

Ponds and rock pools : with hints on collecting for and the management of the micro-aquarium / by Henry Scherren.

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PONDS &
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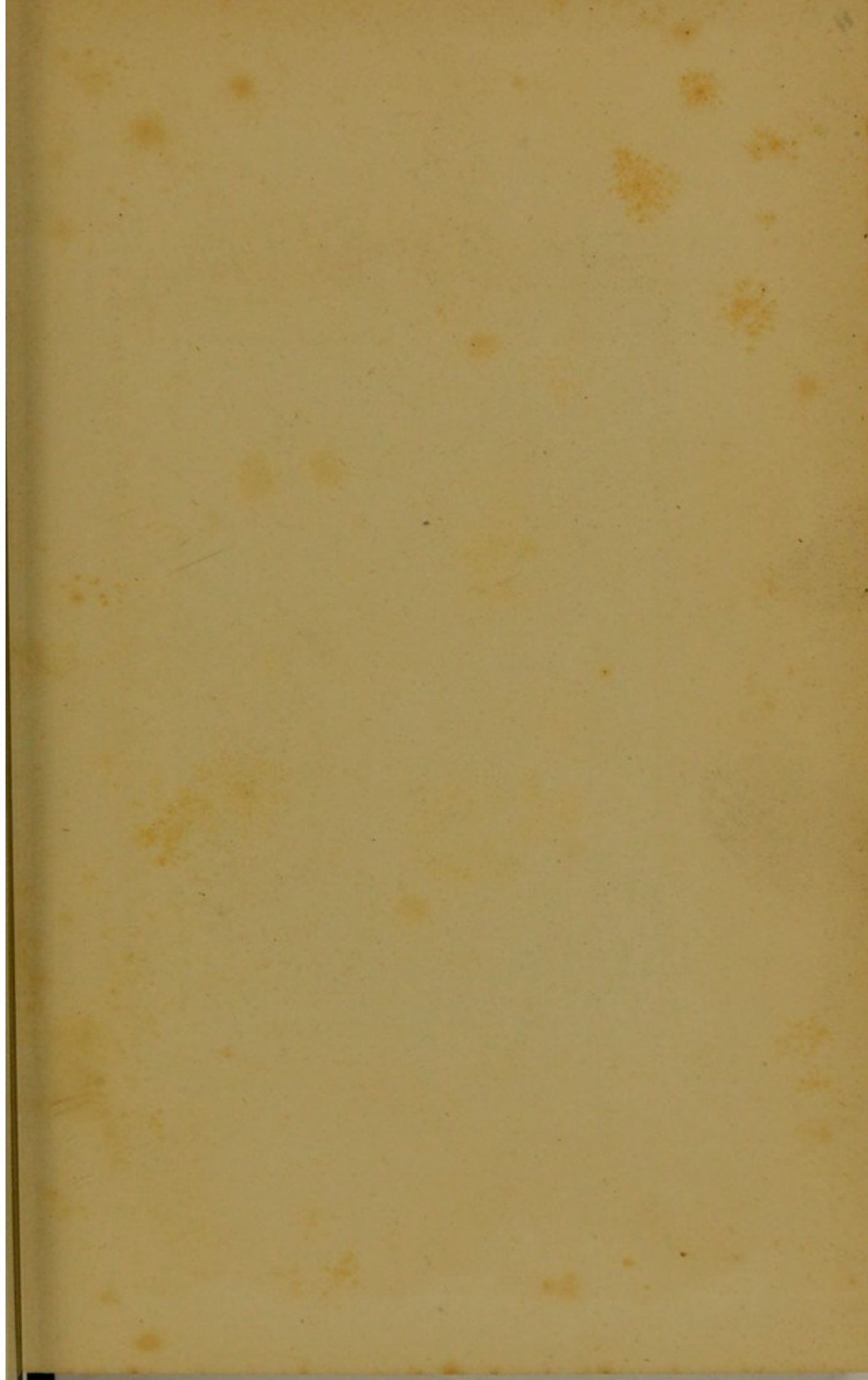
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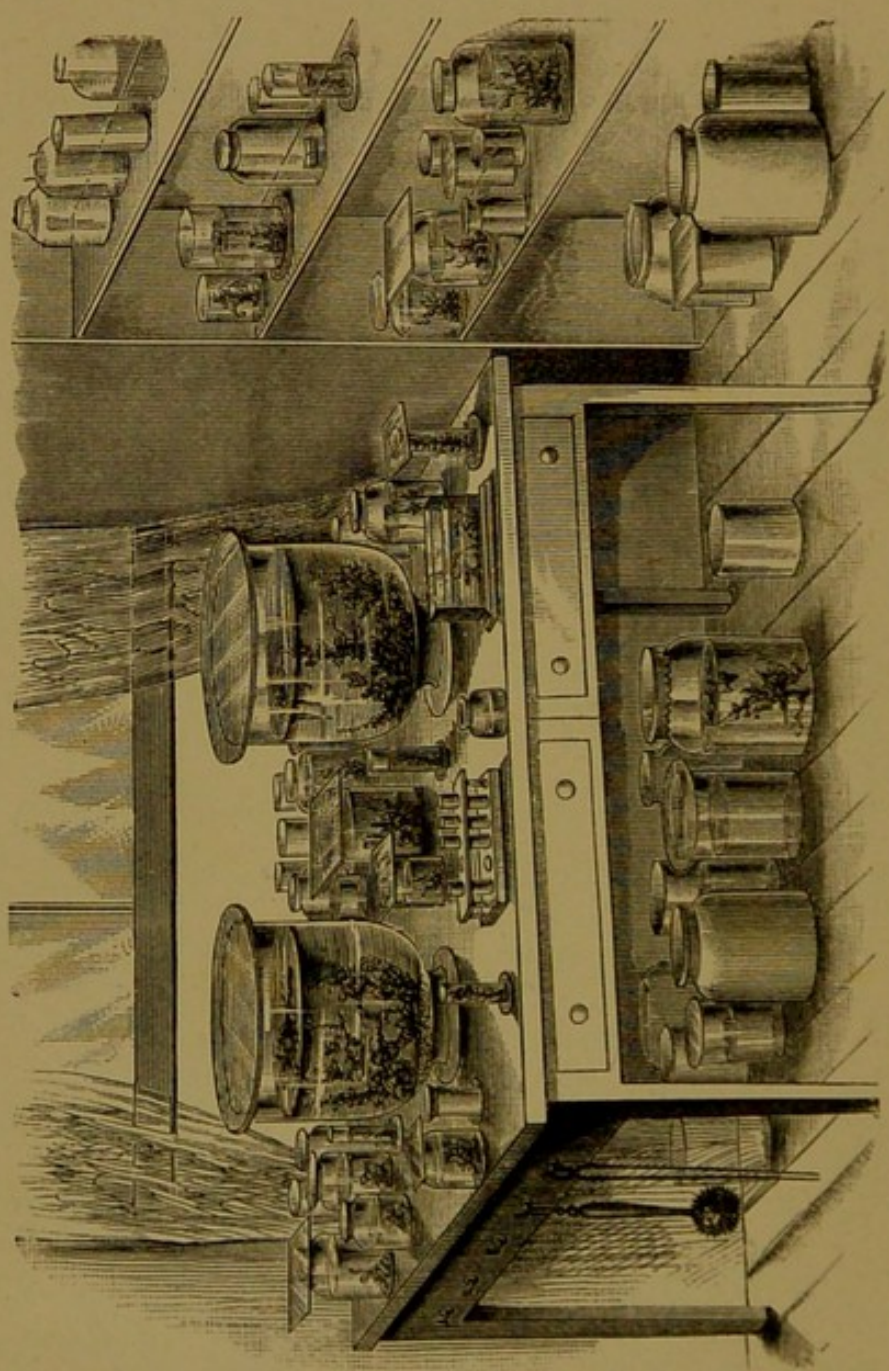


TABLE WITH BELL-GLASS AQUARIA AND SMALL TANKS, AND CABINET AQUARIUM

PONDS
AND
ROCK POOLS

WITH

*HINTS ON COLLECTING FOR AND
THE MANAGEMENT OF THE MICRO-AQUARIUM*

BY

HENRY SCHERREN

THE RELIGIOUS TRACT SOCIETY

56 PATERNOSTER ROW AND 65 ST. PAUL'S CHURCHYARD

1894

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'If Creatures of so low an Order in the great Scale of Nature are endued with Faculties to enable them to fill up their Sphere of Action with such Propriety, we likewise, who are advanced so many Gradations above them, owe to ourselves, and to Him who made us and all things, a constant Application to acquire that degree of Rectitude and Perfection to which we also are endued with Faculties of attaining.'

ELLIS, *Natural History of Corallines.*

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INTRODUCTION

THE chapters contained in this book appeared originally in the pages of the *Leisure Hour*. They have been considerably enlarged and very carefully revised. In their original form they were purely scientific, and this form they retain unaltered in their new dress.

The Committee of the Religious Tract Society have for nearly a century past done all in their power to place within the reach of their readers accurate information on scientific and historical subjects no less than on those which are purely religious. But they exist mainly for the last named purpose, to preach in every possible way through the printing press the Gospel of Jesus Christ, 'the power of God unto salvation to every one that believeth.'

They reissue these scientific chapters under the conviction that the facts so skilfully accumulated and set forth by the author of *Ponds and Rock Pools* testify in a wonderful degree to the power and wisdom of Him 'who made heaven and earth, the sea and all that in them is; who keepeth

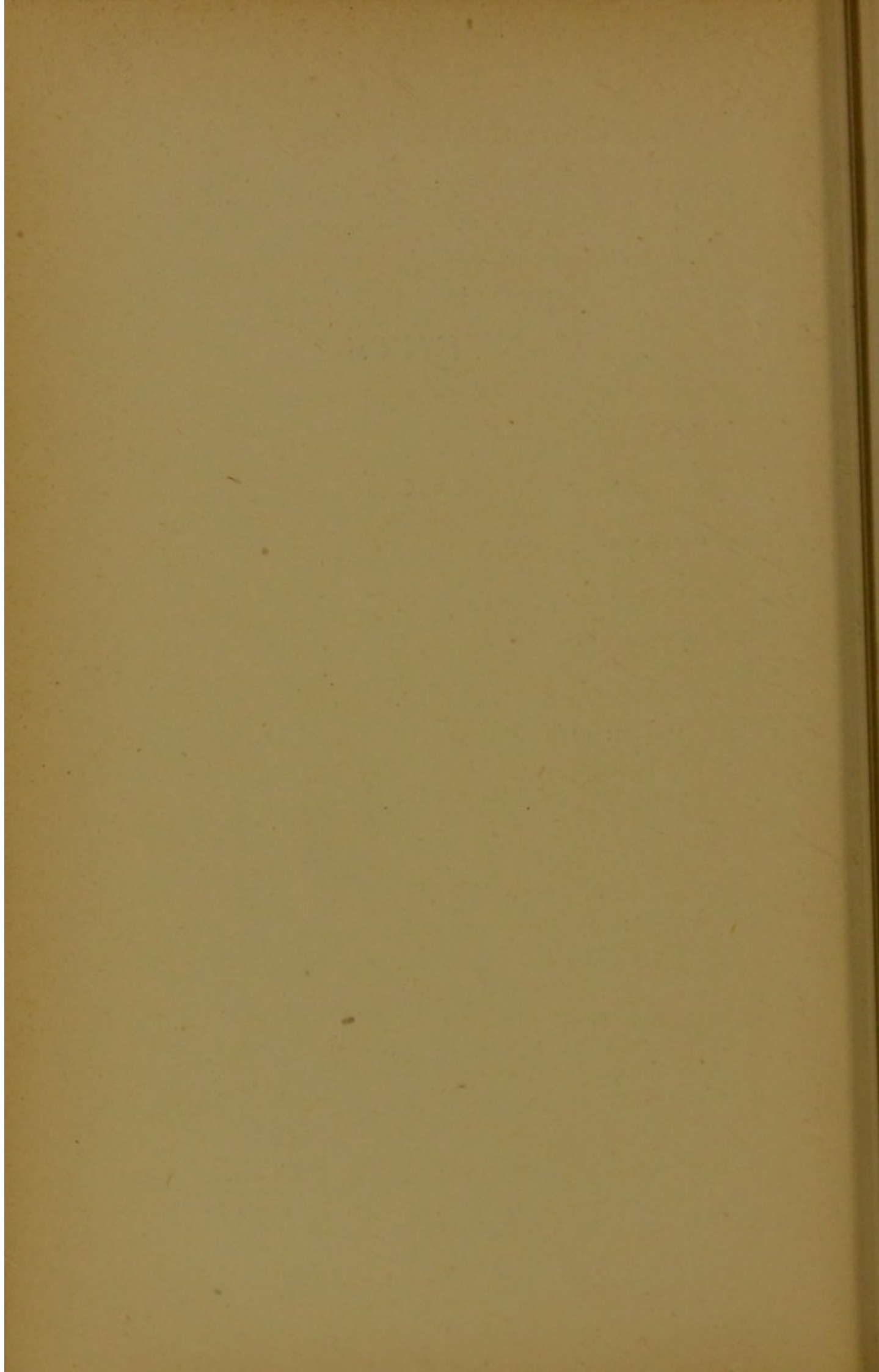
truth for ever.' They are placed at the disposal of all who care to make use of them, in the hope that they may lead the reader to say with the Psalmist of old : ' O Lord, how manifold are Thy works ! In wisdom hast Thou made them all : the earth is full of Thy riches. Yonder is the sea, great and wide, wherein are things creeping innumerable, both small and great beasts. These wait all upon Thee, that Thou mayest give them their meat in due season. That Thou givest unto them they gather ; Thou openest Thine hand, they are satisfied with good ¹.'

¹ Psalm civ. 24-28.

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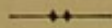


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PONDS AND ROCK POOLS



CHAPTER I

POND AND ROCK-POOL HUNTING

IT is a good thing to own a microscope ; it is a far better thing to use the microscope one owns so as to make it a continual source of interest. Unfortunately there are many persons who possess a tolerably good instrument, to whom it has never been anything better than a scientific toy. When first acquired, whether by purchase or as a present, it was probably used pretty frequently ; but when the novelty had worn off, and the 'collection of slides' had become familiar, the microscope was gradually neglected, and in very many homes the mahogany box containing it has been left standing on a shelf till it is thickly covered with dust, or the instrument has been placed under a glass shade on the sideboard, to serve rather for ornament than for use, and to bear silent testimony to the 'scientific' tastes of its owner.

This state of things arises, in nine cases out of ten, not so much from the fault of the owner, as from his want of knowing how to take up any definite line of investigation fairly easy to follow out, yet offering continual novelty and unceasing interest, and capable by the accumulation of facts of rendering practical service to science. There are many such: and in the hope that some may be induced to take up one which is perhaps of all others the easiest to enter upon, while it has always been found one of the most permanently interesting, these papers, dealing with microscopic aquatic life, have been in part rewritten, amplified, and given the dignity of book-form. The facts recorded and the hints given are for the most part the result of personal experience.

First of all, pond-hunting is an art which is only acquired by dint of experience. One may jot down hints for beginners, but it is only *by collecting* that one becomes a collector. We have it on Dogberry's authority that 'to write and read comes by nature'; the authors of some works on pond-life would seem to be of a similar opinion with regard to collecting, for their directions amount practically to this: 'Put a wide-mouthed bottle in your pocket when you go for a walk; from the first pond you come to take out some of the vegetation on the point of your walking-stick, and drop it into the bottle, which is previously to be filled with water.' *Voilà tout*. Pond-life is so abundant, that even this haphazard method of procedure may now and then be attended

with some measure of success, but it has no claim to be called collecting. The pond-hunter must learn how to hunt his ponds.

To do this some appliances are necessary, which may be either purchased or home-made. The most useful are generally fitted to what is commonly called a 'pond-stick' or 'collecting-stick,' which may be purchased complete for ten or twelve shillings. This differs little from an ordinary walking-stick in appearance, but is fitted with a screw ferrule, which, when removed, allows an inner jointed portion of the stick to be drawn out, so that the total length of the apparatus in working order is about six feet. The end of the extensile portion is tipped with a small brass tube, fitted with a hollow screw, and into this the various fittings are screwed. The bottle (fig. 1), holding two or three fluid ounces, is held tightly by a ring between the curved jaws of the clip, which is screwed into the end of the extensile part of the stick described above. Another form of holder, having a ring into which

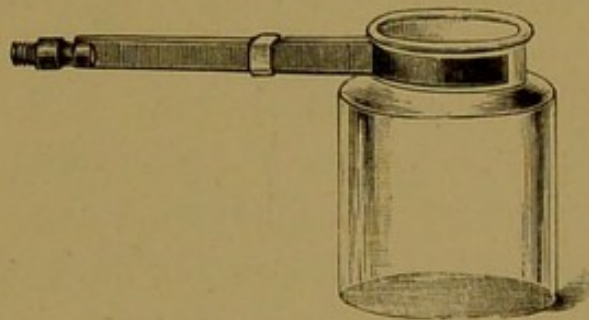


FIG. 1.—COLLECTING-BOTTLE AND CLIP

a screw-neck bottle fits, is sometimes employed. But this is open to the serious objection that such bottles, if broken, are not easily replaced, while the ordinary bottles can be purchased in any village that boasts a chemist's shop. This collecting-bottle

is used in various ways, according as one wishes to procure organisms that frequent the top of the water—as do the Entomostraca in sunny weather,—or to gather material from a greater or less depth below the surface. In the former case the mouth of the bottle is held at right angles to the top of the water, then partially submerged, and two or three horizontal sweeps are made. In the latter case the mouth should be held parallel to the surface, and the inverted bottle plunged in to what is judged a sufficient depth. A turn of the wrist will then bring the mouth into the same position as before, and by this means a gathering can be taken at any required depth.

It will be evident, however, that the water thus simply dipped up in a bottle, even from the richest pond, will bear as large a proportion to the prey taken as did the sack to the bread in Falstaff's tavern bill, and that some method of concentration is necessary, if one does not wish to be overburdened on the journey home. This may be effected in various ways. A plan adopted by some good collectors is to have another bottle of about the same capacity, into the neck of which a cylinder of very fine copper-wire gauze is inserted. Down the centre of this roll the water taken at successive dips in the ordinary collecting-bottle is slowly poured. The wire retains the captures, and the waste water runs out at the neck (fig. 2). By this means excellent 'broth'—the collector's name for water swarming with life—may be obtained. The

credit of the plan is due to Mr. J. D. Hardy, F.R.M.S., the inventor of the flat bottle described on p. 25. A 'filtering-bottle' is also sold for the same purpose, but the price is rather high. For about a shilling a resourceful man can provide himself with a home-made article quite as effective as one that would cost at least a crown. Get a clear glass bottle which holds about a quart—some of those in which preserves are sold will answer the purpose very well. The other materials necessary are a thick cork—a bung in fact—two funnels, and about a foot of india-rubber tubing. The mouth of one funnel is covered with muslin of the kind known as 'mull,' fine enough to prevent any-

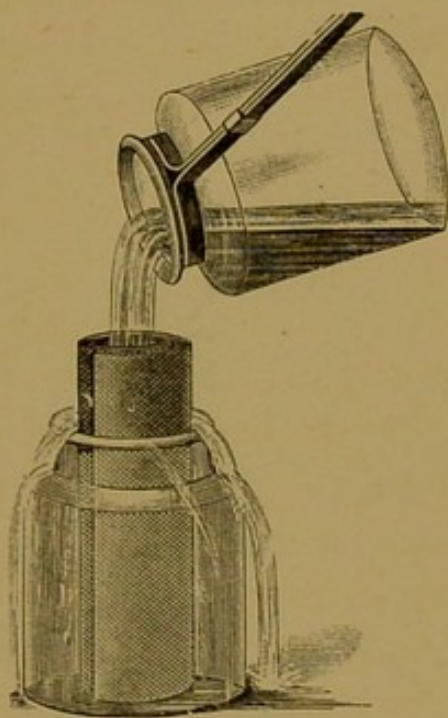


FIG. 2.—WIRE GAUZE STRAINER

thing but the water from passing through; both the funnels are fitted into the bung, and that fixed firmly into the neck of the bottle (fig. 3). The small end of one funnel should project two or three inches above the bung; to this the tubing, which is to act as a siphon, is attached, and the apparatus is complete. The method of using it is obvious; the water collected is poured into the funnel (*a*), and when it rises a little above the muslin-covered

mouth of the other funnel, the siphon may be started and the surplus water drawn off, the muslin at *b* preventing the animals from being also carried away. It is a good plan to fit a looped handle of string round the neck of this bottle, so that it may be readily carried from place to place.

In sweeping along water-plants with the collecting-bottle, insect larvæ, snails, beetles, and water-

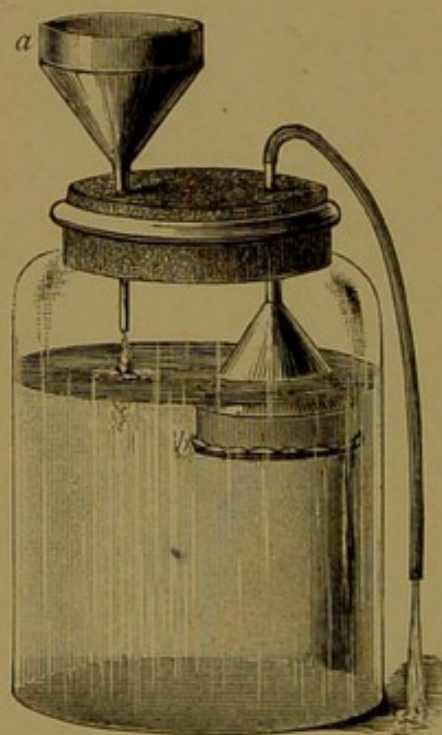


FIG. 3.—FILTERING-BOTTLE

slaters will frequently be taken, and as many of these will not be desirable occupants of the micro-aquarium which is to be the result of our pond-hunting, it becomes necessary to keep them out of the larger bottle, or to have a ready means for removing them. One of the best plans for keeping them out is to cut a circle of perforated zinc (about ten holes to the linear inch), and drop it into the

funnel (*a*), so as to be held tightly by the sides just where they begin to converge. Or the animals may be removed from the collecting-bottle by means of a dipping-tube—a necessary implement in the pond-hunter's outfit, and one which merits a few words of description. Its material is glass, and its shape may be a simple cylinder (fig. 4, *a*),

or one end may be tapered (*c*), or tapered and curved (*b*). Its use requires a little practice. The tube is held firmly between the thumb and the third and fourth fingers of either hand, while the index finger is pressed firmly on the top. Most people naturally prefer the right hand, but it is well to accustom oneself to use the right or left

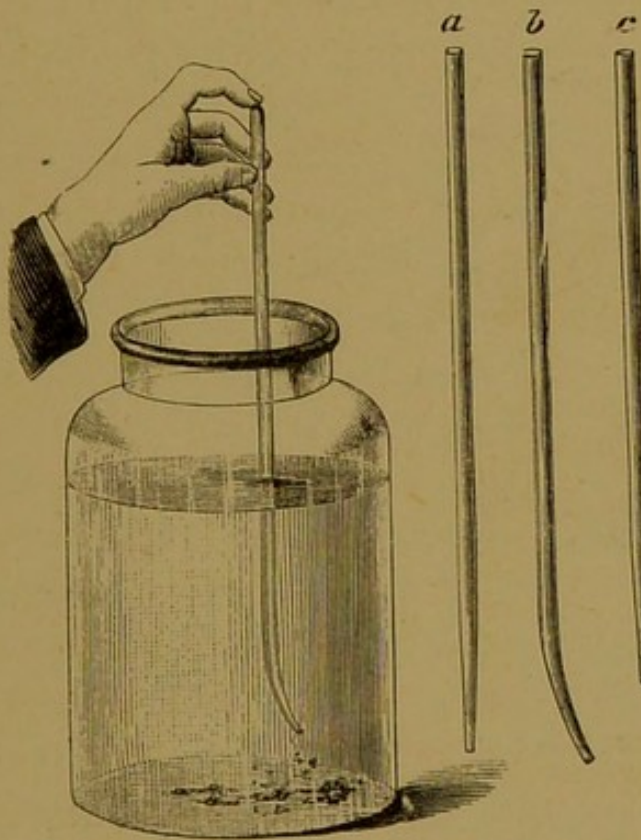


FIG. 4.—THREE FORMS OF THE DIPPING-TUBE. METHOD OF USING IT

indifferently. The open end is then put into the water just over the object to be secured, and the index finger lifted. The rush of water into the tube will carry the object into it, and if the finger be again applied to the top, the pressure of the atmosphere will prevent the water from escaping when

the tube with the captured animal is lifted out. This instrument will also be found useful in transferring animals from one jar to another, or in picking up objects from the bottom of the aquarium, and very little practice will render the task easy.

The ring and net with tube attached (fig. 5) is the form of collecting-bottle generally adopted by members of all field-clubs in and near London. The diameter of the ring, which fits the top of the

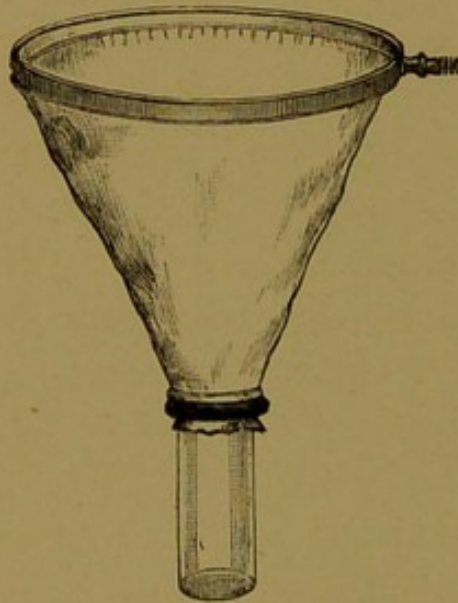


FIG. 5.—RING AND NET

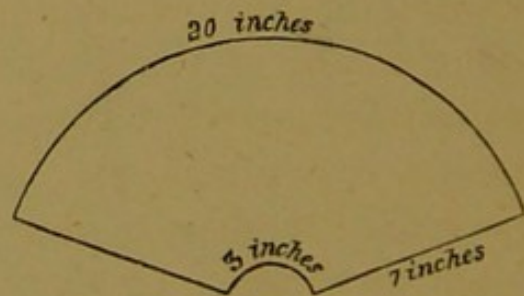


FIG. 6.—PATTERN OF NET

collecting-stick, is six inches; the material of the net is mull muslin, coarse enough to allow water to flow through readily. Fig. 6 shows the pattern of the net, the top and bottom measurements being, of course, taken along the curves. The top part is sewn on to the brass ring, and when the sides are stitched neatly together the net is complete. The tube, which is flanged at the top, is about three and a half inches long and one inch in diameter, and is

affixed to the narrow end of the net by an india-rubber umbrella ring. The great advantage of this method of collecting is that the water is strained out at each successive sweep or dip, and transferred without further trouble to a larger receptacle. No one can use the net in any ordinary pond without capturing sufficient to reward him for his trouble. A ring three inches in diameter, which can be easily carried in the pocket, is employed by some collectors, and the sponge-bag may be appropriated as a suitable waterproof case for it—that is, if the house-mother does not object. Trembley, so well known for his investigations on the Hydra, was quite aware of the advantage of using a net in collecting water-fleas to feed the polyps on which he was experimenting. But he does not seem to have used the bottle, which is the natural complement of the net, when one wishes to see what has been captured.

This apparatus is used to secure free-swimming Infusoria and Rotifers and Entomostracans. For the latter a sunny day should, if possible, be chosen; for then they come in swarms to the surface, and may be dipped up with very little trouble. Indeed, at such times the common water-flea actually discolours the water, and from its very abundance offers little sport. But there are other and rarer forms which may be taken at such times. Whenever a gleam of sunshine falls upon the pond, there the net is to be plunged in and swept across time after time, raising it when withdrawn slightly above

the surface, so as to allow the waste water to flow through the muslin. But lest the rapid outflow should leave the animals taken stranded on the sides of the net, it is advisable after every three or four dips to lift it completely out of the water with a sharp jerk, and impart to it a circular motion—just as a cook would shake the handle of the pan before turning an omelet—so that the vortex thus created in the water in the net may carry them down into their glass prison. The collector should look at the bottle pretty frequently, and when it is crowded should at once transfer the contents to a larger receptacle, in which a little aquatic vegetation must be placed.

It may be well to note here that it is a bad plan to carry the store-bottles partly full for any distance in our basket or bag, for the shaking of the water will probably destroy a large proportion of the animals contained therein. The pond-hunter should also bear in mind the fact that over-crowding is as bad for minute organisms as it is for human beings. No rule can be laid down on this point, but he will soon learn by experience how much animal life a bottle of any given dimensions will safely hold, and he will err on the right side if he falls below rather than exceeds these limits.

If the day be dull the edge of the banks should be carefully swept with the net, and some Entomostracans will certainly be taken, for it is hardly possible to find a pond in which some species at least do not exist. The net should also be plunged

backwards and forwards among masses of aquatic vegetation, for here many kinds of free-swimming Infusoria and Rotifers are to be met with, and the collector will soon learn to recognize their forms and mode of progression through the water as he sees them in the bottle.

It will frequently happen that the funnel-shaped net will be clogged with Duck-weed (*Lemna*) or with vegetable *débris*. It is an easy matter to get rid of this: turn the net inside out by reversing the position of the bottle, and a few strokes to and fro below the surface of the water will clear away all the vegetation or flocculent matter. The same course should be adopted if the water does not flow away freely, from the interstices of the muslin becoming filled up with dirt, which will happen if the net be thrust far enough down to touch the bottom.

When we have filled one store-bottle by means of our net and tube, examination with a hand-lens will show that besides the Entomostracans, still smaller forms of life have been taken, and these we shall need to separate at home. For this purpose a little sieve-like instrument may be advantageously employed. It consists of a watchmaker's eyeglass, which may be bought for sixpence in Clerkenwell. The top part is removed, and the lens is replaced by a square of very fine silk gauze, and when the top part is screwed on again we have a dainty little strainer. This is placed, with the small end downwards, in a saucer, and the contents of the

store-bottle run through it by means of a dipping-tube (fig. 4). The Infusoria and Rotifers will pass into the saucer, while the Entomostraca will be retained by the gauze. In order that these may not be lost, the strainer should be dipped from time to time in a wide-mouthed jar containing water, and their lively motions as they swim away will show that they have taken little harm from the process. When the contents of the store-bottle have been strained, the water in the saucer is to be put in tubes or small bottles, and a little 'soup' introduced daily, if possible, for the nourishment of the tiny captives. Theoretically this 'soup' should be prepared by pounding aquatic vegetation—preferably *Anacharis* or *Chara*—in a mortar, and straining the result through fine muslin; practically bruising it between the fingers and thumb, and allowing the liquid to drop into the water, will answer every purpose.

Some of the free-swimming organisms may be met with in almost every pond; but where possible those ponds should be chosen which are more or less shaded by trees, and into which falling leaves drop and decay. Cattle-pools and horse-pools should be searched for some of the larger Infusoria and some Rotifers, while other forms will be found in clear water, so that the collector will do well, when on a hunting expedition, to pass no pond without taking a dip. A glance at the collecting-tube with his pocket-lens will show whether the animals are abundant or not. In every district,

however, there are well-known hunting-grounds—as, for instance, Epping Forest or Hadley Woods near London. Knowledge of these will best be gained by membership of one of the many field-clubs that exist all over the country, for this will bring the collector into personal intercourse with those already devoted to this pursuit.

One other implement is sold with the collecting-stick. This is a double-curved knife or cutting-

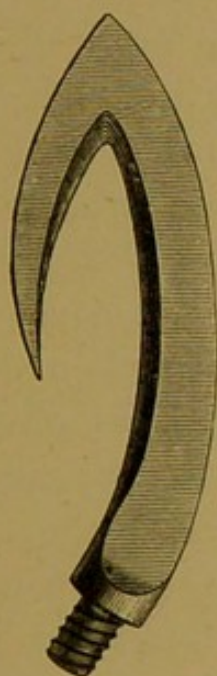


FIG. 7.—CUTTING-HOOK

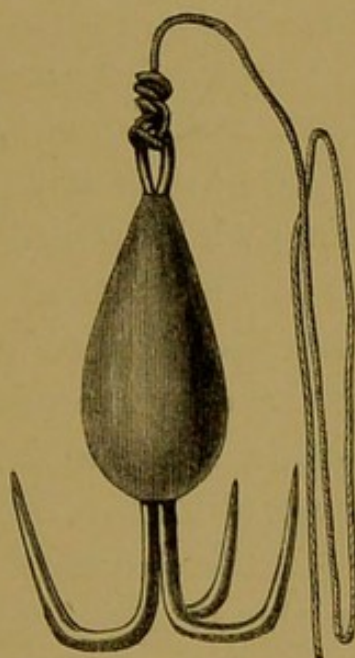


FIG. 8.—DRAG


hook (fig. 7); it is also screwed into the extensile joint of the stick, and is used for detaching and securing weeds that lie at some little distance from the shore.

The drag (fig. 8) consists of a group of three or four hooks—not too sharply pointed, and for obvious reasons not barbed—round the shafts of which

a lump of lead has been run. It is furnished at the top with a metal loop or eye, to which a long piece of stout string is attached. This apparatus, when thrown into a pond, will detach and bring to land floating vegetation, and thus supersede the cutting-hook. It will also secure branches and twigs from the bottom of the pond, and detach and bring up submerged plants, and on the material so secured many of the choicest specimens of pond-life are found. We shall be certain to get many of the Vorticellidæ or Bell Animalcules, the commonest of the sessile Infusoria, and certainly as beautiful as any. The living vegetation will probably yield tube-dwelling Rotifers, while the dead branches are favourite haunts of Plumatella. The stems and leaves of the common Water-lily (*Nuphar lutæum*), when brought up by the drag, should be carefully examined for Alcyonella and Lophopus respectively; and the latter should also be looked for on the under-surface of the leaves of any dead vegetation, especially on the withered leaves of the water-plantain.

Of the living vegetation brought up, that with finely divided leaves is most likely to yield profitable results. The common Water-crowfoot (*Ranunculus aquatilis*) is abundant almost everywhere; Milfoil (*Myriophyllum*) is not so common; nor is the Hornwort (*Ceratophyllum demersum*). Both the Autumnal and the Vernal Starwort (*Callitriche autumnalis* and *C. verna*) are good; but the commonest water-plant in most parts of the country is

the Canadian Water-weed (*Anacharis alsinastrum*), usually known by the generic name *Anacharis*, and, round London at least, the under-surface of its leaves appears to be a favourite dwelling-place for tube-building Rotifers. The stems and branches of *Chara* and *Nitella* are also to be looked over. Quite recently a bed of the former plant, in one of the London parks, positively swarmed with Floscules, and specimens of *Stephanoceros* have been obtained from the same locality.

But suppose that the drag has brought to bank a mass of weed and twigs. What is to be done with it? All cannot be taken home, and even if it could, probably only a portion would have on it microscopic life enough to make the labour profitable. Some plan of examining the weed is wanted. This is to hand in Hardy's 'flat bottle.' From a slab of vulcanized rubber, six inches long by four inches wide, and half an inch thick, a block is cut, so as to leave a -shaped frame, of which each limb is to be half an inch square. Over this on each side is cemented a piece of glass. Marine glue and various other substances have been tried, but the inventor found that lard did 'almost as well as anything,' for a portion of the rubber dissolved in the lard, forming a kind of cement.

