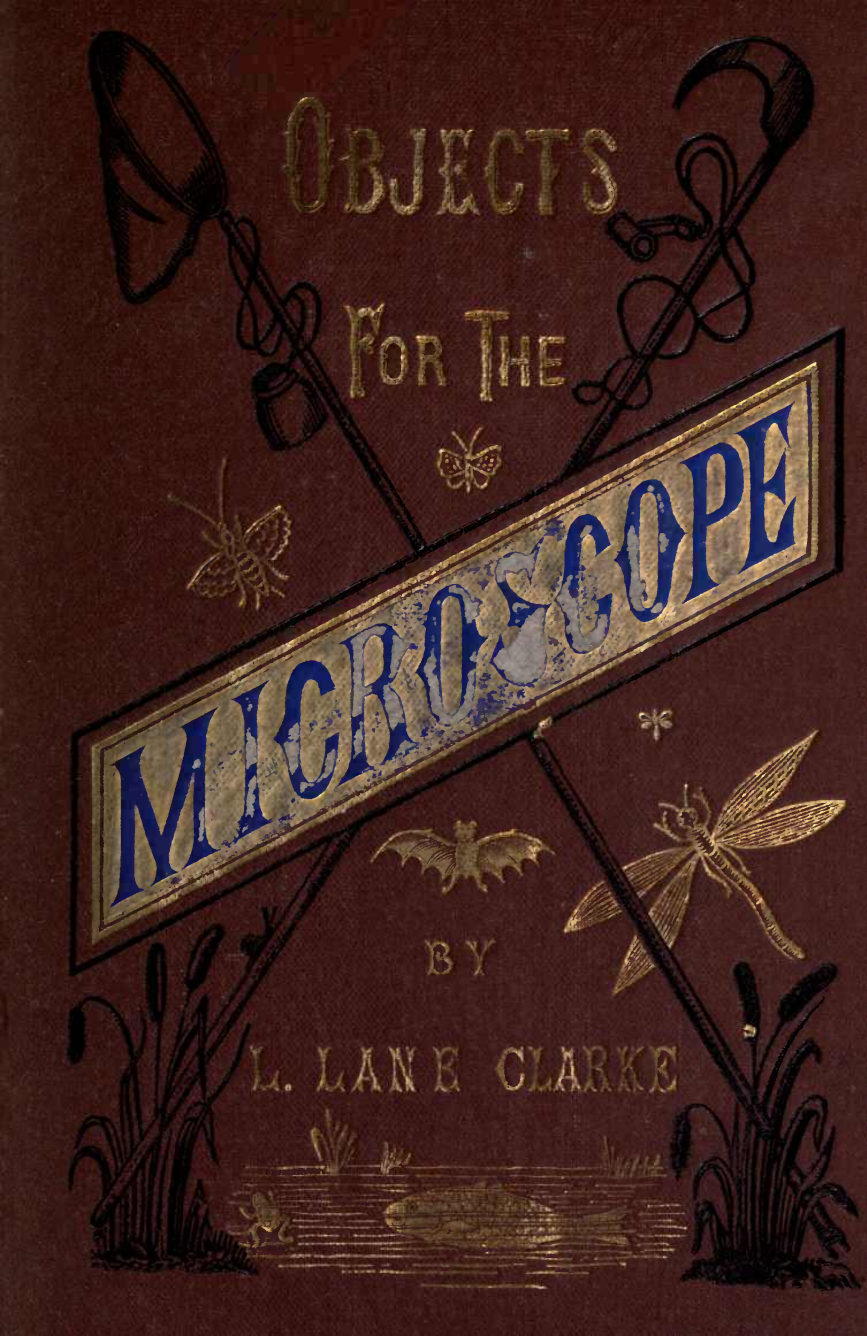
OBJECTS FOR THE MICROSCOPE

BY

L. LANE CLARKE

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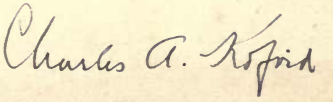

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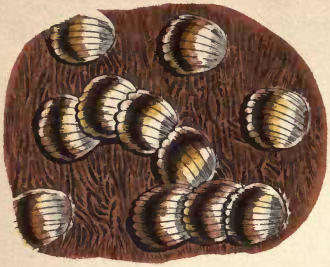

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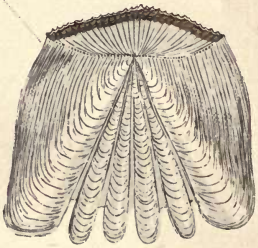

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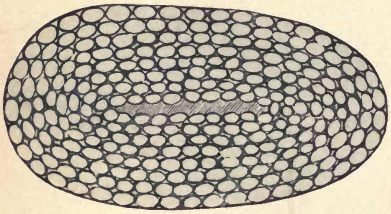

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1. Weevil, natural size. 2. Scales of Weevil, magnified 100 diameters.
3. Scales of Green Weevil, magnified 150 diameters. 4. Scale of Perch, magnified 4 diameters.
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7. Piece of Eel's Skin, magnified 4 diameters.
8. Upper and under layers of Eel-skin, and Eel scales. 9. Scale of Eel, magnified 50 diameters.

OBJECTS

FOR

THE MICROSCOPE

BEING A

POPULAR DESCRIPTION

OF THE MOST

INSTRUCTIVE AND BEAUTIFUL SUBJECTS

FOR EXHIBITION.

BY

L. LANE CLARKE.

"The eye sees no more than it brings with it the power of seeing."

FOURTH EDITION.

Illustrated with Eight Coloured Plates.

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OBJECTS FOR THE MICROSCOPE.

ON THE USE OF THE MICROSCOPE.

Although a minute description of the construction of the microscope would be out of place in this small work, and involve more of the science of optics than could be understood without diagrams and much knowledge of the laws of light, yet it will be useful to give a few hints on the practical management of a newly-purchased instrument.

Assuming the student to be desirous of obtaining an efficient instrument at a moderate cost, he cannot do better than procure what is ordinarily termed a student's microscope, which may be obtained from £3 3s. to £5 5s.

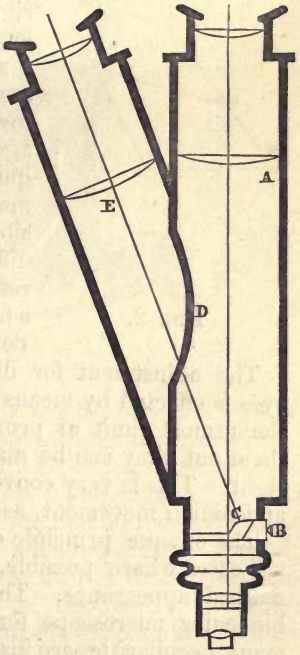


Fig. 1.

It had long been a desiderata with microscopists to obtain the advantage of binocular vision with stereoscopic effect. Mr. F. H. Wenham was the successful adapter of the stereoscopic principle to the microscope, which the following extract from 'Recreative Science,' will clearly explain:—

The result is obtained by the introduction of a small, but very accurately formed, double reflecting prism, immediately above the object glass, so as to intercept half the rays of light which pass through it. Fig. 1 will explain the principle:—A is the body of an ordinary microscope; at B a

square hole is cut, through which the prism C is made to slide so far that its edge will just reach the central line of the objective, and should be made to draw back so as to clear the aperture altogether, when the tube A acts as a single microscope. When the prism is thrust in, it collects a portion of the rays, and reflects them to the opposite side of the tube, where an opening is made large enough to allow them to pass through, into the supplementary body, E, which in size corresponds to the main tube; the remainder of the rays pass uninterruptedly up the principal body.

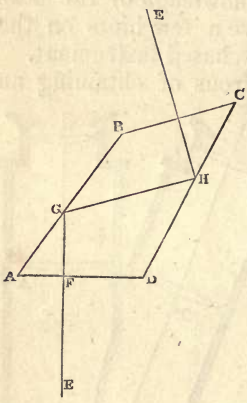


FIG. 2.

Fig. 2 is an enlarged outline of the prism. Let E E be a ray of light having passed through the object glass, and entering the prism at right angles at the point F; passing on, it is intercepted by the surface A B, which being inclined within the angle of total reflection, the ray is towards H, from which point it is again reflected in the direction required. If the prism be correctly made, and of the smallest size possible for admitting the pencil, the difference between the direct and reflected image is scarcely observable; a faulty prism can therefore be easily detected.

The adjustment for difference of distance between the eyes is effected by means of the draw tubes; if they are at the utmost limit of proximity when close in, by drawing them out they can be made to suit every position of eyesight. This is very conveniently done by means of a rack and pinion movement, as shown in Fig. 3.

The opaque principle of illumination should be used in all cases where possible, as this gives to objects a more natural appearance. The effect upon looking through a binocular microscope for the first time is very striking; many peculiarities are instantly presented to the eye, which,

with a single body, would be observed with difficulty. The instrument figured is one of those exhibited by Messrs. Crouch at the Manchester Exhibition of Science and Art.

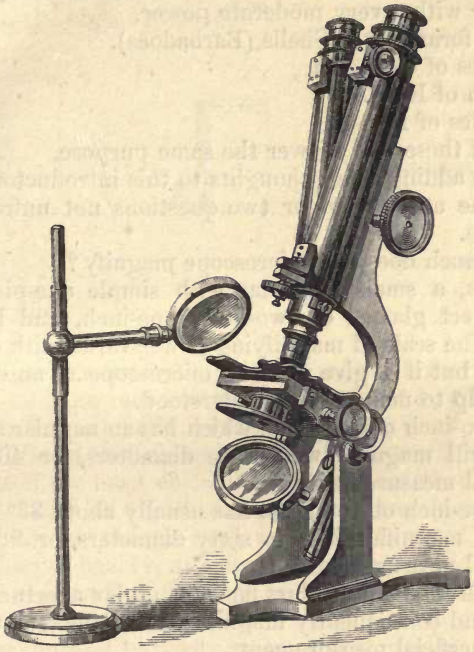


Fig. 3.

The advantage of the binocular is chiefly in the rest it gives the eyes, which have no unequal and unnatural strain. The field of vision is extended, and objects are seen in relief, round, life-like, and distinct. The joints of insects are seen in a wonderful manner, the ball and socket joints and hinge joints, if well prepared, are now perfectly realised; the hairs of plants and animals are seen in their true position; suckers, especially those on the foot of Dyticus, present themselves in the erect attitude of life, and Diatoms

mounted dry on a black disc exhibit their form and markings, as if the more elaborate parabolic reflector was beneath. To test this, obtain a slide of Heliopelta, or of Isthmia enervis, or of Arachnoidiscus, which will show the advantage of the binocular with a very moderate power.

Fossil foraminated Shells (Barbadoes).

Spicules of Gorgonia.

Section of Rush.

Capsules of Moss.

Any of these will answer the same purpose.

Whilst adding a few thoughts to this introductory chapter, let me answer one or two questions not unfrequently put to me.

How much does this microscope magnify?

That is, a small binocular with simple eye-piece, and three object glasses of two-inch, one-inch, and half-inch focus. The scale of magnifying power varies with different makers; but if I give my own microscope as an example, it will help to make others understood.

The two-inch object glass, which has an angular aperture of 15°, will magnify twenty-five diameters, or 400 times superficial measurement.

The one-inch object glass has usually about 33° angular aperture, magnifies fifty to sixty diameters, or 960 times superficial measurement.

The half-inch object glass has an angular aperture of 60° or 65°, and consequently magnifies 120 diameters, or 1,920 times superficial measurement.

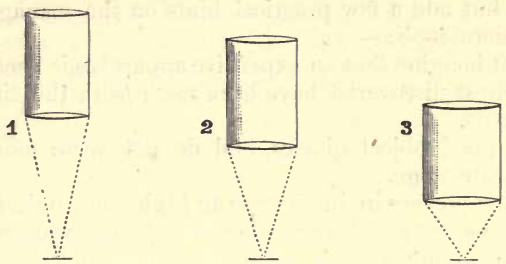
Again I am asked, What is the angle of aperture?

This cannot here be explained beyond the brief statement, that it is *the angle made by two lines from opposite sides of the aperture of the object glass with the point of the focus of the lens.* A diagram is necessary to make this quite clear.

The two-inch object glass requires a certain distance, as at A, to bring the object under examination into distinctness or focus.

The inch, half-inch, quarter-inch glasses, require nearer and nearer approach to the object for the same purpose.

The angles so made by the dotted lines are measured by a graduated semicircle of 180°, under peculiar management of light well known by opticians, but beyond our present inquiry; and denote the number of extreme lateral rays which the object glass admits.



The larger the angle the greater is the number of rays admitted, and the more brilliantly the object is illuminated the greater, consequently, is the defining power. Experiment has shown that obliquity of light is needful for the perception of the most delicate markings, and that an outline visible with an object glass of small angular aperture admitting but few oblique rays, as in Fig. 1, would be filled up with lines of beauty, and striæ of inconceivable delicacy under an object glass of large aperture, as Fig. 3, which gives it an oblique illumination.

The markings on butterfly scales and the valves of Diatomaceæ will illustrate this.

Again it is asked, What is that particular fault which object glasses by inferior makers are liable to, called spherical aberration? It is when objects at the circumference of the field are not in focus at the same time as those in the centre, or when part of a single object fades away towards the circumference.

Another fault is chromatic aberration, when coloured fringes surround the object under examination, whereas an achromatic lens shows a clear colourless field and a purely bright object.

Defining power, not the magnifying power, is the thing to care for; we want to see the real structure of an object, not an exaggerated representation; and those are the best glasses which transmit clear light, give a perfectly flat field, and by which we see sharp distinct lines in the object we are investigating.

I will but add a few practical hints on the management of the microscope:—

Do not imagine that an expensive apparatus is necessary. The greatest discoveries have been made with the simplest instruments.

Have good object glasses, and do not waste money on an elaborate stage.

Use low powers in preference to high ones, unless absolutely necessary; and, remember, we do not want objects *magnified* so much as we want them *defined*. A clearly-defining low power is the best working glass.

A few simple tools will be sufficient for all purposes of dissection and examination, viz.—

Slides of glass.

Circles and squares of thin glass.

A pair of forceps.

A lancet.

A few needles, fixed in handles. Split one end of a match, and tie the needle in with some waxed silk.

Two or three camel-hair pencils.

Six watch glasses.

These are all that are absolutely necessary for daily study.

FOR MOUNTING OBJECTS.

This need not be a difficult or expensive process; but to succeed with insect preparations time and experience are essential. The easiest beginning is with vegetable specimens—cuticles, pollen, &c.—and with palates which are mounted in fluid.

You must have a turn-table, price 6s. to 8s., and make a cell on each glass slide you mean to use, with gold size or Brunswick black. It is better to *see* this done than to

read the best description of "how to do it." A small bottle of gold size or Brunswick black costs 6d.

Make a solution of salt and water; be careful that it is very clean, and better use distilled or filtered water—five grains of salt to one ounce of water. This is the best preservative for *palates.*

Pure glycerine—a small bottle, 1s. This is excellent for leaves of moss and cuticles; but they also mount very well and more easily in Mr. Topping's liquid: one part of acetate of alumina to four parts of distilled water.

Let your cells be quite dry; it is better to make a dozen or more at once and keep them by you. When required, fix the slide upon the turn-table, put a drop of the liquid in the cell with a camel-hair pencil, then lay the object in it. Have a thin glass cover ready, and let it gently fall over the cell. Remove the superfluous moisture with a little sponge or blotting paper; and then, with a steady hand, take a brushful of Brunswick black, make the revolving table run round quickly, and, touching the edge of the cell, a circle of the varnish will safely fix it. Let the varnish be thin, and the circle also; for it dries better, and there is less danger of its running into the cell-contents. The next day go over it again, making the circle thicker and wider.

FOR MOUNTING IN BALSAM.

Have a bottle of clear, pure Canada balsam—it costs 1s.
A little spirit of turpentine, 3d.
Spirits of wine, one ounce, 1s.
A brass table, or tripod.
A spirit lamp.
Solution of caustic potash.

The use of balsam in preparing insect parts is not only to preserve, but to show the structure of the object. When properly applied, it enters into the minutest parts, displacing the air, and rendering the external tegument—hairs, spines, or suckers—perfectly transparent.

For instance, many young students, anxious to see the leg of a fly, or of a beetle, clip it off, and put it under the

microscope. They are somewhat disappointed at seeing indistinctly a row of black joints, and nothing more.

Let that leg be first soaked for a few days in a little potash and water, to soften it and dissolve the internal substance; then washed in clean water and dried; then soaked for a few minutes in turpentine, and finally mounted in balsam; every joint will be clear, every hair visible, the pulvillus transparent, and the structure admirably displayed.

The same results are obtained with the eyes, tongues, and wings of all insects.

The actual mounting is a matter of experience: to keep out air-bubbles is the great and only difficulty.

Place a slide on the brass table, over the spirit lamp, and when heated moderately put a drop of balsam in the centre of it; let this also become warm, but not very hot, and then lay the prepared object in it. As bubbles arise, skim them off with a needle, and take care that the balsam does not *boil*, or your specimen is lost;—it will be full of obstinate air-bubbles, irrevocably fixed in the tissue. When it looks clear, examine under the microscope, and if all right replace it on the table, and having previously warmed a thin glass cover, let it drop gently over the object.

Dry it on the mantelpiece, or a stone slab, and then clean the slide by scraping off the balsam and washing it with a little turpentine; or soda and water will clean it nicely; only if it is *left* in the solution it will unsettle the balsam.

Try experiments for yourself, and do not be discouraged by a great many failures; neither be satisfied with bad mounting, half-prepared objects, and untidy slides.

PART I.

OBJECTS FROM THE VEGETABLE KINGDOM.

" Search out the wisdom of Nature,—there is depth in all her doings.
She hath on a mighty scale a general use for all things;
Yet hath she specially for each its microscopic purpose.
There is use in the prisoned air that swelleth the pods of the laburnum,
Design in the venomed thorns that sentinel the leaves of a nettle,
A final cause for the aromatic gum that congealeth the moss around a rose,
A reason for each blade of grass that raiseth its small spine."

Proverbial Philosophy.

" On every herb on which you tread
Are written words which, rightly read,
Will lead you from earth's fragrant sod
To hope and holiness and God." *Anon.*

CHAPTER I.

In every collection of objects for the microscope we find many preparations from the vegetable world—slides of cuticles, fibro-cells, pollen-grains, raphides, &c. &c.; and few lose more in being hastily looked at, as merely pretty objects, without that knowledge of flower-life which alone can enable us rightly to appreciate them.

If we are wholly ignorant of the structure of plants, their uses, their variety, and the secret mechanism by which their life is renewed day by day, we are apt to look at these slides for mere amusement, for the lust of the eye, pleased as a child or as a savage with strange forms or brilliant colours. Therefore, before we take them up, it will not be unprofitable to learn if we do not know, and refresh our memory if we have once known, something of the mysteries of creation in vegetable life.

Thousands of years have passed away since angel voices sang the praises of God when He had finished the fair work of creation, and—looking upon the lowliest herb of the field as upon the birds of the air, the living creatures of the deep, wide sea, the beasts of the earth, and man, the lord of all—"behold it was very good." Thousands of years have passed away: man has changed, it may be that the lower creatures have partaken of his fall; but of the beautiful flowers and the stately trees we have no reason to believe that there is aught in them that offends their Maker; we fearlessly search into the recesses of their being, and behold they are wondrously beautiful and still "very good."

A flower-plant has been likened by Unger,* a German botanist, to "a most skilfully-planned chemical laboratory, a most ingenious mechanism for the display of physical forces, and one of the simplest, and consequently one of the most sublime, structures ever designed or executed."

He also likens the growth of a plant to the building of a glorious edifice; he compares the cells of vegetable life, in their varied forms and sizes, to the stones of a building forming a kind of masonry. In some parts of a plant the cells are long, and form pipes or cylinders, or they are condensed and thickened into fibre. In the cuticle of leaf and flower we have flattened, oblong, or crenellated cells, which, as a tesselated pavement, protect the more delicate machinery within.

We find, by the help of a microscope, not only this, but also the store chambers of cell-contents where the materials for the plant edifice are collected and preserved.

Again, in the building of a plant there are air-passages resembling regularly-shaped rooms, or romantic caves, or microscopic grottos, terminating in what are called stomata; which stomata have folding doors or valves to open or shut at pleasure, so that the air circulates freely through the plant organism. These are mostly on the under side of a leaf, so the under cuticle is the one we mount for observa-

* 'Unger's Letters.'

tion, and we shall notice these stomata more particularly when the slides are described.

The origin of every plant is a single cell. The perfection of a plant, from the tiniest moss to the loftiest oak, is in a countless multitude of simple cells containing various substances needful for its growth, and of an infinite variety of shape and substance: for some cells are very thick; some are dotted, to allow of the circulation of air in the deep recesses of the stem; some have variegated walls produced by its secondary deposits, like fibre coiled around, and these *fibro-cells* are abundant in some plants. We have them from the Oncidium and Opuntia. Some cells of spiral fibre act as trachea for breathing organs, or give lightness and elasticity to a stem. They are abundant in strawberry leaves, vine leaves, rhubarb stems, spinach, and there are beautiful examples in the slide of spiral cells from the balsam. Much more can be learnt from the examination of the fresh plant, because of the difficulty of preserving cells and their contents. Is it not wonderful to think of a little plant having its store chambers secreting starch, sugar, gum, oils, raphides, colouring matter—aye, and beautiful crystals floating in the cell-fluid, or suspended, as are the cystolithes, in the cell-chambers of the nettle tribe?

The very knowledge that such things *are*, and that they may be seen in an infinite variety, will lead us first to look at these slides understandingly, then to seek further by examination of living plants. This will induce us to study such books as Quekett's 'Histiology,' 'Carpenter on the Microscope,' 'Mohl on the Vegetable Cell,' 'Schacht on the Microscope,' 'Unger's Letters,' &c. &c. Then we shall see our microscope worthily, and our cabinet of objects will cease to be a mere toy.

SHAPES OF CELLS.

As the object of this little book is to excite and not to satisfy the desire of an inquiring mind, let me here suggest that it is well to prove all things; and before you quite believe that every flower and plant is made up of single cells of varied form, examine for yourself thus:—Take a

flower, a few bits of stalk, a lily leaf, or small piece of rhubarb stalk, another of cucumber, a thin slice of raw potato, a wallflower, or a primrose—any flower: macerate it in water for a day or two, until it begins to decompose, and the smallest portion placed under the microscope with a drop of water will show you the now separating cells of various shape: those in stalks oblong or cylindrical; those in the surface of petals and leaves square, or round, or hexagonal, or irregular, with zigzag boundaries, or papilliform, as in the Geranium, Sweetwilliam, &c.; those of the parenchyma or pulp of the leaf generally oval. In looking at these, you will certainly find a variety of contents which are seldom preserved for any length of time, and which you must therefore observe in the fresh and living plant.

CELL-CONTENTS.

In the slice of potato you will find every cell crowded with starch-granules, that is, if it is a *good* potato; for starch is to the potato what fat is to an animal, and if it is in "good condition" the cells should be full of it. The test of this is a drop of tincture of iodine, which turns the starch-granules to a beautiful blue or violet colour; and a diseased potato with empty cells will therefore be detected by a drop of that same iodine.

In the stem of a lily you will find starch-grains, mixed with green granules of chlorophylle, a kind of vegetable wax, which gives the green colour to leaves.

All our farinaceous plants contain abundance of starch, especially wheat, barley, oats, maize, rice, arrow-root; and the granules differ from each other in size and form so decidedly, that they cannot well be mistaken by a careful observer. They are prepared for the microscope, and sold as polariscope objects, because the examination of a starch granule with polarized light shows it with a beautiful black cross, revolving with the polarizer; or, if over a selenite stage, a brilliant play of colours is obtained.

Besides starch-grains and chlorophylle, you will find something else in the cells of that lily stem, which I select as an easy one to obtain in any garden. In some cells, not

in all, you will probably observe a larger granule, with a lesser one within, or perhaps several lesser ones; the large granule is the nucleus, the minute inner ones the nucleoli; they are the supposed origin of new cells, and much that is exceedingly interesting has been written in the works before referred to: 'Mohl on the Vegetable Cell;' 'Hofmeister's Die Enstehung des Embryo.' These nuclei are to be observed in pollen-grains, in the hairs of Tradescantiæ, or Spiderwort, especially in the pollen of the fir-tree tribe.

OIL CELLS.

Cells containing oil are beautiful objects when found as on rose-trees, on the stem of Saxifrage, Geraniums, Collomia, Drasena, raised upon delicate stalks, often brightly coloured, or glittering diamond-like in the sunshine.* Sometimes the oil cells are sessile, in golden spots upon the back of a black-currant leaf; or white and silvery in the recesses of a Sage leaf, a leaf of Rue, or Hop, or Mulberry.

Sometimes these oil cells are internal, as in the rind of an orange, where they are very large and most easily observed; also in the leaves of Myrtle and Magnolia, of Hypericum, St. John's wort, so common in woods and hedges: those little dark dots are the oil cells, and transparent, if you hold the leaf up against the light, and examine it with a pocket lens.

HAIRS OF PLANTS.

The hairs of plants will furnish you with abundant material for study and delight throughout the summer long, and the variety in their form will astonish you. Look at the beautiful bead-like hairs of the Spiderwort — a rich purple chain of cells fringing each stamen. White, transparent, glittering rows of cells from the flocculent mass of hairs we see on the leaves and stem of the common Groundsel. The common garden Verbena has the mouth of its corolla closed by a dense row of beaded hairs protecting its pistil. I cannot describe more, but look at these.

* These are called glandular hairs.

Some are simple; some are branched, or star-like, or tufted, and contain simply water:—

Alyssum leaf	Chrysophyllum.
Draba verna leaf.	Verbascum.
Antirrhinum calyx.	Ivy.
Tradescantia stamen.	Hibiscus.
Verbena.	Deutzia scabra.
Campanula.	Elæagnus.
Nettle.	Dolichos (cowage).
Borage.	Groundsel.

Take the hair of a Borage stem or flower off at the base, and lay it on a slide with a drop of water covered with a bit of thin glass, and you will be delighted. The hair of the Nettle, with its poison gland at the base, must be examined in the same way. The pain is caused by the breaking off of its point, and the acrid irritating liquid springing up into the wound.

The reason why these hairs are mentioned immediately after the cells and cell-contents is, because they are only prolonged and varied cells rising from the cuticle, and when the cell-walls thicken into fibre these hairs become *thorns*. Sometimes they expand and form scales, as we see on the beautiful leaves of Hippophæ and Elæagnus, which are mounted as detached scales for the polariscope, or *in situ* as opaque objects.

CUTICLE AND STOMATA.

The cuticle of plants is that transparent skin which we can easily peel off from various leaves, but especially from the Lily, the Candytuft, Iris, and the petals of flowers; and prove by examination under a piece of thin glass and with a drop of water that it is really composed of a single layer of cells, having pores, called *stomata*, thickly scattered over it.

These slides are very useful to those persons who live in cities, or who have not yet studied plant-life for themselves; and I doubt not that they will lead many a careless

eye to look for other examples, and to find an endless variety in the garden and the field.

These pores, called stomata, are absolutely necessary to vegetable life. Leaves are the organs of respiration—the lungs of a tree, and the stomach also; for they send back nutrition to the trunk and stem, take up the sap which rises from the root, give it the needful quantity of carbon, expose it to the action of the air, and cause the superabundant moisture to evaporate. All this is done by the agency of the little *dots* we call stomata. And this is the way in which they act:—We see that the cuticle is formed of a single layer of cells; these contain air and not fluid, as do the cells of the pulp or parenchyma; also they are so closely fitted to each other as to confine that moisture which otherwise would be too quickly evaporated by a hot sun, and the leaf soon dried up and withered; but at the same time, as air is necessary to the inner cells of a leaf or flower, these stomata, or openings, are placed in great numbers in the cuticle, acting like valves, which admit air freely, give out surplus fluid, and take in atmospheric moisture when required. They are bordered by cells of peculiar form, usually kidney-shaped, with an oval aperture in the centre; and these "guard cells" dilate and contract, closing or opening the passage according to the necessities of the plant. On a hot day they will close, to defend the inner cells from exhausting heat: in dry weather, when the stem does not give enough fluid for the nourishment of the leaves, then the stomata open *at night* and drink in the night-dew, but close again as soon as the cavities of the leaf are full. The number of pores in a square inch of surface is amazing; *e.g.* we find that a square inch of the leaf of

Hydrangea	contains	. .	160,000 under surface
Iris	,,	. .	12,000 both surfaces
Houseleek	,,	. .	10,710 upper surface
Tradescantia	,,	. .	2,000 upper surface
Lilac	,,	. .	160,000 under surface
Vine	,,	. .	13,000 under surface

The stomata are generally largest upon succulent plants, and abound on the under side of all leaves except grasses and upright leaves, such as the Iris and Tradescantia, where they are found equally on both sides.

CUTICLE OF YUCCA.

In the cuticle of Yucca the stomata are bounded by four cells, and are themselves somewhat quadrangular: there are about 40,000 of them in one square inch. The plant is a native of Peru; called also common Adam's needle, bearing a handsome flower in panicles on a stem eight or ten feet high when in its native soil; but in British gardens it scarcely reaches three feet high.

CUTICLE OF ALOE.

The cells are somewhat different in shape, though the stomata are also bordered by four cells: they are more oblong, very prettily disposed, but require a power of 200 diameters to observe properly. First use the $\frac{1}{2}$-inch, and then the $\frac{1}{4}$-inch.

CUTICLE OF DEUTZIA SCABRA.

This is a polariscope object.

The cuticle is siliceous (*see* Indian Corn), and the wavy outlines of the cells and the starry clusters of siliceous hairs are very beautiful. When gathered from the tree, these stars are white upon the green cuticle, and those of the upper surface are many-rayed, whereas those of the lower surface have usually but four or five rays.

This leads us to consider the use of those abundant hairs which clothe the living plant. They serve two purposes—for warmth to the tender bud, or for attracting moisture. On many plants they rise up towards evening and catch the falling dew; then bending downwards at noontide they form a close layer over the cuticle, and give it a protecting shade, at the same time preventing a too rapid evaporation of the moisture they had attracted. There are many kinds of hairs on plants; most beautiful are some of them, especially those which secrete *oils* or saccharine matter.

These are called glandular hairs; they rise up on a slender stem, and expand into a globular head, filled with coloured or white special secretions, such as we find on Sweet-briar and Moss-rose buds, or on the leaves and flowers of Collomia.

CUTICLE OF AMARYLLIS.

This example will show the *two*-lobed stomata, one kidney-shaped cell on each side; it is from any part of leaf or stem of the common white Lily; also compare the cells with those of the

CUTICLE OF INDIAN CORN.

This is what is called a siliceous cuticle. All the grass tribe and the plants called Equisetaceæ, or horse-tails, have the property of attracting silex or flint from the soil in which they grow: the cell walls and stomata become so impregnated with it, that even soaking in nitric acid, which destroys the vegetable part, leaves the skeleton, or frame-work, perfect, as in this slide, which has been thus prepared. Observe the finely-toothed edge of each cell, as well as the peculiar shape of the four cells bordering the pores. The stomata are very abundant in grasses; they cover every part of the stem, and both sides of the leaves.

CUTICLE OF SACCALOBIUM.

The Saccalobium is one of the orchis tribe, a native of Asia, found in the Indian Archipelago, and is cultivated in hot-houses in England. The spiral fibre in some of its cells forms a regular network on the inner surface.

CUTICLE OF ELÆAGNUS.

This is an opaque object; the scales are very beautiful, and when detached from the leaf and mounted in balsam they polarize.

The Elæagnus is a native of all parts of the world, from the northern hemisphere down to the equator, which it rarely passes. The flowers of this species are highly fragrant, and abound in honey.

CUTICLE OF TILLANDSIA.

The under side of the leaves and the stem of this plant are adorned with delicate scales, as of the finest network.

The plant itself is a native of South America and the West Indies. The whole tribe dislike water; and Linnæus named the genus from a professor in Sweden, who, having once experienced a very rough passage from Stockholm to Abo, determined never again to cross the water; he even changed his own name to that of "Tillands," which means on or by land; and actually, when obliged to return to Stockholm, preferred travelling 200 miles round by Lapland to going a direct road of eight miles by sea.

One species of Tillandsia (*utriculata*) which grows upon old and decaying trees in the forest of Jamaica, has leaves a yard long, inflated at the base, which form a reservoir for water. Each leaf holds about a quart of fluid, and wild cattle seek refreshment there. Travellers also, under the hottest sun, may turn aside and find a sweet pool of water in dry seasons, when all other supplies have failed.

CUTICLE OF ONOSMA.

The Onosma is a native of Tauria, near the Bosphorus. The plant is small, with handsome flowers, flourishing in sandy soil; and this cuticle is very beautiful under polarized light.

CUTICLE OF OPUNTIA.

This beautiful cuticle is from the leaf of the Opuntia, a kind of Cactus or Indian fig, and on one of them the cochineal insect is found: this is from the *Opuntia vulgaris*, which bears a large purple juicy fruit, and is a spiny shrub, growing abundantly on Mount Etna amidst its lava. It is, however, a native of South America, and the way in which it has been naturalised and made most useful in Sicily is remarkable. As soon as a little fissure is perceived in the lava, a small branch or joint of Opuntia is stuck in; the latter pushes out roots, which are nourished by the rain which collects round them, or by whatever dust

or remains of organic matter may have made a little soil. These roots spread out and ramify into the most minute crevices, breaking up the lava into small fragments, and finally rendering it fit for culture.

LITHOSPERMUM.

From *lithos*, a stone, *sperma*, a seed.

The hardy stony seeds have given it this name, as well as the old English appellative Gromwell, from the Celtic *grom*, a seed, and mil, a stone.

The leaf of this common plant is extremely beautiful; the hairs are not only bulbous as in borage, but cells are grouped around the base of each like a circlet of crystals. There are three species worth seeking:

The common white L. arvense, in cornfields.
L. officinalis, pale yellow.
L. purpurea, large blue flowers in chalky soil.

RAPHIDES.

These are crystals found in the cells of various plants. No better example can we have than the

CUTICLE OF HYACINTH,

in every cell of which we see a cylindrical crystal. Examined with polarized light they are most distinctly seen, and enable us to understand the position of raphides in other plants. The Cactus, the common Dock, and various other vegetables, have bundles of needle-shaped crystals in their cells. Turkey Rhubarb and the garden Rhubarb have rectangular prisms of carbonate of lime grouped in a stellate form. See the slide of

RAPHIDES FROM RHUBARB.

What their use is we do not know. Another kind called cystolithes, are stalked and suspended in the cells of the nettle tribe. Their formation has been watched: first a little papilla or swelling is perceived at the upper part of a cell, which increases at the end into a clubbed form, from which crystals of oxalate of lime sprout forth.

This is one of the mysteries of creation, how the cells of a plant so regularly secrete each its appointed store of needful substance for the plant-life—how from the earth in which it grows, from the air in which it lives, from the light which quickens it, each tiny chamber receives exactly that portion of nourishment, and that *kind* of nourishment which enables it to produce either the green wax which colours the leaf, or the white starch-grains, or the gum, the sugar, the oil, or the shining crystals, or that nucleus which is the reproductive cell—all this going on invisibly around us in every living plant, and having been thus going on for five thousand years at least, unseen, unknown by us, until the revelations of the microscope. Is there no deep thought stirred in our hearts by the manifest order and minute care of Him who built up this living temple for His own pleasure and for ours? Do we think of all that is contained in the flower we gather by the way-side, in the herb that bends beneath our feet? Is no desire kindled to see these things as they are, and pass on from these slides to the examination of the plant itself? There are a thousand things more beautiful than raphides that cannot thus be mounted or preserved. Shall I give one example only for a summer hour's delight?

ANAGALLIS.

In the garden or the cornfield gather a little scarlet Pimpernel, the Anagallis, or the Poor Man's Weather-glass, that lowly and bright little flower which opens every morning at eight minutes past seven, and closes about three minutes past two in the afternoon. Examine it with a pocket-lens, and you will see that it belongs to the Primrose tribe, with its single-leaved calyx and corolla, wheel-shaped, deeply cleft into fine segments, fine slender filaments and heart-shaped anthers, one-thread-shaped and clubbed stigma. With the same lens you can examine the seed-vessel, a little globular capsule opening all round, and, raising the lid, observe the most beautiful dotted seeds lying closely pressed to the pitted receptacle; and this, if once seen, will not be forgotten. Take it now to the mi-

croscope, and, with a low power, first look at one of the coloured segments of the corolla. Press it lightly in a drop of water under a bit of glass, and you will then see that the edge of the petal is fringed with little bell-like glands, purple and white, and that hues of deeper colour radiate from the base of the petal. Put on a higher power, and you will find these are exquisite spiral vessels; not one only, but many in each line, short, and joined to each other by a delicate dove-tailing process. Think of the mechanism in that one small leaf, and those little oil cells fringing it so prettily, doubtless for use as well as beauty. Then take off one stamen and look at it in the same way. Half way up the slender white stem are purple hairs, each jointed and like a row of tiny amethysts: above is the heart-shaped anther, with its golden store of pollen grains, out of each of which will flow the life-giving germ to the future seed. Take the style and stigma, and examine them next; you will not soon be weary of the sight. Most likely you will find some pollen grains upon the stigma throwing down their tubes invisibly; for this is only seen with a high power, and by making a very thin section of a short style, such as that of a Cistus, or a Chickweed.

After such an examination, that little flower will never be seen with the same careless eye which for years had passed it by unheeded, because unconscious of its beauty.

SPIRAL FIBRE.

Many specimens of these are sold prepared for the microscope, especially the following:—

Spiral cells of Oncidium.	Spiral cells of Sphagnum.
Spiral vessels of Collomia.	Scalariform vessels.
Spiral fibre from Balsam.	

They require some little explanation. We have already seen, in the examination of cuticles and flower-stems, that plants are made up of cells containing various substances, as starch, crystals, oil, or wax. These were for the nourishment of the plant; but here are cells which are supposed

to assist in the circulation of air and moisture throughout the system. Some of them strikingly resemble the trachea of insects, and seem to communicate with the stomata as the trachea do with the spiracles.

SPIRAL CELLS OF ONCIDIUM.

These beautiful little cells are obtained by macerating the pulp of those leaves which contain them, separating them with a fine sable brush, or mounted needle. The Oncidium is an orchis, a native of Peru, Mexico, and the West Indian Islands; cultivated in hot-houses in England. They are curious and beautiful plants, with spotted yellow or purple and white flowers, one species much resembling a gorgeous butterfly. In all these plants the spiral cells abound immediately under the cuticle, and, viewed with polarized light, they resemble coils of coloured wire.

SPIRAL VESSELS OF COLLOMIA.

These fibre-cells are in the cuticle of the seed, and the examination of them is so easily made, that it is well worth doing. The cells which contain the fibre are in this instance so delicate, that a drop of water causes them to break, and the coil unrolls, shooting forth in long tubes, with an appearance of life as they spring across the field of sight. To see this, take a seed of Collomia, and cutting off a very small piece of its skin, place it with a drop of water on a slide under the thin glass, when you will perceive the fibre uncoiling in all directions. The Collomia is a native of America, but naturalised in our gardens, where it grows like a weed, having pretty buff or pink-coloured flowers, covered with glandular hairs.

SPIRAL CELLS OF BALSAM.

These are from the common Balsam of our garden, and show the bundles of long cells made up of spiral fibre, which often break and pass into annular fibre: you may perceive some of these in detached rings. These cells contain air, and are those which most resemble the trachea of insects. Those of the Leek are also very remarkable, and

the common garden Rhubarb will furnish you with abundant specimens. Take a little boiled Rhubarb, and pick it to pieces with a mounted needle in a little water, when bundles of spiral vessels will be easily found.

SPIRAL CELLS OF SPHAGNUM.

Sphagnum is a moss growing in marshy places, and its leaf shows a beautiful arrangement of spiral fibres in its large oval cells, whilst in the smaller ones you will see the granules of chlorophylle which colour the leaf.

SCALARIFORM VESSELS,

so called because they resemble the steps of a ladder, are peculiar to ferns and to asparagus. They are secondary deposits on the cell wall, and somewhat of the nature of spiral fibre. Under polarized light they are very beautiful.

When you pull up a common Bracken or Fern, and cut the root across, the brown figure you see, called King Charles in the Oak, is made up of these scalariform vessels. They are very troublesome to prepare, but this is the easiest way that I know of:—Cut up the root and boil it until tender enough to peel; put the centre part into a jam-pot with water and a little nitric acid; let it stand in boiling water for some hours, then pick the long white fibres carefully out, wash them in boiling water over and over again until perfectly clean and clear, which is only ascertained by examination under the microscope, then mount them in fluid or balsam. If in balsam, dry them well first.

POLLEN.

POLLEN OF MALLOW.

A beautiful object viewed as an opaque—more lovely far when taken fresh from the flower, and looked at upon one

of its own crimson leaves, or the petal of a Geranium. It cannot be worthily described: rest not until you have seen it; and also the

POLLEN OF HOLLYHOCK,

which is like it, only the golden grains are larger, and perhaps more easily preserved. I usually take a portion of the stamen, studded with the spiked globular grains, and dry them on a scarlet petal of the flower; but they are well seen on a black ground, simply mounted, when dry, between two pieces of glass.

POLLEN OF PASSION-FLOWER.

These are not spiked, but have three plain valves and a reticulated cuticle.

POLLEN OF ŒNOTHERA

is curiously triangular, with pores at each corner, from one or more of which the pollen tubes spring forth.

Pollen is always better observed fresh from the plant. The variety in shape and structure is very great; the interest will be unfailing in the examination of it, the deeper we go into the mysteries of plant-life.

This golden dust, which, to the unassisted eye, is all alike in every flower, is fashioned with the most elaborate care for its great purpose, and sculptured with that exquisite finish which all creation bears as the signature of the gracious God who made all things well.

This golden dust, contained by every flower in the few or many stamens which are the caskets of its wealth, is the fructifying principle which causes the seed to become fruitful, and without which no reproduction of a plant could continue, as it does, from age to age.

The purpose of this book being chiefly to explain the objects before us, I will not say more of the pollen-grain than that it must be examined both as a transparent object, with a drop of water or oil of lemon, and dry, as an opaque. Particularly observe the blue pollen of Epilobium; the red

pollen of Verbascum; the black pollen of the Tulip; the varied forms in the following flowers:—

Cucumber
Crocus
Cactus
Cruciferæ (order)
Collomia
Campanula
Cobæa Scandens
Compositæ (order)
Geranium
Heath
Daisy (one of the Compositæ)
London Pride
Saxifrage
Violet
Œnothera
Passion-flower
Lupin
Acacia

A FEW WORDS MORE ON THE POLLEN.

As I lay aside these slides, and desire you to seek for varieties of pollen in the fresh sweet flowers around, the thought arises that some who read thus far may wish to know a little more of the structure of the flower they gather, and the pollen they examine; else the microscope lesson loses half its value, and the student more than half his pleasure. If it is possible, read some better book—Lindley's works, or Balfour's 'Botany,' where *all* is told, and illustrated by plates; but if you cannot do this, then gather a flower and examine it thus: a Chickweed will be easily obtained, and is the best for a microscope lesson.

The organs of generation in flowers are the stamens and the pistil: the stamens varying in number from two to upwards of twenty; and the pistil, which occupies the centre of the flower, having from one to many styles, the upper part of which is called the stigma. The base of the pistil, which is swollen and round, is the ovary. Cut it open with a penknife or lancet, and you will see tiny white cells on either side, which are the rudiments or beginning of the future seed. The pollen fructifies each seed whilst growing in the ovary, and the way in which it is accomplished has only of late years been discovered.

The stamens are filaments bearing at the top single or double caskets, called anthers, full of pollen-grains. When

a flower first opens the anthers are closed all round; but as soon as the air and the light have perfected the pistil and caused it to secrete a kind of gum, or viscid liquid, on the surface of its stigma, intended to hold fast the pollen-grain, the anthers open and the golden dust appears, falling on the ready channel, which conveys it to the ovary beneath. The pollen-grain itself is not a simple cell, as we might at first suppose: minute as it is there are many cells therein, and a subtle fluid, called fovilla, which is in reality the life-giving principle to the ovule. When a pollen-grain falls upon the stigma it presently opens one of its pores, and sends forth a tube more or less long, which descends through the tissues of the style, enters the ovary, reaches a tiny ovule, and pours it into the fovilla, which fovilla forms the embryo or future plant that is preserved and nourished in the seed.

Take a little pollen from a Cucumber plant or Passion-flower, and when it is fairly under the microscope, covered with thin glass, let a drop of water run in. The moisture is absorbed by the pollen-grain, and it throws out a tube and discharges the fovilla. It goes off like a little cannon, a cloud of fovilla waving on the slide.

The quantity of pollen in a flower is astonishing. A flower of the Peony, for instance, has about 174 stamina, each containing 21,000 granules,—total, 3,654,000 pollen-grains. A single Dandelion has 243,000 pollen-grains. The contents of one anther are quite sufficient for the fructification of all the ovules; but the superabundance is not wasted, for thousands of insects live on the golden store, and the busy bee fills her baskets hourly with these pretty cakes for her nurslings.

POLLEN-TUBES.

To see the actual pollen-tubes in their passage down the style is a more difficult matter; nevertheless, with care and a good glass it may be managed. Put on the $\frac{1}{4}$-inch and choose a flower with a very stout style,—a Cistus or this Chickweed; the flower must have *just faded*, then you may be sure the ovules are fructified. With a sharp razor make

a very thin section of the pistil, and lift it with a fine sable brush on to a slide in a drop of water, and cover as usual with thin glass; focus carefully, have good light, and you will see the pollen-tubes actually descending the tissue of the style.

