reader will notice, each species of caddis-worm has its particular dress, which does not depend entirely on its surroundings. That is to say, one species prefers to use the shells of *Planorbis*—the flat-shelled mollusc so common in ditches—and will never, if possible, use anything else; yet should these molluscs be absent, the larva of *Limnophilus flavicornis* does not give up in despair, and having made a thorough but unsuccessful search for what it requires, sets to and builds a case of the most suitable material it is able to find. It then seems to lose all idea of making use of any one material in particular, but chooses the most suitable that it comes across—sticks, stones, leaves, and even barley and wheat grains.

The building of the case is by no means plain sailing, even should the desired material be in abundance. For each little larva has to reckon with ninety or more brothers and sisters, not including distant relations and perfect strangers, who are equally keen on making a home in the shortest possible time. And so, no sooner has one caddis-worm deftly chosen a suitable object for its personal decoration and started weaving it to the others of its choice, than it is rudely interrupted by a relation or acquaintance.

Caddis-worms engaged in building fight continually, in a very similar manner as a large number of dogs would over a meagre supply of bones. The owner of a case just started is seized, and during the subsequent struggle loses the result of its labour—the various parts being instantly utilised by its friends and relations; so one can imagine that the completion of a case is no easy matter should the necessary material be scarce.

The reader may wonder how, considering this excitement and trouble, it is possible to build a case resembling mosaic. It happens that there is usually no scarcity of sand in most places, and so those using this material can each build their

case without interrupting one another, But those dependent on the seeds of the water-mallow, and other rarities, have certainly a difficult matter to perform. It must, however, be remembered that in the struggle the strongest usually wins, and therefore its case is continually becoming longer and larger until finally completed. So that in an order of succession of strength all the cases are gradually finished, and the weakest, presuming that it has not been eaten by fishes, water-beetles, or other enemies in the meanwhile, is at length able to accomplish its purpose.

Under suitable conditions a caddis-worm will take between four and eight hours to build and complete a case. Each stick or stone, or whatever it may be, is woven by silk to the next piece, so that when the case is finished the caddis-worm lives in a silk-lined structure. Each stick is carefully cut to the right length before use, or sometimes is used and the non-required part is subsequently cut off. The cases are usually of a larger diameter at the head end.

The larva, which is a most voracious feeder, must necessarily grow, and as it does so the case naturally becomes too small for the tenant. The little creature shows evidence of common sense, for it neither bursts the case by remaining in too long, nor evacuates it and builds another, but systematically adds a fresh part to the front, and cuts off a portion towards the end.

That the larva should be so eager to build a case is little to be wondered at, for every fisherman knows that the caddis minus its case is a most pleasant sight to all fish. The wily trout and the lowly perch forget their social positions, and bite without more than a glance, for the caddis-worm larva has a soft whitish or greenish body of so tempting an appearance that few things of a carnivorous disposition could refrain from attacking it. Although the head and thorax are protected by chintinous material, yet it is only by frequently and rapidly dodging into the case, which allows nothing large to enter, that the much-chased "worm" contrives to reach its pupa stage. That the caddis is fully aware of its danger is evident to those who have studied it, for it shows the greatest concern in keeping its body in the safety of the case.

Caddis-worms wander slowly over the bed of the pond or stream and climb up amongst the vegetation. Their diet depends on species and circumstances; they are mostly vegetarian—a few varieties are carnivorous; but should, however, food be scarce the vegetarian forgets the morals of the case so far as to turn into a cannibal, tearing open the cases of its victims, and demolishing the owner without remorse.

But a day comes when the much-harrowed larva, who has spent most of its life in escaping, by dint of continual precautions, from its very numerous enemies, feels that it must rest and sleep. It is approaching the pupa stage, a time when it is to change from the caterpillar to the perfect insect. So the thoughtful little creature fastens its case to larger stones so as to prevent its being carried away by the stream, and seals up the entrance with silken threads, or weaves pieces of weed across, so that no enemy may attack it during the period of rest that is now to come.

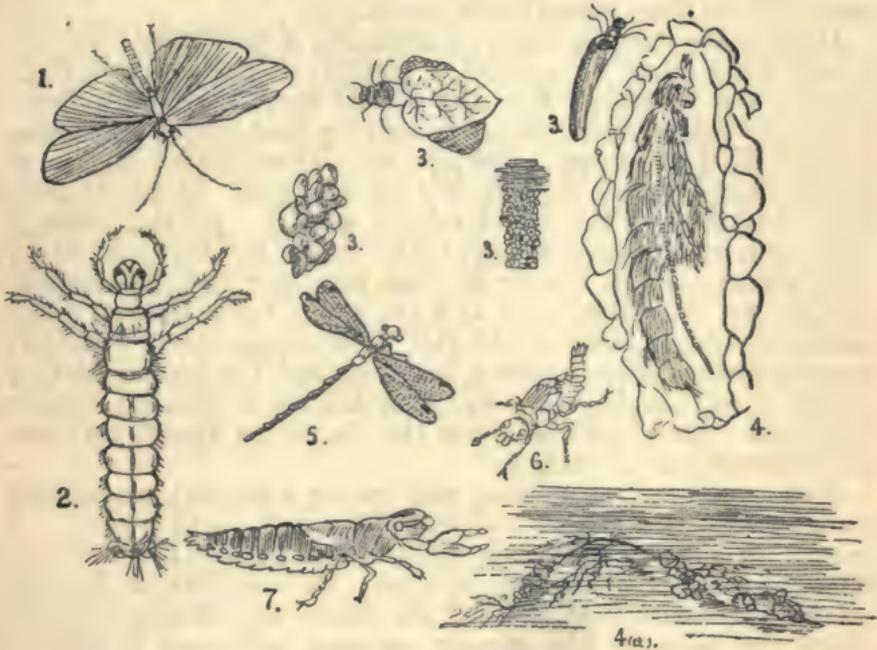
One species on this occasion builds a special case of stones, using large pebbles very many times greater than itself, and fastens these to a rock beneath the water level; and here, protected from everything—for these stone cases are even difficult for man to open—the caddis rests quietly whilst the changes that will ultimately make it a moth-like creature take place. The appearance of the caddis pupa is somewhat ridiculous, for the little creature is enveloped in a transparent envelope, resembling an elongated capsule, and can be clearly seen within, bearing an appearance of sanctity. The little creature rests with folded arms, sometimes moving gently, as if the position was not altogether comfortable. Eventually the time comes when it is ready to leave the water. Then it tears open its celluloid-like capsule, bites through the silk holding the stones together, and swims to a convenient plant, by means of which it climbs to the surface.

The larvae of the caddis-fly are most interesting pets, and live well in an aquarium well stocked with vegetable life. The little creatures, if taken out of their cases, are only too eager to build fresh ones, and for this purpose will make use of any suitable material. The writer has had cases made of glass beads, matches, sealing-wax (chips), &c. In one case a certain artistic worm, although supplied with sealing-wax at the commencement, made its case entirely of sticks, grass, &c., and then actually completed it with a red sealing-wax collar.

To persuade the owner to leave its habitat, guile but not violence must be used. Should you seize its head, a none too easy matter, you may pull until the poor little creature comes in twain, for it is able to hold on inside its case by means of two small hooks situated on the end of its abdomen. But if you attack the larva from the rear, the creature is only too willing to quit. So a piece of fine straw, or the head of a pin, will serve to drive the caddis-worm out of its home without trouble or injury.

Dragon-flies, the hawks of the insect world, are built so as to

allow of rapidity of movement coupled with accuracy of aim, and hence no creature can compare with them for neatness in capturing winged prey. They are beautiful creatures—their long, slender bodies often exquisitely coloured. As one might expect, the eyes play no small part in the physiognomy of the dragon-fly. They practically take up the entire head, and consist of two large compound eyes, often brilliantly coloured,



CADDIS-FLIES

1. Caddis-fly. 2. Caddis larva. 3. Caddis cases. 4. Pupa.
4 (a). Submerged cases on a rock.

DRAGON-FLIES

5. Dragon-fly. 6. Larva. 7, Larva showing mask.

and in addition three simple eyes situated on the front of the head. The prominent compound eyes assure the insect of a large field of view, and that such is the case is proved by the surprising dexterity with which a dragon-fly will twist and turn in order to capture its prey, dodging and darting after the unfortunate flies with that judgment that comes from expert vision and perfect muscular control. The dragon-fly has also the advantage of a singularly movable head, which is

able to rotate in a most original manner. The legs, which play an important part in the seizing of its prey, are veritable steel traps, fringed with hair-like spines; they are brought together at the critical moment, in this way imprisoning the victim. The wings, though so light and graceful, are yet perfectly adapted to the creature's wants. Sometimes they are coloured, but more often so transparent that they would be totally invisible when the insect was engaged in flying, if it were not for their remarkable polish.

Dragon-flies have a habit of choosing a particular district: it may be a glade in a wood, a length of road, or a cottage garden, but whichever it is the insects keep to the boundaries with astonishing exactitude, seldom varying the route, unless in pursuit of an insect. Perhaps the extraordinary fact as to dragon-flies is their dependency on sunlight. It would seem that they rely on the sun for their energy. In the brilliant light of a real summer's day, when clouds are conspicuous by their absence, when the air is clear as if purified, the dragon-flies are at their best. To and fro along their chosen paths, soaring upwards towards the sky, or swooping down, until one expects the creature to dash itself against the earth; darting round trees, turning at surprising angles, or chasing insects that have crossed its path, thus the dragon-fly spends its time, the embodiment of energy.

But should a cloud appear, and but for a single moment veil the sun, the wild life of the dragon-fly seems to be gone. It settles on a convenient twig, folds its wings, and appears as if life was one of worries and sorrows. But as soon as the sun once more breaks from behind the clouds and shines in all its glory, the insect's life rapidly returns, and away it flies, as active as ever.

Can anyone imagine a stranger contrast than that between the young and the adult dragon-fly? We know that there is an old saying that persuades fond parents that the uglier the children the better-looking adults they will be, and contrawise; and the dragon-fly's history seems to not only prove the theory, but to do so to a remarkable extent, for the young creature is the embodiment of sluggishness and ugliness, so fat and slothful that we can hardly believe that it will ever be anything even passable in these two qualities.

The female deposits her eggs on the water or on the leaves of aquatic plants. The young when first hatched have no signs of wings, but after several moults the rudimentary wings make an appearance. The larva, being totally incapable of active movement, would soon die of starvation were it not for a curious

arrangement attached to the head, known as the mask. To understand the use of this appliance, let us imagine that the dragon-fly larva, well hidden by its protective colouring, which facilitates concealment, is resting in the lowest weeds. Should some unwary creature approach, although seemingly at a safe distance from the waiting larva, yet its doom is sealed, for suddenly the young dragon-fly projects its mask, which is armed with teeth, its prey is seized and drawn towards its mouth. So successful, indeed, is this manœuvre, that the voracious larva seldom fails to obtain a sufficiency of food. As its age increases, its agility decreases, until one day it climbs slowly up a convenient reed. Then the case splits and the perfect dragon-fly emerges, and rests awhile until its wings are dry.