Another good plan is to carry half a dozen corked glass tubes, three inches or five inches long, and one inch in diameter, easily purchased for a few pence wherever glass apparatus is sold. One of these may

be used for examination, and the others as store tubes. Three such tubes may be carried in a slip of cloth with divisions or compartments, something like a magnified 'hussif,' or in one of the oval tins in which tobacco is sold. One tube is inserted in each compartment, and the whole may be rolled up and carried in the breast-pocket. A pair of forceps for handling small pieces of weed and a pipette should be added. The chief objection to the glass tubes is that their convexity renders objects a little distorted, but this may be obviated to a great extent by judicious manipulation, and the collector will soon learn to recognize the larger forms of tube-dwelling Rotifers. Having filled the flat bottle or the tube nearly full of water, a piece of weed should be dropped therein. As this falls to the bottom the vessel is to be held to the light and the weed carefully examined with a hand-lens. (The Steinheilachromatic is undoubtedly the best lens, but it is rather expensive; a simple pocket-magnifier with three powers, of from two-inch to one-inch focus, is sold by most opticians for something like 3s. 6d.) One of the first things that will probably attract attention is that the stalk and the under-side of some of the leaves are dotted, or perhaps covered with what looks like a thin layer of white fluff. If this be watched closely parts of the layer will be seen to contract and expand, and the weed may be transferred to a store-bottle with the forceps, for we have secured some Vorticella. If the hand-magnifier shows what seems to be a miniature tree, with

living branches that at one moment are extended and the next contracted, or if the whole mass sinks into a minute fluffy ball, this will be one of the social forms belonging to the family Vorticellidæ, and the spray whereon it is must also be taken home. Perhaps on the under-surface of an *Anacharis* leaf, or on the leaflets of *Myriophyllum*, tiny tubes may be dotted here and there; these are the homes of some of the tube-building Rotifers, probably *Melicerata* or *Limnias*, and they too will go into the store-bottle. And if the collector can discover minute glassy sacciform tubes, he may be satisfied that he has obtained specimens of *Floscularia* or *Stephanoceros*, two of the most exquisitely beautiful forms of pond-life. Where these are found they are generally plentiful. A collector recently gathered from a pond in Epping Forest some conferva which was studded with *Stephanoceros*, and when the tiny filaments were dropped into a tank they looked for all the world like miniature clothes-lines on which fairy garments were pegged out. For this reason, and also because free-swimming Rotifers are also found thereon, some of the thread-like conferva should be taken, but it should be kept in a bottle or jar by itself, or it will multiply so rapidly as to become a nuisance and kill other forms of vegetable life.

In dealing with dead vegetation the procedure is precisely similar, but the objects to be looked for are different. Every part of the stem should be narrowly scrutinized for the tubes of *Plumatella*,

which may often be found encrusting branches at the bottom of ponds. Some little practice is required before these tubes can be readily made out, but if the collector sees a brownish branching mass, the stem or twig on which it is should at once be secured, for even if the animals be dead, there may be statoblasts in the tubes which may develop in the aquarium. If the drag has brought up the stem of a water-lily, with a colony of *Alcyonella*, this will be recognized at once, for it often forms masses a foot long and six inches in circumference at the thickest part, tapering off towards each end. If any is brought away, the best plan is to cut a slice out of the middle of the colony and put it in a large bottle full of water, *carefully returning the other part to the pond.*

Among other requirements must be mentioned a piece of mackintosh about one yard square. This may be bought for a shilling at any shop where waterproof goods are sold, for the colour or pattern is a matter of indifference. It will be found very handy for kneeling on by the side of a pond, in order to reach the leaf-bearing mosses growing on the banks, or the rootlets of willows actually under water. It is in such situations that some of the most beautiful Polyzoa may often be found. A mass of moss or rootlets is to be detached, without squeezing it, and if it is then examined bit by bit the branching horny or parchment-like tubes will be seen. It is much more difficult to detect them on the willow rootlets than on the moss, for the

vivid green makes them stand out more prominently by contrast, whereas they so closely resemble the rootlets in hue, that a rich gathering is likely to be passed over as worthless unless it is looked at very closely, and the vessel containing it turned carefully round so that it may be scanned from every side.

In the district of the Broads, on the banks of the dykes, one is sure of meeting with *Plumatella* and *Fredericella* in such situations in profusion, and not infrequently *Paludicella* is also found. While kneeling at the side of the pond, stones, partially submerged brickwork, and submerged wood should be looked over, for these places are likely habitats of *Polyzoa*. Vegetation near the bottom, especially if exposed to direct sunlight, is a favourite haunt of *Cristatella*; as is also the long grass which often droops into the water. All the other forms prefer the shade. On the return journey the mackintosh will be found useful for wrapping up a parcel of *Anacharis* or *Chara*, a supply of which should be kept on hand for making 'soup.'

To come now to substitutes for the collecting-stick. The late Rev. J. G. Wood's directions were: 'Get a small, rather wide-mouthed phial, and with the piece of string which every sensible man always has in his pocket, lash the bottle by the neck across the end of a walking-stick.' This plan may pass muster as a makeshift: it scarcely deserves any other name. The walking-stick, however, is a necessity, unless the pond-hunter has a jointed fishing-rod, when the two pieces nearest the butt

should be pressed into service. He will want besides some stout copper wire, a pair of pliers, and a couple of india-rubber umbrella rings. A very moderate amount of mechanical skill will suffice to twist the wire into the shape shown in fig. 9. The umbrella rings are to be placed on the end of the stick, and the wire *bb* passed between them and the stick. The loop (*a*) may be small enough to hold an ordinary two or three-ounce collecting-bottle with flanged neck (fig. 1), or large enough to take a net and bottle (fig. 5).

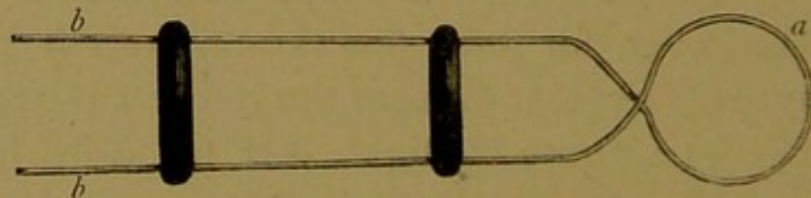


FIG. 9.—WIRE BOTTLE-HOLDER

As to store-bottles, provided that these are of fairly clear glass, wide-mouthed, and furnished with tight-fitting stoppers, shape and size are not very material. A druggist's bottle, of a capacity of from six to eight ounces, will be found a convenient form. Of course, every pond-hunter will carry a pocket-knife, which should have one stout blade for cutting off the rootlets previously spoken of.

How is the outfit to be carried? A small black bag with a square opening is a good receptacle. The bottles may be carried in it safely if wrapped in paper; or loops of tape or wide elastic may be sewn to the lining to keep them in position.

Baskets of various forms are also used, and though these do not look so well as a bag, they are quite as convenient, and less expensive. A satchel with lining divided into compartments for the bottles and tubes, and a pocket for the mackintosh and net, offers a convenient method of carrying the necessary equipment. But this is a matter in which every one must consult his own taste, and the collector will soon learn by experience to adapt his outfit to wants.

The publication of these papers brought the writer much interesting correspondence. The following is quoted to give some idea of the apparatus used by a Fellow of the Royal Microscopical Society in the North: 'Each collector has his own fad in regard to apparatus, &c. Mine is a very simple one. I have a coat made with a large pocket in the skirt lined with waterproof cloth. I have pockets inside and outside—as many as the tailor can find room for. Then, a waterproof bag with a *broad* leather strap to go over the shoulder. The inside has elastic stitched in loops to hold about a dozen tube bottles such as are used by chemists for pills. These are useful for any rarity. Then beneath these bottles about half a dozen two-ounce or four four-ounce bottles fit. I find the finest silk used by millers better and stronger for the net than cambric or muslin, and I use it double, to give greater strength. It is not attached to any bottle, and round the front of the ring is a brass saw-shaped scraper, which is very useful for scraping the

sides of bridges, roots of trees, walls, &c., under water, the net catching what the scraper detaches. — declared it the best stick out. For collecting swimming things I merely sieve the water with the net, letting the water run through. I then invert the net with the finger, and wash out contents into a wide-mouthed bottle, and thus get Rotifer broth as strong as desired.'

A good deal of what has gone before as to pond-hunting is applicable to rock-pool hunting, but while the former is generally the occupation the latter may serve for occupation during a seaside holiday.

Every collector has his own methods, which he naturally considers the best ; and undoubtedly they are the best *for him*, for the simple reason that use has become second nature, and he goes to work, so to speak, automatically, without reflecting why he does thus or thus.

The first thing to be considered by the beginner is outfit, for personal wear, for the capture of the game, and for its examination and preservation. The Rev. Thomas Hincks, F.R.S., one of the greatest authorities on British Hydroid Zoophytes, himself an enthusiast in the work, says that the collector should be 'clad in garments that an old clothesman would hardly covet, and must be totally indifferent to appearances, as indeed he will be if he is a true naturalist.' While accepting this dictum heartily for himself, the writer mentions it here as a counsel

of perfection rather than an absolute rule. The garments should be warm, if old, and nothing but woollen should be worn. The hat or cap should be of soft material; opinions differ as to the brim or peak—if narrow or small it affords but little protection against the sun's rays, if broad it is apt to dip into the water when one bends over rock pools. Every one must please himself as to boots or shoes. As in walking over rocks covered with weeds it is practically impossible to keep the feet dry, many people use canvas-shoes, which let the water run out again as easily as they admit it, and keep a pair of boots and dry socks for the journey home from the shore. But if one decides to wear boots, these should have no nails, for a person unaccustomed to walking over fucus-covered rocks will find the task easier and safer in boots without nails. Nor is it wise to trust to a walking-stick for support; the body should be balanced by the arms, and in this case, as in most others, practice makes perfect.

For the capture of free-swimming organisms the collector will require a stick and net, such as were described on p. 18. With this apparatus he will be able to sweep the rock pools for Infusorians, Rotifers, and small Crustaceans—marine waterfleas; and on boating excursions, if the net be allowed to hang lightly in the water many Medusans will probably be secured. Surface skimmings at sea should always be taken, as in warm weather these will probably yield Noctiluca, which was known in the early part of the century as the marine

night-light. One must have a strong-bladed knife for detaching specimens from the rocks, and a store of glass bottles, to quote Mr. Hincks again, 'ranging from the homœopathic tube to the pickle-jar.' Personally, the line is drawn below pickle-jars. Bottles of the capacity of ten or twelve fluid ounces will be probably found large enough; but they should be wide-mouthed, so as to take without difficulty a good-sized spray of seaweed that may have on it delicate zoophytes, for gentle handling is a necessity with creatures so extremely fragile that a touch would crush them. These bottles may be carried in any fashion that pleases the collector, so that it be not in the pockets. There are two good reasons against such a method of transport: the heat would probably kill a good many of the animals collected, and moreover there is the danger, when one is leaning over or lying down by the side of a rock pool, that the bottles may slip out of one's pocket and be smashed upon the rocks, or that their inverted position will allow the water to run out—an accident that happens to most people when they begin collecting. If one has the necessary courage, it is well sometimes to dispense with a coat, using instead the common blue jersey usually worn by fishermen and sailors, or a cardigan jacket.

A basket of some kind is as good a means of carrying the necessary bottles as can be desired. The spaces between them should be filled with coarse damp seaweed—the common Bladderwrack

(*Fucus vesiculosus*)—to keep them cool and to prevent their jarring against each other, and consequent breakage. In addition to the basket, a satchel slung over the right shoulder will be useful. If the interior is divided into compartments by stout jean lining, room may be found for three ten-ounce bottles, four four-inch tubes, and large wooden and small brass forceps. There should be a pocket in front to take the net when out of use, and two small straps to fasten the flap securely. A geological hammer and a cold chisel will be found serviceable for chipping off bits of rock. It must be borne in mind that seaweeds have no true roots, and that they will not do well in an aquarium if the thallus or disk by which they are attached to a rock or stone is injured.

The collector spending a holiday at the seaside will want besides his microscope a few watch-glasses—or, better still, square blocks of glass hollowed out watch-glass fashion—for examining objects with a low power, some excavated slips three inches by one inch, and some cover-glasses. One may take a zoophyte-trough or two, but the watch-glasses will answer every purpose, and they have no joints or cement on which salt-water can act. The microscope should be carefully cleaned after use, as the salt-water has an injurious effect on the brasswork.

For temporary aquaria nothing can be better than the nests of beakers sold cheaply enough at any glass shop. But if these cannot be got, clear thin tumblers are always at hand. For the better

preservation of such specimens as good fortune may throw in our way, it is well to devote a little time to getting these temporary aquaria into going order. The beakers or tumblers, as the case may be, should be filled with sea-water, and into each should be dropped a few *green* seaweeds, or small stones and shells covered with minute confervoid growth. They should then be placed in direct sunlight, and covered with a small square of glass such as lantern-slides are painted on, or something else sufficiently heavy to fit close and exclude the dust. If we then bring home a mass of the long pipe-like green weed (*Enteromorpha*), the broad Sea-lettuce (*Ulva*), or the branching filamentous *Cladophora*, and, dipping a bunch into each vessel, shake it in the water, we shall by this means have stocked our temporary aquaria with a host of minute animals that will serve for food for more important captures, while the weed and confervoid-covered stones will oxygenate the water.

No hard and fast rules can be laid down for collecting. Whenever an organism is met with for the first time, the surroundings should be mentally noted, and the character of the habitat fixed in the memory, or entered in the collecting note-book, so that the same or a similar spot may be searched for other specimens if they are wanted.

The dredge may be left out of consideration, as it is the instrument of the professional naturalist rather than of the amateur. But though we are not going to incur the expense and trouble of

a dredge, it is possible to make interest with fishermen and trawlers and obtain from them for a trifle some of their 'rubbish.' This consists of stones and shells brought up in the dredge or trawl, and is sure to be covered with minute animal life—sponges, hydrozoans, polyzoans, tube-dwelling worms, and tunicates or sea-squirts, that begin life with a brain, an eye, and a primitive backbone, all which they lose when they become adult.

The best time to start for the collecting-ground—at any rate, when we begin operations—is shortly after the turn of the tide, just as it begins to ebb. By this means the rocks and rock pools high up on the shore may be examined first, then the collector should work seaward, following the tide down. In this way time will be economized, and if it be remembered that the rarer forms of microscopic sea-life will generally be met with as we recede from high-water mark, we shall take full advantage of the ebbing tide and examine the rocks farthest from the shore while we have the opportunity. But while one makes the best use of the ebb, one must be on the watch for the flow. So far as I know, there is no record of any serious accident having happened to a collector, but it behoves every one to be careful and to see that his ardour does not carry him so far as to make his return dangerous or even disagreeable.

The sides of ridges and upstanding rocks should be examined, turning back the coarser fucus, for underneath this grow delicate weeds, on which may

be found some of the exquisitely beautiful hydrozoans described and figured in the standard works of Allman and Hincks. Here, too, stores of *Enteromorpha*—long green seaweeds, like minute sausage-skins—will be found, and we may gather a handful or two of this and rinse it in one of our bottles filled with water. Hosts of tiny Crustaceans, Rotifers, and Infusorians will be shaken off. But no animal life, however minute, should be left by itself; vegetable life should always bear it company.

Rock pools are capital hunting-grounds, and it is impossible to search one with any degree of thoroughness without being well rewarded for the trouble. In looking for a 'likely' rock pool, one should be chosen with the sides broken into overhanging projections like miniature precipices, and dotted or covered with some of the finer seaweeds. The 'proper' way to hunt a rock pool, as taught us by Mr. Hincks, is to lie down beside it, so as to be able to gaze into its depths without the fatigue of stooping. At first one finds it difficult to distinguish anything but the most general outline; by degrees, however, the eye will become accustomed to the strange scene, and the minute tree-like forms of many of the so-called Corallines will gradually grow distinct. The name Coralline, which properly belongs to the pink lime-encrusted seaweed (*Coralina officinalis*), was formerly used to include many of the Hydrozoa and Polyzoa, and, with some qualifying term, is still generally employed—as it

will be here—as a popular name for some members of both groups, though the scientific name will be added. The true Coralline was long considered to be an animal. Its vegetable nature was not demonstrated till 1842, when Dr. Johnston kept some for eight weeks in a jar of sea-water. Had the Coralline been an animal, the water, which was not artificially aerated by syringing or any other method, would have become corrupt, and killed the smaller creatures which swarmed in the same vessel.

It is well, if possible, to choose a pool into which the sun is shining, and the shadows of objects should be carefully looked for, since these can often be detected when the animals themselves escape observation by reason of their transparency. A strong-bladed knife should then be passed under the adherent base, and the tree-like organism carefully placed in a tube. Tufts of weed should be brought to the surface and examined in the palm of the hand held below the surface of the water, or pieces may be detached and put into a tube full of sea-water for examination with a hand-lens. On such weeds we shall find many of the Hydrozoa and Polyzoa, and these will live readily in our aquaria, where we shall be able to observe their reproduction. Most of the former group will send off sexual zooids—some of them marvellously beautiful, and so different from the parent-forms as to have been classed in distinct genera before their true nature was known.

Large stones in rock pools should, if possible, be turned over, and the under-side carefully scanned. The only time I was fortunate enough to meet with Ellis's Tubulous Wrinkled Coralline (*Tubularia larynx*) was on the coast of North Devon. It was high tide, and the beach was covered with large round stones that made walking wearisome. The few pools there were seemed too high up to afford much chance of sport, and from those that were visited the only spoil secured was a few of the commoner kinds that might have been got nearer home and with less trouble. But while hunting over a pool, which I had determined should be the very last, a hermit crab waddled across the bottom and took refuge under a stone. It was not an easy matter to turn this, and when it was turned the crab was gone. It was a brilliant August day, and as I looked into the pool I saw a shadow on the stone, which proved to be thrown by a solitary stem of this charming little hydrozoan, with its polypite 'equal in richness of colour to the Guernsey lily.'

All caves should be carefully explored, as the sides and roof are the habitat of many creatures that will interest and delight us. Often one may meet with rocks disposed somewhat after the fashion of a prehistoric memorial—a flat slab supported by more or less upright pieces. Here is one sure to find abundance of sponges. Only a small quantity should be taken, for sponges are difficult things to keep in aquaria, where there is much other animal life. They seem to go wrong for love of

the thing, and when they die they generally corrupt the water so rapidly as to do a great deal of mischief before one is aware of what has happened. But if a little piece be taken of each kind we meet with, it will be easy to identify our captures by examining the spicules which form the skeleton, or supporting framework of the sponge-flesh. The usual way of obtaining these spicules is to boil the sponge in dilute nitric acid in a test-tube over a spirit-lamp. This destroys the sponge-flesh, leaving the spicules at the bottom. A much simpler way—and it is equally efficacious—is to place a piece of the sponge in a watch-glass or in an excavated slip, and tease it out with a couple of dissecting needles—bonnet-pins will serve at a pinch. If the sponge-flesh be now removed and the water examined under the microscope, we shall find it crowded with these spicules. They should be drawn, and when opportunity offers the sketches should be compared with the plates of some book on the subject. Bowerbank's *British Spongiadæ* is the standard work on our native sponges.

Sand pools are not to be passed by. These are to be found at the base of rocks or stones bedded in the sand, where the tide has made a hollow with its swirl and eddy, and turned the depression into a miniature lake. Floating weed met with in such localities generally repays examination. In very many cases it has been torn from the sea-bottom by the waves, and when thrown on shore has found a resting-place in the sand pool. On the larger

branches sometimes occur the encrusting cells of Ellis's Foliaceous Coralline (*Membranipora pilosa*), and Gosse's Stag's Horn Coralline (*Alcyonidium hirsutum*), while among the vegetation may be traced the tendrils of the Nit Coralline (*Amathia lendigera*), with its cells arranged at intervals in small groups, the Grape Coralline (*Valkeria uva*), and the Dodder-like Coralline (*Valkeria uva-cuscata*), which trails over seaweeds just as one may see the Dodder trailing over heather and furze. But there the similarity ends, for the Dodder Coralline, unlike the parasite from which it takes its name, has no injurious effect on the plants on which it lives.

If the methods described seem to entail too much trouble and inconvenience, there remains what Mr. Hincks calls a 'more easiful way.' Every one can walk along the shore following the tide as it retreats. The weed cast up will always yield some kind of spoil, and sometimes good fortune will throw a veritable 'haul' in the way of the collector. A few summers ago a friend who was spending his holidays in North Kent sent me a small biscuit-box loosely packed with seaweed, which he had selected with the aid of a pocket-magnifier. Among the green weeds were several species of *Cladophora* and the palm-like *Bryopsis*; the red consisted chiefly of *Plocamium* and *Ceramium*, while the brown weeds were represented by *Cladostephus* and *Striaria*. About sixteen hours elapsed between the despatch of the parcel and its

arrival, and about twenty-four hours before its examination. The first proceeding was to lay the weed out loosely in soup-plates full of clear seawater. It was then cut into convenient lengths, put into tubes, and carefully looked over with a hand-lens. That which showed no sign of having animal life on it was thrown away; that which was populated was sorted into jars full of water—Polyzoa into one, Hydrozoa into another, weeds with *Spirorbis* into a third, and so on, till the material could be properly dealt with and transferred to aquaria in going order. Those who are not enthusiastic enough to disregard the discomfort of lying down beside a rock pool will be glad to know that this method of collecting what my friend calls 'sea-wash' proved eminently successful. He sent more *Coryne* than I had ever seen before, or have seen since, at any one time—long spreading branches, crowded with 'heads,' and after they had spent a day or two in a large tank they were as lively as if they had never left their home at the bottom of the Thames estuary, and as if sixteen hours' confinement in a biscuit-box were a joyous interlude in a somewhat dull life. The Polyzoa swarmed on some of the weed to such an extent, that when they came out of their tiny cells and spread their tentacles in search of food the stems seemed covered with the finest down.

This chapter may fittingly conclude with a quotation from Professor Lacaze-Duthiers, chief of

the Zoological Station at Roscoff; and the general drift of his remarks is as applicable to fresh-water as to marine collecting: 'To students who want to be true naturalists, let me say that they must go to the sea and search along the shore for themselves. I never go collecting at low tide without learning something new about the habits of the creatures and the places in which to look for them. . . . The true naturalist must seek and find material for himself. Soon he will learn to "see" and to discover; and even on the shore he will be obliged to pay some attention to his animals, in order to bring them home alive. In every case he will be able to recognize some conditions of their surroundings that will help him when he comes to watch them in the aquarium.'

CHAPTER II

THE BEGINNINGS OF LIFE

THE next step to pond-hunting is the examination of the spoil. To do this with any profit one needs first of all a general idea of the creatures themselves, and next some scheme of classification that will show the relationship between these creatures and those higher and lower in the scale of life. It is not enough to have a microscope, nor even to put upon the stage a zoophyte-trough or watch-glass, or cell containing a rare object: there must be some previous general knowledge of what to look for. Capt. Basil Hall says that one night he was present at a meeting of the Geological Society when a bottle containing zoophytes was handed round. 'The initiated on the foremost benches commented freely with one another on the forms of the animals in the fluid; but when it came into our hands, we could discover nothing in the bottle but the most limpid

fluid—without any trace, so far as our optics could make out, of animals dead or alive, the whole appearing absolutely transparent.’ It is good also to think about what one sees. Small service is it to watch *Amœba* unless one considers the relationship between the viewed and the viewer—the lowest and the highest forms of life.

Our scheme of classification need not be a minute one: it must, however, be based on right principles, so as to lay a sure foundation for a future superstructure of knowledge. All living creatures—from the *Amœba* to Man, can be grouped into two grades:—

A. Single-celled Animals;

B. Many-celled Animals.

Of the first grade are the Infusorians of our ponds and the Foraminifers of the sea and shore. Of the second grade are all the rest, the lowest being the sponges. The Many-celled Animals were formerly divided into Vertebrates and Invertebrates, according as they did or did not possess a backbone. It is now known that no such sharp division exists in nature. The spinal column, which is bony in man and beast, bird, reptile, and amphibian, becomes gristly in some fishes, and is a mere rod without signs of division into joints or vertebræ in the hag and lamprey. Below there are small groups showing signs of a rudimentary backbone, and so we gradually reach the great sub-grade of Achor-dates, which have no backbone or traces of one. It

is with these we have to deal, and they are usually arranged in six groups, the lowliest being placed first:—

SPONGES,	STARFISH,
STINGING ANIMALS,	ARTHROPODS,
'WORMS,'	MOLLUSCS.

Each of these six groups is technically called a *phylum* (from the Greek *phulē*, a tribe), and it would be well to give them that name, which soon becomes familiar. The important thing, however, to remember is that at least five of them constitute fairly natural main divisions of the animal kingdom, while the phylum 'Worms' is a sort of zoological lumber-room wherein are stored many creatures whose proper place is uncertain. These groups have been arranged on the principle of relationship, or of common descent—the only one now admitted. In writing and printing it is necessary to place these one above another, or side by side—an arrangement which fails to make the facts of the case clear. A genealogical tree would show the connexion between these groups and the rest of the animal kingdom better than any other plan. Thus near the roots would be the Single-celled Animals; just above these the Sponges branch off, as do the Stinging Animals a little higher up. Then come the 'Worms'—a great stretch of trunk sending out many small branches; while branches at still greater heights may stand for the Starfishes, the Arthropods, and the Molluscs respectively.

Each large branch gives off branchlets, whence twigs arise standing for divisions and sub-divisions of the *phyla* or main groups. For the examination of the creatures that become the prey of our bottle and net, it is not necessary to go farther up the tree, though no harm can result from remembering that just above the Molluscs lies a piece of trunk that may represent the border-land between the old sub-kingdoms of Backboned and Backboneless Animals. Then the Fishes branch off on one side and the Amphibians on the other. Above the Fishes are the Snakes and Lizards; and above the Amphibians the Crocodiles, Tortoises, and Turtles. Then the trunk divides at the top—the Birds on one side, the Mammals on the other, the topmost twig on the highest branchlet of this branch representing Man.

The first creature to claim our attention is Amœba, which appears to have been first described in 1755 by von Rosenhof as the Proteus Animalcule, from its habit of changing its shape. It exists in plenty among the mud and vegetable *débris* of ponds, and some specimens are pretty sure to be brought home in the flocculent matter at the bottom of the store-bottles. It is a tiny creature, rarely more than $\frac{1}{100}$ th of an inch in diameter. The best way to secure it for examination is to take up a little of the sediment from the bottom of a store-bottle in a dipping-tube or pipette, and drop it into a watch-glass, so that it may be looked over under a low power, and if

Amœba be seen it can be transferred to a glass slide for examination with a higher power.

One must look for a shapeless blob of jelly-like matter gliding across the field of the microscope, now pushing out finger-like processes in one direction and, to compensate for this, shrinking its bulk in another. Dr. Hudson describes Amœbas as 'slow-gliding lumps of jelly that thrust a shapeless hand out where they will, and, grasping their prey with these chance limbs, wrap themselves round their food to get a meal; for they creep without feet, seize without hands, eat without mouths, and digest without stomachs.' The inner part consists of granular matter, which may be seen to flow in different directions,

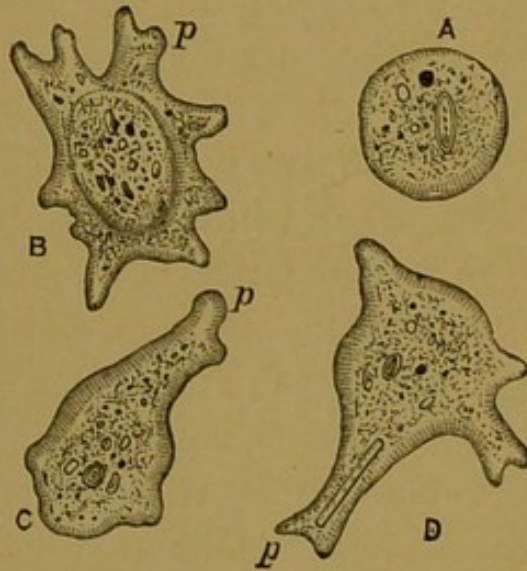


FIG. 10.—AMŒBA. A, CONTRACTED; B, C, D, IN MOTION; *p*, PROCESSES THROWN OUT

and round this is a clear envelope which requires to be closely looked for, with careful management of the light, or it may escape observation. Amœba was formerly described as without structure. The vast improvement that has taken place in the construction of lenses has shown that, so far as we know, no such thing as structureless protoplasm exists. J. A. Thomson, writing of the Infusorians, says that 'Ehrenberg, who described

them as "perfect organisms," and fancied he saw vessels, hearts, and other organs within them, was nearer the truth than those who reduce the single-celled animals to the level of white of egg.' The peculiar movements of *Amœba* may be imitated by taking a lump of putty or dough in the hand and squeezing it so as to allow some portions to come out between the fingers. Prof. T. J. Parker reminds us that there is this great difference between the putty and the *Amœba*—the one is acted on, the other acts for itself. In the granular mass is a darker spot, which does not change its form while the protoplasm is flowing all around it. This is the *nucleus*, which is essential to life and reproduction. The latter is effected by simple division of one *Amœba* into two, and the disappearance of the parent-form. The nucleus, which exists in all one-celled animals, contracts in the middle; part of the granular matter with half the nucleus flows in one direction, and the rest in the opposite, with the other half of the nucleus, till the creatures assume a shape somewhat like that of a dumb-bell. The bar becomes thinner and thinner by the absorption of its granular matter by the heads of this living dumb-bell, till at last the connexion is severed, and there are two *Amœbas* where only one existed before. This shows the simplest form of reproduction in the animal world; and led Prof. Weismann to the conclusion that none of these one-celled creatures can die. One-celled animals in the open sea do probably die in large numbers. Of course

countless myriads are eaten ; and to maintain even the kind of immortality that Prof. Weismann means it is necessary that from time to time different individuals should unite, or the race would seem to be in danger from decay and incapacity to multiply.

In the clear space surrounding the granular matter is a space which widens slowly and then rapidly contracts. This is called the *contractile vacuole*, and probably serves for respiration by taking water laden with oxygen into the body, and for excretion by forcing water laden with waste products out of the body.

Diffugia may be described as an Amœba with a pitcher or urn-shaped shell, often covered with grains of sand. From the mouth of this covering the little inmate protrudes processes by which it moves and which serve to capture its prey. It is found moving slowly the thread-like Confervæ, or among the mud at the bottom.

The two little animals that we will look at next have long, high-sounding scientific names—*Actinophrys sol* and *Actinosphærium eichhornii*, popularly spoken of as Sun Animalcules, from the fact that they somewhat resemble the ‘sun in his splendour,’ as figured by heralds and painters of tavern signs. The latter is the rarer and much the larger of the two, and shows a slightly higher stage of development. The former may be found in almost every pond or lake, swimming among aquatic plants, its favourite haunts being Duckweed, Hornwort, Bladderwort, or the thread-like Algæ. A likely place to find

Actinosphærium is among the fibrous rootlets of willows and alders. A piece of willow-root some six inches long, recently taken near London, when placed in a small window-aquarium for examination, was found to have at least a dozen of these tiny creatures on it. Each consists of a speck of protoplasm, from which radiate long thread-like processes, generally motionless, except when engaged in the capture of prey. These animals are very low in the scale of living creatures—just one stage, and that not a long one, above the Amœba. No sooner does a luckless Water-flea, Infusorian, or tiny

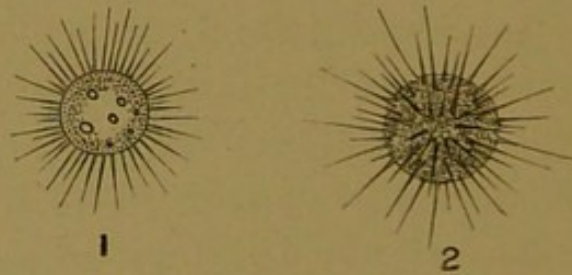


FIG. 11.—1, ACTINOPHRYS SOL ($\times 100$). 2, ACTINOSPHERIUM EICHHORNII ($\times 30$)

Rotifer come in contact with the thread-like rays of a Sun Animalcule, than it is at once held firmly, and the thread begins to contract, while its fellows near bend round to lend their aid, and so the captive is slowly but surely drawn down and engulfed in the living mass which rises to meet it. The voracity of these animals is out of all proportion to their size. One observer saw an Actinosphærium one-thirtieth of an inch in diameter that had ingested a couple of Entomostraca, a few Rotifers and Infusorians, and a quantity of the spores of Algæ, so

that, in his own words, 'the object on the slide appeared about one-third Actinosphærium and two-thirds dinner.' Besides the difference in size—and Actinophrys is rarely more than one-hundredth of an inch in diameter—it will be seen that there is a difference in their structure. In Actinosphærium the protoplasm is differentiated into an interior and clouded, and an exterior and clear portion, which surrounds the other like a ring. The rays of Actinosphærium are more distinctly stiffened with a kind of internal axis, though in both forms these rays can be retracted, and sometimes they are wholly withdrawn into the central mass. When either of these forms is in the zoophyte-trough, some Entomostraca may be introduced, and the process of feeding may be watched at leisure.

The free-swimming Infusoria move by means of cilia—delicate hairs which fringe the whole or part of the body, and also serve to waft food-particles into the 'mouth.' These cilia are, however, not confined to free-swimming forms, and constitute one of the distinctive marks of a whole group.

The store-bottles contain a good many free-swimmers, but in order to take out a few recourse must be had to stratagem. Selecting a bottle in which these minute forms of life are plentiful, we will place it where the rays from the lamp may fall full upon it, for though these little creatures have no sense-organs in any way analogous to those of higher forms, yet in some way they are influenced by light. Now we will take a card, and, having cut out from about the

middle a roundish patch as large as a shilling, lay it against the bottle so that the direct rays shall enter only through that hole. And, just as fish will crowd to a hole in the ice for air, so will these animalcules swarm to the light, and consequently they may be taken out without much trouble by means of a dipping-tube or pipette.

The first that comes to hand is the Barrel Animalcule (*Coleps hirtus*) (fig. 12), fairly common in pond-water, among duckweed and other vegetation.

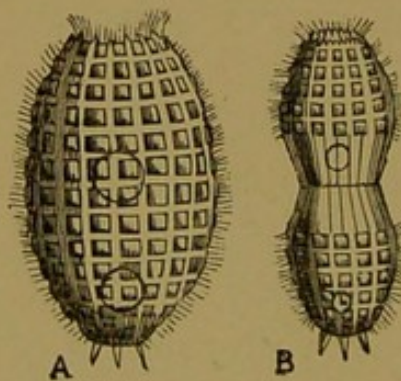


FIG. 12.—*COLEPS HIRTUS* ($\times 400$).
AFTER SAVILLE KENT. A,
ADULT; B, EXAMPLE DIVIDING
BY TRANSVERSE FISSION

It owes its popular name to its shape, and as it goes on rolling over and over on its longer axis across the field of vision, it will be confessed that the name is by no means inappropriate. It is a wonderfully active creature, perpetually in motion, and an admirable scavenger, for

there seems to be no limits to its capacity for assimilating dead and decaying organic matter. Saville Kent remarks that a crushed Entomostracan, or any other creature that has met a violent or natural death in water abounding with this animalcule, 'is quickly surrounded and devoured with an amount of happy despatch that, comparing small things with great, would scarcely disgrace a troop of jackals collected around some desert carrion.' So that, small as they are, these creatures perform an important function in the economy

of Nature by purifying the water in which they live.