Now we are considering a great mystery. We see how varied are the lengths of styles and pistils, yet shorter or longer the pollen-tube stops not until it reaches the ovary, and when there, amidst the many rows of ovules, in many positions, it has to seek the one spot in each ovule by which alone it can enter, and there, and there only, it rests. Perhaps all but one have been fertilised, and are closed—it seeks *that one* and perfects the work. Thus we see the all-directing, all-sustaining, life-giving power of the Omnipresent one; we see His presence in the tiniest flower. He alone knoweth how this may be,—we only see that it is so; and reverently let us ever search into the mysteries of creation, and find new and deep delight in these revelations of His secret order, wisdom, and care for the preservation even of the flower of the field.

STAMENS.

The shapes of stamens are also to be noticed. Some open lengthwise, some across; some have valves like folding doors, flying upward, as in the laurel tribe. The anthers of the barberry are on jointed filaments, which are exceedingly irritable, and, if touched by the smallest insect, spring up and scatter the pollen on the pistil.

Euphorbia, or spurge,—a common weed in every garden,—has a pistil which hangs outward and downward, apparently out of reach of the pollen. The anthers rise up and shoot it out like little guns, one after the other, at the stigma of the flower.

Nettles also have beautiful elastic filaments for scattering the pollen on the pistil, which is in a separate flower. Many plants have these organs thus separated, but provision is ever made for their union, as in the case of our cucumbers, where bees and flies carry the pollen from one flower to the other.

SEEDS.

Having said a little on the beginning of the seed in the ovary, we shall be prepared to look at the seeds themselves with greater interest. Here also we have an endless variety of beautiful microscopic objects :—

POPPY SEEDS,

viewed as opaque objects, show a reticulated surface ;

SWEET-WILLIAM SEEDS,

oblong and dotted ;

SILENE, OR STELLARIA,

beautifully fretted and sculptured—

Foxglove	Portulaca
St. John's Wort	Passion-flower
Saxifrage	Begonia
Geranium	Scropularia
Anagallis	Hyoscyamus.

Look at all these ; and, above all, get a prepared slide of the exquisite

ORCHIS SEEDS.

They are like little net-purses, with the seed in them : the loose net is the skin or cuticle of the seed.

ECCREMOCARPUS OR CALAMPELIS SEED.

This winged seed is a splendid object for the polariscope. The Eccremocarpus, a beautiful creeper, with large bright-coloured, trumpet-shaped flowers, is a native of the tropics.

SEED OF CENTAUREA CYANUS.

The section of the seed of this plant is an excellent object for the binocular. It is common in corn-fields, with small purple florets of the disk, and large bright-blue florets of the ray. Named from the centaur Chiron, who was said to have cured himself of a wound in the foot with the leaves of this plant.

1. Seed-vessel of Fern when unripe, magnified 60 diameters. 2. Seed-vessel of Fern, at the moment when the ring straightens itself. 3. Leaflet of Black Maidenhair Spleenwort Fern.
4. Two sori, or collections of seed-vessels, of Spleenwort Fern, magd. 12 diams. 5. Sorus of Hart's-tongue Fern, magd. 6 diams. 6. Part of a leaflet of Shield Fern.
7. Sorus, magd. 10 diams. 8. Sori of Polypody Fern, magd. 7 diams. 9. Sori and part of leaflet of Hare's-foot Fern, magd. 5 diams. 10. Thin section of Limestone, magd. 20 diams.
11. Group of twenty seed-vessels, natural size. 12. Group of twenty seed-vessels, magd. 6 diams.
13. Leaflet of Polypody. 14. Part of a leaflet of Hare's-foot Fern.

CHAPTER II.

SECTIONS OF WOOD.

The use of these sections is to show the structure of the stem of plants, and the difference between the two great divisions of the vegetable world into endogens and exogens. An endogen is a plant which has long straight-veined leaves like a Palm, a Cane, a Lily, Iris, Daffodil, and all the grasses. The flowers are usually divided into three, or a multiple of three; the embryo has only one seed-lobe, or cotyledon, and the stem is like the section of

RUSCUS,

or Butcher's-broom, a common shrub in waste and watery places, with very rigid dark-green leaves, tipped by a sharp spine: it blossoms in April, but is chiefly admired for its large scarlet autumn berries, one in the axil of each leaf. This pretty section—apparently a fine lace-pattern—shows the structure of an endogenous tree; it grows from within, and is composed of a dense mass of simple cells, in the midst of which, in varied patterns, run upwards bundles of denser cells called "fibro-vascular"; and each bundle has one or more ducts, best seen perhaps in a section of

WANGHAE CANE.

Sometimes the centre cells disappear and leave the stem hollow, as in the grasses and many of the water plants.

Compare now this slide, and also a section of

ASPARAGUS,

with that of the Hazel or Apple.

SECTION OF HAZEL.

Here we see very distinct organization on quite a different plan. The exogen has veined and reticulated leaves; the

seeds have two lobes, or cotyledons; the flowers are arranged in four or five. The wood grows by the addition of cells, in circles, to the exterior of that last formed, and we see distinctly the open cells of the pith in the centre; the medullary rays running from the centre to the bark at intervals, with sap-vessels and cellular tissue in circles, as they were added on.

CEDAR OF LEBANON,

a firm, dense wood; the cells are very minute, the circles very distinct; each circle is a year's growth, and the medullary rays are very fine and numerous, radiating from the centre. Those dark bands forming the circles are made up of vascular tissue, or woody fibre, composed of long pointed cells, which overlap one another, and deposit internally a strengthening wall of a substance called scleragen, which is most abundant where not only density but great power of resistance is required. When young these woody fibres conduct the sap with facility through both stem and branches, especially of the fir tribe; but after they are thickened they only afford support, and become what carpenters call "heart-wood." The sap-vessels of trees are those nearest to the bark, which makes the barking of trees so dangerous to their life.

SECTION OF PINE.

Look next at this section, because it shows some peculiar dots on that same woody fibre, called glandular dots, and which are remarkable as belonging to that tribe, and also at one of the yew tree (Taxus).

SECTION OF YEW.

In this section, if vertical, there is a beautiful combination of spinal fibre with coniferous pits.

These pitted structures require explanation, especially as those of the pine or common deal are used as tests of the defining power of the object-glass. The pits in coniferous wood are surrounded by a broad rim.

The origin of the pitted cell is in the unequal deposit of

secondary matter inside the cell-wall. Always remembering that a young cell is a simple sac of a single membrane, which, containing a certain fluid, is capable of secreting various substances, curiously separated from, or combined with, the various gases and inorganic matter which form the soil in which it grows. These secretions are used for strengthening the cell-walls, as the young plant springs upward; therefore, if the deposit inside the cell is uneven, it causes marks on the cell-wall; if the cell grows faster than the supply of deposit, the markings are spiral or arched, or waved, or dotted; and these are best observed by comparing different cells from fresh plants. The anther of the vegetable marrow, if peeled and then examined with a drop of water, will give beautiful cells of arched fibre. But, to continue with this slide,—these pits are at first only dots in the secondary deposit; then as the cell thickens these pits deepen, the primary membrane breaks, and they become channels from cell to cell, as you may see in a section of vegetable ivory, where you perceive radiations from each cell, which are, in fact, these deep pits, and in a *vertical* section would look like the pitted cells of Fir, or Clematis, or Lime-wood, or *Laurus sassafras*, and many others.

VEGETABLE IVORY.

Vegetable ivory is the seed of a palm called *Phytelephas macrocarpa*, and is composed of a large round mass of bony albumen, in which a small embryo is imbedded. Slices of this ivory-like albumen, placed under the microscope, afford very beautiful examples of these thickened cells.

FOSSIL CONIFEROUS WOOD.

Fossil coniferous wood, which is wood converted into lignite, or a kind of coal, when the vegetable matter is almost entirely removed and replaced by silex (flint), preserving all the peculiarities of structure. This fossil wood, from Tasmania, will show the pitted ducts, which prove it to be one of the Coniferæ, or family of firs.

Always add to your collection sections of

FOSSIL PINE WOOD,

vertical, horizontal, and tangential.

SECTION OF COCOA NUT.

This gives an example of cells thickened into very consolidated woody tissue.

SECTION OF COB NUT.

The cob nut, or hog nut, is the seed of a plant (Omphalea), belonging to the natural order of Euphorbiaceæ, native of Jamaica.

SECTION OF SNAKE WOOD.

This is the wood of a plant called Ophioxylon,* from its twisted root and stem, resembling a serpent. It is found in the East Indies, sometimes as a climbing plant, bearing bright red and white flowers; sometimes as a small shrub, the root of which is a famous nostrum with the native physicians.

MOSS.

SLIDES OF DICRANUM, FUNARIA, ETC. ETC.

There is no season without its beautiful symbols of God's power and love, His wisdom and forethought. Spring flowers fade away; the summer foliage withers and falls from the trees; the autumn soon loses its crown and the last of its flowers; but hardly have the lingering Dandelion and little Daisy left us than on every old wall and knotted trunk we find, in rich profusion and variety, the capsules or seed-vessels of the pretty mosses.

They are our little way-side friends,—we often gather their trailing stems and leafy sprigs; but few persons, comparatively speaking, pause to examine their exquisite seed-vessels; therefore a few mounted specimens will be of great value in the collection for our microscope.

* Ophioxylon, from ὄφις, a serpent, and ξύλον, wood; because it has a twisted root and stem.

Before I describe the growth of a moss or the slides before us, it is necessary to learn the several parts of its fructification, and, if possible, to procure specimens of each of them.

A moss is a flowerless plant; the fruit or seed-vessel is the only visible organ of reproduction, and consists of—

The *capsule*, or urn-like body, which contains the spores.

The *operculum*, or lid of the capsule, which shuts in the spores until they require light and air.

The *calyptra*, or veil, which protects the young capsule.

The *peristome* of the capsule, which in most of the mosses is set round with a single or double row of teeth, such as you see in Dicranum or Bryum, and which are curiously regular in their number, varying from four to sixty-four, but always a multiple of four. Remark this in any you may examine; there will be four or eight, sixteen or thirty-two, and one variety (Polytrichum) has sixty-four; but there will be no odd number.

The *inner peristome*, or cilia, a fringe of delicate inner teeth, often rising like a cone in the centre of the capsule, pale yellow, or pure white, whereas the outer row is usually crimson or brown.

The *columella* is a column in the middle of the capsule, round which the spores cluster, and which you will only see by carefully dividing an unripe capsule lengthwise, making a thin section, and looking at it with a drop of water under a low power, when it will delight you.

The growth of a little moss is so interesting that we shall do well to watch it in our winter walks, from November to April.

Botanists are not yet quite agreed about the green filaments, which are the first appearance of fructification, and whose different cells contain the germs of the future moss. They are called antheridia and pistillidia, analogous to the stamens and pistils of a flower, but very different in their structure and action. Read the chapter on the structure and reproduction of moss in 'Carpenter on the Microscope'; or, better still, read Hooker and Taylor's 'Muscologia Britannica.'

The part that we can daily observe with a simple pocket lens is this:—The little capsule rises from its mossy stem wrapped in a delicate leaf, which breaks from its stalk, and is carried upwards in the growth of the tender bud it is to protect from the winter cold. This leaf forms the calyptra before described, and varies in colour, form, and substance: on some species of moss it is quite transparent, of bright green or pale yellow; on some it is hairy and thick. By-and-by the calyptra falls off,—splits up the side, or comes off whole,—and then the capsule is seen, wholly formed, but closed by its lid or operculum. This also varies much in form and colour; sometimes, as in the tiny Weissia on stone walls, it is bright apple-green, tipped with scarlet or crimson, very beautiful to look upon even thus; but none could guess at the exceeding loveliness concealed beneath this pretty lid, nor without a microscope could we see further into its mysteries.

If we take an unripe moss and divide it, we perceive the spores clustering round the columella, and growing in warmth and security within the closed capsule. But an appointed time comes, and then the operculum opens, falls back, and we see the peristome surrounded with a double or single row of teeth,—four, sixteen, thirty-two, or sixty-four, always an even number and multiple of four, as I have before observed,—the outer row rich crimson or brown, and the inner cilia pure white or pale yellow, forming an exquisite network as they bend protectingly over the mouth of the capsule, allowing the imprisoned spores both light and air, yet saving them from cold and wet and tiny insects, until they are perfected and ripe for dispersion. When their work is accomplished the cilia open, the little teeth unclose, and the spores fall to the ground, or are borne upon the winds hither and thither, to vegetate wheresoever it pleaseth God that they shall grow. All this care hath *He* taken of the spores of a tiny moss! Yes; and these mosses occupy no unimportant position in the economy of nature. They are, with lichens and fungi, called servi, or servants, because they are the earliest forms of vegetable life, and prepare the soil for higher

plants. In the most desolate regions, in the coldest climate, the little moss is found. This very Dicranum, at least its species *Dicranum bryoides*, was once the friend of the great traveller, Mungo Park. He was bewildered in a desert, and, over-weary even unto death, had laid himself down despairingly to die. As he did so, a little Dicranum caught his eye; the sight of its beauty touched him, the thought of God's care for it awakened the better thought of—"If God so cares for the grass of the field, which to-day is and to-morrow is not, does He not much more care for *me?*" He rose up, tried once more to find his way, and was saved.

Mosses abound everywhere; they fill even the rank bogs, and form rich mould for the aristocrats of creation; they cluster round the wild flowers, and protect them in their earliest state from cold and injury. Servants of creation, servants of God, they fill their appointed place, and do their Maker's will, beautiful in their lowliness as the stateliest oak of the forest.

THE DICRANUM

is found from November to April, in hedges or clay banks.

FUNARIA HYGROMETRICA

is to be viewed as an opaque object. The crimson peristome of twisted teeth and the white cilia gathered into a silvery knob in the centre is one of the loveliest objects we can look at. They are best gathered fresh, and all the winter long we find them on walls and in hedges, or waste places, especially wherever wood has been burnt, or near railway stations.

The leaves of mosses are made up of cellular tissue, and in a young leaf of Funaria we see the chlorophyll-grains very distinctly. They want no preparation beyond placing under thin glass with a drop of water.

The capsules of Dicranum and Weissia are better mounted in balsam; and Funaria is best seen when simply gummed on a circle of black paper, and protected by a cell of cardboard and thin glass.

There are upwards of forty genera and a thousand species of moss, of which 39 genera and 400 species are found in Great Britain.

SPORE-CASES OF FERN.

The fructification of ferns affords a great variety of microscopic objects, though we rarely find any but the spore-cases of the common Polypodium mounted in this way; therefore, after looking at the slide, we should by all means collect and examine as many varieties of fern as we can, not only for the shape of the thecæ, as these little cases are called, but for their position on the frond.

This Polypodium is a most common fern, growing upon old walls and hedgerows, and the round yellow spots on the underside of the frond are masses of these spore-cases called sori.

Observe that each theca is clasped by an elastic ring or band, called the annulus, and the spores are kept safely during their growth, as in a golden casket; but, as soon as they are fit for dispersion, the membrane which encloses them breaks, and the elastic band is seen with an empty little cup at each end. The spores themselves resemble pollen-grains, and are very prettily marked; but will require a higher power, and had better be examined from a fresh frond, with a drop of water, or a drop of oil of lemon, which is an excellent assistant in the observation of pollen and spores of all kinds.

The great profusion of these organs of reproduction is astonishing. If we take a leaf or frond of the common Hart's-tongue (*Scolopendrium*), and count those brown lines on the underside, which are the sori, we find at least fifty in a good-sized frond; in each sorus 4,000 of these tiny thecæ, sometimes 6,000; and the thecæ themselves enclose about fifty spores: thus we shall find that a single leaf of the plant may give rise to no fewer than ten millions of young ferns.

An interesting experiment may be made to learn the growth of a fern, by simply shaking some ripe spores on a saucerful of fine mould, covering it with a bell-glass or

tumbler, and keeping it moist, warm, and shaded. In a short time a thin green film will spread over the soil, which take up carefully on the point of a lancet, and examine under the microscope. The little spore first becomes swollen, angular, and bursts, throwing out a fine rootlet, which fixes in the soil and draws in nourishment. Then a number of delicate transparent cells are formed from the mother-cell in the spore, making a little green scale, which as it expands throws out many fibres or rootlets on the underside. The wonderful part is that this tiny green scale produces two kinds of cells, which fructify each other, as do the stamens and pistil of flowering plants.

One set of cells, called *antheridia*, contain most curious spiral filaments, which move spontaneously, and wheel round and round until the cell breaks, and they escape to enter into the other kind of cells, called *archegonia*, or germ-cells, from which the real stem of the future fern is produced. This is difficult to watch, and it requires a power of 300 diameters to see these moving filaments, called *antherozoides;* but the development of the little fern is in itself worth seeing and mounting for the microscope in its several stages.

Ferns are amongst the flowerless plants,—very numerous, very useful; not fewer than 2,000 species inhabit various parts of the world, from the tall Tree-fern of the tropics, more than fifty feet high, to the humble Spleenwort (*Asplenium ruta-muraria*) which haunts our ruined walls. Their claim to usefulness rests on their medicinal properties; the thick mucilage from *Adiantum capillus Veneris* being a famous cough nostrum; a decoction of Polypodium is taken as an anti-rheumatic and sudorific beverage; *Osmunda regalis* is given to rickety children as a tonic; and others are used as styptics and purgatives. The roots, when roasted and peeled, are eaten by the natives of New Zealand as we eat bread.

Shirley Hibberd's 'The Fern Garden' is a most useful companion in a country walk, to assist us in recognising the different species.

ELATERS OF EQUISETUM.

This slide is useful chiefly in directing attention to the plant from which the elaters are taken, and as leading the student to an interesting experiment.

The Equisetaceæ, or Horsetails, are leafless plants found on moist ground, in ditches and rivers, with whorls of long slender branches, and a hollow stem which gives the microscopist a very beautiful siliceous cuticle with stomata. The fructification is found in the spring: a fertile scaly head rises from the earth, having circles round it of shield-like discs, beneath which the spore-cases and these spores, which then appear only as a fine green dust, lie concealed.

Shake a little of the dust on a slide of glass, and innumerable small bodies will be seen, each with four elastic filaments clasping and unclasping them in quick motion for several minutes. If dry and motionless, by lightly breathing on them the action will be repeated. These are the elaters of the Equisetum, and the mechanism by which the spores are dispersed.

ELATERS OF JUNGERMANNIA.

Jungermannia, or Scale-moss, is a plant of lower rank in the vegetable world than the true moss, such as Dicranum or Funaria. The elaters which are here mounted belong to that species called *Jungermannia dilatata*, which creeps over the bark of trees, and tints the trunk of an old elm or oak with a rich brown or crimson; here and there a patch of this scaly plant encrusting the rugged surface, and requiring the aid of a pocket lens to see its fructification.

Any time from November to March look closely at one of these dark masses, and you will see dotted over it tiny globes, white as of frosted silver, rising on a slender stem, and perhaps great numbers of exceedingly minute fawn-coloured flowers. If you gather one and examine it with a good glass, small tufts of spiral fibre will be seen on each segment of what seems to be a flower—these are the elaters. Now this is not a flower, but a simple spore-case. The little white globe before noticed splits into four valves, and these elaters of spiral fibre uncoil with a spring and scatter

the ripe spores. There are seventy species of British Jungermannia, which have been admirably described and delineated by Sir William Hooker. We can find several of them in our country walks anywhere, and the leaves of cellular tissue are particularly worthy of observation under the microscope.

JUNGERMANNIA BIDENTATA.

This is an example of the delicate toothed leaves of one species. We find another, *Jungermannia furcata*, very commonly on the same tree as *J. dilatata;* it has a narrow green frond, *forked* at the extremity, and on the underside we may see the anthers, or antheridia, the male organs of the plant. They are small green globules, which cannot be properly observed without a microscope.

The elaters are best seen when mounted in balsam; the leaves either dry or in glycerine.

FUNGI.

SLIDE OF PUCCINIA, OR PHRAGMIDIUM.

Before we appreciate this apparently simple object, it is needful to learn something of the vast extent and variety of the family to which it belongs; but the limits of this catalogue will not allow of more than a very brief statement of necessary information.

The Fungi are plants of low organization, of which the highest in rank is the common Mushroom, the lowest that fine mould or tiny spot which we find on dead leaves or decaying wood, or as a film upon our preserves, or a tiny forest on our stale paste. Everywhere, in short, we may gather specimens of Fungi, and find beautiful *life in death* under the revealing power of our microscope.

Few of them are at present mounted for the student, but this species may always be obtained; it is a fungus parasitic on the Rose-tree.

The Puccinia is a mildew which infests the straw of Wheat, the leaves of Roses, Blackberry, Potentilla, Box, and Ground-ivy. We merely see small black spots, usually

surrounded by a circle of orange-coloured cells, which if we scrape off and soak for a minute either in turpentine or diluted nitric acid, each particle of black dust (for it appears nothing more to the naked eye) is found to be a pear-shaped seed-vessel, divided into compartments containing spores. This Puccinia of the Rose or Blackberry has from five to seven compartments, or spore-chambers, and is the best specimen to collect for observation. Some botanists call it Phragmidium, and Aregma.

If you wish to see the actual escape of the spore, scrape the fungus from the leaf, and let it soak in a little alcohol on the slide to disperse the air. Before the spirit has quite evaporated, add a drop of nitric acid under the thin glass cover, and warm it over a spirit-lamp, press the glass gently, and in all probability the inner cell of the spore-case will come out, enclosing the spore itself.

To see the germination of Puccinia, you have only to scatter some of these spore-cases in the spring on some moist flannel, or on a floating piece of cork, when they will presently throw out long colourless filaments, at the end of which three or four septa will be seen filled with orange-coloured endochrome or pulp of granular matter; then a spicule will rise on each septum, and expand into a globular head, into which the orange-coloured matter will pass, and these eventually fall off and begin to germinate on their own account.

The spores of fungi, being light and excessively minute, float in the air, enter plants through the stomata, and germinate in the cell beneath.

BLIGHT OF WHEAT (SMUT).

This is a fungus of globular form, black and powdery, covering the young ears of corn like a coating of soot. It is called *Uredo segetum*. The spores are so exceedingly minute, that *upwards of seven millions eight hundred and forty thousand* of them would be required to cover a square inch of surface.

UREDO FŒTIDA, OR BUNT,

is another species, also blighting the wheat, but found in the grain, which looks dark, though otherwise like the sound

wheat, until it is crushed, when a fetid black powder is seen, the spores of which are larger than those of the smut. Nevertheless, each grain contains four millions of them. They are of an oily nature, so that they stick to the healthy grains, and, if sown with them, infect the next crop; therefore farmers dress their wheat with potash to destroy this fungus.

UREDO, OR ÆCIDIUM.

I mention this, although few specimens are mounted, because it is met with abundantly throughout the autumn and winter on the underside of the Coltsfoot leaf, on Spurge in our gardens, on the twigs of Fir-trees, and on almost every garden vegetable. These yellow spots on leaf or stem are beautiful microscopic objects. The orange-coloured spores form under the cuticle, which breaks sometimes like a cup, or coronet, full of golden dust, that is most interesting to the observer.

I will only add that there are 4,000 species of fungi, most of which are parasitic on plants and animals. The human body is also subject to their growth—the internal parts, as well as the bulb of the hair, the tongue and palate. The tartar of our teeth is partly a fungus, and so is the thrush in infants.

We can find a rich store of curious and beautiful forms on every dying leaf or decaying stem. Examine the mould on paste or jam; the Puccinia on Rose-trees, Beans, Blackberries; the Æcidium, growing in bright-red spots, on Gooseberry and Barberry leaves in June and July; also on the white film on leaves of the garden pea. Æcidium is called *erysiphe*, and has little spore-cases dotted over it. So also on the leaves of the willow, a lovely little *erysiphe*, each black dot fringed with hooked filaments. These will give some idea of the variety of fungi, and their invisible and unknown beauty. Look over Greville's work on the Cryptogamia, and Mrs. Hussey on the Fungi; or get at Bulliard's fine old book on Microscopic Fungi, when your winter walks will abound with hitherto undreamt-of objects of delight.

CHAPTER III.

INFUSORIAL EARTHS.

These slides, which require high power and a good microscope to examine, consist of specimens of Diatomaceæ from different parts of the world. Their value is in proportion to the knowledge of their possessor concerning the Diatomaceæ generally and particularly. The Diatomaceæ are minute vegetable forms, called also "brittleworts," from the almost unavoidable separation of their cells or frustules in handling them. Long have they caused disputes as to their animal or vegetable nature. Very eminent naturalists, such as Ehrenberg, seeing them gifted with spontaneous motion,—the little golden Naviculæ sailing slowly across the field of vision, apparently turning back when meeting with an obstacle, or whirling gently round as if by their own will,—decided that they were surely animal, and classed them with the Infusoria, which are microscopic *animals*, found in salt and fresh water. But later researches and patient investigation have placed beyond doubt the vegetable nature of these beautiful creations, to whose variety there appears no limit.

As the wondering astronomer discovers the infinite worlds revealed in unfathomed space, and sees star after star arise in countless myriads within the dim and distant nebulæ,—as his mind bows down overwhelmed by the sense of the omnipotent Creator's dominion and guidance of all those glorious orbs,—even so the microscopist bends in astonished awe before the infinitude of God's works in the uncountable varieties and exquisite beauty of the minute Diatoms.

Bilin Slate.—Wherefore are they thus highly wrought, and why in such abundance? Take up that slide of Bilin slate, and know that in one single cubic inch 40,000 millions of these delicate forms are found!

Richmond.—Look at the earth from Richmond—it is a very small quantity of a marine deposit—eighteen feet deep, underlying the whole city of Richmond, U.S., and extending over an area whose limits are not known.

Algiers, Oran.—Observe the beautiful discs in that slide of earth from Algiers. Use the highest power that the art of man has yet constructed, and hardly will you see all the beauty which the finger of our God has traced on the circular valves of these little Diatoms, called Coscinodiscus, Actinocyclus, Arachnoidiscus, or Heliopelta. These names sound hard and perplexing to beginners, but they are full of meaning to any one acquainted with Greek; and there is this great advantage in such nomenclature—that it is understood alike by scholars of all nations. The difficulty of scientific names lies not in the names themselves, so much as in our deficient education, which wastes the time and the intellect of young ladies in acquiring accomplishments and modern languages without the solid foundation of Latin and Greek, which is acknowledged to be essential for men. These discs, and some others most commonly mounted as objects for the microscope, will be explained presently; it is necessary previously to say somewhat more of the Diatomaceæ generally.

And, first: They are now decidedly placed in the vegetable kingdom. They are found to consist of simple cells, whose membrane is so thoroughly impregnated with silex (flint) that it is indestructible by those powerful acids or by such heat as would totally destroy a simple cell-membrane. They consist always of two valves united at the edges, like a bivalve shell, and containing endochrome, like the plant-cell; sometimes oil-globules, and a granular substance which has been seen to circulate within. For a proper understanding of this read 'Carpenter on the Microscope'; 'Smith on British Diatomaceæ'; 'Pritchard's Infusoria'; 'Annals of Natural History,' 1843 and 1848; 'Microscopic Journal,' 1854.

The markings upon the valves, and their shape and position, are the distinguishing characters which decide the species.

They are found in the living state abundantly in every pond and ditch, ocean and rock-pool. They are in immense deposits in every part of the world. A mud-bank, 400 miles long and 120 broad, has been found on the flanks of Victoria Land, wholly composed of these siliceous valves, or loricæ. In Sweden and Norway they are used under the name of *bergh-mehl*, and mixed with the flour for bread. In the masses of guano these imperishable Diatoms are found in profusion, having been eaten by shell-fish, re-swallowed by the sea-bird, and passed through its digestive organs, to reappear unharmed, in all their beauty, as you may see them on the slides sold as "discs from guano."

DIATOMS OF GUANO.

It is not possible to catalogue the contents of the slides sold as infusorial earths from various parts, because every slide has a different collection, and the student should carefully study each slide, and learn its contents, with the help of such a book as 'Pritchard's Infusoria.'

The earths from the following places contain some of the most beautiful forms:—

Algiers	Kieselguhr	Virginia (discs)
Mull	Lapland	Piscataway
Bilin	Gossa	Manchester, U.S.
Italy	Obero	Rappanhanna
Barbadoes	Habitchtswald	Schockhoe
Auvergne	Tullamore	Rugen
Richmond (discs)	Lock Mourne	Slieve Mor Hills
Bangor, U.S.	Premnay	Bermuda (discs)
New Durham	Wreatham, U.S.	

NAVICULÆ.

Some Diatomaceæ, however, are mounted separately, either as test-objects, for their delicate striæ, or for their peculiar markings; and none more frequently so than the Naviculæ, of which *Navicula hippocampa*, or *Pleurosigma angulatum*, are favourite examples.

NAVICULA HIPPOCAMPA.

The Naviculæ comprise the largest section of the whole body of diatoms, and vary very much in form and markings, but the genus Naviculæ itself is so called from its resemblance to a boat or little ship (Ναυς, a ship). They are found, both in the living and fossil state, of a bright golden colour, the valves delicately striated, with or without a central aperture. Some are striped longitudinally; some transversely; some waved or shaped like the letter S, as

PLEUROSIGMA,

in which the apparent striæ are resolvable into hexagonal dots under a high power. These Naviculæ all multiply by division and conjugation, as do the diatoms generally, which cannot be explained without plates, and the student must refer to the works already mentioned.

MELOSEIRA,

From *melos* (a member), and *seira* (a chain),

is found on marine algæ, a composite plant of many frustules, joined together by siliceous hoops.

MELOSEIRA BORRERI.

No student should be without a slide of Meloseira, because it is a diatom very likely to be mistaken under a low power for a mass of confervæ. In fact, it has been misunderstood even by eminent naturalists. Agardh, the Swedish botanist, found and classed it with the fresh-water algæ; Ehrenberg examined and removed it into the animal kingdom under the name of Gallionella; and now it is replaced in the vegetable world as a diatom, its siliceous lorica being quite ascertained, and many beautiful species found both in salt and fresh water. If possible, obtain a specimen of *Meloseira sub-flexilis*, which is found off Friburg; or *Meloseira nummulites*, found in the Baltic Sea; but meanwhile observe this *M. Borreri*, which is abundant on marine algæ. You see a mass of bead-like filaments, which towards the edge is better seen and with a high

power. The frustules, or valves, are quite apparent—cylindrical, round at the edges, and with a strongly-marked central line. Some of the frustules are larger than others; in these most likely the process of self-conjugation has begun.

ACHNANTHES LONGIPES,

From *achne* (chaff or down), and *anthos* (a flower).

These now scattered frustules were connected in life by a stem, and the upper and lower frustules had different markings. You may observe that some have a transverse line, forming a cross upon the valve; this is one of the lower frustules. Achnanthes are common in sea-water, attached to algæ. There are several species,—some fossil, others found in fresh water; but this is the most beautiful.

SYNEDRA ULNA,

From *sunedra* (a sitting together),

are common in fresh water, sitting together in groups of golden wands, striated and open at the ends, which in age dilate, and three obtuse teeth are visible, with openings between them. These often occur in such numbers as quite to encrust the confervæ, or the stones in ponds and rivers.

We need but to take a very little of the brown-looking vegetation which we find on the walls of wells or horse-troughs, or quiet ponds, and placing it on a slip of glass, with a drop of water, cover with another piece of thin glass, to see many of these living microscopic plants.

BACILLARIÆ,

From *baculus* (a staff).

These are much shorter than Synedra, and are found adhering together by one corner, in a zigzag manner, or free, like naviculæ, gliding about in a drop of water. They are so abundant as to cover the confervæ like felt.

GOMPHONEMA,

From *gomphus* (a wooden peg),

is shaped like a wooden peg or wedge, and grows like a tree, on long filaments, attached to confervæ or stones in fresh water, varying in shape, being sometimes round at the tip, or notched, or with a plain edge.

LICMOPHORA,

From *likmos* (a fan), and *phora* (bearing),

grows likewise on a stalk, but in dense masses, and is a marine diatom, parasitic on seaweeds. Its growth is different from that of the Gomphonema. The stalk widens in the process of multiplication, and so spreads out the frustules like a fan.

RHABDONEMA,

From *rhabdos* (a staff).

These are marine also, and used as test objects, because, besides the striations, each frustule has two or four rows of marks called vittæ. They were joined together when alive, forming a long tube; but usually we only see the separated frustules here.

GRAMMATOPHORA MARINA,

From *gramma* (a letter).

This is used as a test object to discover some very delicate striæ on the borders of each valve, and is also remarkable for its vittæ, which resemble letters; especially this *G. marina*, which has four Greek gammas (γ) on each frustule. The vittæ are internal siliceous folds, and distinguish a large section of the Diatomaceæ. There are fifteen species of Grammatophora. This one is found on seaweed in the Atlantic and Pacific oceans.

BIDDULPHIA,—AMPHITETRAS,

Biddulphia is one of the chain-like diatoms which adhere to one another by projecting angles, or horns. A band of

minute cells forms a hoop round the valves, and when they multiply the young cells slip out from between the valves, and the hoop often becomes detached.

Amphitetras is a square cellular diatom, which frequently has its frustules piled up one over the other, with a large cell in each corner of the frustules. They are found alive in the sea off Cuba and the Canary Islands, fossil in Bermuda earth and Barbadoes deposit.

ISTHMIA ENERVIS.

A lovely diatom, found on seaweed on the English coast and in the Channel Islands. Its exquisite areolated structure is very remarkable, and will repay careful examination. Its mode of increase is unlike all others. Two cells form within the valves, and as they enlarge break forth; but still the siliceous hoop which once joined the new frustules to the old one remains attached for a time round one of them and alters its shape, causing some to appear truncated instead of round. The areolæ of Isthmia are never well seen except with the parabolic illuminator, or mounted dry and viewed with a binocular microscope.

ARACHNOIDISCUS,

From *arachné* (a spider), and *discus*.

This beautiful disc is one from the guano, and is also found attached to seaweed; especially one species, which is much used by the Japanese in making soup. It does, indeed, somewhat resemble a spider's web. But how can we describe the wonderful delicacy of its tracery, or cease to wonder at the perfection of its form, when we learn that this double disc has two inner valves; the outer one horny, upon which are the web-like marks, is indestructible in nitric acid; and the inner valve siliceous, supports the upper one upon fretwork like a gothic window. This should always be looked at with a Lieberkuhn, or a parabolic illuminator.

HELIOPELTA,

From *helios* (the sun), and *pelta* (a shield).

This diatom is found in *Bermuda* infusorial earth. We sometimes find two or three species on the same slide, and few mounted diatoms are as beautiful as the Heliopelta viewed as an opaque with the binocular. We then see the really raised compartments in relief, forming a five or six-rayed star of exquisite workmanship, with a striated margin and lateral spines, which are thought to connect the frustules together when in a young state. The number of rays determine the species. If the heliopelta has a five-rayed star in the centre and ten compartments, it is *H. Leuwenhoekii.* If there is a six-rayed star and twelve compartments, it is *H. euleri.* If there is a perfect Maltese cross and eight compartments, this is *H. metii.* But is quite necessary, in order fully to observe the structure, to have two slides of this diatom, the one for transmitted the other for reflected light, and the latter must have the Heliopelta mounted without balsam.

OMPHALOPELTA (CELLULOSA VERSICOLOR).

This diatom so nearly resembles Heliopelta, that a little close observation is necessary in order to detect the difference between them. The rays, though distinct, are less raised, and the margin has fewer spines, the rim is broader, and one species, *O. versicolor,* has, with transmitted light, a play of colour from tawny to red, also a bright, clear, six-rayed star in the centre, and the rim, though narrower than *O. cellulosa,* is very radiant. This is also found in Bermuda fossil earth, and other species in guano.

ACTINOCYCLUS,

From *actin* (a ray of light), and *cyclus* (a circle),

has no marginal spines, and from eight to ten divisions; is found alive at Cuxhaven; fossil in Virginian earth.

ASTEROMPHALUS ASTEROLAMPRA,

From *aster* (a star), *omphalos* (the navel), and *lampra* (shining).

Look for these in the slides of fossil guano, Bermuda earth, Virginia deposit, and Piscataway earth. They present beautiful umbilical rays, reaching only half way towards the margin, and alternate rays proceeding from the margin, forming a bright star in the centre, having five areolæ in each marginal division.

COSCINODISCUS,

From *coscinon* (a sieve),

has no rays or divisions, but resembles the Indian turn of a fairy watch. The structure is wholly cellular, and the species, of which there are forty, are known one from another by minute yet regular markings, tubercles, and variations in the size of the cells. They are found alive in the sea off Cuxhaven; fossil in the Richmond, Virginia, and Bermuda earths, also in the chalk marl of Oran.

These are the specimens most commonly sold by opticians, and they show us what Diatomaceæ are; but to pursue the study, and learn the myriads which a little bog-water or a spray of seaweed would reveal, we must read Pritchard's work on Infusoria; or, if further interested in the manner of their propagation,—which is really wonderful—read the article "Diatomacea" in the works on the Microscope by Carpenter or Hogg.

DESMIDIACEÆ.

These are minute plants, of green colour, found in fresh water, shallow pools, and ditches.

VOLVOX GLOBATOR.

This is one of them, which, from its animalcule-like movement and extreme beauty, has long been considered as one of the Infusoria. If mounted, it may be beautiful, but is much more so in its living, moving state, in a drop

of water; revolving round and round, sometimes gliding along, sometimes rolling through the water, a transparent globe, enclosing from one to seven, or even twenty, lesser and darker green globules, of various sizes. Each of those globules in time breaks from its parent cell, and becomes likewise a mother plant, producing young volvoces with such rapidity that ponds are often thronged with them, and the water is coloured to a deep green. There is a pond at Blackheath which, in the months of July and August, abounds with *Volvox globator*.

CLOSTERIUM

is a favourite specimen of Desmidiaceæ. Its little half-moons, or ovals, sometimes joined together, are frequently found in all pools, especially on moors and in exposed places.

Lately the Closterium has been closely examined with high powers, and a circulation of fluid was seen throughout the cell. This requires a power of 300 diameters and careful management of light. Then a peculiar whirling movement may be distinguished in the large round space at the end of the cell, as well as along both the concave and convex edges of the Closterium. It is like the circulation in Vallisneria, Chara, and Anacharis, which I do not describe, because I am only noticing those objects which are mounted for students, in the hope of leading them to examine the living plants for themselves, with other books of a higher order. (Read 'Carpenter's Microscope,' chap. vi., on the Desmidiaceæ.)

To find the Desmidiaceæ, try small shallow pools, and not stagnant water.

The Closterium, Euastrum, Micrasterias, &c., will be found as a gelatinous stratum at the bottom, on stones, or stems of water-plants. The Staurastrum, Pediastrum, and all the smaller species, float as a thin film on the water, or form a dirty-looking cloud round the aquatic plants.

Raise the film with a small muslin net, or pour the water through your handkerchief, scrape off the deposit, and transfer it into bottles of fresh water for examination at home.

If on plants, strip the stem with your fingers, and in the same way drop the gelatinous mass in water. Let it settle, and the little plants will flourish and remain long enough for you to study, not only their lovely forms, but also their manner of propagation, which is threefold. They multiply by self-division, by conjugation, or by zoospores.

The most common way is this: when a simple cell has come to its full growth, a partition forms in the middle, the cell gradually separates into two halves, each of which speedily becomes a perfect species of Desmidiacea.

The increase by conjugation, observed particularly in Closterium and Cosmarium, takes place thus: two fronds approach each other, and the outer cell-wall of each splits and throws out a connecting-tube which joins them together. Through this tube the contents of one cell is poured into the other, and mixing with the endochrome of the receiving-cell, forms a body called *sporangium*, which is afterwards set free by the breaking up of the parent cell.

Multiplication by zoospores has been observed in Cosmarium, Pediastrum, and many others. The endochrome divides into a number of granular particles called gonidia, which escape through the cell-wall, and develop into perfect cells.

Or they are ciliated and have a spontaneous movement, both in the parent cell and out of it, when they are called *zoospores*.

CONFERVÆ.—ZYGNEMA.

This is mounted for the microscope, as an example of conjugation amongst the Confervaceæ.

Confervaceæ are those plants which form the green or brown scum on ponds and ditches, and the long green, silky threads, that float in running water. Most beautiful are their ribbon-like filaments of varied pattern, and most useful their life on the stagnant water, which they purify by absorbing the noxious gases, and giving out the life-sustaining oxygen.

Looking at this scum for the first time will probably surprise us as much as anything. It does seem so won-

derful that what we have passed by unheeded for so many years, or even turned from in disgust, should be so very beautiful. The filaments are worked by the hand of God in such varied pattern, that every pool may furnish us with a new specimen, and read us a lesson of the infinite care that has been bestowed on the lowest orders of creation.

The conjugation of Zygnema resembles that of Closterium, only as the filament is long and divided into many cells, every cell throws out a connecting tube, and one filament completely empties itself into the other, remaining colourless, whilst the recipient has a dark-green star of condensed endochrome in every division.

ACHYLA PROLIFERA.

I have come reluctantly to the end of the vegetable slides, and upon each have said so little of all that there was to say that I can only hope my few words may prove very unsatisfactory, and so send the reader to better works and to the study of that open volume which lies around us, the hieroglyphics of which our microscope deciphers for us. Only one more little plant I will mention: it cannot be mounted, but you may raise it for yourself in a glass of water at any time. It is a parasitic plant on dead animal substances in water, and produces the *zoospores* of which we have been speaking. Throw two or three dead flies in a glass of water, and in a few days they will be covered with a cloudy film of minute colourless filaments; that is the plant *Achyla prolifera.*

I will describe what I saw the first time I examined it. I found one day in a small glass tank a dead larva of some aquatic insect, covered with a transparent mould, and on examining it with a half-inch object-glass, saw a mass of delicate white filaments. Some of these were filled with green granules in constant motion, and as I watched them the filament under observation began to expand into a club-shaped head, and the granules to form into small angular bodies, moving slowly round and round. The progress seemed so rapid, that I took out my watch to time the

changes, which astonished me. It was a bright July evening.

20 *min. to* 7. The angular bodies were forming.

15 *min. past* 7. The gonidia, or zoospores, as I should call them, were becoming oval.

20 *min. past* 7. The gonidia were in violent motion, revolving and bounding against the end of the cell.

25 *min. past* 7. The end of the cell contracted and elongated, then suddenly opened like a beak, and out rushed the whole multitude of little zoospores, merrily swimming hither and thither, evidently ciliated, and always moving the small end foremost. The empty cell collapsed, and I forgot it in watching the other filaments, all progressing in the same way. The spores continued to move about rather more slowly for nearly half an hour, when the quasi animal life seemed to cease, and they floated away to germinate upon the nearest decaying substance.

I hope you will prove the truth of what I write; it will afford much pleasure and a most useful lesson.

PART II.

OBJECTS FROM THE ANIMAL KINGDOM.

"The desire which tends to know
The works of God, thereby to glorify
The great Work-master, leads to no excess
That reaches blame, but rather merits praise
The more it seems excess;
For wonderful indeed are all His works,
Pleasant to know, and worthiest to be all
Had in remembrance alway with delight."—*Milton.*

The slides usually prepared from the animal kingdom consist of insect parts, palates of Molluscs, Zoophytes, and miscellaneous objects, rather difficult to classify, since they seem to be mounted chiefly to please the eye of the purchaser.

The demand for "pretty objects" has been caused by the absence of any plan for the proper use of the microscope; but now that we begin to find its real use, and appreciate its value as an educational instrument, the optician will have a better selection of slides on sale, and each object will be chosen as much for its usefulness as for its beauty.

There is a class of slides now sold by several opticians, which deserves especial recommendation. They are insects mounted *whole;* one single preparation affording material for a day's study at least. Instead of isolated parts belonging to unknown insects, we have the perfect body of Fly or Beetle, displaying its external anatomy, and giving us such an insight into its structure as we should hardly acquire with much reading and the best-drawn illustration.

Take, for instance, the slide of Scatophaga, or common Dung-fly, and read the description in this catalogue; or the Telephorus Beetle; and compare the two carefully in all

their parts; reading at the same time, from Cuvier, or Westwood's 'Introduction to Entomology,' the generic characters of the Coleoptera and Diptera, and the young entomologist will have received a lesson never to be forgotten.

For those who have not begun the study of natural history, a few words are added on the classification of insects generally, without which some descriptions may be unintelligible.

Insects are so called from the word *in-secta*, their bodies being divided into many distinct segments. They are a class of invertebrate articulated animals. The head is always distinct and furnished with antennæ; the body usually consists of thirteen segments; they breathe by means of tracheæ; possess a nervous system, a circulation of blood, and a digestive apparatus varying with the necessities and habits of the species.

According to Cuvier's arrangement, insects are divided into twelve orders. The first four orders have no wings.

1. Myriopoda,	example	Julus or Centipedes, and Woodlice
2. Thysanura	,,	Lepisma, or Sugar-louse
3. Parasita	,,	Pediculus (Louse)
4. Suctoria	,,	Pulex (Flea)
5. Coleoptera	,,	Beetles
6. Orthoptera	,,	Grasshoppers, Crickets
7. Hemiptera	,,	Bugs, Aphides
8. Neuroptera	,,	Dragon-flies
9. Hymenoptera	,,	Bees, Wasps, Ichneumons
10. Lepidoptera	,,	Butterflies, Moths
11. Strepsiptera	,,	Stylops
12. Diptera	,,	Flies

The objects themselves will be the best illustrations of these orders.

Preparations of animal tissues, blood, injected respiratory and digestive organs, and other objects relative to the physiology of the human body, are reserved for a separate pamphlet.

CHAPTER I.

OBJECTS FROM THE ARACHNIDA.

SPIDER'S FOOT, JAWS, SPINNARETS, EYES, EPIDERMIS.

SPIDER'S FOOT.

THIS favourite object should always have three companions in its box—a preparation of Spider's eyes, Spider's jaws, and Spider's spinnarets,—therefore I shall say something of each of these, and also a little of Spiders themselves. We are so familiar with them, so apt to dislike them in the house and overlook them in the garden, that it will be well to learn somewhat of their history.

Few persons realize the dignified position they hold in the order of creation. They are called *insects;* and are certainly not considered so aristocratic as Butterflies, or so grand as the great Beetles; perhaps a little higher than the Fly they so cunningly ensnare. Therefore let us consider the Spider as a whole before we examine his foot.