Dragon-flies have so savage an appearance that it is hardly surprising that, in an age when it was customary to give everything a character on mere superficial evidence, they should have been labelled with a bad reputation, although harmless and useful. It is thought by the ignorant to be a highly dangerous beast, stories of how horses and cattle have been maimed and killed are often believed; but fortunately for the dragon-fly it has been generally understood that however wicked the insect might be, if left alone it would do no harm, hence a peculiar neutrality between the man and the insect was gradually evolved.

The abdominal appendage, thought by many to be its sting, is, of course, nothing of the kind. It is used by the male for the sole and special purpose of capturing a wife. Holding her by the neck, he is able to take her with him, whether she wishes to come or not.

The lovers of our country-side and its wild life will learn with regret that the dragon-fly, like many other beautiful objects, is becoming rarer, in particular certain species. And those interested in the economy and balances of nature will understand that, apart from the pity of losing so interesting and beautiful an animal, there is also to take into account the countless numbers of flies, detrimental to man, which will thus be saved to produce their species—*ad libertum*.

THE GNAT

Even the name of this creature produces a sensation of horror, for although the so-called bite or sting, as some people will have it, is by no means dangerous, yet the "buzz" of the insect and its blood-thirsty persistence to obtain a meal at all

costs, even though its "wouldn't be" prey be flourishing a tennis-racquet in one hand and a hair-brush in the other, imbibes such a feeling of inferiority, that it is not surprising that human beings greatly dislike it. Although the fact is not generally realised, there are ten or more species of mosquitoes in our delightful country. In fact the common gnat—"the biter"—is a mosquito pure and simple. Fortunately no parasite detrimental to the health of human beings is carried by the British species; although their relations of the tropics are well-known carriers of many very serious diseases.

To make the gnat even more objectionable we are told the high-pitched buzz is a sign of great happiness and means "high expectations." In fact the gnat might be said to be licking its lips, in preparation for the enormous meal awaiting it.

It may come as some relief to the reader to know that only one sex has a taste for human blood. The female head is equipped with a set of surgical instruments, a pair of lancets, wedges, saws, and lastly a drinking tube. Settling, may be on the ear, or some other particularly tender spot of its victim, it deftly makes an incision, and finding that the hole is not large enough to allow the drinking tube to enter, enlarges it by means of the saw or wedge. Then having made matters satisfactory, in goes the tube, and out goes the "aqua of life." Out of fairness to the operator it must be remarked that the pain and swelling is not due to any poison, maliciously injected, but is the result of the irritation produced by the operation. It is therefore clear to those who read the above, that gnats neither bite nor sting, but that the obtaining of the meal is a surgical operation. The male is perfectly harmless, and is a pretty little insect, on account of the well-fringed antennae, which resemble egret plumes. The male gnats on hatching spend most of their time dancing, sometimes in such numbers as to form huge crowds of insects. The females fly away in search of a suitable spot for egg-laying, and it is possible that it is for this purpose that they often enter our dwellings.

It can only be surmised that the sight of man has a demoralising effect, for we seldom, if ever, find gnats' eggs in our wash basins or jugs, yet we often experience a painful swelling, the result of her ladyship's attentions during the early hours of the morning. If this book were devoted to gnats, or to Diptera, we might spend much time in the study of these interesting insects. For their habits, peculiarities, and histories are intensely interesting.

The female gnat, when laying her eggs, stands on a convenient leaf or stick, and carefully builds an egg raft, by means of her hind legs. This little craft, which is composed of 100 to 300 eggs, is so perfectly arranged that it defies the elements, and remains upright even when the miniature pond becomes a storm-driven ocean. Each egg is cigar-shaped, the submerged end being capped. When the eggs hatch the cap or lid opens, and the young gnat, a most original little creature, drops into the water beneath. The larva spends its life feeding, washing into an ever waiting mouth, by means of a small brush, small creatures or organic matter. Nature has kindly arranged that the breathing tubes should be at one end of the larva, and the mouth at the other, and so it is able to breathe at the surface, and feed beneath the water at one and the same time.

The gnat larva is dependent on atmospheric air, and therefore is not perfectly adapted to aquatic conditions, few if any of the water-flies are, for it would seem that in some bygone days the flies with aquatic larva of to-day found life in the air not over pleasant, and hence preferred aquatic to aerial conditions. The larva of the gnat, being heavier than the water it displaces, relies on the water film to hold it whilst obtaining air from the atmosphere. Several moults are undergone during the three or four months before the larva turns into a pupa. For several days the pupa swims by means of a peculiar jerking motion, and although unable to feed is sensitive to its surroundings, and exhibits clear visionary powers. The pupa case splits, and the Imago, drawing itself out, stands on the empty skin, which is utilised as a raft, and after stretching its wings flies away, either to join the dance or to lay eggs, and possibly torment some unfortunate biped.

Many a Corethra, innocent though it be, falls a victim to the hands of man, on account of the striking resemblance it bears to the much-hated mosquito. It is only during the larva stage that the two insects are in any way alike. The young corethra is known as the phantom larva, a name little to be wondered at, for no sooner is a specimen noticed than it as mysteriously vanishes, only to re-appear the very next moment, possibly half an inch from its previous position—for some moments the larva rests contented and motionless near the surface, until suddenly with lightning velocity it changes its direction and faces the other way. It is a long narrow creature of extraordinary transparency, resembling clear glass; in fact hundreds of these creatures may be in the pond under

examination, large numbers practically on the surface, and yet they cannot be discerned, until one notices their air sacs, which are coloured. These sacs, of which there are four arranged in two pairs, act as floats, and possibly also play some part in respiration. Why they should be coloured is not understood, but possibly, as Professor Miall remarks, the pigment may functionise in the production of gases.

Corethra is predaceous, and its transparency assists it in the capturing of its prey. It is also possible that the pigmented air-sacs draw attention, and thus attracted by the coloured spots its victims are less able to make out the motionless creature's form, until it is too late. For the next moment the Daphne or Cyclops, as the case may be, is roughly seized and held in the larva's mouth, from which it is prevented from making its escape by strong hairs. In the mouth of its captor the victim is acted upon by digestive juices, until little except the indigestible parts remain. Thus the prey of the young Corethra is not swallowed, but only its juices extracted.

The larva is so transparent that under the microscope the digestive canal, heart, &c., can be as clearly seen as if they had been dissected out. Peristalsis, the extraordinary involuntary movement of the alimentary canal, can be clearly watched. The heart, which is tubular, can be seen "beating," driving the blood along the various canals.

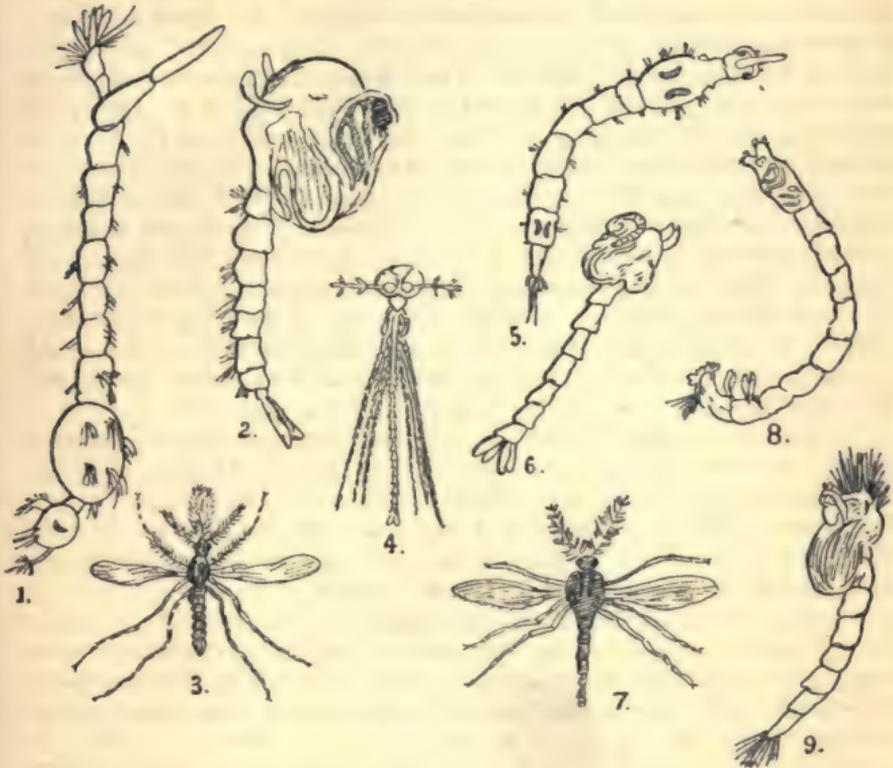
It is interesting to know that Livingstone mentions a cake (Kungucake) eaten by the natives in Central Africa, which is made of the bodies of gnat-like insects, and from comparison it appears that the appetising sweetmeat is composed of a species of Corethra.

A little red "worm-like" creature lashing its way through the water, twisting itself into the figure 8, and yet always keeping in the same direction, such is the larva of Chironomus, another gnat-like insect. The larva will be found of all sizes, the largest being three-quarters of an inch long, whilst the younger members will be smaller and smaller, as their ages decrease, until some will be found very minute indeed, but they are all characterised by their method of swimming. The larger and therefore older "blood worms" will be noticed to testify to their increase in age by swimming less violently, as if no longer able to twist and turn as nimbly as the younger members of the family.

Each little worm, as soon as it settles after a swim, builds for itself a case of decaying vegetable matter, mud, &c. In fact, it chooses anything suitable, and each piece is rapidly woven

to the others, and so little time is wasted in the building of the home.