We shall also be pretty sure to meet with the Swan Animalcule (*Trachelocerca olor*), for it is very common, and if any are present, we shall certainly find two, for they hunt in couples. It is generally found in pond-water, among decaying vegetation, or on thread-like Algæ. This is one of the earliest known forms, and was called the 'Proteus' by Baker, who was the first to figure it in 1752. Its general form and structure may be made out from the illustration (fig. 13), and it will be noted that the specific name, which means 'swan,' is particularly appropriate, though Kent considers that this little creature suggests the restored figures of the extinct Plesiosaurus. To

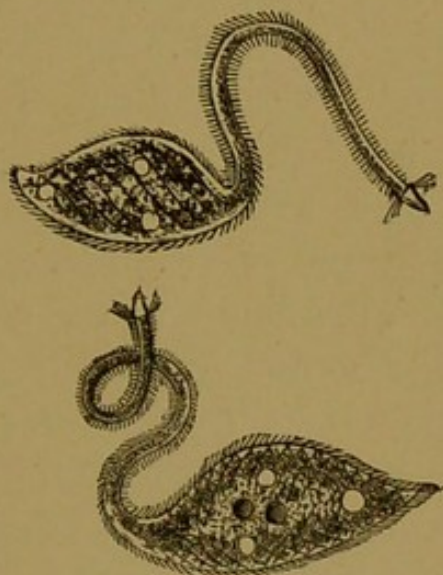


FIG. 13.—A, B, TRACHELOCERCA OLOR (× 300)

the writer, however, this Infusorian—with a name as long as its neck—always suggests a swan, and when it is seen thrusting this long neck among the flocculent vegetable *débris* on which it feeds, one can almost fancy he is looking at a tiny swan searching the bottom of some ornamental water for its food. There is one other form to be mentioned—*Amphileptus gigas*; but though it is much larger than the 'long-necked

swan'—for it is sometimes found one-sixteenth of an inch in length—there is so much similarity between them that it only requires a few words of description. Its mouth is situated at the base of the neck, which serves as a proboscis, with which food is collected and conveyed to the proper receptacle. No words, however, can convey more than a faint idea of the extraordinary pranks *Amphileptus* plays with this proboscis. Not only is it turned this way and that way in search of provender; it is alternately contracted and extended, and wreathed about the creature's body in fantastic shapes, just as one may see flamingoes do in the large aviary at the Zoological Gardens before settling to sleep.

The name Bell Animalcules was first given to the genus *Vorticella*, but has been extended in popular phrase to include all, or nearly all, the family. *Vorticella* appears to the naked eye as a delicate film on aquatic vegetation and rootlets. At first sight, under a low power (say one inch), it will be seen that the edges of the leaf and stem in the zoophyte-trough are studded with a number of bell or cup-shaped objects, each mounted on a stalk, which continually contracts and expands with a spiral motion. This is effected by means of the *axial-fibre*, an elastic thread which runs down the stalk. We can perceive the play of the cilia round the rim, and notice the optical illusion which makes their successive contraction in the same direction resemble the revolution of a toothed

wheel. Close inspection will enable us to make out the vortex created by these movements, and if we watch we shall probably see food-particles taken in. But a higher power is necessary to give some idea of the structure of these creatures. We will carefully detach a likely-looking leaf from the weed, and lay it on a plain glass slide, adding a drop of water, and placing a cover-glass over the whole. If now we substitute a quarter-inch or

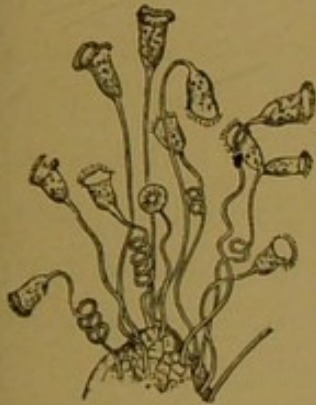


FIG. 14.—VORTICELLA
NEBULIFERA ($\times 50$)

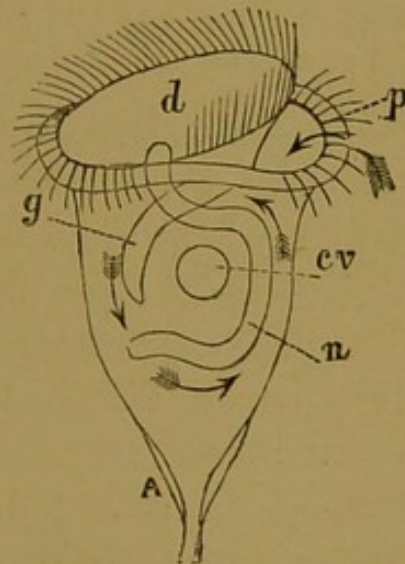


FIG. 15.—DIAGRAM OF VORTICELLA
NEBULIFERA ($\times 400$). THE ARROWS
SHOW THE COURSE OF THE FOOD-
PARTICLES

one-fifth inch objective for the one inch, we shall discover that the bell or cup is not such a simple affair as it seemed at first sight. We saw before that it was fixed by its smaller end to the top of the stalk; now we can make out that its upper end is thickened so as to form a rim, which is called the *peristome* (fig. 15, *p*) or region round the mouth. Inside the *peristome* is the *disk* (*d*), higher on one side than on the other, which has been compared

to 'a circle of cardboard fitted into a breakfast-cup.' The mouth (marked by the curved arrow on the peristome) is formed by a depression between the rim and the raised side of the disk, and leads into a conical gullet. The cilia form a spiral wreath, running round the inner border of the peristome, continued on the right into the *gullet* (*g*), and on the left encircling the disk. But though *Vorticella* has a mouth and a gullet by which it can take in food, it has no stomach wherein to bestow it. Where, then, does the food go? Into the body-mass. Each particle is surrounded by a tiny globule of water, which with its contents, when ingested, forms a bubble called a *food-vacuole*, and such food-vacuoles circulate in the inner protoplasm till they are absorbed, while particles incapable of absorption are got rid of at the base of the gullet, and swept out of the mouth by returning currents. The *nucleus* (*n*) is really nothing more than a denser spot of the protoplasm enclosed in an extremely delicate membrane. The *contractile-vacuole* (*c v*) is a clear round or nearly round space, which contains a watery fluid. This vacuole periodically disappears with a sudden contraction, and then slowly reappears, reminding the microscopist of the beating of a minute colourless heart.

Reproduction is effected by fission—the splitting up of one individual into two, the one given off being for a time free-swimming. It seems, however, that this process cannot be carried on indefinitely,

and rejuvenescence, or the renewal of the capacity to multiply in this fashion, is accomplished by the union of two dissimilar individuals.

There will probably be, dotted here and there on the film-covered weed, a Vorticella-like animalcule with a body $\frac{1}{500}$ -inch long, fixed on a rigid stalk or column about a quarter the length of the body. This will be one of the species of Rhabdostyla—probably *R. ovum*; and a knowledge of this, as well of the preceding genus, is necessary before one can understand how the compound forms, Carchesium and Zoöthamnium, Epistylis and Opercularia, may have developed.

We have seen that the fission of Vorticella resulted in one stalked and one free-swimming form. After a short period of independent existence the latter may develop a stalk and become fixed, or may rejuvenate the race by conjugation. But suppose that the fission were continued down the stalk: we should have a stem giving off two branches, each ending in a Vorticella-like individual. And if the process were continued again and again the result would be a tree-like colony, with numerous branches, each bearing at its extremity the normal cup-like body of Vorticella.

Now there are three forms of tree-like colonies, which fall naturally into two groups, one derived from Vorticella, the other from Rhabdostyla. The first group consists of the genera Carchesium and Zoöthamnium, compared by Saville Kent to a wall and a standard tree respectively, and from one-

sixth inch to one-quarter inch in height, therefore plainly visible to the naked eye.

In *Carchesium* the axial-fibre is discontinuous, each animalcule and each branch contracting and expanding independently of all the rest; in *Zoöthamnium* it is continuous, so that the whole colony is affected by the movement of a single unit—if one contracts, the rest do so simultaneously. In both these forms the main stem is contractile, like the stalk of *Vorticella*, and the whole colony can subside into a mulberry-like mass. In *Epistylis* the

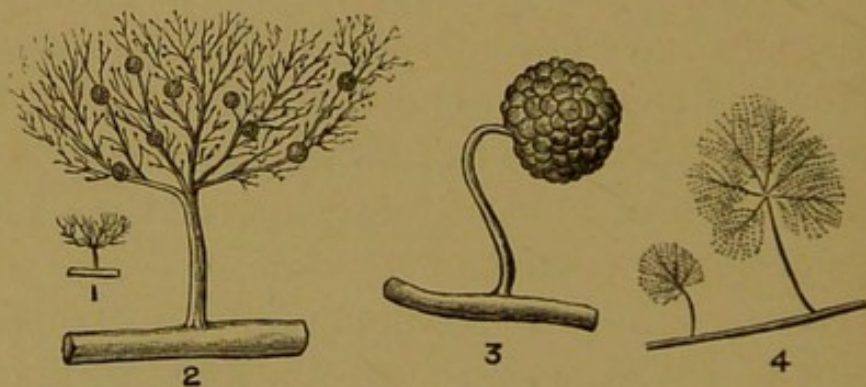


FIG. 16.—1, ZOÖTHAMNIUM ARBUSCULA, NATURAL SIZE. 2, THE SAME EXPANDED $\times 10$. 3, THE SAME, CONTRACTING $\times 10$. 4, CARCHESIUM POLYPINUM (NAT. SIZE AND $\times 4$)

stalk is rigid like that of *Rhabdostyla*, and the individual units contract and expand from the point where the stalk joins the main body. The animalcules themselves in all these colonies correspond in structure with *Vorticella*. All these forms are worth close attention; and the probable derivation of the tree-like from the simple forms may give some hint as to the origin of the branched colonies of Stinging Animals.

One species of *Epistylis* (*E. flavicans*) often

occurs in round masses—sometimes, it is said, as large as a nut—and settles on the sides of aquaria to such an extent as to coat them with ‘a grey felty mass.’ I have repeatedly seen colonies as large as a pea, and when these papers were written one of my tanks had at least fifty patches on its inner surface. The genus *Opercularia* closely resembles *Epistylis*, but differs therefrom in having the disk capable of elevation to some distance above the rim of the cup, so as to form a kind of lid or cover. The following solitary members of the same family will probably be found: *Vaginicola*, inhabiting a cylindrical glassy sheath; *Thuricola*, which has this sheath closed at the top with a valve-like apparatus when the animal contracts; *Cothurnia*, with a bulging vase-shaped dwelling on a short stalk; and *Platycola*, whose habitation, generally bent into a kind of neck, is always attached on the whole of one side to the leaf or host on which the tiny animal lives. All these forms may be found on water-weed, aquatic insects, and small crustaceans.

If a roundish, green, gelatinous body be seen floating about or attached to some of the weed in a store-bottle, this will be the colonial Vorticellidan *Ophrydium versatile*, which lives indifferently in fresh and salt water, as do many of the others. It is fairly plentiful in one of the ponds in Richmond Park, and may often be met with, usually free, as large as a cherry. If examined with a hand-lens, it will be seen that the surface is not smooth; and from time to time minute Vorticella-like animals

will protrude at different points of the circumference. After this has been studied, and acquaintance made with the general form of the colony, and the fact fully grasped that it consists of hundreds of individuals, the mass should be dropped into a watch-glass full of water, and a strip cut from it with a sharp pair of scissors. This should be placed in a very thin trough, or on a slide under a cover-glass. The plan of the colony will then be apparent. Each animal has a separate contractile footstalk, so that,

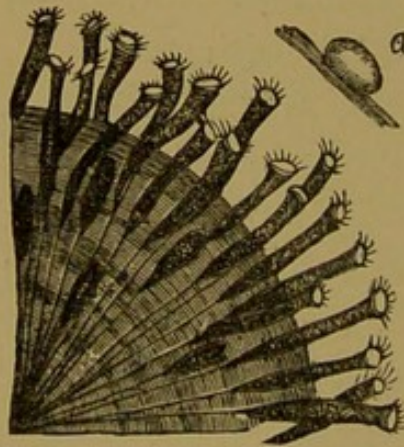


FIG. 17.—OPHRYDIUM EICHHORNII ($\times 50$). AFTER SAVILLE KENT. *a*, NATURAL SIZE

independently of all the rest, it can come out to seek for food or retire into the central gelatinous mass. This independent movement is like that of *Epistylis*, and the footstalks of all the members of the colony are joined to a central footstalk, which reaches each after a succession of branchings (thus, Y,

each arm again giving rise to two branches, and so on). The length of one of the extended bodies is from one-eightieth to one-thirty-fifth of an inch. When thus examined some of the individuals will probably become detached from the matrix, and swim about freely in the trough or under the cover-glass. Another form frequently met with is *O. eichhornii* (fig. 17), which is much smaller, and in which the gelatinous matrix is quite transparent. The footstalk of each individual is carried directly

down to the centre without branching, so that the two forms cannot possibly be confused with each other.

The genus *Stentor* contains the Trumpet or Funnel Animalcules, so named from their shape, which, in some species, is not unlike that of an old posthorn. Some are usually adherent to weeds by the narrow end of the body, occasionally swimming off from their resting-place by means of the fine cilia with which the body is covered, while others never settle down. Trembley, so well known for his researches on the Hydra, was the first to record this group, and described them under the title 'Funnel-like Polyps' in the *Philosophical Transactions* for 1744, for he considered them closely related to Hydra, as apparently did Linné, who put both in the same genus. Trembley described three varieties, which are now recognized as distinct species. The largest, and probably one of the commonest, is *Stentor polymorphus* (fig. 18), which, when fully expanded, is one-twentieth of an inch long, contracting to about one-sixth that size. It is usually green in colour, owing to the presence of chlorophyll granules in the outer layer. The plan of the animal may be compared to that of the cup of *Vorticella*, elongated and tapering in shape, endowed with the power of contraction and expansion, but possessing no disk. The opening into the

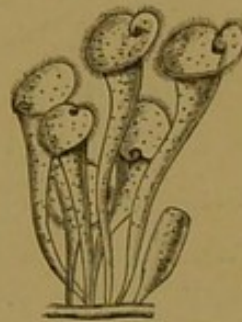


FIG. 18. — STENTOR
POLYMORPHUS
(× 20)

mouth corresponds roughly to the bell of a trumpet, or the top of the funnel whence the creature derives its popular names. The curve, however, is a spiral, not a circle, the right-hand limb being generally higher than the left. This curve is fringed with cilia, which act in a similar way to those surrounding the cup of *Vorticella*. This species is found in standing water, on green and decayed vegetation, and generally secretes for itself a mucilaginous sheath, into which the body can be retracted. Commonly, each sheath is tenanted by a single individual, but this species seems to have the social habit, and colonies of them are occasionally found inhabiting a matrix something like that of *Ophrydium* in substance though not in shape. Such a colony is figured by Saville Kent, who found it on the rootlets of *Anacharis* in an aquarium in 1871, and he appears to have been the first to put such a fact on record. One word of caution may be necessary here: the large size of *Stentor polymorphus* has sometimes caused it to be mistaken by beginners for some of the tube-dwelling Rotifers; but its spiral ciliary wreath and its low organization should guard against such an error. Black Stentors (*S. niger*) are much smaller, always free-swimming, extremely changeable in shape, and when fully extended about three times as long as broad. Kent records it only from bog-water on Dartmoor, but in some of the ponds near London it is very abundant, and in some of the ponds in Epping Forest it is said that these animalcules swarmed

to such an extent as to give an ordinary observer the idea that the water was discoloured by a shower of 'blacks.'

Euglena viridis (fig. 19) is a good example of an Infusorian furnished with a *flagellum*, or whip-like filament, which serves as a swimming organ. This little animal is a minute speck of bright green protoplasm. It is normally spindle-shaped, but undergoes many changes of form, which, however, principally affect the centre of the body-

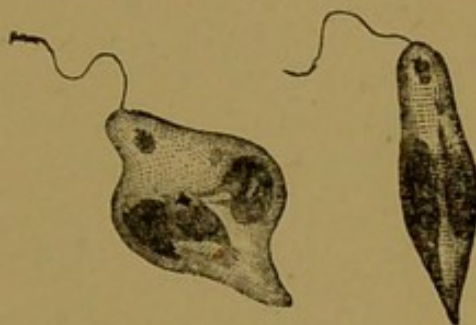


FIG. 19.—EUGLENA VIRIDIS
($\times 350$)

mass, for the two extremities always remain more or less pointed, as shown in the illustration. From what is by courtesy called the head the flagellum projects, and at its base is a minute aperture serving as a mouth and leading into a gullet, which is soon lost in the body-mass. Just at one side of the mouth is a minute red dot commonly called the 'eye-spot,' though it is certain that the name is misapplied. These animals are sometimes so numerous as to tinge with green the water in which they are found, and they are often met covering stagnant pools with a floating surface of green, which, when collected on paper, will preserve its colour for a long time. According to Professor E. Ray Lankester, species of *Euglena* formed the 'green matter' from which Priestley obtained oxygen gas. *Euglena* is, however, most important

from our point of view, as leading up to the compound form.

Volvox globator (fig. 20) is globular in form, and fifty of them placed side by side would measure about an inch. It is common in many clear ponds round London, and on the Hertfordshire border

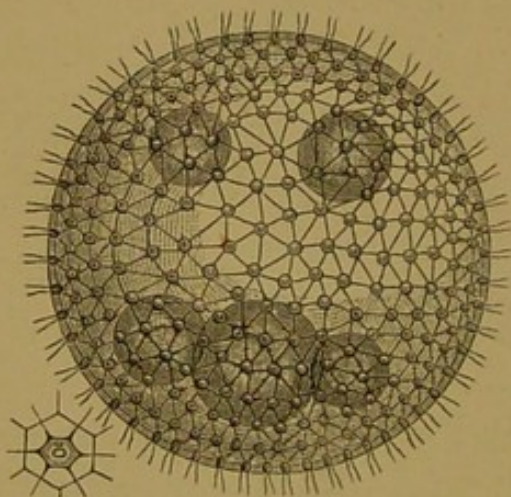


FIG. 20.—VOLVOX GLOBATOR ($\times 75$)

it has been taken in such large quantities that the two-ounce dipping-bottle, when held up to the light, was quite coloured with the 'light green crystal spheres sailing slowly along like planets revolving through space.' Each sphere, however, is not a simple animal, but a colony made up of a number of zooids, or individuals capable of independent existence. This will be better understood from the illustration, where these individuals will be seen as tiny circles on the surface of the sphere which directly meets the eye, and round the edge the two flagella with which each is furnished may be seen. A high power will reveal the fact that each zooid is the centre of a regular hexagon, and connected with its neighbours by minute threads of protoplasm, so that the whole mass is bound together by a living network, the interstices of which are filled with a transparent substance.

it has been taken in such large quantities that the two-ounce dipping-bottle, when held up to the light, was quite coloured with the 'light green crystal spheres sailing slowly along like planets revolving through space.' Each

This hexagon, much more highly magnified than the colony itself, is shown in fig. 20. Here, then, we have a hollow sphere, composed of a multitude of individuals: by the motion of the flagella with which each is furnished the colony revolves. This sphere is filled with liquid, in which similar but smaller spheres may often be seen revolving. These are built up on precisely the same lines as the parent-sphere in which they are enclosed, and furnish a strong argument for the animal nature of the organism, for such a method of reproduction is certainly not plant-like. When the organism has been examined as a whole, and made out point by point, one should be placed under a cover-glass or compressed in a live-box so as to burst the sphere, and under a high power the zooids will be seen swimming in different directions, affording incontestable proof of the colonial nature of *Volvox*, which seems to show how the gulf separating the single-celled from the many-celled animals may have been bridged over.

Amœba will often be found on seaweed or among the vegetable *débris* that will be sure to accumulate at the bottom of bottles and tubes containing microscopic marine life. What has been said about the fresh-water form is equally applicable to the marine.

The Foraminifera—Forams, collectors call them—are *Amœba*-like creatures, enclosed in membranous shells, generally impregnated with lime taken up

from the sea-water. In some cases, as in *Miliola*, there is but one aperture to this shell; in others, as in *Discorbina*, the shell is pierced with tiny holes, through which the protoplasm streams—in both

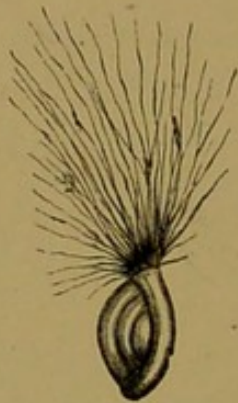


FIG. 21.—MILIOLA

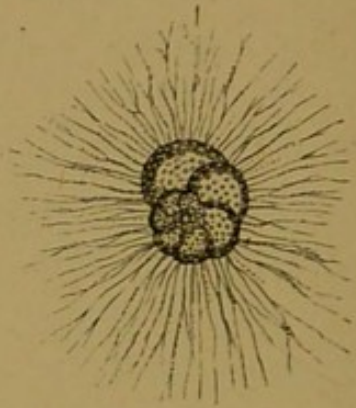


FIG. 22.—DISCORBINA

cases in delicate filaments, not in blunt finger-like processes, as in *Amœba*.

From surface-skimmings on a bright calm day

we are pretty sure to get the tiny Infusorian *Noctiluca miliaris*, popularly called the Marine Night-light. It is from $\frac{1}{80}$ in. to $\frac{1}{20}$ in. in diameter, in appearance resembling a minute grain of boiled sago. Gosse says that in one of his excursions he obtained as

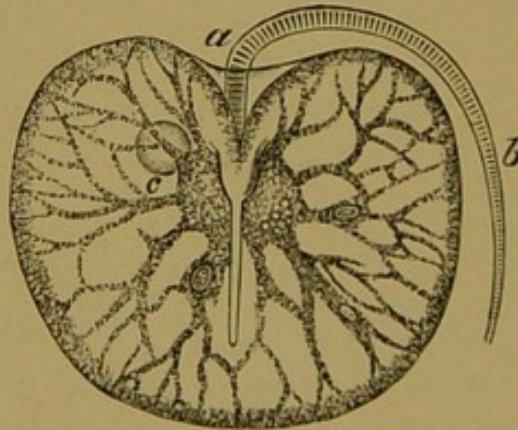


FIG. 23.—NOCTILUCA MILIARIS (AFTER ALLMAN), GREATLY ENLARGED. *a*, ENTRANCE TO GROOVE; *b*, FLAGELLUM; *c*, NUCLEUS

many as would fill the bowl of a large teaspoon, and that, though individually they have no distinctive tint, in a mass they present a pale red or salmon-

colour appearance. These minute animals, which are very abundant round our coasts, are one of the agents in producing the phosphorescence of the sea. Saville Kent notes that the luminous flashes seen by sailors at night, and attributed to fishes, are in many cases due to Noctiluca. Fishes are often seen to break away from under the sides of a ship, leaving a luminous track, and he concludes that the light really comes from the animalcules disturbed by the passage of the fish, and that 'this light is reflected as by a mirror from the glistening scales while the Noctilucas remain scintillating for some moments, . . . thus producing the more or less conspicuous tracks of light left in wake of the fish.' 'Not unfrequently,' says Professor E. Ray Lankester, 'the phosphorescence on the British coasts seems to be solely due to Noctiluca, which then occurs in millions in the littoral waters.'

When seen under the microscope Noctiluca appears as a spherical gelatinous mass, generally smooth, but sometimes having wrinkles on the surface. At one side there is a sort of infolding or groove like that of a peach, and just where one would look for the peach-stalk is the proboscis, or big flagellum, which has transverse striations and by means of which the animal moves. Near this is the oral aperture, or mouth, and a cylindrical passage, in which is a smaller flagellum, leading to the body-mass, which forms a kind of network. Early observers thought they could make out a stomach and a vent, but nobody dreams of

looking for these now. *Noctiluca* feeds upon the diatoms which swarm near the surface of the sea, and often when examining this Infusorian under the microscope the flinty cases of the diatoms may be distinguished in the network of the body-mass.

The seat of the phosphorescence has been determined by Professor Allman to lie immediately below the cell-wall; the luminous points may be made out with a hand-lens, but they are seen to much better advantage if one or two are placed in an excavated glass-slip with a little sea-water, and examined under the microscope. If a drop of methylated spirit be added, the phosphorescence, instead of being intermittent, as is normally the case, will be continuous, and will glow with intensity till the animal dies. If we have a good stock of them, another experiment is worth trying. Place one on a similar slip in a little iodine solution. Very shortly the reticulated body-mass will be found to have shrunk up to one side of the cell-wall, leaving a clear space nearly all round, but still presenting the appearance of network.

If small filaments of red or green seaweed be examined under a low power, we shall be almost certain to find thereon various kinds of the simple bell animalcules so common on pond-weed. One tube-dwelling Infusorian, however, which is confined to salt-water and by no means rare, deserves special mention. It is frequently found upon the shells of *Spirorbis* (fig. 24, *c*), which are sometimes covered with growths of this organism, just as pond-

snails are with dense forests of *Vorticella* and its close relatives. Unfortunately this tiny creature has no English name, and its scientific title *Folliculina ampulla* seems disproportionately long for a species of which about a hundred would go to the linear inch. But shells are not their only habitat. They may be found pretty thickly clustered on filamentous weed, and especially in the

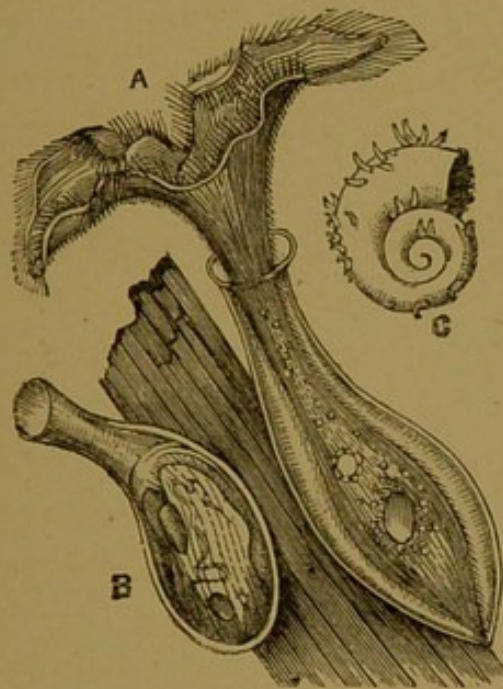


FIG. 24.—FOLLICULINA AMPULLA (MODIFIED AFTER STEIN). *a*, THE ANIMAL PROTRUDING FROM, AND *b* RETRACTED WITHIN, ITS SHEATH; *c*, SHELL OF SPIRORBIS, BEARING THESE INFUSORIANS

angles made by branches springing from the stems. In general appearance they are not unlike the freshwater *Stentor* in a gelatinous sheath. In adult specimens the sheath is a beautiful glaucous hue, and the animal itself is dark in colour, not from the nature of its food, but from the presence of colouring matter, as in some species of *Stentor*.

It is an extremely pretty sight to watch three or

four of these creatures, with dark-ground illumination, as they slowly come out of their cases, and open what by courtesy may be called the mouth, while the rapidly vibrating cilia lash the water into a vortex that carries down into the body-mass tiny particles of animal and vegetable food. Any weed or shell on which these creatures are found should be preserved and dropped into the aquarium, for they are almost sure to increase and multiply.

CHAPTER III

SPONGES AND STINGING ANIMALS

FROM the days of Aristotle down to the middle of the eighteenth century, the proper position of sponges was a matter of dispute. The skeleton of the sponge of commerce was long supposed to be a plant; then a colony of polyps—though the polyps were never seen; and still later it was said to be made by a nereid worm which lived in the interior. 'Coralline' Ellis observed the inflow and outflow of water from the openings of sponges, and concluded that they were animals, and in this way took in nourishment and got rid of waste matter: Grant, however, in 1825 carried Ellis's work much farther, and it was completed by Bowerbank and others, who showed that the inflow and outflow were due to the action of whip-like filaments similar to those of *Euglena*.

The simplest sponge is a sac-like body, consisting of three layers—a delicate outer skin, a middle layer in which lie spicules of lime,

forming the framework or skeleton, and an inner layer of cells furnished with cilia like those of an Infusorian. Through minute pores in the outer skin, water is drawn out of the central cavity, carrying with it minute food-particles, which are seized by the cells of the inner layer and swallowed, the nutritive matter flowing from cell to cell or into the middle layer, while waste products are carried off with the outflow of water through one large opening. Many sponges are very much more complex, but it is pretty certain that they have all arisen from this simple form.

The spicules of sponges, whether limy or flinty, are of the most diverse forms, and serve as one standard of classification. The simplest are like a needle pointed at both ends. Other forms resemble pins, nails, crosses, stars, wheels, grapnels, anchors, and every conceivable modification and combination of these figures. In some sponges they are so arranged as to constitute a regular lattice-work. The spicules of our British sponges are for the most part microscopic: those of the spiral anchoring wisp of the Japanese Glass-rope Sponge are sometimes a foot and a half long, and probably the largest known.

The Fresh-water Sponge (*Spongilla fluviatilis*) has its skeleton formed of spicules of flint, like needles pointed at both ends. 'It grows on the banks of docks, canals, rivers, and on floating timber, in the form of thick encrusting masses, which are usually of a green colour, and require a constant supply of

fresh water for its healthy maintenance.' Under a low power of the microscope the inflow and outflow of water can be clearly traced, especially if a little powdered carmine be added.

A fresh-water sponge may be cut into half a dozen pieces, and each will carry on an independent existence; or two or more may be placed side by side, and they will soon unite to form one organism. The same holds good of many other forms, and the bath-sponge is regularly propagated by cuttings.

Reproduction in sponges is effected by budding, and by the union of male and female elements. In addition to these methods the fresh-water sponge possesses a third, for it develops winter-eggs or statoblasts somewhat like those of the Polyzoa, but giving rise to male and female forms, thus showing alternation of generations. These statoblasts occur in all the family to which the fresh-water sponge belongs, and probably serve to perpetuate the race, since they only appear in hot climates in time of drought, and in cold climates in autumn and winter. They also serve to spread the species, for all are light enough to float, and some so light as to be scattered by the wind.

During a stay at the seaside many opportunities will occur of collecting sponges, for they are very plentiful all round the British coasts. Common sac-like sponges may be looked for on seaweed. The sponge known as the Mermaid's Gloves (*Chalina oculata*), with a flinty skeleton, may be picked up

in abundance on the southern coasts, notably at Hastings and Eastbourne. Another common form is the Crumb-of-Bread Sponge (*Halichondria panicea*), found on large weeds and covering rocks; while oyster and scallop-shells are the favourite home of the Boring Sponge (*Clione*). All the smaller sponges are worth examination and patient study, but attempts to keep them alive will probably end in failure. They are not only difficult to keep alive, but their death in an aquarium is nearly certain to corrupt the water and so spread desolation around.

The first of the Stinging Animals to be noticed is the Hydra, named from that water-serpent of classic mythology, of which it was fabled that its heads were reproduced as fast as they were cut off by Hercules. Hydra is common in almost every pool, on the stems and leaves of aquatic plants, on twigs and dead leaves that have fallen into the water, and on submerged wood. When contracted it appears like a tiny speck of jelly, almost colourless, or brownish, or apple-green in hue, according to the species. When fully expanded it is a thread-like tube from $\frac{1}{4}$ to $\frac{3}{4}$ inch long; at the upper extremity there is a food aperture—for it does not realize the ordinary idea of a mouth—leading into the primitive stomach into which the animal puts its prey, and serving also as a vent for the expulsion of innutritious matter, such as the shells of water-fleas. The lower extremity or base is closed, and serves as a point of attachment by

which the animal can adhere to weeds, stones, or, as may often be seen, the shell of a snail. The primitive mouth is surrounded by a circle of long delicate arms or tentacles, varying in number according to the species, and very often in the individuals of the same species. These are well worth careful examination, for they are terrible weapons. Water-fleas, cyclops, and worms may struggle for a moment when seized by these organs, but in a few minutes the struggle is over, the victims are struck motionless, and gradually drawn in. Dr. Mantell thought that the Hydra, like the electric eel, killed its prey by a shock. It is now known that the tentacles are studded with *nematocysts* or thread-cells, each capable of emitting a slender filament by which a specific poison is injected into the prey. These thread-cells are common to the group of which Hydra is the lowest member, and for that reason the name Stinging Animals (a translation of the German *Nesseltiere*) is coming into use as a popular name.



FIG. 25.—HYDRA VIRIDIS, BEARING A BUD (NATURAL SIZE)

There are three species of Hydra, all common. *H. vulgaris*, whitish with an orange tinge, usually has from seven to twelve tentacles longer than the body. *H. fusca* is brown, with from six to eight tentacles several times the length of the body; and *H. viridis*, the Green Hydra, has from six to ten tentacles shorter than the body.

Reproduction is ordinarily effected by budding,

that is, a new individual is developed from the substance of the adult, which, if plentifully supplied with food, will send off buds at different parts of the body, and these in turn may send off other buds, so that three generations will form a temporary colony. Sometimes also sperm-cells and germ-cells are developed in the sides of the Hydra, and when these are liberated by the rupture of the separate sacs in which they are contained, the germ-cells, after fertilization, fall to the bottom, and in due time develop into perfect animals.

Hydra, however, is chiefly interesting from the fact that it may be propagated artificially by cutting or division. In 1740-44, Abraham Trembley, a Swiss tutor in the Bentinck family, at Sorgvliet, made some experiments on Hydra, and published the results in 1744. It seems almost impossible to kill this animal. Cut it down the middle, and you will have two Hydras instead of one; cut it across, and the base will settle down and develop a new mouth and tentacles, while the upper half will develop a new base. It has been said that if the tentacles be cut off, each will give rise to a new body. There is no evidence for this, but it is certain that in such a case the body would put forth a new set of tentacles. Trembley succeeded in turning these animals inside out, and the experiment has been frequently repeated, for it is by no means so difficult as it appears. But the conclusions he drew were incorrect. He saw that some of the Hydras operated on took food readily; and

he hastily judged that the ectoderm, or outer layer, did duty as a new stomach, while the endoderm, or inner layer, which had originally formed the walls of the stomach, and contained the digestive cells, functioned as a kind of skin. What really happened was this: those Hydras which he saw taking food had, unknown to him, slipped back to their normal condition. He seems to have had some suspicion of this, for when he turned some others inside out, he pegged them down with blunt needles. The Hydras, however, were more than a match for him; for by an outflow of the original outer layer through the puncture, the inner layer containing the digestive cells was restored to its proper position, and so the creatures were enabled to take and digest their accustomed food. When they are prevented from returning to their normal condition they speedily perish. As Trembley's conclusions have been, and frequently are repeated without any qualification, it may be well to put on record the authority for these statements. This will be found in a paper by Dr. C. Ischikawa, of Tokio¹. One could wish that a European had been fortunate enough to correct Trembley's oversight. There is, however, a crumb of comfort: the Japanese doctor is a Jena student, and he has given his researches to the world in a European tongue. And now one word of caution. The pond-hunter will find Hydras in plenty, but he must not expect to meet with such a monstrous form as that figured with nineteen buds, and

¹ *Zeits. f. wiss. Zool.*, Band xlix, Heft 3.

reproduced, time after time, even in books of high pretensions—the last edition of Carpenter's *Microscope and its Revelations* is a case in point—without one word of explanation that it was artificially produced by high feeding. Trembley is careful to state that he never took a Hydra with more than seven buds, and that specimens with so many as seven were rare¹. Those who copy his plate should, in fairness to him and to collectors, give his explanation also.