The Spider is not an insect. It ranks higher than any insect, no matter how large or how beautiful; and this on good grounds. In all God's works a perfect plan and regular order are established, and the organization of living creatures is gradually perfected, from the lowest form of animal life in the simple ciliated monad, up to the elaborate anatomy of man. Now the Spider might be an insect if we strictly adhered to the meaning of the term *in-secta* (divided into parts); but as its internal anatomy is more perfect, its respiratory apparatus, its circulation, and mode of reproduction, superior to those in any of the twelve orders of *insects*, the Spiders are called

ARACHNIDA,

and placed above them in natural order.

The Arachnida have oval or round bodies; the head, which is joined to the thorax, has simple eyes, which in

structure more nearly resemble the animal than the insect eye. Sometimes there are eight, sometimes six, or only two. They have a mouth with jaws (*maxillæ*), a tongue (*ligula*), remarkable palpi, and frontal claws often of great magnitude. But the nervous system is the great distinction. The organ of sensation, which is the brain in man and animals, is a series of knotted nerves called ganglia in insects, from which proceed nerves to all parts of the body. The imperfect insect, such as a Caterpillar, has more ganglia than the perfect butterfly. And whereas the insect has generally from six to eight or ten ganglia, or little brains, in different parts of its body, the Spider has but *two*, and they more brain-like, more concentrated, and consequently of a higher order.

Then again as to the circulation: we know that in all creatures the blood is the life; it is the fluid which nourishes all parts of the body. Not always *red;* it may be white, or yellow, or green; but it is blood, and constituted more or less like our human blood, as the microscope reveals. All insects have a heart or dorsal vessel which pumps out the blood (as we shall see explained when examining the larvæ of ephemera) that circulates loosely in the body, bathing the air vessels which supply it with oxygen; but the Arachnida have a true heart; long, indeed, like the insect heart, but furnished with arteries and veins which give it perfect circulation. This raises it another step higher.

The respiratory system is different in various species; but the Spider whose foot we are looking at had lungs or pulmonary sacs, with two or four breathing orifices, situated just near the base of the abdomen, and inside those sacs a number of delicate white triangular plates which aërated the blood. This is more like animal respiration than the trachea of insects. (*See* Spiracles.)

The Arachnida do not undergo metamorphosis. The female lays eggs, making very pretty cocoons or nests for them, and the young Spiders come forth perfect from the shell, with the exception of the two fore legs, which are not always developed until a few days after their birth.

And if we read any good work on the Arachnida we

shall not fail to be struck with the intelligence of their habits and the amount of their instinct. For instance, in the structure of their habitations, one species (Clotho*) found in the south of Europe makes a beautiful tent in the shape of a cup, festooned at the edges, with the outer covering of the finest texture, like taffeta, and weaves a second apartment, of still softer material, for her young. In this inner room, kept scrupulously clean, she hangs five or six little bags, wherein her eggs are laid enveloped in fine down. When she goes in and out of her tent she lifts the edge of a festoon and drops it again. The Mygale Spider, whose nest you may see in the British Museum, brought from Jamaica, is made of the hardest clay, having a trap-door fitting most exactly, and hinged with stout layers of silk; the use of which she knows so well, that if it is half-opened by an intruder, she will pull it strongly inwards to defend herself.

The cunning and amusing way in which the Hunting Spiders catch their prey—creeping under a twig or window-ledge as gently as a deer-stalker, lying motionless for a while, moving as the Fly moves, turning with incredible swiftness round and round, ever keeping the prey in sight, until, quite certain of its being within reach, they spring like a Tiger, as fierce and as unerring in their leap.

We may watch these ourselves in our garden on a warm spring day, *e.g.* a little black and white striped Spider, called Salticus, which, before it leaps, cautiously fixes a good strong thread to the wall in case of a fall.

Again, we may see high instinct and deep affection in those vagrant Spiders of the wood, Lycosæ, which hunt with their cocoon of eggs so firmly clasped to the body that they will die rather than part with it.

A wise little Spider of our neighbourhood—its name I do not know—lives on the ponds and ditches of Otmoor, and spins a web round a kind of raft of Lemna, with a stem of grass or a little twig—to make it stronger, I suppose—and floats about on this, pouncing on any half-drowned or newly-hatched Fly which may come within its reach.

* Uroctea.

Last of all that I shall mention,—as paper would fail me if I noticed all our spider friends,—is the Diving Spider of our aquariums (*Argyroneta*), common near London, rare in many parts of England: which has been taught to make a diving-bell for the work which God has appointed her. The water-world requires its avengers to keep down the fast-multiplying creatures therein, and the *Argyroneta aquatica* is one of them. True her gill-like lungs enable her to breathe under water; but still she requires more oxygen than it affords, and comes up about four times an hour for a supply of air. This she conveys to a silken house she has previously spun amidst the weeds in still water, and which we see shining like a little globe of silver; the Spider half inside, her breathing organs immersed in the air, and her head outside, watching for a tiny Beetle or a little Cyclops. For a more detailed account of the Water Spider, see 'Kirby and Spence's Entomology,' or the smaller work called 'Insect Architecture.' I only mention these facts to prove the reasonableness of the high position the Arachnida hold, and the unreasonableness of the neglect and dislike they often meet with. I bring them forward because the whole Spider is to be purchased beautifully prepared, and its external parts may thus be studied; also because the comb of the foot is in every collection, and it is more interesting when we have some further knowledge of the body to which it once belonged.

SPIDER'S FOOT.

The Spider's legs have a different formation from those of insects. Each has seven joints; the two upper ones form a kind of haunch; the next is the *femur;* the fourth and the fifth are tibiæ; the first or second according to the species, much the longest; the last two are the tarsi, less distinct than those of insects, but remarkably furnished with toothed claws called the combs. In our Garden Spider, the Epeira, there are no less than five of these combs, besides three upper and untoothed claws, to each foot; also a strong moveable spine or hook at the joint of each tarsus.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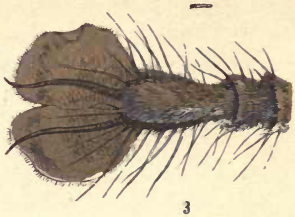
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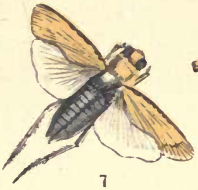
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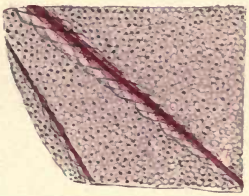
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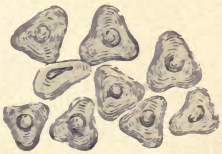
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1. Foot of Spider, magnified 18 diameters. 2. Claws of Spider, magd. 100 diams.
3. Foot of Fly, magd. 20 diams. 4. Foot of Boatfly, magd. 4 diams.
5. Boatfly. 6. Boatfly floating. 7. Boatfly on the wing. 8. Petal of Geranium.
9. Piece of Geranium Petal, magd. 8 diams. 10. Minute portion of Petal, magd. 150 diams.
11. Pollen of Clarkia pulchella, mag. 100 diameters. 12. Pollen of Crown-imperial, mag. 100 diams.
13. Grain of the above, magd. 300 diams. 14. Pollen of Salvia patens, magd. 100 diams.

The use of these combs is for cleaning itself and its web, the Spider being a most tidy creature. It has been seen to spend an hour or more in scraping the delicate threads of its web, when dust or soot had collected on them; and if they were too thoroughly incrusted with dirt, these little claws broke the thread, rolled it up, and threw it away.

The combs have from fifteen to seventeen teeth, necessary for the swiftly running Spider when crossing the fragile web or twisting the silken bands that form its dwelling or its snare.

Whoever has patiently watched a Garden or a House Spider spinning its web, will have noticed how with these claws it shakes and tries the strength of each supporting line, and is able to cling to it or roll it up by means of these handy little combs, as well as to regulate the issue of the threads from the spinnarets,—as it were *reeling* it off.

SPIDER'S SPINNARETS.

These are not always well prepared. They are difficult to keep in position, but you could see them well by catching a good-sized Spider, and examining it as an opaque object. At the end of the abdomen you will find four or five teats or spinnarets, pierced with an immense number of minute holes, from which a viscid fluid, a kind of glue, exudes at the will of the animal, and is drawn out as a fine thread. In reality, each of those fine lines which we can scarcely see is composed of *thousands* of threadlets, for there are often 1,000 orifices in each teat. The fluid, first uniting from all these in one twist, descends about the tenth of an inch, and then twining with the three or four others, it becomes a cable in structure and in strength.

The formation of the web would be too long a process to describe here. Only one fact I add; which is, that the Spider makes two different kinds of thread, and every web is fashioned of these different materials.

Take one of those common garden geometric webs, and throw a little fine dust against it. Look closely; you will see that the dust adheres to the cross lines which form the circles, but *not* to the radii or supporting lines. This is

because the Spider secretes a viscid matter, which she deposits in little globules all along each circle, and which acts as bird-lime in securing the prey. In one web of moderate size not less than 87,360 of these globules have been counted; and yet the time occupied in its whole construction was only about forty minutes.

I often think that invalids, or mechanics, or town-people, who cannot enjoy many of our country pleasures, or learn God's wonderful ways in the instinct He has bestowed upon our humble fellow-creatures, might find much profit, much amusement, if they only knew a little more about the flies on their window-pane, and the spiders on the wall. And those careful housewives who so diligently sweep away this beautiful work, might leave just one sometimes, as a little page from God's Book of Creation, which, if rightly studied, would lead to happier thoughts than come with the over-carefulness about household matters.

SPIDER'S EYES.

I have said already that the eye of a Spider is of a higher type than the compound eye of insects. It has a single arched cornea, a spherical lens, and a concave vitreous body, with a cup-shaped retina and a layer of pigment corresponding to the choroid membrane of the animal eye. It shines in the dark like a cat's eye, and evidently can see in the night as in the day. This is very remarkable, and denotes higher organization than we find even in the aggregate lens of a Butterfly's eye.

The position of these eyes—for the Spider has six or eight—is admirably varied for their different habits and pursuits.

The Garden Spider, Epeira, has two very large red ones in front and two behind, forming a square; two on each side almost confluent.

The House Spider has a double row of four each arching the forehead.

The Hunters have two fierce large eyes in front, four little ones just beneath, and two some distance behind, like watchmen or an "arrière-garde." Whilst the common

Phalangia, or Harvestmen, which run always on the ground amongst moss and leaves, and are of the lowest rank in the society of Spiders, have but two eyes, seated on a tubercle or watch-tower on their back.

There are seventeen different positions at least in the eyes of those Spiders most common to us.

SPIDER'S JAWS.

The jaws or chelifers of the Spider—properly speaking, the mandibles—are various in form, but always tremendous weapons, not only from their size and sharpness and the serrated edges and spines with which they are beset, but also because the upper joint contains a little sac of intense poison, which is emitted through a minute orifice in the next joint, and effectually kills whatever insect is bitten.

SPIDER'S PALPI.

The palpi, or feelers, serve as organs of taste and touch, and also as distinguishing marks of the sex. The male Spider has very large knobbed palpi, by which it is easily recognised.

EPIDERMIS OF SPIDER.

The skin of the Garden Spider (*Epeira*) is frequently mounted, and displays very beautiful undulating lines, surrounding the roots of the hairs. These concentric markings arise from the existence of folds in the inner membrane, beneath which lies a layer of pigment cells, to which the variegated appearance and beautiful colours of the Arachnida are owing.

The skin is merely washed, dried, and mounted in balsam.

CHAPTER II.

INSECT PARTS.

TONGUES OF INSECTS.

TONGUE OR PROBOSCIS OF HIVE BEE.

This is a common and favourite object in all collections, and very beautiful; but it should always be one of at least five others in the insect division, in order rightly to appreciate and enjoy the exhibition it affords of adaptation for a particular purpose.

A moderate power gives a view of the whole tongue, so called, which in truth consists of several parts. The habits of the Hive Bee are well known, and need not here be described; but it is worth observing how beautifully this organ is adapted for gathering the honey which lurks in the deep nectaries of such flowers as the Columbine or Honeysuckle.

Those strong-looking maxillæ are chiefly used as protecting sheaths for the delicately fringed and jointed ligula or tongue, which is stretched forth, having two feelers, called *labial palpi*, one on each side. These palpi are jointed at the tips, and used for steadying the proboscis in the flower-cup as it laps up the sweetness there. The *ligula* has forty joints, or more; the number varies with the species; you will easily see them with an inch lens. They render it perfectly flexible, as it sweeps round both concave and convex surfaces; and with a tremulous lapping motion the fluid is drawn up along the hairy channel into the opening valve which protects its throat. There is a knob or kind of button at the tip, which has been falsely supposed to be a perforated sucker. The tip of the tongue is simply cartilaginous, but the base is hollow and capable of inflation to a considerable size. In this hollow part the nectar drawn from the flowers is collected previous to its passing into the honey stomach.

If possible, the jaws or mandibles of the Bee should be mounted with the tongue, to show the instruments with which they fashion their waxen cells, seize their enemies, destroy the drones, &c. The mandibles vary in form and power with the different necessities of the species. The Hive Bee has simple spathulate jaws; the wild Humble Bee has toothed and stronger ones; as also the Carder Bee, Mason Bee, and Carpenter Bee.

A comparative view of the tongues of these Bees would be most interesting, and for those who like to make a collection I will give the easiest way of preparing them for observation.

Soak the heads for about a fortnight in liq. potassæ, to soften the skin and dissolve the fatty substance within, which prevents the parts from being distinctly seen. Then wash them in water, and press them flat between two pieces of glass until quite dry; drop a little turpentine upon them and let them soak in it for a few days, when they will mount beautifully in Canada balsam. If bubbles of air remain in the tissue, lay the tongue on a glass slide, and cover it with a piece of thin glass; take a camel-hair pencil and drop turpentine between the glasses, which must now be suffered *to boil* over the spirit lamp, and the air will rush out in bubbles; keep supplying turpentine until the object is perfectly transparent, then quickly and gently apply the balsam.

TONGUE OF WASP.

How very different this is from the tongue of the Bee! Instead of the long and slender ligula, here is a short broad two-lobed membrane, far more useful to the Wasp, who does not trouble himself to collect the honey he will eat ready-made out of the comb, but who prefers rasping rapidly away the soft ripeness of the Peach, the Apricot, or the Plum; or gnawing the juicy meat at the shambles, or sucking out the life of a fat Fly. This broad flat membrane —how handy it must be in making those curious paper nests wherein they rear their young; a trowel and a smoothing iron, a spoon and shovel, as may be required; and with

those two brushes on either side ever keeping it clean and unclogged for its work; whilst those four feelers, the labial palpi and maxillary palpi, ceaselessly vibrate over all, to ascertain the fitness of food or material.

There are many species of Wasps; and some of them, especially foreign ones, feed more upon honey than do our common Wasps, and their lingulæ are therefore modified for their wants, being longer and sometimes three-lobed, with a variation also on the mandibles or outer jaws.

These would make a very interesting collection prepared like the Bee's head.

BUTTERFLY'S TONGUE OR PROBOSCIS.

This is a beautiful piece of mechanism; a long elastic coil which the hovering Butterfly throws lightly into the recesses of the deepest corolla. It cannot, like the Bee, dive down into the Honeysuckle or Campanula, or passionately tear open the nectary of a Foxglove. Its beautiful wings cannot fold so closely as to let it creep into the Salvia-cup or Lily-bell. Therefore its Creator gave it this excellent instrument adapted exactly to its wants. In the living insect it is coiled closely to its head, so as to be scarcely visible, and not at all to impede its movements. When unfolded, we perceive that it consists of two long tubes hooked together most curiously by minute teeth, which on either side are inserted into little pits between each row of teeth. Moreover each of these tiny teeth has a second tooth, which forms a deep notch, and prevents the accidental unhooking of this double tube. Then at the edge of each tube there are seventy-four little barrel-shaped bodies, or papillæ, considered to be the organs of taste, and inside each tube, which you may observe is delicately striated, there are spiral vessels or tracheæ connected with the larger tracheæ in the head. Now the fluid does not pass up the interior of this *antlia*, which is its proper name, but is drawn upwards along that channel which is formed by the union of the two tubes. The papillæ are best observed near the tip, and with a high power.

PROBOSCIS OR TONGUE OF BLOW-FLY.

This is a true proboscis, but not so well seen alone if all its parts and uses are to be considered; you should have the proboscis of a Gnat and of a Tabanus or House-fly rightly to understand the whole.

We see the little House-fly busy in our sugar-basin, or the Blow-fly, unwelcome in our larder. We feel the tiresome tickling on a hot summer's day when they gambol over our hands and face; but we know not how beautiful is that little mischievous tongue. Here it is spread out, the simplest form having a broad fleshy lobe which is striated with spiral fibres, by which it obtains a sucking movement and draws up the juices it feeds on. Little short stiff hairs are set around it, and these are what do us mischief in rasping off the polish of our book-covers, and causing the irritation to our skin.

PROBOSCIS OF TABANUS.

This is the more complicated proboscis of the Tabanus, or Horse-fly. Who does not know how it torments our cattle, and the carriage horse in particular, in a dusty drive through the country? A large brown Fly, with variegated wings, and such magnificent eyes! She is easily caught; for when she fixes on the horse and tastes the warm blood, her whole attention is given to the feast. I say *she*, because the male Tabanus is found harmlessly hovering over flowers, and loves the haunts of the Honey Bee: his mouth has no lancets, whereas the female is supplied with very powerful instruments of assault.

The head should always be mounted with the proboscis, which greatly increases the interest of the slide; because, although the eyes lose in preparation their gorgeous colouring of green, purple and gold, in zigzag bands across the facets, yet the delicate network remains, and shows the 4,000 meshes, which in life each contained an eye. As is the case with many of the Diptera, the eyes of the female are parted by a narrow band. Beneath the eyes, near the mouth, are the antennæ, which are supposed to be organs of hearing, as they certainly are of feeling. Six-jointed

these are; the first and second bristly, the third is very long, and the last three very short. It is important to observe these things, as the shape of *one* joint in the antennæ will determine the species. In this very case, if we were examining the large and true *Tabanus bovinus*, we should see a very different *third* joint.

Next let us examine the mouth.

That long and broad membrane is called the labium. Those lines at the inner edge of the two lobes are spiral muscular fibre, which enable it to lap or draw up the fluid it feeds on; and those lancets are instead of jaws, or rather are modifications of the mandibles and maxillæ, which are the inner and outer jaws of insects. These lancets pierce the skin, and the labium sucks the blood of the horse. If the slide has the head of *Tabanus bovinus*, and not the common *Tabanus pluviatilis*, also called Hæmotopota, or "blood-drinking," the head will be armed with a strong pair of mandibles besides the lancets. The larvæ of these flies live in the earth—long grey footless grubs, feeding on decayed vegetables.

PROBOSCIS OF GNAT.

Here is another of our little tormentors, and a *female* Diptera also; for the male Gnat dances gaily in the sunshine with his beautiful plumed head, and has not by any means so well-developed a mouth. He does not suck blood, and probably sips a little nectar from flowers or the dew upon the leaves in the short time he has to live: the business of his life is to choose a mate and die. The female Gnat lives longer, and is very bloodthirsty. Here observe a long fleshy lip, or labium, which is the sheath containing two mandibles, two maxillæ, one labium, one ligula or tongue. They may not all be visible on the slide, as some may remain inside the sheath, and some may be broken off, they are so very delicate; but if perfect it would show all these. The *mandibles* are finely toothed like a saw; but you require a quarter-inch glass to see this well. The ligula is shaped like a spear-head. The stiff horny labium is pointed like a needle. When the Gnat pierces the skin,

the two serrated mandibles work rapidly up and down, the sheath folds backward, the pressure of the lancets causes a little poison-bag, situated at the base of the proboscis, to emit one drop of acrid matter, and when the little creature has sucked our life-blood, and her small body is distended and crimsoned with her draught, she flies off like a winged ruby in the sunlight, that little poison-drop rankling in the wound and causing our after uneasiness and irritation. It is worth the slight annoyance, however, to watch the process of her feast. With a pocket lens we can see the working down of the lancets, and the up-flowing of the blood into her stomach.

The shrill buzz of the Gnat, like a fairy clarion, is peculiar to the female, and only heard when she is bloodthirsty. Her delicate wings then vibrate 3,000 times in a second, and are supposed to cause this sound by the friction of their bases against her body. Her eyes, which quite cover her head, and the long fourteen-jointed antennæ waving to and fro, make her a beautiful object, in spite of her unpleasant propensities.

PROBOSCIS OF ASILUS.

The Asilus is one of the Diptera (Flies)—the largest and fiercest of them—most frequent in sandy situations. They flit about in the hot sunshine, pouncing upon all smaller flies—Beetles and Hymenoptera, Ichneumon flies, &c.—holding them between their fore legs, and plunging their sharp lancets and fleshy tongue into the softest part of their prey. The colour of these flies is mostly tawny, gold-coloured, or reddish-yellow; the wings finely-veined and clouded at the edge; the body long and narrow. The larva lives in the earth: it has twelve segments, and changes to a spiny pupa, from whence the Fly emerges in June.

PROBOSCIS OF EMPIS-FLY.

The Empis is often called the Snipe-fly, from its remarkable labrum, which really resembles a Snipe's beak. When at rest it is folded close to the breast, but very frequently

is seen transfixing the body of some poor smaller fly which the Empis is greedily sucking. The Empidæ are generally small black flies, and there are many species of them. They are more fully described with the slide of *Empis stercorea;* also the peculiar veining of their wings.

PROBOSCIS OF DIOCTRIA,

one of the Asilidæ, flies which inhabit meadows, trees and bushes, feeding on lesser flies, and more common than the true Asilus. They are usually black and shining, and carry their antennæ very fiercely erect. The head should be mounted in profile to show the tubercle upon which the antennæ are seated, five-jointed and porrect, close to each other at the base and diverging outward. The proboscis stands out almost horizontally.

HEAD OF CONOPS.

This is a pretty black and yellow Fly, frequenting flowers, having a bright triangular spot on the top of the head. The thorax with two yellow scapulæ, and the abdomen is banded black and yellow. The remarkable part of the head is a singular proboscis curved suddenly upwards; a labrum notched at the tip, arched above and hollow beneath; labium bilobed and slightly hairy, with three shallow transverse furrows at the tip. The antennæ should be well displayed, for their structure alone would determine the species, and therefore furnish a useful lesson on the absolute necessity of minute observation, if we wish truly to learn and enjoy the insect world.

The antennæ of Conops are about as long as the head, fiercely seated on a tubercle, and have *seven* joints; the first, short and slightly hairy, forming an angle with the second, which is much longer and rather club-shaped: the third is seated on the second like a cone, and the fourth is very small; so is the fifth, and the others are like little spines; nevertheless they are seven in all. The eyes are prominent and oblong; but the eye of the Fly is particularly described in the head of Rhingia.

HEAD OF RHINGIA, OR SYRPHUS.

This beautiful preparation is the one I have chosen for drawing particular attention to the eye of the Fly. That fine delicate lace, now perfectly transparent, is the skeleton or framework in which were set four thousand perfect organs of sight, which we call *the eye* of a Fly. That outer membrane, which is all that is now left, is the cornea; it was lined with an intense black pigment, excepting one tiny spot in the centre of each facet, through which the light was admitted. Behind the pigment was a broad zone, orange-coloured and black; then a second zone, deep blue or black; then the optic ganglion, gathering all the filaments of each eye into one knot—the brain.

The brain of insects is not a solid mass, or great ganglion, like the brain of animals; but the medium of communication between insects and the external world, is a nervous system consisting of two medullary threads or cords, and a series of knots or ganglia placed at intervals throughout the body.

Larvæ have usually two of these ganglia to each segment of the body. The perfect insect has fewer; but the first ganglion, as in the Fly, always sends out the nerves of the eyes, tongue, maxillæ, mandibles, and antennæ. Therefore we understand how the organs of sight are united in the head of a Fly upon the first ganglion or brain. And whilst each eye receives a perfect image of the object before it, one single impression may be conveyed to its possessor.

This head of Rhingia has also a very beautiful tongue, long and slender, lobed and edged with spiral fibre, capable of great extension to accommodate the habits of the Fly.

The *Rhingia campestris*, or *Rostrata*, is so called from its projecting horny beak. It is a very pretty Fly common in woods and gardens during the summer; remarkable from its hovering like a Humming-bird over the flowers, and darting suddenly into them, sucking the honey-drop with this long and slender ligula, and then out again with a swift jerking flight not very easily followed. Its body is a dull red; the wings finely veined, like all its family, the Syrphidæ.

HEAD OF DRONE-FLY, OR HELOPHILUS.

This so nearly resembles the Rhingia that little need be added in explanation, except of the fly itself, which is one of the Syrphidæ, nearly related to the Rhingia. The Helophilus is that large black and yellow fly so common in the autumn on Michaelmas Daisies, often mistaken for a Wasp, as it makes a loud humming noise and is very intent upon its feast. It passes through a greater change than most of the fly tribe; for it lived and fed in the foulest sewer as a rat-tailed larva which is very curious in its manner of breathing. This larva has a long retractile tail, with the action of a telescope, capable of immense extension to reach the surface of the water or mud for air. The body being very transparent, the tracheal vessel is distinctly seen in a wavy line the whole length of the tail.

HEAD OF ERISTALIS,

differs only from Helophilus in having a black hairy body, more like a Bee. The antennæ are very beautiful.

HEAD OF TIPULA.

This favourite and beautiful preparation is the head of our familiarly called Daddy-long-legs. The colour adds to the beauty of the lacework eye, and the fine antennæ, simple yet varied in the length of the joints, which are each slightly hairy. The palpi have four joints, and bend over the broad fleshy proboscis, in which large trachea are distinctly seen. These Tipulæ are very destructive in the grub state. The female deposits her eggs in deep burrows by means of a long ovipositor, consisting of four pieces; two of them bore like an auger the required hole in the earth, and the other two join and conduct the egg to its appointed place. When the larva hatches it has two short horns on its head, several fleshy conical appendages on the abdomen, and two very strong mandibles working against two horny convex dentated plates. Very destructive are they to the farmer's grass land, often destroying hundreds of acres in England and France. The more, therefore, of these beautiful heads that are thus prepared the better.

HEAD OF LIMNOBIA.

This is essentially like the head of Tipula. I need only say that Limnobia is one of the same family, only of a different genus, and the larvæ are much less destructive, living mostly in fungi.

HEAD OF HEMEROBIUS.

This is usually mounted as an opaque object, to show the metallic lustre of the eyes. The Hemerobius belongs to the order Neuroptera. Is has four exquisite light green wings resembling delicate lace, and lays its eggs on the twigs of lilac trees; these eggs are stalked and placed in rows along the twig, from which a very useful little larva emerges—a destroyer of the Aphides.

HEAD OF PANORPA.

The Panorpa is called the Scorpion-fly, and is very common on nettles in the middle and end of summer. They are not difficult either to distinguish or to catch; for the male fly is very conspicuous with his long turned-up tail, at the end of which he brandishes an unpleasant-looking pair of forceps. The wings, four of them, are highly reticulated, which denote it to be of the order *Neuroptera*, and first cousin to the beautiful Dragon-fly and brilliant Hemerobius; they are prettily spotted, and of equal size. If we look at the head we shall see a pair of long antennæ inserted between the eyes, three ocelli, or little eyes on the crown of the head, and this long snout-like proboscis, with mandibles, maxillæ and lower lip nearly linear, and four or six short palpi. Upon this beak we often see a little insect spitted, whilst the tongue is rapidly sucking out its life's-blood. The Panorpa is a carnivorous fly, and hunts in the hot sunshine, not only on the wing, but running swiftly under and over the nettle-leaves, intent on his pursuit, and easily captured himself whilst thus engaged.

TONGUE OF CRICKET.

(*Achetœ.*)

This is an example of a true insect tongue, and must be examined with several powers if we wish to see all its beauty. For a general view use an inch lens, and observe the two strong muscles which move it, from whence numerous fine spiral fibres arch over the transparent membrane. Afterwards use the half-inch and the quarter-inch, when these fibres appear to be furrowed or fretted, like little files, and must form a most useful tongue for the voracious Cricket. We all know how destructive it is in the house; gnawing linen or books, or feeding on flour, meat—in short, anything it can find. After this tongue has performed its office, there is a complicated gizzard, which will be explained in its proper place; though it ought to be looked at after the tongue, and with the wing-case of the male Cricket, whose drum and file is a very interesting microscopic object.

The House Cricket belongs to the order *Orthoptera*, or straight-winged insects. The female does not chirp; she is known by a long pointed ovipositor, with which she deposits about 300 eggs in a season.

GIZZARD OF CRICKET.

This is a most interesting object in connection with the tongue of the Cricket, as illustrative of the digestive organs of the Orthoptera. It is usually mounted in Canada balsam and viewed with transmitted light; but the effect is more beautiful, and the structure better displayed, by examination with the parabolic reflector, or a simple Lieberkuhn, when the scale-like plates are thrown into relief, and the formidable apparatus for digestion is manifest.

The Cricket has a long and dilatable œsophagus, which ends in a crop or sac for the reception of food in a rough state, and this is followed by a gizzard, consisting of two skins, the inner one plaited into six folds having longitudinal rows of teeth resembling toothed scales, the outer row much smaller than those in the centre, and each

capable of elevation and depression. The whole grinding machine is moved by thousands of muscles, which enable it to reduce the food to a pulp, and it is then passed on to the intestinal canal or lower stomach, where biliary vessels, analogous to the liver in the higher animals, pour in the bile, which finally prepares the food for the general nourishment of the body.

A most interesting collection of gizzards may easily be made, and the variation and adaptation of structure observed, by preparing the stomach of Dytiscus, of the large Grasshopper or Locust, the Cockroach (Blaps), Tenebrio (Beetle) and most of the predaceous Beetles. One small Beetle, a wood-borer, *Cryptorhynchus lapathi*, has a gizzard so minute as hardly to exceed a large pin's head in size, and yet it is said to be armed with no less than 400 pairs of teeth, moved by a far greater number of muscles.

MOUTH OF BEETLE.

(*Telephora*, or *Soldier-beetle.*)

This is a common and favourite object, and should be considered carefully, for it belongs to that large and useful tribe of insects which we could no more spare from their place in creation than we could the flowers of the field, or the birds of the air.

A Beetle's mouth will be more interesting if we say a few words about the Beetles themselves.

Coleoptera they are called, from two Greek words, signifying "wings in a sheath." No less than 30,000 species are known, of which 3,600 are found in Britain; exceeding the amount of all our other native animals, and forming a third part of our insect population. They vary in size from the great Prionus, which measures six inches long, and has nine inches expanse of wing, to the minute Trichopteryx and Atomaria, hardly one-eighth of a line—quite microscopic; and yet every external joint, every internal organ, is as perfect in the small as in the large.

The usefulness of the Beetle tribe is far greater than is imagined. Not only in the perfect state do they remove dead animal substances, excrements, &c., but in their larval

state feed on decayed vegetable matter, which else would render the air unwholesome for our existence, and more offensive to our senses than can well be imagined. Let us examine, therefore, the mouth of our little scavenger.

It has six parts. An upper lip, called *labrum*, which covers the mouth, and is horny or leathery, but simple in form.

Two upper jaws, called *mandibles*, varying in shape, but strong and toothed, or hooked, for seizing their prey and tearing it to pieces before it is passed on to the more delicate under jaws or

Maxillæ, which are fringed with delicate hairs, and to which are attached jointed palpi, or feelers. The tips of these are often triangular, or hatchet-shaped, which will distinguish them for your observation. These palpi move very rapidly, apparently examining the food, and two others are attached to the under lip or

Labium, for the same purpose. Part of the labium is called the chin or mentum, usually having a notch in the centre. Some of the Beetles have a distinct tongue inside all this—the Dung-beetle for instance—lying between the labium and labrum. It is a simple membrane, sometimes fleshy, sometimes horny.

The mouth of a Beetle would be much better examined by taking a large Beetle, and soaking the head for a few days in liquor potassæ; then washing it in a watchglassful of water, when the parts are easily separated and studied. Do this, because from one mouth we cannot learn all that is useful or interesting. For instance, in the mandibles are found different kinds of teeth; molar teeth for grinding food, or incisive teeth for tearing it. The maxillæ also vary extremely in their form and appendages. The lobes are often furnished with spines or teeth, and are single or double, fringed or plain; but the predaceous Beetles have always fringed lobes like stiff brushes, as if for cleansing the food or the other appendages of the mouth. Also, I may mention that the palpi of those Beetles which feed on the pollen of flowers, such as the tribe of the *Nitidusidæ*, are used by them to open the anthers in a very curious way.

The antennæ of the Beetle are not described here but in connection with those of the Blow-fly and Bee, concerning which some interesting discoveries have been lately made.

MOUTH OF BEETLE.

(Bouche et palpes de *Calathus Castelloides.*)

This is a black Beetle about half an inch long, very common in the neighbourhood of London; found under stones.

The object is good as showing beautifully fringed maxillæ with two pair of labial palpi; the outer pair have four joints, the lower pair only three. Some species of Coleoptera have one pair of labial palpi, and one pair of maxillary palpi.

Observe, the little tonguelet in the centre has two ear-like appendages, called paraglossæ. That broad curved plate above it is the mentum, with a notch in the centre, which distinguishes the section of the Carabici to which it belongs.

MOUTH OF BRACHINUS.

(Bouche et palpes de Brachinus.)

The mouth of the Bombadier Beetle (*see* leg of Brachinus), one of the Carabici, which has the maxillæ terminated simply in a point; the tonguelet exposed, and labial palpi distinctly three-jointed; the mentum not toothed; the last joint of both maxillary and labial palpi evidently dilated.

MOUTH OF ONTHOPHAGUS.

(Bouche et palpes.)

One of the Dung-beetles or Scarabœides, the earliest species of the spring. It belongs to the large family of the Lamellicornes, having the antennæ clubbed and composed of leaflets arranged like a fan, opening and shutting in the same manner. The first pair of legs are remarkably strong, the tibiæ toothed for burrowing in the earth and manure upon which they feed. Many of the species are very large and beautiful, with metallic bodies and sculptured Elytra. The Onthophagus is small, but of a brassy black colour;

the elytra dull grayish-yellow thickly clouded with black, and it has a curious pair of horns on its head. The mouth shows a pair of broad curved and delicately fringed maxillæ, which deserve examination with a high power. The last joint of the maxillary palpi is the largest, and the labial palpi are very hairy.

MOUTH OF ANCHOMENUS,

a species nearly allied to Brachinus, a small green Beetle found under stones. We observe the maxillæ terminate in a single hook, with two pair of palpi, and the tonguelet having the paraglossæ mentioned in the mouth of Brachinus.

MOUTH OF CRIOCERIS.

(*Asparagus Beetle.*)

This abundant and pretty Beetle is found in the hot sunny days of July laying eggs upon the asparagus plants. It is blue and red, with the elytra marked in the form of a double cross, yellow and blue. It belongs to the order *Tetramera*, having four joints in the tarsi.

The mouth displays a membranous two-lobed tonguelet, the maxillæ whitish and membranous, delicately fringed; the terminal lobe straight, the palpi filiform.

MOUTH OF LADYBIRD,

(*Coccinella,*)

too well known to need description; but it may be noticed that it belongs to the last order of Coleoptera, the *Trimera*, having only three joints in the tarsi.

The mouth is very remarkable from the hatchet-shape of the last joint of the maxillary palpi. The maxillæ are armed on the inner edge with a horny tooth.

When the Coccinella is alive and in its youth, the circulation of blood may be seen in the veins of the wing.

MOUTH OF STENOPTERUS RUFUS.

A black Beetle with red antennæ, not common in Eng-

land; found in June near Darenth Wood and Coombe Wood. It is one of the Cerambycidæ, a section of the Longicornes. These have only four joints in the tarsi, the last three furnished with short brushes, and the first and second joints heart-shaped. The mouth is very differently constructed from those before described. The two maxillary lobes are remarkably distinct and prolonged beyond the palpi: the last joint of the palpi thick, conical, and dark-coloured. I may mention here, as Stenopterus is rare in England, that a very pretty species of the same family may be readily found on willows, and the mouth will show the same kind of maxillæ, with this one difference in the palpi —that the *maxillary* palpi are very much smaller than the *labial*, or even the maxillary lobes.

The beetle to which I refer is *Cerambyx moschatus*, or Musk-beetle, about an inch long, green, shaded with blue, or a more golden colour, emitting a scent of musk or of otto of roses on being handled. It has long antennæ, and kidney-shaped eyes surrounding the base of the antennæ. The larva is a soft white maggot, burrowing under the bark of trees.

ANTENNÆ.

The antennæ, or feelers, are very important organs in all insects; but especially in the flies and beetles. In both these orders the shape, position, and number of joints in the antennæ, form distinguishing characters in the genera and species of insects.

They are situated on the head, near the eyes. They deserve particular attention and study; for no organs are more wonderful or more useful, and, until lately, none so little understood. The order Coleoptera is divided by them into the families, Lamellicornes, Clavicornes, Serricornes, and Palpicornes. For examples of these, which are very beautiful, look at the head of the common Dung-beetle, which has a clubbed antenna, formed of leaflets, capable of being shut up.

ANTENNÆ OF COCKCHAFER,

another Lamellicorne beetle, every leaflet of whose beautiful antennæ shows a cellular tissue of oval cells, with nucleus and nucleolus, according to Quekett; but with an external cuticle of hexagonal cells, according to Carpenter. The organs of sensation, sacs and sacculi, are found in them, and occupy the place of the nucleoli of Quekett. (*See* antennæ of Syrphus.) The leaflets of the male are much longer than those of the female.

ANTENNÆ OF NITIDULARIA.

An example of *Clavicorne* antennæ. These Nitidularia are small beetles which haunt our flowers and swarm upon nettles all the summer long, and may be recognised by their antennæ having eleven joints, the last three clubbed.

ANTENNÆ OF HYDROPHILUS,

is an example of *Palpicorne* antennæ; clubbed also, but differently shaped, and having only nine joints—never more.

ANTENNÆ OF ELATER.

Here is a common little beetle, often called Skip-jack, from its springing up with a jerk when laid on its back; easily recognised on plants by its depressed head, and long dark body; also by its habit of falling down as if dead when alarmed. The antennæ are an example of the *Serricornes*, toothed or serrated, especially those of the male insect.

For examples of variety of antennæ in the Diptera, look at the heads of Dolichopus, Empis, Sepedon, and Syrphus, Phora, Tabanus, &c. Compare these with the antennæ of Bee, Saw-fly, Ichneumon-fly, and Dragon-fly. The antennæ not only vary in the species, but in the sexes, and are always most beautiful in the male; as in the head of a Gnat, which is plumed, whilst that of the female is quite plain.

The wild Bees, Saw-flies, and Beetles, present many examples where the different shape and length of the

antennæ enable us at first sight to recognise the sex. Therefore we should study them, especially in the following insects :—

WILD BEES.	BEETLES.	Rhipicera	MOTHS.
Chelostoma	Cerambyx	Chelonus	Bombyces
Specodes	Anthrenus	Elater	Saturnia
Halictus	Colymbetes	——	
Andrena	Scolia	ICHNEUMONS.	
Eucera	Anthrophila	Pteronus	

It has been supposed that they were chiefly the organ of touch, probably of smell also, and of hearing. Certain it is that they are most important to the insect, and that special contrivance for their preservation and use may be observed in many tribes. I will but mention a few examples. The common Water-scorpions, Nepa and Belastoma, have very deep kidney-shaped boxes between the eye and the throat to defend their singular antennæ. Cryptocerus, a remarkable ant, has a square plate, the sides of which form a longitudinal cavity in which the antennæ lie quite concealed and safe. Many of the Diptera have furrows in their foreheads, which receive and protect the antennæ in repose. Many beetles, Anthrenus and Byrrhus, have cavities under the prothorax or breast, where, when alarmed, their antennæ are secreted.

But in proof that they are certainly organs of sensation in a high degree, it has lately been discovered that the antennæ of Bees, Wasps, Flies, Dragon-flies and Ichneumons have peculiar structures which had never been described before. Dr. Hicks published his papers on the subject in the 'Transactions of the Linnæan Society, 1857.'

ANTENNÆ OF SYRPHUS, OR OF BLOW-FLY.

(*Musca Vomitoria.*)

Either of these may be taken to illustrate what is stated by Dr. Hicks. If properly mounted they will be transparent; and on the third joint of each example will be seen a multitude of transparent dots. These dots are perfora-

tions of the inner coat of the wall of the antenna, closed externally by a very thin membrane. Behind this perforation is a sac which, when the antenna is crushed or broken up, may be found floating about in the fluid. There are about 17,000 of these sacs in each antenna. Besides these simple sacs there are large spores, which lead into chambers from which numerous little sacs or sacculi radiate. These apertures are fringed with very minute hairs. There are about eighty of these cavities on each side of the antennæ. They are filled with fluid, closed in from the outer air by a very thin membrane, and to each little sac a nerve proceeds from the large antennal nerve.

This will be seen better in

ANTENNÆ OF BEE.

On the last three joints of these antennæ, but only on one side, we find these vesicles or sacs; and if properly prepared the great nerve may be distinctly seen, giving off three bundles of finer nerves, each of these dots receiving one.

ANTENNÆ OF ICHNEUMON.

One species of Ichneumon will give singularly-shaped perforations, in which the transparent membrane over-arches and extends beyond the aperture, and gives it the appearance of an inverted canoe.

ANTENNÆ OF ARGYNNIS.

Argynnis, or Fritillary Butterfly, tawny coloured, with black lines and spots on the upper wing, and silvery streaks and spots on the under side of the hind wing. The antennæ possess small transparent dots and chambered cavities.

PALPI OF ARGYNNIS,

a very pretty object, showing the scales or feathers of the Butterfly *in situ*.

ANTENNÆ OF DRAGON-FLY

furnish the most beautiful examples of these acoustic chambers, and display the nerve well.

ANTENNÆ OF SILKWORM MOTH.

These will form an example of the variation of the Antennæ in the sexes, those of the male Moth being pectinated throughout equally, while those of the female have shorter branches, and alternately one long and one short.

To prepare the antennæ of Bees, Wasps, and Flies, for these observations, it is necessary to soak them in chlorate of potash, with a few drops of hydrochloric acid, until they are colourless; then dry them and mount in balsam.

SPIRACLES AND TRACHEÆ.

SPIRACLES OF DYTISCUS.

The Dytiscus is a large Water-beetle, very common in ditches and ponds, belonging to the pentamerous Coleoptera. It passes its first stage of existence wholly in the water as a most voracious larva, with long narrow body and strong head, armed with mandibles, breathing by the anus, and rising frequently to the surface, when it hangs head downwards and the body curved like an S. When full-grown as larva it buries itself in the earth, changes to a pupa, and afterwards to the perfect insect. It is from the Beetle that these spiracles or breathing organs are taken.

Few objects are more beautiful than those prepared from the respiratory apparatus of insects. The blood of insects is aërated, not by its passing through particular organs, as the lungs in some land animals, or the gills of fish; but the air is circulated in every part of their body by means of delicate spiral vessels, called tracheæ, or air-tubes, which ramify into the minutest organs. As you observe these spiracles, look also at these slides, which are very commonly found in all collections.

TRACHEÆ OF DYTISCUS.

You see they greatly resemble the spiral vessels of plants; within the outer membrane an elastic fibre winds round and

round in close and regular coils, and then comes another thin transparent membrane, closing it in and securing it from disturbance. When these tubes are pressed flat and are large, as the tracheæ of Dytiscus, then the double wall of fibre crossing each other gives an appearance of watered silk. Vessels such as these in the tongues, wings, and throughout the body, are easily dissected for examination, by opening the abdomen and floating off the fine white threads which branch off on either side from every spiracle. This brings us back to the spiracle itself, which is on every segment of the abdomen, an oval opening defended by those beautiful arborescent hairs, preventing dust or particles of harmful substance from entering in and lacerating the delicate tracheal vessels.

SPIRACLES OF COCKCHAFER.

(*Melolontha.*)

Here is a difference of structure in the spiracles of the larva of Cockchafer, which burrows in the earth to a great depth, and whose naked body has no defence for its tracheal aperture; therefore the spiracle, though very small, is doubly protected by a framework of bars, stretched from side to side of the thickened margin, and a membrane dotted with minute holes covers these again, effectually protecting the tracheæ, whilst it freely admits the air.

SPIRACLE OF FLY,

is a modification of the spiracle of Dytiscus. It is interlaced with branching fibre.

SPIRACLE OF TIPULA.

This has a solid disc in the centre, and radii proceed from thence to the margin.

SPIRACLES OF WATER LARVÆ.

These are best examined in the living larvæ of the Gnat, where the last segment of the abdomen is prolonged into a tube, the mouth of which remains at the surface of the water whilst the animal breathes.

There are, however, other and quite different modes of respiration in aquatic larvæ, which form beautiful microscopic objects.

AERATING LEAFLET OF LIBELLULA,

the larva of one of the Dragon-flies, those slender, beautiful blue and scarlet flies, which glance like living sunbeams across our path on a summer's day, and may be found in thousands resting on the reeds and bushes at the river's side. When these are in the larval state, they have three leaflike plates at the extremity of the abdomen, over which innumerable tracheæ ramify and draw from the water that supply of air which is needful for their life.

ABDOMEN OF EPHEMERA, OR SPIRACLES.

The larva of the pretty May-fly, or Ephemera, has on either side of its body a row of little leaflets, each of which is an external spiracle, and when alive it is most interesting to watch its palpitations, the play of those tiny organs drawing oxygen from the water to aërate the blood. It is best thus to see it, because we are able to observe the circulation of the blood through the transparent skin.

CIRCULATION OF BLOOD.