At times Chironomous ventures out, and swims rapidly towards the surface, possibly in order to obtain air, for the



GNATS

1. Larva of gnat. 2. Pupa of gnat. 3. Gnat. 4. Surgical instruments.

CORETHRA

5. Larva of Corethra. 6. Pupa of Corethra. 7. Corethra.

CHIRONOMOUS

8. Larva of Chironomous. 9. Pupa of Chironomous.

habitat of these little creatures is usually a stagnant pond, well supplied with decaying vegetable matter and poor in oxygen, on which the larva depends. And this may make one wonder how these little creatures manage to live at a considerable depth in stagnant water. It so happens that

each little worm is able to store up some of the oxygen it obtains by means of the red substance—Haemoglobin—to which its colour is due. Life among these little worms is one of activity, for some of the members are always either making or leaving a home. It often happens that a larva settles near to a burrow tenanted by another member of its family. Then a most amusing incident occurs, the new comer gradually makes its way in, whilst the owner most unwillingly makes its way out, and probably fearing that the visitor is purely on business bent, hesitates not but swims away to a fresh spot, where it either plays the same game on some other unfortunate larva, or else rapidly weaves a few pieces of mud and decaying leaves together to form a fresh home. If a large number of these larvae are present in a small pool they will gradually arrange the mud in so many little heaps, that gives a most curious effect. Whilst at home they are by no means sleeping, but are continually undulating so as to produce a constant stream of water through their habitat, and at times they vary the monotony by pushing their tail-end out and waving it to and fro, in order to obtain any free oxygen that is present in the surrounding water. Every now and again the head end makes its appearance, and after making a quiet survey of the neighbourhood and having collected any mud that it may require, by means of its clawed feet, withdraws again. Its feet, which are furnished with several claws, are well suited for collecting debris. The head is supplied with a most complex set of hooks, spines, teeth, &c., some of which are probably used whilst engaged in the weaving operations. The Chironomous larva, like all other larva, not only lives, but lives well, until it changes into the pupa, which remains in the mud at the bottom of the pond. The pupa of Chironomous bears a slight superficial resemblance to the pupa of *Culex* (gnat) and *Corethra*, but is black in colour, and has curious tufts of "hair" on the head portion. These tufts, which take the place of the pair of "horns" in *Culex*, are respiratory tubes. The changing from the pupa to the imago is a thing of surprising rapidity. Firstly the pupa rises without effort to the surface, owing to the fact that its skin has become well filled with air, which it extracted from the water towards the end of the pupa stage. In fact so low is its specific gravity, owing to the collected air, that the pupa is totally unable to sink, even if it wishes to. Within a few seconds from the moment it reaches the surface the case begins to split, and the adult fly gradually comes farther and farther out. There is no hitch of any kind, no struggle, but simply a continual movement. No sooner are the head and

thorax of the adult free, than the wings, legs and abdomen appear, and are rapidly drawn out of the case, and practically the same moment the insect flies away, the whole transformation taking but one minute or even less to be completed. To sit by a water-butt or pool and see hundreds of these pupas changing into flies, is most fascinating. No sooner is one gone than another is ready to follow, and so it goes on, and in the meanwhile pupa after pupa floats towards the surface. A few days later nothing but the empty black skins with their queer white breathing filaments remain. The adult Chironomous in appearance may certainly resemble *Culex*, but it is interesting to know that it has not an operating set like that of the gnat, in fact it is probable that neither male nor female feed after their larva stage is completed. For the stomachs of dissected specimens have always been found empty. The females lay their eggs in a gelatinous envelope usually in strings. These are moored to stones, &c., near to the surface of the pond.

We must now regretfully leave these graceful and interesting Diptera, whose lives are partly spent in water, and partly in the air above.

CHAPTER V

WATER SPIDERS AND MITES

PERHAPS one of the most remarkable things about spiders, is that they have not become extinct long ago. Their enemies are numerous, both four and two-legged, and in addition their numbers are much reduced owing to their cannibalistic instincts.

In fact entire families are frequently destroyed by the unnatural parent, whose maternal feelings are already forgotten, when her stomach craves. Later we will see that it is not only the youngsters that fall a prey to the gentler sexed individuals, but that the male is often a victim, and pays dearly for his impertinence and other faults.

To our minds such unnatural cannibalistic instincts seem heinous offences. But whatever their faults may be, or how often he or she may break the rules of civilisation and friendship, yet nevertheless spiders are most interesting animals, and well repay any time spent on their study.

Unfortunately childish fables, stories of virulent poisons, savage attacks on human beings, and other non-scientific

anecdotes, have led to much unwarranted persecution. In fact many people consider it little less than a duty to destroy spiders on sight.

Their economic importance certainly is not great. It is recorded that one ardent worker made a pair of stockings and mittens out of spiders' silk ; and when one considers that it takes over 27,000 female spiders to produce a single pound of silk, and that each thread-maker must necessarily have a separate home, else chaos follows and cannibalism runs riot, the project of a spider silk industry is not very bright.

Nature, who so tenderly looks after her children and helps them to be efficient, has not by any means forgotten the spider. For each little creature has a splendid set of eyes, a most important matter, as they rely largely on their eyesight.

Some have six simple eyes, others eight, arranged in a systematic manner ; and it is interesting to note that the number of eyes and their position is used as a means of classification.

Having now made an examination of spiders as a class, we will refer to those particular species that are to be found in ponds and streams.

Several species are semi-aquatic—that is to say, will take to water when necessary, living the remainder of their time on the banks—one species is totally aquatic.

Lycosidae or wolf-spiders (*Lucus*=wolf), so-called because they hunt their prey, instead of building a web, contains two examples—*Lycosa piratica* and *Dolomedes fimbriatus*. The former is a brownish-yellow spider with a characteristically long body.

The females are about one-third of an inch long, whilst the males are smaller, a general rule amongst spiders.

Lucus piraticus preys to a great extent on aquatic insects, and will follow its victim on to the surface of the water without fear. Occasionally in case of sudden emergency it will dive beneath the surface, but usually prefers to escape to the bank.

Dolomedes, however, does not rely to the same extent as *Lucus piratica* on the safety of the water-film, and will be seen to use the leaves of water-plants as stepping-stones when on a hunting expedition.

In case of danger *Dolomedes* curls up in the characteristic spider attitude, or else runs towards the bank, but never even at the most critical moment does it attempt to make its escape by diving.

In appearance *Dolomedes* differs from *Lucus piratica*, firstly in size, the female being three-quarters of an inch long, and secondly as to its general appearance. For *Dolomedes* is a brown hairy spider with noticeable yellow markings, which readily indicate its genus.

The females of both the above genera weave egg bags, which are fastened and carried on the under side of their abdomen.

In the case of *Dolomedes fimbriatus* the egg cocoon is large, brown and round in shape, whilst the cocoon of *Lycosa piratica* is much smaller and white in colour.

Warburton, in his excellent little handbook on spiders, mentions several interesting experiments on wolf-spiders and their egg cocoons. From some of the results Mr. Warburton seems to think that spiders are unable to reason. To my mind the experiments do not show this.

I consider that under ordinary normal conditions a spider is able to reason, but is naturally at a loss to understand complicated arrangements entirely out of its sphere of life.

But to return. The female of the *Lycosidae*, of which the *Lycosa* and *Dolomedes* are two genera, carry their egg bags beneath their bodies. When the eggs hatch the youngsters immediately climb on to their mother's back, where they remain until old enough to start life on their own.

Seemingly aware of the fact that an accident to the "bus" would mean a misfortune to themselves, the young spiders are most careful not to cover their mother's eyes, even when resting on her head.

But the life of the passengers is far from being dull and uninteresting; sometimes thick grass dislodges them, or the mother may meet another of her own sex engaged similarly in carrying her family. The result of the meeting, friendly as it well might be, considering that both are occupied in the same manner, is seldom so. They have no wish to compare notes on their family histories. But, on the contrary, no time seems to be wasted in idle compliments, but hardly having met, a fierce conflict takes place.

The youngsters are dispersed as their respective mothers fight furiously with only one object, and that to kill. And when the battle is over the offspring of the slain and those of the victor re-assemble, and climb up the legs of the survivor, who meanders off little aware that her family has increased to such an extent.

The *Lycosidae*, as the reader will no doubt notice when attempting to capture a specimen, are strong and fast runners, and the weight of a family, whether in the form of eggs or of

youngsters, seems to make little difference to the agility of the parent.

Wolf-spiders, although often found together, do not hunt in packs. Each relies on its own power of hunting, and tracks its prey down by stealth and speed. When searching for food every inch of water or land is most carefully scrutinised. The spider makes a short run, and halts, and seems to be most minutely examining its surroundings. At last its prey is viewed—a sudden rush on the water-film, and the unfortunate pond-skater is seized and carried triumphantly to terra firma.

Argyroneta aquatica is a totally aquatic spider. If the pond-hunter is fortunate to be in a district where it is plentiful, the first pond or stream may result in the capture of several of these beautiful little creatures. Contrary to the general rule, the male is larger than the female in this family.

“Wait and watch,” and if one has patience enough and fortune favours, “the water-spider” may be seen to rise to the surface of the pond, resembling to all extent a globule of quicksilver with eight blackish legs. It rises head downwards, and on reaching the surface extrudes the end of its abdomen through the water-film. If undisturbed it will remain in this position several seconds, until with a sudden pull, as if the water-film resisted its departure, it swims down to the bottom of the pond, carrying with it a fresh quantity of air. The watcher, if he is unaware of the habits of *Argyroneta aquatica*, may continue to wait and watch, hour after hour, in the hope that it may make a reappearance.

But the water-spider does not return unless perchance it is filling its air store. Carefully concealed amongst the weeds is a thimble-shaped structure of closely woven web.

The diving bell has an aperture at the base, through which the water-spider passes when entering or leaving. The dome takes several hours to build, for it is not so simple as it looks, and apart from the structure itself threads are stretching in various directions in order to capture small creatures.

The spider having formed its home rises to the surface for a supply of air. Its abdomen is covered with fine hair closely packed, thus preventing the water from wetting its body, hence the imprisoned air forms the bubble.

On reaching the dome the spider by a sudden movement, or by rubbing against the sides of the dome or the leaf, to which its home is anchored, liberates a part of the air, which rises to the apex of the store-house. It then visits the surface for a further supply, and continues to do so till the home is complete.

Unaware of the danger that lurks beneath the leaf, small

crustaceans and other animals swim past. A pair of legs suddenly appear, a wild attempt is made to seize the visitor. It may prove successful, and next moment the victim is held by a pair of forceps. But frequently the spider is unsuccessful, and wildly grabs at its would-be victim, which makes off as fast as nature allows it. The disappointed spider withdraws inside its dome, and waits for another opportunity.

It is really a most interesting sight to see *Argyroneta aquatica* attempt to seize an adult freshwater hog. The latter appears totally at a loss as to where the enemy is concealed, and will often blunder into the "arms" of the spider several times before finally making its escape.

Sometimes, if the spider seizes its victim a great struggle takes place. The water-hog wildly attempts to break away from its captor, whilst the spider evinces great unwillingness to leave its retreat, and often, after the water-shrimp has escaped, the spider's ruffled feelings are such that it will continue its ferocious behaviour in a most childlike manner.

"Love-making" in spiderland is fraught with grave dangers, and the proverb that "none but the brave deserve the fair" is certainly true.

Her ladyship believes in business before pleasure, and realises that food without a home is preferable to a home and an empty larder. So the suitor makes his appearance, and does his utmost to look "nice," often unfortunately with so much success that he is promptly eaten by the object of his affections. And the next suitor fares no better, nor even those that may follow, until the creature's hunger is appeased. Then with so much love inside her, her thoughts turn to ethereal matters.

In the case of the water-spider the male builds a cell next to that of his "heart's" desire, and having filled his home by the usual methods, he cautiously bites through the dividing wall.

As the reader will understand, it all depends on the lady's temper what the result of his entry may be; if pleasant, all is well, but if not the suitor probably has much to regret.