If the Hydra buds were permanently attached to the parent-form, we should have a branching colony stock. This we find in Cordylophora, which bears pretty much the same relation to Hydra as do the compound forms Carchesium and Epistylis to the simple Vorticella. Cordylophora is generally spoken of as rare. Till within the last few years it was. It is not met with in ponds, but lives in canals, docks, and rivers on submerged roots, vegetation, and woodwork, and on the bottoms of boats. Dwellers in East Anglia are sure to find it in the Ant and the Bure, and when the weeds are cut to clear the waterways the colonies may be seen in great abundance on the floating vegetation. In answer to inquiries about it in 1891 a friendly correspondent wrote, 'On either side of the river in the neighbourhood of Hickling Broad, you can soon get a boatload if you want it.' This was naturally accepted as a mere figure of speech; it was, however, literal fact. It has been found in the Severn

¹ *Mémoires pour servir, &c.*, pp. 177, 179.

and the Dee; large colonies have been taken from the woodwork of some of the London docks, and manilla mooring-ropes that had been for some time in the water have yielded it abundantly. *Cordylophora* forms very large colonies, often investing the stems of reeds for some foot or more, and sending off branches from two to three inches in height in all directions. Reproduction is effected by simple budding, and by *gonophores*, or cases containing reproductive elements, which, when ruptured, liberate free-swimming ciliated embryos, that soon settle down and become the starting-points of other colonies.

It may be well to consider here what has been said before as to the derivation of branched forms of Bell Animalcules from *Vorticella* and *Rhabdostyla*, and to see how this applies to the relationship between *Hydra* and *Cordylophora*.

Only one other fresh-water polyp is known in England, and that is met with in the tanks at the Botanic Gardens, Regent's Park. It was probably brought from South America to Kew, and from Kew to Regent's Park, whence it has been propagated in the Botanic Gardens at Sheffield. It is an insignificant-looking creature, somewhat like a tiny *Hydra*, without tentacles, but having the space round the mouth covered with little pimple-like projections that contain thread-cells. From it is developed the Medusa known as *Limnocodium sowerbyi*, supposed to be the only fresh-water form till *Limnocoidea* was discovered in Lake Tanganyika.

Mr. F. A. Parsons, of the Quekett Microscopical Club, seems to have been the first to detect this polyp¹; some months later it was found independently by Dr. Bourne, and in 1888 Dr. Fowler saw the Medusas develop from the free ends of the polyp².

On pieces of coralline, or stones or shells from rock pools, one is nearly certain to meet with minute creatures about a quarter of an inch high,

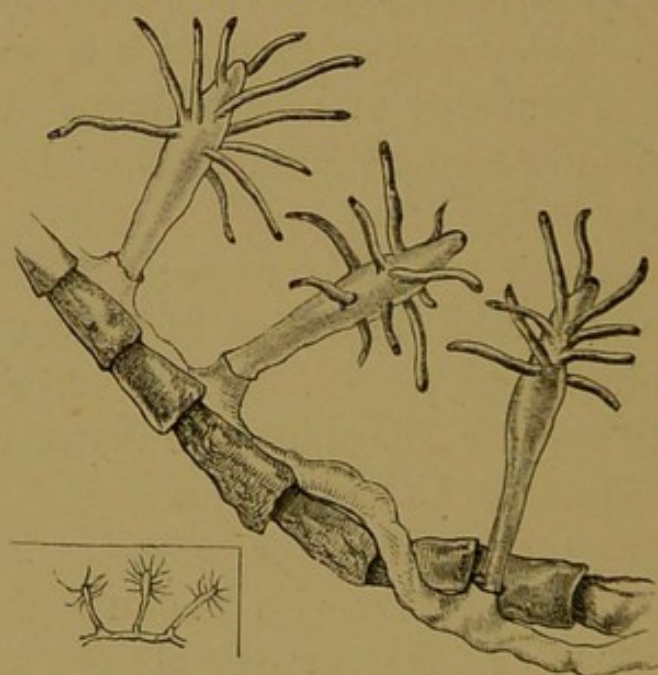


FIG. 26.—CLAVA MULTICORNIS ON THE COMMON CORALLINE (GREATLY ENLARGED FROM LIFE)

looking like white, or rosy-red, or flesh-coloured bristles, a little thickened at the opaque white top, whence radiate a number of thread-like arms or tentacles, varying in number with age. In young specimens there may be ten or a dozen, in adults from thirty to forty. This is *Clava multicornis*—found all round the coast, from Cornwall in the

¹ *Journal Quekett Microsc. Club*, June, 1885, pp. 125-30.

² *Nature*, Dec. 7, 1893, pp. 127, 128.

south to Shetland and the Orkneys in the north. As we watch *Clava* under the microscope, we shall see that each of the hydra-like heads, or polypites (three of which are figured in the cut), springs from a creeping thread-like base, called the *stolon*, sheathed in a chitinous covering which rises into a little cup at the base of each polypite; that the tentacles are thickened at the tips, and that these are covered with minute hairs. These hairs, which are organs of touch, are called palpocils. When they give notice that any tiny creature has come in contact with them, the tentacles move towards it instantly, and by means of their thread-cells kill or paralyze the prey, which is then grasped, and slowly but surely brought near the mouth at the top, which bends over to receive it. When the creature has fed, it loses its delicate thread-like appearance, and becomes like a miniature sausage. The tentacles contract, the body sinks down, gaining in breadth what it loses in height. If one has a colony of *Clava*, some of the polypites will be always ready to feed, and to watch them it is only necessary to put the whole colony into a watch-glass or zoophyte-trough, with some sea-water, and drop into it a few *Entomostracans*. They will pay as little heed to their enemy as does the rabbit or fowl to the boa into whose cage it is put at feeding-time. And the result will be the same.

The next Stinging Animal to be considered has a Greek name of precisely the same meaning as the Latin one borne by the little creature just

treated of. That was called Clava; this is known as Coryne. Both words signify 'a club,' and the reason for these names is to be found in the shape of the polypites, which are not unlike miniature copies of the club with which the wicked giant, in the toy-books of our youth, was figured as attempting to slay the valiant and virtuous Jack. And just as that club was studded with terrible knots and snags, so these creatures have projecting from their bodies tentacles or arms, which make the resem-

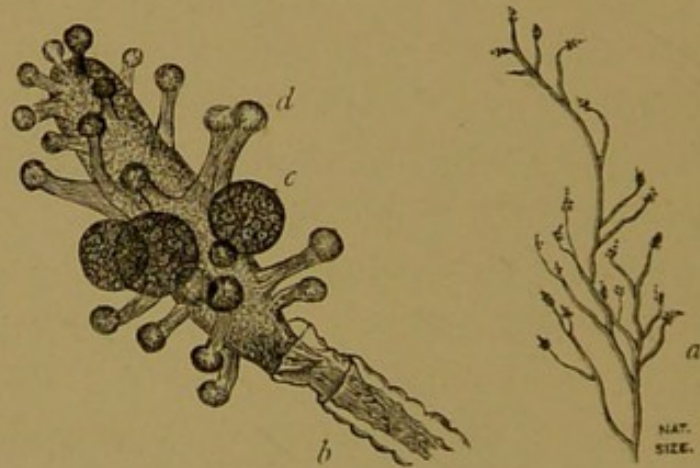


FIG. 27.—CORYNE FRUTICOSA. *a*, NATURAL SIZE; *b*, POLYPITE ENLARGED, SHOWING (*c*) GONOPHORES; *d*, CAPITATE TENTACLE, ENLARGED.

blance more complete. In Clava they are filiform, or thread-like; in Coryne they are capitate, or furnished with a kind of head or ball, which is nothing more than a collection of thread-cells. Syncoryne also has the tentacles capitate (fig. 28). These tentacles are capable of motion in every direction, but not to so great an extent as the thread-like weapons of Clava.

Of the genus Coryne there are several species, some of which are simple, while others are branched

or bushy or shrubby; while one (*C. fruticosa*), common in the Channel Islands, is almost tree-like in its growth. But all agree in that they spring from a creeping, thread-like stolon, which, like the stem and branches, is sheathed in a thin chitinous tube, sometimes smooth and sometimes marked with rings, and having at the end of the stem or branch a single club-shaped polypite, with capitate tentacles, either disposed in whorls or scattered irregularly all over the body. The polypary, or outer covering, is well developed, thus differing from that of *Clava*, in which it forms a tiny cup-like expansion at the base of each polypite, so that the animals of that genus were for a long time supposed to be destitute of this investing sheath.

The common *Coryne* (*C. pusilla*) is abundant nearly everywhere—on the flat shores of the estuary of the Thames, on the sandy coasts of the Channel, and in the rock pools of the north and west. Indeed, there is hardly a spot on our coasts where a collector would not meet with it. It is sparingly and irregularly branched, and grows in straggling tufts from an inch to an inch and a half high on seaweed, stones, and shells. It is usually common enough in my tanks, but when this was written I could not find a piece with polypites developed, so that another species was chosen for illustration.

Syncoryne greatly resembles *Coryne* in general appearance, but is not so common. The scientific definitions of the two genera differ only in what

relates to their method of reproduction. The *gonophores*, or reproductive buds, of *Coryne* liberate free-swimming ciliated embryos—‘the analogue of the winged seed of the plant.’ These, after a short period of independent existence, settle down and form colonies resembling that from which they

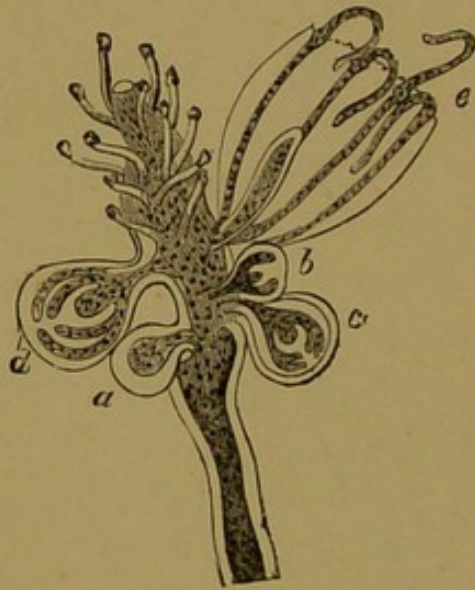


FIG. 28.—SYNCORYNE WITH BUDDING MEDUSA. (AFTER DESOR)

were sent forth. In *Syn-coryne* the bud itself undergoes a series of changes, shown diagrammatically, on a large scale, in fig. 28. The dark central part is the *cænosarc*, or body-mass, expanding at the upper part into the polypite with capitate tentacles set in whorls. At *a* is a gonophore just budding, at *b*, *c*, and *d* further developments are shown, and at *e* we have the perfect Medusa form (so called from its likeness to a Medusa, or Jelly-fish), ready to break away and swim off.

This will give us a good example of what is called the alternation of generations, in which, as Chamisso puts it, ‘the mother does not resemble her own mother or her daughter, but her sister, her grandmother, or her grand-daughter.’ The nutritive zooid without sex buds off a form in which the sexes are combined, and this, in its turn, gives rise to sexless forms.

There is little doubt but that *Cladonema* (fig. 29) has a wider range on our coasts than it is generally credited with. It was first recorded from St. Malo by Dujardin in 1843, then from Devonshire by Gosse (who called it the Slender Coryne, *C. stauridia*¹), then from some of the tanks in the Fish House at the Zoological Gardens, and still later by some of the naturalists at the Marine Biological Laboratory, Plymouth. The specimen figured was discovered on some sponge sent me by Mr. Sinel, of the Biological Laboratory, Jersey. The sponge had been examined again and again with the hand-lens and a low power of the microscope, and as it looked unhealthy it was decided to take it out of the small tank in which it was living, and throw it away. But before doing this it was looked over for the last time, and on a tiny fragment, which till then had been unnoticed, there appeared a dark, thread-like mark in the substance of the sponge. On turning the piece over some tiny projections therefrom could be made out, and the hand-lens revealed the fact that these were the polypites of *Cladonema*—till then unknown to me except from books. The dying sponge was carefully dissected away down to the stolon, which was then put into a jar in good going order. The same colony lived for about three months, but though the polypites died down and were renewed, they unfortunately threw off no generative buds to propagate the species when they themselves had disappeared.

¹ *Devonshire Coast*, p. 257, pl. xvi, figs. 1-5.

There is little doubt that search along the shores of the Channel would reveal this charming little animal. It will be seen that the capitata tentacles are disposed at the top in a whorl of four, and beneath are the same number of 'false tentacles,' rounded at the tip, and covered with tactile hairs (fig. 29). The function of these false tentacles seems

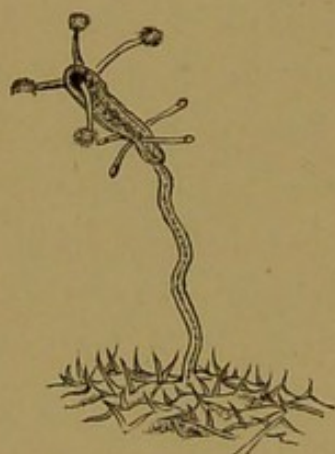


FIG. 29.—CLADONEMA ON SPONGE (ENLARGED FROM LIFE)

to be to give notice of the approach of prey; for if anything comes in contact with them the head and tentacles bend over towards it, and generally the prey is seized by the tentacles and passed to the mouth, which is just at the top of the polypite. Some observers have come to the conclusion that these false tentacles are rigid, and stand always at right angles to the body; I am inclined to think that they are capable of motion, and believe that I have seen them move. In Allman's figures they certainly do not stand at right angles to the body. The point, however, needs further investigation, and any examples met with should be carefully watched, and the result of the observations put on record.

This commensalism of a Stinging Animal with a sponge is by no means a solitary instance. Häckel found similar cases in the material brought home by the Challenger expedition, and in the *Annals of Natural History* for September, 1892,

there is a still stranger case recorded of a hydrozoan which lives on the throat and gill-openings of a fish. Here it seems to be a direct benefit to its host, for it appears to supply the place of the wavy filaments present in allied species, which gives the fish a deceitful resemblance to the weed-encrusted rocks of its environment.

The strange-looking creature represented in fig. 30 is not a new kind of starfish, as one might at first sight suppose, but the reproductive bud of *Clavatella prolifera*, which, unlike that of *Syncoryne*, does not swim, but walks or climbs, and is on that account dignified in books with the long name 'ambulatory gonozoid.' This 'walking bud' may be taken at the end of the summer in the rock pools off the Capstone, at Ilfracombe, and near Torquay. The few specimens that I have collected came either from Barricane or from Lee. They escaped observation at the time of capture, and were not discovered till some store-bottles were being packed for the homeward journey. It is certain, however, that they came from one of the two places mentioned. The adult form has eight capitata tentacles in a single whorl at the base of the proboscis. The generative buds are sent off in the same way as those of *Syncoryne* (fig. 28), but from near the bottom of the stalk. In the rock pools they are generally found among weeds, and especially among the common Coralline; when in the tank they climb about the vegetation, or move slowly and deliberately along the side of their glass

prison. A comparison of fig. 30 with fig. 28 (*e*) will show that the structure of the two buds is the same, though the habit is so different. The membrane uniting the arms in the bud of *Clavatella* corresponds to the umbrella or swimming-bell in that of *Syncoryne*. The proboscis, or mouth, is in exactly the same position in each, and the tentacles, which serve the last-named form only as organs of prehension—motion being due to the rhythmic contractions of the umbrella—are in *Clavatella* modified so as to serve also as legs for walking or as arms for climbing. These modified tentacles fork at the end, and the outer branch of the fork ends in a ball of thread-cells, while the inner branch terminates in

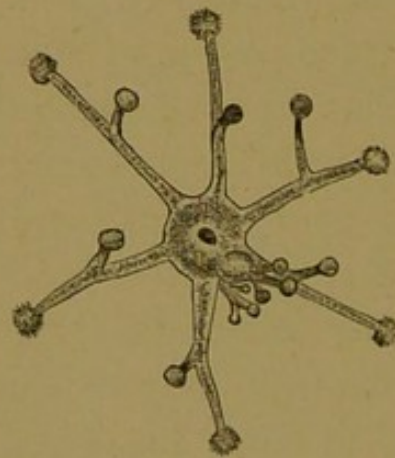


FIG. 30.—WALKING BUD OF CLAVATELLA PROLIFERA, WITH A YOUNGER ONE JUST BUDDING (ENLARGED FROM LIFE)

a sucker-like disk. It is a very droll sight to see these modified Medusas climbing about the seaweed, and now and then capturing a stray Entomostracan. The arm, with its prey, is then bent under and curved upwards, so as to bring the dainty morsel near the proboscis, which inclines towards it and engulfs it, just as the adult polypite would do. This sexual zooid is a somewhat abnormal case of alternation of generations; for in the early part of its life it sends off buds similar to itself from between the arms, as shown in fig. 30. Towards the end of the season this sexual

zoid grows sluggish and settles down; the membrane between the arms is ruptured, allowing the male and female elements to escape, and the tiny creature perishes in giving birth to another generation.

Tubularia, common though it is, is to other hydrozoans what the rose is to other flowers. There are many species of the genus, but that usually taken is *T. indivisa*. The stems resemble small oaten straws, and in a large colony, such as may be taken with the dredge, these tubes often rise to a height of from six inches to twelve inches. The head of the polypite is a fine scarlet or crimson, and the tentacles pearly white. Of these there are two sets, the *aboral*, the longer, set round the base of the flask-like polypite, and serving as prehensile organs to capture prey; and the short *oral* tentacles round the proboscis or mouth. These latter receive the prey from the lower set, and pass it down into the mouth. In captivity these polypites fall off and are renewed again and again, and retain the power of motion for some time after they are separated from the body-mass. The generative buds are developed in clusters at the base of the lower tentacles, and somewhat resemble tiny bunches of currants. When the embryos are liberated they may often be seen climbing up the sides of the tank with their long arms, and after a brief period of free existence they settle down, develop a stem, and become the starting-point of a new colony.

That represented in fig. 31—about life-size—was picked up near the last groyne eastward at Hastings, in the early part of October, 1892. It was then quite dry, and looked so much like a twisted bunch of oat-straw as to impress one with the appropriateness of Ellis's popular name for it—the Oaten Straw Coralline. I turned it over with my stick, half-doubtful if it were worth bringing away. But as there was just a chance that it might revive, or that there might be some animals living parasitically on the outside of the tubes, the whole was dropped into a bottle for further examination. The mass of tubes was about three inches high—showing that the colony was of that year's growth—and twisted at the base, which had been swept off some rock or shell, probably on the Diamond Shoal, by the force of the waves. A little way from the bottom they separated into three bundles, each containing some half-dozen tubes, and before the colony had been in the tank a week these tubes had seven heads, or polypites, between them. Two of the tubes ran closely side by side and then diverged, looking at first sight as if one tube were dichotomously branched (thus \prec), and as each of these tubes had a head, it seemed as if one tiny column of protoplasm had given rise to them both. This, of course, was not the case; the common Tubularia is always simple—that is, the stems rise direct from the base without branching, though they are frequently bent into a series of curves. The outside of the stems was covered with a swarm of parasitic organisms,

smaller Hydrozoa and Polyzoa. And this point is one that should not be overlooked by the collector. Not only is every organism deserving of careful examination for itself, but it may be the host of other and rarer creatures. The most remarkable feature in this colony is the double polypite (fig. 31, *a*),

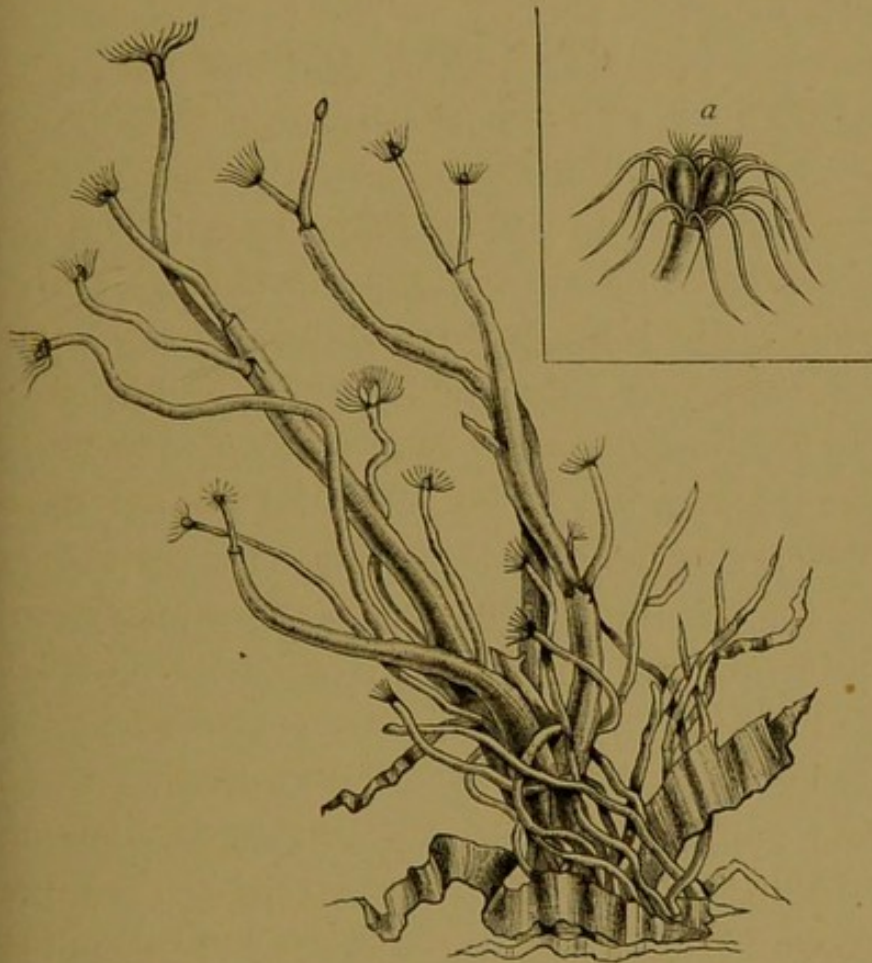


FIG. 31.—TUBULARIA INDIVISA, FROM LIFE. *a*, ABNORMAL POLYPITE, WITH TWO FLASK-LIKE BODIES AND TWO SETS OF ORAL TENTACLES

which lived for about a fortnight and was then carefully preserved. Two-headed Tubularians are apparently rare, for no record of such a case can be found in the standard works of Allman and Hincks. But in a new species of the genus Eudendrium,

dredged from twenty-four miles WNW. of Warrior Island, and forming part of the collection made in Torres Straits by Professor A. C. Haddon in 1888-89, something similar appears in the single specimen on which the species was founded, for the column of protoplasm above the tube gives rise to two distinct heads in more than one case.

We shall probably find two kinds of Eudendrium—so called from its resemblance to a well-branched tree. These will almost certainly be *E. insigne* from rock pools, and *E. capillare*, parasitic on larger hydroids. Only the dredge would give us *E. rameum*. Sir John Dalyell describes the latter as one of the most singular, beautiful, and interesting among the boundless works of Nature. 'Sometimes it resembles an aged tree, blighted amidst the war of elements or withered by the deep corrosions of time; sometimes it resembles a vigorous flowering shrub in miniature, rising with a dark-brown stem, and diverging with numerous boughs, branches, and twigs, terminating in so many hydroids, wherein red and yellow intermixed afford a fine contrast to the whole.' But the others, though so much smaller and less brightly coloured, are quite as beautiful, and they may be met with without the trouble and expense of dredging. In this genus the proboscis is trumpet-shaped, and there is a single row of filiform tentacles at its base. The authorities do not record *E. capillare* from the south-east coast, but it covered the stems of the Tubularia mentioned above.

The Stinging Animals treated of above form part of a group Athecata, or Gymnoblasteria, in which the polypites and generative buds are not enclosed in cups or protective cases, the presence of which is one of the distinctive marks of the second group—Thecaphora or Calyptoblasteria.

In these the form is generally tree-like or shrubby; the stem may be plain or marked with rings, and in many cases it is divided by joints into a number of what Mr. Hincks calls *internodes*; and he has used the disposition of the branches and of the branchlets, or pinnæ, on these internodes as one means of distinguishing the different species of some genera.

The beauties of microscopic sea-life are great and manifold, but none can surpass the charm of a colony of these tiny creatures when seen with a hand-lens or under a low power giving a field large enough to take in several polypites at once. The calyces seem formed of the finest crystal, and from the centre of each there slowly rises what seems to be a living flower, which gradually unfolds its long strap-like florets, sometimes waving them gracefully to and fro, or with equal grace allowing them to droop in gentle curves by the side of the glassy calyx.

These calyces are seen in their greatest beauty in the Campanularians, in which they bear some resemblance to a little bell. This family is generally treated first, but here it will be more convenient to begin with the Plumularians.

The genus *Plumularia* contains several species, some of which are very common. *P. setacea*, the 'Sea Bristles' of Ellis, is generally distributed round our coasts, and may be found in rock pools, on weed, and parasitic on other hydroids, especially on the long stems of the Lobster-horn Coralline (*Antennularia*), which owes its scientific and popular names to their resemblance to the antennæ, or 'feelers' of the lobster. It is from an inch to an inch and a half high; the stem is slightly waved and regularly jointed, and the branches are alternate, springing from just below the joint of each internode. Mr. Hincks describes it as one of the commonest and prettiest of the species to be met with on the shore, and writes with enthusiasm of the forests of it that clothe the sides of rock pools or cover the stems of seaweed.

The species figured, *P. halecioides*, is a little smaller, and is less commonly met with. Its favourite habitat is on stones, and amongst sponges that cover the rocks near low-water mark. It is also pretty plentiful in the rock pools off the Capstone, and it ought not to escape a diligent collector anywhere along the coast between Combe Martin and Barricane Bay. Nor is it hard to meet with in the Channel Islands. It is rarely more than an inch high, and the disposition of the branches may be seen from fig. 32, where a specimen is shown of the natural size, and part of the stem and a branch enlarged. This illustration should be carefully gone over and compared with figs. 27,

28, 30, and 31, so as to clearly apprehend the difference between the hydroids without and those with protective cases or calyces (*hydrothecæ*) into which the polypites of the latter can withdraw. It will also serve to emphasize the difference between the Plumularians and the Sertularians; in the former the calyces are unilateral—in the latter, with the exception of the Sickle Coralline (*Hydrallmania falcata*), they stud both sides of the branches or twigs. This last named species may generally be

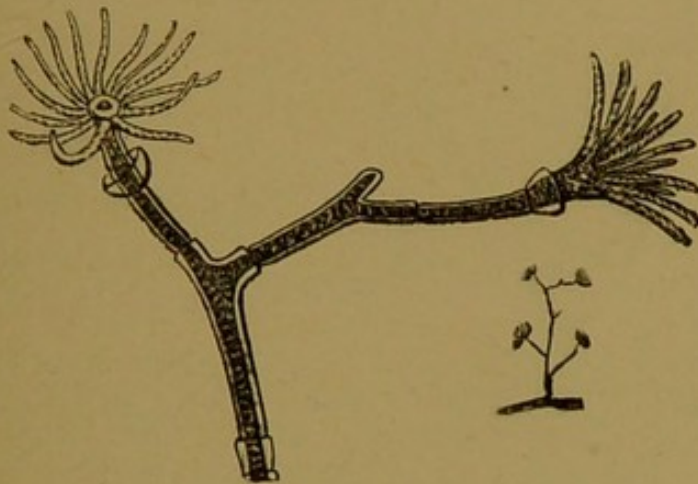


FIG. 32.—PLUMULARIA HALECIOIDES. (AFTER HINCKS)

found on the shore after a storm. A well-grown specimen is too large for the aquarium, but the collector should make himself acquainted with its form and general appearance, and one of the pinnate branches may be brought away for examination. The stem is twisted in large curves, and the branches have been described as 'a series of feathers implanted in spiral arrangement round a slender stem.' The calyces containing the

minute white polypites are tubular, and very closely set along the pinnæ.

The Sea Oak Coralline (*Sertularia pumila*) is abundant between tide-marks on large coarse seaweed. The shoots, from half an inch to an inch in height, rise luxuriantly from the creeping stolon, either straight or in gentle curves. The branches

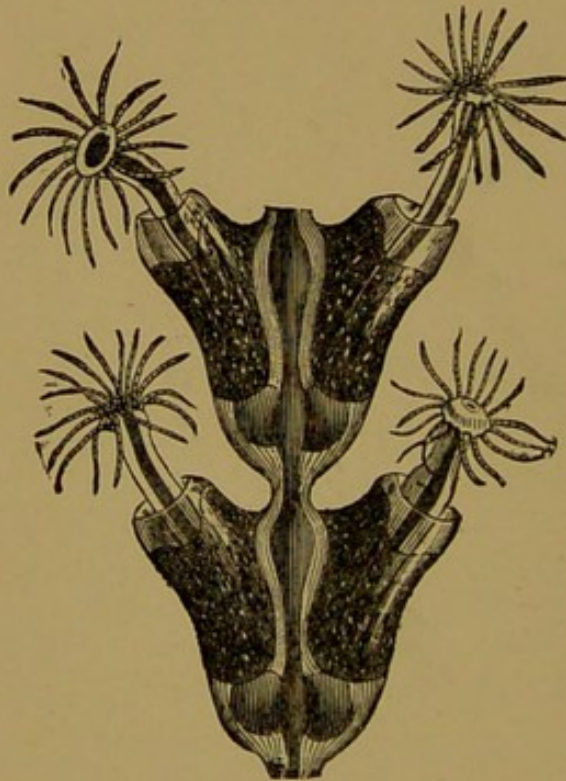


FIG. 33.—SERTULARIA PUMILA

are opposite, and in fine specimens give off smaller branches. These, like the stem, are divided at short distances into internodes, each of which forms a figure somewhat resembling a V, and at the extremity of the arms are the tubular calycles from which the polypites rise and expand their tentacles in search of food. This species is phosphorescent, and

if a piece of fucus bearing a colony of it be struck smartly in the dark the tips of the calycles will be distinctly illuminated.

The Knotted Thread Coralline (*Obelia geniculata*) is very abundant on seaweed, especially on the common tangle, about low-water mark. The veriest tiro at collecting cannot possibly mistake it for

any other form, particularly if he examines it for a moment with the hand-lens. The stem is about an inch high, sometimes with and sometimes without branches. The internodes are short, and so disposed that the stem forms a zigzag, at alternate angles of which the calyces are set. But its most extraordinary feature is that the calyces are supported by a kind of bracket from which rise the ringed pedicels, or stalks, of the calyces. The general colour is pure white, but some specimens are of a brilliant red, owing to the presence of a microscopic algal which grows on the stem. The Knotted Thread Coralline is phosphorescent, and the 'sudden illumination of a forest of it on some sombre laminarian frond is a truly beautiful spectacle. If it is agitated in the dark a bluish light runs along each, flashing fitfully from point to point, as each polypite lights up its little lamp.'

In the genus *Campanularia* the stem may be simple or branched; the calyces are glassy and bell-shaped, the rim being often cut into minute teeth, and sometimes into crenulations like the battlements of a tower. Ellis's name, long but appropriate, for *C. volubilis*, the species that has been longest known, was the Climbing Coralline with Bell-shaped Cups. This is an unbranched form from deep water, but it is often found, washed up on the shore, on other Hydroids and Polyzoa. The shoots are spirally twisted, and beneath each calyche is a single ring, which Ellis compared to

'a very minute spherule or ball, as in some drinking-glasses.' A very common branched form of this genus is the Flexuous Campanularia (*C. flexuosa*), in which the calyces are wide above, with the sides sloping abruptly towards the base, and borne on footstalks with six or seven rings. It is found between tide-marks on stones, in tidal pools, and on the surface of the rocks that are covered at high tides.

The calyces of the forms already noticed are inoperculate—that is, they possess no cover and are quite open at the top, so that the polypite, though protected by glassy walls all round, is undefended above. In the Creeping Bell Coralline (*Calycella syringa*), however, the polypite can not only retreat within its dwelling, but can secure itself from intrusion or attack. Round the rim of the calyche rise eight or nine tapering segments which meet in a point at the top, and so form a conical roof. The force exerted by the polypite in rising separates these segments, thus allowing it free egress, and when it withdraws itself they fall together and completely roof in the calyche. This species is very common, and should be looked for on other Hydroids, Polyzoa, and on seaweeds.

Probably the best book on the subject is Hincks's *British Hydroid Zoophytes*, which contains a good list of the literature of the Hydroida up to the date of its publication. Of the older books, Ellis's *Essay towards a Natural History of Corallines* (1755) should be read and re-read, as should Gosse's

Naturalist's Rambles on the Devonshire Coast, and Tenby.

In fig. 34 we have the Common Lucernarian of our coasts (*Haliclystus octoradiatus*), which belongs to another group of the Hydrozoa. It is sometimes met with on the fronds of seaweed in rock pools—Gosse so took it at Weymouth—but its favourite habitat is in the beds of *Zostera* or grass-wrack that fringe the shore, generally a little beyond low-water mark. This little creature, which is of a brownish liver-colour, and may be from half to three-quarters of an inch in height, and as much across, possesses a sheathed footstalk, and when captured often slips away, leaving the sheath behind it. In the centre of the disk is the mouth, and set round it at equal distances are eight arms, each bearing at its extremity a tuft of thread-cells. Between every pair of arms is a kidney-shaped body, the function of which has only recently been made out. These bodies are called 'marginal anchors,' and serve as a means of attachment. It was formerly said that these animals moved through the water like Jelly-fish, swimming by alternate contractions and expansions of the disk. Those who have watched them most closely say that the mode of progression is a kind of creeping or stalking over bodies like the Common Hydra, using the marginal anchors to fix itself while the disk is thrown forward to another point of support. Lucernarians feed on small marine animals, which they paralyze in the same way that Hydra does.

An early observer came to the conclusion that their chief diet was water-slaters, which he often found to be the sole contents of the stomach. 'When the little victims struck against the spreading disk the tentacular arms closed in upon them, and they were immediately swallowed.'