All creatures that have life have blood: it is the nourishing fluid which is needful for existence. In insects, it is colourless, but composed of minute corpuscles, which are propelled through the body, not by arteries and veins, but by one great dorsal vessel, constricted at intervals, and one end of which is closed, the other open and acting as the aorta of the heart. We see it here constricting and dilating, pumping out the blood which bathes the whole interior of the body, flowing into the antennæ, the legs, the wings—taking all directions. Here also we see a regular current through each appendage of the tail, and backward it is drawn into the long dorsal vessel through some lateral fissures in it, which are closed by valves, preventing its return. Moreover, we can see in this larva the constrictions of the heart,

its divisions into parts or chambers, called cardiac chambers, each of which is closed by a little door or valve, only opening upwards, so that the onward flow of the blood is secured, and out it is forced from the aorta again to continue its circulation. We understand better when we have watched this in the living creature, how the delicate tracheal vessels receiving air through the spiracles give it out to the blood in which they are immersed. Although there are no distinct membranous veins in insects, yet the blood flows in regular channels formed by the interstices of the flakes of fat, air-cells, muscles, &c. The pulsations vary in different insects. Hunter counted thirty-four pulsations in a minute in the heart of a silkworm; which we can do, as the great dorsal vessel is very distinctly seen constricting and dilating in the full-grown larva. When excited by fear or muscular exertion, the action of the heart is accelerated to as many as 100 and 140 pulsations in a minute.

In examining the larva of Ephemeræ, which are abundant in most ponds, simply confine it in a live box with a drop of water, and just press it sufficiently to keep it still, yet unhurt. If you cannot easily find a larva of Ephemeræ, any waterbutt in summer will abound with larvæ of Gnat, and they will do nearly as well. So also will a newly-hatched Fly, or a young Bee, just before it emerges from the pupa case; in these the circulation will be observed in the wings.

SPIRACLES OF LARVA OF BOT-FLY.

(*Œstrus.*)

See egg of Œstrus for an account of the Bot.

WINGS OF INSECTS.

There is much to learn in the wings of Coleoptera, Hemiptera, Hymenoptera, and Diptera. The scales or feathers which clothe the wings of Lepidoptera are noticed under Scales of Moth. The Diptera are classed by the veining of the wings, and therefore it is absolutely necessary to have a few specimens mounted as lessons for the names of the nerves or veins of the wing.

The wing itself may be described as a transparent membranous organ, consisting of two laminæ, or plates, which are united by canals called veins or nerves. These veins are hollow channels through which the circulating fluid flows, and a tracheal vessel runs in communication with the tracheæ in the thorax.

In the Ladybird's (*Coccinella*) wing, the blood is not confined to these canals or veins, but circulates freely through a large part of the wing. The circulation may be seen in the wing of any newly-hatched fly, but especially in that of the beautiful lace-winged fly, Hemerobius, where it was first noticed by Dr. Bowerbank.

WING OF SCATOPHAGA.

Although this is fully described for the slide of Scatophaga, mounted whole, it is mentioned here as the best lesson on the veins, and very easily put up separately. If merely mounted dry, the veins are sufficiently seen, but when soaked for a few days in turpentine and mounted in balsam, they become transparent from the expulsion of the air; and then not only the canals, but the tracheæ, may be visible, especially in the costal vein.

Observe that strong vein bordered with hairs on the fore-margin of the wing—that is the *Costal* vein; and in the Coleoptera there is inside a little bag of fluid called the *Phialum*, by which the fly can, at its pleasure, increase the weight of its wing, and sink or fly slowly.

The short vein next to the *Costal*, ending at about one-third of the length of the wing, is called the *Sub-Costal*.

The next to that is the *Mediastinal*.

The next is the *Radial*, which forks off at its base; and the farthest branch is the *Cubital*, always an important vein.

After the *Cubital* comes the *Præbrachial*, joined to it by a transverse vein, called the *Discal transverse*.

WING OF HOUSE-FLY.

(*Musca.*)

This is an example of the true fly's wing. The Muscidæ are very numerous, and divided into many groups and

families; the third joint of the antennæ, always the largest in this family, enables us to recognise a true Musca at once. After that we must look at the wing, which varies very much in the number and position of its veins.

There are many house-flies. The *Musca domestica* will show the præbrachial vein, forming a rounded obtuse angle at its flexure, nearly straight from thence to the tip; the discal transverse vein nearly straight, parted from the border by more than half its length.

This little wing makes 600 strokes a second, carrying it five yards; if alarmed, can increase its velocity to thirty-five feet in a second.

WING OF BLUE-BOTTLE FLY,

(*Musca Vomitoria,*)

will show the *Discal transverse* vein with *two* distinct curves, parted from the border and from the flexure of the præbrachial by hardly one-third of its length. The antennæ of this fly have the third joint remarkably long, and furnished with peculiar organs of smell. (*See* Antennæ of Blow-fly.)

WING OF SYRPHUS,

not one of the Muscidæ, or true flies, and therefore a good example of a beautiful variety. The Syrphidæ are a numerous family, comprising thirty-one genera; they are mostly seen hovering over flowers, vibrating their wings as they pause awhile, then darting with rapid flight a short distance only, and becoming stationary again. Many of the species make a humming noise like a Bee, and are mistaken for either Bees or Wasps.

The veining of this wing is an excellent lesson. The *Costal* vein ends just before the tip of the wing, and receives the *Radial*, or *Cubital;* for both these veins are not always present in the Syrphus wing.

The *Mediastinal* is very distinct; a transverse vein connects the *Cubital* with the *Præbrachial* near the margin. But the chief distinction lies in one or two spurious veins,

one of which crosses a small transverse vein between the *Præbrachial* and *Cubital*, and the second, when present, runs behind the *Pobrachial* vein.

These examples of wings are most useful in awakening attention to the importance of minute observation, to the perfect order of Creation in all its parts, to the distinct individuality of each tiny fly in the presence of Him who made it. How little we think of this; how carelessly we glance at the flies on our window-panes; they are nearly all alike to our unseeing eyes. We complain of them, lay traps for them, kill them, but it seldom occurs to us that we had better *study them.*

WING OF MIDGE.

(*Psychoda.*)

Only two examples more will I give—the wing of a Midge and the wing of a Gnat. These both belong to the first order of Diptera, the Tipulidæ, which comprises all the Gnats, Midges, and Daddy-long-legs, or Tipulæ. There are many more veins in this tiny wing than in any yet noticed, and the number of *areolets* or enclosed spaces in the wing is thirteen, every vein thickly covered with fine hairs; these are supposed to assist the insect in its downward flight, by fixing the atmospheric fluid, which glides over it as they rise.

The motion of a little Midge on the window-pane is always zigzag, from right to left, and left to right. Some wings have six or seven spots upon them, and are called *Psychoda sexpunctata.*

WING OF GNAT.

This wing differs in the various species of Gnats which haunt our waterbutts, and tanks, and stagnant ponds. Some have more beautiful scales than others, but this wing of the common Gnat (*Culex pipiens*) is a good study and a most pleasing object. Look at it with the lowest power for the veining, and then with the highest for the scales.

The Gnats belong to that division of flies called Tipulidæ, and also Nemocera, which means having the head

branched. They all have long and beautiful antennæ, which, in the males, are plumed and whorled like the stems of Equisetum.

The wings are narrow and lanceolate.

Sub-costal vein ends a little before the tip of the wing.

Radial, branched from the *Sub-costal*, and is forked.

Cubital vein begins from the *Præbrachial* small *transvese.*

Mediastinal is between the *Radial* and *Costal.*

Præbrachial is also forked. There are fourteen areolets.

The scales of a Gnat form test objects of the defining power of an object glass. Scales are composed of two or three layers of membrane, and probably the longitudinal ridges in these scales may represent folds of the outer membrane. We should not only see these striæ, but the delicate transverse markings and projections of the lines beyond the top of the scale.

Gnats fly silently in winter and early spring, before the thirst for blood is awakened, and then the female only sounds the shrill clarion of war in her eager flight to and fro. See the Gnat (*Culex*), mounted whole, and for the complete knowledge of Flies, consult 'Walker's British Diptera,' vol. iii.; 'The Insecta Britannica.'

WING OF COLEOPTERA.

Beetles have four wings; but the upper pair, being crustaceous and used only as a protection for the under pair, are called *Elytra.* Their use is obvious from the habits of the Coleoptera; they burrow in the ground and reside under the bark of trees, or beneath stones, when the undefended membranous wing would receive the greatest injury. The under wing is particularly described when examining the slide of Telephorus.

Both of these should be mounted and observed. The upper pair, or Elytra, if properly prepared, are very beautiful polariscope objects, especially those of Dytiscus and Cockchafer (*Melolontha*).

But there is a more important notice to be taken of the internal structure of the Elytron. Dr. Hicks discovered the same vesicles here as he did in the antennæ of Flies

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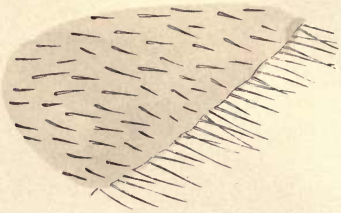

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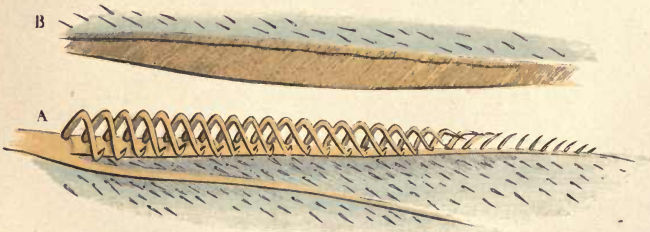

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1. Wing of Earwig, shewing its method of folding up.
2. Wing of Earwig, magnified 4 diameters. 3. Earwig flying, natural size.
4. Wing of Whirligig-beetle, magnified 5 diameters. 5. The same, natural size.
6. Minute portion of Beetle's wing, magnified 420 diameters. 7. Wasp's wing, folded.
8. Wasp's wings, hooked together, magnified 3 diameters.
9. Hooks on Wasp's wing, magnified 60 diameters.

and Bees. (*See* Antennæ.) The wing-nerve branches over the Elytron, and those dots which exhibit the black cross with polarized light, are vesicles or organs of sensation, to which a distinct branch of the nerve may be traced.

Soak the Elytron in potash for a week or more, and when perfectly transparent mount in balsam.

The under wings exhibit groups of these vesicles on the under side of the sub-costal nerve, as many as 200 and 300 in each wing. Observe the wing of Strangalia, a Longicorne Beetle. (*See* 'Journal of Linnæan Society,' vol. i. p. 136, Nov. 1, 1856). See also Elytra of Diamond Beetle.

WING OF CRICKET.

(*Acheta domestica.*)

This is mounted to show the organ of sound, the drum and file by which the male Cricket chirps. Each of the upper wings, or Elytra, has a round transparent space called the drum, or tympanum; at the base of each Elytron is a transverse horny ridge, furnished with numerous short transverse ridges or teeth, and forming a kind of bow or file. The insect rubs the Elytra across one another, and the grating of the files, together with the action of the drum as a sounding-board, causes the loud chirp. Some naturalists think that the *legs* work against this file and produce the sound, particularly in the Grasshopper, whose thighs are armed with rough ridges and short spines, and act as the bow against the files and drum of the Elytra.

The male Cricket only chirps. The female, silently at home, occupies herself in laying about 300 eggs and in rearing her brood. The tongue of a cricket is a beautiful object.

SCALES OF INSECTS.

The feathers of a Moth, a Butterfly, a Gnat, the scales of a Beetle, of a Weevil, of the Podura, are all both favourite and useful objects for the microscope. It is well known to every one that the dust which remains on our fingers after touching a butterfly's wing is a mass of beautiful feathers,

or scales, varying in shape and colour with the species; and that some are so delicately ornamented with a tracery that no unassisted eye can see that they form test objects for the defining power of the microscope.

Besides that use, we learn much from viewing a part of a butterfly's wing as an opaque, and observing how the scales are arranged on the membrane of the wing exactly like the tiles on the roof of a house;—this is called being "imbricated"; each scale furnished with a point at one end which fits into a cup-like socket, attached to the skin of the body or the membrane of the wing. When the scales are rubbed off and transparent, we can better observe their structure, and we have some excellent examples in the slides numbered here.

SCALES OF MORPHO MENELAUS.

Each scale or feather consists of three distinct laminæ, two external and coloured, the inner one a highly polished colourless membrane, which reflects the light and increases the brilliancy of the scale. The *Morpho menelaus*, a large foreign butterfly of gorgeous blue, has striated scales, and with very high power, each line is slightly beaded, giving the appearance of transverse scoriæ; but to see this the achromatic condenser must be used.

SCALES OF POLYOMMATUS ARGUS,

a British Butterfly common as the pretty blue butterfly of the cornfield, or the seaside Downs; has peculiar scales shaped like a battledore with long handle, and the longitudinal lines are swollen at intervals into rounded elevations, which give it a dotted appearance, except towards the base, where a crescent-shaped cloud of minute pigment-cells crosses the scale, and forms a distinguishing mark of the species.

SCALES OF HIPPARCHIA JANIRA,

our little meadow brown Butterfly, which flits so merrily about the long grass in June to October, laying its exquisite eggs upon the stems, from which a green striped caterpillar emerges in due time. These are the scales of

its brown wings, most excellent test objects, and giving different markings. When dry, or in balsam, or when viewed by oblique or direct light, we see that the rounded end is toothed, and bears a brush-shaped appendage.

SCALES OF PONTIA BRASSICA.

The common Cabbage Butterfly, whose history is too well known to need remark; the earliest and latest of our summer friends and garden enemies. There are several shapes in the scales of its wing, a very long and slender one, and some more of the battledore shape, and heart-shaped, with beautiful striæ. Observe also a portion of the membrane, where the scales or feathers are rubbed off. The apertures into which they are fixed are little cups or tubes, the orifices of which are set backward; and around each are radiating folds of the upper membrane, giving them a star-like appearance.

SCALES OF THE SILKWORM MOTH.

The Silkworm Moth (*Bombyx mori*) has a variety of scales, toothed, and broad or narrow, and Leuwenhoeck reckoned no less than 400,000 of these delicate scales on the wings of one moth.

SCALES OF CLOTHES MOTH.

From the under side of that troublesome little Tinea we obtain a beautiful test object of very fine striæ. Also from the Podura.

SCALES OF PODURA.

The Podura is a small gray wingless insect with six legs, and a long forked tail, bent inwards, and by means of which it leaps and springs about in the sawdust of our cellars, and under stones, and in moss in damp places.

SCALES OF LEPISMA SACCHARINA.

A first cousin of Podura, haunting our sugar stores, and originally a native of America. It does not leap so well as Podura, if at all; for its body does not terminate in a forked tail, but in several long thread-like styles, and it runs swiftly along, the little silvery gray body closely covered

with these beautiful scales which require high and good powers to see distinctly.

A few words may be added on the appearance which Podura scales should present as a test object. Under a medium power they resemble watered silk; light and dark lines wave across the scale in irregular bands; but with better definition every dark band should be resolved into rows of short lines, thick at one end, and very fine at the other. Yet these apparent lines are *not* lines. We must have a higher power, a good quarter-inch lens, and then with careful management of light—always a most important thing—we shall see that the apparent lines are really *spaces* between the wedge-like particles which make up the layer or upper surface of the scale. As a test object it is out of fashion; the dots of the Pleurosigma and the striæ of Grammatophora and Pygidium of a flea being preferred by many scientific observers.

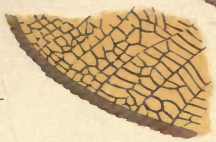
ELYTRON OF DIAMOND BEETLE.

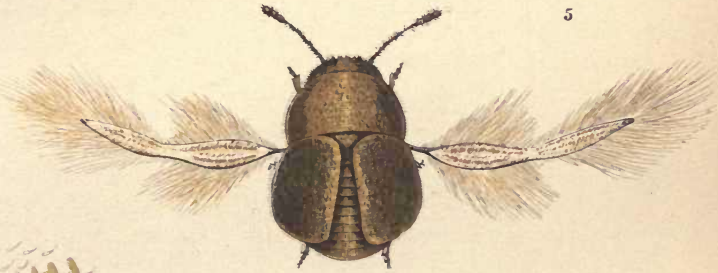
A most beautiful object, to be looked at with reflected light—that is as an opaque. These brilliant spots are groups of scales, fashioned precisely like those of a butterfly's wing, but owing to their iridescence, to the peculiar thinness of the upper layer and the reflecting power of the secondary layer, the colour changes like that on a soap-bubble by the varied position of the light, the dark cell in which the scales are set adding to their brilliancy. The Diamond Beetle is one of the weevil tribe, and a native of South America; but we have smaller Diamond Beetles in our own country, and the Curculio of the oak and of the beech, a little green and gold weevil, by no means rare on nettle-plants, is quite as beautiful under the microscope, having the same kind of scales, set in dark cup-like recesses on its elytra.

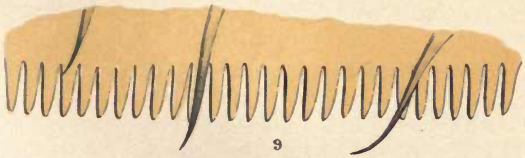
FEET AND LEGS OF INSECTS.

FOOT OF SYRPHUS.

Although the feet are better studied with the leg and upon the whole insect, yet as those specimens are not so







1. Small Dragon-fly. 2. Part of small Dragon-fly's wing, magnified 7 diameters.
3. Wing of another species of Dragon-fly. 4. Part of wing, magnified 7 diameters.
5. Minute Beetle, common in Spring 6. Beetle, magnified 30 diameters.
7. Hairs of Beetles, magnified 420 diameters. 8. Wing-case of Beetle, magnified 50 diameters.
9. Teeth at the base of wing-case, magnified 900 diameters.

easily obtained as the foot of Syrphus, it should by all means form part of an educational box.

The Syrphus is one of those flies which vibrate over our flowers in the summer, and haunt the Michaelmas Daisy in the autumn. They are called Drone-flies and Wasp-flies, and are mistaken sometimes for one of the Hymenoptera.

This foot displays that pair of membranous expansions called *pulvilli* which enable the fly to walk up and down smooth surfaces, on glass and on ceilings, in opposition to the laws of gravity. They are fringed with minute hairs, each of which is tubular, and secretes a viscid fluid which attaches the foot to the surface of the glass or wall, and the hooks on either side act as fulcra or props, with which the fly pushes against the substance when it desires to detach itself. The joints above the pulvilli are called tarsi.

LEG OF DYTISCUS, OR DYTICUS.

A most splendid object for the polariscope. The Dytiscus is a large water-beetle, common in ditches and ponds, and this is the fore-leg of the male. That large round disc is composed of three joints of the tarsi, which are studded with suckers; one is extremely large, furnished with radiating fibres, and another is somewhat smaller, with single cup-like suckers raised on stalks, altogether giving it an immense power of adhesion.

FOOT OF WASP,

another favourite object for the polariscope: the tarsal joints are well seen, as also the hooks on each side of the pulvillus.

FOOT OF OPHION.

These toothed claws belong to an Ichneumon-fly (Ophion), which deposits its eggs in the larva or caterpillar of a moth (*Bombyx Vinula*, Puss Moth). The fly is yellow and has a sickle-shaped body, the ovipositor slightly exserted.—(*See* Hymenoptera Microgaster.)

HIND-LEG OF BEE.

This is to show the peculiar structure of the hind-leg of the Hive-bee. The worker-bee—not the queen, nor yet the drone—has this beautiful contrivance for gathering the bee-bread, and carrying it home to the hive. The Bee collects the pollen of flowers, and rolls it into little pellets, which she places in two hollows on the outside of her hind-legs, called *the baskets*. This is done by her mouth and these hairy legs, which help to collect the pollen, and work it into shape and consistence.

Every leg has ten rows of these hairs, and sixteen hairs in a row. Count them, and observe how short and stiff they are, exactly what the Bee wants for her work.

FORE-LEG OF BEE.

The fore-legs of the Hive-bee, or Carder, or Humble-bee, exhibit a peculiar notch and spur on the tibia, which the insect uses for clinging each to the other in the festoons of wax-secreting labourers, or for nipping the legs of an enemy. There is a deep notch edged with stiff short bristles, and above it a spur, fashioned somewhat like the blade of a pocket-knife, which closes over it, and must be a most useful appendage to the busy Carder-bee in hackling its moss. It must not be soaked long in potash or the spur falls off. Mounted dry for the binocular it is well seen, and the modifications adapted to each species are very interesting.

LEG OF GYRINUS.

The Gyrinus is a small Water-beetle, that merry little fellow who assembles with a host of comrades, whirls round in ceaseless play on the surface of the quiet pond, or sunny margin of the river. Boys call it the Whirligig Beetle. These curious hind-legs, of which he has four, are the oars and helm by which he propels and steers his little body with such velocity through the water.

The structure is remarkable, the femur and tibia are somewhat triangular, the latter fringed with short spines, and long flattened filaments; in the middle pair of legs

these filaments are on both margins, on the hindmost only on the outer margin.

The tarsi are five-jointed, but the three upper ones are most curiously fashioned into long leaf-like lobes, fringed with spines, the fourth joint is about the same size and semi-circular, and the fifth very short-armed, with two claws, as indeed is each tarsal joint.

Circulating currents may be seen in the hind-legs. Also, if you catch one, examine its very curious eyes divided into two parts, the upper group for viewing objects in the air, and the lower those in the water. The antennæ are remarkable, not only in shape, but in being retractile and having each an ear-like joint fringed with colourless flat hairs, which shuts it into the cavity in front of the eyes.

LEG OF BRACHINUS.

(*Bombadier Beetle.*)

A small red and black Beetle, common near London, which has the power of defending itself by letting off smoke with the noise of a pop-gun. It is furnished with an internal bladder capable of firing off twenty shots in succession. If this smoke gets into the eyes it makes them smart as if they had been bathed with brandy. This little fellow has a bitter enemy in the Calamosa, a larger beetle, which hunts it without mercy. As it finds it impossible to escape by speed of foot, it stops short and awaits its pursuer; but just as he is about to seize it, he is saluted by a discharge, and while he is for a moment stupefied with surprise, the bombadier endeavours to gain a hiding place.—(*See* 'Insect Miscellanies'; also Bouche de Brachinus, in Baker's collection.)

LEG OF ANCHOMENUS,

a small green Beetle, nearly allied to Brachinus, as the leg will show; both of them have that very curious curve in the tibia which is peculiar to the Carabici. These are swift-running beetles, and many of them have no wings under their elytra: they belong to the Pentamera, having *five* tarsi or ankle-joints.—(*See* also Bouche et Palpes, in Baker's collection.)

LEG OF CALATHUS CASTELLOIDES.

A very abundant and pretty Beetle about half an inch long, black or brown, with black, or sometimes red legs. Found under stones near London. It has five joints in the tarsi, therefore belongs to the first order of Coleoptera, the Pentamera. The claws are toothed like a comb, and the male has three joints of the anterior tarsi dilated. (*See* also Bouche et Palpes de Calathus, in Baker's collection.)

STING OF WASP AND BEE.

The weapon of defence given to these insects consists of a barbed dart and a bag of subtle poison. The dart itself is composed of two blades, with serrated edges, enclosed in a sheath, and attached by strong muscles to the side of the abdomen; near the slit by which it protrudes are two hairy appendages, which act as brushes and keep it clean, and at a short distance within a slender canal leads to the bag of poison, which, pressed by the muscles in the act of stinging, gives out the acrid drop which irritates the wound to such painful swelling.

STING OF GNAT.

See Head of Gnat.

STING OF TABANUS.

See Head of Tabanus.

EGG OF BOT-FLY, OR ŒSTRUS.

There is not a more curious and interesting object than this. Those little spots which cover the fore-legs of horses from the latter end of July to the end of September, are eggs like this, deposited by a fly called Œstrus, or Gad-fly. The longest period of this fly's life is passed in the intestines of the horse, and all the winter every horse exposed by field work or pasture feeding to the attacks of the Œstrus is full of the larvæ which hatch from this egg.

The fly itself appears only in July, and is properly called

Gasterophilus, or Stomach-lover. A tawny body very hairy, wings dingy white, and with a transverse gray band; without any proboscis, for it lives but a very short time—only to lay its eggs and die. The abdomen is bent inwards, the female having a retractile tube consisting of four pieces, and terminating in five points, within which she holds the egg, and hovers over the horse, lightly darting at him, and depositing each egg upon a hair. This egg is firmly attached by some glutinous substance, and is, as you may observe, finely striated and furnished with an operculum or lid, hinged and fitted on that oblique top. When the larva is fully formed, the egg, which is always placed where the horse most frequently licks itself, opens under the warm moisture of the tongue, and the larva, which is provided with hooks for the purpose, clings to the tongue, and is swallowed with the saliva or the food. By two long sharp hooks you may see folded downwards on the larva it attaches itself to the inner coat of the horse's stomach, nourished by the warmth and the mucus until the spring, when it has grown nearly an inch long; it then unhooks itself, mingles with the food, and passes out as what grooms call *bots*. The next change is that it wriggles into the earth, and becomes a pupa, lies there a few weeks, and comes forth as a perfect fly, to rise up and seek its mate, who dies immediately after their union, and the female lingers but a few days longer, to deposit a hundred eggs, or more, as her appointed task on earth.

CHAPTER III.

INSECTS MOUNTED WHOLE.

COLEOPTERA, HEMIPT. HYMENOPT., as C. iv. DIPTERA.

Hitherto we have only examined parts of various insects, and whilst they have surprised and delighted us by their curious or beautiful forms, and shown us how perfectly they are adapted to the wants of each insect; yet we have but a very imperfect idea of the anatomy of any single insect without one of these beautiful preparations.

They cost years of thought and experience to bring to this perfection. To preserve the delicate body entire, yet make it perfectly transparent, so as to display every joint, and in many cases its internal muscular structure; to fix it in its natural position, and embalm it, as it were, in the clear preservative medium, Canada balsam; to draw out the beautiful tongue, or the wonderful ovipositor, and show the varied and fragile antennæ, or lay out the fine tissue of the wings, was the work of many a day before this art was attained.

And these slides are so valuable to the young student of natural history that no microscope box should be without one or two illustrations of each of these orders—Coleoptera, Hemiptera, Hymenoptera, and Diptera.

No engraving can teach the lesson upon insect anatomy so well as that which is learnt at the microscope with one of these slides upon the stage.

Take, for instance, one of the Coleoptera—

THE TELEPHORUS, OR SOLDIER-BEETLE.

We find this little creature abundantly in our gardens, on hedges, and on the long grass of a sunny June morning; but especially on the flowers of all Umbelliferæ, such as

the wild Parsnip, Carrot, and Parsley. They have orange-coloured elytra, or green or buff, tipped with red. Children call them "soldiers" and "sailors." Carnivorous in their tastes, they haunt flowers for the smaller insects they feed upon, and seize them fiercely in their strong pointed mandibles. When we touch them they depress their heads, become motionless, and counterfeit death.

They lay their eggs in damp shady places in the earth, where the larvæ hatch and live. These are velvety, black, long, soft-bodied maggots, with strong mandibles on their heads, and a curious fleshy tubercle beneath the last segment of the body, which they use in walking.

Use your lowest power in examining these preparations for a general view of the insect, and then change the object glass progressively upward to the highest power for such parts as require particular attention—the tongue, the eye, &c.

The first part to look at in a slide of Coleoptera is the foot, because the number of joints immediately above the claw, which are called tarsi, determines its position in the family group. All the Beetle tribe are divided into families according to the number of joints of their *tarsi*. There are four sections—

The Pentamera .	or five-jointed.
The Heteromera .	or five-jointed anterior, and four-jointed posterior tarsi.
The Tetramera .	or four joints to all the tarsi.
The Trimera . .	or three-jointed tarsi.

The foot of Telephorus, having five joints, belongs to the first section. Observe how deeply the penultimate joint is bilobed—that the *tibia* or joint above the tarsi has two small spurs—that the *femur* or thigh is stout, and attached to the thorax by two other joints called the *coxa* and the *trochanter*.

Next observe the antennæ; for after deciding this little beetle to belong to the section of the Pentamera, you will know that it is also one of the Serricornes, or third family

of the Pentamera, by its long slender eleven-jointed antennæ of the same thickness throughout.

Next examine the curious hatchet-shaped joint at the end of the palpi—small feelers attached to the jaws, and which are very important points for observation, as their number and shape determine the species of many beetles.

We now see the various parts of the mouth—the *labrum* or lip notched in front; the two hairy *maxillæ* formed of five pieces delicately fringed, and used for cleansing the food; two strong *mandibles* or jaws for seizing their prey.

Two compound eyes which, in the male, occupy nearly the whole of the head.

The thorax, or body, to which are attached the three pairs of legs, and the wings and wing-cases.

This thorax is a wonderful piece of mechanism. It cannot be so well seen in this slide, because the elytra or wing-cases partly cover it; but it should be carefully studied in various specimens. There are three chief parts—

The pro-thorax; the segment nearest the heart, and supporting the first pair of legs.

The meso-thorax: bearing the elytra, or wing-cases, and the middle pair of legs.

The meta-thorax; bearing the wings and the last pair of legs.

But these are again composed of no less than twenty-two smaller pieces, equally distinct and present in the thorax of the tiniest beetle; and if we consider the complicated machinery necessary for the direction and control of all the muscles required for insect locomotion, the care bestowed upon the formation of the thorax will be at once accounted for. The movement of the legs in running, creeping, climbing, swimming, fighting, seizing their prey, cleansing their bodies, and the varied motions of the wings and wing-cases—these all demand distinct muscles and points of attachment. The whole cavity of the thorax is occupied by the wing and leg muscles, and the great ganglion of nerve which directs them as a viceregent from the seat of sensation, the head.

And whilst looking at the thorax of this little Beetle, as hereafter we may look at that of a Fly, it will not lessen our pleasure to be reminded of the many kinds of muscles that worked unerringly the will of this small creature. It had its *levator* muscles for raising its limbs; *depressors*, antagonistic to these, for depressing them; *flexors* for bending the joints; *extensors* for unbending or extending them; *abductors* for drawing an organ backward, and *abductors* for drawing it forward; *constrictors* that contract a body or an opening as in breathing; *laxators* that relax it. All these are in quick action in the little insect that runs over your hand or escapes from your eye; all these have been planned and attached, and the numbers so accurately interwoven, that they work without hindrance or confusion by the creative word of the Most High.

As the head for sensation, with its ganglion and branching nerves, and the thorax for locomotion, so the abdomen, usually in nine segments, is appointed as the digester of food and the organ of generation.

The internal parts of an insect cannot be seen in these preparations. We must therefore confine our attention to the external anatomy, and, before this slide is put away, examine the wing.

The wing of a Beetle should be compared with that of a Fly, in order to appreciate its peculiar structure. The substance is membranous, double and joined together by canals or nervures, through which the blood circulates—a tracheal vessel runs, and a nerve, branching from the thoracic ganglion, and giving off innumerable fibres to groups of vesicles situated immediately beneath the costal nerve. This is only seen with very high powers and good glasses; also requiring a particular preparation of the wing. It must simply be soaked in turpentine for a week or more, and mounted in balsam warmed just enough to receive the wing, when the tracheal vessel, the nerve, and the vesicles, may be distinctly seen with a good $\frac{1}{4}$-in. or $\frac{1}{8}$-in. object glass.

That strong nerve on the forepart of the wing is the costal nerve. As the Beetle's wing is folded under the

elytron when in repose, the costal nerve ends abruptly, as we see, at about half the length of the wing, and turning backward into the post-costal nervure, forms a kind of hook, strengthens the base, and allows of the easy folding up of the tip of the wing.

There is a particular provision made for the regulation of the specific weight of the beetle's wing by means of a long pocket just under the costal and mediastinal nervures, called the Phialum, into which a liquid is introduced at the will of the insect, which augments its powers of resistance in flight.

The veins, or nervures, are so placed throughout this wing as to strengthen and stretch every part: at the same time to admit of its being closely and easily folded under the protecting elytron; a most necessary arrangement for creatures who live in the earth or under stones, or in the water, where the delicate texture of the wing would be in constant danger of destruction.

Having thus examined one specimen of the Beetle tribe, we shall be able with increased interest to look at another, one of the small Water-beetles.

HELOPHORUS GRANULARIS.

This is an abundant little creature in our ponds and ditches, feeding on decayed or vegetable matter, and, being easily procured, is selected as an example of a Pentamerous Coleoptera, but of the family of the Palpicornes, the antennæ being very different from those of the Telephorus. These are clubbed, composed of nine joints, and carried backwards.

It is a bad swimmer, and the legs are scarcely, if at all, feathered; the striped pro-thorax and the beautifully dotted elytra make it a favourite and valuable object.

The sculpture of the elytra of Beetles is most remarkable; the ridges strengthen, the furrows lighten, the dots give air to the spiracles beneath. In the Helophorus alternate rows of large and small dots answer both purposes, and usefulness as well as beauty write the wisdom of God upon the wing-case of this little creature.

CATHERETES URTICÆ.

This is a lovely little Beetle; as we see by its tarsi, it is one of the Pentamera, though at first sight easily mistaken for one of the four-jointed Coleoptera, as the fifth joint is very small, and only visible from beneath. The antennæ show that it belongs to the *Clavicorne* family, for they are clubbed. This particular little Beetle is one of a flower-loving group called *Nitidulidæ*, always easily recognised by having eleven joints in the antennæ, and the last three in a club, or strung like beads, with an interval between each. The spotted elytra are beautiful. The facetted eyes and the delicate mouth will require a higher power rightly to examine them. And this exquisite insect is one we may see in swarms upon nettles revelling in the pendent blossoms any sunny summer's day—very small black creeping things we pass unheeded by.

COCCINELLA, OR LADY-BIRD.

This familiar little visitor is not only a beautiful object for the microscope, but a real friend to the florist, who is apt to be disappointed and angered by what is called the "green blight" upon the roses, and is not perhaps aware that two or three Lady-birds would clear it all away much better than the usual means applied by gardeners.

The Lady-bird is particularly fond of Aphides, and, in its larva state, pupa state, and perfect form, will greedily devour them, darting at an Aphis, and seizing it in those strong little jaws, shaking it as a terrier does a rat, and sucking its life away; then dropping the empty body, and springing upon another and another. The little Coccinella has frequently saved our fir plantations from the host of destroying Aphis in the spring; and our bean-fields, when attacked by the black blight (*Aphis faboa*), are often cleared again in an incredibly short time by the avenger God has given us in this lovely little Beetle.

It is one of the Trimera, three joints only in the tarsi.

The antennæ eleven-jointed, and terminated by a reversed conical club.

I must not describe so fully any more of these beautiful slides; but recommend you, if possible, to obtain the following whole mounted Coleoptera:

Lœcophilus Minutas, remarkable for its feathered legs.
Hattica, or Turnip-fly, ,, ,, thick muscular thighs for leaping.
Thyanus, or Grass-flea, also with muscular thighs and sculptured elytra.
Dimonia cynoglossi. one of the Tetramera, with thickened thighs and beautiful head.
Haliplus confinus . one of the Hydrocantheri, or Swimmers, with beautifully fringed legs for swimming.
Hyphidius ovatus . one of the Water-beetles, with fringed legs for swimming, and a curious spine at the tip of each elytron.
Oyrinus natator . a Water-beetle. (This is described in leg of Gyrinus.)

HEMIPTERA.

These are sucking insects. Their mouth has a long retractile tube, and several fine lancets, forming a long proboscis, which is laid along the breast during repose, and may be seen in all the Field-bugs (*Cimex*) and the Aphides, which belong to this order. The wings are membranous, and covered with semi-transparent cases analogous to the elytra of Beetles. The tarsi are always three-jointed. A few of them inhabit the water, and of these the *Velia rivulorum* and *Notonecta* are mounted whole.

VELIA RIVULORUM.

Most people have observed groups of water insects sporting on the surface of small ponds, or swimming

against small streams, walking lightly on the still water, and resting on the stems of grass or water weeds around. One species (Gerris) has a long thin black body and very long legs; but Velia may be known by its scarlet spots on each side of its body. The two-jointed sucker and the wing-cases should be carefully examined.

NOTONECTA, OR THE WATER-BOATMAN,

is a beautiful preparation, exhibiting the retractile sucker, which is a formidable weapon, and pricks sharply; the eyes very large; the hind-legs fringed with long hairs and in the form of oars, which it uses with great rapidity, rowing or swimming always on the back, and looking like a canoe propelled by a clever boatman. The eggs of this insect are found abundantly on the other side of Water-lily leaves, or of Potomageton; small flask-like eggs through which, in an advanced state, the red eyes of the little Notonecta may be seen, and when it comes forth, it only resembles its parent in its feathered legs and quick movements, having no wings until it has moulted several times, and changed from the larva to the pupa state, in which, however, it is by no means inactive, for the pupa of Hemiptera feeds as heartily as the perfect insect. This Notonecta is a fierce and powerful enemy to all smaller aquatic insects, transfixing them with his sharp proboscis, and sucking their life away.

REDUVIUS, OR BED-BUG,

is one of this order, and the sucker, though short, is very strong, and capable of producing much pain.

CIMEX, OR FIELD-BUG.

These are beautiful objects when mounted. The head is prolonged like a snout, more or less triangular; and the sheath of the sucker is composed of four distinct joints; they prey upon other insects; the body is often brightly coloured and spotted. We find them abundantly on long grass or field flowers in the hot days of summer, and one

species, *Pentatoma griseus*, is interesting from the care which the female takes of her young, not only in brooding over her eggs, but in leading her little family about as a hen does her chickens.

APHIS.

A specimen of the green or black blight will be very interesting to the florist, although the Aphis of the elder or the box are prettier in having variegated bodies. There are no less than 160 known species, and few insects have a more curious and interesting biography. 'Kirby and Spence's Entomology,' and 'l'Histoire des Hemiptères, de MM. Serville and Amyot,' will give abundant information to the student of natural history.

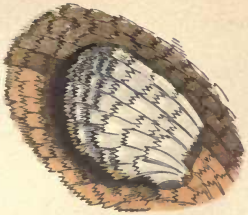
I can only draw attention to the external form, and point out the remarkable long antennæ thrown backwards; the proboscis, fine and sharp, with which it pierces the young shoots of our rose-trees, or the fibres on the under side of our currant-trees and vines, causing them to curl up and turn red. Those two horns on the back are tubes from which exude small drops of saccharine matter or honey-dew, of which the ants are so fond that, wherever these Aphides abound, there the Garden Ant will follow, and may be seen sucking it from them.

These Ants take absolute possession of some species.

The *Aphis radicum*, which feed on the roots of plants, are kept by the Yellow Ants in their formicaries under-ground, and milked as cows are by us. This may be watched on rose-trees or oak-trees, the little Ants following an Aphis, tapping them, and pressing their sides to make them jerk out the sweet fluid.

The tarsi are only two-jointed, the eyes compound. They are both winged and wingless, and the Aphis wings are always carried with the fan edges upward, and have either a row of hooklets or a tuft of seven or eight hooks, which attach the wing-case and wing together, like the *hamuli* of the Hymenoptera.

The rapid increase of these insects is astonishing: a single Aphis may in one season become the parent of as



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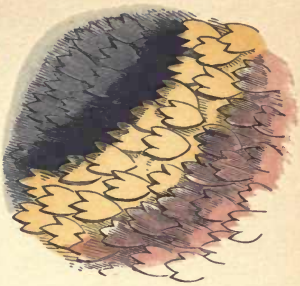

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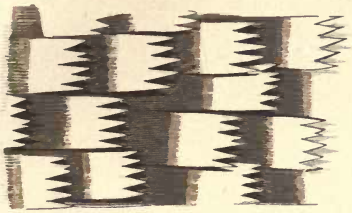

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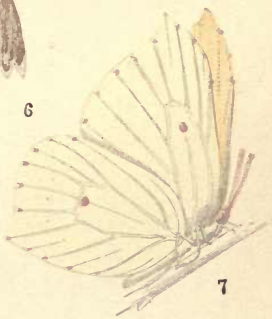

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1. Wing of Herald Moth. 2. Spot on Herald Moth's wing, magnified 60 diameters.
3. Eye-like spot on wing of Emperor Moth. 4. Part of eye-like spot, magd. 60 diams.
5. Scales of Underwing Moth, magnified 80 diameters.
7. Brimstone Butterfly. 8. Scales of Brimstone Butterfly, magnified 150 diameters.
9. Scales of Red Admiral Butterfly, magnified 100 diameters. 10. Scale, magd. 150 diams.

many as 5,904,900,000 descendants. The fact that these are produced by females without more than one impregnation throughout nine generations long perplexed our naturalists. Bonnet isolated females most carefully, and obtained nine generations in three months. It is now ascertained that certain females couple and lay eggs only in the autumn, and that throughout spring and summer the young ones are produced alive by a process of gemmation from what are called Nurses.

All through the winter one solitary female Aphis, which I had placed in my bedroom window on the leaf of a tulip, continued to present me with pretty little pink-eyed staggering things, until the whole plant was covered with them; and very curious it was to see the small Aphis keep close to its mother's side for some hours, whilst she seemed tenderly to caress it with her long antennæ, until another required her care, and this one was able to join the group of sisters at a little distance, whose tiny suckers were plunged into the juices of my Van Tromp.

For an account of their enemies and our avengers, see Hymenoptera, *Aphidius avena.*

APHROPHORA, OR CUCKOO-SPIT.

I suppose all florists will like to have this slide, because they so well know a certain frothy substance which abounds on their Carnation plants, Lychnis, Rose-trees, and Willows, in which sits a little green creature with red eyes; a soft, frightened, innocent-looking little larva, which I never could help covering again with the white froth if I had blown it aside for a moment. And this was the defence of the young Aphrophora we are now looking at: it passed from that larva into a pupa, and then into this perfect state with wings and wing-cases, with a long sucking tube, which pierced the stems of our flowers and dried up the plant by abstracting the sweet fluids needful to its growth. Observe the mottled wing-case, all of uniform texture, which shows it to belong to the second division of Hemiptera, called *Homoptera;* the wing with longitudinal nerves forked at the tip. The legs, which leap wonderfully high, are remarkably circled at each

tibia by a crown of spines. The mouth is better displayed in a specimen of Cimex.

THRIPS.

This is not now one of the Hemiptera, but belongs to a very small order called Thysanoptera. We find these very minute insects swarming in our flowers, especially in the Carnations and Lilies. They are long, black, active little creatures, looking like small beetles, and turn up their tails in a quick impatient way that reminds us of the Staphylinus, so fragile that we cannot handle them, except when mounted thus.

The short antennæ we see have eight joints, the terminal joints armed with a seta. There are four wings of equal size deeply fringed with hairs on all sides, and usually unnoticed, because they lie horizontally upon the back, and we seldom see them in use. The tarsi are short, and terminated by a vesicle instead of a claw. The mouth has mandibles and palpi, as well as a rostrum, or beak, with which it pierces the delicate young leaves of our Cucumbers, Melons, Vines, and fruit-trees, causing them to shrivel up. They also feed upon the pollen and pistil of the blossom, and often cause the failure of our fruit, and of the wheat crop, by creeping in between the valves of the green ear. Earwigs avenge us by preying upon them, which florists would do well to remember when they accuse the earwig of the destruction of their Carnations.

HYMENOPTERA.

TENTHREDO, OR SAW-FLY.

Sometimes we find "the saws" only of this curious fly mounted for the microscope; but at Baker's, and Smith and Beck's, you will doubtless obtain the whole insect beautifully prepared, and it is worth any money in the naturalist's collection, both as an example of the Hymenoptera wing and head, and also for its complicated and wonderful ovipositor. Few of the Hymenoptera can be mounted whole, for the order comprises all our Bees, Wasps, Ants, Saw-flies,

Ichneumon-flies, and Gall-flies. It is a most interesting group in the insect world, extremely intelligent, and commissioned by its Creator to minister to our comfort and to defend us from injury in a way that is little known beyond the labours of the Honey-bee.

The Hymenoptera are distinguished from all those which are called flies, by having four wings instead of two, wholly membranous, veined, and divided into cells, but not assuming the appearance of network, as do those of the Dragon-fly, the Hemerobius, the Ephemera, or May-fly; neither are they veined at all like the wings of the real fly (*Diptera*),—yet the plan is perfect, both to distinguish the group, and in that group the species from each other, as we shall presently prove. The eyes are large and compound in all the Hymenoptera; they have generally three simple eyes, or ocelli, on the crown of the head; the jaws are strong; the tongue of varied structure (*see* Tongue of Bee and Wasp), because the mouth organs are used not only for food, but also for labour in the structure of nests, and in providing for their young. The feet are somewhat like those of the Diptera, but are sometimes terminated by toothed claws (*see* Foot of Ophion); the tibia are often armed with spines, or very curious spur-like appendages, especially in these Saw-flies, and the tarsi are five-jointed. As a rule they all feed upon flowers, but I have found them very voraciously attacking insects in the hot sunshine of a June morning.

Their metamorphosis is complete; that is, they lay eggs, become larvæ with six-hooked feet, spin a cocoon, and change to pupa; then rise up and go forth winged and perfect.

The wing of the Hymenoptera is the most important part in ascertaining the genera, for all the antennæ are long, varying from thirteen joints to as many as sixty or seventy. They vibrate with singular sensitiveness, but are not like those of the Diptera, where the antennæ alone will often decide a fly, and the minute differences of their structure is in itself a study.

Here the index to God's order is in the wing, and if the

wings of your specimen are crumpled, as often happens when the chief anxiety is to show the saws of the female, then you had better get a male Saw-fly (*Cypheus pigmæus*), where I doubt not they will be expanded and perfect.