In the resulting conflict the entire home is uprooted and demolished. As the male is fortunate in being larger he often comes off victorious. But should the female be in the right mood, when her lover bites his way into her dwelling, an egg case is woven and between seventy and one hundred eggs are laid.

The young spiders on hatching have each a bubble of air and lead an independent existence.

Argyroneta aquatica is of particular interest to the pond-

hunter, because it will build its dome and live to all intents a natural life, even in so small a pond as a glass jar full of water. The entire process of weaving its dome, love-making, the forming of the egg-bag, and the subsequent hatching of the young can be watched at leisure.

Before turning to water-mites, mention must be made of the extraordinary power that water-spiders have to remain in a trance resembling death. The writer on one occasion found his water-spiders "dead" at the bottom of the aquarium. He took them out and placed them on glass slips in order to make an examination. They seemed peculiarly slimy—several days elapsed, and no signs of life were noticed, nor were any looked for—in fact, the writer was engaged dissecting one of the specimens when his attention was called to another of these "dead" spiders, that was distinctly moving a fore-leg.

The glass plates were placed in the cooler part of an oven. Within a very short time the spiders not only were perfectly restored to health, but were more than usually alive. When returned to the aquarium, they dived beneath the water as if nothing had happened. A few days later the spiders were again in a death-like condition. After allowing them to remain for two days beneath the water, the oven was chartered once more, but this time it acted not.

Water-spiders sleep during the winter in their sub-aquatic homes and re-emerge as soon as the water has been warmed by the return of summer.

The age to which a spider may live is not exactly known. Some have lived to the age of four years in captivity.

Water-mites belong to the Hydrachnidae. They differ from spiders in that their bodies are in one piece and lack the characteristic waist of the latter.

Their sizes vary—some are three-quarters of an inch in diameter, whilst others are only just visible to the naked eye without the aid of a lens or microscope.

The water-mites are beautifully coloured. Some are crimson, green, and blue; others are spotted either with white or various colours.

Their shapes are most varied. Some are characteristically ball-shaped; others resemble "king crabs," whilst a few are so curious that they are difficult to describe.

Water-mites are noticeable for their exceedingly long legs, covered with closely set hair, often of a different colour to the body. One very frequent example has a red and brown body and light green legs.

They are all as far as we know egg-layers, the eggs being

deposited on various objects to be found in every pond and stream, on stones, leaves, stems, and roots of water-plants, &c.

The young on hatching have six legs. They are often parasites, and live the first part of their lives on higher animals such as water-beetles. They attach themselves to their host by their mouths, and hang there until they reach maturity. Strangely enough during this period their legs fall off, and the creatures remain fastened to their host by the mouth organs. Eventually they mature, and start a free existence, with the proper number of legs, which is eight. One more moult takes place before the creature is fully grown.

Their eyes are simple in structure, similar to those of the spider. In some cases they are very large and prominent.

The species most often met with is a comparatively large mite of a crimson hue, which when seen against a dark background attracts the attention of even the most unobservant.

Water-mites are found in most parts of the world, and the number of species is enormous. They are extremely hardy and thrive in the aquarium, and are most charming little creatures to keep, owing to their beautiful and varied colours.

CHAPTER VI

INHABITANTS OF THE WATER-FILM

To the naturalist a pond would lose half its charm if none of the Gerridae were present. For who does not admire those graceful little insects skating on the surface of the water without the slightest fear of drowning? The water-film is capable of resisting far greater weights, and their feet only produce aquatic dimples where each leg rests.

Although known as pond-skaters, the word skating does not in any way describe the insect's movements, for a few powerful strokes of the second pair of legs produces the necessary impetus, and the insect slides, rather than skates, along the water-film.

At times, especially when alarmed, the pond-skaters leap into the air in the most astonishing fashion. The intrusion of a whirligig beetle is often the cause, for although the beetle shows no wish to interfere, yet in its rapid and erratic journey it often collides with the pond-skaters, much to their horror, causing the nervous little insects to spring up into the air until the intruder has departed. During this acrobatic per-

formance, some will occasionally fall on to their backs, and then will be seen the advantage of long legs. For by carefully manipulating various joints the creature is able to lever itself back to a normal position.

Like all insects, the Gerridae have three pairs of legs. The first pair are placed on the thorax just below the head, and are held in front with only the first joint resting on the water-film. The second pair are stretched out to the greatest advantage, and in this case more than half rests on the water. These legs, which are the oars of the insect, are attached to the lower end of the thorax, and are remarkable for their distance from the fore legs. The third or last pair act as rudders, and are very seldom used in any other way. It is most remarkable that each pair of legs does its particular work only. The last pair, the rudders, steer the course, and are never used for swimming; and even, when the insect is attempting to escape capture, remain stretched in their usual position. The insect has perfect control of all its legs, but the habit of only using the second pair as swimming organs is so customary that the idea of employing these for any other purpose does not seem to occur, even at the most critical moments, when their use would be of great assistance.

The pond-skater's head is terminated by a trunk-like organ known as the beak. The under side of its body is covered with close velvety hairs, which, should the insect be submerged, prevent the water from reaching its body. But under normal conditions this very seldom occurs, for the healthy insect is most particular to keep its body distant from the water surface.

Occasionally a pond-skater will take advantage of the wind or of the prevailing current, and will drift without effort for some distance. They seem to have a great liking for herbage, and are only too glad to rest amongst the partly submerged grass. Should they be disturbed they escape on the water-film, and as soon as the cause of the trouble has departed hurry back to their favourite haunts.

Their eyesight is certainly remarkably keen, and they notice every movement of the clumsy biped, man, even when he is several feet away, and dodge the net with surprising dexterity.

Pond-skaters spend much of their "free time" brushing their legs and beaks in a somewhat similar manner to a carver sharpening a knife, first doing one side and then the other.

Their food consists of dead and living insects. Should an unfortunate non-aquatic fly tumble into the water, near to a

waiting skater, the latter turns sharply towards it, and after carefully polishing its beak makes an attack. On one occasion an adult skater was seen to advance towards a struggling fly, but before seizing its prey it very carefully cleaned and brushed its beak with both its fore legs. Whilst so engaged in preparation for the feast, a young and eager pond-skater turned and saw the fly, and without more ado rushed forward and captured it. Whether the adult realised the humour of the situation it is difficult to say.

The Gerridae seize their prey in a most interesting manner. They place their front legs over the victim, and then elevating their bodies, lift it well into their embrace. Now the beak comes into action, and, as in the case of the gnat, a surgical operation is rapidly performed, and the blood of the victim extracted.

Once having made a capture, *Gerris* is most unwilling, or unable, to relinquish its hold, and will even leap as much as an inch into the air, without dropping its victim.

The ten British freshwater species are all very similar in general appearance, but differ in size, and in the length of their leg joints. Captured species often differ in the size of their wings, because they are dimorphic—that is to say, some of the adults have two pairs of long wings, whilst others have short wings; but although the size may differ, one pair is always leathery, whilst the other pair is membranous.

In summer pond-skaters congregate in large numbers, seemingly socially inclined. On the approach of winter they hibernate, and, in order to do so, wander some distance from their usual habitat; in fact it is recounted that a *Gerris lacustris* was found sleeping under a fusbush in moss, half a mile from the nearest pond.

Although pond-skaters are very timid little beasts, yet they are easily tamed, and, if looked after, will live and do well in an aquarium.

Velia currens, popularly known as the freshwater cricket, is a more beautiful creature than the *Gerris*, but, similarly to the latter, it lives on the water-film. *Velia currens* is a dark brown insect, with two orange ridges along its back. Its movements are noticeably different to those of *Gerris*, for whilst the latter, as we have already seen, skates, *Velia currens* runs along the water-film, and seems to find it difficult to make headway. In certain localities are found minute black pond-skaters $\frac{1}{16}$ of an inch in length. They are very interesting little creatures, but unfortunately do not thrive in an aquarium.

Mention must be made of *Hydrometra stagnorum*, which

rejoices in being the only British example of that genus. It is a most astonishing insect, so thin indeed that the pond-skater seems over-nourished in comparison. Its body, $\frac{1}{2}$ of an inch in diameter, is elongated, and forms a surprisingly long head terminating in a beak. The head, which is longer than the thorax, becomes narrower until it reaches the antennae, where it again thickens.

The eyes, which are small and very prominent, are situated on the sides of the head, near the middle.

But the most surprising thing about the creature is its limbs, for each leg resembles a hair in fineness. The entire insect is so fragile that one wonders that it can exist at all. Owing to its extraordinary thinness, the water-gnat is very difficult to find, and constantly causes much surprise when it slowly emerges from amongst the weeds, which have been most carefully examined.

Similar to its relatives the pond-skaters, *Hydrometra stagnorum* preys upon any unfortunate insects that may come in its way.

SPRINGTAILS

Although springtails frequent practically all ponds and streams, yet very few people have ever seen one of these queer little insects. They are so small that they readily escape observation, unless particularly looked for. There are several British species. *Podura aquatica*, one of the commonest, is a blue-coloured insect strangely clumsy in shape, with three pairs of legs, each furnished with a sharp claw. The antennae are short and thick and the eyes prominent. Wings it has none, although it is a member of the Insecta.

They usually congregate in large numbers and appear as a little patch of blue dust on the surface of the water. Should we by means of a stick disturb such an assembly, the little creatures very soon show that they are far less inanimate than they appear to be, for without a moment's delay they disperse in all directions. The rapidity with which they escape and the distance they travel compared with their size is certainly most astonishing, until one of these small insects is carefully examined. Under the microscope a peculiar forked arrangement will be noticed. It is attached to the end of the abdomen and is held when walking tightly pressed against the body. This appendage is called the spring, and is used for the purpose its name implies.

By taking advantage of the elasticity of the water-film, and

by suddenly releasing the spring, it is projected to an enormous distance. A jump of 40 times its own length is by no means breaking the record, and should we compare a 6-ft. man with this little creature we would come to the astonishing result that he would be able to leap 240 ft., and not only do this once, but practically continually, if he were as agile as *Podura*. Yet *Podura* has by no means the grace of an athlete, but is on the contrary a badly built little creature, the essence of ungainliness. The spring is held by the insect in the correct position, and does not remain so on the death of the creature, thus proving that it requires muscular power to hold it in its place. The manipulation of the spring before and after jumping causes some inconvenience, and so we find that springtails prefer to walk unless the occasion necessitates more rapid progression. Apart from the trouble involved, a jump often ends in the creature landing on its back, instead of in the normal position, and once so placed the unfortunate insect finds it no easy matter to regain its legs.

Springtails have one great advantage over most birds and beasts that roam our world, for they cannot break the water-film however much they may leap and frolic on the "element" so treacherous. But the springtail, like many others, is far from being satisfied as matters are, and so occasionally wanders down the stem of a plant, holding on the support by means of its sharp little claws. This enterprise sometimes ends in disaster: for should a storm arise and the weed be violently shaken, the investigator losing its foothold rises to the surface, and there, unable to break the film, must remain beneath it and die eventually. It so happens that *Podura* is well clothed with fine hairs, and so remains dry although immersed.