Great abnormality, or divergence from the ordinary form, occurs in these animals. Out of

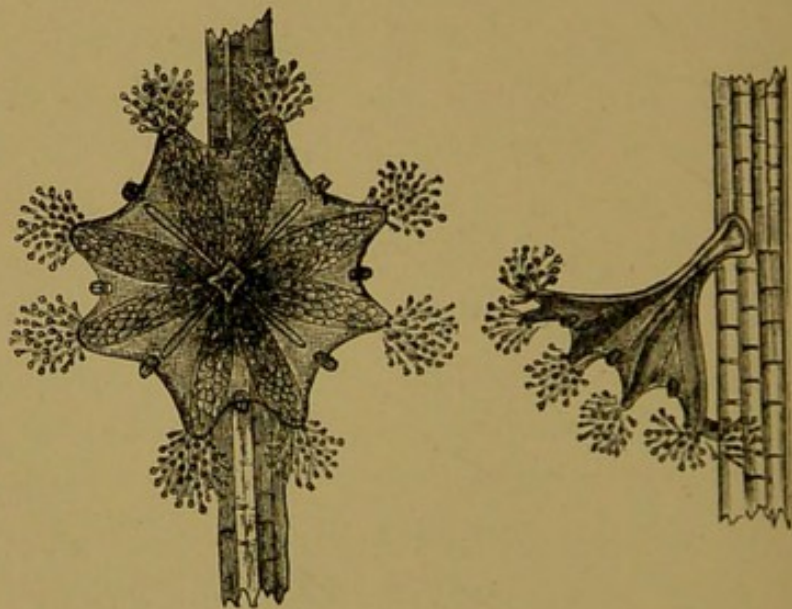


FIG. 34.—LUCERNARIAN. (AFTER CLARK)

eighty specimens examined and dissected in the Laboratory of University College, London, the rate of abnormality rose as high as 50 per cent., and a correspondent writes that 'abnormality is so common as to be the rule rather than the exception¹.' Johnston (*British Zoophytes*) records one specimen with seven and another with nine tentacles,

¹ Excellent technical papers on this subject will be found in *Natural Science*, vol. iii, pp. 204 and 209.

and mentions 'a white form with five,' probably not a Lucernarian at all. One specimen that lived for about a fortnight in my tank was abnormal in a very high degree. It was impossible to figure it, so a description must serve. Suppose the animal on the left in fig. 34 to be divided into two equal parts by a horizontal line joining two marginal anchors. The lower half in my specimen was perfectly normal; the upper half seemed exactly as if the creature were about to multiply by fission. The normal four arms of the upper half increased to seven, with some traces of a budding eighth, and even the reproductive bands (the V-shaped bodies in the figure on the left) of that half doubled in number. Every care was taken to keep the animal alive—unfortunately in vain. It died at the Marine Biological Laboratory at Plymouth, whither it had been sent for examination, and was there skilfully preserved, and to that place, after a short stay in London, it has now been returned, so as to be at the service of workers interested in the subject¹.

To the Stinging Animals also belong the Jelly-fish, the Sea-anemones, the Corals, and the Comb-bearers or Sea-gooseberries, as the fishermen call them. The only two forms likely to be of interest, from a microscopic point of view, are Hydra-tuba (the larval form of the common Jelly-fish) and the common Sea-gooseberry (fig. 35). The former is rarely collected: in most cases the tiny embryo,

¹ A diagram of this animal is given in *Natural Science*, iii. 320.

which resembles an Infusorian, is introduced, unperceived, into tanks with sea-water, and there settles down on stone or weed, develops a mouth, and buds out tentacles, generally sixteen in number, and so lives on for some time. In the autumn growth is



FIG. 35.—COMMON SEA-GOOSEBERRY (*Pleurobrachia pileus*)

carried on upwards, and the creature resembles a minute pine-cone attached by the small end. Then the mass is marked off into a number of rings, and the animal is then comparable to a pile of saucers increasing in size from the base, only the top-most ring or saucer bearing tentacles. In course of time these rings float away, and in due course become Jelly-fish.

Sea-gooseberries may be taken in the net as they float on the surface of the water. Sometimes they are left in rock pools by the tide, and they may be picked up half dead on the sea-shore. In the autumn of 1893, the shore between Whitby and Sandsend was literally strewn with them, and some which were picked up and put into a large vessel of sea-water revived sufficiently to display their brilliant iridescence in the sunshine and their phosphorescence in the dark. The body is about half an inch long, and the streaming tentacles five or six times as much. Its substance is clear as crystal, and divided lengthwise into eight equal crescent-

shaped bands, along which are set comb-like plates in vertical rows. These are fringed with cilia, and act as paddles to propel the animal through the water. The long tentacles with their appendages serve to capture prey, and when not in use can be retracted into sac-like cavities, one on each side at the end of the body farthest from the mouth.

CHAPTER IV

'WORMS'

PROFESSOR HUXLEY called the Worms a 'heterogeneous mob,' and other authorities have used language quite as forcible. Attempts have been made to break up the group into manageable parts, in other words, to arrange its members in smaller divisions according as they are closely or distantly related. Those who care to follow out the attempt should study Professor E. Ray Lankester's article 'Zoology' in the last edition of the *Encyclopædia Britannica*. Here the old 'lumber-room' is retained. The chief reason for such a course is that in very many cases the degree of relationship between the forms is not clearly made out. Increase of knowledge will probably lead to some better method of grouping.

In ponds among the water-weed and in rock pools among the seaweed we shall find the Planarians, the lowest of the group. All are small: the fresh-water forms are generally elongated; marine Planarians are more leaf-like. If they are

divided, each part will continue to live and develop a new portion corresponding to that which has been cut away. Just above these are the Flukes, which lead a parasitic life, some on the skin of their hosts and others in the intestines. The common Liver-fluke (*Distomum hepaticum*) is a good example of the development of these creatures; and in one of its stages—the Cercaria—it is sure to be met with by collectors. The embryos are voided from the bodies of sheep, and hatched in water, leading a free-swimming life for a little while. Then, if things go well with them, they bore their way into water-snails, where they increase and multiply, giving rise to forms unlike themselves. From these a free-swimming form (the Cercaria), like a microscopic tadpole, arises, and this makes its way on land, and if eaten by sheep bores into the liver, causing the disease called the 'rot.'



FIG. 36.—CERCARIA STAGE OF FLUKE (GREATLY MAGNIFIED)

Next to these come the Tape-worms, which may be dismissed with mere mention. These three forms are classed together in one series as Flat-worms, from their shape.

In the next series are the Nemerteans or Ribbon-worms. Like their fellows of the first series

they are flat, and are not divided into segments. Most of them are free-living, and the sexes are usually distinct.

In the third series, the Nematodes or Thread-worms, the only one we are likely to meet with is the Horse-hair worm (*Gordius*), which according to folk-story is nothing more than a horse-hair endowed with life and motion. 'Paste-eels' and 'Vinegar-eels' and the *Trichina*, parasitic in the muscles of persons who have eaten diseased pork, are related forms.

This brings us to the Annelids or True Worms, in which the body is divided into a number of rings or segments, as may be tested by taking a common earth-worm into one's hand or laying it in a dish and watching its motions. Each ring bears bristles or other processes which serve as organs of locomotion.

The River-worm or Summer-worm (*Tubifex rivulorum*) is common enough all over the country; and in some localities they occur in such quantities as to discolour the water. They burrow in the mud, head downwards, with the tail projecting and waving to and fro in the water. The skin is transparent, and the red colour is due to the blood showing through. Under a low power, or even with a hand-lens, the rings or segments may be seen and counted, and the bristles on each may also be distinguished. The great blood-vessel is prominent, as is the intestinal canal, which twists from side to side, one turn for every segment.

The common Naïs is to be met in most ponds. If not taken with the bottle and net, it should be looked for on water-weeds, especially about the rootlets. It will be readily seen from the long proboscis, and the spines projecting on each side of the body far beyond the bundles of bristles, with which the segments, except the first three or four, are furnished. These worms prefer animal food, and prey upon Water-fleas, Rotifers, and Infusorians. The chief point of interest about them is the manner in which they multiply by budding before they become mature. A bud is thrown out between two segments, generally near the middle of the body; and this bud not only develops into a worm, but the head part of the parent grows a new tail, while the tail part grows a new head. Before the bud is set free other buds are thrown out from the segment that originally budded, and so before separation takes place a chain of worms is linked together, all nourished by means of the mouth of the worm whence the buds sprang.

Dero, another worm closely related, is worth notice from the ciliated finger-like processes at the end of its tail. It dwells in the mud round the roots of water-plants, generally head downwards like the River-worms, and when the respiratory organs are at work looks not unlike a tiny Polyzoon, for which it was taken by some early observers.

The True Worms are arranged in two groups, according as the bristles on the segments are few

or many. To the first belong those already mentioned; to the second those which follow.

The collector at the seaside will be sure to meet with worms in plenty, but though all are interesting, and many exquisitely beautiful, discrimination must be exercised as to those selected for the aquarium. With the large free-swimming marine worms and those which wander over the rocks we need not concern ourselves. Our business is with the Tube-dwellers—creatures living in structures built up of lime taken up from the seawater, or grains of sand and tiny fragments of shell fastened together by a glutinous secretion from the body of the tenant. On most of the segments are little bundles of bristles, by means of which these creatures come partially out of and retire into their dwellings. Their breathing apparatus is in the form of gills on or near the head, and in addition to these organs tentacles are sometimes present. The young are developed from eggs, and when born are unlike their parents. *Spirorbis* (fig. 24, *c*) may be collected for keeping, for it does well and multiplies rapidly. The tiny spiral shell is attached by one side to the fronds of the common Bladderwrack and the stems of the common Coralline. Indeed, in some localities it is almost impossible to take a piece of the last-named weed from a pool without obtaining scores of these worms. The branching gills are specialized into ciliated tentacles, and the operculum or stopper is a modified tentacle, which closes the aperture of

the tube when the worm retires into its shell, and also serves as a brood-chamber for the reception of the ova. A spray of coralline studded with these tiny worms, with their tentacles expanded, when viewed with a low power and dark-ground illumination, presents a scene of striking beauty. If one of these worms be left in stale sea-water for a little time it can be easily shaken out of its tube, and its different parts examined at leisure.

Othonia gracilis is another tube-maker, but its dwelling differs from that of *Spirorbis* in being straight instead of spiral, and is formed of mud lined with a fine membranous skin, not of lime. A favourite habitat is on the disk of red seaweeds. This worm has thirteen segments, and on the first and last are two eye-spots. The tentacles are a light straw colour, and of considerable length. It will be good practice to dissect away the tube from one of these little creatures, and drop it in its houseless condition into a vessel of clear sea-water, in which are some animalcules and weed. It will immediately set to work and construct a new house; but as there is no mud with which to plaster the outside, the movements of the creature can be watched with a hand-lens through the transparent tube-skin. That shown at fig. 37 was so treated, and lived for about three months in a 4" x 1" tube.



FIG. 37.—OTHONIA
GRACILIS × 5
(FROM LIFE)

Serpulæ may be taken, for there is scarcely any difficulty in keeping them. Every one knows their white shelly tubes tapering backwards and marked with a distinct ridge on the top. They are generally found intertwined in a mass, but if possible a single specimen should be taken, at most two or three. Not because they are scarce, but if one dies, probably the whole will have to be sacrificed to save the water from becoming corrupted. One attached to a mussel-shell picked up at Worthing lived in one of my tanks for some months, and often gratified me by displaying his brilliantly coloured gill-tufts, though a tap on the side of the glass, or the interposition of any substance between the light and that part of the tank in which he lives, caused him to furl his fans and retreat with a sudden jerk. Another specimen sent from Plymouth more than a month ago is still living. It is fixed on a large stone, and made the journey packed in wet seaweed in a tin. On the day after the stone was put into a tank the worm was seen to be alive, and it is now apparently as much at home as it was in the deep water whence it was dredged. As in *Spirorbis* there is an operculum, or stopper, to close the mouth of the tube, and through it there is little doubt that these animals breathe when retracted.

The Shell-binder (*Terebella conchilega*) lives in a house in some respects like the case of a caddis-fly, though of much larger size. The tube is exceedingly brittle, as is to be expected from the nature of the materials out of which it is con-

structed; but unless the worm itself is injured, no harm is done, for the damage will soon be repaired. This worm is an exceedingly interesting inmate of an aquarium, and differs from those already mentioned in being at times locomotive. Gosse watched one that had come out of its tube, and moved up the side of the aquarium. 'The body hung down, and the tentacles, some fifty or sixty in number, were spread out on each side and above, on the surface of the glass, adhering to it evidently, and alternately elongated and contracted, with an impatient writhing, twisting action, the result of which was to crawl, not very slowly either, up the glass.' He adds: 'It was interesting to see how much at home the little worm was at this performance; I doubt not he had enjoyed the fresh air in the same manner many a time.'

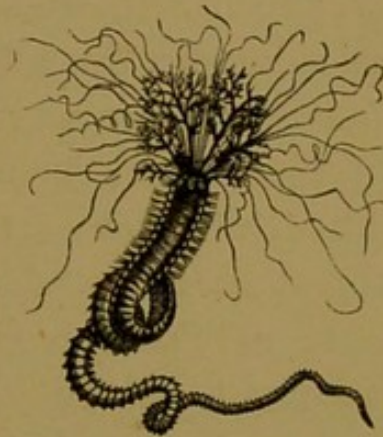


FIG. 38.—TEREBELLA

Next in order come the Leeches, readily known by their sucking mouth and the sucker at the tail by which they can affix themselves to any surface. Clepsine is common in most ponds, and is interesting from the fact that it carries its young about with it attached to its under-surface. Some other forms, freshwater and marine, are parasitic on fish.

The position of the Rotifers has long been

uncertain. The reason for their inclusion here is that some authorities believe them to be descended from ancestors resembling the larvæ of the True Worms. According to Dr. Hudson it is out of the question to attempt to frame a definition which shall include them all, though it is easy, after the study of one form, to say whether any particular organism belongs to the group. They are mostly microscopic, but all the fixed and a few of the free-swimming forms are visible to the naked eye, some of the former being one-ninth of an inch long. The chief points that they have in common are the possession of a ciliary wreath in front, the motion of which produces the wheel-like appearance to which they owe their name, and by means of which the free-swimmers move through the water, and a peculiar pair of jaws, formerly called the 'gizzard.' The first subdivision, the Rhizota, contains all the fixed forms, and one which is colonial and free-swimming, the members of the colony being adherent to each other by their bases, thus radiating from a common centre. They are also called Tube-dwelling Rotifers, from the fact that most of them excrete gelatinous sheaths, often encumbered with diatoms and vegetable *débris*, into which they can retire, or build up, pellet by pellet, tower-like structures in which they dwell. This definition, however, does not include *Megalotrocha*, for it makes no sheath and builds no tower. In the genus *Floscularia* (the species of which are called *Floscules*) and in

Stephanoceros (sometimes known as the 'Crown Animalcule') the tube is gelatinous. Some species of the former genus are quite common, as is the single species of the latter. They are found on various kinds of aquatic vegetation, chara and the finely divided leaves of milfoil and hornwort being favourite haunts.

The Common Floscule (*Floscularia ornata*), according to Dr. Hudson, is met with 'in fresh waters everywhere.' The form of the animal will be best understood by a reference to fig. 39, *a*. It consists of a corona or hemispherical cup, cut into lobes varying in number and size in different species—that with which we are now concerned having five. Each of these is furnished with a bundle of hair-like filaments. Below this cup is the *vestibule*, bounded by a collar set with cilia, corresponding to the 'wheel apparatus' of others of the group. Still lower is the *crop*, by which the prey passes to the masticating organs, and, when these have broken it up, to the intestines, situated at the top of the contractile foot. Imagine this creature enclosed in a nearly transparent tube, into which it can retire at will by the contraction of the stem-like foot and the invagination of the lobes of the corona, and you will have some idea of the structure of the Floscule. But words cannot convey more than a slight idea of its marvellous beauty. The Floscule is perhaps seen at its best when, cautiously emerging from its filmy dwelling, it slowly unfolds its lobes and expands its cup, while the filaments on the lobes spread out

like rays of living light. Then the cilia on the collar begin to move, and a vortex is created which sweeps Infusoria and even free-swimming Rotifers down into the vestibule, whence there is no return, for the long filaments, technically known as *setæ*, close up and bar the way. In the vestibule the prey is retained till an appreciable amount is

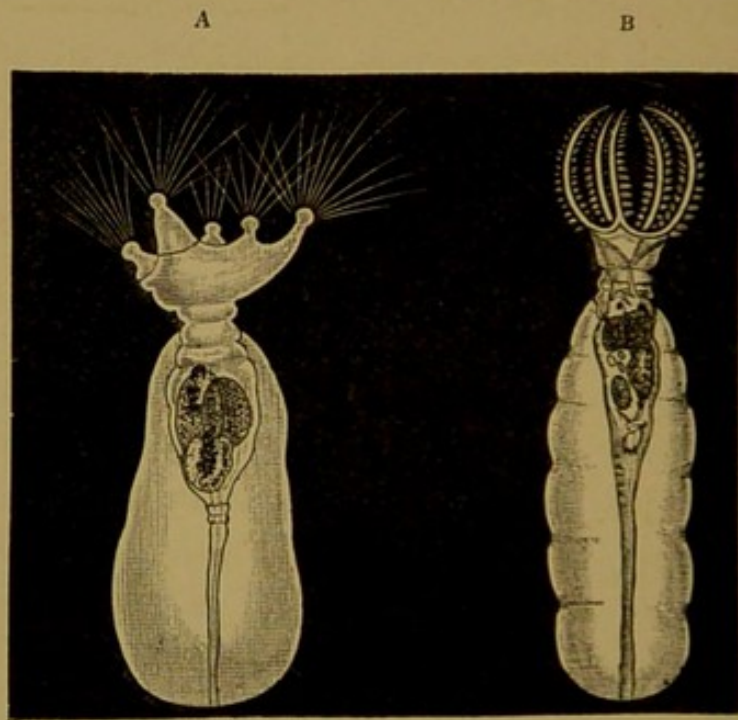


FIG. 39.—A, FLOSCULARIA ORNATA (THE COMMON FLOSCULE $\times 75$);
B, STEPHANOCEROS EICHHORNII ($\times 50$). (AFTER HUDSON)

collected, when the whole is forced down into the crop and subjected to the action of the jaws.

In general plan *Stephanoceros* closely agrees with the *Floscules*, the chief difference being in the armature of the corona. There are five lobes or processes, but they are long and slender, and after bending outwards in the middle converge so as almost to meet at the points. Instead of the

bundles of long setæ which characterize most of the Floscules, those of *Stephanoceros* are short and gracefully curved. They have a similar function to those of their allies, for if the prey attempts to pass back from the vestibule to freedom the setæ of one process unite with those on each side of it, and so form an almost impervious living network, while others are violently agitated, and thus the prey is thrown back into the vestibule and promptly forced down into the crop.

In both these forms the eggs are sometimes hatched within the tube, through which the young have been seen to bore their way into the outer world.

The tube of an adult *Melicerta* is about $\frac{1}{30}$ " long. If a piece of weed on which are two or three of these creatures be dropped into the zoophyte-trough the operation of tube-building may be studied at leisure. With a moderate power it can be seen that the tube is composed of a number of nearly hexagonal pieces, reddish brown in colour, and that it grows slightly wider at the top. The microscope must be kept very steady, for *Melicerta* is apt to resent disturbance, and remains within if alarmed. At last, however, it slowly rises from its dwelling, and expanding its four disks, sets to work. The lower pair are set at an oblique angle to the upper, and as the cilia move it requires a strong effort of the

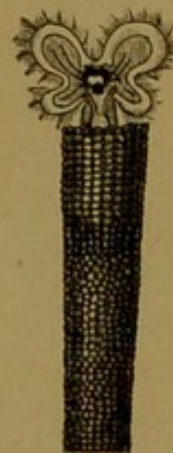


FIG. 40.—
MELICERTA
RINGENS

judgment not to believe that four small wheels are revolving. Between the upper and lower pairs of disks, and just below the knob known as the *chin*, is the workshop where the pellets or bricks are made. It consists of a nearly hemispherical cup, covered within with fine cilia, the movements of which give a roundish form to the particles driven into the cup, and these are made to cohere by being mixed with the glutinous secretion of which the inner sheath is composed. In about two minutes the pellet is ready; it is then seized between the chin and the knob beneath, and as the animal bends its upper part over the upper part of the tube, it is dropped into its place and there pressed into shape. Leeuwenhoek, who discovered this animal, saw and described the laying of the pellets; but it was reserved for the late P. H. Gosse to find out how they were made. In a second species (*M. conifera*) the pellets are sub-conical; in a third (*M. janus*) they are ovoid and formed in the intestines; and in the fourth (*M. tubicolaria*) there is no outer tube, though, like the other species, it has an apparatus for making pellets.

There are three other fixed forms differing from *Melicerta* in the character of their dwellings and in the shape of the corona. In *Limnias* the corona is distinctly two-lobed; in *Cephalosiphon* it is nearly circular, and in *Æcistes* it is a wide oval with two indistinct lobes.

There is only space to mention the clustered forms, though they are of rare beauty. *Lacinularia* lives

in a fixed cluster of many individuals, having the corona heart-shaped, and adhering to each other by their gelatinous tubes. *Megalotrocha* is also fixed, though the units, which have the corona kidney-shaped, are tubeless. *Conochilus*, in which the corona is horseshoe-shaped, is a free-swimming clustered form, the units adhering to each other in much the same way as those of *Lacinularia*.

Next come the free-swimming Rotifers, and to take them out of the store-bottle recourse must be had to the stratagem employed in the case of the Infusoria (p. 53). First come the leech-like forms (*Bdelloida*), which use their ciliary wreath as a swimming organ, but also creep principally by means of a telescopic foot that can be retracted within the body. The Common Rotifer, or 'Wheel Animalcule' (*Rotifer vulgaris*), has a just claim to priority, for it was the first of its class to attract attention, and the revolution of its ciliary wreath gave the animal its popular, and the class its scientific name. Dr. Hudson says that in this genus ciliary rotation is shown in its most effective form, 'for the wreath, when in full action, looks precisely like a pair of escapement wheels of a watch whirling round at great speed.' Its length when extended is $\frac{1}{50}$ " ; it is found in fresh-water everywhere, and specimens are also recorded from the sea. The body is white and smooth, tapering gradually from the head to the foot, which has three toes, as, indeed, have all the leech-like forms. This little creature may often be seen creeping

along the side of the zoophyte-trough, fixing itself by a gummy secretion from the toes, extending its body, and attaching itself by the fore part, and then drawing up the hinder part into an arch, somewhat like the mode of progression of a looping caterpillar. In this way it can get over a good deal of ground for such a tiny animal in a short time. Now and then it will put out its ciliary wreath and go for a swim, but soon some stray bit of vegetable

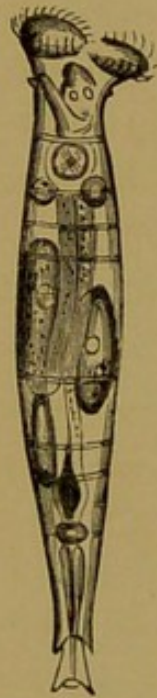


FIG. 41.—
THE COMMON
ROTIFER

débris will stop it, and it moors itself by its foot and makes a temporary home, or, as is evident from the action of its jaws, feasts on some dainty morsel luck has thrown in its way. In this species the phenomenon of desiccation was first observed, specimens having been dried up, and then revived by the application of water. This capability of enduring great dryness is not, however, confined to the Rotifers, for it is found in some of the Thread-worms, in the Tardigrades or Water-bears, and in a slight degree in some of the Entomostraca. The facts were long disputed, but they are now universally admitted, and the explanation is simple. The animal secretes for itself a gelatinous covering, which hardens when exposed to the air, and so preserves the internal fluids from evaporation. The drying-up must be effected slowly, or the creatures will not have time to secrete this covering, and will therefore perish. The individual in fig. 41 is a female,

for although this species is very abundant and very prolific, no male has ever been found ; and among Rotifers generally the females are capable of perpetuating the race.

The Ploima employ their ciliary wreath almost continually, and swim about as if they felt it ' a joy to be alive.' They fall into two groups, distinguished by the absence or presence of a lorica or investing-case, though the division is not a sharp one, for there are some forms which stand on the border-land between the two. We will take a couple of examples of each. The genus *Asplanchna* is a capital one for beginners. The species, though of a low type, is of comparatively great size and beautifully transparent, resembling a bubble of clear glass, thus allowing the internal economy to be studied. The stomach is a blind sac, so that matter from which nutrition has been extracted is necessarily ejected through the mouth. The young are brought forth alive, and may be clearly made out within the body of the mother. The species represented (*A. brightwelli*), $\frac{1}{24}$ of an inch long, was discovered in a pond near Norwich in 1841, and the observer who is commemorated in its specific name was fortunate enough to find both males and females at the same time (fig. 42, *a*).

The genus *Synchæta* is remarkable for the rapid and varied motions of the species, and for the auricles or auxiliary swimming organs on each side of the head. *S. pectinata*, $\frac{1}{70}$ " long, common in clear ponds and reservoirs, is compared by Hudson

to a swift for 'the grace and ease of its varied motion.' In shape it is nearly conical, and Gosse saw in it some resemblance to a top, the iron point of which had been driven in by continual pegging. To others, however, it may suggest an old-fashioned kite, the auricles doing duty for the paper tassels on each side, though of course the 'tail' is wanting, for the forked foot is very minute (fig. 42, *b*).

Perhaps the most beautiful of the mailed group are the species of *Euchlanis*, and the lorica is

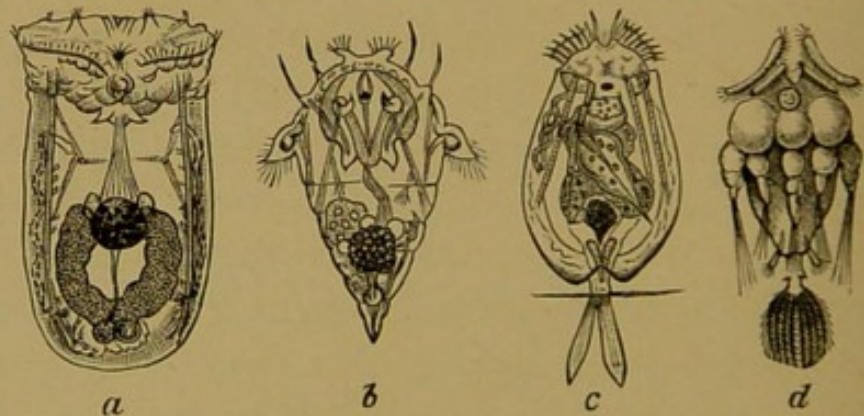


FIG. 42.—*a*, *ASPLANCHNA BRIGHTWELLI*; *b*, *SYNCHÆTA PECTINATA*; *c*, *EUCHLANIS DILATATA*; *d*, *PEDALION MIRUM*. (AFTER HUDSON)

a complicated affair. Hudson compares it to the empty shell of a tortoise, the flat base of which is split longitudinally, and a piece turned down on each side at right angles to the split, a flat oval plate covering the opening thus made. From the fore part at the top the ciliary wreath protrudes, as does the deeply forked foot at the opposite end. In their clear glassy armour these little creatures are beautiful objects for the microscope, and should always be viewed with dark-ground illumination.

E. dilatata is $\frac{1}{70}$ " long, and is common in clear ponds and ditches (fig. 42, *c*).

In the genus *Brachionus*, or Pitcher Animalcules, the body is short, broad, and urn-shaped. The lorica is somewhat like a box open at each end, and generally armed with spines. The foot is a long muscular tube capable of being bent in every direction, and may be withdrawn into the lorica. Gosse, in speaking of its amazing flexibility, says: 'I have actually seen it tied in what looked for the moment like a knot!' The toes are forked, and serve the animal as a pivot, on which they may be seen revolving as if in sport. The female carries her eggs about with her attached to her body just where the foot protrudes from the coat of mail. There are several species. *B. pala*, $\frac{1}{75}$ " long, is common in ponds and ditches (fig. 43).



FIG. 43.—
BRACHIONUS PALA

The last Rotifer to be mentioned is one of the two genera, each with a single species, which make up the order Scirtopoda—'forms that swim with their ciliary wreath, skip with jointed limbs terminated in fans of setæ, and have no foot.' *Pedalion mirum* (fig. 42, *d*) is, including the ventral limb, $\frac{1}{85}$ " long. It was first found in England by Dr. Hudson, in 1871, in a pond near Clifton. Since then it has been taken by Mr. Bolton near Birmingham, by Mr. T. Shephard from ponds near Chester, and

by the members of many metropolitan field-clubs from ponds not far from London. Apart from its limbs the great peculiarity of Pedalion is its mode of locomotion, which greatly resembles that of a cyclops larva, the only difference being that, instead of resting after every jump, Pedalion glides along for a little before making a fresh start. This peculiarity in its motion has, in Dr. Hudson's opinion, caused this Rotifer to be thrown away hundreds of times in mistake for young Cyclops, so that anything resembling these tiny Crustaceans should be carefully examined, lest rare objects be unwittingly rejected as worthless.

In marine collecting, in company with Noctiluca we shall probably find a luminous Rotifer (*Synchaeta baltica*), from $\frac{1}{170}$ in. to $\frac{1}{120}$ in. long. In form it is not unlike *Synchaeta pectinata* (fig. 42, *b*), but the body is cylindrical, and there are two minute toes. It is pretty generally distributed round our coasts. Gosse took it at Tenby in 1854, and to him we owe our knowledge of the fact that this Rotifer is self-luminous, though it is not very difficult, now that he has shown the way, to satisfy ourselves by personal observation. He was standing on the quay at Tenby watching the departure of the Bristol steamer, which was just leaving the wharf. 'An impatient stroke or two from her paddles illuminated the dark water under her quarter, and the lowest step of the quay stairs was every instant covered with sparks like diamond dust by the tiny wavelets that washed over it.' On examination he found specimens of

this Rotifer in the water, associated with Noctiluca, to which, as being undoubtedly more numerous, the greater part of this brilliant display was probably due.

The Polyzoa or Bryozoa are among the most beautiful objects of aquatic life. The general plan of these animals is that of a tube open at both ends, and consisting of gullet, stomach, and intestines, bent on itself, with a kind of platform, called the *lophophore*, thickly set with ciliated tentacles round the mouth. This bent tube is suspended in a kind of sac filled with fluid, and the anterior part can be protruded from or pulled back into this sac, by the expansion or contraction of strong muscular bands. When retraction takes place, and the polypide retires into its sac or cell, the upper portion of the sac is invaginated or turned inwards, just as one would pull the finger of a glove down into the space for the palm. The sexes are combined in each individual, and reproduction is effected both by true eggs, giving rise to forms quite unlike the parents, and by different forms of gemmation or budding. The first, generally called *continuous gemmation*, takes place by the development of a new zooid in an outgrowth or prolongation of the cell or tube. *Discontinuous gemmation* is that form of reproduction in which the bud is packed in a minute horny case, consisting of two more or less

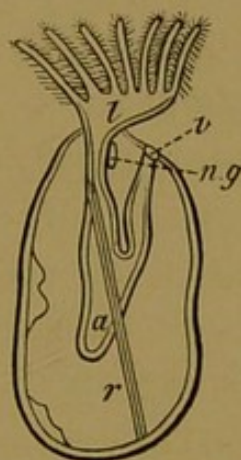


FIG. 44. — DIAGRAM OF POLYZOON. *a*, INTESTINAL TUBE; *l*, LOPHOPHORE; *n.g.*, NERVE GANGLION; *r*, RETRAC-TOR MUSCLES; *v*, VENT

circular plates joined at the rims, the whole being known as the *statoblast* or resting-bud. These remain enclosed in the parent-cell till the death of the polypide whence they proceeded, and the consequent decay of its cell sets them free. Under favourable conditions, generally in the following spring, the investing-case opens like a bivalve shell, and the young animal—a miniature copy of its parent—begins its life journey, floating passively about till it finds a resting-place, where it settles, and soon begins to perpetuate the race by simple budding. The shape of these statoblasts (found in all the fresh-water genera except *Paludicella*) serves as one means of discriminating different forms. There is one bundle of nerve-cells, but no trace of a heart or vascular system, the want being supplied by the circulation of the fluid surrounding the alimentary tube, and this circulation is also respiratory in function. Six genera of fresh-water Polyzoa are fairly common in England. The other British genus, *Victorella*, discovered by Saville Kent in the Victoria Docks in 1868, is a rare form, found on the tubes of *Cordylophora*. It was doubtless originally marine, and has only eight tentacles. The Polyzoa, as their scientific name implies, are colonial¹, and consist of a number of these membranous sacs or cells—really nothing more than the hardened cuticle—each, at some time of its existence, containing an individual or polypide;

¹ There is one exception. *Loxosoma*, a Mediterranean form, parasitic on worms, is solitary.

the whole forming a colony, which may go on increasing in size and numbers, notwithstanding the death of some of its component zooids. Our six forms fall into three groups. (1) *Alcyonella*, which, though at first like *Plumatella*, forms large spongy masses. (2) *Cristatella* and *Lophopus*, having the zooids enclosed in an investing membrane, the whole colony being locomotive. (3) *Plumatella*, *Fredericella*, and *Paludicella*, which are branching forms, and, like *Alcyonella*, these colonies are always fixed and their sacs or cells are tubular. The great beauty of this group consists in the crown of tentacles with which they create the vortices that sweep the food down into the gullet. They vary in number from sixteen in *Paludicella* to eighty in *Cristatella*, and are set usually in a double row round the edge of the lophophore, which is generally horseshoe-shaped, but nearly circular in *Fredericella*, and quite so in *Paludicella* and the marine forms. In the Polyzoa with a circular lophophore the vent is within it (whence the technical name for the group, Endoprocta); in the rest it is outside (whence they are called Ectoprocta). Each tentacle is capable of independent motion, and is ciliated on both sides. When seen under dark-ground illumination, the movements of these tiny hairs convey the impression of a stream of water running up one side of the tentacle and down the other. If a spray of one of these branching forms be dropped into a zoophyte-trough, the zooids will soon make their appearance,

and, to quote Professor Allman, the whole is an 'object which in elegance can hardly be surpassed. These strange sentient flowers, instantly retreating on the approach of danger, and when all is once more quiet, again coming forward in their beauty, present a spectacle not easily forgotten.' *Alcyonella* needs only a passing notice, for it differs little from *Plumatella* except in having its tubes or cells adherent to each other by their sides, the whole forming a spongy honeycomb-like mass, which has been frequently mistaken for a fresh-water sponge, and indeed this animal was so called by at least one naturalist in the eighteenth century. The great number of polypides in a colony renders it very difficult to keep *Alcyonella* alive for any time, and only a very small portion must be kept for examination. Some may be preserved, however, by cutting a ring out of the colony, and dropping a small segment of this ring into a tube of methylated spirit. The arrangement of the tubes and the forms of the statoblasts sure to be found therein can thus be studied at leisure.