The first great rule is this: look at the costal nerve which bounds the fore part of every wing, and is the main support. Observe in all the Saw-flies and Ichneumons there is a dark horny spot called the stigma; from that a nerve or vein runs to the front tip of the wing, dividing the enclosure into one or two cells, called the *marginal* or *radial* cells. There is but one in Cypheus—a large oblong one. Behind this cell, and running nearly parallel at a little distance, is a nerve which ends at the tip of the wing, and the intermediate space is divided into from one to four cells, called the *submarginal* or *sub-cubital* cells, others in the centre are called *discoidal* cells, and others, long and narrow towards the base, are *basal* cells; but the two former are those upon which the genera are founded. Is it not wonderful—this invariable order exhibited by the presence or absence of one tiny nerve?—always present in every individual of a given species throughout the world; varied perhaps slightly, yet unerringly in the adjacent species; and the progress of neuration designates the rank of the species more easily in this than in any other tribe of insects. The little Platygaster, a very small Ichneumon-fly, which is noticed presently, has only the costal nerve and stigma—no cells at all. The pretty Chrysides, those scarlet and green or blue flies, which rush about restlessly on windows and walls in the hot sun, and are called the Humming-birds of insects, have only the front wings veined, and those with but a single cubital cell, and that not closed, and very imperfect submarginal ones. And then in other genera they go regularly increasing, until the wing is perfected in the Saw-flies and Bees. It makes our microscope so much more valuable when it helps us thus to a personal acquaintance with the "winged things" around us—when the eye becomes educated to discern the letters of creation's alphabet; for we are but children in the 'First Reading-book,'

and I doubt not there are volumes, countless and full of eternal wisdom, laid up in store for those who delight in the study of God's works.

We can now return to the slide before us. The colour of the Saw-fly is necessarily lost in preparing it transparently for our examination; but it was a bright and beautiful fly, yellow, or scarlet, or light green dotted with black. They provide for their young thus. I had the pleasure of watching the motherly care of the Saw-fly of the rose (*Tenthredo rosæ*) last summer.

A busy little fly with black thorax and yellow abdomen was at work upon a rose-tree so intently that she did not stir when I drew near to see what she was about. She bent her abdomen as you see here, and had protruded a pair of cutters such as these. They are, in fact, finely-toothed saws with about eighteen teeth each, and run backwards and forwards in a grooved back-piece, which fits on each like a carpenter's tennon saw. They worked alternately, and presently she changed her position: she had been cutting down *deep*, now she wanted to make a long groove, and straightened her body, sawing quite fast and steadily, making a furrow about half an inch long. Then she paused, and a little greenish egg was laid on one side, another on the opposite side, all along until a double row had been deposited of about twenty eggs; she then gave out a frothy glue which seemed to fix and protect them, drew in her ovipositor, and flew off to a neighbouring tree, where I took her for examination of the saws. The little eggs I looked at with a pocket lens, and found they were separated up the middle of the groove by a fibre left on purpose. From day to day I watched them, and they increased in size, which is different from *all* other eggs; the edges of the furrow became black and swollen, but did not close, and about ten days after I found all the little eggs empty, and several tiny green and black-dotted caterpillars wandering about, very like true caterpillars, which they *are not*, as may always be known by counting their feet, eighteen or twenty, whereas the larvæ of butterflies and moths, which are real caterpillars, have only from ten to sixteen, and never more.

Frequently our gooseberry trees are stripped bare by hosts of these young Saw-flies in larvæ; they spin cocoons, and remain coiled up in them all through the winter, remaining but a few days in the pupa state, and emerging in May and June.

CYPHEUS PYGMÆUS,

another Saw-fly. It will be most interesting to the farmer, because its larva is very troublesome in the wheat and rye-fields, especially in France, where it often destroys a great part of the crop. The fly itself is black and yellow; the male, as usual, differs from the female in colour and size; that is, he is of a brighter yellow, and the wings clearer and more iridescent; hers are clouded, and the yellow of her body and legs more ochreous. The larva is singular in having no legs at all, but a kind of tube at the end of its body with a telescope movement by which it progresses along its tunnel, for it feeds in the stem of wheat or rye; and its history is interesting. The female Saw-fly may be seen in a warm April day sawing a hole just bēneath a knot in the tender stem of the young wheat, and depositing one egg in each straw. This is soon hatched, and forthwith the larva begins to gnaw, with some exceeding strong though tiny mandibles, the juicy inside cells of the stem, which of course disturbs the economy of the plant, and prevents the upward flow of all the nourishment which is needful for the growing ear. As soon as it *can* it proceeds to grind away the interior of the knot also and ascend the stem. As it grows and thrives, the plant withers; but in the month of July begins to descend toward the earth, and a few days before harvest-time it settles itself near the root of the wheat, cuts the straw regularly round inside, so that it breaks off under the first puff of wind, and the little creature spins a warm cocoon and lays itself up for the winter, fat and happy, unless a certain little cousin, one of the Ichneumon-flies, has found it out, when his life will not have reached this period, or its mischief have been so fatal

ICHNEUMON-FLY.

(*Pachymerus calcitrator.*)

Always have several of these in your collection; they are beautiful and most interesting; they have been appointed to do a certain work, they have been gifted with wonderful instinct, and provided with fit instruments to perform it, and they are one of our many examples of obedience to the order of God, which we would do well to pause and consider. This little unheeded fly,—watch for it and learn its habits; examine it here as it is prepared for you.

It was black and reddish, with brown edging, and white lines across the segments of the abdomen. This we cannot see here; but we can see the antennæ, its first needful instrument for work, with twenty-two joints, each with a bristle inside, the wings large, transparent, and iridescent, the stigma yellowish-brown, the *one* marginal cell elongated. (Compare it with the wing of Cypheus, which has two marginal and four sub-marginal cells) and one sub-marginal large cell, with a little nerve running into it. The thighs are thick, and the tibiæ spurred.

They abound often on Umbelliferæ.

And this is its use in the world: to find out the larvæ of *Cypheus pygmæus*, wherever it may be, and destroy it by laying one of its own eggs inside its body, which, when hatched, will feed upon the fat of the destroying insect, and finally kill it, by preventing its further development. Now, considering that the Saw-fly maggot is carefully concealed in the wheat-stalk, the work is not so easy; for the stem must be pierced at precisely the spot where it lies, and the Ichneumon must ascertain that no other fly has preceded her, or the life of her own offspring will fail.

The antennæ ascertain this for her; they vibrate incessantly as she runs rapidly up and down every stem, and whether they *hear* the gnawing of the little maggot within, or *feel* the consequent vibration, or *smell* the larva through the pores of the stomata I cannot tell; but it may be that it by all these finds out the precise spot, and then with its long ovipositor, which is barbed and works like an auger,

a hole is pierced and the egg laid just where it ought to be. The great and unaccountable marvel is, how it knows whether the larva has been touched before or not. But so it is, and thus it avenges us of our tiny enemy.

MICROGASTER GLOMERATUS.

These you will always find mounted at Baker's, Smith and Beck's, and Ladd's. They are exquisite little creatures and some of our best friends. Observe its large eyes, its beautiful antennæ, the last joint sculptured so delicately that it can only be well seen with a $\frac{1}{4}$-inch lens. The ovipositor is partly drawn out, and if the insect is well prepared, you may see the mechanism by which it acts,—two powerful elastic springs, braced across by three loops or tendons on each side, which keep the instrument in place during its rapid action. This fly is metallic green and gold; the wings have but two cubital cells, and, owing to their want of nerves, can seldom be properly displayed. So they should be examined on the unprepared insect, which is abundant on our windows and in our gardens.

The first time I saw the transformation of this Ichneumon was a great surprise,—a child's wonder never forgotten. I had kept some Cabbage Caterpillars in a box, feeding them duly, and expecting the white butterflies whose pretty eggs I had read of and longed to see; when, one day as I was considering my largest caterpillar, now full-grown and ceasing to eat, instead of commencing as usual to prepare itself for transformation, I saw in one moment that it was dying, and a host of tiny worms suddenly pierced from its inside in all directions, wriggled out, and began to spin so fast that in about ten minutes nothing could I see but a heap of small yellow silk cocoons, and the skin only of my poor fat caterpillar. What it meant I could not tell, nor had I then read the account of it in Kirby and Spence; but I took the cocoons, put them in a glass covered with muslin, and in about a fortnight from that time the cocoons were pierced and empty, and twenty of these pretty green and gold flies were out. I learnt their name afterwards,

and that they are our appointed avengers to check the depredations of the Cabbage Caterpillar,—the *Microgaster Glomeratus.*

APHIDIUS AVENÆ,—EPHEDRUS PLAGIATOR,—CERAPHRON CARPENTERII.

These Ichneumon-flies defend us in the same way from the Aphides which disfigure our rose-trees. The first two lay an egg in the body of the Aphis, which is inwardly devoured by the larva and dies; we may see it turned brown and still adhering to the leaves. If the fly has escaped, there will be a small round hole in the side of the Aphis, and a little circular door attached by an uncut portion of the skin. The Ceraphron, a most lovely little fly, destroys, not the Aphis, but the larva of the Ephedrus inside the Aphis. It is able to find out, even in an apparently healthy Aphis, that an egg has been deposited by its sister Ichneumon, and that the larva is hatched, when it immediately pierces the already smitten insect, and provides for its own offspring in laying its egg inside the internal parasite. Thus, in preparing many of the brown and black dead bodies of Aphides, we may obtain specimens of each of these beautiful Ichneumons.

CHELYMORPHA PHYLLOPHORA, OR THE TURTLE-SHAPED LEAF-BEARER.

This most curious insect is the pupa of Chelymorpha, an insect discovered by the Rev. J. Thornton, on the leaves of the Maple (Acer campestris); it is intermediate between the Aphis and the Coccus. The singular leaf-like appendages round the body and attached to the legs require a half-inch object glass.

CHAPTER IV.

DIPTERA.

"O happy living things! no tongue
Your beauty may declare;
A spring of love gushed from my heart,
And I blessed you unaware."

Ancient Mariner.

Of all the insect tribes in that world which lies about us, and of which we know so little, with all our learning and research, there is none which has been more neglected than the numerous and interesting one of the Diptera, or two-winged flies. Most strange that it should be so; for they are the least harmful and the most truly beneficial to man of any small creatures; few of them assault us, and as a body they are so important that the world could almost as easily do without flowers or sunlight as without *Flies!*

They are beautiful. Who has not unconsciously paused to admire the metallic lustre of an unknown Beris or Dolichopus, as it rested on the laurel-leaf by his side; or the golden Leptis sitting on the gray bark of some old tree; or the variegated Syrphus and the pretty Empis thronging the umbelliferous plants by the wayside? Who has not, in the listless heat of a summer's day, watched the merry dance of the little House-fly, and wondered if there was not more intelligence in that world of flies than he had dreamed of? They are *useful;* for the Diptera in their larval state feed upon the dung of animals and decaying substances, and we should perish from the noxious vapours or gases which arise from dead matter without these little scavengers.

We are indeed in a world *visible* yet unknown, the perfection and order of which no human eye had ever seen without this help from God, whose directing providence

gave man the microscope. His world it is; His creatures these, and of all the countless host of "creeping things," the Diptera seem to come most nearly and constantly within our reach. Other insects we must seek abroad in woods and meadows and by the river-side, and only at some seasons of the year do we meet with them; but the Diptera are ever within reach—our little home friends. The invalid may sit all the year round within the shelter of his room, yet seldom fail of finding a few of these to watch and to admire. The little Phora lingers through the winter on our window-panes, and the pretty *Midge* hops to and fro in December days; whilst with the earliest sun of February the quiet heavy-looking *Musca rudis* appears in numbers long before the active merry little *Musca domestica*, or House-fly, awakes from its long nap in some snug unsuspected hiding-place.

Those who have not learnt to know and love the living things around us, walk to and fro amidst many untasted pleasures. I often think the difference between such ignorance and the knowledge we might easily attain resembles that which we feel when walking alone and friendless in the crowded streets of London with a stream of fellow-creatures hurrying past, of whose life-history we know nothing, and for whom we care nothing; and the same walk taken in our native village or island home, where every one we meet is an acquaintance, relative, or friend, or friend's friend, striking unconsciously the electric chain of sympathy. Even if we know but a name, it is something that is akin to brotherhood. Thus also before we know the structure, habits, and names of insects, what are they to us? Every worm is a worm; a beetle is a beetle; every fly is a fly—nothing more.

But take the trouble to examine one little insect—the humblest, the commonest—learn how wonderfully it is fashioned, how gifted with happy instincts, and how obedient in its work—learn its name, and give it a kindly look *just once*, and a little friend is gained for life; you will never again catch a sight of that small insect without a feeling akin to brotherhood—*you know it*, and it may be

association of place and time will enhance the pleasure ten-fold.

There is not any small work that I know of on the classification of the Diptera: the best manual of British Flies is that of the 'Insecta Britannica,' in three volumes-too expensive and too scientific for popular use.* Therefore these slides of whole-mounted Diptera, with the brief descriptions of this catalogue, will be the more valuable, as giving the young student his first introduction to a family he will become better acquainted with hereafter.

Very briefly let me preface the examination of the first slide with a list of the principal families into which naturalists have divided the Diptera. As the Coleoptera are known by the joints of their tarsi and structure of their antennæ, so the Diptera are classed according to the form of the antennæ and the veining of the wings.

There are two great groups, *Nemocera* and *Brachyura*. *The Nemocera* comprises all the Tipulæ, Gnats, Midges, &c., which have long antennæ, from six to ten-jointed, and inserted in front of the head between two large compound facetted eyes. The slides of head of Tipula and head of Gnat will illustrate this better than any description, and enable us at once to recognise one of the Nemocera. A slide of a whole Gnat and of a Ptychoptera will give a better lesson on their general structure, if carefully examined, than any book.

CULEX PIPIENS.

The common Gnat, both male and female, should be mounted, as the former only has the beautiful plumed antennæ, and the latter only the apparatus called the sting, of the Gnat, and described under "Head of Gnat." Its wing is often mounted as a separate object, to show the scales, and has therefore been noticed with the wings of other insects (page 89). But as this little fly is one of our most common acquaintance, though not a very pleasant one, a slight sketch of its habits will be interesting.

* Insecta Britannica: Diptera, by Walker. Histoire Naturelle des Insectes: Diptères, by Macquart.

The female Gnat is that blood-thirsty little creature whose shrill clarion sounds an attack upon man and beast throughout the warm summer's day and night. She flies silently in the spring, and seldom thirsts for blood until she begins laying eggs; of these she produces about 300 in one season in stagnant water, and their transformations occupy about a month; so there are several generations in one year, which accounts for the swarms which occasionally trouble us.

A few of the larvæ of the Gnat are amusing in the aquarium, and being, when young, very transparent, give excellent observation of the circulation of blood and of the tracheal organs.

The little Gnat lays her eggs in the form of a boat, which floats upon our waterbutts or ponds for about a week, when it sinks down to the bottom, and the young larva escapes from each egg. This rises to the surface for air, which it breathes through a most curious organ placed at the extremity of its body, and it hangs, therefore, head downwards whilst breathing. This organ is a tube which springs from the last segment but one of its abdomen, and terminates in five points like a star. In the interior of this tube a tracheal vessel runs which supplies the body with air, and carries down a little bright globule when the larva descends to the bottom of the water; this renders it so buoyant that its greatest effort is required to *descend*, and when the insect wishes to rise again, it has only to unclose its tube, and it ascends without any exertion to the surface, remains suspended there, drinking in the surrounding element, and swallowing shoals of little "living things," invisible except under the microscope. A tumbler of stagnant water will not only show the merry evolutions of these larvæ, but an abundant variety of the Infusoria, upon which they feed, Monads, Paramecium, Rotifers, together with the Desmidiaceæ, which abound in such water.

In the next change the Gnat larva becomes a pupa, with quite a different appearance and respiratory organ; for now it has two horn-like appendages on the upper side of the

thorax, and it rises with its head upwards to breathe through them. As soon as the last change is at hand, the pupa raises its thorax out of the water entirely, and slightly turns up its tail, floating like a boat; presently the skin bursts, and the head of the enclosed perfect insect emerges, the long antennæ wave to and fro, and the frail bark rocks from side to side in some peril, for the lightest breath of air would overset it. Then one by one the legs are drawn forth and stretched forward to some floating leaf or stick whereby to steady itself; slowly the rest of the body follows; the wings, hitherto pressed to its side, crumpled and damp, are dried by the warm atmosphere, and the quick breathing of the little Gnat sends a rush of air through the delicate veins; they are gently waved for a few seconds, then up and away flies the rejoicing creature into its new and happy life.

Such is the history of the pretty microscopic object on the slide before us.

Of its structure it is necessary to know that all the Diptera are distinguished from other orders of insects by having only two wings, and a pair of stout organs, called halteres, which are supposed to represent the posterior wings of the four-winged tribes, and respecting which entomologists are much divided. They have been specially noticed at page 142. The Diptera have mouths variously constructed for their necessities. Their food is essentially fluid; the juices of plants or of insect bodies, and of decomposing matter, forming their nourishment; and, therefore, instead of the strong horny mandibles of a Beetle, we find in such flies as Tabanus a pair of lancet-like organs for plunging into the skin of the animal whose blood it delights in, and beneath these another pair, to which are attached large palpi, exactly corresponding to the maxillæ and maxillary palpi of the Coleoptera; a labium or lower lip, which in all flower-haunting and honey-loving flies is very long and beautiful, as in Rhingia, Syrphus, Conops, and many of the Muscidæ; a labrum or horny borer prolonged in the predaceous flies, and very remarkable in the Empidæ and Asilidæ, which have also

a beautiful lower lip or labrum, used first for steadying the lancets in their descent through the skin, and then for sucking up the fluid. This may be watched by any one who will permit this little Gnat quietly to take a meal on the hand; and once fixed she is not easily alarmed, but will allow the approach of a pocket lens, and observation of her proceedings.

The Diptera have also a tongue (*lingua*); it is not the organ usually so called, but a lancet, which with four others lie concealed within the horny lip or labrum of Tabanus. The part we so much admire in the proboscis of the Blow-fly, Tipulæ, and others, is the lower lip or *labium*, with its lobes striated by radiating tracheæ.

The head of a fly is attached to the thorax by a very slender neck, and appears to move upon a pivot, having the power of turning quite round.

The thorax is compact, and gives support to the wings, halteres, and three pairs of legs.

The abdomen is composed of from five to nine segments, and females are provided with ovipositors, sometimes of great length, and consisting of a series of little tubes sliding one into another like a telescope.

The legs have always five tarsi, two claws, and two or three membranous lobes, or pulvilli. Of the internal anatomy of flies I must not allow myself to say much; but it may interest many to know that they possess the dorsal vessel or heart which ensures the circulation of blood, an alimentary canal for the digestion of food, provided with salivary vessels, biliary tubes, and a chylific stomach which seems to supply the whole intestinal canal with a power of digesting food when necessary. Flies have a crop or gizzard, situated just above the stomach, and appended by a long, narrow neck to the throat or œsophagus; but it is used chiefly as a reservoir for food, when the insect takes more than is needful for its immediate wants. This was proved by that great anatomist, Hunter, who kept a fly twelve hours without food, and then gave it milk and killed it; he found no milk in the crop, but it had got through almost the whole tract of intestines; the animal had immediate

occasion for food, and therefore the milk was not detained in the crop, the intestines having the power of digesting it. Another time Hunter allowed some flies to feed plentifully, and then found the crop quite full, as well as the intestines. Insects have no absorbents; the chyle, which is a clear, greenish fluid, with round oval corpuscles, is supposed to transude through the coats of the intestine into the abdomen, where it meets with the blood in the ill-defined veins that permeate the body. (*See* 'Owen's Lectures on Comp. Anat.')*

The tracheal vessels or breathing organs have been noticed in the chapter on spiracles and tracheæ.

The nervous system is similar to that of other insects, consisting of two spinal cords or threads, exhibiting a series of knots or ganglions. The Fly has one in the head, a very large one in the thorax, and one, or sometimes two, in the abdomen; these give out nerve-branches to the wings, halteres, and legs.

In looking at a slide of Culex observe the length of the *coxa*, and the small joint called *trochanter*, between the coxa and femur.

If possible, obtain the male of *Culex annulata* with its magnificent antennæ and feathered palpi, and the female of *Culex pipiens* for the display of the suctorial mouth.

PTYCHOPTERA.

This is one of the family of Tipulæ, Crane-flies, or Daddy-long-legs, which abound in the neighbourhood of water, and are recognised by their black and yellow bodies and spotted wings. The larva is an aquatic worm, and the pupa has a curious, long, thread-like appendage, through which it breathes. We find it in shallow water at the brink of muddy ponds.

The wing is a good study after that of the Gnat, as an example of wings without scales, and of the peculiar

* The stomach of the Fly, mounted in balsam, is an interesting object, and kept in most collections for sale.

veining of the Nemocera. The *costal* vein is the one which borders the fore-part of the wing, ending at the tip. The next to that is the *sub-costal*, which here is prolonged to five-sixths of the length of the wing, and connected with the *radial* by a very short veinlet close to the tip; the *radial* and *cubital* spring from a common petiole, which is about one-sixth of their length, and proceeds from the *sub-costal* at half the length of the wing; it is connected with the *externo-medial* by a transverse veinlet at a little before its fork; the *cubital* is forked at half its length; the *externo-medial* also forked. These two veins being distinguished thus, help the eye in determining the others. Observe also that faint streak or spurious vein between the forked veins. This wing has no discal areolets, such as are always found in the true Tipulæ, or Daddy-long-legs. These numerous parallel veins in a solitary wing would enable us to ascertain the division to which the fly belonged, even if the long antennæ and peculiar palpi were unseen. A collection of wings alone from this group would be highly interesting for comparison, and for their beautiful delicate forms.

The halteres also should be carefully mounted, and the clusters of nerve-vesicles observed, especially those of *Tipula gigantea, T. Oleracea, Limnobia, and Bibio.*

SCATOPHAGA.

This brings us to the second great group of the Diptera, in which the common House-fly, the Blow-fly, the Horse-fly, and others well known, are found.

THE FAMILY OF THE BRACHYCERA,

in which the antennæ are short, never exceeding ten joints, more frequently having only from three to six. The wings also have branched veins, and are fewer in number than those of the Nemocera. Their bodies are stouter, and the palpi short, projecting above the proboscis, or lying on it.

These are the flies which throng our flowers, haunt the

woods, the meadows, the leaves of trees, or act as scavengers to remove the noxious substances in the field or by the wayside.

There are twenty-eight families, each containing many genera and species, which can only be learnt by long and careful study, with the help of such works as 'Walker's British Diptera'; but we can very easily become familiar with those which are thus mounted, and, through them, with others which flit as yet unheeded around us. Nor will it be long, I hope, before some small manual of the Diptera is published, more attainable to the young student than the one already mentioned.

THE SCATOPHAGA,

(*Stercoraria,*)

is the common Dung-fly, seen all the year round, but especially in summer, resting upon cow-dung and depositing its eggs therein. It is also often on the window-panes. The male has a round hairy abdomen, the female a naked pointed one. They are yellowish or olive-green flies, the head yellow between the eyes, and with black drooping antennæ; thorax brownish above with four darker stripes; the wings are grayish, with a tawny tinge along the veins.

This preparation is very valuable, as showing the antennæ well. We perceive the very different structure from those of the Gnat or Tipula. There are only five joints visible, although six are reckoned by naturalists. The third joint (reckoning from the base) is twice as long as the second, the fourth obsolete, fifth and sixth seated upon the third like a bristle, and called the *arista*. The head of Scatophaga is very bristly, as you see; and so also are the legs, which we may next observe. The eye and tongue of a fly are fully described under the slide of Head of Rhingia, or Syrphus. The joint of the leg nearest to the body is the coxa, the next to that the femur, or thigh, then the *tibia*, or shank, and then the *tarsi*, or small joints immediately above the foot. To see the foot well requires a higher power, that the delicately fringed pulvillus may be

seen edged with glandular hairs, open at the point, and secreting a glutinous substance, which enables the fly to attach itself firmly to glass or ceiling, whilst those two strong hooks are used to detach it from the surface to which it clings.

The wing is next to be observed. It is the most important to the naturalist. Those small winglets at the base are called the *alulæ;* they distinguish some families, and generally cover and protect two small organs, the halteres, supposed to be the seat of smell, described at page 142. The wing itself consists of a double membrane, more or less transparent, attached to nervures or veins, which are hollow tubes containing spiral air-vessels, communicating with the spiracles or lungs in the trunk. This construction is wonderful for lightness and for strength; the larger and *heavier* the body is, the more of these strengthening veins the wing has. And as by breathing only these vessels are filled with air, or some subtle fluid, the very act of flying may be but the palpitating of a joyous little heart. We know that the tracheæ *are* filled with air, and that the dorsal vessel is in truth the heart, sending forth streams of the life-blood throughout the body and into the wings, as may be distinctly seen in the transparent veins of a newly-hatched fly.

But to learn the names of the nervures or veins of a fly,—a most useful lesson,—no wing is better than this simple one of the Dung-fly. That strong vein bordered with hairs on the foreside is the *costal* vein; it runs round the tip of the wing, and ends where it meets the *cubital* vein. The *sub-costal* is a pale short vein nearest to the fore-border, and ending at one-third of its length.

The *mediastinal* is the next and a stouter vein, ending at beyond half the length of the wing.

The *radial* forks at its base, and the farthest branch is the *cubital* vein, joined to the *præbrachial vein* by a clouded transverse vein.

The upper transverse vein, which unites the *præbrachial* to the *pobrachial,* is called the *discal transverse.*

The membrane itself is exquisitely dotted with fine hairs, and fringed all round with longer ones.

The Scatophagæ feed on smaller Diptera, and deposit their eggs in dung, and these eggs are so shaped that whilst they are warmed and nourished in the soft excrement, they cannot sink, two little horns on either side supporting them in it, which enable the young larva safely to escape.

LONCHOPTERA.

Small flies, very active and abundant in marshy woods and grassy spots.

You can observe a difference here in the antennæ; the roundness of the fifth joint and long arista; the first three joints are scarcely seen in this specimen. The wings will give a good example of a simple veining, no transverse vein at all, and the præbrachial forked; each vein is fringed with delicate hairs. This is a male fly, and has two hairy lamellæ at the base of the abdomen.

BIBEO.

(One of the Gnat tribe.)

Look at the very different antennæ projecting fiercely forward, with nine joints; the palpi on each side of the tongue with five joints. The wings, how different from the true Fly or Musca! It has many veins, and thirteen areolets, but so faint that we cannot see them all in this preparation; only the *costal*, *sub-costal*, and *mediastinal* being distinctly marked. The legs are worthy of observation.

The *fore-tibia*, with a circle of spines at the joint; the *fore-femur*, very stout, and the *coxa* and *trochanter* are distinctly seen in this specimen. The larva of Bibeo lives in the earth, feeding on decayed vegetable matter; it has rows of short hairs which it uses for locomotion, and twenty spiracles for breathing. The pupa is found naked in an oval cell with a very gibbous or horny thorax. There are twelve species of Bibeo.

DOLICHOPUS.

A very curious fly, and one of our common garden friends, in the neighbourhood of Oxford or anywhere near ponds and rivers; for it is a water-loving insect, though we find it on our window-panes, and basking in the hot sun at

noonday on rose-trees and other shrubs. It is quickly noticed from its long legs and metallic round-backed body, carrying its head low, and sometimes found with another fly in its mouth, being very predaceous.

There are fourteen genera of the Dolichopidæ, each containing many species; and some parts of their internal anatomy present peculiarities so great that much has been written about them by Latreille, Harris, Dufour, and others. Their habit is to run along the surface of still water like the *Velia rivulorum* (*see* Velia), and they catch smaller flies, aquatic worms, and even small gasteropods, the little Physa, and smaller Planorbis; there is a gaping orifice at the end of the proboscis, which admits and holds the prey until the iuices are sucked out.

We know not where they lay their eggs, but the larvæ are found as white slender worms of twelve segments in May, underground in damp earth, and in June they change to pupæ, casting their skin. The head of the pupa is armed with several points, the ends of the legs in their sheaths, somewhat detached from the body, and a process resembling an S is on each side of the thorax probably for respiration. The Dolichopus emerges from the pupa in about three weeks' time. Now let us examine the slide.

The head is broad; the eyes large, and in life were very brilliant. The antennæ stand fiercely out and require examination with the $\frac{1}{4}$-inch; they are quite unlike any we have yet seen. Observe three distinct joints besides the arista or spine, which points forward; the second joint, the shortest, fringed with spines and intromitting a slender tube obliquely into the base of the third; you can see a kind of loop or dark spot where it is inserted; the third is so remarkable that whenever you see this compressed and peculiar shape you need not doubt that you have a Dolichopus. The *arista* is two-jointed, and in some species it is ciliated.

The proboscis is short, directed downwards; the head itself is armed with long bristles. The abdomen has five segments, and on each of them you see a double row of white spots, which are the spiracles; the end of the

abdomen bends suddenly inwards, and these last two segments are called the hypopygium, which has an outer pair of appendages like fringed plates; they seem to be concave and join together to protect a number of internal organs of varied shape which we see projecting beneath, and the use of which has been largely considered by Dufour. ('Annales des Sciences Naturelles,' 3me serie, tome i.)

The wings furnish us with a good lesson, and an easy one, for becoming familiar with the nerves or veins.

The *costal vein* is fringed and strong, ending where the præbrachial meets it.

The *sub-costal* is very short and stout.

The *radial* and *cubital* spring together from a dot at the base of the wing, and the *præbrachial*, after passing the transverse vein, make a slight curve toward the cubital. Now, that very slight curve is of the utmost importance, both as to position and shape; it serves to assure you of this being a true Dolichopus; it is never wanting in the species—never altered—no, not even by a microscopic line. But in one of the same family, a cousin, called Psilopus, there will be a little branch at the angle of the curve, and in another relation, *Dolichopus diadema*, the curve is rectangular, with a little branch. This Fly is common on pools overgrown with plants.

So is *Dolichopus nobilitatus*, which is a gilded green fly, easily known by its *white-tipped* wings, and when examined with a lens you will observe that the arista is long and very hairy; the wing very narrow, and sloping away without any lobe, or even angle, the anterior lines being waved within the dark patch.

No Dolichopus ever has an axillary lobe to the wing.

That vein beyond the *probrachial* is the *pobrachial;* but the base of the wing offers the particular marks of the group, and ought to be examined in a separated wing. I dwell upon this, because the careful study of one wing is a most valuable lesson: the eye learns *what* to look for; it learns accuracy of observation; it learns what it never forgets—the vast importance of *little* things; and what

the eye sees often the heart feels. Find out, therefore, a very short and oblique vein, between the *cubital* and the *præbrachial*, down close to the dot of the *radial*, and the space thus bounded at the base is called the *præbrachial areolet*, and its minute size and position in *every one* of the genera is decisive of the family.

Pass on now to the legs, and remark the spines on the *femora* and *metatarsus;* they will also serve to show the species, for in some Dolichopus there is invariably but *one* spine, in others four or two, and in some there is a double row.

THE OPOMYZA

is one of a family group called Geomizides; they frequent recent or decaying vegetable substances, also our windows, and are very present little unknown friends. We may know these by their spotted wings, by the tawny body, yellow head, thorax striped with *three* pale lines; the abdomen has a dark dorsal stripe or dark bands; they abound in herbage. Now examine the head and wings.

The head is broad and eyes large; the antennæ, like those of a true Musca, three joints drooping, the third round and large; the arista long, slender, hairy, and with a small joint you will hardly see unless the head is in profile.

The thorax is bristly; the abdomen has seven segments —a little hairy; and then pause to look at the wings, and compare them with those of Dolichopus.

You will first observe *two* transverse veins slightly clouded; the *præbrachial* straight; the *discal transverse* hindermost, and joining the *pobrachial* vein to the *præbrachial;* the *cubital* and *radial* veins are quite straight.

CHLOROPS.

A mischievous little Fly; and the farmer will be interested in seeing the parent of that larvæ which sometimes commit such havoc in his wheat-field. In England there is a disease known as the gout, from the swelling it occasions

in the stems of wheat and barley, but which is called the *frit* in Sweden, where it occasions enormous loss—as much as *one hundred thousand* pounds sterling annually. This is caused by the little innocent-looking Chlorops on the slide. It effects this by simply depositing its eggs early in June on the stem of the young wheat, which being as yet low in the sheath, the little maggot hatches and feeds in the shelter of a leaf, mines into the stem, but does not enter the hollow part. It is well that it does not do so; for we know that if the cells of a plant are destroyed in the channel of its life, which is the stem, of course it presently withers, or brings forth but imperfect fruit.

More harm would this insect do if its propagation was not checked by a good little Ichneumon-fly (*Cœlinius*), which is commissioned to destroy its larvæ by laying its own egg inside the maggot of Chlorops, just as the Microgaster does in the caterpillar of the Cabbage Butterfly, and thus defends us from our tiny foe.

These Chlorops frequent our windows, often in swarms—known by their large *green* eyes; their yellow and black bodies and beautiful wings lying along the body and extending beyond it. You can rarely mistake it; and then if you have this mounted specimen you will observe its peculiar antennæ, the third joint knobbed, the arista seated sideways upon it, and like a fine long bristle. The thorax striped; three broad stripes and one slender line on each: outside of these a black dot on the side of the breast. The scutellum was yellow; the abdomen short, broad, with dark bands, and itself pale greenish-black.

Observe, in the wings, how the *sub-costal* and *mediastinal* are joined in one strong vein, which meets the *costal* at nearly half its length; the *cubital* ending at the tip of the *costal;* the *radial* ending at three-fourths of its length; the *præbrachial* ending on the hind border, near the tip; the *pobrachial* ending at beyond half the length. There are two transverse veins.

This slide will help us to recognise both our enemy, *Chlorops teniopœ,* and our little window-friend, *Chlorops lineata.* The abdomen of the *latter* has a yellow tip and

base, also three black spots on the pectus, or fore part of the thorax.

PHORA.

All the year round the little Phora is upon our windows and in our stables, when no other flies are to be seen, but perhaps some eccentric little Midges, hopping diagonally here and there—scarcely a living thing to study; yet we shall always find a Phora running restlessly but happily to and fro, with a bent body and depressed head; the antennæ very short, but with a long slender arista carried backwards, the third joint quite round, the first and second very small.

The wing has no transverse veins at all; it is of the simplest form, strengthened at the base by the stout *costal vein*, which ends however before half the length of the wing, and is ciliated; the *mediastinal* vein, also stout, ends at two thirds the length of the costal; the *cubital* vein and *radial* vein in one, and forked at the end of the *costal*, all the other veins represented by four veinlets, often indistinct. Now compare this with the Leptis wing.

LEPTIS.

(*Tringaria.*)

A splendid preparation of a fly that is easily found and captured by any rambler in woods, because it has a quiet habit of sitting upon trunks of trees with its head downwards, and will allow a wine-glass to be capped over it without any alarm. It may be useful to mention here that most flies may be caught by a small tumbler, or stemless wine-glass, and a handkerchief, or piece of card-board. I prefer the handkerchief. The Leptis may thus be recognised: it is a large fly with long pointed abdomen, tawny coloured, and having three rows of black spots. The wings are spotted. The thorax is that part which supports the wings and legs, and in the Leptis it has *three* fawn-coloured stripes. The legs are tawny and clothed with short black hairs.

This fly appears in the early part of the summer, and haunts meadows and hedges as well as woods. It feeds on

smaller insects, having a stout short labrum and slender sharp maxillæ, with which to kill, as well as a thick broad labium (called the tongue), to suck the food. The larva lives in the earth, in sand or manure, or decayed wood. The pupa is brown, bare, with eleven segments, of which the five posterior are furnished with a series of little teeth.

As it is quite impossible to prepare insects so as equally to display all parts, we may find some difference in the slides, even of the same insect. The Leptis I am now looking at shows the beautiful eye and tongue, but not the antennæ, and yet they are to be observed as indicative of its individuality, for the veining of the wing is, at first sight, so like that of another family (the Stratiomidæ) that we might mistake it if we did not read its name in the antennæ. They are small, and seated side by side in the middle of the face, four-jointed, the first short and cylindrical, second transverse, third cyathiform, or cup-shaped, and a long fine bristle makes the fourth joint.

Here we cannot but admire the delicate network of its compound eye: in life it was of a bright green, and the facets numerous and small. The labium, or under-lip, furrowed in the centre, and beautifully marked with tracheal vessels, acts also in contracting and dilating the tongue in the act of drinking. The palpi, or feelers and tasters, are remarkably large and hairy, projecting on each side of the tongue.

The wings are to be the chief lesson; comparing them with the simply veined wings of the Phora, as an indication of farthest remove in relationship, whilst they also show us that the Leptis is a near cousin to the Tabanus, or Horse-fly, and to all flies whose *wing-veins are crowded together near the fore-border;* the *costal* vein ending at the tip of the wing, the cubital vein deeply forked, and the fore-branch having a small areolet. There is a discal areolet, large, and emitting three veins to the border, and the anal areolet is open. Eight families, comprising many genera and numerous species, have wings upon this plan, and are known by the variation in the joints of their antennæ. (*See* head of Tabanus and slide of Pachygaster and of Beris.)

No better example can we have of the leg and foot of the fly than this slide presents; for we see very distinctly the *coxa*, or hip-joint; the *trochanter*, a small joint by which the thigh or femur fits into the coxa; the *tibia*, or shank-joint, which here is armed with two spines, and the *tarsi*, or ankle-bones, as some think analogous to our instep-bones, having two claws and pulvilli, or cushions, set with glandular hairs. (*See* foot of fly in Scatophaga.) Here observe the Leptis has three instead of two lobes.

ASILUS.

These are the most powerful and ferocious of the Diptera, destroying Beetles and Ichneumon-flies, and may be seen on the sunny side of woods, silently darting about, or resting with a huge meal in their mouth, and *then* they are pretty easily caught. They are bright, tawny-coloured flies, very hairy; the antennæ erect and long, curved upwards, and the proboscis standing forward.

This is an example of relationship with Leptis as to the wing-veins, and yet with a difference. You see the cubital vein is forked, but simply so; the discal areolet gives out but *two* veinlets, and is joined to the cubital by a short transverse vein. The foot also observe—two deep lobes with a spine between them. Then look carefully at the antennæ, and compare them with those of Leptis; you see they are slender and styliform, and indicate an approach to the tribe of Empis-flies, which, as they abound in our gardens and may easily be procured, should have a place in our object-box.

EMPIS.

(*Snipe-fly.*)

Either the black *Empis livida* we see so often on our laurels or flowers in the months of May or June; or the *Empis stercorea*, which swarms on the umbelliferous plants by the wayside; or the pretty little Hilara that plays over the water-meadows or great ponds:—any of these will give a remarkable proboscis and a very pretty wing.

EMPIS STERCOREA.

A small, shining, yellowish fly, clothed with a few black hairs or bristles; the thorax with a black linear stripe; abdomen with three black stripes; legs long, slender, and yellow; tarsi of a darker hue. The Empidæ are a large and very distinct family, containing twenty-three genera, and are inhabitants of woods, hedges, fields, and gardens, where they find their prey—smaller Diptera, and all kinds of lesser insects. They are fierce and voracious, transfixing their prey with their long proboscis, and sucking out the juices with their beautiful up-curved tongue. The eyes of a male Empis touch one another; those of the female are parted by a narrow front, a distinguishing mark of the sexes in most flies. The antennæ of the Empis always stand forward, and observe how different they are from those of either Dolichopus or Scatophaga. It is only by thus comparing one slide with another that we learn our lesson *well.*

The antennæ are five-jointed, close to each other at the base, porrect, that is, standing out; the first and second joints bristly: first cylindrical; second cyathiform, or cup-shaped, about half the length of the first; third, subulate compressed; the fourth very minute; the fifth like a style, pointed sharply. The thorax has a broad, black stripe; abdomen three black stripes, and every segment is punctured with a double row of light dots. The legs are long; the *coxa* shorter than the *femur,* the *trochanter* very distinct; the third joint of the leg, *femur,* or *humerus,* is usually the largest and most conspicuous; generally speaking, the anterior pair are shorter and smaller than the posterior pair. If the insect *leaps,* the thighs of the hind-legs are very much thickened for the development and action of its muscles. This is particularly seen in the legs of the small beetle called Turnip-flea (Haltica), in the flies *Ascia podagrica,* one of the Syrphidæ, and also in *Syritta pipiens,* which should be mounted as examples of the thickened and toothed *femur,* and of a curved *tibia* joint. The Ascia is very common in the month of June,

hovering over the long grass, and may be recognised by its black and yellow body, and peculiar darting to and fro from flower to flower. The *fore-tarsi* are often dilated in the male Empidæ, but those of *E. stercorea* are not so.

The Wing.—The wing of *Empis stercorea* will give an excellent example of the veining peculiar to the family. They are distinguished by these three variations:—

1.—The *costal* vein vanishes suddenly at the tip of the wing, just where it meets the *cubital* vein.

2.—The *cubital* vein is forked.

3.—The *discoidal areolet* emits three veins to the interior border.

The wings of Leptis and of Asilus have also a forked *cubital* vein, and three branches from the *discal areolet;* but they have other veins crowded together, which are wanting in the Empis wing, and as the antennæ are quite as important to the entomologist in determining a genus as the veining of the wing, by comparing those of a Leptis with those of the Empis, a striking illustration will be obtained of the progressive order and variety of likeness, and yet of distinct difference, between the families.

HILARA.

By the wing and the antennæ we recognise one of the Empis-flies, but a variation in the form of the *third* joint and the shortness of the first two joints is the first remove from the true Empis. Observe also the stout, short proboscis, and if it is a male Hilara the fore *meta-tarsi* are much dilated, forming quite a disc on that part of the leg.

How beautifully the wing is ciliated, the *cubital* vein forked, the *discoidal areolet* emitting three veins, and a spot upon the *costal* vein called the stigma, which in this wing is marked by a broad brown shade.

These Hilaræ feed upon smaller insects, and also on the nectar of flowers. They assemble in swarms, and dance together over a rivulet or river, on fine, warm summer evenings. We have often seen them rejoicing in merry play, rising and falling in graceful evolutions, sometimes by one common impulse sweeping off down the stream, as

if a breeze had suddenly wafted them away, or invisible beings had chased them; then slowly and prettily they re-flitted back again to commence their gambols.

SYRPHUS PYRASTRI.

Many of the Syrphidæ are mounted whole; they offer a great variety in the structure of the antennæ, the mouth and the legs. Some are so large that the head only is mounted, to show the beautiful eyes and labium, as Rhingia, Helophilus, Eristalis, &c.

They are our prettiest and commonest flies; honey-loving, flower-haunting, harmless little creatures. Most of them are striped or banded black and yellow, and love to hover in the air, over one spot, their wings almost invisible with rapid vibration, accompanied by a shrill hum; if alarmed, they dart away with astonishing velocity, and are somewhat difficult to catch. The family contains *thirty-one* genera; some of them so unlike the others as to require microscopic observation and comparison; the Eristalis, for instance, is often mistaken for a Bee; the Helophilus also, and Rhingia, —the two former abound in the autumn on the Michaelmas Daisy, and the latter frequents the woods and hedges, darting like a Wild Bee into the flower-bells, with a long proboscis, looking to the unassisted eye like a Bee's tongue.

The two distinguishing characters of this large family are these:—the coalescence of the palpi with the maxillæ, and the spurious veins of the wing, one before the *præbrachial* the other behind the *pobrachial.* The wing alone will decide a Syrphus for a young entomologist; therefore, in examining this slide, let the chief attention be given to its veining, also collect a few varieties, comparing the wing of the common Helophilus with this one of *Syrphus pyrastri,* the type of the family.

The *costal* vein ends at the tip of the wing, where it receives the *cubital.*

Mediastinal vein distinct, ending about the middle of the *costa.*

Sub-costal, continued nearer to the tip, and ending separately in the margin.

Præbrachial vein connected with the *cubital* by a transverse vein near the margin, and between the two is a faint streak or spurious vein crossing a second transverse vein nearer the base.

The *mediastinal* areolet is coloured in this wing, and appears like a narrow stigma between the *sub-costal* and *mediastinal* veins.

Areolets are enclosures formed by the branching and crossing veins; they are important in the wings of the Syrphidæ, and must be observed.

All the Syrphidæ have alulæ, which are membranous scales at the base of the wings, protecting and sometimes quite covering the halteres. They are particularly beautiful in *Rhingia* and *Eristalis*, and deserve to be mounted separately.

In the wing of Helophilus the *cubital* vein curves suddenly inwards, forming a loop in the centre of the areolet.

The feet of Syrphus are beautiful, and from the transparency of the preparation we see the articulation of the tarsal joints distinctly, the spine at each tarsus, and the strong hooks and delicate pulvillus of the foot.

Some of the Syrphidæ have their abdomen nearly filled with air, and partly diaphanous or transparent, when by careful management the circulation of their blood may be seen, and the pulsations of the dorsal vessel or heart may be counted. Place the fly in a live box with just sufficient pressure to keep it still, and between the segments the fluid may be seen. The following extract from 'Walker's British Diptera' (vol. i. page 285) will be interesting to the student:—

"The dorsal vessel of this fly (*S. pyrastri*), instead of the usual form which it had in the larvæ, assumes the shape of a flask, having its long end directed towards the thorax; the pulsation and transmission of the fluid in it is manifest. This vessel extends in length from the junction of the trunk with the abdomen to about the termination of the second segment. The included fluid is propelled at intervals by drops, first from the wide end towards the trunk, and then in the contrary direction. It is conjectured that the neck of this vessel is composed of two or more approximated

tubes, and that the blood is conveyed forward by the outward ones, and backward by the intermediate one; also that there is a secondary heart, at the extremity next the thorax, for the purpose of causing the reflux."

BORBORUS EQUINUS.

These are very abundant everywhere in rank grass, and near decaying vegetable matter, upon which the larvæ feed. They are small black flies, remarkable for their thick fleshy labium, and a broad bellying sheath below, which should be seen in profile. Antennæ rather distant, short, and turn outwards with a long slender arista; the first joint so small as to be scarcely perceptible, the second nearly as large as the third, which is obliquely compressed and ciliated. The legs are long, and *fore-femora* thickened; there is a curious spine at the end of the hind *tibia*, and the *tarsi* are short and broad. The wing, being very simply veined, is an easy study; the chief mark of this family being in two small areolets near the base of the wing, close to the hind border, which are called *anal areolets*, and in this wing they are complete. The discal transverse vein is also near the border; it joins the *præbrachial* and *pobrachial* together, the latter does not continue beyond it. The *radial* and *cubital* are branches from one common vein at the base.