The young springtails are as agile as their parents, but naturally smaller and lighter in colour. They are full of fun, only too willing to leap on to an adult's broad back, and to cling there however much the latter may try to dislodge them. At times two or more youngsters will play a game worthy of boy scouts, a regular rough and tumble. They are certainly pugilistic even when mere babies, and savage fights are continually taking place. When two adults meet they will often salute each other by violently agitating one of their antennae, and sometimes without more than a moment's hesitation seize each other by the head.

Life amongst the springtails is not all jump and fight. Hygiene also plays a part; in fact when time allows old and young, children and babies, wash their faces and comb their backs. The little animal licking one of its front legs, as it is

unable to break the water-film, carefully washes its face like some diminutive cat.

The eggs are laid on or in the leaves of water-plants, and when about to hatch are transparent. The young are very similar to their parents in appearance. During the winter, springtails hibernate in the mud.

The following incident is of interest. On the surface of the aquarium some peculiarly long springtails were noticed, which on examination turned out to be two springtails, one leading the other by the hand. By means of a dissecting needle the leader was persuaded to relinquish hold. The other, left to its own devices, seemed perfectly incapable and at a loss as to direction. The microscope revealed no trace of eyes, and it can only be surmised that the creature was blind.

CHAPTER VII

AQUATIC WORMS

THE members of the "Vermes" inhabiting our ponds and streams are usually very different to what one imagines a worm to be.

All the vermes are soft-bodied animals, and in this respect no one breaks the rule.

When examining weeds under the microscope, minute transparent slug-like creatures may often be seen. They glide along, altering their shape on meeting obstacles: swelling, elongating, and behaving altogether in a quite unique manner. These little creatures are members of a family of worms known as Rhabdocoelida, a branch of the Turbellaria, of which there are many and various kinds. They all bear a ferocious expression, and one is little surprised to learn that they are carnivorous.

On first seeing these Turbellaria, one is liable to mistake them for members of the Protozoa, owing to their minute size and general appearance. Members of the Tricladida, another sub-order of the Turbellaria, are very common in every pond and stream. In fact in some districts, depending on the season, their numbers are legion. These little black shining animals, known as Planarians, are familiar objects on the leaves of watercress and other plants, and may also be seen wandering slowly over the mud and stones at the bottom of the stream. When at rest their shape is not constant, sometimes

resembling a minute drop of black sealing-wax, but when on the move they elongate and glide slowly and gracefully. Their black eyes, so characteristically cruel, are protected between two thin membranes, so that the creature is probably able to see both above and beneath it at the same time. Similarly to the Rhabdocoelida, the Planarians are carnivorous, feeding upon both living and dead insects, molluscs, &c. Their skin is furnished with rods, some resembling needles, whilst others are hook-shaped. These constitute the Planarian's protective weapons, and are fired out in case of emergency. These darts, although only visible under high-power lenses, are certainly formidable weapons to the various micro-pond inhabitants.

The mouth is not on the head, as one might expect, but is situated on the underside of the body, towards the centre of the creature, so that we might roughly say that an opening in the abdomen "acts as a mouth." Therefore, when eating, the Planarian must cover its victim. The animal certainly does not bolt its food, but eats slowly, taking several hours to finish a meal. On one occasion the writer placed a small may-fly larva near to a Planarian. The latter rose up in a very peculiar manner and curled up the sides of its head, and then advanced slowly towards its victim and covered it. After an hour the Planarian glided away, leaving nothing but the skin of the unfortunate insect. On another occasion a dead snail was placed in a saucer containing two Planarians; one of these creatures, as if scenting the snail, lifted itself, and slowly turned back the edges of its head. It then glided towards the snail, and was on the point of touching it when, as if changing its mind, it rose and passed to the left. The very next moment the Planarian again turned and came towards its prey, rubbing up against it (simulating a purring cat), rubbing and twisting as if it enjoyed the sensation, occasionally allowing one side of its body to glide over the obstacle and then the other. After behaving in this manner for a considerable time, the Planarian wandered away. The next day the snail was no longer there, and it can only be concluded on circumstantial evidence that it had been eaten, although neither of the Planarians showed any signs of a heavy meal.

On one occasion two Planarians were seemingly at logger-heads. They raised themselves on the posterior end of their bodies and, entwined about each other, were swaying to and fro. On being separated the cause of the trouble was revealed in the personage of a small worm, well covered with some sticky slime-like substance (probably digestive juices).

Planarians multiply both sexually and asexually. In the latter

case the creature divides into more than one part, each of which ultimately becomes a fresh individual. Planarians seem to be highly intelligent, but many more experiments must be carried out before this can be definitely stated. Comparatively little is known as to their habits and life histories, and so a large field of research is open to the ardent pond-hunter.

Wishing the Planarians the best of luck, we must unwillingly turn to the Nematode worms, which are the cause of very many serious illnesses to higher animals, man included.

Thread-worms, as they are popularly known, frequent ponds and ditches. Some are minute, others large.

In *Ascaris lumbricoides* the male is 4" to 6" long, whilst the female is 10" to 14". It is said that in Finland very few people are free from the companionship of this unwelcome stranger. As if to add insult to injury, even the examination of *Ascaris lumbricoides* is not unfraught with danger, for it is able to give off an odour of surprising power, so irritating, indeed, that it produces catarrhal symptoms.

Rhabdonema nigrovenosum, another thread-worm, inhabits the excreta of frogs. After a very short time the male and female worms meet and pair. The fertilised eggs eventually hatch and the youngsters with practical filial devotion devour the internal organs of the mother, thereby causing her death. The offspring then hurriedly decamp, and wait patiently until some frog appears and foolishly swallows them. Thus having made an entry into their host, they waste little time in making their way to the lungs: here they live happily and comfortably, mature and fertilise each other, resulting in a fresh generation of embryos. These eventually escape into the water and find their way to frogs' excrements. Male and female worms again meet, and the story is repeated.

Nematomorpha are very similar in appearance to the nematode worms, in fact up to quite recently they were classified as members of this family. We need not waste much time in describing the creature, for we are all familiar with the thread-like little worms seen in every pond.

The life history of one member of the *Gordius* is so unique that it deserves some notice. The *Gordius* is the only freshwater family of the Nematomorpha. The male is distinguished from the female by its forked tail, and by its colour. In April the males and females meet and fertilisation takes place. Subsequently the eggs are laid in long threads, and after some weeks the larvae appear. These little creatures are furnished with boring appliances, which they deftly use in order to obtain an entry into the body of a young (larva) of an alderfly.

The worm now rests contentedly, hiding in the muscles so as to prevent injuring its host. For it is of the greatest importance to the worm that its host should live to maturity. The alderfly larva, when the time comes, changes into the mature insect. It so happens that many of the mature alderflies fall a prey to a black beetle known as *Pterocheilus niger*, and this is seemingly what the worm expected, for the unfortunate beetle must necessarily subsequently play its part in the life history of this lowly worm. No sooner has the alderfly been demolished by its captor, the beetle, than the latter suffers the penalty. The young *Gordius* now attacks its fresh host, eating both organs and the fat body. Again the worm's future is far from a security, for the beetle must fall into the water or else the worms will be unable to make their escape. It so happens that some of the beetles meet with this accident. Then the worms bore their way through the body of their host and escape into the water, where they mature.

Bristle-worms are members of the Polychaeta, and are often found in the aquarium; *Ophryotrocha* is an example. Several of the *Aeolosoma* representatives of the Oligochaeta are usually common in streams, and are most lovely creatures when examined under the microscope. Their body is transparent, and contains beautifully coloured gold, orange, brown and green globules, the colour depending on the species.

Large numbers of worms belonging to the Naidomorpha are frequently met with in the aquarium. *Nais* is found amongst the roots of aquatic weeds; its body is adorned with several groups of bristles. It is of peculiar interest because of the manner in which it buds. The bud is produced between two segments of its body. This bud gradually grows to form a worm, while the head and tail portion of the parent, thus divided, forms a new tail anteriorly, and a fresh head posteriorly. Further buds are produced until a long chain of worms is in existence. The humour of the situation lies in the fact that the head of the parent is responsible for the food of the entire family, until they disperse. *Dero*, another worm similar in appearance to *Nais*, has ciliated projections at the posterior end of its body.

Tubifex rivulorum is a common inhabitant of most of our rivers and ponds; it is a little red worm, and loves to burrow in the mud. It does so in such a manner as to allow the tail part of its body to project. Subsequently, constantly waving to and fro, a continual change of water is produced. For the worm breathes by obtaining air from the water and returning to it the waste gases it no longer requires.

The word leech brings back memories of the good old times, when the cure for all ills was blood-letting, and in those beneficent days the worthy little creature, the medical leech, was imported from the Continent, and spent the rest of its life on British blood.

Hirudo medicinalis, although the fact is not generally known, is to be found in our country. It is about 3 inches long, but is able to extend to 5 or 6 inches when it so wishes. There are several British leeches, the most common being



WORMS

1. *Gordius*, conjugating. 2. *Ophryotrocha puerilis*. 3. *Aelosoma*. 4. Horse-leech. 5. *Hirudo medicinalis*. 6. Young *Clepsine*. 7. *Planarian*. 8. Microscopic worm.

Aulastomum, the horse-leech. It is of a reddish colour, with transverse marking. Often fastened to a stone, *Aulastomum* undulates in a very original manner, and continues this behaviour hour by hour. But it is only when swimming that the horse-leech is really at its best. Lengthening out into a thin ribbon, it swims by most graceful undulations. When not in such a hurry the leech wanders by dragging itself along by means of its sucking discs (looping).

Every stream contains leeches, but in some districts they are much more common than in others. The general appear-

cane of the leech needs little description ; it is a typical worm-like animal, except that its body, which is convex, has the under side flattened.

The horse-leech, similarly to the medical, is a blood-sucker, attacking tadpoles, frogs, worms, and other soft-bodied creatures.

Leeches are able to secrete slime and thus escape from their enemies. Even the most carnivorous water-beetle, unless starvation be imminent, leaves the leech severely alone. Although the Hirudinia are hermaphrodites (both sexes in one), yet self-fertilisation never takes place. The horse-leech lays her eggs in a case made of saliva, and leaves them to hatch.

Members of the family Clepsine behave differently ; in this species the eggs are not left to their fate, but are carried with the mother until they hatch ; the young then fasten themselves to the under side of their parent and thus accompany her on her travels. In case of violent accident the young Clepsines may be dispersed ; should this occur, having lost their parent, they loop along in a perfectly up-to-date manner ; but are, nevertheless, only too willing to regain their former position at the first opportunity.