Cristatella, when fully developed towards the end of the season, and with the tentacles protruded, bears some resemblance to a small hairy caterpillar. When young the colony is globular in form, increasing in length but not in width as it grows older, till it reaches a length of two and a half inches, and specimens of three inches, and even four inches, are recorded, but a width of $\frac{1}{4}$ inch is rarely, if ever, exceeded. Then the entire colony is oval in shape,

flat below and convex above, with the polypides arranged all around in three concentric series near the margin and alternating with each other. The statoblasts, which are round, and when mature set with hooked spines, may be seen in the oval space in which no polypides occur. The under-surface resembles the foot of a gastropod—say a slug—in form and function, for by it *Cristatella* creeps over the surface of aquatic vegetation or along the sides of an aquarium. This form is noteworthy as being

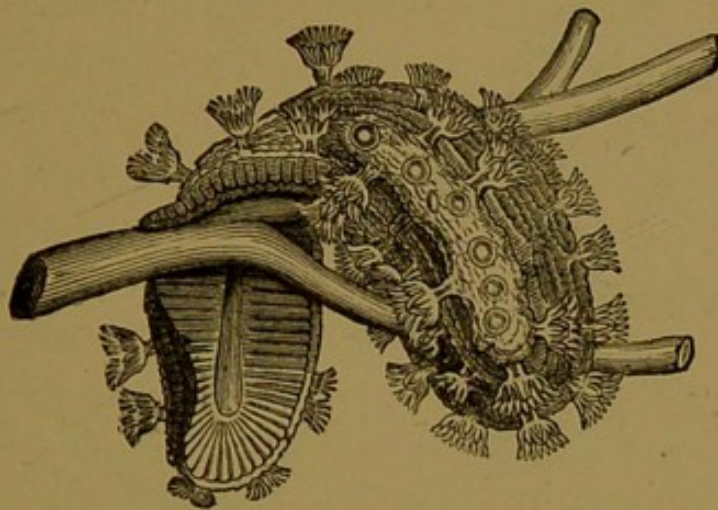


FIG. 45.—CRISTATELLA MUCEDO ON SPRAY OF WATER CROWFOOT ($\times 5$). (AFTER ALLMAN)

a lover of sunlight, which all the others shun, and in being truly locomotive, not only in its adult but in its immature form. At a meeting of the Quekett Microscopical Club (April 7, 1893), a member exhibited two zooids just liberated from the statoblasts. When first seen under the microscope they were at opposite ends of a spray of *Nitella*, but during the evening they approached each other, and when next observed their bases were directly apposed. Unfortunately they were not seen in actual motion.

Lophopus, which, like *Cristatella*, has a single species, is the Plumed Polype (*Polype à panache*) of Trembley. The polypides are enclosed in a clear, glassy, gelatinous membrane, which leaves only the orifices of the cells free, and as the colony increases



FIG. 46.—LOPHOPUS CRYSTALLINUS ($\times 20$). (AFTER ALLMAN)

in size becomes deeply cleft or lobed. Occasionally these lobes become points of division, the colony breaking up where the lobes occur. *Cristatella* also undergoes this fissive process, becoming constricted in the middle till the colony separates, each part moving off in different directions. Baker and Van Beneden assert the locomotive powers of *Lophopus*, which Professor Allman doubts, as does Dr. A. C. Stokes in his *Microscopy for Beginners*, which deals with American pond-life, for he calls *Cristatella* the only locomotive Polyzoon. Mr. Bolton, of Malvern Link, however, writes to me on the subject: 'Lophopus also, as perhaps you know, moves by the secretion of fresh gelatinous matter.' Mr. Shephard, F.R.M.S., says, 'I have, however, on several occasions observed a *very* considerable change in the position of colonies placed in glass cells for examination¹.'

The tree-like forms come next. The colonies of

¹ *Proceedings Chester Society of Natural Science*, i. 59.

Plumatella and Fredericella are branched, and composed of a series of tubular cells of horny consistency, each constituting a branchlet with round terminal opening, and generally separated from the other cells by a more or less complete division. The first-named genus has many species, or, it may be, varieties. Fredericella has but one. In Plumatella the lophophore or platform carrying the tentacles is crescent-shaped, and the tentacles vary in number from sixty to forty; in Fredericella the lophophore is orbicular and the tentacles do not number more than twenty-four. Paludicella, a fairly common form, has the cells club-shaped, with a perfect division between them, so that each zooid is completely shut off from its neighbour, and the orifice is square. It is extremely interesting from the fact that it approaches marine genera in the absence of statoblasts. It has true eggs, and also multiplies by continuous gemmation (see p. 125). Side by side with this, what are called *hibernacula*—winter quarters for the resting-buds—are developed. Van Beneden was the first to notice them. He says: 'At the approach of winter the buds become covered with a horny sheath, and thus the embryo is preserved till the following spring.' Mr. Shephard, F.R.M.S., of Chester, was the first English observer to record these arrested buds. In 1878 he gathered some Paludicella from the canal locks, Chester, and he has very kindly allowed me to use his notes, from which the following is taken: 'The buds are completely sealed up, and covered with

débris, and look dead during the winter. In the spring, when they begin to grow, the terminal tube splits vertically and presents the young, which develop in the usual way.' I have not watched *Paludicella* through the winter, but in some kindly sent me by Mr. Bolton, the *hibernacula* were dis-

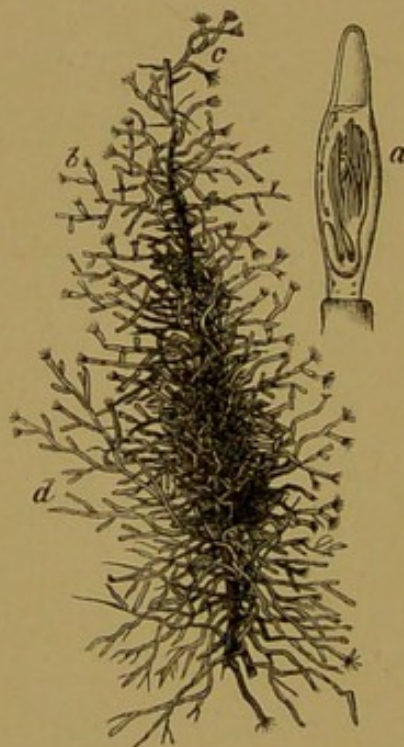


FIG. 47.—ROOTLET OF WILLOW WITH POLYZOA AND HYDROZOA (NATURAL SIZE). FROM LIFE. *a*, HIBERNACULUM OF PALUDICELLA ($\times 20$); *b*, FREDERICELLA SULTANA; *c*, PALUDICELLA EHRENBERGH; *d*, CORDYLOPHORA LACUSTRIS

tinctly visible, and the young polypides were in a similar condition to those of *Plumatella* and *Fredericella* when emerging from statoblasts — exact copies, in miniature, of the older form. Since then I have received a quantity of weed from the Broads, and in several distinct colonies the hibernacula were conspicuous. In some, though the colonists had succumbed to the effects of their journey, the vertical slit could be clearly traced with a hand-lens.

In fig. 47, *a*, a hibernaculum containing a young polypide is figured from life. The capsule by which the bud is sealed up should be noted; the details of the animal can be made out—the bent tube, and the closely packed tentacles, somewhat like a tiny tassel. It was alive beyond all doubt, for I distinctly saw it move more than once. The artist,

who was in my 'den' at the time, sketching the large colonies, also saw the movements, and then it was decided to figure the little creature, which at the time of writing had not emerged from its shelter.

The Marine Polyzoa are much more abundant than the fresh-water forms; one can count the genera of the latter on one's fingers, but to enumerate the former in like manner one would need more than half a dozen pairs of hands. The chief characters by which the three great groups of Marine Polyzoa are distinguished from each other are the nature and shape of the chambers in which the polypides dwell, and the character of the orifices from which they protrude their tentacles. We must not be frightened at the long names which these groups bear, nor at the unfamiliar terms used to describe the parts of the animals themselves. It is necessary to mention them, so that students may know where to turn in consulting the recognized authorities on the subject, but no term will be left unexplained, and English equivalents will be employed for technical terms wherever possible. The zooids, or individuals of which the composite animal is made up, are known as *polypides*, and were called by earlier writers *polypes*, a term now dropping out of use; the separate home of each polypide is called the *zoecium*, which we shall turn into 'chamber'; the technical *zoarium* we shall replace by 'colony'; and the *oecium*, in which the ova

develop into the larval forms, by 'brood chamber.' 'Cell' is often loosely employed to designate the dwelling of a polypide. 'Chamber' is purposely substituted here because 'cell' has a definite biological meaning—'the unit-mass of living matter.'

The first and largest group are the Lip-mouthed Polyzoa (or Chilostomata), in which the chambers are horny or calcareous, and furnished with a kind of hinged door or shutter, operated by muscles, which opens outwards so as to allow free egress to the polypide, and closes again after its retreat. In very many of this group some of the polypides of a colony undergo great modification to serve as brood chambers, bird's-head processes (*avicularia*) or vibratile spines (*vibracula*), and root-like processes, which anchor the colony to some point of support. The second group, the Round-mouthed Polyzoa or Cyclostomata, have long tubular chambers with round openings unprotected by a valve. These are the oldest known species, and some form large encrusting masses on weeds, stones, and shells. The chambers of the third group—the Comb-mouthed Polyzoa or Ctenostomata—are horny or gelatinous, and the 'lip' or cover to the opening of the chamber is replaced by a row of bristles. For classification Hincks' *British Marine Polyzoa* should be studied, and the latest bibliography will be found at p. 171 of Professor Ray Lankester's *Zoological Articles*.

One of the strangest of the British Polyzoa is the Snake's-head Coralline (*Aëtea anguina*), extremely

common on the smaller red weeds, the bright colour of which is often concealed beneath the ivory whiteness of the upstanding chambers of the little animal (fig. 48). It is most abundant on the south and west coasts, growing somewhat

rare as one goes northwards. The creeping

thread-like stolon winds along the weed, broadening out at frequent intervals. 'From very small

holes in the broadest part of this irregular winding-stem there arise here and

there small, testaceous, white, hollow figures, exactly resembling a snake without the lower jaw, in the place whereof is the entrance into the chamber.' So Ellis wrote nearly a hundred and fifty years ago; and the figure in his book does great credit to the exactness of his observation. Others have compared the upper part of the chamber to the bowl of a spoon turned downward; but the resemblance to a snake with the fore part of the body upreared as if in act to bite, is very striking, and is rendered more so by the fact that the upright part is closely ringed, and the swelling top marked with tiny dots. The polypide has about a dozen slender tentacles, and when retracted into its strangely-shaped house is not bent upon itself in the usual way (see fig. 48), but simply shrinks up and draws backwards. When the little creature comes out for

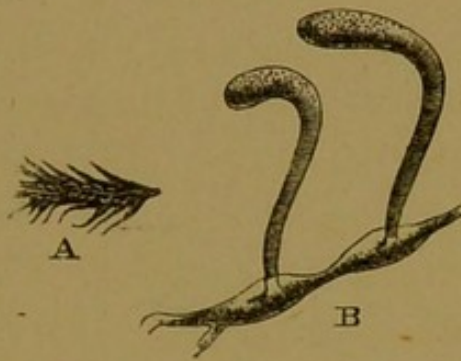


FIG. 48.—SNAKE'S-HEAD CORALLINE.
A, COLONY (NATURAL SIZE); B, TWO
POLYPIDES GREATLY ENLARGED

food or air, the membranous sheath surrounding the tentacles is partly extruded, and one may see that its extremity is surrounded by very fine hairs, like a fringe of filmy rays. This form should be carefully examined, for though it has the operculum or trap-door of the first group, the fringe to the tentacular sheath connects it with the Comb-mouths.

The Bird's-head Coralline is a popular name for several forms in which some of the polypides are modified into 'birds' heads.' These are found in different stages of development in thirty-one of the forty-five British genera of Lip-mouthed Polyzoa; vibratile spines occur in four genera, and in two both these appendages are found together. Ellis was the first to notice these peculiar organs, which Darwin describes as closely resembling the head of a vulture, though the lower jaw opened much wider in proportion than in the real bird's beak. While serving as naturalist on board the *Beagle* he investigated the Polyzoa met with near Tierra del Fuego and the Falkland Islands; and in species akin to, if not identical with, those of our own seas, he found that when one of these vulture-like heads was cut off from the cell, the lower part of the beak retained the power of opening and closing, and when touched with a needle the beak generally seized and held the point so firmly that the whole branch might be shaken.

Various views have been put forward with regard to the function of these organs. Johnston, in his

British Zoophytes, suggested that their duty was to assist in procuring supplies of food, by seizing animalcules and retaining them until the current set up by the ciliated tentacles bore them away to the region of the mouth. But

Hincks points out that the beak and mandible are not fitted to capture animalcules, and that the only animals they have been seen to seize are small worms, much too large to be swallowed whole by the tiny polypides, and that even if they were retained in the horny jaws of the 'bird's-head' till decomposition set in, the chances for and against the decaying particles coming within the influence of the vortex set up by the tentacles would be pretty evenly balanced. He inclines to the opinion that their function is rather defensive, and that they serve to arrest or scare away

unwelcome visitors. The continual snapping of the jaws may act as a warning to small free-swimming animals, while the sight of one of their number firmly gripped, as shown in fig. 49, may serve them as an object-lesson on the danger of approaching such formidable weapons.

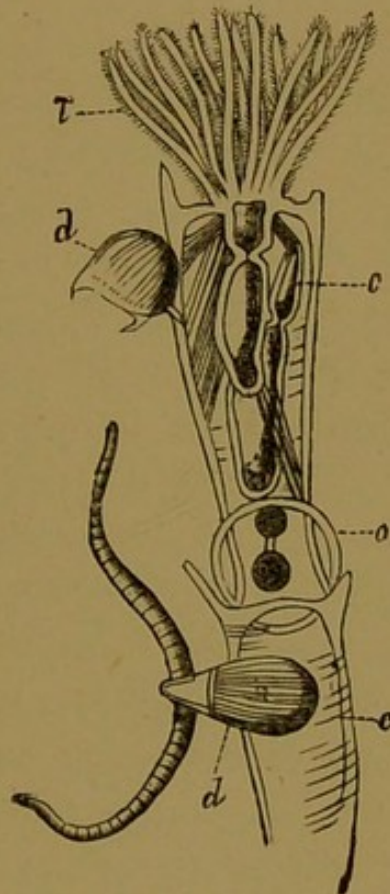


FIG. 49.—BUGULA AVICULARIA (AFTER BUSK). *cc*, CHAMBERS; *d*, BIRD'S HEADS, THE LOWER ONE HOLDING A WORM; *o*, BROOD CHAMBER, OR OECIUM; *t*, TENTACLES

The 'bird's head' may be seen in perfection in the genus *Bugula*, one species of which, *B. avicularia*, the Bird's Head Coralline of Ellis, is fairly common between tide-marks on other zoophytes, especially on the common Sea Mat (*Flustra foliacea*) and on shells. The general habit is plant-like and bushy; the branches are divided and subdivided into narrow segments which wind round the stem in corkscrew fashion, so that the colony forms a spiral, the whorls of which grow larger as they ascend. The chambers are in two rows, with two spines on the outer and one on the inner side. The polypide has about fourteen tentacles.

The collector who meets with a colony of this species for the first time will find it profitable to work it out under a low power of his microscope, not merely once, but again and again, till he is thoroughly satisfied, by his own investigation, that the 'bird's heads' are really modified individuals; that the lower jaw corresponds to the operculum, or trap-door of the chamber in which the ordinary polypide dwells, and that the muscles which produce the snapping action of the beak are the same as those which open and shut the trap-door. It was not till long after Ellis's discovery that the path of development of these organs was traced. To follow it up here would take too much space, but it is briefly and clearly described by Darwin in his *Origin of Species*, chap. vii, a book accessible to every one.

The ordinary polypide may be further modified.

The 'bird's head,' after passing through a series of transitional forms, loses its prehensile character, and appears as vibratile spine (or *vibraculum*), which consists of a chamber, containing a bristle moved by muscles corresponding to those which enabled the jaws to seize and hold a worm (fig. 49). Busk says that these spines have defensive and cleansing functions, and may be observed in almost constant motion, as they sweep over the colony, removing therefrom whatever might be noxious to the delicate inhabitants of the cells when the tentacles are protruded. In some Polyzoa described in the *Voyage of the Rattlesnake* he considered that these organs, which are enormously developed, served for locomotion, and indeed saw them so used. Professor E. Ray Lankester thinks that they are organs of touch.

These organs are shown in fig. 50. The Whip-bearing Coralline—for so, carrying out Ellis's principle, we may term the form *Mastigophora hyndmanni*, one of the old genus *Lepralia*, or Sea Scurfs—is confined to the northern and western coasts, and forms small flat patches on stones and shells in deep water, so that it is only to be taken by dredging. It is, however, figured here, as showing how great is the extent of modification in this group.

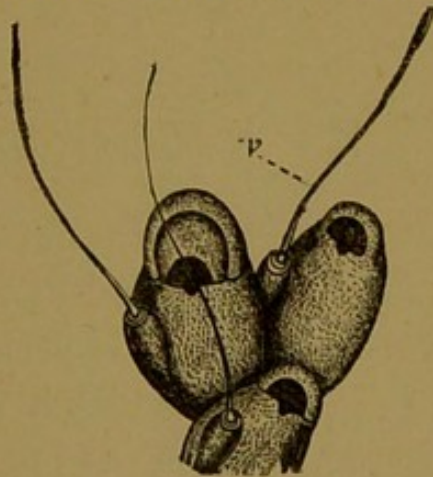


FIG. 50.—CHAMBERS OF THE WHIP-BEARING CORALLINE, SHOWING VIBRATILE SPINES (v)

The Sea Mat, or Broad-leaved Hornwrack (*Flustra foliacea*), is one of the commonest 'objects' of the sea-shore, and great tufts of it may be seen—dead—at about high-water mark almost everywhere. It is as plentiful on the stony beaches of Eastbourne, Hastings, Bexhill, and Deal as it is on the sands of Skegness, and one might load carts with it anywhere between Runton and Trimmingham. But though this is a deep-water form, it is not difficult to meet with a live piece by carefully examining that which has just been cast up by the

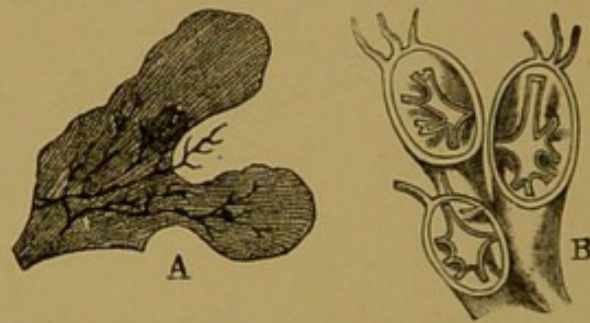


FIG. 51.—A, PART OF A COLONY OF FLUSTRA FOLIACEA, WITH SCRUPOCELLARIA REPTANS (NATURAL SIZE); B, CHAMBERS OF SCRUPOCELLARIA REPTANS (GREATLY ENLARGED)

waves. The colonies are erect and flexible, spreading out into frond-like expansions, and are too well known to need description. The fragment shown in fig. 51 A was picked up near Cromer—which I was assured was one of the worst collecting-places in the kingdom. The colonies shown in figs. 52, 53, and 54 came from the same locality. But this little piece deserves examination, for it shows how small organisms live on, or with, each other, and raises the question to what extent this habit may be for the advantage of any one of the group. Trailing over

the broad fronds of the Flustra were large colonies of the Creeping Coralline (*Scrupocellaria reptans*), which are shown by the dark lines, and standing up between these were many of the chambers of a colony of Bowerbankia. These last are too small to be distinctly seen, but their presence is indicated by the minute lines in the forks of the branches of the Scrupocellaria. All these were alive, and lived for some days after they were taken, though they showed no sign of life when sent to the artist to be drawn. Whenever Flustra is met with it should be examined, so that the simple form of 'bird's head' present in that genus may be compared with the well-developed form in Bugula (fig. 49).

Of the Creeping Coralline, which is to be met with almost everywhere, Hincks says that the student can find no better form to work on, at least for external characters, and it is these which the beginner will generally choose. It creeps over weeds, rocks, and flustra; the branches divide and subdivide; the chambers are ovate in shape and disposed in two rows. There is a branched operculum, which 'spreads out like an antler over the aperture, which it completely protects;' and the colony is rooted by a disk, like a seaweed, or clings to the substance of a Sea Mat or Sponge by grapnel-like hooks.

The next group—the Round-mouthed Polyzoa—is the simplest of all, and the oldest in point of time, for most of its members are fossil. The

chambers are always tubular, and the trap-door closing the orifice which is distinctive of the Lip-Mouths is wanting, as are the 'bird's heads' and vibratile spines.

There are two divisions: (1) those that are of plant-like growth and fixed to weeds, shells, and stones; and (2) those that form incrustations on similar surfaces. Both contain forms of exquisite beauty. One scarcely knows which to admire most—those which rise in shining white tufts, often rendered more brilliant by contrast with the red weeds on which they live, the delicate stony lace-work of some of the incrusting forms, or the fanciful aggregations of tubes, often charmingly sculptured, of others. The first group contains but one living family (*Crisiidae*), the single genus of which is well represented on our coasts. The branching colony is made up of calcareous chambers, in a single or double series, and disposed in a number of segments united by horny joints, sometimes light brown in colour and sometimes jet black.

The Tufted Ivory Coralline is a good descriptive name for the common British species (*Crisia eburnea*). A large colony may be an inch in height, and consists of bushy tufts, rivalling the finest ivory in whiteness. The chambers are alternate, with a slight curve forward, and marked with minute dots. The number of chambers (fig. 52, *z*) in the segments—or internodes—of the branches ranges from as few as three to as many as nine. The

brood chamber (fig. 52, *o*) is marked with dots irregularly distributed over the surface, and has a tubular orifice for the escape of the larval forms. The polypides are small in size and simple in organization, with eight tentacles, which are not protruded for their whole length beyond the orifice of the chamber, in the cavity of which the tiny creature lies quite straight when retracted.

We must not neglect the incrusting coral-like forms, which, however, are chiefly met with in the south and west. Occasionally they may be found in their natural habitat—at home, so to speak, at very low tides; but as most of them live beyond the zone of the long oar-weed, it is better to search for them on the larger weeds cast up after a storm. Species of the

genus *Lichenopora* are the most likely ones to come in the collector's way, the larger ones growing on the fronds of tangle, and the smaller ones clasping the stems of finer seaweeds. They are of such a size as to be occasionally taken for Madreporae, among which, indeed, Fabricius placed one species, while another borrows its specific name

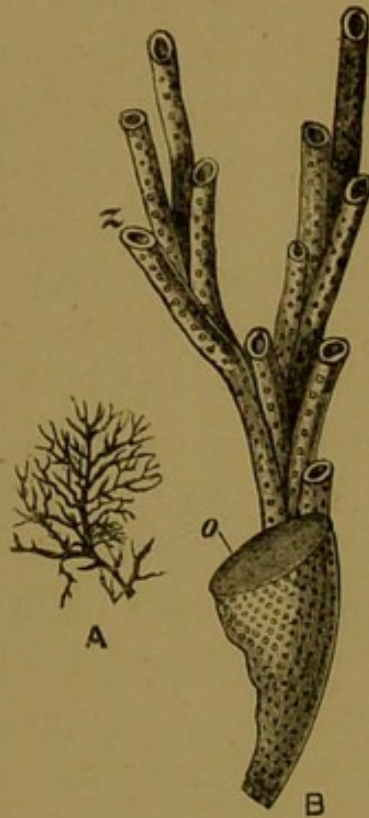


FIG. 52. —A, COLONY OF TUFTED IVORY CORALLINE ON PLOCIUM (FROM LIFE); B, PORTION OF COLONY GREATLY ENLARGED; *z*, ZOECIA, OR CHAMBERS; *o*, OECIUM, OR BROOD CHAMBER

from the brain-coral. Mr. Hincks has a specimen from the Cornish coast about half an inch in diameter, and specimens have been taken at Ilfracombe of at least half that size.

The last group are the Comb-Mouths, in which the lid or operculum of the first group is replaced by a fringe of fine bristles connected by a membrane. The collector is pretty sure to meet with *Alcyonidium gelatinosum*, which Ellis called the Sea Ragged Staff, and Gosse the Stag's Horn Coralline, because it is branched and lobed, somewhat like an antler, and its gelatinous substance of yellowish-olive hue, and clothed with a short dense pile, seemed to him to resemble the young horn of a hart that is clothed in 'velvet.' This upright growth is the rarer of the two forms of the species. Colonies that spread their gelatinous mass over other lowly animals and seaweeds are far commoner, and one species (*A. albidum*) is rarely found except on the curved branches of the Sickle Coralline (*Hydrallmania falcata*). To the naked eye the Stag's Horn Coralline is a very unattractive object, but if a little piece be snipped out of a living colony, dropped into a zoophyte-trough, and allowed to remain for a while till the polypides have expanded their bell-shaped crown of tentacles, the observer will find it difficult to believe that the dark, sponge-like mass he put into the trough is the same organism he sees under the microscope, for the surface is studded with glassy bells, in such profusion that they almost hide the gelatinous

chambers whence they protrude, and even when seen by the naked eye they appear to form a light blue mist over the surface of the colony.

The Nit Coralline (*Amathia lendigera*) is a very pretty form, and as common as it is pretty. It ranges from about low-water mark to deep water, and according to most authorities is generally found on the long pod-like air-vessels of what is popularly known as the Sea-Oak (*Halidrys*

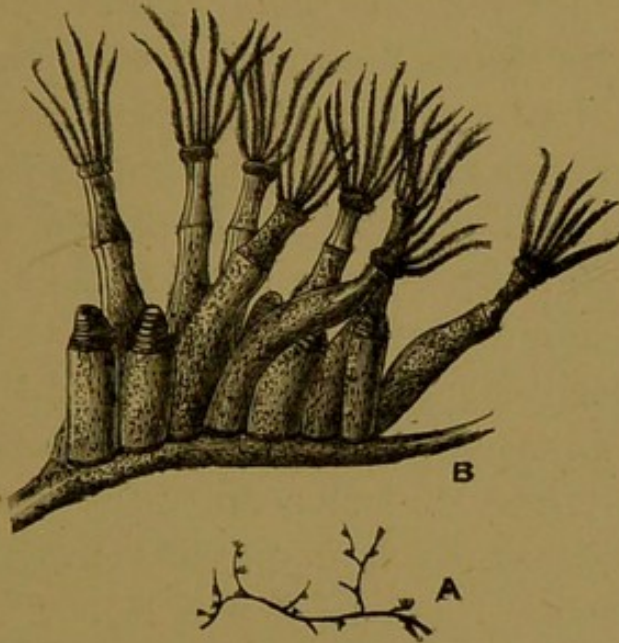


FIG. 53.—NIT CORALLINE. A, NATURAL SIZE (FROM LIFE);
B, CHAMBERS (ENLARGED)

siliquosa). I have never been fortunate enough to meet with it on this weed, which is extremely plentiful, but have found quantities of it on *Plocamium*, and still more on the Common Coralline (*Corallina officinalis*), taken from the rock-pools of North Devon, and from among the seawash of the Thames estuary or of the Norfolk coast. It is of such peculiar habit of growth that

it may be identified on the spot with a hand-lens, and after a little experience without this help, especially if the weed on which it is be dropped into a tube of clear sea-water. The creeping tubular stem gives off at intervals upright thread-like shoots which fork into two, these again often forking in a similar manner (fig. 53). The chambers are in groups of two parallel rows, decreasing in height towards the upper extremity, so that a line drawn over their orifices would form a curve. This grouped arrangement has been compared to the Pandean pipes of itinerant showmen, and the comparison is not inapt when the groups are seen in such a position that the front row hides that behind it. This polyzoon in general habit closely resembles a climbing plant, for not only do the slender branches twine and cling round the stem of an allied animal or of a seaweed, but tiny fibres are also given off, which fasten on to the nearest point of support, from which an expansion of the colony takes its rise.

Closely allied are the species of *Bowerbankia*, named in honour of the late Dr. Bowerbank, the great authority on British sponges. Here the colonies are either closely attached to weeds by a creeping stolon, or form bushy tufts which may be as much as three inches in height. The chambers are large and stout, and, when the polypide has withdrawn its bell-like crown of ten tentacles, appear as if cut off square at the top. The walls are exquisitely transparent, so that the structure

of the polypide—the most highly specialized of the group—can be examined and worked out under a moderate power. In summer, colonies that show a distinct red tinge will be frequently met with. This colouring is not due to any difference of structure, but to the presence of larval forms, and after their escape the chamber becomes colourless once more.

The Grape Coralline (*Valkeria uva*) and the Dodder Coralline (*V. uva cuscuta*) have the same habit as *Bowerbankia*, which indeed was formerly classed in the same genus, but removed therefrom by Dr. Farre because of its higher organization, the upper part of the stomach being enlarged to form a 'gizzard,' the inner surfaces of which are furnished with processes or teeth that serve to crush the food, as in a mill. It is now known that there is another important difference. In *Bowerbankia* the tentacular wreath is circular, while in the Grape and Dodder Corallines (fig. 54), and other species of *Valkeria*, two of the tentacles are directed outwards. This peculiarity may be watched at leisure if a small piece be examined in a zoophyte-trough under a low power. The polypides are by no means shy, and after a short period of rest will come forth from their chambers in search of food. The tentacles issue in a straight bunch for about halfway, when one suddenly diverges on each side, the others continuing close together till they are completely everted. Then the bell-like wreath expands, and the two tentacles will be clearly seen

standing apart from the rest. The stem is jointed at intervals, and it is at these joints that the chambers are generally situated in both kinds, though they sometimes occur between them.

The last of the Polyzoa to be mentioned is *Pedicellina cernua*, for which there is no popular name, unless one chooses to call them—as a collector did when he met with

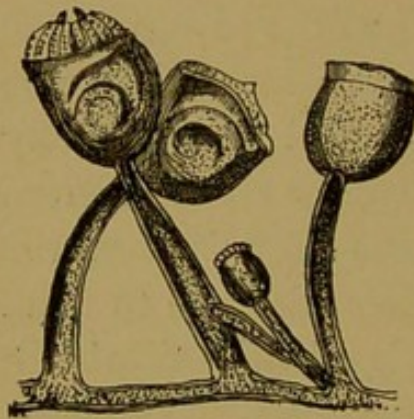


FIG. 54.—PEDICELLINA (GREATLY ENLARGED)

them for the first time—‘noddors,’ from their peculiar motion. They were for a long time regarded—without adequate reason—as a ‘connecting link between Vorticella and the Polyzoa,’ probably from the distant resemblance in shape. Gosse considered them as in some


way bridging the interval between the Rotifers and the Polyzoa, since they are certainly nearer to *Stephanoceros* and *Floscularia* than any other polype yet discovered. But even here the relationship is very remote, as may be gathered from Professor E. Ray Lankester’s article ‘Polyzoa,’ and the classification in his article ‘Zoology’ in the *Encyclopædia Britannica*. These animals are found on weed, shells, and hydrozoa, on the branches of which they are often so numerous as to form a kind of fringe. They spring from a creeping branching stolon, and are borne on footstalks, capable of a considerable degree of

motion. The tentacles do not protrude above the orifice, which renders their identification somewhat difficult to beginners. But one cannot mistake the vigorous movements of the members of a colony. Sometimes these are rhythmical, and the swaying to and fro of the polypides has been compared to the wave-like motion of a field of corn swept by a strong breeze. At other times the polypides seem to act independently of each other, sweeping round and round in circles, of which the footstalk forms the radius in each case. But if one happens to touch its neighbour, that also begins to sway about till the whole colony is in a violent state of commotion. There are two varieties, both of which are very common; in one the footstalk is studded with little spines, in the other it is perfectly smooth.

Like the Hydrozoa, many of the Polyzoa are phosphorescent. Mr. Hincks says that two of the species mentioned here—the Creeping Coralline and the Dodder Coralline—exhibit this property, and there is good evidence as to its existence in some tropical forms of *Bugula*.

CHAPTER V

STARFISH, ARTHROPODS, AND MOLLUSCS

 STARFISH themselves are not microscopic objects, yet they interest us from the marvellous fashion in which the adults are developed from larval forms, and the changes they undergo in the course of this development. Everybody knows the general plan of a Starfish, for these creatures are among the commonest of the 'objects' of the sea-shore. This plan, however, may be much modified. The central disk, from which the arms radiate, may be enlarged so as to fill up the spaces between the arms, and thus give the animal the form of a pentagon; or the disk may be reduced out of all proportion to the arms, which become long and slender, so as to make the animal bear some resemblance to five small snakes joined together by their heads, their tails being free and wriggling in every direction.

The Gibbous Starlet (*Asterina gibbosa*) is an example of the first kind of modification, while the

Brittle-stars exemplify the second. Specimens of both less than an inch across may be taken in rock pools, and may be kept alive without much trouble in the aquarium, where, if they be fairly well fed with small pieces of meat or fish, they will often repay the hospitality shown them by perpetuating their race, and so giving us interesting objects for examination. Quite recently Mr. Waddington has succeeded in rearing the Starlet from the eggs up to maturity, and his experiences are given in No. 2 of the *Journal of Marine Zoology and Microscopy*. The larva of the Starlet makes its first appearance as a free-swimming creature armed with cilia like an Infusorian. These become restricted to two bands upon the surface, which enlarge and form two crescent-like shields. From these long slender moveable arms are developed, which serve as organs of locomotion, but by the currents they set up drive small organic particles towards the mouth. Then the disk begins to form at the hinder extremity, and the arms are absorbed, and the substance of the larval form goes to feed the growing Starfish. If the eggs be isolated in water in tubes or wine-glasses from which the foot has been broken, and then these vessels be left to float in a large aquarium, the development may be watched from day to day, and what one actually sees taking place before one's eyes makes a much deeper and more lasting impression than what one reads about. The next best thing to breeding these creatures for oneself is to examine a set of the models of the

different stages of their development. These are to be found at the Natural History Museum, South Kensington, and (probably) in most museums of any size in the country.

The larvæ of the Brittle Stars are abundant on the surface of the sea in the latter part of the summer. They are exceedingly minute and somewhat conical shaped, dividing below into long processes or arms supported by calcareous rods, and in the middle is the disk with the budding arms of the future Brittle Star. The tiny creature looks as if it were formed from dull glass, the only colour about it being an orange tinge at the top, and at the extremities of arms. It was formerly known as the *Pluteus Animalcule*, because early observers saw in it some resemblance to a painter's easel, and at that time no one had the slightest idea as to what the creature really was.

Closely allied to the Starfish are the Sea-Urchins, and in both are found the curious organs known as *Pedicellariæ*. These consist of minute stalked forceps, with two jaws in the Starfish, and three in the Sea-Urchins. They are used to help these animals to climb by catching hold of weed, and also to remove ejected matter and drop it into the water. When mounted they form favourite microscopic objects; but their operation during life can be watched with a hand-lens, or some may be removed with a pair of forceps, and examined in a watch-glass under a low power.

We can only mention the Stalked Crinoids and

the Sea-Cucumbers, and then pass on to the next phylum or sub-kingdom.

Most of the Arthropods are too large for our purpose, except in the larval condition. The body is divided into segments, which bear jointed appendages modified for walking, swimming, organs of mastication, and weapons of attack and defence. There are five great groups, three of which concern us here. The first is represented by the Waterfleas, Barnacles, and Shrimps, the Wood and Waterlice, and the larval forms of the Crab and Lobster; the second by the Water-Bears, Mites, and the Diving Spider; and third by a few insect larvæ. The fourth contains the Millipedes and Centipedes and the fifth, a strange form, with about a dozen species from Africa, America, and New Zealand, resembling true worms in some characters and insects in others.