There is a full account of this species and its larvæ in the 'Entomological Magazine' (vol. iii. p. 323).

SEPEDON.

A most beautiful specimen for the shape of the antennæ and the structure of the tongue. The wing closely resembles that of Borborus,—the same transverse veins and anal areolets; but the antennæ separate the genera entirely. Instead of the short second joint in Borborus, that of Sepedon is very long and spiny, with a conical and convex *third* joint, from which springs the three-jointed arista.

The labium is set round with double hooks and curiously dotted,—a most interesting variety in the proboscis of flies.

The legs are rather long, hind femora thickened, and armed with a double row of spines.

These flies are found amongst water-plants; they are black, shining, slightly metallic, with bright red legs; the halteres, also red, with a whitish band. Thorax with four black stripes; wings gray, with a lurid tinge in front.

SEPSIS.

The pretty little fly which we find upon our laurels, walking about with raised and quivering wings. The larvæ feed on decaying matter.

The antennæ are drooping and short, with the third joint oval and larger than the first or second; the arista bare.

Proboscis broad and large; the wings simply veined, but very delicate and beautiful, and with a black spot at the tip, without alulæ. The legs are remarkable for the large spines in the *fore-femora* of the male, and for the spiny *meta-tarsi*.

In all flies, as a rule, the fewer the veins the smaller the body, and the more sluggish the flight; the comparison between the veins of Leptis, Tabanus, and Phora, or Sepsis, will prove this.

The Sepsis wing has a *costal* vein running quite round the tip of the wing, and ending on the hind border; *sub-costal* ending before one-third of the length; *mediastinal* ending before half the length; *radial* ending near the tip of the wing; *cubital* ending quite at the tip. There are two transverse veins.

This list of the Diptera, though by no means complete, is sufficient to show how very instructive and interesting these preparations are, and to encourage the young entomologist to mount insects in this way for himself. The method is easy, but requires patience and experience.

Soak the insects in liquor potassi for a longer or shorter period, impossible to fix, because it varies necessarily with the size and texture of the insect. A beetle may require months, a fly but a few weeks or days, to render it transparent, by dissolving its inward parts, and giving flexibility to its integument. It is then washed in cold water, and laid out upon a glass slide in the desired position. When perfectly dry it should be soaked in oil of turpentine,

which may be applied with a camel-hair pencil, and afterwards mounted in balsam. In this last and most difficult part let the balsam be very fluid, and the warmth gentle, that the air may be quietly dispersed, and the bubbles removed before the final covering with thin glass.

I recommend the Borborus and *Empis stercorea* as the easiest specimens to begin with. When caught, if immersed in hollands or spirits of wine, they will keep any length of time until wanted for mounting.

THE HALTERES, OR POISERS, OF DIPTERA.

These small organs, which are very apparent as little knobs on a stalk, like drumsticks, just behind the wings of Blow-flies and the Tipulæ (especially the *Tipula olacea*, which flutter against our window-panes), are rudimentary wings. We only find them in the Diptera, which all possess these much-disputed organs.

They are called poisers, or balances, because it was formerly supposed that the insect used them as the rope-dancer does his pole, to steady itself in the air. Some naturalists fancied that they produced the humming noise in flight by beating against two little scales at the base of the wing, called alulæ; but that can hardly be the case, seeing how many insects buzz who have no halteres, such as Bees, Cockchafers, Dung-beetles, &c., and that so many flies who do possess them fly silently. They certainly do move very rapidly, quivering as the insect flies, and even when at rest I have seen the vibration. They are placed immediately on the margin of the great thoracic spiracle, and the late discoveries of certain organs inside these halteres lead us to suppose they are organs of smell, as the antennæ may be of hearing.

HALTERES OF BLOW-FLY.

These, if mounted carefully in balsam, have become transparent; we see that they consist of three parts, the base, shaft, and head. The organs in question are at the base, two distinct groups of vesicles, which look like dots

arranged in rows. The upper group is in spiral lines, the lower is on a broad flat surface, and only on one side. Each vesicle is a small sac, filled with fluid, and over-arched by a protecting hair, and when a good side view is obtained they are seen to be quite spherical.

The two naturalists, Dr. Hicks and Mr. Purkiss, who have noticed these organs, suppose them to be olfactory vesicles. There is a very large nerve given off from the great thoracic ganglion into the halteres, larger even than those branches which pass into the wings and legs of flies, which makes it very likely that in these very small appendages lies a great sensitiveness of some kind. No less than 360 of these vesicles are found in the halteres of Rhingia; and for what purpose?

Dr. Hicks justly remarks, that it is scarcely for *hearing*, as they are so near the buzz of the wings, and themselves in constant motion, so that other sounds would be drowned; but that the current of air produced by this very fluttering, and also the position of the halteres near the largest thoracic spiracle, make it extremely probable that they receive the floating odours in the air, and communicate them to the brain, or cephalic ganglion, directing thus the Blow-fly to the carrion, the Rhingia to the flowers.

HALTERES OF TABANUS.

"These are very similar to those of the Rhingia, with the addition of seven vesicles on the shaft of the halteres to the upper part of the facet of the ridge, and another group of eight or nine beneath the ridge opposite the boarder facet."*

The shaft of the halteres is tubular, and is the channel for the branch of the nerve which passes up and expands in the head.

The head of the halteres contains cellular substance; there is also a groove on one side lined with a very delicate membrane, and beneath which there is a group of hairs.

* See 'Journal of the Proceedings of the Linnæan Society of London,' November, 1856.

CHAPTER V.

PARASITES.

A GREAT many objects are sold for those who are curious in learning the forms of those "living creatures" which are nourished on the bodies of higher animals.

Every animal, from man downwards, is a pasture land for many fellow-creatures. So surely we may call them, formed as they are by the Almighty hand which fashioned our own wonderful body.

However repugnant it may be to our refined tastes to examine a flea or a louse, this arises from no inherent ugliness of these creatures, but rather from our association with them in scenes of dirt and misery, of personal discomfort also. Very probably they are the avengers of our evil habits, the consequences of our fallen state, and yet mercifully ordered to do us good rather than harm, by compelling the careless and the poor to that watchfulness and cleanliness which might otherwise be neglected.

THE FLEA,

man's great annoyance, is nevertheless a beautifully-formed creature.

It has to be prepared by long soaking in turpentine, and mounted in balsam, before we can see its various parts.

The flea belongs to the order of the Suctoridæ. The head bears antennæ four-jointed; eyes small, round, and simple; the proboscis is composed of two long mandibles with serrated edges; two long narrow plates with fine teeth and longitudinal ribs, these are the lancets; two leaf-like plates, nearly triangular, which are the maxillæ; two labial palpi, two maxillary palpi, one slender suctorial organ

called labrum. The thorax is composed of three segments, and the abdomen of seven segments; the female has nine; and both sexes on the last segment have that beautiful breathing apparatus called

THE PYGIDIUM OF A FLEA.

This must be mounted separately to be seen well, and it forms an excellent test object. Topping mounts it beautifully.

There are twenty-five disc-like areolæ; in the centre of each of these is a long hair, and round them a ring of rectangular rays. It must be seen rather than described.

The legs of the Flea are long and many-jointed, the hind pair having thick muscular thighs, formed for extraordinary leaps, and terminated by five tarsi, and two curved and toothed claws. Every part is worthy of observation.

The *coxa*, or first joint, is very thick; the *trochanter* is very small, the *femur* long and thick, the *tibiæ* hairy.

There are many species of fleas, each of them parasitic, on various animals, with some difference in structure. The most curious are the

Pulex talpæ, or Mole-flea, with its rows of spines on the neck.

Pulex Gallinæ, or Fowl's flea, which does not leap, but runs swiftly, and has a most tormenting bite, driving hens from their nests, and compelling their masters to keep the hen-house clean.

Pulex Columbæ, or Pigeon's flea, very curious. The antennæ should be particularly noticed; the male carries his erect, and the female has hers partly concealed in a furrow near her eyes. The form is beautiful,—eight cup-like joints set one within another, and surrounded by a circle of stout bristles.

Pulex vespertilionis, or Bat's flea, has a row of dark spines just over its proboscis, called its cephalic setæ, and a collar of spines, called its proto-thoracic setæ.

Pulex felis, the Cat's flea, which has a prettily spotted head, and in which we can see the spiracles on every segment of the abdomen, and also the pygidium, is one of

the best to mount for observation. The dots on the head, and the femora being without hairs, distinguish it from the human Flea.

The eggs of fleas are white, long, and viscid or sticky; the larvæ vermiform, with thirteen segments; the pupa is enclosed in a silken cocoon.

PEDICULUS, OR LOUSE,

a genus of anoplurous insects.

Man is infested by three kinds of Louse; but the common head louse is the one usually mounted for observation. It has a flat and nearly transparent body, three pairs of legs, terminated by a claw or hook, and a head which has two simple eyes, and a long sucker concealed in a little fleshy tubercle or snout. They multiply prodigiously, two females producing no less than 10,000 eggs in eight weeks. Leuwenhoek described them minutely, and seems to have watched their manner of feeding and propagating with great interest. Certainly their eggs are curiously formed, with a little moveable lid on a hinge, which opens for the escape of the young larvæ, and the egg of the Pheasant-louse is beautifully striated and dotted, giving it the appearance of worked net. Some parts of the internal organization of a Louse are well worthy of attention and dissection; being naturally transparent, a little soaking in oil of turpentine will dissolve the fat and render many of the organs apparent.

The nerves of a Louse are remarkable, as forming a thick spinal cord without breaks or intervals, after the ganglia of the head, and from the end of which several rays or nerves are given out to lower parts of the body, a slight constriction only marking the united ganglia. These are visible when the insect is properly prepared. The ovaries also are in ten branches of bead-like threads. All the internal apparatus is as perfect as in more beautiful insects, so little reason is there for shrinking from or thinking meanly of *even* a loathsome louse.

Birds have many varieties.

The Pheasant-louse;

The Parasite of the Rook and Chaffinch, called *Ricinus pavonis*, are interesting objects.

THE ACARI, OR TICKS, MITES.

These parasites are found on animals, birds, and insects. They belong to the lowest order of Arachnida, the Spider tribe, and many of them are beautiful microscopic objects.

The Acarus scabici, or itch insect, is a very valuable preparation. It is the occasion of that disgusting disease the Itch, and is exceedingly difficult to obtain. It lodges in a burrow near the pustule; but, being scarcely visible to the naked eye, is rarely extracted in a perfect state. When examined under the microscope it is found to have an oval body, a mouth of conical form, and eight feet terminated by bristles. The head has five strong mandibles, with which it cuts out a little nest under the skin; it lays many eggs, and is most difficult to eradicate.

ACARUS DOMESTICUS, OR COMMON CHEESE-MITES.

The dust of decayed cheese is composed entirely of these mites,—their eggs and their excrement. Mounted properly, we should see their oval body, with a head from which extends two large mandibles, somewhat resembling the claws of a lobster. When the insect is in repose it crosses these mandibles over its head, forming a kind of roof over the mouth. The legs are reddish, and inserted in two different groups, the anterior pair considerably larger in the male.

These Acari are both viviparous and oviparous.

ACARUS PASSULARUM,

found abundantly in dried figs, is like the cheese-mite, but has very long bristles at the sides of the mouth.

ACARUS PASSERINUS.

Found on all young birds.

IXODES, OR DOG-TICK,

a curious parasite, which has no perceptible eyes. It has a toothed beak, which it fixes in the skin of the dog and of the hedgehog, and it holds so tightly that it can scarcely be detached alive. It deposits a prodigious number of eggs, and are so voracious as to cause the death of some animals from exhaustion.

MELOPHAGUS.

(*Sheep-tick.*)

This parasite belongs to the Diptera, though it is wingless. They abound on sheep, are easily taken and prepared. Let them soak in potash for at least a month, then press them and wash them well; when dry, soak in turpentine before mounting in balsam, and their structure will be well seen. They are very brilliant objects when viewed with polarized light.

The Melophagus is one of the family *Hippoboscidæ*, of which there are six genera, all of them parasites of mammalia and birds, feeding on the substance at the roots of the hairs and feathers. The species pass their egg and larva state in the body of the mother, who produces only a single egg at a time, which is in reality a pupa. This pupa egg is nearly as large as its parent, and has a slight motion, with spiracles, or rather spiraculiform points, down each side, and in a short time it changes to a perfect Fly.

The Melophagus has no wings, but six stout bristly legs with very long curved and toothed claws, which they fix in the wool of the sheep. The head is very large, broader than the thorax; the antennæ are mere tubercles; the eyes small, oblong, and bare. The mouth consists of a pair of short hairy valves, in which a long sucking-tube is concealed; it usually uncoils in mounting, and is well seen as a very fine hair, protruding from between the valves.

STENOPTERYX.

This should be looked for on swallows: you may find them abundantly in nests of the young birds. They run very quickly, but do not attempt to fly, although they have wings, and are good examples of another genus of the Hippoboscidæ.

Here we find a difference in the male and female; the former having long narrow wings, ciliated in front, the costal vein more than two-thirds the length of the wing, and longitudinal veins crowded close to the costal. The female has short triangular wings; the rest of the body very like that of Melophagus.

ORNITHOMYIA.

(*Parasite of Birds.*)

A green and tawny fly, more perfectly winged than the preceding genera, but seldom, if ever, using the wings, and running with great swiftness amongst the feathers of all birds.

NYCTERIBIA.

This is a rare parasite, but quite worth seeking, upon bats. The head is thrown back in an extraordinary manner; the mouth has a large bulb-like organ, from which proceeds a horny style. It has no wings; the claws are strong, dilated beneath; and the abdomen is terminated by two styles. There are specimens of this in the British Museum.

CHELIFER.

This parasite attacks flies. I have seen a common fly run wildly about the window-pane, shaking itself violently, and apparently in great distress. Upon catching it, I found a small scorpion-like creature fixed upon one of its thighs, by a pair of tremendous claws,—hardly could it be detached for examination, and then it ran quickly like a crab, sideways. The Chelifer belongs to the *Trachean Arachnida*, that is, they breathe by means of trachea and spiracles, and not, as the higher order of spiders, by lungs, or internal gills. They have eight legs, two long palpi armed with claws; the eyes are at the side of the thorax, and the flat abdomen is jointed.

ACARUS GAMASUS,

found abundantly on the Dung-beetle, which it infests. This has a trifid labium, mandibles cheliform, denticulate, the tarsi terminated by two claws, and an elegant pulvillus, which make it worth mounting.

Scottish peasants have a habit of examining the Dung-beetles in the spring, and observing the position of the acari on their bodies: if the parasites are clustered near the head, there will be a fine harvest, if towards the end of the abdomen, a late one.

TROMBIDIUM PHALANGII.

A pretty little parasite, which attaches itself to the Phalangium, or Harvest-spider. These spiders have small oval bodies and very long legs, with two eyes on their backs, and always run upon the ground; we find these little scarlet mites attached to their legs and bodies.

TROMBIDIUM AUTUMNALE.

(*Harvest-bug.*)

This troublesome little parasite is found in corn-fields in August, and burrows in the skin, causing much painful irritation. The best way of catching it is to tie pocket-handkerchiefs round the legs, and walk through a stubble-field, when we are nearly certain of finding specimens enough in the folds of the handkerchief. They are mounted in balsam.

In all the Trombidia, observe the form of the cheliceræ, with their moveable claw, and the *palpi*, which have a singular appendage or finger beneath each extremity, which distinguishes them from the common Acari, and show their relationship to the pretty scarlet Water-mites, the Hydrachna.

WATER-MITES.

(*Hydrachnidæ.*)

The beautiful Hydrachna and Limnochares are parasites upon the Water-beetle (*Dytiscus*), and Water-scorpion

(*Nepa*), and worthy of attention in their metamorphosis, also when mounted thus as objects for the microscope.

There are several species; some bright scarlet (*Hydrachna*), others dotted with black, having blue legs (*Atax*), some parti-coloured black and scarlet (*Diplodontus*), one, bright green (*Arrenus*); all of them to be found in rivers and ponds merrily swimming about, and laying millions of small red eggs on leaf and stem of water plants. They seize on small crustaceans, such as the Cyclops and Daphnia, and suck them.

The metamorphosis is as follows :—The eggs are laid in great abundance throughout May and June, six weeks after a curious larva comes out, having a long blue snout and two large round eyes. We do not know how long it remains free in the water, but towards the end of the summer we find it change into a scarlet oblong pupa, fixed by a strong hook to the tail of the Water-scorpion, or under the elytra of Dytiscus. These pupæ were once mistaken for eggs; but the French naturalist Dugès watched them well, and saw every stage of the metamorphosis. From the pupa emerges a six-legged mite, which moults and becomes perfect, with eight ciliated legs for swimming.

The claws and palpi should be particularly noticed, and the epidermis of the green mite Arrenus, mounted for its dotted appearance.

ENTOZOA.

These are parasites attached to the internal parts of the animal body, and consist of intestinal worms, some extremely minute, burrowing in the skin, others of larger size infesting the viscera. No part of the human body is free from their attacks, the liver, the kidneys, the intestines, and the brain, are their food and abiding-place. There is scarcely one animal, especially of the vertebrate classes, which is not infested by several species. The human body has eighteen internal parasites, and those which inhabit one animal are rarely found in one of another genus. Those who desire further knowledge of these parasites, had better read 'Owen's Hunterian Lectures,' vols. iv., v., vi.

CHAPTER VI.

MICROSCOPIC MOTHS.

"Small fowl that sun their wings on the petals of wild flowers."

Proverbial Philosophy.

A NEW class of objects, especially adapted for the binocular microscope and a three-inch object glass, will give the young student both surprise and delight, when from his own researches he obtains these common and yet little known Lepidoptera. Their history has been written most ably by Stainton, in seven unattainable volumes, and the 'Insecta Britannica' has an extinct volume on the Tiniena—at least it is out of print, and to be found only in museums and the libraries of the subscribers, so that what I now give is chiefly the result of my own observations and collecting. I purpose a much more detailed account, with illustrations, for "the Intellectual Observer," at the proper time.

One of the wonders of my childhood was the variety and strangeness of the hieroglyphics I found on bramble-leaves and rose-leaves, the white winding stream with a dark line waving through it; and after picking open several, and finding within the small green caterpillars, and after often gathering, and keeping them only to find the leaves wither and the larvæ die, I made small muslin bags, and covering the mined and rolled leaves, I was rewarded by the perfect insects, of such exceeding beauty as led me to renewed attention and patient watching.

Every folded leaf, in truth, is the habitation of a microscopic moth in its larval state, and beneath the leaf a blotch, a pucker, or a tiny tent, will, if watched, give one of these beautiful objects. They may be caught with a net, swept off the bushes they frequent at certain times; but they are so very delicate and tender, that it is scarcely possible to do this without ruffling the beautiful plumage; and I prefer

breeding them or collecting the grubs, and keeping them under muslin shades, to ensure a perfect specimen.

I must, however, forewarn my young friends that every leaf *miner* is not the larva of a moth; for the primrose, ranunculus, and several other plants, are mined by the larva of flies, the Phytomyzides and Agromyzides.

The following list of the prettiest specimens will direct the collector :—

NEPTICULA AURELLA.

This is the bramble-leaf miner. The parent lays an egg on the under surface of the leaf, and as soon as hatched, the larva, which is a very small caterpillar, with very undeveloped legs, and no coronet of hooks on its fore-legs, begins to bore through the cuticle and feed on the parenchyma, between the upper and under skin. As it feeds and grows, the wavy line widens visibly, and along the centre is a string of excrement, black and wavy also. When full fed, it emerges and falls to the ground, spins a cocoon, and changes to a pupa ; at the end of three weeks it rises as the perfect insect, and flits over the brambles in calm, sunny weather ; or we may find them in windy weather resting on the sheltered side of a paling.

To the unassisted eye, this tiny moth is a mere brown speck, a very dot of life. Placed under the microscope, we see two upper wings of rich brown passing into deep purple, and then a violet spot and band of brightest gold. Two under wings of soft gray, deeply fringed with silvery scales, and these scales are all remarkably large for the size of this minute insect, which does not exceed three lines in length.

NEPTICULA MALVELLA,

is the moth of a small leaf miner on apple trees, in July and October, for all these little creatures have double broods; and its dark-brown upper wings are streaked with a single bright pale band.

NEPTICULA PRUNETORI.

Mines the sloe leaf, and has a beautiful dark wing, with a well-defined black line preceding a silvery band.

NEPTICULA TRIMACULATA,

the three-spotted moth of the poplar-mining caterpillar, which deposits its egg on the upper, and not on the usual lower side of the leaf, and makes a long gallery running close to one of the ribs, then suddenly eats out a *blotch*. The larvæ are found in July and October; the moth in May and August, easily recognised by the broad, whitish streak, taking up half the breadth of the wing, with two triangular whitish spots beyond the middle.

But the microscopist need not go further than the common laburnum for one of the prettiest—nay, it is a *lovely* little creature, that glistening, white-winged

CERIOSTOMA.

Those unsightly blotches on the leaves are the abode of its larva; and we lament over the spoiled and crumpled laburnum leaves until we have learnt the life of that most beautiful little moth. The upper wings are pure white, with a pale yellow spot on the costa beyond the middle, and a second spot with parallel lines; then, near the tip, a large black spot with violet pupil, and three radiating brown streaks in the cilia. No large butterfly is so beautiful.

There is another Ceriostoma, so like the first as scarcely to be distinguished, and yet it has a variation, and is one of the manifestations of design and order that I cannot but draw attention to. It mines the broom plant, and is easily taken from the middle of June to the end of July. The upper wing is like that of the laburnum miner, except that the second dot has always *converging*, and not parallel lines—that is all; it is but the bending of a narrow line, invisible to the naked human eye, yet there it ever is, drawn by the Hand whose lightest touch hath purpose and perfection of design.

Another species, perhaps lovelier still,

CERIOSTOMA SCITELLA,

mining the hawthorn, the apple, the pear, blotching the leaves and making our hedge-rows wither before their time. How exquisite is the soft gray wing of this species, mottled, fretted, banded, and streaked, with a golden tinge around

the large violet eye, like a microscopic Peacock Butterfly, but far more beautiful. This well deserves careful mounting.

But as my space is limited, I must not enumerate many more of these moths, for it is only to give an impulse to the study of them that I write so much, and to suggest them as new and interesting objects for the microscope.

There are no less than seventy species of Lithocolletis, whose brilliant gilded or silvered wings have given them the appellation of the Humming Birds of the Lepidoptera, and it will well repay any trouble to obtain the following species :—

LITHOCOLLETIS SYLVELLA.

Abundant on the maple, and found near London, Tenterden, Guildford, Oxford, Bristol and Shrewsbury. The pure white wings have ochreous fans, bent into angles, and edged with jet-black scales.

LITHOCOLLETIS SCHREBERELLA.

The larva puckers the under side of elm leaves, and the perfect insect flits to and fro, with bright-reddish, orange-coloured wings, striped with silver glittering bars, and with a pair of silver dots. These are very abundant near London and Oxford in May and in August.

LITHOCOLLETIS TRIFASCIELLA.

Whoever cares to find this, need but observe the lower leaves of the honeysuckle shoots in April, all puckered *aslant*, and the under side mined. Three broods in the year does this honeysuckle feed, and around it will flit the moth with reddish-yellow wings and white bands, deeply bordered with black scales. This also is common near London.

LITHOCOLLETIS HORTELLA.—L. ROBORIS.—L. AMYOTELLA.

These all mine oak leaves, and have very pretty variegated wings, white or yellow, and with golden-brown bands and dots, and delicate gray under wings, with white cilia.

The collector must also seek the leaf rollers as well as the leaf miners.

GRACILLARIA SWEDERELLA,

common on the oaks in May, June, and August. The upper wings bright-reddish, with a violet gloss, pale-yellow streaks, and triangle, and under wings of shining gray. This pretty little creature sits upon its tail when at rest, with a smooth head and its long antennæ folded back; not difficult to catch.

GRACILLARIA SYRINGELLA.

Abundant in gardens where lilac trees sufferfrom the rolling up of the leaves, and the little chocolate-variegated moth comes forth to give another brood to the already disfigured trees.

COLEOPHORA GRYPHIPENNELLA.

There are about forty-one species of these moths whose larvæ make tents in the most ingenious manner, eating away the parenchymæ of a leaf until enough is hollowed out for a convenient habitation, and then joining with silken threads the upper and lower cuticle, they cut it quite out and walk off with it. These are found commonly on rose trees in May, and the little moth in June. Other species on Stellaria, Sallows, Hawthorn, Ground Ivy, the Pear, the Plum, and the Cherry in May, when the pupa cases may be collected and the moths taken.

ORNIX GUTTEA.

A pretty spotted moth whose larva folds down the edge of apple leaves and feeds there.

LITHOCOLLETIS SCABIOSELLA.

In the herbage near scabious plants this pretty species will be found and easily taken.

It is reddish-saffron coloured, the upper wings with three pure bright white stripes, edged on the inner side with black scales, and there is a double spot at the apex of the wing, white also, but with a stream of black scales, spreading fan-like towards the edge. The larva of this *Lithocolletis* crumples up the root leaves of the scabious by mining the under surface of the leaf, and in the shelter of its excavation

spins a slight cocoon where it undergoes its transformation. This moth is plentiful in the neighbourhood of Croydon.

GLYPHIPTERYX THRASONELLA.

Several of these are the prettiest little *green* moths flitting in open meadows, and one species, haunting the rushes in damp places, has, upon the dark-bronzy, green ground, five bluish silvery streaks, and above the anal angle a black blotch, enclosing three silvery violet spots. The wing is deeply edged with bronzed cilia, and the under wings are gray.

Another extremely pretty species is found in June and July flying over the flowers of Stonecrop—this is *Glyphipteryx equitella.*

Enough, perhaps, are now described, yet I would draw attention also to the form of the heads, the feathered antennæ, and the tufts of scales on the heads and palpi of many of these moths. For instance—

THE HEAD OF OCHSENHEIMERIA,

feathered in a marvellous bird-like manner, the antennæ thickened with scales, labial palpi very hairy, and the head alone making an excellent object. The moth is gray, and very abundant in some meadows towards the end of July. They are rarely seen, however, except between the hours of twelve and two, in the heat of the sun, and then they are hopping about the grass stems, and depositing eggs on the stems of *Dactylus glomeratus.*

The heads of the following are remarkable, and worth mounting:—

HEAD OF PLUTELLA,

with tufted labial palpi.

The moth is spotted gray, and is often very abundant among cabbages and cruciferous plants.

HEAD OF CORSICIUM.

This should show the front of the head, and the curved labial palpi, with long pendent scales. The moth is grayish-brown, and hovers about oak trees in June, August, and September.

CHAPTER VII.

PALATES.

PALATE OF HELIX POMATIA.

Helix pomatia is that very large snail found in woods and hedges on chalky soil and oolite formations in the Southern and Midland Counties of England. The shell is often two inches high, of pale tawny colour. These snails were highly esteemed in the olden time by the imperial gourmands of Rome, who preferred them fried in oil of almonds, and then delicately grilled on a silver gridiron. When previously fattened upon bran and wine, they grew to an enormous size; three snails, two eggs, and a lettuce, being a favourite supper of Pliny the younger. At one period in England we feasted upon them ourselves, boiled in spring-water, and seasoned with oil, salt, and pepper; and highly relished them as a foreign luxury, introduced for that purpose about the middle of the sixteenth century, and first cultivated in Surrey, afterwards in Buckinghamshire and Northamptonshire. Of later years they have been used medicinally in cases of consumption, as also the common garden snail, *Helix aspersa*, which is exported from England yearly for this very purpose, and sent to America packed in old casks. The glassmen at Newcastle have still a snail-feast yearly, and generally collect the snails themselves on the Sunday previous to the feast.

We may also care to know that this edible snail, which abounds in the neighbourhood of Mount Sinai, has been thought to have supplied the Israelites with food in that part of their journey towards the land of Canaan; for the whole sides of that valley between Mount Deouchi and

Mount Torah are covered with shrubs of tamarisk broom, and with clover and saintfoin; and the herbage beneath is so thronged with these snails that travellers say it is difficult to walk without crushing them.

So much for the general interest of the snail; but the palate chiefly relates to its depredations, and shows us the cause of its mischief-making in our gardens.

HELIX ASPERSA.

The mouth of the snail is armed with two horny lips, sufficiently powerful to bite the tender stalks of lettuce and other young vegetables; and is further provided with this palate, which is not in the mouth, but lying far back in a kind of pouch which opens in front, and is capable of projection forward and backward, as may be well observed in the water-snails kept in aquariums. We can there see the opening lips and the palate thrown forward, rasping away the conferva spores on the surface of the glass. The palate of *Helix aspersa* is broad and short, set with about 150 rows of stout serrated teeth—altogether no less than 21,000 in this single palate.

LIMAX,

(*Black-slug*,)

is nearly the same, but contains yet more teeth. A full-sized and aged slug has 26,000 teeth, which accounts for its power of destruction in our gardens.

HELIX HORTENSIS.

Helix Hortensis is a variety of the common garden snail, reddish, yellowish, or pale gray.

HELIX NEMORALIS.

Helix nemoralis is the pretty banded black and yellow snail, which, if long lying in the warm sun, often turns rose-coloured or fine pink, to the great admiration of little shell collectors.

HELIX RUFESCENS.

Helix rufescens, a reddish-brown snail, flattish, and in the middle of the largest whorl it has a narrow white line or band, which distinguishes it.

HELIX VIRGATA.

These pretty small brown and white banded snails are most abundant on our sandy sea-coasts, quite covering the marine plants there; also they are often in great numbers on sandy commons on the wayside turf.

The palates of all these terrestrial gasteropods are upon the same plan—broad, short, and with long rows of teeth; the prettiest variety is found in the palate of

ZONITES, OR HELIX NITIDA.

This small snail is a species passing out of the genus Helicidæ; it is small, transparent, pale yellow, or light brown, with five whorls, and the under side clouded with white; found under stones, and in violet beds at the roots of the plants, also in cellars and yards in cities. The side teeth slope towards the centre, which is occupied by what may be called double teeth, or teeth with several projections. There are few prettier palates than this of the common little *Zonites*, or *Cellar-snail*.

PALATE OF WHELK.

(*Buccinum undatum.*)

Compare this with the palate of any of the terrestrial gasteropods—snails or slugs—and the difference of structure will be apparent: instead of that broad short membrane thickly set with rows of nearly uniform teeth, we have here a ribbon-like tongue, having strong serrated teeth at the edges, and rows of small finer ones between them, better observed by polarized light, which makes it a splendid object. This tongue is contained in a long fleshy proboscis, with which the Whelk bores through the shell of those molluscs which serve it for food, and the muscles by which it moves this tongue are immensely strong, not only drawing

it backwards and forwards, but raising or depressing the teeth.

The whelk is largely consumed in London; it is dredged off every part of the British coast. Dr. Johnson tells us that at the enthronisation feast of William Warrham, archbishop of Canterbury, in 1504, 8,000 Whelks were dressed as side dishes for the lordly epicures of those days.

PALATE OF PURPUREA.

The Purpurea, or Dog-whelk, is a small species of Buccinum very abundant on our rocks; it has a white shell, and is often found with a little semi-transparent flask beside it, or a cluster of them filled with eggs, which are most interesting microscopic objects, as the development of the little mollusc is easily watched. The palate is pretty and resembles that of the larger Buccinum. It was from this shell-fish that the Tyrians procured their famous purple dye, making a bath of the liquid in the proportion of two pounds of Buccinum liquor to one pound of the purpurea. The process being tedious, and the needful quantity of these little creatures very great, the price of the wool so dyed was enormously high—no less than 1,000 Roman denarii, or thirty-six pounds sterling, per pound.

NASSA.

A smaller species of Buccinum.

PALATE OF TROCHUS ZIZIPHINUS.

This is the palate of that very pretty variegated spiral shell called "Tops," which we delight to find on the rocks at low water under the thick hanging masses of sea-weed. No palate is so beautiful, or requires such careful examination; for when we have had a general view, we should always use a higher power, and explore further the wonderful workmanship displayed in this tiny tongue. Not only are there triple rows of finely notched teeth arching over towards the centre, but the intermediate space is thronged with delicate leaf-like teeth, curved downwards

with minutely serrated edges—making a powerful instrument for rasping the surface of the sea-weed upon which the Trochus feeds.

The mouth (of the Trochus) has no upper horny plate, and therefore probably needed this elaborately toothed tongue.

PALATE OF TROCHUS CRASSUS.

Trochus Crassus is a variety of the same family, having a large gray shell, and the tongue less beautiful.

PALATE OF TROCHUS UMBILICATUS.

Trochus umbilicatus; a smaller and more abundant shell, also of gray colour.

PALATE OF PERIWINKLE.

(*Littorina.*)

The Periwinkle is too well known to need description, and the palate is very like that of the *Trochus Crassus.*

PALATE OF HALIOTIS, OR AUMER.

The Haliotis is that beautiful univalve mollusc found in the Channel Islands, under stones at low tide; the fleshy foot is sold in the market there, and highly esteemed as an article of food, either stewed or fried in batter. The shell is brought to England, and sold to manufacturers of works inlaid with so-called mother-of-pearl, which is really the beautiful interior of this shell. The palate is one of the finest prepared for the miscroscope, and yet more complicated than that of *Trochus ziziphinus,* which it resembles. The central band here has rows of teeth, having nearly straight edges instead of points; there is on each side a lateral band consisting of large teeth, shaped like those of a shark; and beyond this, again, another lateral band on either side, composed of several rows of smaller teeth. (*See* 'Carpenter on the Microscope,' p. 605.)

The Haliotes are carnivorous as well as vegetarian, often found feeding on dead bodies.

PALATE OF PLEUROBRANCH.

The Pleurobranch is a lemon-coloured, oval-shaped mollusc, found under stones in tide-pools, and breathing by a beautiful branchial plume, which is thrown out on the right side, as it glides along, and protected, when at rest, by a thin shell inside the mantle. This palate is quite unlike any of the others, more resembling a tesselated pavement, with a single tooth in each lozenge-shaped division.

PALATE OF APLYSIA.

Aplysia is a sea-slug, found in deep rock-pools gliding about with a thick hump-backed body, olive-brown, and tentacles like ears, causing it to resemble a hare. If handled or frightened, it jerks forth a deep purple liquid, which stains the hand or discolours the water. This is evidently its defence, and conceals it from the pursuit of ravenous crustaceans. It belongs to the family of the Pleurobranchs, which have their breathing organs concealed within the mantle, but always on the *right side*, and the palate is broad and short, resembling that of the garden snail, only very much larger.

PALATE OF DORIS.

(*Tuberculata.*)

Another variety of sea-slug, much more beautiful, and the palate curiously set with strong hooked teeth like a harrow; it has forty-four rows, each with 140 of these curved teeth, used for rasping sea-weed. There are many species of Doris usually found under stones at low tide, or beneath tufts of sea-weed; they are orange-coloured, or pale-yellow, and vary in size from our largest garden slug to a very small one; on their backs they carry a plume of branchial organs, and are therefore called *Nudibranchs*, or naked-gilled animals.

PALATE OF LIMPET.

Who does not know the Limpet, clinging to the wave-beaten rock, and seemingly as motionless as its native cliff?

—who has not jerked it off for bait or for the variety of colour in its pretty shell, and in so doing noticed a long slender thread attached to its head, and many times longer than its body? That was the tongue we are looking at. It has, we see, alternate rows of four hooked teeth, and two notched large teeth all the whole length of that thread-like palate, which lies coiled up loosely inside its body, and is thrown forward like a scythe to mow down the lichen upon which it feeds. When the front row of teeth wears away, a second is brought forward, and so the length of the tongue only provides for the little creature's necessities and duration of life.

PALATE OF CHITON.

Not so abundant, and very different in formation, is the Chiton, which we find hidden in crevices of the same rock to which the Limpet clings. The Chiton is the only mollusc which has many shells in one. This little creature has eight plates or shells overlapping each other, round the external edges of which the breathing organs lie,—a row of triangular leaflets vibrating in the water, and resembling gills in structure. The palate we see is long and ribbon-like, with dark-brown teeth on either side, and smaller in the centre; they are set in a kind of double arch, jointed, and capable of elevation or depression, and used, like those of the Limpet, for vegetable food.

PALATE OF YELLOW NERITE

is very pretty, and somewhat like the Periwinkle. The Nerite is that bright-yellow shell so common on our sandy coasts. Children call them "yellow tops."

PALATE OF NERITINA FLUVIATILIS

is a fresh-water mollusc, found in slow rivers adhering to stones, the shell very prettily chequered with spots or bands of white, brown, purple, or pink.

PALATE OF LYMNÆA STAGNALIS.

The three following palates belong to fresh-water molluscs.

Lymnæa is a large snail, whose shell, making six or seven whorls, terminating in a fine point, is found in all ponds and stagnant water, floating or gliding foot upwards, and feeding voraciously on all kinds of vegetable matter. The palate resembles that of the garden snail.

PALATE OF PLANORBIS CORNEA.

Planorbis is a flat snail with a shell in horizontal coils, the size of a shilling, other species being smaller. The tongue is oblong, and set with many rows of fine teeth.

PALATE OF PALUDINA.

Paludina is a remarkable fresh-water shell, more resembling a large Periwinkle, but banded black and yellow, with a strong operculum. It brings forth its young alive, and they may be found in all stages of life in the space between the mantle and the shell. The tongue of the Paludina differs much from those of Lymnæa and Planorbis, being long and slender, and the teeth like horny plates laid over one another—more like those of the land-snail, Cyclastoma, and showing that it is, in truth, as La Mark conjectured, the family which links the two great divisions of land and water molluscs. Here then we have a very interesting palate, and proof of the usefulness of microscopic observation; for nowhere but in the palate do we find the very marked distinction between the Paludina and Lymnæa, both inhabitants of the same stream, and at the same time the close relationship to the little Cyclastoma, which lives high and dry upon the chalky hills, and under the hedge-rows of a limestone district.

PALATE OF CYCLASTOMA.

The *Cyclastoma elegans* has a white and finely striated shell; its palate should be mounted in fluid, as indeed all these are. Simple salt and water well preserves them.

CHAPTER VIII.

SLIDES OF ZOOPHYTES.

"O Lord, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches. So is the great and wide sea, wherein are things creeping innumerable."

Psalm civ. 24, 25.

"Look who list thy gazeful eyes to feed
With sight of that is fair: look on the frame
Of this wide universe, and therein read
The endless kinds of creatures which by name
Thou canst not count, much less their natures aim;
All which are made with wondrous wise respect,
And all with admirable beauty deckt."

Spenser.

An explanation of these useful slides to every sea-side student seems necessary, from the fact that many persons inquire, "What is a Zoophyte?" and if shown one of these under the microscope, will presently declare that it certainly may be an animal, for *it moves*. This has happened to myself more than once, and an explanation required to prove the fact is a *post-mortem* examination, and then we only see the body, or rather the framework, which supported the once living polype.

These are the skeletons of Zoophytes mounted to show the beauty of their structure, and the variations of form which determine the species.

If we would see them alive, we must gather them at the sea-side fresh from their native element, on the sea-weed or the rock, and by placing them in a watchglassful of water under the microscope, the question "What is a Zoophyte?" will be answered far better than any tongue can tell or pen describe. Nevertheless, to appreciate these slides we must explain that Zoophytes are, with one exception, marine animals, varying in size from the little microscopic creatures mounted here, to the large tree-like Gorgonias, and the huge Madrepores and Corals of the tropical seas. They are plant-like animals, often mistaken for sea-weeds,

requiring minute attention and microscopic study to understand; but even the careful observation of those specimens on our lists will open a wide field of interest, and help the young student considerably in his first researches.

The number of British Zoophytes amounts to about 35 genera, and 240 species. These are divided into two great divisions, and hold very different ranks in the scale of creation; for the Zoophytes called Polyzoa, being much more highly organized than those called Anthozoa, they are placed with the Tunicate Molluscs (Ascidians, &c. &c.), and above the Radiata (Starfish and Echini); whereas the Anthozoa are only just above the Infusoria, or lowest form of animal life.

These slides contain specimens of both these orders, which will be further explained when under the microscope. Those of the Anthozoa are—

Sertularia.	Coryne.
Plumularia.	Halecium.
Laomedea Campanularia.	Thuiaria.
Tubularia.	Antennularia.

Their bodies are globular, contractile in every part, symmetrical, mouth and vent one, gemmiparous and oviparous. The Polyzoa are—

Gemellaria.	Flustra.
Cellularia.	Pustulipora.
Crisea.	Lepralia.

If we describe the Sertularia as an example of Anthozoa, and Gemellaria as one of the Polyzoa, the student will understand each of the others, and when at the sea-side will have 'Harvey's Sea-side Companion,' or 'Landesborough on Zoophytes,' to teach the variety of the species, and direct to their particular habitat.

ANTHOZOA.

SERTULARIA PUMILA.

This little branch of zigzag cells was once creeping along the Fucus, or common sea-weed, on rocks at low-water mark, often so thickly crowded together as to cover the alga. The cells are opposite each other, and at inter-

vals large capsules or ovarian vesicles rise from the base of a smaller cell. In life this horny skeleton was filled with a living pulp, and each tiny tube right and left was the abode of a beautiful white creature called a Polype, which rose up and threw out eight or ten fine tentacula, or feelers, drawing food into a mouth placed in the centre of these tentacles. From the mouth there was a digestive sac, or stomach, communicating with the stem, and a circulation of fluid went on throughout the polypidom, that is to say, the branch of cells we have described, though each Polype had an independent life.

It has been observed, that at the base of the Zoophyte stomach there is an orifice closed by a contracting and dilating sphincter muscle, and through this the digestive food is propelled to the stem, after enough has been appropriated by that Polype, besides which a spiral movement of particles is seen in the stem, somewhat resembling the rotation in Chara.

The manner of propagation and of growth is very remarkable. Those ovarian pear-shaped vesicles you may see here and there on the branches contain buds, or gemmæ, which, when mature, escape and swim freely in the great ocean. Their form is most unlike that of their parent; they are called Medusyides, and in turn produce fertilised ova; these being edged with ciliæ move for several hours in the water, and then, fixing on sea-weed, rock, or stone, develop into a polypidom like this spray of Sertularia. When the ovule fixes, minute fibres are observed to proceed from the under side, and the pulp dilates and ascends, covered by the horny substance, inside which the dark pulp runs like a thread. At a certain foreordained point it stops, becomes bulbous, a tube or cup (according to the species) forms gradually, whilst the pulp is fashioned into the Polype with little knobs lengthening into tentaculæ, which no sooner are complete than they are thrown forth for food; and the nourishment, instead of increasing the size of the Polype, is passed to the stem, and a second cell buds forth on the opposite side, or the stem is prolonged a little, according to the plan of the species. Look at the next slide—

SERTULARIA POLYZONIAS.

You see here that the Polype cells are not opposite each other, but alternate and far apart. There are two varieties of this Zoophyte, the one upright, the other spreading and branching; it is found on shells and sea-weed, especially on branches of Halidrys.

These little creatures are very phosphorescent in the dark; if we shake or strike the sea-weed upon which it rests, a shower of diamond sparks seem to be scattered over the frond; each cell on the delicate spray is a fairy lamp, a moment seen and gone, or sometimes shining on with a faint, gentle light, showing where the little Zoophyte is dwelling. Often when, having gathered a quantity of *Sertularia pumila* during the day, I have handled it at night, the flashing out of a thousand tiny stars has astonished me. What must it be if the tossing wave shakes glory thus from the dark weed in the stormy night, and the ocean depths are illuminated by their living lamps?

SERTULARIA OPERCULATA,

or Sea-hair Coralline, shows the sharp tooth-like cells peculiar to this species, and the vesicles with a rounded operculum on the top. This zoophyte is abundant on the coast, often thrown up on the beach in tufts as much as six or eight inches long, especially after a storm.

SERTULARIA ROSACEA,

called the Lily or Pomegranate Coralline, will give you a good specimen of varieties in species, and show you what to observe; for the cells are not so unlike those of the common *Sertularia pumila* (the upper part of the cells bent outwards and downwards slightly), but the vesicles are most unlike. You see they are pear-shaped, wrinkled, cleft at the top, and more silvery in hue. This coralline grows on shells in deep water, and is parasitic on other zoophytes, small white clusters being often found on *Plumularia falcata* and *Sertularia argentea*.

LAOMEDEA GENICULATA,

the Knotted-thread Coralline—a very common and beau-

tiful zoophyte, one of the family of Campanularidæ, and worthy of minute examination. In this species we are successful in preserving the polypes themselves inside those tiny cups. The fibres are twisted in a network on the sea-weed—usually a frond of Laminaria or Fucus, and slender threads bristle thickly from the stem—a zigzag line, on each side of which rise winged stalks bearing the polype cell; here and there are large vesicles containing Medusoides. The peculiar interest of these Laomedea is the wonderful adaptation of their structure to the element in which they live. How would this fragile cup and slender stem resist the wild storms of the ocean if it had not been provided with that jointed pedicle, which bends to and fro on every side in ease and safety, whilst the little inhabitant stretches forth its single row of tentacles, and draws food into its probosciform mouth? The vesicles also, though apparently sessile, are fixed upon a footstalk like a screw, which enables them to resist the shocks of a stormy sea.

LAOMEDEA DICHOTOMA.

Laomedea dichotoma, or Sea-thread Coralline, is found in long, filiform, zigzag branches, on old shells or stones, or sea-weed, within tide-mark.

PLUMULARIA CRISTATA.