The parent's maternal feelings are certainly most acute, for, on meeting one of her offspring, she will twist the anterior portion of her body round it, probably in order to facilitate its regaining its former domicile. It is a most fascinating picture to see a female Clepsine carrying her family, the youngsters undulating from their maternal home, the mother showing every sign of careful movement, so as not to dislodge or injure those dependent on her. In fact many a human mother might take a lesson from Clepsine and her large family, for in her case no single heir enters the world, but eight to ten sturdy miniature Clepsines arrive to be looked after ; and instinct or no instinct, whatever it may be, tells the mother that when she loops she must be careful, and even when she undulates caution is required.

Clepsine is said to have a partiality for snails, in fact to suck these unfortunate molluscs. To our minds this seems a very nasty habit. Fortunately Clepsine has not seen an oyster-swallower !

There are several more species of British leeches, some very worm-like and some very small. They all live happily in the aquarium, thriving to all appearance on nothing, loving to wander over the glass, which, owing to their transparency, allows an easy examination of their internal organs.

The first Wheel Animalcule or Rotifer was discovered in

1696. The finder described the creature as "an animal like a large maggot, on the tail of which appeared forceps like that of an earwig."

Some years later, in 1703, Leewenhoch noticed a rotifer, which he depicted as "an animal with two wheels thickset with teeth resembling the wheels of a watch."

Strangely enough, these two old-fashioned descriptions, when taken together, are accurate enough to help the beginner in recognising rotifers from other micro-organisms.

All the members of the Rotifera are minute, the giants amongst them being $\frac{1}{8}$ th of an inch in length, whilst the majority are $\frac{1}{100}$ th of an inch or even less. Before describing the species or their habits, a cursory examination must be made of the little creatures themselves.

We may roughly divide the rotifer into head, body, and foot. The head consists of the "disc," which bears little hairs known as cilia. These cilia wash the food into the mouth, and from there it passes into the oesophagus (throat). The oesophagus, which is similarly lined with cilia, leads into the gizzard. The gizzard, or mastax, is an organ especially adapted for crushing. The food then passes into the stomach, an organ also lined with cilia, where digestion takes place. The head contains the brain. Two or more eyes are often present, usually red, and sometimes violet in colour. Certain species, however, are eyeless. The body, which is of such transparency that it allows perfect inspection of the internal organs, is variously shaped. In *Synchaeta* it is peg-shaped, whilst in *Hydatina senta* it is wedge-shaped, oval in the *Asplanchnaceae*, and so forth. In certain species the body is enclosed in a case known as the lorica. Others, again, build cases of pellets, or are surrounded by a tube of gelatinous material.

The foot in some species is absent, but in the majority it is well developed. It may be retractile or telescopic, and is usually furnished with two or three toes and a special gland, known as the cement gland, which secretes a sticky material, in order to "anchor" the creature, when it so requires.

In the *Bdelloida* (leech-like) the foot is telescopic, and retracts into the body: like a true foot, it is used for the purpose of walking. When so doing one toe is expanded telescopically and the cement gland comes into action; the rotifer then "closes the telescope" but does not liberate the foot to do so. Hence the body is drawn towards the toes. The foot is then released, and is again stretched to its full length. Sometimes the movement is contrariwise, that is to

say the rotifer fastens its foot, stretches to its full length, and after attaching itself by the head, liberates the foot. But both these are slow movements, and seem to be contrary to the liking of the rotifer, for usually, after walking a few seconds, it opens its disc, and by means of the cilia swims rapidly away.

(Bdelloida) *Rotifer vulgaris*, $\frac{1}{50}$ th of an inch long, is a member of this family. It is of special interest, not only because it has given the name to the Phylum, but also as it is peculiarly able to resist drying by secreting a gelatinous covering, which becomes durable when exposed to the atmosphere.

Some of the Rotifera are roamers, and seem never happy unless on the move; others, however, are only too willing to remain in one spot for at least part of their time.

The Ploima, but for a few parasitic members, are nearly all free swimmers. They seem so characteristically happy, so very interested in their work, as they dash here and there, dodging obstructions, occasionally resting, but only for a brief moment, before hurrying off again. The Ploima are divided into two sub-orders, comprising those enclosed in a case and those without:

- (a) Without lorica—Illoricata.
- (b) With lorica—Loricata.

Amongst the Illoricata we find the *Synchaeta*—a family notable for the beauty of its members, all characteristically active. *Branchionus* (sub-order Loricata) is familiarly known as the Pitcher Animalcule. The lorica (case) resembles a box open at both ends. The foot, which is projected out of the lorica, can be drawn inside, and is a surprisingly elastic and flexible structure, being able to bend in a most extraordinary manner. In fact sometimes *Branchionus* will fasten itself by its foot and whirl round at right angles, revolving at a tremendous pace. Then off it will go until it settles on some chosen spot and repeats the extraordinary behaviour.

The Schirtopoda are queer little creatures, very different to the ordinary type of rotifer; in fact they resemble young crustaceans to such an extent that they have often been returned to the aquarium as members of this Phylum.

Padalion Mirum, one of the Schirtopoda, is about $\frac{1}{85}$ th of an inch long. The body is drawn into long, peculiar "limbs," which terminate in fanlike adornments. The head is furnished with two eyes. The rotifer, when viewed in a certain position, resembles to some extent the head and shoulders of a diminutive old man, with a prominent bulbous nose.

Parasitic rotifers will be frequently found happily rotifering on the caudal fork appendages of Cyclops, also on the backs of water-beetles, &c. Nematode worms occasionally show some evidence of uneasiness, and on examination several parasitic rotifers will be discovered, causing the trouble. Many species of sedentary rotifers live on the stems and leaves of water-weeds, and there, fastened by the foot, work away merrily. If an intruder should blunder against it, the rotifer ceases work and immediately withdraws the discs, and takes refuge behind the weed. But as soon as quiet is restored it regains its normal position, gradually opens the disc, and continues its work.

The Flosculariaceae contain *Floscularia cornuta*, a common freshwater species. Even ditches are inhabited by colonies of this most beautiful creature. Each little animal is enclosed in a glassy gelatinous case. The head end is prolonged into five finger-like processes, adorned with very fine hairs, which are thought to act as a net in preventing the escape of organic particles, and thus facilitating their capture.

But the jewel of the Floscularia is *Stephanoceros*, the Crown Animalcule. In this case the finger-like projections are elongated, and are fringed along their entire length with cilia.

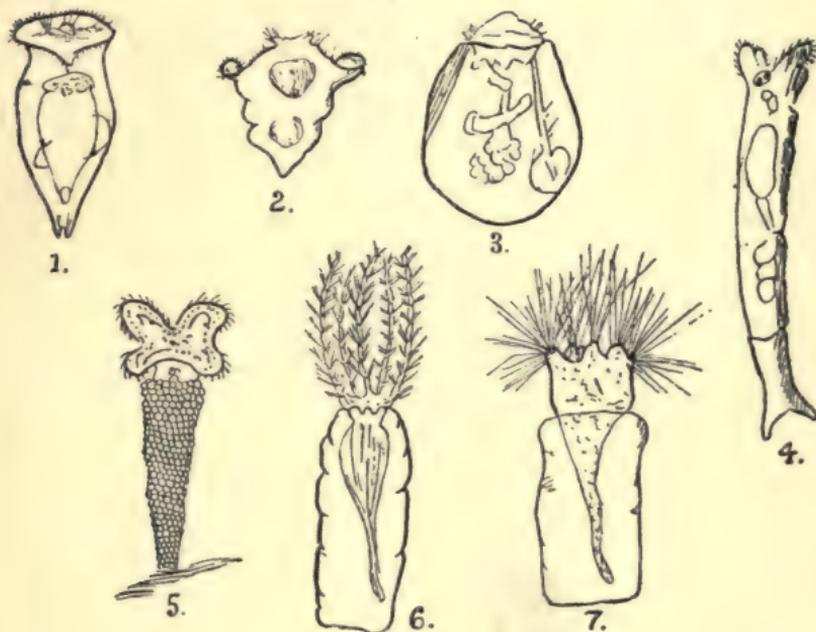
The Melicertaceae build cases of bricks which are formed of waste food. It is interesting to watch one of the *Melicerta* at work. Each brick can be seen in the making, and when it is ready, the rotifer suddenly bends backwards and neatly places it on the top of the last layer. There is no hesitation nor measuring, nor is a plumb-line used, and yet each brick remains where it is placed. Gradually the case becomes larger and larger until complete. The bricks, which are always made of the same size and shape by the builder, are reddish-brown in colour: for some time this colour was thought to be due to iron, but it is now well known that the bricks, made of waste food, are stained during the process of digestion in the rotifer's stomach by a brownish fluid—hence their colour.

It is interesting to know that each species of *Melicerta* makes its bricks of a particular shape. That the cases are occasionally most curiously built structures will be seen if the reader will refer to Hudgson and Goss's famous work on the Rotifer.

It so happens that, if one specimen be discovered, many will soon be found, as the Melicertaceae are of a social, or perhaps better-termed gregarious persuasion, and owing to the size of the case and the angle at which it is fastened to the stalk or leaf, its discovery is simple, even without the aid of a lens.

Each case is practically $\frac{1}{25}$ th of an inch in length, and to the naked eye resembles a tiny brown rod. There are several species of the Melicertaceae that do not build cases of pellets, but are yet most original in that they love a social life.

The Conochilus volvox are not satisfied to live independent lives, but fasten themselves to a centre mass of jelly, so as to form a ball. The number of colonists continually increases, for the young are no sooner hatched than they fasten them-



WORMS (ROTIFERS)

1. *Hydatina senta*. 2. *Synchoeta mordax*. 3. *Asplanachna*. 4. *Rotifer vulgaris*. 5. *Melicerta ringens*. 6. *Stephanoceros*. 7. *Floscularia cornuta*.

selves amongst the adults, often with the result that the jelly gives way, and is broken into many separate colonies, each of which increases in a similar way.

Perhaps the most original matter is their manner of progression, for the living ball rolls through the water in a similar manner to volvox. There are several species of colonists similar in appearance to the latter. *Lacinularia* is often found fastened to stems of aquatic weeds, but occasionally is met with behaving in a similar manner to *Conochilus*—that is to

say, free swimming. But it seldom does so, and prefers to fasten to some support.

The Rotifera are characterised by one general rule, and that is that the females preponderate, whilst the all-important "man" is noticeable by his absence. In this kingdom the gentler sex has no need to break down cell tissue for "their rights," for the male is not only rare, but, in addition, lacks digestive organs, and so is therefore much handicapped. In fact he only appears when he is wanted, and never shows his face otherwise. Owing to the rarity of the males, the production of unfertilised (known as summer) eggs is usual. These eggs frequently hatch within the parent. Rotifers also produce fertilised winter eggs, so called as they are able to resist adverse conditions. It need not be remarked that the male is essential for the production of these winter eggs.

We now come upon a most curious but wonderful scheme, showing how Nature looks after her children, although they may be microscopical. As the summer wears on, and the pond becomes depleted of its water, the unfertilised females produce special eggs, which hatch into males only. Winter eggs are wanted to resist the coming drought, and these can only be produced by union with the male. So numbers of males are produced so as to fertilise the females, and thus lead to the production of the required winter eggs.