Holding up one of our store-bottles to the light, we see a number of little creatures moving about rapidly with a brisk, jerky kind of motion. We will take out some of them with a dipping-tube, and drop them into a watch-glass, whence one or more may be transferred to a live-box for examination under the microscope. These are some of the Entomostraca, popularly known as 'waterfleas,' not because they are closely related to the too well-known domestic pest, but because that name was given to what is, perhaps, the most abundant species, *Daphnia pulex*, the common Water-flea, by those who first described it, on

account of its leaping motion, its red colour, and the prolonged beak, which was mistaken for an organ of suction.

The Entomostraca belong to the same order, the Crustacea, as the lobster, the crab, and the river

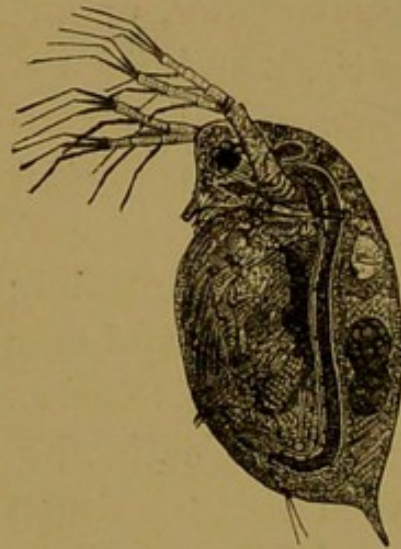


FIG. 55.—DAPHNIA PULEX
($\times 20$)

crayfish, from which, however, they differ greatly in size and appearance. The species we are going to examine first is the common Water-flea (fig. 55).

The females, throughout the group, preponderate largely over the males, and greatly exceed them in size. The eggs are of two kinds—winter and summer eggs. The former are large, thick-shelled, and may remain for a long time in the hard mud at the bottom of dried-up ponds. They only develop after fertilization, and always produce females. The summer eggs are smaller and thinner in the shell, develop without fertilization, and always produce males.

As the creature lies gently compressed in the live-box, we see that it consists of two distinct parts: the head, which is free and prolonged into a kind of beak, and the body—really the thorax and abdomen—enclosed in a reddish ovate shell, composed of two valves joined at the back and completely open in front. The greater part of the shell is clear and smooth, but in front and in the

middle it is marked with fine lines which cross each other. At the lower extremity the valves are produced into a spine set with teeth on the front side. This shell is transparent, so that with the dark ground illumination we can see the internal economy quite plainly. In its early days the animal had two eyes; these, however, have now coalesced to form a single organ of vision, consisting of about twenty crystalline lenses arranged round a central mass of black pigment. The digestive tube can be clearly traced, and the worm-like motion, continually kept up in the intestines of the higher animals also, by which innutritious matter is removed from the body. In the upper half of the space behind this tube the heart is seen pulsating, and just below are two bunches of eggs, and here, if all goes well, they will remain till fully hatched.

One can see the segments or joints of a lobster or crayfish from the outside: one must look inside to see those of a Water-flea. Though they need a high power and close examination, they are there, nevertheless, eight in number; the first being the largest, and the only one attached to the valves. There are five pairs of feet, not one of which does the animal put to the use for which it is generally supposed feet were intended—progression. They are, however, in constant motion, and their movements drive a stream of water through the valves, thus aiding respiration; and to this work the comb-like branchial plates on the third and fourth pairs largely contribute. The feet also collect food-

particles from the water, and form them into pellets on which the mandibles may act. The head bears two pairs of appendages, the inferior and the superior antennæ. The function of the first and larger pair, however, is not that of feelers, for it is by their means that the animal moves through the water ; and the form and branching of these organs are used as a means of discriminating species.

Before removing Madame Daphnia from the live-box and dropping her into a tank, it will be well to take another look at her fellows swimming about in the store-bottle, and endeavour to trace out in them with the hand-lens what has been seen with the microscope. Wherever practicable, this is a good plan to adopt.

The next of the Water-fleas to be noticed are Cypris and Candona, 'insects with bivalve shells,' as Baker called them a century and a half ago in his *Employment for the Microscope*. They cannot be mistaken, for their shape differs widely from that of either of the other groups of Water-fleas, of which Daphnia and Cyclops may be taken as the types. They are about the size of a grain of millet, but the body is enclosed in a more or less oval covering of two valves, somewhat resembling a tiny mussel shell, but joined only in the middle third of the back, where they are connected by a ligament, so that they may be opened or shut at will. The eye is single, and in both genera there are two pairs of antennæ, and the difference in these serves to discriminate the forms. In Cypris the lower pairs are

furnished with a pencil of long hairs of filaments, by means of which the little creature swims freely in the water. In *Candona* these hairs are absent, and the tiny creature can only crawl over the aquatic vegetation or move about on the bottom.

The Crustacean shown in fig. 56 is popularly spoken of as Cyclops. This little creature is something like a liliputian crayfish deprived of its claws, with its head flattened out, and furnished with a tapering tail. It moves through the water in a series of short darts, scarcely any successive two of which are in the same plane. The head, in the centre of which is the single eye (whence the name of the genus, from the giant Cyclops of classic mythology), is joined to the thorax, in which four segments can be made out, and in the abdomen there are usually six. This form may be easily separated from all other pond Crustaceans by the external egg-bags, one on each side, near the junction of the abdomen and thorax. These are omitted from fig. 56, which is contrived to serve a double purpose—to show the form of Cyclops, and some of the parasitic Vorticellidans which frequently infest these little animals.

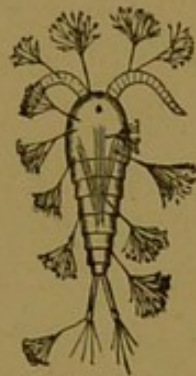


FIG. 56.—CYCLOPS ($\times 10$),
SHOWING PARASITIC
GROWTH OF EPISTYLIS
ANASTATICA

It has been said that the common Water-flea never bears about with it any of the Bell Animalcules which flourish so luxuriantly on the Cyclops, and this is said to be due to the presence

of a slimy film, which is secreted by the skin and covers the whole body. Of the presence or absence of the film I am not in a position to speak; but I think that search in some of the London ponds would bring to light swarms of *Daphnia* on which *Vorticellidans* are living; and I am told by experienced pond-hunters that they have often met with *Daphnia* in that condition.

If the egg-bags are removed from the parent and left in the aquarium under favourable conditions, the young will still be hatched, and on their entrance into the world they are so unlike their mother that early observers placed them in a distinct genus. The bags may be floated in a tube or stemless wineglass in the same fashion as recommended for watching the development of *Starlet*, and if this be done there is no necessity to remove them from the mother.

To the same family as *Cyclops* belongs the still smaller *Canthocamptus minutus* (found also in salt water), which has a single egg-bag attached to the under-side of the body. This form also possesses ten segments, but they taper much more gradually than in *Cyclops*, and at the junction of the fourth and fifth segments the body is very moveable, and the animal can bend its tail over its back like a scorpion, or that evil-smelling beetle, *Ocyptus olens*, popularly known as the 'Devil's Coach-horse.'

Diaptomus castor, a larger form, is somewhat rarer. Its generic name refers to its bold flight-like motion through the water, and its specific name

was chosen because the naturalist who described it fancied he saw in the large egg-bag lying across the abdomen some resemblance to the broad flattened tail of a beaver. In this little animal the distinction between the thorax and abdomen is well marked, and the first segment, in which the large ruby eye is placed, is much the largest. The antennæ are very long, much longer than in any other example of the group, and stand nearly at right angles to the first segment, to which they are attached.

Representatives of the higher Crustaceans may

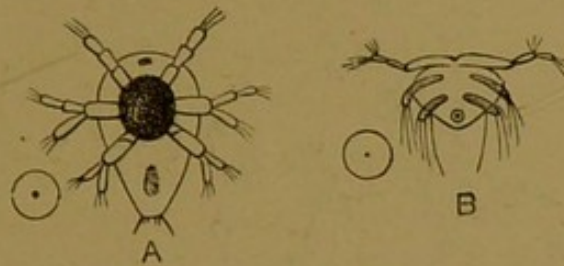


FIG. 57.—LARVAL FORMS OF—A, CYCLOPS; B, CANTHOCAMPTUS

be found in our pond-hunting: the Fresh-water Shrimp and the common Water-louse. The latter is worth examination, from the method in which respiration is carried on by a series of flat appendages on the under-side of the abdomen.

The larval forms of the Crab occupy the first place among our marine forms of this group. About the end of the eighteenth century a Dutch naturalist published the result of his observations on the metamorphosis of some Crustaceans; but the matter seems to have rested till some fifty years later Mr. Vaughan Thompson proved beyond doubt

that what had been thought to be a distinct genus of Crustaceans was really only the young of a prawn. Larval forms of the common Shore Crab (*Carcinus mænas*) will often be taken. When liberated from the egg the creature is said to be in the Zœa-stage (because it was formerly placed in a genus Zœa). The head, a tiny copy of a diver's helmet, is armed with long spines in front and rear; the eyes are disproportionately large, and the long abdomen bears no appendages. After the first moult the creature enters the Megalopa-stage, then,

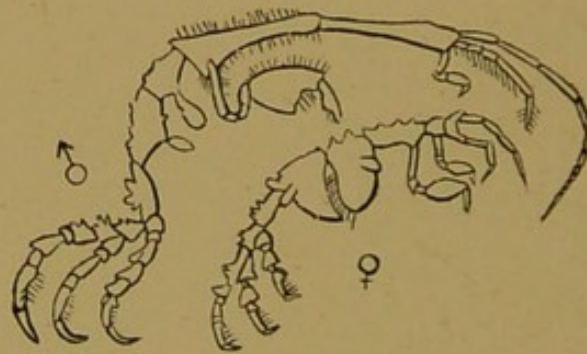


FIG. 58.—THE SPECTRE SHRIMP (*Caprella TUBERCULATA*)

distantly resembling a small lobster. In the third stage, though still unlike the parent form, the creature can be recognized as a Crab, from its general appearance, and a Shore Crab, by the notches on its oddly-shaped carapace.

Among the seaweeds in rock pools, generally near low-water mark, the Spectre Shrimps, of the genus *Caprella*, may be met with, and will often be brought home without being recognized. Kingsley in *Glaucus* described one as clinging by its hind claws to seaweed, and waving its gaunt grotesque

body to and fro, while it makes mesmeric passes with its large fore-claws—one of the most ridiculous of Nature's many ridiculous forms. Those which are found round our shores are about a quarter of an inch long, but Atlantic species are five or six times that size. Gosse saw in these shrimps a close resemblance to the insects known as the Praying Mantis; and compared them as they moved about the branches of a colony of Plumularia to spider monkeys swinging from branch to branch among the trees of South American forests. The female carries on her under-surface a brood-pouch in which the ova are hatched, and from which they climb out on to the back of the mother. The Natural History Museum has a preserved specimen in which the back of the parent is covered with her young. The pouch (shown in the smaller shrimp in fig. 58) is absorbed after it has served its purpose.

Larval Barnacles in the first stage of their existence may be recognized from their likeness to a young Cyclops (fig. 57). At the second moult this likeness is partly lost, and at the third the animal resembles a Cypris, with a gigantic head bearing two antennæ. The single eye of the Cyclops form is replaced by two large eyes on the ends of the outer arms of two bent processes. After leading a free-swimming life for some time the creature settles down, and becomes fixed by its antennæ, head downwards, to some point of support. Then the last moult takes place, the shell is cast off, the legs are modified into end-like grasping

organs, the abdomen shrinks up, and the carapace of several pieces covers the whole creature. The shell is never cast; but the skin of the legs is moulted, and the cast skins are often taken in great numbers in surface skimmings.

Mites, fresh-water and marine, are sure to come in the collector's way. There is no difficulty in keeping them, and they breed readily in confinement. Some of the fresh-water forms are parasitic on water-beetles; one has been supposed to contribute to the formation of pearls in the Water-mussel by the irritation it causes in the mantle, thus stimulating the mollusc to secrete the matter of which pearls are formed. They are generally brightly coloured, and feed upon animal and vegetable *débris*.

The little Water-bears or Sloth Animalcules live in swampy places, and have been met with among the damp dirt in roof-gutters. A good way to obtain them is to take a handful of moss from a bog and shake it lightly in a vessel of water. When the solid particles thus shaken out have sunk to the bottom leaving the fluid clear, one may hunt for water-bears by taking up a little of the sediment in a dipping tube, and examining it in a watch-glass or an excavated glass slip. These little creatures have a worm-like body with four pairs of stumpy limbs, armed with claws. The organs of the mouth are adapted for piercing and sucking. The sexes are combined, and the eggs are enveloped in the cast skin of the parent. These creatures have been compared to new-born puppies and unlicked

bear-cubs; and the comparison is certainly apt. But as they move across the field of the microscope moving the mass of broken-down animal and vegetable matter from side to side with their heads, they give one the idea of pigs routing with their snouts among rubbish for some dainty morsels.

The Diving Spider (*Argyroneta aquatica*) is said to be becoming scarce, at any rate round London, owing to the persistent way in which it is collected by dealers. The length is about half an inch, and the male is larger than his mate—a reversal of the ordinary state of affairs among spiders. The abdomen is covered with hairs, which serve to carry down air into the spaces between them when the creatures go down under the surface of the water. I took one last October in a pond in Epping Forest, and it is still living in a six-ounce bottle. The vegetation therein consists of crystal-worts and thread-like conferva. By some means the spider has made a clear space near the bottom almost triangular in form, and extending about an inch up the side and half-way across the bottom. Between these two glass boundaries stretches its web, with an opening at the corner, allowing the creature to pass to the top. It seems to have no relish for flies; two or three have been put in at different times, but have been left untouched. Its favourite diet seems to be water-fleas of the genus *Cypris*, that is, if the empty shells dotted here and there about the web have the same meaning as the empty skins of flies in the web of a house spider. Eight

months the little creature has thus lived in confinement, and is apparently quite content in its narrow prison. The only sign of displeasure, or it may be alarm, the spider shows is that when the bottle is held up to the light to admit of its being seen, it generally scrambles through the passage in the web, and takes refuge in the mass of vegetation beneath which its tent-like dwelling is constructed. But its flight is useless: the large quicksilver-like bubble of air on its abdomen always betrays its presence. These spiders usually make retreats, enclosed by a web, at the bottom of ponds, and in these they are said to hibernate, and there the female deposits her bundle of eggs. Mine showed no signs of going to sleep for the winter; but this may have been owing to the fact that it was living in a temperature much higher than that at the bottom of a pond.

The last representatives of the Arthropods to be noticed are insect larvæ, which may be taken at some stage or other, at almost every season of the year. Nor is it necessary to go far from home to obtain some specimens, for a water-butt or open cistern will generally yield good store of gnat-larvæ in the warmer months.

Insects, the highest of the Arthropods, breathe by means of branched air-tubes. They are generally of small size, with the body divided into three more or less distinct portions, covered with a hard skin, having six legs, and in the adult condition they are generally furnished with wings. Many of them are aquatic in habit during their whole lives;

and of the others, some that go through their larval stages in the water pass the rest of their life on land, while other aquatic larvæ develop into aërial insects, and of these last the May-fly and the Dragon-fly are well-known instances.

The common May-fly larva is one of the most interesting creatures that can be kept in a small aquarium. It is, however, an exceedingly ravenous creature, and preys greedily upon any living thing smaller or weaker than itself. But if kept well supplied with small crustaceans, they will do well in confinement, and their growth may be watched for a considerable time—in many cases till they develop into the sub-imago or 'Green Drake,' and thence into the perfect fly, whose whole adult life is crowded into a day. The body is flat and elongated, and at the end of the abdomen are three feather-like appendages—the caudal bristles; the two outermost branching like arms of a V, while the middle one projects directly from the body. Along the sides run the breathing organs—tracheal gills. These leaf-like or plate-like processes are expansions of the tracheæ or air-tubes, and may be seen in rapid motion with the aid of a hand-lens. It is in these organs that the chief interest of the May-fly larva consists. Not only are they used for breathing: they are also swimming organs; and the development of wings in the May-fly may probably throw some light on the problem, How did insects come to have wings? Mr. J. A. Thomson's remarks are worth pondering over: 'As to

the origin of wings, this at least should be remembered, that in many cases they are of some use in respiration as well as in locomotion. Seeing that the power of flight is evidently an accomplishment which the original insects did not possess, it seems to me very likely that wings were originally respiratory outgrowths, which by-and-by became useful for aërial locomotion.' And after special reference to the May-fly larva, he adds that their tracheal gills 'in origin and appearance are like young wings.'

Now these statements may be easily tested by watching the development through all its stages; and examination may show how the wings present in the pupa arise. Sir John Lubbock kept a small allied species under observation during its life in the water. It moulted twenty times during this period, each moult being accompanied with changes in structure, until at last the wings had reached considerable development.

The larval forms of Dragon-flies may also be watched as they grow and change into the perfect insect. Their breathing organs, unlike those of the May-fly larvæ, are situated at the extremity of the body, and open, to allow oxygen-bearing water to penetrate into the digestive tube, the sides of which are furnished with gills communicating with the air-tubes. The water, having given up its oxygen, is then expelled with sufficient force to drive the larva forward. These larvæ should not be kept in any vessel where there are other small animals that

one wishes to preserve. Insects, molluscs, and fish fry fall a prey to them, for their mouth armature is of a kind to render their attack irresistible. When anything comes within their reach the modified labium, generally called the mask, which has been described as a mouth and arm in one, is darted forward, the victim is seized between the two pincer-like claws, and quickly transferred to the true mouth.

Our last phylum or sub-kingdom is that of the Molluscs. It consists of three great groups, of which the Cuttlefish, with its numerous arms, the Snail, creeping by its flat foot, and the Oyster, enclosed in a shell of two valves, may be taken as representative types, the first being the highest.

The eggs of the common Cuttle-fish (*Sepia officinalis*) must be known to everybody who has spent a holiday at the seaside, and paid some attention to the objects cast up on the shore. They resemble black grapes, attached by a flexible stalk to seaweed or floating wood. The collector who meets with a bunch of these 'sea-grapes,' as the fishermen call them, will do well to transfer them to a bottle of sea-water, and the young will very probably come out. If one of the eggs be separated from the mass, and the covering removed with a couple of dissecting needles, one may examine the young *Sepia*. Mr. Henry Lee says: 'When about half developed the little animal has the head and eyes disproportionately large, but

gradually acquires a greater resemblance to the parent. If the black integument be removed as one would skin a grape, it may be seen moving in the fluid which fills the egg. Cut down to the little living grape-stone under water, and away it will swim, with all its wits about it, and in possession of all its faculties with as much facility and self-possession as if it had considerable knowledge of the world. It sees and avoids every obstacle, and if you take it out of the water in your hand, the precocious little creature, not a minute old, and not sufficiently matured to leave the egg naturally, will spout its ink all over your fingers.'

The Gastropods, of which the Pond Snails and Periwinkles, Limpets and Sea Hares are good examples, are too large to have a right to a place in the Micro-Aquarium for themselves. They are no longer kept to graze down the vegetation on the sides of a tank. But they often bear about on their shells animals of greater beauty and rarity than themselves. I have a Periwinkle shell on which are growing the common Coralline and Cladophora. The pink stems of the one are encrusted with Polyzoa, while between the bright green sprays of the other colonies of Clava and Coryne stand erect. The eggs of pond snails are deposited in capsules on water weed, and look not much unlike small pieces of sago-pudding enclosed in a skin. When kept in confinement these creatures will often fix their eggs to the side of the tank, and then the development of the embryo may be watched at

leisure with a hand-lens, and they may be seen in motion long before they leave the egg.

When collecting at the shore one is certain to meet with some of the gaily-coloured Sea-slugs, which have plume-like gills on the back and sides. Most of them are flesh-eaters, and will make a meal of a colony of Hydrozoa or Polyzoa without scruple, so that if they are kept they should be put into a vessel by themselves. Even here they will manifest a pugnacious disposition, and fight fiercely over food supplied to them ; and even, if the food-supply be short, will become cannibals, the weaker falling a prey to the stronger.

But if the creatures themselves be too large, their egg-masses will afford material for observation. The sexes are combined in one animal, and the race is perpetuated from spawn deposited on seaweed, rocks, or stones. When the spawn leaves the animals it is, in most species, like transparent mucus, and becomes hard by contact with the water. Some of the sea-slugs as they deposit their spawn move slowly round and round, coiling it like bands of ribbon, or frills of fine lace, and this resemblance is closest when the operation takes place on a flat surface, such as the frond of oar-weed or fucus.

If a piece of this egg-ribbon be snipped off, and kept in a small vessel of sea-water, the development

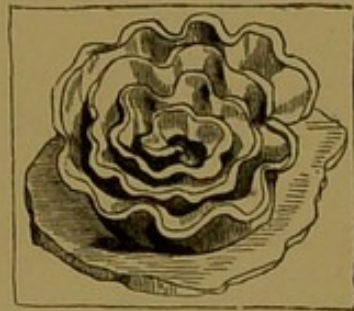


FIG. 59.—EGG-RIBBON OF DORIS

may be watched, and the shell which is lost in the adult may be detected in the larval stage.

Prof. T. Rymer Jones says that the number of eggs in the egg-ribbon of *Doris* cannot be less than 50,000; and there are frequently two and even three yolks in a single egg! The period necessary for their attaining perfection is generally about a fortnight, after which time the mass presents an animated spectacle. When examined with a common magnifier the full-formed embryo may be seen in some, whirling round with great velocity in the transparent egg; others, having broken the shell, will be found performing more extended gyrations in the general envelope; while others, again, are swimming hither and thither in search of an aperture through which to escape into the open water.

The body is enclosed in a shell in shape like that of a nautilus. From this protrude two broad wing-flaps, covered with cilia, by means of which the young sea-slugs swim. In the next stage eyes and tentacles are acquired; then the shell falls off, and the larva closely resemble the parent-form, though the ciliated lobes remain. When these are absorbed the sea-slug moves as does its fellows on land, by crawling with its broad 'foot.'

The Bivalves need no description. The Oyster, the Scallop, the Cockle and Mussel are known to every one. Their interest to those interested in microscopic life lies in their development. In many forms this is like that of the Gastropods. That of the Swan-mussel may be pretty easily followed,

or at least some stages of it. The eggs are fertilized in the gill-plates of the parent, and live there till they reach the glochidium-stage, in which they are enclosed in a toothed bivalve shell. When set free from the gill pouch, they swim by opening and shutting the valves, trailing after them a long thread, till this comes in contact with the fin of a fish, where they fix themselves by the toothed edges of the shell, and become enclosed in a cyst. Here they are developed, and when they drop into the water they are miniature copies of the parent-form. Some difficulty has been found in obtaining glochidia to keep under observation; but a correspondent of *Nature* (July 6, 1893) seems to have found a means by which they may be procured. He says that they 'appear to be retained, and shed only when fish are swimming near. Tadpoles have the same influence as fish, and a good supply may be obtained by examining the tails of tadpoles swimming in a dish in which a few swan-mussels have been placed.' Oysters pass through no glochidium-stage, but the young are hatched in the gills of the parents during the close months.

CHAPTER VI

THE MICRO-AQUARIUM

WE have now to consider the best means of preserving our stock of minute animals under conditions that will enable them to breed freely, so as to afford a pretty constant supply of objects for microscopic examination. To do this we must start an aquarium—not necessarily an expensive construction, such as was the fashion some forty years ago, when the British public suffered severely from what was then known as the ‘aquarium mania;’ but any simple vessel just large enough to keep our captives in health, yet not so large as to prevent our watching their operations at our leisure.

The beginner will probably commence with one fairly large tank. It will not be long, however, before he will find that he needs a second, and a third, and so on, though, as he gains experience, these will be of smaller dimensions.

Of what form, then, shall our first aquarium be? It is not a matter of great importance. Theoretically, an oblong vessel, having the front and two

ends of glass, the depth of which does not greatly exceed one-half the width, is the best, as exposing the greatest surface to the air in proportion to its cubic contents. This is the form advocated by many writers of experience when treating of the ordinary aquarium. They, however, contemplated the introduction of vertebrate animals, which, it need scarcely be said, will be rigidly excluded from ours. On the score of convenience, as well as on that of cheapness, most people now adopt the form known as the 'bell' aquarium. This is simply a propagating-glass, or one of the cake-covers used by confectioners, inverted and placed in a wooden stand sold for the purpose. A pound jam jar, or a two-pound glass jar in which French plums are sold, will serve as a makeshift stand, but this should be packed with dried moss, to keep the tank steady and to guard against the risk of breakage. This aquarium may be from six inches to ten inches deep, and, within reasonable limits, the broader it is in proportion to its depth the better. When making the purchase it is well to select a bell-glass as flat as possible at the top near the knob, for one of this shape will be much firmer than one in which the top curves sharply down to the sides. We shall also need a circular glass cover, which should overlap the edges of the aquarium by about half an inch all round. If it is thought desirable to raise this cover a little for the admission of air, this may be done by fastening three or four thin slips of cork or rubber on the

edges of the aquarium. But as this will inevitably admit dust in quantities sufficient to form a thick film on the water, and as no corresponding advantage is gained, the collector will soon come to the conclusion that it is better for the cover to rest flat on the edges of the tank. Moreover, by this plan the loss from evaporation is reduced to



FIG. 60.—TREMBLEY'S STUDY, IN WHICH HIS EXPERIMENTS ON HYDRA WERE MADE

a minimum, for the vapour is condensed on the under-surface of the cover and rolls back into the tank (see frontispiece).

Trembley, whose experiments on the Hydra were referred to on p. 78, appears to have been one of the first to keep aquatic animals in vessels of water for scientific study; and towards the close of the

eighteenth century his example was followed by Sir George Dalyell. But neither of these naturalists had 'aquaria' in the sense in which the word is now used. They were reduced to the necessity of frequently changing the water in which the animals under observation were kept, and this involved considerable trouble and loss of time. In the micro-aquarium, where a large part of the stock cannot be discerned without the aid of a lens, changing the water would ruin the collection.

It was not till nearly the middle of the present century that the true principle on which an aquarium should be maintained was discovered. And probably no single naturalist can claim the discovery—which is really nothing more than an endeavour to make the aquarium a reproduction of what is found in nature. The late Dr. Bowerbank seems to have been one of the first to hit upon the right way. In the Memoir prefixed to his treatise on British Sponges, we are told that, 'it was in his museum at Highbury Grove that the first idea of an aquarium was started. A small glass jar was used to keep *Chara translucens* for microscopical purposes, to which were afterwards added some fish and animalcules, until at length the idea was worked out by Mr. N. Ward, Mr. Warrington, Mr. M. Marshall, and others' [amongst whom Gosse should have special mention], 'and brought to its present state of development.'

Now this plant lived and flourished in the glass jar, and rendered it possible for the fish to do so

likewise. The explanation usually given of this is, that animals inhale oxygen and give off carbon dioxide, popularly known as carbonic acid, while plants inhale carbon dioxide and give off oxygen, so that in this way a balance is maintained. No doubt the balance is maintained, but in somewhat different fashion. Both animals and plants—between the lower forms of which it seems impossible to draw a sharp dividing line—inhale oxygen and give off carbonic acid (which consists of one atom of carbon and two of oxygen); but the *chlorophyll*, or colouring matter, of green plants exposed to sunlight absorbs the carbon into the tissues of the plant and restores the oxygen to the atmosphere, thus contributing to render it capable of supporting animal life. Nor is this property confined to plants: it is shared by some of the lower forms of animal life, notably by the Green Hydra, whose presence in a tank has, therefore, a distinctly beneficial effect, though the little crustaceans on which it feeds would probably think otherwise, if they were capable of thinking about the matter.

The best situation for an aquarium is undoubtedly in a window facing the north; but there will be many cases where a north window is not available for this purpose, and where one cannot do as he will, he must perforce do as he can. Excellent results have been obtained in windows facing east and south, and my own tanks, which have done fairly well, are most of them in a window with a western aspect. But in nature the sun's

rays illuminate a pond only from above, and, imitating nature as closely as possible, some system of shading from direct lateral illumination should be adopted. A folded newspaper or a piece of cardboard placed at the side of the tank just where the sun's rays strike will answer the purpose, or a strip of the dark green linen sold for window-blinds may be gummed or fastened with cement to the glass cover. This is, of course, the neater plan, but the other is equally effective.

Having fixed the vase in position, the next business is to stock it, and so convert it into an aquarium. The bottom should be covered up to the point where the curve ends with fine gravel which has been washed three or four times. This will give a fairly level floor which we should not otherwise obtain, and the algæ, which will soon make their appearance on the gravel, will be active agents in aerating the water. Two or three large pieces of stone, with as many angles as possible, may be advantageously fixed among the gravel. They, too, will soon be covered with confervoid growth, and will also afford shade to such of the Polyzoa as may be kept in the large tank.

Strange as it may seem, running water is the worst possible for our purpose, for it 'goes wrong' with marvellous rapidity. The best water for an aquarium is that taken from a clear pond fairly rich in infusorial life. If this cannot be had, clean rain-water will do; and failing this, we must put up with water from the tap. A small siphon is the best

instrument for filling the aquarium ; but a watering-pot with a fine rose will serve the purpose, though this method of filling will render the water turbid for a little time, but that is a matter which will right itself in a day or two.

Next comes the question of what plants shall be put in the aquarium. The Italian Water-weed (*Vallisneria spiralis*) is generally recommended as a good oxygenating agent ; and so it is, but it has one distinct disadvantage, so far as we are concerned ; it needs to be rooted in sand or mould, and neither of these should be admitted into our tanks. But this plant shows cyclosis, or the streaming of protoplasm in the vegetable cell, very plainly, and those who, for this reason, determine to grow it, should choose a small potted plant, and bed the pot in the gravel about the centre of the tank. It generally grows with great rapidity, sending out runners like the strawberry, and needing vigorous thinning to keep it within bounds. It is not a native of this country, but specimens may be obtained for a few pence from any dealer in aquarium requisites. Frog-bit (*Hydrocharis morsus-ranæ*) will suit very well, for it is a floating plant, which never takes root and is very hardy. Like *Vallisneria* it sends out runners, which put forth small buds that develop into new plants. In the winter the buds and seeds will sink to the bottom, to rise again and produce a new crop in the following spring. It is not a common plant, but is found in many ponds in the eastern counties, and in some

places in the neighbourhood of London. By far the commonest plant used in aquaria is the Canadian Water-weed (*Anacharis alsinastrum*); for it grows rapidly, and is a favourite habitat of the Floscules, Stephanoceros, and Melicerta, and if a spray be dropped into the tank it will grow as it floats about. If, however, one wishes it to take root, it is only necessary to tie it to a stone or a piece of a broken flower-pot, and insert this among the gravel, and in a very short time the spray will send out roots and shoot upwards with amazing rapidity. The difficulty is not to get it to grow, but to restrain its growth within reasonable limits. The common Spiked Milfoil (*Myriophyllum spicatum*) will do well and grow readily, though not so rapidly as *Anacharis*; and any spray taken which is fairly rich in animal life may be dropped into the aquarium. There is no necessity to root it, for it floats near the surface, and affords a home for tube-building Rotifers at the same time that its finely divided leaves do their share in aërating the water. Hornwort (*Ceratophyllum demersum*) and the Water Crowfoot (*Ranunculus aquatilis*), a near relative of the buttercup known to every one by its flowers, very much like those of the strawberry, are both good aquarium plants, and at least a spray of each may be put in. The latter is to be met with everywhere; the former is not quite so common. The Water Starworts (*Callitriche verna* and *C. autumnalis*) are good. If sprays be just dropped into the water and left to take their

chance, in all probability they will grow luxuriantly and give out a fair amount of oxygen. But if they are rooted in the gravel or tied to stones and sunk, the lower part will quickly decay, and we shall have more dead vegetation than we want, though some must be allowed to remain, to provide food for Infusorians. The Water Violet (*Hottonia palustris*) should not be admitted; it is by no means a free grower, and decays rapidly. There should, if possible, be added a spray or two of Bladderwort (*Utricularia vulgaris*), for this plant will repay all the attention that can be given to it. It will grow readily enough, and we may observe at our leisure the strange sight of a plant capturing living prey and absorbing the products of decomposition. The 'bladders' with which this plant is furnished, and to which it owes its popular and scientific names, are modified leaf-organs, and form hollow chambers, closed by a valve which opens inward, admitting ingress, but incapable of being opened outward, so as to allow of the return of any little animal that has entered the valve. These bladders are death-traps for water-fleas, many of which enter without difficulty, though none ever returns. Once inside, there is no escape; death speedily ensues, and the sucking-cells on the inner walls of the bladder absorb the body as it decays. Towards the end of the summer the plant sinks to the bottom, rising again in the following spring, but the bladder will then be somewhat smaller. When growing in a pond or in running water this de-

generation does not occur. Willow moss (*Fontinalis antipyretica*) is a showy and useful plant for our purpose, and grows very rapidly. It is abundant in the New River, and a piece of it, growing on a stone if possible, should be obtained. It is not only a good agent for aërating the water, its small leaves are often studded with *Melicerta* and *Floscules*. The Stoneworts (*Chara* and *Nitella*) must on no account be omitted, not only because of the readiness with which they grow, but because of the enormous cells of which they are made up, and the ease with which the streaming of the protoplasm may be seen therein.

Thus far we have dealt with the aquarium as if one tank would be sufficient for all our needs. It is an excellent thing to have one large tank, because the amount of water therein is sure to give our stock a better chance of survival, but before long the following difficulty will have to be met. Supposing that rare forms—or it may be forms entirely new, to us at any rate—are found in some pond-hunting expedition, how are they to be dealt with? To put them into the large tank is certainly to give them a good chance of life, owing to the large water-space and the quantity of oxygen this contains. On the other hand, such a proceeding may mean, especially if the forms are minute, endless trouble in finding them again. More probably, indeed, they would be lost beyond recovery. So that, in the majority of cases, if a man takes seriously to the study of pond-life, the single tank

with which operations were commenced will probably be added to again and again, though not necessarily to the extent shown in the frontispiece, which, it may be well to add, is not a fancy sketch. At the left-hand side of the table hang the stick for cleaning the inside of a bell-aquarium, and a pair of wooden forceps for picking up weed from the bottom of the tank. For some time, at any rate, the beginner will find the bottles and tubes he takes with him on collecting expeditions quite sufficient for all practical purposes. When more vessels are needed, pound jam jars will answer the purpose very well. They have the merit of being exceedingly cheap, and their uniformity of size and shape is another advantage.

The arrangement in the corner to the right of the table is a modification of the Cabinet Aquarium, the introduction of which is due to Shirley Hibberd. As planned and figured by him, the Cabinet Aquarium was capable of being 'elaborated into a noble piece of furniture for the adornment of an elegantly furnished room.' It consisted of two sides, holding four shelves, diminishing in width from the lowest upwards. It was designed to keep pots and jars containing objects for which there was not room in the large tank, or which the aquarium keeper wished to have under observation, so as to watch development or habit. He always kept the ornamental side of the matter well to the front, and therefore arranged his shelves as described. He also insisted strongly on the advantage of having

all the tanks on one shelf of one size, the largest being naturally on the lowest shelf. As will be seen from the frontispiece, a shallow recess in the corner of a room and at right angles to a window has been utilised. Shelving has been fitted up at a trifling expense, and the jars are for the most part two-pound plum jars, which cost, with their screw tin covers, one penny each. The space on the floor serves well for larger jars, if these are needed for any purpose, and for the utensils used in collecting.