Observe this both with reflected and transmitted light. It is the Feather Coralline picked up as sea-weed by children on the sea-coast, after a gale of wind has cast up treasures of the deep within our reach. It belongs to a family (*Plumularia*) which has several species, but none so beautiful as this. We find it twined round the stems and pods ot *Halidrys siliquosa;* sometimes a mussel-shell will have a feathery plume upon its rich blue surface, and tens of thousands of tiny creatures spring forth from those sessile cups, ranged all along the pinnæ; they are shaped somewhat like lilies of the valley, with a projecting spine beneath each, and the vesicles are oblong, pod-like, and banded with cristated ribs; the more of these, the better the specimen; but it should be examined when fresh, and is more easily found, perhaps, than any other zoophyte.

PLUMULARIA FALCATA

is another species, in which you may observe the polype cells seated in close array along the pinnæ of the branches; these, when dry, bend inwards like a sickle, and give the name of Sickle Coralline to this zoophyte. It is dredged in deep water, and common on oyster beds. A wavy branch of it will not unfrequently be found on the back of some old crab, which has served as its perambulator, and carried it into rich stores of Diatoms and Infusoria, such as it delights in.

POLYZOA.

GEMICELLARIA.

This is one of the Polyzoa, more highly organized than Sertularia, &c., and therefore ranking considerably higher in the scale of creation. The difference in the skeleton here prepared is, that we have a calcareous cell instead of a horny one. Almost all the Polyzoa have calcareous sheaths, or polyzoaries, as this skeleton is called, instead of polypidom, which belongs to the lower class of zoophytes. The difference between the two is this: a polypidom is a separate horny case, which is formed *before* the indwelling and connected polype, and the polype itself is part of a common central mass, having a simple stomach, thread-like tentaculæ, which seize food and draw it to the mouth, and which multiply by ovarian vesicles containing medusoides. The polyzoary is a case or tunic investing the body of a distinct and separate polype, which is either horny or calcareous, sometimes forming a dense hard crust on stones and shells.

The polype within is quite different from that of the Anthozoa. It has *ciliated* tentacles. The Polyzoa is a part of the polype itself, investing it as a tunic or case, which is sometimes horny, but most frequently *calcareous*, even forming dense crusts upon shells, stones, or sea-weeds. Though always found in a mass, the Polyzoa are strictly solitary individuals, without inward connection, each polype

being perfect in itself, and distinguished from the Anthozoa by that of its *ciliated* tentacles, which do *not* seize the prey, but create currents in the water whereby food is carried into the mouth.

This is a great distinction, and must be observed, of course, in the living animal; a very curious sight it is to watch the shoals of little golden fish-like naviculæ whirled into the vortex of a hungry polype, the currents running along the cilia or delicate fringe which edges each tentacle. Some polypes have two stomachs, one a kind of gizzard, triturating the food, and the other digesting and discharging the refuse. There is even a rudimentary liver—a valve at the pyloric opening; the stomach itself is lined with cilia; in short, the living polype you are now looking at in its dead state was a wonderfully organized little creature, though scarcely visible to the naked eye. Instead of the ovarian vesicles of the Anthozoa we find, especially on Flustra and Lepralia, little pearly cells, which are gemmæ, or buds, thrown forth from the body of the polype. They have two methods of propagation, one by gemmation, the other by a true sexual generation. (*See* 'Carpenter on the Microscope,' p. 575.)

MEMBRANIPORA PILOSA.

An abundant and beautiful zoophyte for examination in the living state, as the fearless little polypes rise up in crowds from the shelter of their pearly homes, and fling forth their white ciliated tentacles, waving, curling, contracting, and expanding, in very ecstasy of life, drawing in the food they require by means of the currents these tentacles make.

In this living state the Membranipora is only a brown, thick crust on rock or sea-weed; but when the zoophyte is dead, we find it on the brown fucus or the crimson Delesseria, or sheathing the stem of *Chondrus crispus*, like a delicate net, pure white, or pale fawn colour; when mounted dry it is perfectly lovely. We now see the oval horizontal membranous cells, sharply toothed and granulated, whilst behind the mouth of each is a long jointed bristle, which in life lashed the water to and fro, keeping the Polypidom

free from obnoxious particles. If, however, the observer is at the sea-side, whilst examining a living Membranipora, he may look for the singular organ described by Dr. Farre and by the Rev. T. Hincks. It is oblong, placed between the base of two of the arms, and attached to the tentacular ring. Round the opening at top is a play of cilia, and it is lined with cilia. These gentlemen observed numbers of filamentous bodies wriggling up from the visceral cavity, and as they reached the base of this organ, they were drawn into, carried upward through the ciliated channel, and ejected, being then whirled away by the tentacular currents. These are supposed to be spermatozoic bodies called cercariæ, and subservient in some way to the function of generation.

Besides Mebranipora, I would direct attention to various species of Lepralia. Scarcely a stone or a shell from the great deep but yields most varied forms of these zoophytes. In the Channel Islands, Jersey, by Mrs. Gatty, of Eccles-field, Guernsey, on *Phylophora rubens,* and also at Sidmouth, the loveliest species called

LEPRALIA GATTYÆ,

may be found in winter thrown up after a storm, exceeding small—a little branching speck, once seen never forgotten, differing from all other Lepralia in having a rich pattern carved upon the centre of each cell. A raised knob and a circlet of dots, then rays or raised lines, between each of which is to be found a dot or puncture larger in size than those of the other circle; again, the termination of each cell is delicately fluted, that is, if not overcrowded with cells or ovarian capsules. In all Lepralia we find round, pearly, smaller cells, dotted over the surface, sometimes almost hiding the parent cells; these are most abundant on the pretty

LEPRALIA HYALINA,

common on mussel-shells.

LEPRALIA NITIDA

is like a miniature human thorax, ribbed and with a broad band representing the sternum; a lip armed with five long

spines, and having a metallic glow over all the pure white fabric.

The observation of a few specimens will lead to a large collection; not a speck upon sea-weed, stone, or shell, should be overlooked, and for a pleasant, easy guide, take 'Dr. Landesborough on Zoophytes.'

ALECTO GRANULATÆ.

This is found creeping on stones and shells and weed dredged from the deep; cells tubular and creeping, four or five abreast, with long spines, and granulated texture and erect circular aperture. *Alecto major* has no granular markings. This zoophyte, amongst others, is sold by Baker, and a collection would be found most useful preparatory to further researches at the sea-side.

GEMMELLARIA LORICULATA.

This *Gemmellaria loriculata* is an example of the branched, half-horny, half-calcareous polyzoary; it is a splendid object with polarized light, if mounted in balsam, the cells pale pink, with a framework of carbonate of lime, giving a fine orange tint.

We find Gemmellaria abundantly on the south-western coast, or thrown up on the beach, after a gale, in bunches, easily distinguished by the position of the cells back to back in pairs.

GEMECELARIA, OR NOTOMIA BURSARIA,

a rare but lovely zoophyte, always to be looked at as opaque, and the singular appendages to its lid observed. The triangular cells are in pairs, each capped by an organ resembling a tobacco-pipe, or, some say, a bird's head. It is also called the Shepherd's Purse Coralline, from its resemblance to the seed-capsules of that plant. We only find it in very small tufts, parasitic on other zoophytes; but, minute as it is, the tiny creature has the same highly organized body as the rest of the Polyzoa.

CELLULARIA AVICULARIA

is the true Bird's-head Coralline found on stones in deep water or at very low tides, growing in spiral fan-like tufts about an inch high. This is a calcareous polyzoary: the

cells have a spine at each upper angle, and an appendage called the bird's head. With a little management of light, you will see the muscular lines by which the neck opens and shuts; when alive it snaps in all directions, seizes any passing animal, and holds it fast until death. Now, as they have no inward connection with the stomach of the polype, neither give the food to the tentacles, it is doubtless for protection that they are placed over the otherwise defenceless zoophyte—a sensitive and ever-ready police to keep the cities of the great deep. Cities they are indeed; for examine a piece of Flustra—

FLUSTRA TRUNCATA.

On one specimen you may count 18,000 inhabitants, all rejoicing in the life bestowed upon them, and all in obedience and harmony performing their task in the ocean world. Yes, they all have an appointed work—they had it long ago in the ages beyond our own existence—before the green earth had risen from the chaos of waters, or even before the Saurian age of reptiles, in the calm clear ocean of the earliest formations, the little polyzoaries of these zoophytes existed, and their fossil forms are found with those of the lonely Trilobite.

It is possible to mount these zoophytes with the polypes displayed, and a more beautiful object is rarely seen. The way to manage it is thus: Watch the living creature placed in a shallow dish of its native element, and whilst they are "out" dash in a tumbler of cold spring water, which paralyses the Polypes, and they may be mounted in fluid permanently. Another way I have heard, but not tried, is to pour gently some spirit into the water, which irritates the zoophyte, and it comes forth to drink of the intoxicating fluid, and falls a victim to its poisonous influence.

PUSTULIPORA FOSSIL,

of which the present species are *Pustulipora, Deflexa,* and *Proboscidia;* calcareous, erect Polyzoas, with tubes half immersed; found on shells in deep water off Plymouth and Zetland; whilst the fossil slides sold by Tennant are from the chalk of Kent and Wilts.

FLUSTRA CHARTACEA

abounds at Hastings; thin, glistening, and scarcely two inches high, of a light straw colour; the cells are an oblong figure, protected by a helmet-like operculum. Called also the Paper Seamat.

The name Flustra is from a Saxon word *flustrian*, to weave; and wonderful, truly, is the living web which the Almighty hand has woven in the deep sea!

CELLULARIA REPTANS.

(*Creeping Cellularia.*)

The Cellularia polyzoa has a mixture of horny and calcareous matter; the cells have an oblique opening, each with four or five short spines: it is a very common species on fucus, in circular branched tufts.

CELLULARIA CILIATA.

A delicate little pearly-white coralline, often found amidst the bunches of red sea-weed—the *Ptilota sericea* especially. The cells are at the tips of the branches, and armed with five very long calcareous spines, which are so brittle that you seldom get them mounted perfectly; and over the mouth a most exquisite little operculum, transparent yet firm, closes the door against intrusion, and falls back when the twelve or sixteen ciliated tentacles come forth for food.

CRISEA EBURNEA.

The Ivory-tufted Coralline, common on such sea-weeds as Delesseria and Dasya, also on the roots of the Laminaria which has been thrown by a rough sea upon the beach. Finely granulated pear-shaped vesicles are often scattered over its branches; it is strongly calcareous; the cells tubular, with circular apertures looking towards opposite sides.

CRISEA CORNUTA.

The Goat's-horn Coralline, more rare, and parasitical on other zoophytes. This is a very minute species, with long tubular cells, shaped like goat's horns, and placed one over

the other. A fine hair-like bristle projects from the side of each cell, and speckled oval-shaped gemmæ are often found on the branches.

SERIALARIA LENDIGERA.

The Nit Coralline. Large tangled masses of Serialaria often lie upon the sea-sand after a storm, or come ashore clinging to the up-torn branches of *Halidrys*. It looks to the naked eye but as some knotted thread; yet even with a pocket lens we find each knot to be a little pan pipe, with from eight to twelve polype cells seated side by side on the fine silken thread which runs on a little space, and again a small pan pipe or family group makes what is called the Nit on the coralline.

FRESH-WATER ZOOPHYTES.

POLYZOA.

These objects, accessible wherever there is a quiet, shadowy pond, or a sluggish canal, or a ditch semi-covered by the road-side, are worthy of close attention; indeed, the development of the Statoblast or Gemmæ of fresh-water Polyzoa is too great a pleasure to pass unnoticed.

STATOBLASTS.

Small oval bodies, found floating on the water of ponds and ditches all through the winter; they may be mounted dry, and are useful thus, enabling the young student to recognise them in the water. They have an oval brown centre, and a lighter brown reticulated border, more or less wide, according to the species. One variety is exceeding beautiful—the Statoblast of *Cristatello mucedo*—which has a scalloped edge and hooked spines of crystal, proceeding in rays from the border, giving it a sun-like appearance. These bodies are formed in the interior of the parent zoophyte, growing like buds from the funiculus or small cord which attaches the stomach to the endocyst or internal coat of the tunic. They are not true eggs, yet they produce perfect polypes, and are not expelled from the Polypidom,

but may be seen in long files within the horny tube of *Plumatella repens* (the most abundant species), both during the life and long after the death of the parent polype. Probably the shelter is a needful protection against the hungry minnows or sticklebats; but when the Polypidom decays the Statoblasts float freely on the surface of the water, attach themselves to Lemna and Anacharis, or even to stones and sticks, until the warmth of a spring morning quickens them into life.

If kept in a room they develop sooner. As I write in this month of February, there are several *Statoblasts* in my aquarium with a young Plumatella fully formed, sheltered beneath the open valves, and waving a circlet of white tentacles, feeding almost incessantly, and with body so transparent that every part of its internal economy is visible. The lophophore, or membrane, which bears the tentacles, can be seen drawn in like the retracted finger of a glove, the open œsophagus and striated stomach, its muscular bands across, and longitudinal, the pyloric cavity, the cardial cavity, and the movement of the intestine, as it ejects the rejectamenta.

In a further state we should see the ovary and developing Statoblasts.

THE PLUMATELLA REPENS,

so called from the Latin word signifying *plumed* and *repens*, or creeping, because of its habit of lengthening the small brown tubes along stones or leaves, or twining round Lemna. It looks merely like a dead spray of horny substance when taken out of the water; but replace it in a tumbler of its own soft element, and from every spray will peer forth a multitude of ciliated polypes, like Membranipora, except—and *observe this*—the tentacula, ranging from twenty to fifty in number, are not in a starry ray, but in the form of a double horseshoe, the outer one fan-shaped, and the inner one likewise, but more compact, only it sometimes arches over, and the plumed tentacles seem like a feathery tent protecting the indweller; or, as was really the case, enclosing hopelessly the caught infusoria whirled by the outer current into the hungry mouth beneath. When,

however, a larger species of prey is taken in the net the result is sometimes inconvenient. A Notommata heedlessly sailing along I once saw drawn into the horseshoe snare, and though with strong bounds he dodged the encircling arms, and evidently went down against his will, yet down he went, when presently I observed that he recovered heart within that prison, and began feeding on the smaller fry that had been swallowed with himself. The next day the poor Plumatella looked weak, and was evidently ill at ease with that rampant Notommata within still jerking about and feeding. The next day the polype was dead. Out of the perishing body sprang the triumphant infusoria.

Let me urge every one who can do so to obtain either the Plumatella itself or Statoblasts, and for all such supplies of vegetable or animal life the student had better go to King's, 190, Great Portland Road.

PALUDICELLA

is found in still or slowly running water, attached to stones in dark corners, the cells very much resembling those of the marine *Eucratia chellata*.

LOPHOPUS

has a transparent gelatinous tunic, enclosing several polypes, and attaches itself to the stems of Lemna Polyrhiza in dark ponds or ditches.

ALCYONELLA

may be found in sluggish water in dense masses, after encrusting the branches of trees which dip into the water.

CRISTATELLA MUCEDO.

The large light-loving, beautiful creature, flinging its broad polypidom over stems of the water-lily, and they come forth in a watch-glass under the microscope, neither shrinking from the light, nor frightened at a jog of the table, a whole army of tented tentacles waving to and fro. Sometimes this polypidom looks like a little bit of greenish sponge floating on the water. The Statoblasts are spined and crystalline; they very soon develop a polype which immediately in a new process of generation multiplies by gemmation.

CHAPTER IX.

SEA-WEEDS—MARINE ALGÆ.

"The gentleness of Heaven is on the sea.
Listen! the mighty Being is awake,
And doth with his eternal motion make
A sound like thunder—everlastingly."

Wordsworth.

"The water is calm and still below,
For the winds and waves are absent there,
And the sands are bright as the stars that glow
In the motionless fields of upper air;
There, with its waving blade of green,
The Sea-weed streams through the silent water,
And the crimson leaf of the Dulse is seen
To blush like a banner bathed in slaughter."

Percival.

THESE slides of sea-weeds will surely be very popular objects; the student at the sea-side will refer to them again and again for the verification of his own specimens, and for instruction in the varied tissues and parts of fructification. The student at home and far inland will bend over them in delight until he *hears* the booming wave, and *feels* the spray of an up-rushing tide—until, on the wide, wild coast, after a storm, he seems to see the tangled treasures of these beautiful plants cast up to perish. Or, as slide after slide is examined and learned, the strong yearning will come for a wandering by the sea-side—a rest beside a rock-pool. If the sea-side has ever been *a Home*—if our childhood's joy has been to patter on the sands with naked feet, and chase the scrambling crab into its cranny—or, later, with eager hand to gather Zoophyte and Weed, with an understanding heart and loving eye for the great works of the Almighty, then these beautiful specimens will come with the power of association and memory, as well as with their scientific value.

A slide of that exquisite *Ptilota plumosa* sent my spirit far away from the quiet country home. A sound of a

gushing tide was in mine ears, the vast expanse of a sunlit sea before mine eyes—my feet were slipping and bounding from rock to rock, down to the edge of a retreating wave, a long way from the shadow of the Serk cliffs. Suddenly, as in a dream, a deep rock-pool lay before me, on the outer side of which a forest of *Laminaria* and *Chorda-filum* was streaming out into the sea; all round the interior margin were thick clusters of olive sea-weeds, and the dense foliage of *Lichinia*, *Cystoseira*, and *Furcellaria*. Here and there beautiful tufts of the jointed *Catanella*, the delicate *Ceramium*, *Laurentia*, *Plocamium*, and in one dark corner some fronds of the crimson *Rhodymenia*, whilst in the deepest shadow grew the purple *Chondrus crispus* turning green and olive in the sunny side of the pool. The water was clear and untroubled, when with little splash a *Cabot** darted across from crevice to cranny beneath a boulder in the pool; a Prawn, gracefully poised, and waving its long feelers, was lurking under the weeds, and a green, greedy Crab, was watching a purple, passive Mussel gaping in the warmth and quietude: myriads of living creatures, tiny Molluscs and Cytheridæ, were rejoicing in that little world—one single tide-pool.

Not to dream on, but to explore deeper still into the mysteries and beauties of the sea-flowers—as they should be called—not weeds.

> "Call us not weeds—we are flowers of the sea;
> For lovely, and bright, and gay-tinted are we,
> And quite independent of culture or showers;
> Then call us not weeds—we are ocean's fair flowers."
>
> *Landesborough.*

We must consider steadily their microscopic parts, and learn their place in creation.

MARINE ALGÆ,

or Sea-weeds, are in the ranks of the lower Cryptogamia: yet the range is very wide, from the fructification of the simple *Ulva* to the highly organized antheridia and antherozoides of the *Fucus platycarpus*.

* The Guernsey name for the Blennius, or Blenny.

The greatest interest of the Sea-weed slides will be lost unless we are acquainted with their fructification; for no slide is of much value unless it displays either the *Tetraspores*, or *Favellæ*, or *Ceramidium*, or *Sori*, or *Nemathecia*, or *Antheridia* of the various plants.

It is best to look at these preparations first with the *lowest* power, a two-inch object glass, which gives a large clear field, and displays the general form to the greatest advantage. Then raise the power successively to examine the fructification, in doing which we may find some beautiful specimens of Diatomaceæ attached to the Algæ. In looking over a slide of Ptilota I observed a chain of the frustules of *Grammatophora* depending from one of the pinnæ, and two or three beautiful *Isthmia obliqua* entangled in another part of the frond; some *Licmophora* were attached to the stem, and this single slide gave long and delightful study, with the use of *all* the powers of the microscope.

The fructification of Sea-weed, which is the most important part, can only be understood by having a collection of about twelve slides, of the following varieties:

Two slides of Ptilota, which will show either an involucre, containing three spores, or a lacinia, or little leaf, bearing numerous *tetraspores*, that is, cases containing FOUR spores or seeds.

Two of Plocamium, which give branches bearing tubercles containing tetraspores, or *stichidia* containing spores.

One of Polysiphonia gives an example of a *Ceramidium*, an elegant urn-shaped capsule, open at the top, and containing a group of crimson pear-shaped spores.

Two of *Odonthalia*, which has two kinds of fructification; and on the slide should be either capsular fruit, somewhat like that of Polysiphonia; or *stichidia*, long, delicate pod-like receptacles, enclosing crimson spores in separate chambers or cells.

Two of Callithamnion, which has capsules seated along its pinnæ, or branchlets with bi-lobed *Favellæ*.

Phyllophora shows quite a different kind of fructification,

called *nemathecia*, or warts, concealed under leafy processes composed of delicate moniliform or bead-like filaments.

Rhodymenia gives an example of embedded tubercles containing spores called *coccidia*.

Nitophylium is spotted with *sori*, each of which contains a number of tetraspores.

Polysiphonia fastigiata abounds with *antheridia* at the tip of its filaments amongst spiral fibres.

The fructification of the highest order is that of *Fucus serratus* and *platycarpus*, which should be examined fresh from the plant, and is seen in perfection between the months of December and April. It has a truly sexual character, and as the receptacles of this Fucus contain both the "sperm-cells" and the "germ-cells," it is considered an hermaphrodite plant.

In the common *Fucus vesiculosus* (Bladder-wrack) the receptacles containing antheridia are found on one plant, and those containing sporangia on a separate individual; it is best, therefore, to obtain the *F. platycarpus* or *serratus*, which latter is found abundantly at half-tide, and easily recognised by the toothed edges of its frond, when both organs are observable in the same plant.

Choose a mature receptacle, which may be known by its discharging little gelatinous masses adhering round its orifice. Make a section through it, and you will see a globular cavity lined with filaments, some of which project through the pore. These filaments are jointed, or rather are composed of cells containing what are called *anthero-zoides;* these are yellow dots with two long thread-like appendages, which, when liberated by the breaking of the cell, have a spontaneous and rapid motion, and they immediately swarm around the sporangia, and fecundate them. The sporangia are pear-shaped bodies lying amongst these filaments near the walls of the cavity, and they are the parent cells of the germ cells, which produce the spores or seeds. Each of these *sporangia* gives forth a cluster of eight cells, and are therefore also called *octospores*.

In the hermaphrodite fuci the spores do not leave the receptacle until after their fecundation; but in *Fucus vesi-*

culosus, which is a dicœcious plant, the *antherozoides* meet the spores in the water directly after they issue from the receptacle.

To observe this, take an olive-green receptacle, which is the female, and set free a few pores in a drop of sea-water in a shallow cell; then liberate a few ripe filaments from an orange-yellow receptacle, which will contain the antherozoides, and the whole process of fertilisation may be watched with a power of 250 diameters.

Then, if you further wish to prove the subsequent process of germination, a little care and patience will enable these very spores to grow from the cell of what is called a "growing slide," or even in a tumbler of water, taking precautions to keep the water fresh and *still*, by drawing it off with a siphon, and renewing it daily in the same gentle way.

The fructification of the Rhodospermeæ, or red sea-weeds, has not yet been so thoroughly investigated, and the varied forms of the spore-cases will be the chief beauty as well as value of the following preparations.

CALLITHAMNION.

There are twenty-five species of this plant, and most of them are common on the shores of Great Britain; its name is derived from two Greek words, signifying "beautiful little shrub," and *it is* very beautiful, with a rosy or brownish-red frond, or rather filament, jointed and branching, bearing two kinds of fructification:

1. External tetraspores seated upon the branches.

2. Roundish or lobed berry-like receptacles, called favellæ, seated on the main branches, and containing many spores.

Callithamnion delights in mud-covered rocks. *C. roseum* is found at Torquay; also *C. gracillimum* growing along the mud-covered base of the harbour. In fact, the collector must often content himself with a handful of mud, showing merely a few red filaments, and then on washing these carefully he will find not only one, but perhaps many species of this lovely Sea-weed.

CERAMIUM.

Fourteen species are on the list of British Algæ.

The filaments are of varied colour, from red and purple to white, jointed and dichotomous, which means regularly and repeatedly cleft; it has two kinds of fructification—

1. Capsules, with a membranous pericarp or outer skin, containing numerous angular seeds.

2. Oblong granules partly imbedded in the joints of the filaments called *favellæ*.

The name is from a Greek word signifying "*little pitcher*," which the capsules nevertheless do not resemble.

Ceramium botrycarpum is found in fruit from August to November, with clusters of favellæ on all the branches—most beautiful. Its chief habitat is Torquay and Bristol.

Ceramium rubrum is common everywhere in tide-pools between water-mark.

PTILOTA PLUMOSA.

This lovely little plant, rightly named Ptilota, from a Greek word signifying "*pinnated*," from its innumerable small branches or *pinnæ*, is one of our best preparations; for, even without the fruit, its cellular tissue being very transparent, the cells containing the crimson endochrome are distinctly seen, and render it a favourite object. The stem is closely branched right and left with branchlets called *pinnæ*, and these again cut into exceedingly fine divisions called *pinnulæ;* at the tip of the latter we find the fructification. This consists of two or three minute capsules called *favellæ*, each of which contains three or four oval seeds, and they are themselves surrounded and apparently protected by several linear segments bending over them.

When fresh gathered for observation, these *favellæ* are of a rich crimson with a pellucid border, and, seated in their little cage of crimson pinnulæ, are really beautiful.

Another kind of fructification is found on Ptilotæ, but on distinct individuals; the pinnulæ are broader at the tips, and covered with oval bodies called tetraspores, from their containing *four* seeds.

Ptilota is a perennial plant found in summer and autumn frequently growing on the stems of *Laminaria digitata*, and therefore our best specimens may be gathered on the beach after the autumnal equinoctial gales. At Torquay it is found on rocks, but *Ptilota sericea* is often mistaken for it; this is very abundant on the rocks at Moulin Huet in Guernsey, hanging in rich silky masses on the sheltered side of the rocks, and thronged with that minute but lovely zoophyte *Eucratia chelata*.

PLOCAMIUM VULGARE, OR COCCINEUM.

Plocamium *coccineum* it is called from its fine crimson colour, and the word Plocamium means, in Greek, "braided hair," which the fine divisions of the frond resemble.

A small branch of this lovely weed has been thus happily described in a French botanical work, and will direct the eye in examining this slide. I shall therefore transcribe it:—

"Sa tige est très-rameuse, et toujours dans le même plan; l'ordre des ramifications est très-remarquable; chaque rameau est légérement flexueux, et n'emet de ramifications que du côté convexe: *la première* est un filet simple et pointu; *la deuxième* est un filet qui a trois dents du côté antérieur; la troisième est un filet qui a deux dents, et qui au lieu de la troisième dent pousse un filet muni d'une dent en dehors; la quatrième est un filet qui n'a qu'une dent, la deuxième dent est devenue une filet a une dent, et la troisième un filet rameux.

"Après ces quatre ramifications il y a une espace vide, et la tige emet des rameux semblables du côté opposé."

The fructification is of two kinds:—

1. The stichidia, or oblong vesicles containing spores in separate divisions or cells—very beautiful.

2. Spherical capsules, seated upon the branches, containing a cluster of spores.

This is a common Sea-weed everywhere in summer and autumn.

POLYSIPHONIA.

There are twenty-four species of this Sea-weed, some of

them inhabitants of the rock-pool, some of the wide wild ocean, growing on the stems of Laminaria, and therefore often found upon the beach after a storm, or obtained by dredging on all the British coasts. It also loves to grow upon Melobesia on the steep sides of rock-pools.

Of all these the *P. urceolata and P. elongella* are the best for microscopic observation. The former has a beautiful fructification; an urn-shaped capsule called a ceramidium, furnished with a pore or opening like the mouth of a vase, and containing a tuft of pear-shaped spores.

A second form of fruit is met with on the same plant—the tip of a branch expands, and a row of tetraspores is imbedded in it; also on *Polysiphonia fastigiata* such an abundance of antheridia is found as to give a yellow colour to the plant, quite visible to the naked eye, and deserving particular microscopic observation.

SPHEROCOCCUS.

A common plant, often cast ashore after a gale, and found all along the coast of Cornwall and Devonshire, Isle of Wight, and the Channel Islands.

It is difficult to obtain perfect specimens of the beautiful fructification, they are so often destroyed by the violence of the waves; but a careful dissection of it freshly gathered would be both delightful and instructive.

We find minute spherical capsules supported on slender stalks and mucronate, that is, having a little spine obliquely projecting from their apex; upon opening this, by making a section through it, we see a cluster of crimson seeds, also stalked. The structure of the branches should be noticed; they are obscurely but perfectly veined, a faint narrow mid-rib and lateral parallel veins may be distinctly seen.

GRIFFITHSIA,

so named in honour of Mrs. Griffiths of Torquay, found on the coast of Devonshire, and other parts of the southern coast of England. The frond is rose-red, filamentous, and jointed. The fructification is of two kinds:—

1. Tetraspores affixed to whorled involucral ramuli or small branches.

2. Favellæ, or gelatinous receptacles, surrounded by an involucre, and containing a mass of minute angular spores.

There is a beautiful species, called *Griffithsia coralinæ*, the filaments of which resemble a string of fine glossy crimson beads, found on rocks at low-water mark, or in deep pools during summer. This should be mounted, if possible, with its tetraspores.

GRACILLARIA,

one of the Sphærococcoidæ, named from a Latin word signifying "slender."

Gracillaria erecta is found on sand-covered rocks, at Sidmouth and Torquay; it fruits in winter,* when it should be gathered and mounted; for both kinds of fructification are beautiful, especially the *coccidia*, of which sections should be made to show the spores imbedded in the outer skin, and the delicate hexagonal cells of the interior.

The *coccidia* are pod-like receptacles at the tips of the filaments, and, when magnified, appear to be dotted with crimson spots. Make a transverse section to observe the position of the spores. The other kind of fructification is a frond covered with sessile capsules, about the size of a poppy-seed, containing a cluster of oblong red seeds.

Gracillaria compressa is sometimes cast ashore attached to coral and algæ at Sidmouth, where it was found by Mrs. Griffiths, and also in the Channel Islands by other collectors. It is not generally known that the Island of Alderney is famous for its rare and beautiful Sea-weeds, many of them made known by Mrs. Gaudion, wife of the late judge of Alderney, an indefatigable collector and admirable preserver of Sea-weeds, to whom I am greatly obliged for some excellent specimens.

LAURENSIA.

There are several species of this abundant and pretty Sea-weed. It varies much in colour and size; some species, *L. pinnatifida*, being of a dark purple and even olive colour, whilst the *Laurentia obtusa* has a fine pink colour; though

* February and March.

in rock-pools much exposed to the sun it hangs in dirty yellow bunches, and for that reason is often unrecognised. The rare *Laurentia tenuissima* is found plentifully in the Channel Islands.

The fructification of Laurentia is both various and remarkable, requiring microscopic investigation.

1. It has broadly ovate capsules, about the size of a poppy-seed, containing red pear-shaped seeds, supported upon narrow stalks. A section must be made through the capsule to show them well.

2. Ternate granules imbedded in the ramuli, or tips of the short branches. Simply magnified they appear to be dotted. A transverse section should be made.

Then, again, on some specimens of the same plant may frequently be found swollen tips, forming large spurious capsules, and these are very curious. Some of them have only a minute pore; others are spread out more like the shield of a Lichen, and edged with pink. On making a section through these, numerous transparent linear bodies are seen pressed closely together; they are composed of minute filaments surrounding a slight column, and terminate in several round pellucid lobes. In the round capsules they are also present, and by a gentle pressure under the microscope are seen to issue in numbers from the pore.

Laurentia is found in perfection from June to September.

ODONTHALIA.

This is only found on the Northern coasts of England, Yorkshire, and Scotland. It comes on shore from the deep sea finely dotted with fruit in the month of November. The beautiful *stichidia*, reddish purple, and the *ceramidium* —both kinds are on this plant.

BONNEMAISONNIA,

named after Bonnemaison, a celebrated French Algologist. Nothing can be more graceful and beautiful than this exquisite little plant; the fronds so delicately ciliated, of a bright rose colour, and dotted all along with tiny capsules —the true *ceramidium*; each urn-like vase containing a

group of stalked spore-cases, in which are numerous seeds. The texture of the plant also is a beautiful microscopic object. It is found from June to September all round the English and Scottish coast.

DELESSERIA

is only microscopic in its fructification, and as an example of Sori. It has two kinds of fructification :—

1. Capsules, containing spores, and these are always found upon the mid-rib and stem of the plant.

2. Sori, or masses of granules collected into little spots or lines in the substance of the frond, or in little leaflets or distinct pod-like leafy processes, which form a sort of fringe on the mid-rib and margin of the plant. We never find more than one kind of fruit on any individual.

Delesseria is a well-known and abundant Sea-weed, a favourite in all collections, from its beautiful colour and broad fronds.

Delesseria limosa is found after storms attached to the stems of *Laminaria digitata*. Specimens have been gathered in which the frond measured four inches across.

There is one species, *Delesseria ruscifolia*, which deserves microscopic attention from its substance between the mid-rib and margin being transversed by white pellucid branched veins composed of a single row of elongate cellules. The colour is a fine rose-pink ; it is found from May to September at Yarmouth, Torquay, Bognor, Ilfracombe, &c.

RHODOMELA.

This is a large, bushy plant, beautifully tufted in the spring, and bearing feathery tufts of ramuli of light brown-purplish colour. In early summer, about June, the fruit is found, and is of two kinds :—

1. Nearly globular capsules, full of free, pear-shaped seeds.

2. Stichidia, pod-like receptacles, with ternate granules imbedded in the substance.

Sections of a ripe pod and of the stem are beautiful under the microscope. The external appearance is as if it were

ribbed or jointed; but upon examination we find a tissue of hexagonal cells, each with a red dot in the centre, and if we make a longitudinal section we find oblong cells, through which runs a red filament. It is found upon the drifted stems of Laminaria and upon rocks in the sea. There are several species, of which *Rhodomela pynastroides* is the most common.

SPYRIDIA FILAMENTOSA.

This is rare in England, but found on the coast of Devonshire, the Isle of Wight, and the Channel Islands. The name is derived from a Greek word signifying "*basket,*" which the receptacles resemble; for the stalked gelatinous receptacles have a membranous pericarp often surrounded by an involucre of short ramuli, containing two or three masses of roundish granules; it is these which look like baskets.

CHAETOSPORA WIGGII

is very beautiful, but rarely obtained in fruit, and has not yet been thoroughly investigated; therefore it is mentioned rather to induce observation when the plant is found in perfection. It is gathered on the coast of Normandy and in the Channel Islands; Sidmouth, Brighton, and Yarmouth also yield it occasionally. It is of a fine rose colour, and has very delicate filiform fronds.

HALYMENIA

has a compressed frond, pinky red, consisting of a very delicate membrane, which when in fruit is dotted with Sori, and a transverse section should be made, which will show the spores, called in this plant "*favellidia,*" attached to the inner surface of the membrane. It is found abundantly on the coast on rocks and stones, in the sea during summer.

DASYA.

There are four species of this lovely Sea-weed. The name is taken from a Greek word signifying *hairy.* The commonest of them, *Dasya coccinea,* is often mistaken for

Ptilota plumosa, being found in long crimson feathery sprays on the coast after storms, or dredged in deep water. It is a great favourite with collectors of sea-weed for ornamental purposes, and is equally valuable for the microscope, yielding two kinds of fructification; the *Ceramidium*, containing pear-shaped spores, and the *Stichidia*, containing tetraspores, ranged in transverse bands.

A delicate section of the *lower* part of the stem will show the internal structure, which is of numerous parallel tubes surrounding a central cavity, and edged with a circle of the short stout hairs which clothe the stem.

Sections of the fruit and of the stem are often indispensable for determining the species, and give innumerable varieties of beautiful objects.

DASYA ARBUSCULA.

A delicate plant not uncommon at the verge of low-water-mark in many parts of Scotland and in the Channel Islands; remarkable for its beautiful and abundant stichidia, clustered amidst the fine *ramuli*, which cover the frond densely, and are forked at the tip, jointed, and of a clear crimson-lake colour, sometimes more or less brown, and always discharging its fine colour if left in fresh water.

DASYA OCCELLATA

is of a purple colour, and the dense tufts of *ramuli* at the tips of the branches give it a dotted appearance, like an eyelet on each delicate feathery stem. The stichidia are very long slender pods, full of tetraspores.

DASYA VENUSTA.

A most beautiful and rare little plant, found in the Channel Islands in summer and autumn. The shape of the stichidia, which have long acute points, and the repeatedly forked ramuli, distinguish it from *Dasya arbuscula*, which it otherwise much resembles.

These marine Algæ are prepared in Paris, by Bourgogne, and sold by Baker, of High Holborn. A collection of even

a few would be most useful to a young student, who thus might learn what to mount for himself at the sea-side.

As to the method; when the form only of the plant is desired I find Canada balsam a good medium. The Sea-weed being perfectly dry, it only requires placing in warm, *not hot*, balsam, and covering with a previously warmed thin glass cover. But for the display and preservation of the fructification the following liquid is preferable:—

GOADBY'S SOLUTION FOR MARINE ALGÆ.

Four oz. bay-salt, two oz. alum, four grains corrosive sublimate, two quarts of boiling water.

A cell is to be made on the revolving table with Brunswick black, and thoroughly dried. The specimen then laid in the cell with enough of the solution to fill the cell, and the glass cover carefully laid on. Let it stand for a few minutes, and dry the surrounding glass with blotting paper before the varnish is applied, which hermetically seals it. The Sea-weed must be mounted fresh from the sea.

CHAPTER X.

FORAMINATED SHELLS.

I BELIEVE that every one is surprised and delighted with these lovely little shells; so minute that they resemble grains of the finest sand; and so perfect in structure that they seem to be the habitation of a more highly organized animal than they really are.

There are two kinds of foraminated shells, calcareous and siliceous. The calcareous shells are found alive in marine deposit, and on sea-weed; the siliceous are also dredged up from the depths of the sea, and found in strata formed of fossil deposits.

The animals which dwell in these beautiful little shells are of the lowest order in the scale of animal creation, not yet perfectly understood, and are variously placed by scientific men. Formerly they were considered as belonging to the family of Cephalopods, or Cuttle-fish. Ehrenberg, a great naturalist, regarded them as polypes, and placed them amongst the Bryozoa, or Zoophytes. Du Jardin, a French naturalist, and most modern authors, agree in the relationship of foraminifera to those very curious animals, *Amœba* and *Actinophrys sol*, which are found in fresh water, and may be studied from our aquariums.

Their internal organization is a simple body of what is called sarcode, a kind of pulp which has the power of assimilating and digesting food in all its parts. The body has no particular mouth, stomach, or intestine, neither has it eyes or other senses, except feeling; but it can put forth long feelers through the perforations in the shell, and can entangle and draw in its appointed food, which, whenever it enters, is presently digested, and the residue ejected, not always out of the shell, for the cavities are sometimes choked up by these undigested atoms.

Now in some of the Foraminifera the body is single and

jointed, in others the chambers of the cells are so distinct that the sarcode body may be considered as compound, and one tiny shell to contain a family, the members of which have been produced as gemmæ or buds, one from the other.

The subject is still under investigation by scientific men, therefore I shall not enter further into it, but recommend the student, if desirous of further information, to read 'Weaver's Abstract of Foraminifera' in 'Annals of Nat. Hist.,' 1841; 'Williamson Trans. Micros. Soc.,' vol. ii., and 'Micr. Journal,' vol. i.; also 'Carpenter on the Microscope,' chap. x.

The structure of the shell itself is various, some being single-chambered (Lagena, Miliolina, and Gromia); the greater number are compound shells, with cells arranged lengthwise, or circular, or spiral, all of them dotted with numerous foramina, or holes, from whence they are named foraminated shells.

We should have at least three slides of these in our collection: one of the mixed specimens, one of the beautiful Cristellarea, or Operculina, and one of the siliceous Foraminifera from the Barbadoes deposit.

THE OPERCULINA

is the best example of a compound shell, to show the division into chambers; it is like a tiny nautilus, and if we saw the interior we should find each chamber separated from the other by double walls, or septa, containing tubes, and which give off lateral branches, and a network of minute veins for circulation of fluid. A large syphon or tube forms the margin of the shell, and is the medium of communication between the cells.

The shells of this Foraminifer being calcareous, are easily dissolved by muriatic acid; and a recent specimen may be examined by placing it in a watchglassful of water with one drop of strong acid, when, in a very short time, the shell will dissolve, leaving the animal naked and perfect with every mark of its habitation left upon its plastic body.

On examining a mixed slide you will find that some are starlike (Astoma), some in complex whorls (Cassidulina),

some straight and yet chambered (Verneucilina)—the variety is immense. They are dredged from the depths of the Mediterranean, the Adriatic, and Ægean Seas, and on our own coast they are found also plentifully in the white drifted sand, or amongst the corallines in rock-pools. The Cassidulina and Rosalina are the most common in the Channel Islands. The ouze of oyster-beds also abound with some species.

FOSSIL FORAMINATED SHELLS FROM BARBADOES.

These are of a different kind; the shells are siliceous; the variety even on this one slide is probably amazing, and the delicacy of form and workmanship truly worth a long and careful examination. They were first discovered by Professor Ehrenberg, at Cuxhaven, on the North Sea, afterwards found by him in collections made in the Antarctic Seas. Fancy these fragile and lovely little creatures having been brought up by the sounding-lead at the depth of 2,000 fathoms! Such are the beautiful forms which the hand of God has fashioned in His wisdom, where human eye never sees and foot of man never treads, and which, but for our microscope, had remained unknown to us as they have been for the ages past.

Nothing do we examine thus but it reveals such perfect finish, such loving design of adaptation to the creature's necessities, that we have deeper thoughts than our tongue can utter, and learn lessons that philosophy has never taught. Nothing is done carelessly; nothing is isolated or loose in the scale of creation; the plan is seen ever wider, deeper, higher, but complete and in perfect order, whatever part is presented to our finite mind. We see very little, we know very little; but we gaze on, and our hearts are directed upward even by a slide of microscopic shells sculptured with hieroglyphics of the Creator.

The Barbadoes deposit alone furnishes 282 varieties; and when we consider that in a single ounce of sand 6,000 of these shells were picked out, and in another ounce from the shores of the Antilles no less than 3,840,000 were dis-

covered; when we learn that these little shells are increasing so fast as to block up navigable channels, obstruct gulfs, and fill up harbours, we feel how little we can know of that Infinite Mind who has so ordered the multiplicity, and so elaborately worked these foraminated shells.

ORBITOLITES

are circular fossil shells, varying in size from a sixpence to very minute species, found in all foraminiferous sand. It is the habitation of a composite animal, often found alive on sea-weed, but more abundant in the fossil state. The chambers or cells are arranged in circles—the shell not sculptured. The animal is of a less high order than the true Foraminifera. Perforations in the shell are doubtless for the Pseudopia; their habits and mode of propagation are not known.

NUMMULITES.

These are a species of Foraminifera, but only in the fossil state; they are much larger, too, varying in size from a fourpenny-piece to half-a-crown; they are the habitations of a composite animal, and the structure of the shell is very complicate; the chambers are arranged in spirals round the centre in great numbers. They abound in the United States, where a mountain 300 feet high seems to be entirely formed of these shells. The crystalline marble of the Pyrenees and the limestone ranges of the Adriatic Sea are wholly composed of small Nummulites. The Great Pyramid of Egypt is built upon blocks of limestone consisting of these foraminated shells—habitations of beings who lived long before the age of man, and were, amongst others, God's instruments for preparing the earth for the perfection of his creation.

CHAPTER XI.

SPICULES OF SPONGES.

SPICULES OF SPONGE.

THESE slides, although useful, and to a certain extent interesting, are very far from what is wanted to illustrate the nature of a sponge. They are isolated siliceous spicula of the horny skeleton of the sponge; very various in form, but all for the same purpose of strengthening the framework of the animal.

Sponges in their living state are by no means like the dried specimens sold for domestic purposes; these are but the dead form, the mere skeleton of what was once a living creature. When alive it possesses a firm, fleshy substance, composed of cells about 1-7000th of an inch in diameter; the horny skeleton is developed in the inter-cellular substance, and within cells of horny matter these spicula are secreted.

Sponges present a great variety in their external appearance; some being soft as jelly, whilst others are as hard as flint; some very large, and others exceedingly minute. The nature of the body closely resembles that of the Foraminifera and Amœbæ, having no distinct organs, and capable of assimilating food in all its parts. There is a current flowing in and out through the whole sponge, entering the small apertures or *oscula*, and being expelled by the animal through the large apertures or *oscula*. The channels through which the currents are drawn and expelled are furnished with ciliated cells, which promote the circulation of the water from whence the sponge derives its needful supply of oxygen and food for the maintenance of its life.

This action may be observed by the seaside student on carefully removing *Grantia ciliata*, or *Halichondria paniceæ* from its native rock, and placing it in a basin of fresh sea-water, when they will presently pour forth streams of the fluid from their oscula, and give full evidence of *life*.

Their propagation is by gemmation, or by winter-ova, for a full description of which we must refer to Mr. Bowerbank's papers in 'Trans. Micro. Soc.,' 1840, and 'Johnson on British Sponges.'

What we particularly want for an educational box is a good section of sponge, showing the spicula *in situ*. The following slides are, however, very useful, because after examining the tri-radiate spicula of *Grantia*, the stellate pin-shaped spicula of *Tethea*, the anchor-headed spicula of *Pachymatisma*, and the peculiar bi-rotulate spicula of the fresh-water sponge, *Spongilla fluviatilis*, we are able to understand many of the miscellaneous contents of fossil earth or recent sand, and discern not only the remains of a sponge, but to what particular family an isolated spiculum belongs.

GEMMULES OF PACHYMATISMA.

These are young sponges or gemmules; they grow from the sarcode body, and occur in great numbers towards the base or root of the sponge; at first they appear as little knobs, arising from the cellular tissue, their stem lengthens, they become detached, ciliated, and soon escape from the parent sponge to whirl for some time in the water, and finally fix upon their appointed habitat and grow into a sponge.

SPICULES OF GRANTIA NIVEA.

These are tri-radiate spicula of carbonate of lime. Without sections of the sponge itself, or engravings, it is not possible to explain or understand the beautiful arrangement of these spicula for support and for defence; many of them project into the cavities of the sponge to prevent the entrance of foreign bodies, which would assuredly injure the delicate fibres of its frame.

Grantia compressa is an abundant animal in the caves at Tenby, and the Gouliot Caves in Serk. *Grantia ciliata* is

found in rocky pools hanging like a little bottle with a circle of silvery spiculæ round its mouth.