The Rotifera are not examples of longevity, at least from man's point of view, for the males die in two or three days, whilst the females have the good fortune to live to the ripe old age of a fortnight. But during this short lifetime no valuable seconds are wasted. Sleep probably plays no part.

Maupas has found that in thirteen days the female rotifer is able to produce about fifty eggs, and it is therefore hardly surprising that rotifers are found in enormous numbers in all ponds and streams.

The earthworm, owing to its abundance, is so well known that man is liable to imagine that it is "the" type of the worm family, and that every worm should necessarily resemble *Lumbricus Terrestris* to at least a noticeable extent. But it is not so: *L. Terrestris* is only a type of one kind of worm, and there are very many kinds vastly different in appearance, and totally unlike in their habits.

The Polyzoa, known by some as Moss Polypes, bear little, if any, resemblance to the earthworm. In fact for several years they were classified as members of the jelly-fish family, which is not surprising, as their appearance is certainly similar. When the matter was carefully inquired into, although the creature

bore a striking resemblance to the Hydrozoa, yet their general characteristics labelled them definitely as worms.

The Polyzoa are chiefly marine, but several freshwater species are to be found, in large numbers, more especially towards the end of summer. Every species of the Polyzoa has its views as to the best position for its home. Some species live on the under side of leaves, others choose stones and sticks, whilst a few prefer the submerged roots of willows. Although differing in the choice of situations, in one point they all agree, except *Cristatella*, for they all dislike sunshine, and prefer shady conditions. *Cristatella* probably thinks itself more up to date, believing, as it does, in the value of the sun. So, except for *Cristatella*, we may search for these interesting little animals beneath stones, under the banks, and amongst well-hidden roots—in fact, in every conceivable shady place. If luck favours the searcher, a peculiar little colony of Polyzoa, resembling a small mass of jelly, will be found hidden among the dead sticks and leaves. The search is frequently successful, for although the colonists love shade, yet they have no wish to live at any great depth beneath the surface.

If we place the captives under a low-power lens, such as the 1 inch, and use a 1 or 0 eyepiece, we can not only make out the entire structure, but also see well into the creature. In appearance each little animal resembles a bent tube swollen at one place to form a stomach, whilst the end broadens into a table-like structure, known as the lophophore, on which tentacles are borne. The tentacles are fringed with cilia (hairs) on both sides, and each one is able to move independently of the others. The shape of the lophophore, and the number of the tentacles present, is characteristic of the species. Each little animal consists, as we have seen, of a bent tube, one end broadened and adorned with tentacles. It is enclosed in a bag-like structure containing a liquid. The contraction of the outside bag forces the liquid into the tentacles, with the result that the creature must necessarily protrude. A muscle fastened to the base of the sack, and to the top, helps somewhat in the movements, more so in those of contraction. The outside case is usually gelatinous and colourless, and so the Polype can be clearly seen within.

It is most remarkable how rapidly the number of Polyzoa increases. A single specimen in the aquarium at the beginning of the week will probably mean a multitude of colonies before the end of the same week. And this can be easily understood when one inquires into the various means these animals have of reproducing their kind. Firstly there is the sexual method.

About August spermatozoa appear, and fertilise the ovules in that same individual, for Polyzoa are hermaphrodites (both male and female in one). The next method is by the production of statoblasts, formerly thought to be winter eggs, but to-day considered to be buds. These structures are formed inside the creature by a particular part known as the Funiculus. Each statoblast is surrounded by a layer of aircells, so as to make it lighter, and thus able to float more easily. The shapes are various; some are round, others egg-shaped, and yet others are adorned with hook-like projections. In fact each species has its typical statoblast. After resting for a certain time the statoblast germinates, and on the case splitting a young colony, containing at least one fully grown member, makes its appearance. The number of statoblasts produced by a single individual is probably very great indeed. Under the microscope it is often quite easy to count thirty or so of these structures, in various stages of development. Certain species are able to form winter buds known as "hibernacula."

On the approach of cold weather the parent colony loses its vitality, and produces these winter buds. Subsequently to their death the buds rise to the surface, where, should the winter be severe, they are frozen. Strangely enough, this drastic treatment, contrary to being detrimental, as one might expect, acts as a tonic.

The following spring the outside case bursts, and the young colony makes its appearance, ready to continue the good or bad work left undone by its predecessors.

Lastly the Polyzoa breed by fission; spontaneous division of the colony often occurs, and the daughter parts thus produced increase by budding. There are six British freshwater genera:

Plumatella	Alcyonella
Cristatella	Fredericella
Lophopus	Paludicella.

Those most commonly found are members of the Plumatella, a branched family, the colonists of which spread into long, thin, branch-like forms covering the stems of aquatic weeds. Each polype lives an independent life in its own sack, appearing at intervals to wave its tentacles, so as to obtain some of the various good things floating in its neighbourhood, for the food of the Polyzoa mainly consists of decomposing organic matter. The Plumatella have a crescent-shaped lophophore, furnished with between forty and sixty tentacles. Perhaps it is not

remarkable that this family is more in evidence than any other, for we can only presume that the more the arms the more the food. *Plumatella repens*, the most common variety of this family, has egg-shaped statoblasts. *Lophophore*, although not so common, rejoices in the fact that it is the only species of its kind. The *Polypides* are enclosed in a jelly-like glassy case.

As the colony increases in age it alters, becomes segmented, the holes more deeply cleft, until, as one would expect, separation takes place. The divided part floats away to lay the foundations of a subsequent colony.

Lophophore has the power of movement, and is able to wander to its "heart's" desire. Compared with the immobile condition of *Plumatella* and many others, such freedom seems "too good to be true." *Lophophore* is no lover of excessive exercise, and its travels, although of long duration, are not of great distance—half an inch is usually the maximum. The undertaking of so great an enterprise takes twenty-four or more hours to accomplish.

Cristatella Mucedo is the great traveller amongst the *Polyzoa*; in fact it is especially equipped for a wandering life. The outer case has a flattened sole, on which the creature moves. On the upper surface the colonists protrude their plumes, seemingly perfectly contented in whatsoever direction the foot is taking them.

It is interesting to know that the base of the colony produces a thin film that oils the surface on which the creatures are moving. Thus friction is minimised, and should the direction lead downhill, and the colonists at the same time be energetically waving, it is quite easy to follow what must necessarily occur. On levels and uphill, if *Cristatella* does walk uphill, matters are different. If the foot oils the surface, it is doubtful whether the creature would be able to advance in the latter case, but on the level, by reason of certain alterations of the under surface of the sole, a slow movement would easily result. It is peculiar that the movement is always in the direction of the longer axis, and never sideways. This fact would seem to denote that some of the creatures are responsible for the steering, so that the direction is not a matter of mere chance, as one is given to suppose. Colonies of *Cristatella mucedo* are often as much as 4 to 5 inches long, but very narrow, as although the colony is continually increasing in length, yet the breadth does not. As time goes on some of the community die, but no alterations are made, so that the living and the dead remain together. In fact it

seems that a colony once started continues until not a single individual is left. Mucedo when carefully examined bears a similarity to a mass of greenish jelly. On the appearance of the Polipedes, it is now no longer so uninteresting an object, but somewhat resembles a woolly caterpillar, a creature so original and beautiful that, if once seen, it will not readily be forgotten, for the effect of these minute graceful plumes, waving in all directions, is certainly most astonishing.

CHAPTER VIII

THE HYDRA

THIS little animal, containing chlorophyll, a substance usually only found in plants, has the honour to have an order practically produced for its particular benefit. It is a member of the "Eleutheroblastea," a tongue-twisting name with an ending that is a nasty word to some minds.

The Hydra is one of the few Coelenterates to occur in fresh water, but it is by no means exclusively British, nor even European, occurring as it does in so many parts of the world.

At certain seasons, particularly towards the end of summer, hydras increase enormously; on every stick, plant, stone, &c., hundreds of these beautiful little creatures will be discovered, some fat and short, others thin and long, some with "little hydras" projecting from their sides (buds), others with swellings which on examination prove to be egg-bags, but in one respect they are all alike—each one ends in a number of tentacles. Perhaps while we are watching we may have the fortune to see a small "cyclops" brush against a tentacle, and then it will be noticed that the accident, which hardly seemed severe, was certainly so, for the cyclops is gradually drawn towards the hydra's mouth. One wonders why the victim does not at least make an attempt to escape. A microscope would have revealed that when the unfortunate crustacean touched the hydra numbers of long threads were instantly shot out, and these threads in some way or other paralysed the victim.

The mouth, which would better be named the stomach—for in the case of the hydra it is one and the same thing, and resembles the latter more than the former—can expand to

swallow large victims. Occasionally this curious animal wanders off, and may do so either by sliding along on its foot, or by continual somersaults, each one making some alteration in its position. When so engaged the hydra at every revolution stands once on its tentacles, foot upwards, and in this position reminds one forcibly of the days when little vulgar boys took up a similar position for the price of a copper coin.

The word foot, it must be explained, is merely a name for the end distant from the tentacles.

The hydra is altogether a mystery; firstly one and the same creature will occasionally turn into a female, and lay eggs in the right and proper manner. And then should food become



HYDRA

1. Group of hydra. 2. Thread capsule not in use (lash curled up).
3. Thread capsule in use.

a matter of "Wait and be patient and be thankful for what you receive," the females "that were" quietly change into hermaphrodites (male and female in one). It may happen that times get worse, when it is a matter of wait without receiving, and on this auspicious occasion the hermaphrodites, possibly ignorantly thinking that "two sexes in one may mean more food required," sedately change once more into males. But this is not all; the hydra, if it were large enough, would be termed "the vivisectors' ideal," for cut off a piece, and the "cut off" grows the missing part, whilst the "cut from" becomes complete. And a hydra can be cut into very many pieces and each piece will grow into a perfect specimen.

There are three British species; *H. viridis* is probably the commonest. It is green owing to the chlorophyll it contains,

and has eight short tentacles. *Hydra vulgaris* is orange-brown in colour, with six tentacles as long as its body. A hydra often found with six remarkably long tentacles is *H. Oligactis*. All these live and multiply at an enormous rate in an aquarium. They make excellent living slides, and if a drop of a weak solution of ordinary salt is added beneath the cover glass, the hydra will oblige by firing a regular broadside of its thread-like weapons.

CHAPTER IX

SNAILS

WATER-SNAILS do not usually meet with much interest, partly because their life histories are little understood. However, the study of the freshwater molluscs is not so dull as one might think.

Water-snails are perhaps of most concern to the agriculturists, who have suffered heavy losses by the death of sheep. Not that the snail has any evil intentions, but a parasite known as *Distomum hepaticum* uses certain snails as hosts during part of its life history. The host, unaware of the damage it is thereby doing, leaves the water and wanders over the grass-land. The liver fluke then escapes and encysts itself on the grass, to eventually be swallowed by some unfortunate sheep.