When we begin to collect for the purpose of stocking our aquarium with animal life, we shall probably find that we have more water-fleas than anything else. They may be turned in wholesale, and the task of watching their movements and habits will afford plenty of occupation. We shall soon be able to discriminate the different genera by their motion in the water, and the dipping-tube will afford us a ready means for taking out any particular specimen for examination under the microscope. They are all extremely prolific, and will soon begin to breed, so that in a little time we shall find plenty of the larval forms (see p. 159). Authorities have differed as to what these animals feed on; for a long time it was held that their diet was vegetable, but Dr. Brady says that most of them are essentially carnivorous, and fulfil in some sort the office of scavengers. He has seen species of *Cypris* feeding on animal matter, and dead specimens of the same genus in their turn preyed on by *Cyclops*, 'so intent on their prey that they

were scarcely frightened away from it by being touched with a brush.' And he records another experience, which could probably be confirmed by most persons who have watched these animals in a tank. He put a quantity of them into clear water, free from other animal life, but containing some aquatic vegetation, and in a little while they lost their liveliness, and numbers were seen lying dead at the bottom of the jar. Some water rich in infusorial life was then added, and in a short time those that were still living recovered activity and throve and multiplied. Our pond-water will be almost sure to contain plenty of Infusoria, but if it does not, the commoner forms can be readily obtained by exposing an infusion of hay for a few days in the open air. If the tube or bottle be then examined with a hand-lens, the Infusoria will be seen like minute white spots in immense numbers, and a little of this water dropped into the tank will furnish food not only for the water-fleas but also for other forms of life.

Hydras will be certainly found on some of the weed, and they will begin to feed and multiply as soon as they are dropped into the tank. It has already been remarked (p. 78) how difficult it is to kill these animals. Even when they cannot obtain animal food it may be doubted if they starve, for they will take the thread-like conferva when nothing better offers. In Professor Parker's *Elementary Biology* a section of one is figured in which a desmid is ingested. Trembley's *Mémoires pour*

servir is a storehouse of curious lore concerning this little Hydrozoan. If the beginner is tempted, as he probably will be, by the perusal of this charming book to imitate Trembley's experiments, the animals dealt with should on no account be returned to the large tank, but be isolated in a tube or small bottle with a little water-weed, some Infusorians and small Crustaceans being also added. The divided Hydras should be examined daily, and a note made of their condition.

We need take little trouble to secure a supply of Vorticella and its near allies, if these are once introduced into the tank; and as it is almost impossible to fish half a dozen pieces of weed out of a pond without finding one form or other, some will certainly occur in one of the collecting-bottles to start with. As soon as the type genus is known, and can be easily recognized with a hand-lens, other forms (see pp. 59-62) should be sought out and examined under the microscope.

It is almost hopeless to attempt to keep Volvox for any length of time—a fortnight being generally the extreme limit for which it lasts. It is said that there is only one case on record in which it was successfully preserved throughout the season. Some hundred individuals were put in a four-ounce bottle, 'on a shelf, at the side of an out-house which had no gutter, so that the rain in running off would drip into the bottle,' which remained here for more than a year, and they not only remained in perfect health, but multiplied and became abundant.

There is not much difficulty in keeping the commoner forms of tube-building Rotifers. *Melicerta*, *Stephanoceros*, *Limnias*, and most of the *Floscules*, bear the narrow limits of an aquarium very well indeed. Not only will they live, they will also propagate; and if it be remembered that they feed on the smaller Infusoria, and care be taken to supply them pretty plentifully therewith, they will do well. A correspondent of *Science Gossip* (vol. xxiv. p. 13) gives an interesting account of how he kept *Melicerta* in his tank without interruption for a whole

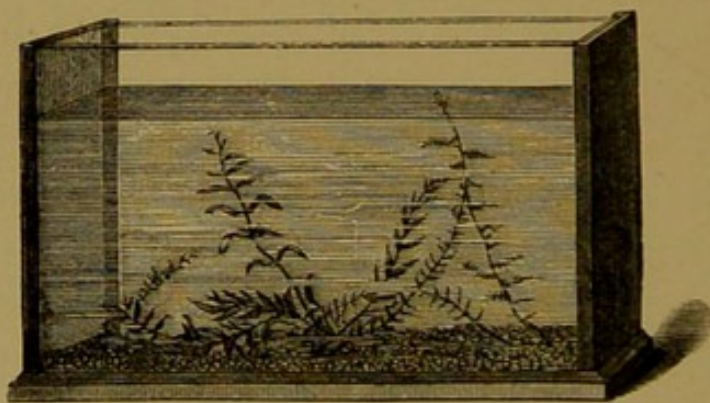


FIG. 61.—WINDOW AQUARIUM

year, so that he must have had very many generations of them, and there is no reason why others should not have a similar measure of success. *Melicerta ringens* has lived in my tanks without much attention, and the rarer form, *M. tubicularia*, supplied to me by Mr. Bolton, flourished and multiplied in a four-ounce bottle. A spray of willow moss was the only vegetation therein; and a little water in which infusorial life was plentiful was added from time to time. *Megalotrocha* and *Lacinularia*

have both been kept in small tanks, but *Conochilus*—more's the pity—falls to pieces after a day or two, in spite of all efforts to preserve it.

A form of aquarium is shown at fig. 61 which is very useful for keeping these animals under observation. Care should be taken not to overcrowd this tank, and it should be placed on a table rather than on a window sash, for the strong light in this latter situation would encourage too plentiful a growth of *Conferva*. This small tank is also very useful for another purpose, the examination of aquatic vegetation brought home from pond-hunting expeditions. This, of course, has been hurriedly looked over at the pond-side, but closer examination at home will often reveal the presence of forms which were not detected in the first rapid survey.

The free-swimming Rotifers, when strained out, should be put in small bottles or tubes and fed with the expressed juices of aquatic vegetation. Care must be taken not to overstock a tube, or indeed any vessel, with animal life. Too little, rather than too much, is a safe rule, but the beginner will probably see bottle after bottle turn 'milky' and go wrong before he puts it into practice. When a bottle does go wrong the only chance of saving some of its contents is to turn the whole into a larger vessel, adding fresh water and some more weed, and then exposing it to direct sunlight.

The Polyzoa require some amount of attention.

The first requisite for all except *Cristatella* is shading from direct sunlight. If they are put in the large tank the spray or rootlet bearing the colony should be laid on the gravel by the side of a large stone so placed as to ward off the rays of the sun that fall on the one side of the aquarium. But it is better to utilize a wide-mouthed bottle or a jam jar as a dwelling-place for these forms, for in a small

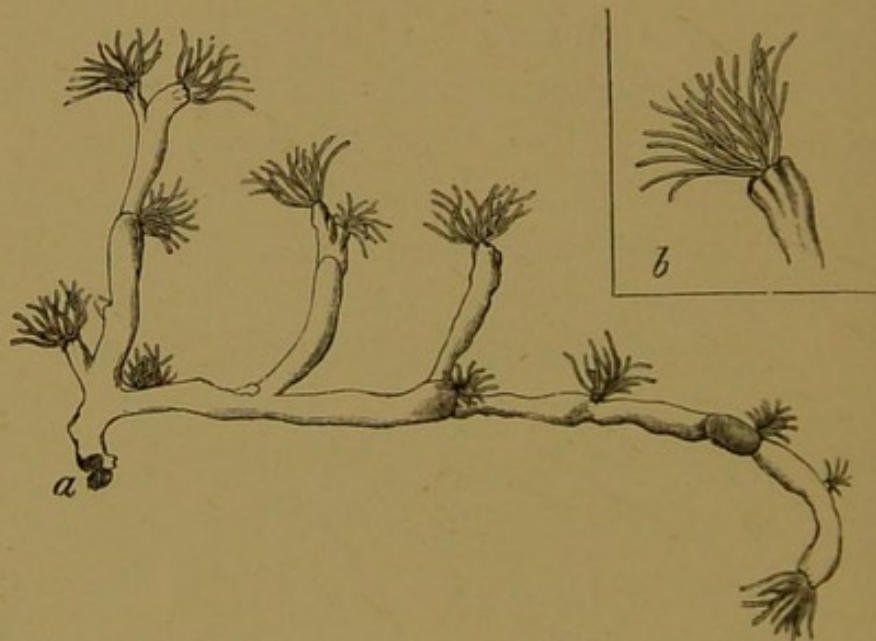


FIG. 62.—COLONY OF PLUMATELLA, GROWING ON THE SIDE OF JAR. ENLARGED FROM LIFE. *a*, STATOBLAST FROM WHICH THE COLONY STARTED; *b*, TENTACLES, MORE HIGHLY MAGNIFIED

vessel they can be more surely supplied with the Infusoria on which they feed, and their motions and growth more easily watched with a hand-lens, than would be the case if they were kept in the bell-aquarium. In fig. 62 is represented a colony of Plumatella that developed on the side of a glass jar in 1891. Some weed from the Broads on which was a large colony was put into the jar, and

when the colony died down and the tubes decayed a shoal of statoblasts floated up to the surface. Little notice was taken of them for some days, till examination with a hand-lens showed that in several the valves were opening, and in more than one instance the expanding tentacles of the young Polyzoon could be seen. A day or two after this one of the statoblasts found a resting-place on the side of the jar, and founded the colony in question. Other colonies of *Plumatella* have been kept for months in window aquaria, and some *Fredericella* sent me by Mr. Bolton lived for over three months. *Paludicella* and *Lophopus* may be kept under similar conditions. *Cristatella* has been kept for a whole season in a tank, and the statoblasts opened to allow of the egress of the discontinuous buds in the following spring.

If we meet with a bit of *Cordylophora* in a river or canal, it may be kept for a considerable time. A colony taken in August last year is still 'going' in one of my small tanks, and a Toynbee student has been equally successful with some gathered at the same time, and some taken in May this year is living in a bell-aquarium. Like its relative *Hydra*, *Cordylophora* seems to prefer a diet of small crustaceans, with which it should be plentifully supplied, in order that a succession of buds may be kept up and the colony prevented from dying out.

Insect larvæ are dangerous inhabitants of an aquarium for microscopic life, because very many of them are rapacious, and will prey on forms which

we wish to preserve ; so that if they are kept at all, they should be put in separate vessels and supplied with worms and small crustaceans on which to feed. One of the most interesting is the larval form of *Corethra plumicornis*, popularly known as the skeleton larva, and sometimes called, from its transparency, the glass larva. It is pretty common in clear ponds, and from the length of time that often elapses before it enters the pupal stage it affords ample opportunities for examination.

Some aquarium keepers recommend the introduction of the Water-louse (*Asellus aquaticus*) as a scavenger to feed on decaying vegetable matters. Every one must judge for himself in this matter, for there is little doubt that, though generally vegetarians, these creatures do not object to occasional meals of animal food by way of a change. Moreover, they multiply so rapidly as almost to overrun a tank. If they are kept, they should be examined from time to time in the zoophyte-trough, for Rotifers are often found living upon them as commensals.

Shall we admit Snails? When they are kept the reason is that they may clear the inside of the glass of confervoid growth. But as we need some kind of shading, a little management will enable us to dispense with these molluscs, and have a natural green blind covering the inside of the greater part of our tank. It is quite easy to keep a space—say one-third of the whole—free for inspection of the interior. This may be easily managed by tying

a piece of sponge or soft flannel firmly to the end of a stick and occasionally rubbing the inside of the glass therewith for a few minutes. This will remove the microscopic vegetation, and it may be suffered to grow unchecked on all other parts. In addition to serving as a screen, it will act as a purifying agent in absorbing carbon dioxide from the water.

THE MARINE AQUARIUM

The general principle of managing a fresh-water and a marine micro-aquarium is the same—the reproduction of natural conditions as exactly as circumstances will permit. But it seems to be a pretty general experience that there is more difficulty in keeping the latter in good going order than the former. To obviate this various contrivances have been employed, the only one calling for mention here being a modification of the water-chamber tank with a sloping back, so much advocated in the 'fifties.' This plan was introduced by Mr. H. J. Waddington; and the following description is abridged from his own account of it¹.

Having fixed upon a bell-glass of the requisite size and form, a U-shaped piece of cardboard is cut, so as to slope at an angle of about 45° from the bottom of the aquarium to within about an inch of

¹ *Journal of the Quekett Microscopical Club*, July, 1888, pp. 241-246.

the top. This serves as a pattern by which a piece of stout glass is cut to serve as the back of the aquarium. Two wedges of cork keep it off the bottom, and similar wedges support it at the sides and relieve the pressure. Sea-water is now poured in, with some green seaweed, and the vessel, covered with fine muslin, is exposed to the full action of light and air. Meanwhile the stones and rockwork to be used are exposed in another vessel of sea-water. When the inner side of the aquarium shows a coating of vegetable growth, the vessel is emptied, the part of the aquarium in front of the U-shaped plate wiped clean, the stones, &c. arranged on this plate, and the water poured down the clean side so as not to disturb the vegetation. The plan is an excellent one, and its author has been wonderfully successful in keeping forms of marine life for a long time. There seems, however, to be one objection to it: one cannot insure the development of new colonies on the *right side* of the plate. The cork wedges allow free circulation of the water, and larval forms are just as likely to float behind the back of the aquarium, and develop there, as they are to mature on the other side, where the observer can watch their movements in the clear water.

A dealer in London had a somewhat similar theory as to the propriety of keeping one part of his fresh-water tank for animal and the other for vegetable life. He tried to effect this by dividing a bell-aquarium into two parts by a vertical glass

plate, on one side of which he put a quantity of vegetation, leaving the other side free for the development of microscopic animals. It was all in vain ; free-swimming Rotifers swarmed over the vegetation naturally enough, for there they sought their food, and though he had a fine show of tube-building Rotifers, the bulk of them had rooted themselves to the glass, which in some places was dark with the tubes of *Melicerta*.

If a mass of floating green weed be kept on one side of the tank—and this can easily be done—any partition may be dispensed with. When the sides of the tank and the stones on the bottom are covered with confervoid growth, very little, if any, other vegetation will be needed, except as a resting-place for colonies of microscopic animals.

The form of the vessel does not matter very much ; but one that is broad and shallow should if possible be chosen in preference to one that is narrow and deep—a cake or sandwich cover rather than a propagating or confectioner's glass. Beginners naturally think that animals which come from a depth of many fathoms will thrive best in deep vessels. And they probably would, if the conditions under which they live in such vessels were approximately the same as those under which they lived when at liberty. The continual motion of the sea carries down into its depths large volumes of oxygen, whilst the forests of submarine vegetation complete the work of aëration. To render matters in any way comparable, we should have to establish

an artificial supply of atmospheric air to the tanks, which is out of the question. If the depth of our aquarium exceed its breadth, the air absorbed by the surface will be insufficient in amount, and the defect must be compensated by abundant vegetation. Rare anemones have been successfully kept for long periods in pie-dishes covered with glass, and similar vessels are constantly used by investigators for breeding Ascidians.

If the water brought from the collecting excursion be not enough to fill the aquarium, and leave some over for smaller vessels into which rare objects may be put for frequent examination, in London at least there need be no difficulty about the supply. The Great Eastern Railway Company will deliver three gallons for sixpence, within a reasonable distance of any of their stations.



FIG. 63.—AQUARIUM
HYDROMETER

The average density of sea-water compared to that of pure water is as 1027 to 1000; and in order to keep the inmates in our aquarium in health, that density should be approximately maintained. The instrument used for this purpose is called a hydrometer, and shows by its graduated scale whether the water contains too large or too small a proportion of salts. That shown in fig. 63 is of German make and costs, delivered in England,

about eighteenpence. The stem should not rise much above, or fall much below 26° . Salt-water beads, as they are called, are often employed instead, as they act automatically. These are two round glass beads, one blue, the other white. When the water is of the proper density the blue bead rests on the bottom, and the white one floats at the surface. Should it become too salt, the blue bead will gradually rise ; and its appearance on the top is a danger signal that should not be disregarded, for the salts are in excess, and the balance must be restored by the addition of fresh-water. Distilled water is best, but cold boiled water, rain-water, and tap-water have all been employed. If the white bead begins to sink, there is a deficiency of salts, and the best remedy is to remove the cover till the superfluous fluid has been carried off by evaporation. A third plan, which savours of the time-honoured 'rule of thumb,' but which works fairly well in practice, is, when the tank has been filled with sea-water of the proper density, to paste two strips of paper on the outside of the tank, opposite each other, so as to mark the level of the water, and to supply the loss from evaporation by adding either rain or distilled water.

In a fairly large aquarium, holding from two to three gallons, the bottom should be covered with large stones, angular rather than round. If these can be brought direct from the seaside, so much the better, for then such as have weeds growing on

them, or are coated with patches of green, brown, or red confervoid growth, can be selected.

Having filled the aquarium, the weeds should be our first care. *Ulva*, or Sea-lettuce, and the slender tubular *Enteromorpha* are the best to begin with. They are met with everywhere, and even if torn from the disk will live for some time in the aquarium, floating on the surface and contributing to the purification of the water. On these two weeds minute organisms are rarely found, but some *Ulva* recently received from Ilfracombe had its bright green frond overspread with the delicate network of a *Polyzoon*, and on some more in my aquarium a colony of *Clava* has settled.

The thready green weeds of the genus *Cladophora* grow well in the aquarium, and some should be introduced, at least at first, and suffered to remain till a coating of vegetation appears on the glass and the stones. Besides aërating the water, these weeds serve another useful purpose in providing pasture grounds for the minute Entomostracans, which will almost certainly be introduced into the aquarium with the weeds and from the collecting bottles, and which will be needed as food for the Hydrozoa.



FIG. 64.—BRYOPSIS
PLUMOSA

The last of the green weeds to be mentioned is *Bryopsis plumosa* (fig. 64). It is by no means uncommon, and grows freely and rapidly in a tank.

Quite apart from its exquisite beauty, it deserves a place because its slender stalks are generally clothed with colonies of Polyzoa. A plant sent me in 1892 was growing from the shell of a piddock (*Pholas dactylus*). Its stalks were coated with Bowerbankia and the Tufted Ivory Coralline, and twining among them were colonies of Hydrozoa. The plant figured was taken not far from the Morte Stone, which Kingsley has rendered famous in his *Westward Ho!* It has multiplied beyond expectation, and young plants have been pretty freely distributed.

All the green weeds multiply rapidly; unfortunately the larger ones also decay very fast, so that there is pretty sure to be before long an accumulation of vegetable *débris* at the bottom of the tank. A little of this is very good for our purpose. It gives a home to Amœba and Infusorians, and tiny Crustaceans generally swarm in it. But if an unfortunate worm or mollusc happens to die, and falls down amongst it, sulphuretted hydrogen will be evolved, and if not stopped at once, will cause something like a pestilence to attack the inhabitants of the aquarium. The inky black patch round the dead animal will make known the presence of this gas, even if it is not evident, as it probably will be, to the sense of smell. The offending matter must be removed at once. A dipping-tube of wide bore is as good a means to employ as any, and then the tank should be exposed to the influence of direct sunlight. The same instrument will be found useful

to prevent too great an accumulation of *débris*. If the matter so removed be dropped into a bottle or a small jar, the floccose sediment will gradually sink to the bottom, and then the clear water, which will probably swarm with minute animal life, may be carefully returned to the tank.

The majority of the brown weeds are too large and coarse for our purpose, and the quantity of spores they send forth in fructification would soon render the water turbid. But since the larger kinds



FIG. 65.—FRONDS OF FUCUS, WITH ASCIDIANS AND HYDROZOA
(NATURAL SIZE)

often serve as the home of many delicate little animals, pieces like those shown in fig. 65 may be snipped off and dropped into the tank. The weed will, of course, gradually decay; but if the water is in good condition, long before this happens the animals will have multiplied and established fresh colonies on other weed, on stones, or it may be on the side of the tank. The weed on the right is *Fucus vesiculosus*, the common Bladderwrack, with

a colony of *Sertularia*; the other is *F. serratus*, bearing a colony of compound Ascidians.

Where a frond of the great oar-weed is found, it should be looked over for *Obelia* and some of the Polyzoa that cover flat surfaces with dainty chambers like the tiny meshes of silver lace. If any of these are discovered they may be snipped out and dropped into the tank.

As soon as the tank is in good going order, which will be known by the clearness of the water, and the bright bubbles of oxygen on the filaments of weed, animal life may be freely introduced. From the weed itself there will sure to be a store of Infusorians and Entomostracans, some of which will serve as objects for microscopic observation, though their chief end is to furnish food for larger forms.

Noctiluca will live for some little time in the aquarium, though probably a week will be the limit. Gosse could not keep them long, though he seems to have taken them in very large numbers. In his aquarium they came to the top, and crowded into a layer five or six deep, and at night this 'scum,' as he calls it, was most vividly luminous, especially on a tap or shake being given to the vessel. A friend who recently took a large gathering of Noctiluca and put them into his tank, was startled on going into the room in the dark to see what looked to be numberless points of fire scattered all over his aquarium.

The Hydrozoa will do well in confinement: the chief difficulty one has to encounter is one that

unfortunately often affects far higher animals—the food-supply, though they are capable of supporting long fasts. When the change of density in seawater is gradual, for example, from evaporation, they do seem to notice it; if, however, it be sudden, as in the case of removal from one tank to another containing water of greater or less density, they suffer therefrom. When these papers were written *Coryne*, *Syncoryne*, *Clava*, *Cladonema*, and *Hydractinia* were living and multiplying in my tanks; since then *Clavatella* has developed, probably from the walking buds, figured on p. 90.

If any of these creatures have taken up their abode on weed growing on a stone, they can be examined through the side of the aquarium with a hand-lens, which will reveal quite enough to enable the genus, and perhaps the species, to be determined. But if, as will probably be the case, we have only a small piece of each kind, and that on loose floating weed or a small stone, some plan must be adopted to prevent it being lost sight of, and perhaps knocked to pieces in the swirl when the tank is turned round. It is an excellent method to put the colony into a small tube, and lower it into the tank, or the tube may be partially filled with water, corked, and allowed to float in the aquarium. When one wants to look at it, if the tube be withdrawn the Hydrozoan can be looked over with the hand-magnifier, or removed from the tube to a zoophyte-trough for examination under the microscope.

Given a fair-sized tank in good condition, there is very little difficulty in keeping the common Tubularia. One case is recorded in the *Journal of the Quekett Microscopical Club*, where a colony lived for more than eighteen months. A friend has succeeded in keeping it for nearly two years, though now, judging from appearances, very few more 'heads' will be developed. In a bell-aquarium, containing only about two gallons, I had at one time as many as four colonies all flourishing. One was dredged at Whitstable on September 3, 1892, and afterwards separated into two, and two were picked up apparently dead on the beach at Hastings. To show how hardy a creature is Tubularia, I may perhaps be allowed to relate my treatment of the Whitstable colony.

It was affixed to a piece of limestone, and one head with its expanded tentacles was nearly level with the surface of the water, so that, after a few sheddings and renewals of the head, the polypite bid fair to rise out of its native element. Moreover, at the base of the colony were several Tunicates, which not only devoured the food—Entomostraca—intended for the Tubularia, but also consumed more oxygen than could be spared for them, thus destroying the balance of life, and deranging the economy of the tank.

Books were consulted, but in vain. They threw no light on the matter. At last I determined to operate on the Tubularia. A large pie-dish was requisitioned and filled with sea-water. In this

the stone was placed so that the Tubularia stems lay parallel to the bottom. A pair of sharp scissors soon made two colonies out of one by severing the longest stem at its middle part. The Tunicates still remained to be dealt with. Two, as large as Barcelona nuts, were comfortably seated on each side the original colony; a third was completely enveloped in the root-stock of the Hydrozoan. But by gently inserting the large blade of a pocket-knife between the base of the Tunicates and the limestone they were gradually prized off without damage, though not without protest. Immediately leverage was applied, each in its turn emitted a tiny jet of water, as from a miniature fire engine, thus abundantly justifying their popular name of 'Squirters' or 'Sea-squirts.' The colony was cut on December 3, 1892, and the severed stem lived till the end of May, 1893, throwing out several fine heads in succession. It was then so covered with confervoid growth that it was removed to another tank, where, probably owing to the conditions being in some way unfavourable, it died. The lower part continued vigorous up to about the same date, when some other experiments were tried on it unsuccessfully.

The Polyzoa may be treated like the Hydrozoa—that is, if the colonies are small—put into tubes, and lowered into the tank. They are almost sure to multiply, and the only limit to their increase seems to be the extent of the food-supply.

The true Coralline (*Corallina officinalis*) is

a capital habitat for many of the Polyzoa. It grows freely enough with me, and has spread its pinkish disk on stones at the bottom and on floating weed on the top. The piece shown in fig. 66, *a*, was taken from my tank, as was *Plocamium coccineum*, the weed growing to the left on the same stone. They are often found in company, and are pretty

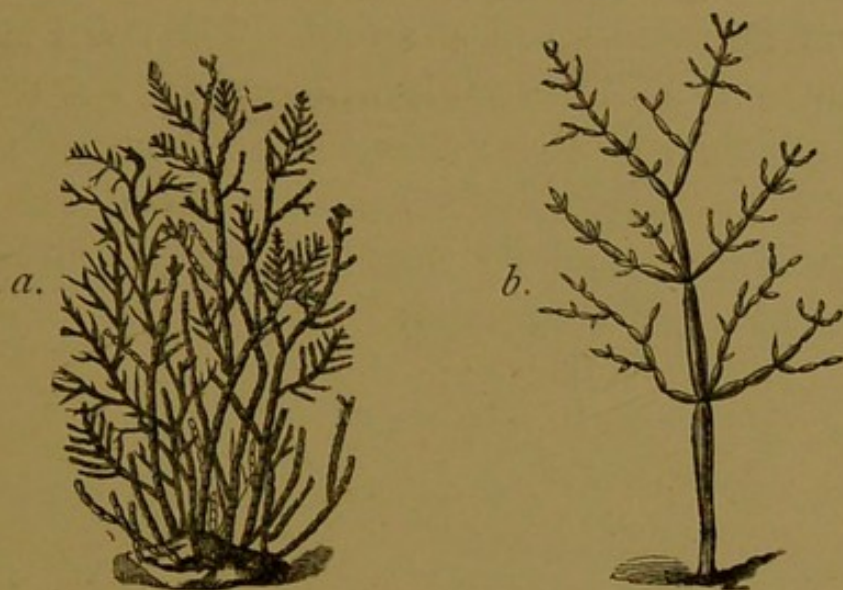


FIG. 66.—*a*, CORALLINE (*CORALLINA OFFICINALIS*); *b*, CHYLOCLADIA KALIFORMIS

sure to have on them choice specimens of minute life.

Chylocladia is another red weed that will sometimes grow in the aquarium. That shown at fig. 66, *b*, was collected at Cromer, and is now showing signs of fructification. On all three weeds were various forms of animal life, most of which are figured in this book. In another plant of Chylocladia which came from North Devon, the pure white of the Snake's-head Coralline ran along the warm red of

the weed, which seemed all the brighter from the contrast.

Molluscs should be sparingly admitted; periwinkles may not do harm, I scarcely think they do much good; and if one waits for them to clear the confervoid growth from the inside of the tanks, one will need a good deal of patience. A small sponge or a *clean* piece of chamois leather tied to a piece of wood is much more effectual. The few I have were introduced unwittingly with weed. Far more useful are their much smaller and prettier relatives of the genus *Rissoa*, which confine themselves to confervoid diet, and do not, like the periwinkles, feed on good growing weed.

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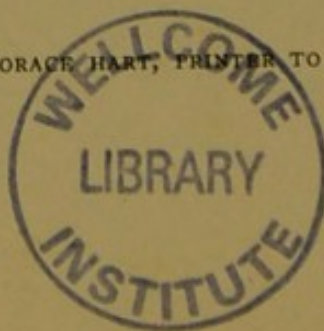
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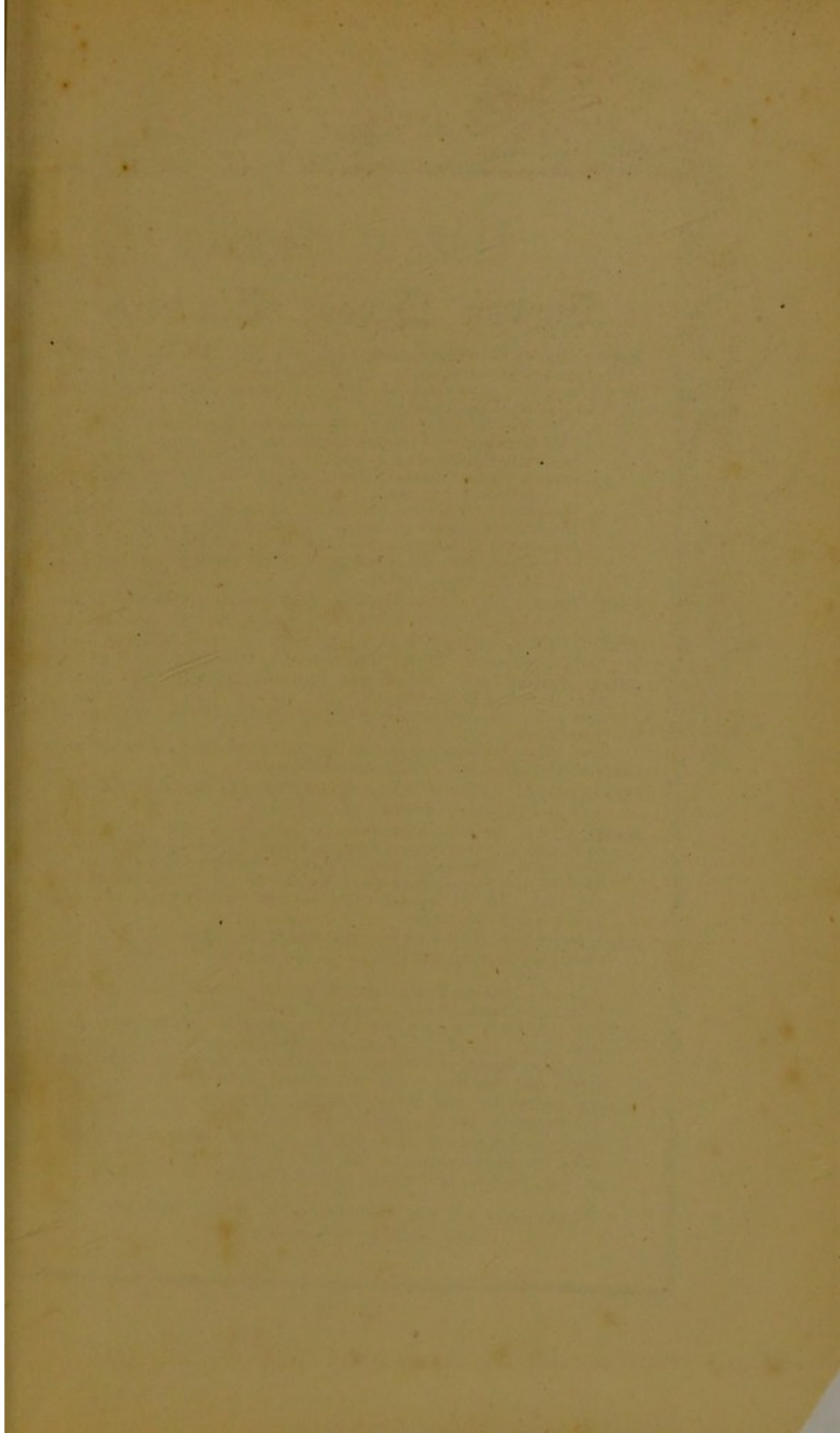
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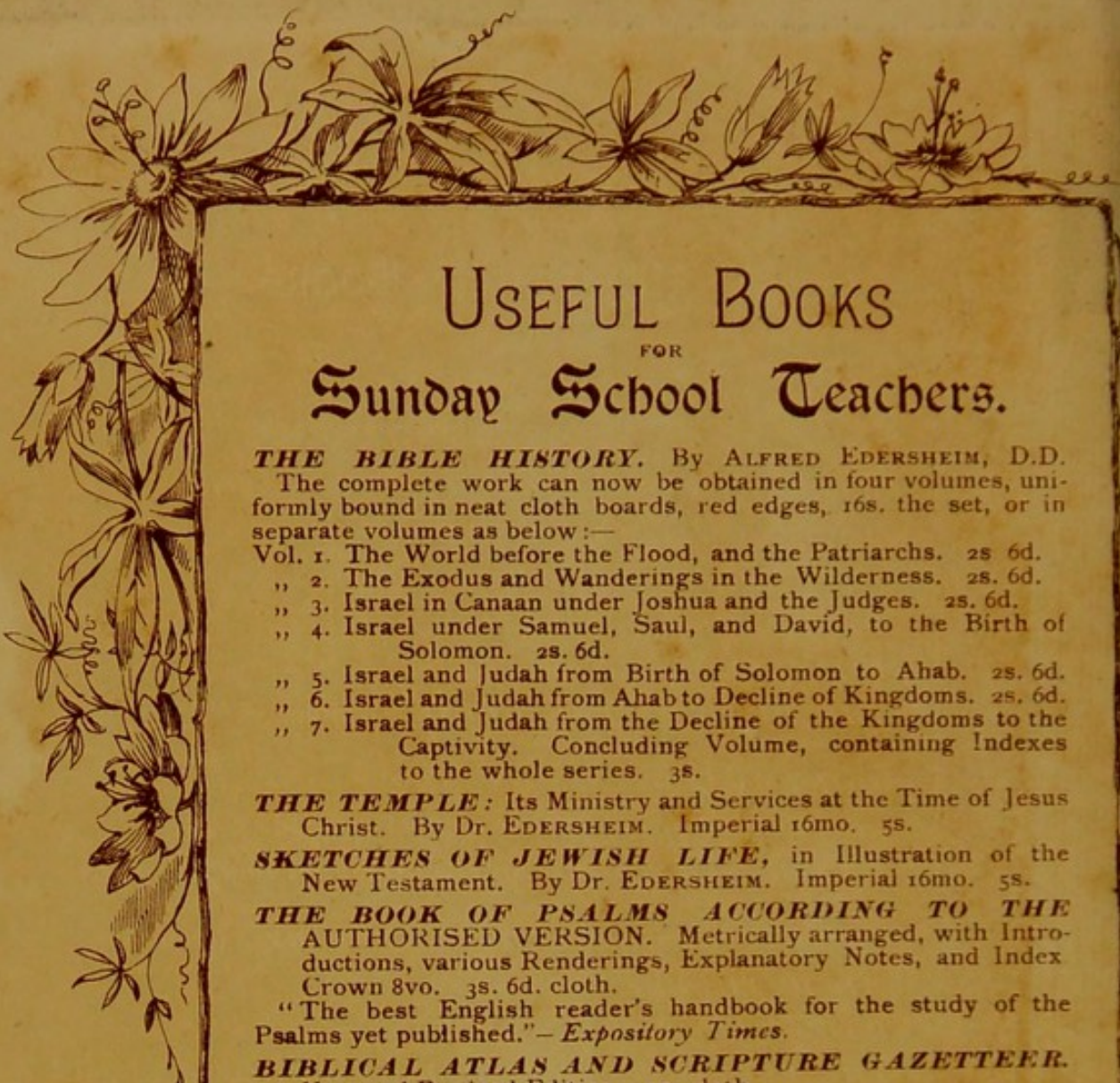
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