But even if an agriculturist, care must be used not to give all water-molluscs a bad name, because it happens that only two of the many species of snails so common in ponds and streams are guilty—*Limnaea peregra* and *Truncatula*.

The pond-hunter will often find specimens of a spiral but flat snail, members of the *Planorbis*. These snails are particularly charming whilst young—in fact the appearance of their diminutive flat spiral shells is most original. Sometimes the *Planorbis* will walk along carrying its shell at practically right angles to its body, and seemingly requires to make some effort to draw its encumbrance with it.

Members of the *Ancylus* are very similar in appearance to limpets. *Ancylus fluviatilis* is common in some fast-running streams, *Ancylus lacustris* prefers still or slowly flowing water. The former with its peculiarly beaked shell is a very fascinating little object. The freshwater mussels—the *Sphaeridae*, *Unionidae*, and *Dreissenidae*—are very frequently found. The last-named has only one British species, and is thought to have been imported many years ago in timber.

Anodonta, the freshwater mussel, has a peculiar life history. The larvae hatch inside the parent, and remain there until the end of the summer. They are then ejected, or perhaps leave on their own account, and swim about until they happen to meet a member of the pisces (fish); no sooner have they touched their unlucky host than they hold on to the best of their abilities, and remain until mature. Strangely enough, not only are they carried about by the fish, but also its skin grows so as to cover the parasitic mollusc, thus preventing it from dropping off should an accident occur.

Snails' eggs are so frequently found that they deserve mention. Molluscs are hermaphrodites—that is to say, both male and female in the same individual. On two snails meeting a peculiar battle takes place. In a sac kept for the sole and special purpose a number of darts are kept, and on this auspicious occasion they are fired at each other by the molluscs. What the use of this conduct may be is difficult to say, as it hardly seems affectionate to hurl darts on such a trivial pretext; when this preliminary battle is over the two snails join together. It is interesting to know that one snail is temporarily male, whilst the other is temporarily female. The eggs are laid on sticks, stones, weeds, or the glass of the aquarium, in long jelly-like masses. The "time being" male, his work accomplished, now changes into a temporary female, and subsequently meets some other snail of the opposite sex, which will later in the season become a female.

CHAPTER X

FROGS

A BOOK on pond life would hardly be complete unless some pages were devoted to frogs and newts. Few people care to keep frogs except in a conservatory. Their incessant croaking, especially during the night, is far from pleasant, and owing to their surprising agility, sooner or later one or more frogs are certain to evacuate their home and perambulate the house, much to the horror of the gentler members of the household. How they have managed to escape is often a difficult question to solve.

The life history of the frog is of particular interest, because the young are so very different to the adult. It is hard to

believe that the one-day-old tadpole, a creature more fish-like than frog-like, should turn into the stately and dignified *Rana temporaria*.

During March and June, depending on the weather, frogs congregate at suitable ponds, often in hundreds. They come from all ways, sometimes travelling several miles. All the paths and ruts leading to the meeting-place are alive with frogs, wandering slowly towards their destination. And the pond, which but yesterday contained only a few frogs, has now a teeming population, even the banks being covered. We will notice the male, which often seems ridiculously small, fastened upon the female, holding her under the arms. When once settled he has no wish to leave go, and seems to lose the power of liberating himself, even if he so wishes. For accidents do happen. In one case a pair so united fell a distance of four feet, and even that experience made no difference to the male, who remained calmly where he was. In the pond the female swims to and fro, carrying with her her inactive mate, who occasionally varies the monotony of the proceedings by uttering croaks. The eggs, which are fertilised by the female after they have left her body, are laid in a continuous string. Each egg is about $\frac{1}{15}$ th of an inch in diameter, and is covered by a substance that by absorbing water swells to form the well-known jelly.

No sooner have the eggs been fertilised than they show signs of life. In fact, the alterations in the embryo during the first few hours are remarkable. The owner of a microscope, if interested in embryology, may watch the changes taking place hour by hour.

Six or seven days later the young tadpoles are no longer round but oval in shape, and very gradually, as time goes on, the oval becomes indented to form a head, body, and tail. Then two pairs of minute external gills, the eyes, a large ear, and a peculiar sucker beneath the head, makes an appearance. The embryo is now becoming tadpole-like, and is nearing the day when it will enter the world to start a life "on its own." The young tadpole now shows signs of active life; it no longer rests in the egg motionless, but moves occasionally. For a few more days it remains within its gelatinous sphere, becoming longer in shape and more active in disposition, until the day comes when it forces its way through the surrounding case, and escapes into the world.

At first the young tadpoles, having no mouth, are unable to eat, but live on the remains of the yolk, as a chicken does for the first twenty-four hours after hatching. Two days later the

mouth opens, and the little creature now feeds on water-plants. The external gills become less evident, and eventually vanish. In the meanwhile internal gills have been formed, and these gill slits are covered by a thin skin.

In appearance the creature has made great changes. The tail is now "a thing to be proud of," very different to that of the young tadpole, and during this period, which is roughly six weeks, the internal arrangements are very similar to those of a fish.

Up to this time the tadpoles seldom trouble to come to the surface; the blood in the gills and the water containing air meet, except for fine membranes, and thus an interchange of gases takes place. But now the tadpole's habits alter; it will be seen to frequently swim to the surface in order to breathe, for the lungs are being formed, and although the gills still remain yet they no longer function as previously. Gradually the gills atrophy, the eyes become larger, the lungs more powerful, the digestive organs completely changed, the tail becomes shorter and shorter, the feet webbed, and the little creature with a stump of a tail evinces great eagerness to escape out of the water.

Occasionally tadpoles grow very large before forming their limbs, or it may happen that the creature remains small although maturing.

Tadpoles are queer little creatures. They are very gregarious, loving to crowd together for no obvious reason. Sometimes they are only too pleased to swim singly, but occasionally nothing can be too crowded. Then they behave in a similar manner to a crowd attempting to board a tramcar, on the way to a football match. In fact, they rush and push until one wonders that they do not injure themselves in their violent struggles. Tadpoles evince some intelligence, and are most expert dodgers when occasion needs. The poor little creatures are always in trouble. Firstly, the enormous numbers means a possible shortage of food, and, in addition, they have many enemies; water-beetles, even the smallest, destroy large numbers, the larva of *Dytiscus* will kill a score or more a day. Even leeches will seize them, and more than one Nematode worm passes part of its life history within the body of the tadpole.

The adult *Rana* becomes active early in the morning and towards evening. During the day it hides away either in the water, beneath stones, or under banks. Its food consists of insects, which it captures by means of its tongue, used with great rapidity. The body is encloded in a loose skin, which

contains a great number of special glands for the purpose of keeping it moist.

That so many people should dislike frogs is really surprising, and only leads to show how blind we civilised beings are to God's great work. For the frog is no coarse or ugly creature, nothing repulsive, but much to the contrary, and there is no justifiable reason to dislike a harmless animal, which was created for a good purpose.

The newts or elfts, similarly to the frogs, are greatly disliked and feared by people who ought to know better. What there is to fear nobody exactly knows. In some places the idea seems to be that the poor, quiet, inoffensive, timid, little newt is an evil spirit. Civilisation certainly makes slow progress. Well—we must leave the creatures more timid than the newt to their own reflections and return to the latter.

The female newt lays each egg on a leaf which she bends over, so as to protect it from predaceous fish, and other dangers. The eggs hatch into most charming little creatures, delicate, graceful, and beautifully coloured. Gradually the young newt grows more like the adult; the large external gills which give it so original an appearance disappear.

If the young newt be placed under the microscope the blood can be watched circulating in the gills, a most fascinating spectacle. When the young newts are mature they leave the water and do not return until a year or two later.

There are three British species, two common and the other rare.

The great Warty Newt (*Molge cristata*).

The skin of this species is rough, hence its name. In colour it is almost black, with a light orange throat and abdomen, the latter marked with dark lines; in addition the tail of the male bears a conspicuous white streak.

During the breeding season, both the male and the female become even more highly coloured. The former now bears a crest along its back, and the white streak on its tail becomes even more clearly defined.

Molge cristata is the largest British newt, often measuring as much as 5 inches when mature. Both male and female bear a stolid but peculiarly savage expression, yet are perfectly harmless.

Towards winter the newts wander from the pond, and hide in any convenient spot. Sometimes they will enter houses in search of a suitable spot, much to the terror of the original inhabitants.

Molge vulgaris, which is smaller than *Molge cristata*, is

more generally found, and cannot be mistaken for the latter. During the breeding season especially it is a very pretty little creature, some 4 inches long, the skin differing from *M. cristata* in that it is perfectly smooth.

Newts thrive in an aquarium if fed, but should this be forgotten they gradually become smaller and smaller until they eventually die. Their food consists mainly of worms, which are swallowed whole.

It is a most interesting experiment to drop a tempting morsel in the shape of a worm between two newts. They wake very slowly to the fact that the wriggling thing is a worm, and gradually their interest becomes more acute. Then slowly and very judiciously, step by step, they advance towards it, and even then they seem hardly able to realise their good fortune. But when *Molge* does wake up, no time is lost; the worm is suddenly seized, probably somewhere near the middle, the newt gulps and gulps, vainly attempting to swallow its capture. Shaking the worm violently at intervals, it tries and tries again, but without success. Eventually it drops it and after some hesitation seizes the end, and now its efforts are met with greater success. Gradually the worm becomes shorter and shorter. But during this time the other newt has also awakened, and is slowly, as if hurry were out of the question, nearing the fast-disappearing meal. Then with a sudden rush the new comer seizes the free end and starts to swallow in haste, as if to make up for lost time. Little by little the nose of the one and the nose of the other amphibian come closer and closer together, until they meet nose to nose. In this position they rest; nothing happens, but each newt looks at the other in evident disgust. Suddenly one of them starts to pull and struggle, and the unfortunate worm is as rapidly disgorgeed by the one as swallowed by the other. But all at once the loser of the meal seems to realise what is occurring, and makes up its mind on "no surrender." After some violent struggles the cause of the trouble comes in two, and each *Molge* gulps down its own particular share. Newts shake the worm in a similar manner as a terrier does a rat. If really hungry, *Molge* becomes more active, but if well fed, not even the most appetising worm will alter its expression or cause it to change its position.

Newts periodically cast their skins, and those who believe in ghosts might easily be deceived; for after the newt has changed, the empty skin remains floating in the water, the feet resembling little tiny gloves. Very often the creature devours its old skin, as soon as cast—in fact this seems to be

customary. Space forbids us to go further into the life history of these original little creatures, on which several chapters could be easily written. It must be remarked, however, that newts are easy to keep as long as they are allowed to escape from the aquarium towards the end of summer; they should then be placed in a spacious box, containing moss and a miniature pond. Here they will remain safely until the following spring, when they may be returned to the aquarium.

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