Spicules of Pachymatisma (crutches).
Halichondria incrustans.
,, Griffithsia.
Dysidea fragilis.
Tetheæ.
Spongilæ fluviatilis.
Geodia.
Sponge Spicules, Thames.
,, ,, Serk.
,, ,, Pin-shaped.
,, ,, Parallel-spined.
,, ,, Anchor-shaped.
,, ,, Truncated.
,, ,, Clubs.
,, ,, Stars.
Sponges from the Phillippine Islands.

CHAPTER XII.

SECTIONS OF BONE.

THESE are favourite objects for the polariscope, and are usually selected from their brilliancy under polarized light; but the structure of bone is a most interesting study as connected with comparative anatomy and geological researches, opening a wide field of observation.

Bone is formed, like all other parts of the body, by the development of cells, in which secondary deposits of earthy or inorganic matter consolidate the tissue and form the substance. Chemically, bone consists of gelatine, with phosphate of lime, carbonate of magnesia, fluoride of calcium, small quantities of carbonate of lime, and a little oxide of iron.

The marrow or medullary tissue of bones consists of ordinary fatty tissue, a particular liquid, and cells, with vessels and nerves.

The structure will only be understood by the examination of a few of these slides. Take, for example, a section of human bone,

MAN'S METACARPAL.

The first thing we notice is the number of apertures surrounded by laminæ or layers of substance in circles. These are the Haversian canals which serve for the transmission of blood-vessels to the interior of the bone. The numerous black spots with radiating fibres are called *lacunæ*, or bone-cells, and the fine lines are little tubes called *canaliculi*, or calcigerous canals. They are dark, because filled with air, and their shape and size are most important matters to the naturalist, who thereby can determine to what class of Bird, Beast, Reptile, or Fish, any given bone belongs.

Not only so, but by the arrangement of the Haversian canals and bone-cells, differing in every bone of the body, from the bones of man to those of the smallest creature,

there is an infinite variety of structure adapted to the necessities of the animal, more or less of strength, or of lightness, or of flexibility.

A knowledge of this has enabled Owen, the great osteologist, to ascertain the order and exact position of an antediluvian reptile from a mere fragment of fossil bone.

By microscopic examination of bone the existence of Keaper reptiles in old red sandstone has been determined, and the supposed reptile *Saurocephalus* been removed into the class of fishes. It is marvellous to observe in the section of a fossil bone which belonged to an animal of extinct race, such as the huge Mastodon and Megatherium, the very same structure and proportionate size of bone-cells that we find in our domestic animals, and in man himself; to compare a section of bone from the colossal Iguanodon with one from the timid lizard, and find them modelled after the same type, and by the peculiar form and large size of the lacunæ and canaliculi to recognise the reptile; or to examine a section from the fossil bones of the gigantic Dinornis, whose species has been extinct for ages, and yet find in the still existing Apteryx a continuance of the race, and the unmistakable small lacunæ of Birds.

It was from a fossil bone of the *Dinornis* and microscopical examination that Professor Owen ascertained that it was the femur or thigh-bone of a *Bird*—that the bird was large, heavy, sluggish—of the ostrich tribe, and therefore probably with the habits of that bird. Afterwards, when a few more bones were sent to the naturalist, he not only discovered that they belonged to nine different species, but was able to determine that one Dinornis was a bird ten feet six inches high, another nine feet, another five feet, and so on.

With a very moderate knowledge of the structure of bone, and a habit of observation and comparison, the student of geology or of natural history may be able to ascertain to which class of vertebrate animals any bone, fossil or recent, belongs. A collection of the jaws and small bones of Moles, Rabbits, Weasels, and Rats, will give beautiful preparations. Nor are they difficult to mount; all we require

is a small web saw, a good hone, and patience. Slice a thin bit of bone with the saw, and rub it on the hone with water until transparent. Towards the end of the operation fasten the section with balsam to a glass slide, and finish the grinding carefully, when it may be dried and mounted like any other object.

The whole jaw of a Mole well ground down is very beautiful, showing the Haversian tubes like a tree branching out between the fangs of the molar teeth.

Longitudinal sections generally show the structure best.

In the position and use of a bone, the size and number of the lacunæ and Haversian canals are modified to give the required strength or lightness. The wing-bones of Birds abound in Haversian canals and lacunæ, which give both elasticity and strength, and there is an interesting paper on this subject by the Rev. J. B. Dennis, in the 'Microscopical Journal' for 1843. For the guidance of the student who may wish to collect specimens and prepare sections of bone, the following table of the relative size of bone-cells in Fishes, Reptiles, Birds, and Man, will be useful :—

Measurement of bone-cells in parts of an English inch.

(TRANSVERSE SECTIONS.)

Human bone .	Long diameter	one of the largest	$\frac{1}{1440}$
		one of the smallest	$\frac{1}{2400}$
	Short diameter	one of the largest	$\frac{1}{4000}$
		one of the smallest	$\frac{1}{8000}$
Ostrich	Long diameter	one of the largest	$\frac{1}{1333}$
		one of the smallest	$\frac{1}{2250}$
	Short diameter	one of the largest	$\frac{1}{5425}$
		one of the smallest	$\frac{1}{9650}$
Turtle	Long diameter	one of the largest	$\frac{1}{375}$
		one of the smallest	$\frac{1}{1150}$
Reptile	Short diameter	one of the largest	$\frac{1}{4506}$
		one of the smallest	$\frac{1}{5840}$
Conger Eel . .	Long diameter	one of the largest	$\frac{1}{350}$
		one of the smallest	$\frac{1}{1135}$
	Short diameter	one of the largest	$\frac{1}{4500}$
		one of the smallest	$\frac{1}{8000}$

See 'Transactions of the Microscopical Society,' vol. ii. part ii. p. 46.

The following preparations of bone may be obtained at Baker's, and most other opticians :—

Femur of *Poliocephalus Edwardsi.*
Femur of Monkey.
Femur of Eagle.
Bone of Alligator.
Bone of Turtle.
Rib of Python.
Rib of Tortoise.
Horn of Rhinoceros.
Seal bone.
Bone of Antelope.

FIN-BONE OF LEPIDOSTEOS.

A genus of fishes belonging to the family of Clupeidæ, natives of tropical America. They are remarkable for their long rasp-like teeth, and the hard scales like stone. They are, with the genus Polypterus, the only living representatives of the vast numbers of extinct voracious fishes whose remains are found in various secondary formations.

FEMUR OF TETRAO UROGALLUS.

Tetrao urogallus, one of the Grouse tribe, an English species of bird called Cock of the Wood.

SECTIONS OF TEETH.

These are brilliant polariscope objects, and offer the same interesting subjects for observation and comparison in various animals, fish, reptiles, and mammalia.

The teeth of Mammalia consist of a crown, or that portion above the jaw-bone and gum ; and a neck, or narrower intermediate portion.

The substance of human teeth consists of three parts : *the ivory,* or *dentine,* which is white, and of a silky appearance, composed of numerous tubes or canaliculi, called ivory tubes ; *the cement,* or bony portion, which forms the outer coating of the fangs, and is like other bone with lacunæ, but rarely with any Haversian canals ; *the enamel,*

which covers the ivory, and is extremely hard, brittle, and fibrous. The fibres of enamel, separated by muriatic acid, are found to be six-sided prisms, about 1-6000th in breadth, and transversely striped, which are well seen under the polariscope.

SECTION OF HUMAN TOOTH,

(Perpendicular,)

will show the enamel on the crown, like a narrow border running round; the ivory in a broad band round the pulp-cavity; and the cement round the fang, dotted with lacunæ.

SECTION OF HUMAN TOOTH,

(Transverse,)

will only show the enamel and the ivory.

Tooth of Saw-fish.
Sperm Whale.
Jaw of Myliobates, or Eagle Ray-fish.
Wolf-fish.
Elephant's Tooth.
Tusk of Sus Indicus.

CHAPTER XIII.

HAIRS.

HUMAN HAIR.

THE interest of these slides is greatly increased by viewing them with polarized light, as they give beautiful colours over the selenite stage. But, besides the mere play of colour, it is worthy of observation that the hairs of animals and insects are so variously fashioned and so delicately finished, that each species has in some cases a distinct form, though to unassisted eyes they are perfectly alike. The structure of hair is cellular, like every other part of the body, and if it is soaked in acetic acid, or soda, that apparent tube is found to be made up of scales outwardly, pigment cells, linear cells, and nucleated cells within; growing from the skin in which it is planted, having a bulb-like root, nourished by ducts and follicles, or small pouches on either side of the hair-bulb.

When a human hair is young and healthy, it has abundant pigment cells, and therefore is coloured; but, when old or diseased, either the pigment cells become empty, or only filled with air, or it is preyed upon by fungi, several species of which infect the human hair.

HAIRS OF DORMOUSE AND COMMON MOUSE

show a beautiful arrangement of air-cells, and if soaked in potash these become more visible, with the medullary cells in two rows.

HAIR OF MOLE.

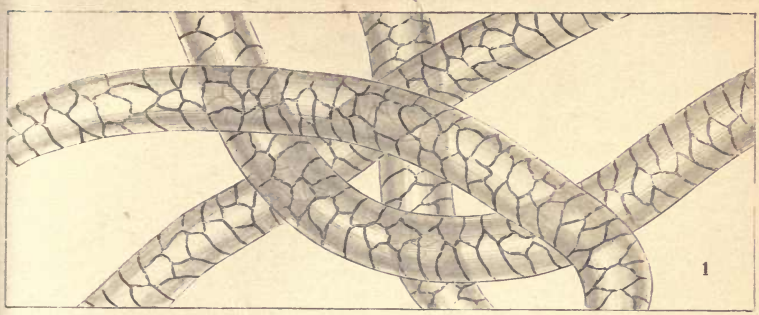
The cells in the medulla very distinct.

HAIRS OF BATS.

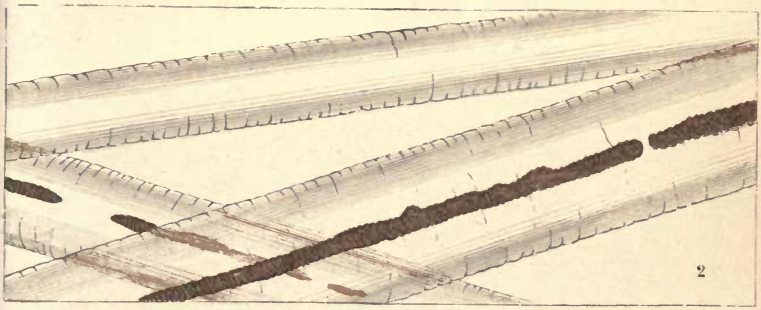
These are very remarkable, that of the Indian Bat presenting whorls of scales at regular intervals along the shaft; others give variety in the medullary structure.

HAIR OF ELEPHANT.

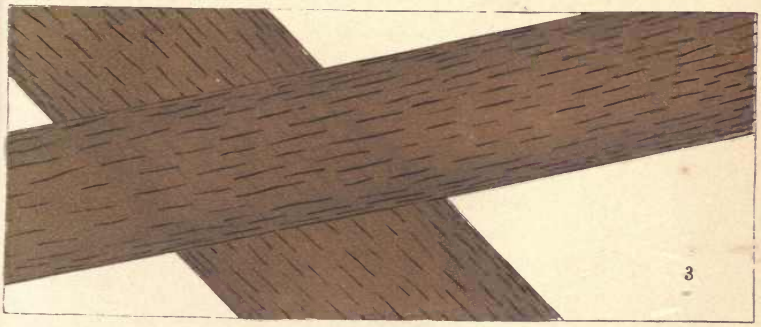
This is a transverse section, showing groups of empty cells here and there, and others in dense clusters containing pigment. Examine with polarized light.



1. Wool.



2. Hair of Horse



3. Human Hair.

HAIR OF CAMEL.

More nearly resembling wool, soft and flexible, with distinct cortical cells, giving it the appearance of being jointed.

HAIR OF REINDEER.

In the Deer there are few cortical cells, but the medullary cells are so developed, that they resemble the cellular tissue of vegetables.

HAIR OF ORNITHORHYNCHUS.

A whole hair of this curious little animal presents a combination of wool and of hair. The base, which is long and slender, being quite woolly, and the upper part enlarged considerably, and showing imbricated scales on the surface. The Ornithorhynchus is a most singular little animal, about one foot and a half long, with a head somewhat like a duck; a body like a mole, and yet so unlike any other animal that it was at first disbelieved such a genus existed. It is a native of New South Wales, and called by the colonists the Water-mole.

HAIR OF LARVA OF DERMESTES.

This is used as a test object, and, when viewed with a good clear $\frac{1}{4}$-inch object glass, should show the shaft thickly covered with minute spines or scales, placed on whorls up to the tip, where the last whorl is composed of broader hairs or scales, somewhat resembling the petals of a flower, and each scale terminated by a little knob.

The *Dermestes lardarius* is a small black beetle, very destructive to bacon; it has a broad gray band, spotted black at the base of the elytra. It belongs to the Pentamera, having five joints in the tarsi, and to the Clavicornes, having clubbed antennæ. The larvæ are most mischievous in insect collections. So, also, another of the family *Anthrenus*, whose hairs are mounted as test objects.

We find the larvæ of *Anthrenus* under the bark of old elm trees in February; of light brown colour, with tufts of long hairs on the three lower joints of the abdomen. These hairs are wonderfully beautiful. Soak them a few minutes in turpentine, and mount in balsam.

CHAPTER XIV.

SPICULES OF HOLOTHURIÆ.

HOLOTHURIÆ are marine animals nearly related to the Star-fish and Echini, belonging to the Radiata, but very unlike them in appearance; they are outwardly like a simple tough sac, with a plume of delicate feelers or tentacula at its head. It is divided, like the Sea-urchin, into five parts, having five avenues of suckers, and the plume, though more or less plumose, is always a multiple of *five*.

They glide about in sunny rock-pools, or lie under stones, and have a curious habit of ejecting all their intestines if irritated or alarmed, yet live a long time perfectly empty, and have the power of reproducing their very complicated internal parts. They possess, though outwardly of such a simple form, heart, liver, intestines, a wondrous system of circulation, and are so prolific that an individual has been known to lay 5,000 eggs in one night.

The spicules we mount for the microscope form a kind of skeleton, being deeply imbedded in the skin, and their form varies with the species.

SPICULES OF SYNAPTA.

A species of Holothuria found in the Adriatic Sea; these calcareous plates are imbedded in the skin and perforated each with ten or fifteen holes, in one of which an anchor-like spine is fitted with a hinge, by which it is erected or depressed at the will of the animal.

These are best observed with the blackground illumination.

SPICULES OF CHIRODOTA.

Another species inhabiting the Mediterranean, and the plates remarkable for their delicate wheel-like markings.

CALCAREOUS SPICULES OF DORIS.

The Doris is a soft-bodied animal, often called a sea-slug; it is one of the Nudibranch mollusca, having its breathing organs outside its body, and like a starry plume on its back. It is often seen gliding about in sunny rock-pools, or sheltered under loose stones—feeding on sponges, and also on dead fish. The tongue is very beautiful, and has been noticed amongst the palates.

CALCAREOUS SKELETON OF DORIS.

The skin appears to be strengthened by these calcareous spicules as a kind of skeleton, and their position is better viewed when thus mounted.

The shape of the spicules varies a little with the species.

SPICULES OF GORGONIA.

These slides present a variety of calcareous spicules, which, when examined with the $\frac{1}{2}$-inch power and dark-ground illumination, or simply with polarized light, show curious shapes and beautiful colours. They are found in the skin of the Gorgonia, and each species has its peculiar shape and colour.

Gorgonias are zoophytes; when drawn up from the ocean, as they live at a great depth, they look like a shrub or small tree of bright salmon colour; the branches are spotted with little depressions, but have no appearance of life. If, however, it is quickly replaced in sea-water, a lovely sight is seen—from every dot, on every branch, comes forth a living creature, flower-like, pearly white, and spreading forth a circle of delicate pinnæ or filaments, edging eight petal-like tentacula. They are feeling for their prey, and drawing in shoals of marine infusoria, like other zoophytes. When the animals die, the petals shrink in and the skin hardens, and these spicules are found in masses throughout. Some—the *Gorgonia cristata*—have spicules shaped like double crosses; some are of a rich purple; others crimson; others again of golden hue even by natural transmitted light and with moderate power.

SPICULES OF ALCYONIUM DIGITATUM.

These are likewise abundant in that polype so common in some parts of our coast, the caves at Tenby, and the Gouliot Caves in Serk, or are often washed up on the sea-shore after a storm. Fishermen call them dead men's fingers, and they do look like a large yellow finger or thumb, tough and ugly, until, as with the Gorgonia, we replace it in sea-water, when the same kind of beautiful zoophytes appear from the multitude of little spots which stud the surface. These spicules give firmness to the skin, and form a sort of skeleton.

SECTION OF ECHINUS SPINE.

This beautiful purple or golden star, with fretwork and circles in many varieties, is a section or very thin slice of one of the spines of the Echinus, Sea-urchin, or Sea-hedge-hog, as it is sometimes called at the sea-side by fishermen and boys, who either dredge them up from the depths of the ocean, on oyster-beds, or find them at low-tide in the crannies of rocks. There are many species; some very large and bristled over with small spines; some exceeding small, scarcely larger than a marrowfat pea; others, again, about the size of a hen's egg, with fewer but much longer spines, the Cidaris. The common Echinus has no less than four thousand spines for its defence, the structure of each spine presenting these beautiful variations. The centre is usually occupied by a network, bounded by a row of what appear to be transparent spaces, but are really sections of those strengthening pillars which run up the spine and form the exterior of every layer. Sometimes these sections of Echinus have annular bands, dividing a finely reticulated space, and some have hollow spaces. They should be seen on the dark illuminated ground with the dotted lens, or the parabolic illuminator, when the effect is quite magical. Also using

the blue selenite the structure is better seen by polarized light.

A short account of the animal to which this spine belongs may be interesting to those who cannot read its perfect history in the work of Forbes on the Radiata. It belongs to the same division as the Star-fish, the Holothuriæ, the Medusæ, or Jelly-fish, the Entozoa, Polypes, and Infusoria, in all of which the external or internal parts radiate like a star, and which are therefore called the radiatæ. In all these, but especially in the Star-fish and Sea-urchin, the parts are divided and formed by the number five in a most remarkable manner, and few things would afford a pleasanter study than one of these sea-urchins, easily procured in every fish-market in London, or at the sea-side. The animal is easily killed in cold fresh water, and then the spines may be examined, with their curious ball and socket joint, so firmly fixed, yet so easily bending on every side at the will of the Echinus, who uses them, not only for defence, but for burrowing in the sand. Between the spines are multitudes of minute organs, the uses of which are as yet unknown, called pedecilariæ ; they are of three kinds, pearly white with dotted and toothed beaks, and move about when the Echinus is alive, opening and shutting their trifid beaks as if each had an independent life.

They are beautiful objects mounted in balsam, and viewed with a low power. When the spines have been examined they are easily removed by dipping the shell into boiling water and brushing them off; then fresh beauty appears in the tesselated wall of that wonderful house built up by the Almighty for the Sea-urchin according to a certain plan, and with such contrivance for its comfort as it is worth while to examine quietly. First we notice double rows of very minute holes, dividing the shell into *five* divisions ; through each hole a small sucker protruded by which it walked, or attached itself to rocks or stones ; 1,860 of these suckers occupying each two of these pores. The plates between each double row of pores are studded with the balls which fitted into the socket of each spine ; these fine plates are

called ambulacral plates, and are not in one piece; closely examined each plate consists of many smaller ones, no less than 300 of them in those five divisions, and again in the avenues between the pores there are 300 more. 600 plates, besides the 4,000 spines and countless pedecilariæ in the outward form of the common Sea-urchin!

The structure of the mouth is one which has long been the wonder and admiration of naturalists, and was compared by Aristotle to a lantern without a skin, from whence it has derived the name of Aristotle's Lantern. Again we see the number *five*, in five jaws, each with a long sharp tooth converging in the centre, close to the mouth, and the framework of these jaws consists of *five* times *five* pieces, moved by six times *five* muscles, working with great power the jaws of this little animal, who feeds on any dead fish or flesh it can attain, eating also young crabs with great greediness, and catching them with the suckers which surround the mouth. The opposite end of the shell is occupied by *five* ovarian plates, in each of which there is an aperture by which the eggs are excluded; they are strengthened by transverse bands inside, and again separated by *five* smaller plates which bear each a little red eye. The internal anatomy I shall not enter upon; enough is written here to give much interest to the various sections of Echinus spines which we purchase as microscopic objects, and which are sometimes glanced at as very pretty crochet patterns.

OBJECTS FOR THE POLARISCOPE.

POLARIZED LIGHT.

The possession of a polarizing apparatus with a good microscope is a source of much gratification even to the unscientific, inasmuch as common substances are glorified thereby in a marvellous way. My parish boys declared they had no notion their cows' horn was so beautiful, and some of them wished audibly for a waiscoat like the elytra

of a Dyticus. However, the effect of polarized light is not only beautiful to the eye, but of real use to the investigator of tissues, and in the researches of the pathologist, for by it, the true structure of organic bodies may often be made clear, when the ordinary white light has failed to develop it.

Hardly in a concise manner can the question be answered, which is so often asked, "Why are these objects so coloured?" and, What *is* polarized light? But I may briefly explain that rays of light reflected from a body under special conditions, or transmitted through certain transparent crystals, undergo such change in their properties, that they are no longer subject to the same effects of reflection and refraction as before.

The common ray of light may be compared to a glass rod smooth and white, uniform in texture, whilst the polarized ray is smooth on one side, rough and dark on the other.

How it becomes so, requires too long a dissertation on the laws of light and colour; but so it is. And when this polarized ray is either thrown upon or transmitted through various substances, it is either reflected, or absorbed and extinguished according to the structure of the object presented to it. The most brilliant colours are developed by this process, especially in crystals, feathers, sections of quill, bone, hoof, horn. A good selection of these objects is of value to the microscopist.

SELENITE,

which is a mineral substance consisting of crystallized hydrated sulphate of lime, when split into thin layers or laminæ, are very beautiful under polarized light, and discs of blue or red selenite are used to enhance the colour of objects for the polariscope. There are many crystals and organic substances whose thickness is not suitable for the production of distinct colour, which, when a plate of *selenite* is placed beneath them, exhibit a brilliant array of the most gorgeous hues. A good disc mounted in brass costs five shillings, but smaller ones may be obtained at Baker's for one shilling, and answer every purpose.

RHINOCEROS HORN.

A section of this beautiful and familiar object is a good example of the effect of polarized light. By common light we see a pale yellowish substance composed of horny fibres interlacing and forming cells of concentric layers round a minute central point. All this is faintly visible; but subjected to the action of polarized light, brilliant bands of gold mark out the compartments, whilst the layers of blue, purple, or green, circle round a spot which probably corresponds to the papillæ of the cutis.

WHALEBONE.

A longitudinal section exhibits the laminæ of compressed cells on either side of the medullary cells, varied and beautiful in colour. The transverse section shows the large concentric cells and pigment granules yet more vividly bright.

ELYTRA OF DYTICUS.

This exquisite preparation for the polariscope requires considerable time and care to give it the necessary transparency, for the exhibition of colour entirely depends upon the preparation.

The elytra is naturally hard, black, ribbed, and dotted; the structure scarcely visible. It must be soaked in potash for a month, then examined, washed, dried, soaked in turpentine, and finally mounted in balsam; when nothing but the suckers of that same beetle can exceed it in colour. The richness of the golden ground, the blue and crimson spots on which the black cross of polarized light is seen, makes it a truly glorious object.

Hairs from the leaf of a fern show like glittering stars in the dark blue, midnight sky.

THE CUTICLE OF DEUTZIA LEAF

shows the stellate siliceous hairs of all colours on the cellular tissue.

SECTIONS OF QUARTZ

give infinite variety and arrangement of colour.

The following list of objects is specially for the polariscope, and may be obtained at Baker's and at other opticians:—

Sections of bone.
Hairs of animals.
Hairs from plants.
Fibres of Palm.
Section of Vegetable Ivory.
Papyrus.
Palates of Whelk.
Sections of Marble.
„ Granite.
„ Agate.
Foot of Wasp.
Elytra of Beetle.
Section of Cuttle-fish bone.
Crystals of Borax.
Salicine.
Cellularia (Zoophyte).
Gemellaria (Zoophyte).
Sections of Infant Skull.
Section of Tooth.
Crystals of Iodo-disulphate of Quinine.
Oxalate of Ammonia.

CHAPTER XV.

ANATOMICAL INJECTED PREPARATIONS.

These beautiful and instructive preparations will be found most suitable objects for examination with a binocular microscope; and as this little hand-book is intended for the non-medical and young students of Natural History, a description of the usual preparations shall be as brief and clear as possible.

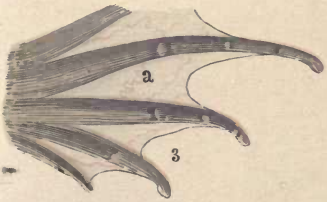
If the structure of a Bee's tongue, or of a Cricket's gizzard, be interesting to us, and the spiracle of a Beetle and egg of a Fly be worthy of a place in our cabinet, much more so must be those organs of our own life upon which our health of body or of mind depends, and which in their elaborate workmanship and forethought prove how fearfully and wonderfully we are made. It is not a merely curious study, for if we did understand the mechanism of our body better we should not so recklessly peril its safety, by the careless folly of fashion or the unbridling of our passions.

INJECTED PREPARATIONS

Of Human Liver—Rabbit—Pig—Monkey, &c.

These are either injected with chromate of lead, vermillion, or, if for transparent injections, with Prussian blue and carmine. The sections give the lobular and interlobular vessels, sometimes the blood-vessels only, or the interweaving capillaries and hepatic vessels in different colours.

The preparation before me of Sheep's liver is one of Topping's, presenting a beautiful series of radiating, minute vessels, in a mingled network of blue and carmine; the stereoscopic effect detaches every capillary, and we look *through* the delicate structure.



1. Stickleback. 2. Small portion of Stickleback's tail-fin, magnified 35 diameters.
3. Part of Frog's foot. 4. Minute portion of the web, magnified 100 diameters.
5. Capillaries in web of Frog's foot, magnified 580 diameters.

To appreciate this preparation we must understand the action and office of the Liver.

This organ is employed in abstracting from the blood that secretion called Bile, which is necessary to complete the process of digestion, though its precise mode of acting is still unknown. The liver is situated at the right side of the stomach, and at its *lower* end a large vein, called the portal vein, enters, charged with blood that it has received from the intestinal veins, returning with impure blood from various parts of the body. This portal vein is injected *blue*, and has spread into those innumerable capillaries which distribute the blood throughout the liver, and in a most unusual way reunite and coalesce into a large cavity at the upper end of the liver, called the *vena cava*. Through this channel the cleansed blood is propelled into the heart, to be afterwards sent through the lungs for further purification.

The substance of the liver itself is made up of secreting cells and passages, called hepatic ducts (colour injected with carmine), with branches terminating in enlargements, called *lobes*, round which the capillaries spread. The bile withdrawn is poured forth through a third passage into the *duodenum*, or small intestine nearest the stomach. Here it mingles with the food, performs the office assigned to it, and the superabundance passes on and away from the system altogether.

VILLI.

Small Intestines of Man—Monkey—Pig—Dog—Cat—Rabbit.

Any of these will show the structure which absorbs the nutritive part of our food immediately after its leaving the stomach. We see in this preparation a crowd of papillæ, covered with a network of vessels injected either with vermillion or chromate of lead. These are the villi, or minute processes of the mucous membrane of the small intestines; two or more arteries are distributed to each villus, and from their capillaries proceed one, two, or more veins, which pass out at the base of each villus. Also there are one or more lacteal vessels in each of these minute villi, spreading in a

network over the surface, interwoven with the capillaries, and absorbing the fatty part of our food, whilst the blood-vessels absorb the dissolved part of any kind. The villi are closely crowded in the small intestines, preventing the too quick passage of the food, which here receives the needful bile from the liver and pancreatic fluid.

A transverse section of

DUODENUM OF MOUSE

gives a transparent view of the villi, in which both blood-vessels and lacteals are distinctly visible.

THE LUNG.

Human—Monkey—Bear—Puppy—Pig—Cat—Sheep—Fowl—Goose—Turtle—Rattlesnake—Frog—Tortoise.

The usual sections of lungs of animals present the capillaries of the veins charged with impure blood, woven in close network around these bronchial tubes, which aërate the life-blood, and send it back pure and bright into the heart, to leap forth again throughout the whole living frame. The air we breathe is composed in every one hundred volumes of seventy-nine volumes of oxygen. It is the oxygen that gives life and is the essential agent, the nitrogen merely modifies its too energetic action, and when this gas comes into contact with the carbon contained in the blood of these fine capillaries, carbonic acid, deleterious and noisome, is the result, and we breathe it forth at every expiration. Then the sluggish purple blood brightens, and in vermillion streams flows on in a web of capillaries, which, if those of the lungs only were extended, would cover a space of 2,642 square feet, and the air-cells themselves number 600,000,000. This lung in a single year will have contracted and dilated 9,000,000 times, will have inhaled 100,000 cubic feet of air, and aërated more than 3,500 tons of our life-blood.

If, however, we are looking at slides of other than human lungs—the reptile, or the bird—we shall see modifications wisely arranged for the habits of the creature. In the lung of the Fowl or Pheasant, an immense number of

capillaries are exposed to the air by means of lobules or lunglets, each of which has its own bronchial tube and system of blood-vessels. Each lobule has a central cavity surrounded by a solid plexus of blood-vessels, which is not covered by any limiting membrane, but admits the air freely between the meshes.

In the lungs of Reptiles the respiratory surface is formed by the walls of an individual internal cavity, with thin membranous wall, and simple, smooth expanse, except at the upper end, where the tracheal vessels enter, close covered with a network of capillaries, and these ramify over the surface, depressing it into sacculi or air-cells, each of which has a capillary network of its own, very considerably increasing the surface of blood-vessels exposed thus to the air.

THE GILL OF AN EEL

will present a beautiful object, and show how this external lung is adapted for life in another element than pure air. The laminæ are divided into minute leaflets, over each of which the finest possible web of capillaries is traced, and the strength of the muscular apparatus connected with each arch of laminæ renews the fluid necessary for their perfect aëration, without the cilia, which is needful in the gills of Oysters, Mussels, and Molluscs, also in the temporary gills of the young Water-newt.

THE INJECTED FIN OF A TURTLE

is an exquisite object, showing the blood-vessels like coral-branches gleaming in the water depths, less numerous, and therefore more distinct in form, than in most circulatory preparations.

THE STOMACH OF A MOUSE.

This is the best object for examination of and understanding the structure of the stomach, as the section gives a transparent view of the gastric vessels, and also of the pyloric opening.

The animal stomach is a strong muscular sac, consisting of three separate layers or sets of fibres, which give it the power of contraction and dilatation. It is lined with a mucous membrane, smooth and velvety when distended,

but loose and plaited when contracted. The internal surface is somewhat like honeycomb, with shallow cells, at the bottom of which lie the minute orifices of the gastric glands. We see these glands looking somewhat like villi in the injected preparation, but they are essentially different both in structure and office. These tubular glands produce the cells containing the gastric juice which digests our food. When the stomach is empty they are at rest and the orifice of each is closed, but no sooner does food enter the stomach than the capillaries surrounding each gland become excited, and the glands commence actively secreting an acid fluid, which oozes in minute drops from their open mouths and mixes with the contents of the stomach.

The pyloric opening is the passage into the duodenum; during the first part of digestion it is completely closed, but as digestion progresses it relaxes more and more, suffering even undigested portions to go through it.

THE SKIN.

Injected portions of the skin usually show the fibro-cellular tissue called the corium, elastic, yet dense and tough, beneath which lie the important sweat-glands, the hair-follicles, and the papillæ. The web that we see is composed of fat-cells, blood-vessels, absorbents, and unstriated muscular fibre.

SECTION OF PALM OF THE HAND OR FOOT OF CAT—DOG—MONKEY.

This will show the cutis above and the papillæ beneath, forked or trifid with loops of capillary blood-vessels. The papillæ are not all furnished with nerve-fibres; many of them have merely blood-vessels for the supply of the epidermis, and those which possess nerve-fibres are usually destitute of blood-vessels. The sensory papillæ contain a peculiar "axile body," or bundle of fibrous tissue, upon which the nerve-fibre terminates.

If you do not mind snipping a papilla from your own tongue with a sharp pair of curved scissors and soaking it in a solution of soda for a few minutes, it becomes transparent, and the nerve-fibres are distinctly seen. In some

sections of the skin, hair-follicles are visible, and the foot of the Cat exhibits these. In other preparations the sweat-glands are shown, which are long tubes coiled into a knot near the closed end, and a straight or spiral duct piercing the skin at the surface between the papillæ. These glands are most numerous as well as large in the palm of the hand—there are 2,736 in each superficial square inch; upwards of *two millions* in the whole body, carrying off carbonic acid and water, as well as various other substances superabundant in the system—chloride of sodium, muriate of ammonia, phosphate of soda, lactic acid, and carbonate of lime.

The lower animals, more particularly the naked Amphibia, as Frogs and Toads, exhale carbonic acid gas most abundantly by the skin, and respire also, absorbing water as well as air, by means of the sudoriparous glands.

THE SKIN OF THE TOAD

is very interesting, for it shows not only the network of the capillaries, but the pigment-cells beneath.

CILIARY PROCESSES.

THE EYE OF THE OX.

This is a magnificent object, exhibiting the blood-vessels of the choroid membrane and ciliary processes.

THE EAR OF A MOUSE.

A really beautiful preparation, showing the cartilage-cells and the structure of the mouse's hair, also the injected arteries and veins. The cartilage-cells are simple in this part of the body, resembling the parenchyma of vegetables, and the substance is without blood-vessels, being nourished by those which spread over them in the enveloping membrane of the ear.

They are the lowest order of animal cells, like the Algæ of the vegetable kingdom, without vessels of any kind, and nourished by inhibition.

THE TOE OF THE WHITE MOUSE.

A very popular object, and worthily so. If the section

is thin, transparent and perfect, it will show the structure and position of the nail, the corium and papillæ beneath; the joints and shaft of each bone of the toe, with its attendant arteries and returning veins; also the hairs, with bulb and follicle to each. In these hairs the outer cortical or investing membrane is distinctly seen, banded or crossed in the centre with a double row of medullary cells. When these last two slides have been looked at with a low power, examine further with a half-inch.

INJECTED PREPARATIONS.

THE KIDNEY.

The Rabbit or the Cat gives an excellent preparation of this organ.

The whole substance of the kidney is made up of urinary tubules, with attendant arteries and veins. These tubes or passages are lined with cells like paving-stones, called "epithelial cells," and those round bodies injected blue or crimson are the Malpighian tufts, or terminations of a tubule, into which an artery runs and twists about, forming a plexus of minute blood-vessels, ultimately uniting to a single outgoing or efferent vessel, which branches off again into a capillary network, situated in the cortical or outer substance of the kidney. These solitary efferent vessels are like the portal-vein system of the liver, both serving to convey blood between *two* capillary systems. The interstices between the blood-vessels, nerves, and tubules of the kidney are occupied by areolar tissue.

TONGUE.

Human—Monkey—Dog—Cat—Mouse.

If a perpendicular section of the human tongue be obtained, we shall see that it consists of a free surface, covered with structures analogous to those of the skin, a *cutis* or *corium*, on which are placed *papillæ*, which are more developed in the rough tongue of the Dog and the Cat than in the human subject; consequently an injection of the dog's tongue is a more beautiful object. The fungi-

form papillæ spread out in looped capillaries, whilst on the surface beneath is seen an intermediate plexus of minute vessels. The artery and its vein are distinctly visible in each papilla, with the attendant nerve.

THE BRAIN.

Cat—Rabbit—Mouse, &c. &c.

OR, SECTIONS OF SPINAL CORD OR GANGLIA.

We touch any slide of Brain reverently, for we stand here upon the border-land between the visible and the invisible, the known and the unknown, whether it be of animal instinct or human reason, whose seat lies here.

Beautiful are these delicate capillaries, spreading round and over each convolution of the brain; strange are these stellate forms of nerve corpuscles imbedded in a dimly-shaded or granular substance. Nerve fibres ramify and interlace—nerve force flies along each fibre with immeasurable velocity. We know that, chained within this complex nerve system, the *living soul* goes to and fro in contact with the outer world, upon the countless paths which issue from the twelve pair of cerebral nerves and thirty-one spinal nerves; each of these has a double fibre of sensation and of motion; they are separate, yet sheathed together; if we cut one of them the power of movement is gone, whilst sensation remains; if we cut the other, then convulsive, irregular movement stirs a limb which can no longer feel. We know that, flashing from the invisible dweller within that little brain, instinct or intelligence governs the whole of this material frame. We have learned works on the phenomena of motion or the physiology of the nerves, theories plausible and wild concerning this organ of the mind, and we feel keenly how very slight a jar may trouble for ever the right action of the intellect; but we really have little knowledge beyond the mere structure of the Brain, and we gaze wistfully, it may be, at the most difficult of all preparations to prepare satisfactorily.

All these preparations may be procured at Baker's, from fifteen pence to two shillings each.

CHAPTER XVI.

SLIDES OF CRYSTALLIZATION.

These are beautiful polariscope objects, and extremely useful to the young student as first lessons in crystallography, and incentives to experimental knowledge of the various forms of mineral substances. Crystals are constantly met with in the examination of both animal and vegetable tissues; it is therefore necessary to become acquainted with the most common forms, if we use our microscope understandingly.

In the cuticle of onion we find crystallized oxalate of lime; in rhubarb also, but varied in form, as it is combined with tartaric, citric, or malic acid. Every crystallizable mineral substance has a definite form of crystallization, and often many accidental or secondary forms. Carbonate of lime—a substance well known as forming chalk, marble, &c., and abundant in animal structure—is found in hundreds of secondary forms; in groups of radiating needles, in hexagons, in rhombohedral forms, as in the shell of the Oyster; thus the perfect knowledge of the laws and accidents of crystallization is a deep study; in fact, it is to mineralogy what mathematics is to common arithmetic, and cannot be entered upon in a mere catalogue of slides.

The following preparations are recommended for beauty and utility, when examined with polarized light; a plate of selenite is frequently indispensable for the display of colour and accurate observation of outline.

SELENITE

is itself a form of crystallization; native crystallized hydrated sulphate of lime, called also satin gypsum or quarry-glass. It is found in the quarries on Shotover Hill, Oxford; but the finest crystals are met with at Montmartre, near Paris.

The primary form is that of an oblique rectangular prism, with ten rhomboidal faces, two of which are larger than the rest.

It is split into thin laminæ, and mounted on glass slides for the polariscope, and upon the thickness of the film depends the colour.

The following list of crystals may direct the student to many interesting specimens :—*

Acetate of Copper.
Acetate of Manganese.
Acetate of Soda.
Acetate of Zinc.
Acetate of Lead.
Agate, transparent sections.
Alum.
Arseniate of Potass.
Bicarbonate of Potassium.
Bichromate of Potassium.
Borax, or Birate of Soda.
Boracic Acid.
Bismuth.
Carbonate of Potass.
Carbonate of Lime.
Carbonate of Soda.
Chlorate of Potass.
Chloride of Barium.
Chloride of Cobalt.
Chloride of Sodium.
Citric Acid.
Deut-iodide of Mercury.
Granite, transparent sections.
Hydrochlorate or Muriate of Ammonia.
Iodide of Potassium.
Iodide of Quinine.
Nitrate of Ammonia.
Nitrate of Baryta.
Nitrate of Bismuth.
Nitrate of Copper.
Nitrate of Soda.
Nitrate of Uranium.
Oxalic Acid.
Oxalate of Lime.
Oxalate of Ammonia.
Oxalate of Potass.
Oxalate of Soda.
Phosphate of Ammonia.
Phosphate of Soda.
Salicine.
Sulphate of Ammonia.
Sulphate of Copper (Blue Vitriol).
Sulphate of Iron.
Sulphate of Magnesia (Epsom Salts).
Sulphate of Soda.
Sulphate of Zinc.
Sulphate of Nickel.
Sulphate of Cadmium.
Tartaric Acid.
Uric Acid.

The formation of Crystals under the microscope may be watched with the greatest facility. A little common salt (chloride of sodium) dissolved in water, and a drop of the solution placed on a glass slide gently heated over a spirit lamp, or by applying the corner of the slide to the candle,

* These are mounted for the Polariscope by Mr. Topping.

will show the formation of crystals in primitive cubes, terminated by quadrangular pyramids. The water slowly evaporates, and the atoms held in solution return to their natural form.

ACETATE OF COPPER

is made by dissolving common verdigris in excess of diluted acetic acid, and when crystallized on the slide will exhibit the phenomena of dichromism or double colour, deep blue and yellowish green.

SULPHATE OF COPPER.

Blue vitriol dissolved in water, and likewise treated with a gentle heat, will show the formation of beautiful blue crystals in oblique rhomboidal prisms.

ALUM

does not polarize, but gives crystals of the octohedral form.

OXALURATE OF AMMONIA.

This is most beautiful in the formation of its crystals; they appear on the slide as circular discs or very flat spheres, consisting of minute needles radiating from the centre, and sometimes projecting beyond the circumference of the disc. Without the selenite stage these discs are like brilliant little white stars, traversed by a black cross; with the selenite they are splendid objects, the colours often disposed in concentric rings.

MUREXIDE OR PURPURATE OF AMMONIA

is an artificial product of the decomposition of uric acid. The crystals are flattened, short, four-sided prisms, of bright ruby red by transmitted common light, and the two broad surfaces are emerald green by reflected light.

HYDROCHLORATE OR MURIATE OF AMMONIA.

This salt crystallizes in cubes, octohedra, and trapezohedra. A very little of the powdered salt dissolved upon a slide and heated gives a beautiful exhibition of feathery crystals darting across the field of sight, and breaking into stars and crosses. They do not polarize.

OXALATE OF AMMONIA.

This is obtained by neutralizing a solution of oxalic acid with ammonia or its carbonate, and evaporating, which gives long, slender needles belonging to the right rhombic prismatic system, and very brilliant crystals under polarized light.

SALT OF BRUCIA.

Using a solution of ammonia with certain salts will give an infinite variety of beautiful crystals; for instance, a little salt of brucia, diluted and mixed with ammonia, will produce delicate star-like groups of crystals; and if a solution of sulphocyanide of potassium is used instead of ammonia, the crystals are more feathery, and resemble sheaves of brilliant little lances.

Solution of hydrochlorate of strychnine with ammonia gives an immediate precipitate of minute prismatic crystals, well defined.

A solution of quinine with ammonia gives a perfectly amorphous precipitate; with sulphocyanide of potassium it gives very pretty, irregular groups of circular crystals; but it is well to allow twenty-four hours for the formation of these, as if hurried they are extremely minute, and not so perfect.

IODO-DISULPHATE OF QUININE.

This is sold prepared for examination; the crystals possess a more intense polarizing power than any other known substance. They are difficult to mount, though the formation is an interesting process, and may be attempted. The salt is prepared by dissolving disulphate of quinine in strong acetic acid, warming the solution, and dropping into it an alcoholic solution of iodine in small quantities at a time, and placing the mixture aside for crystallization. They dissolve in hot alcohol, but are not soluble in cold alcohol or ether.

To prepare for mounting, a little of the liquid containing the crystals should be placed on the slide, and the liquid

removed with blotting paper. When the crystals are dry, the Canada balsam, previously made thin with ether, may be applied *without heat.*

BORAX, OR BI-BORATE OF SODA,

is soluble in twelve times its weight of cold and twice its weight of boiling water, and crystallizes in very perfect forms of oblique octohedral prisms. Dissolved in alcohol, and dropped on a slide, it crystallizes immediately.

BORACIC ACID

is the acid of the salt borax, and is prepared by mixing three parts of borax dissolved in twelve parts of boiling water with one part of sulphuric acid.

When a little phosphoric acid is added to the boracic acid, and the solution dropped upon a slide, then laid upon a warm iron plate, most beautiful discs are obtained, which exhibit the cross and coloured rings under polarized light.

From the simple solution of boracic acid we obtain crystals belonging to the doubly oblique prismatic system, having two optic axes. Sometimes, when rapidly crystallized, the boracic acid forms arborescent crystals on the slide.

SULPHATE OF MAGNESIA.

(*Epsom Salts.*)

The solution will deposit crystals belonging to the rhombic system, and varying in form according to the treatment in crystallizing. They polarize brilliantly with the selenite stage.

AMMONIO-PHOSPHATE OF MAGNESIA

is a salt frequently met with in animal secretions which have undergone decomposition; they belong to the rhombic system, but their varieties are endless. Stellate and penniform crystals are frequently found in urine.

URIC ACID, OR LITHIC ACID.

This acid abounds in animal secretions, in the excrement of birds, serpents, &c., and the urine of mollusca and carnivorous mammalia. The crystals belong to the right

rhombic prismatic system, but are various in form and size. They polarize light splendidly.

NITRATE OF POTASH, NITRE, OR SALTPETRE.

This salt is dimorphous; it crystallizes in various forms, but they all belong to the right rhombic prismatic system; sometimes six-sided prisms with dihedral summits are on the slide, and sometimes obtuse rhombohedral crystals, resembling those of nitrate of soda; but they all polarize, and exhibit the phenomena of *analytic crystals.*

Analytic crystals are those which possess the power of analyzing light, like the tourmaline used in the ordinary polariscope.

SALICINE,

an alkaloid extracted from the bark of the willow tree, and crystallizing in beautiful forms, either in discs exhibiting the cross and concentric circles of colour, or in prismatic crystals in stellate and irregular groups, polarizing admirably.

NITRATE OF SILVER,

crystallized on a slide, shoots over the glass in most brilliant feathery crystals, and is also a splendid object viewed with a spotted lens or parabolic reflector.

I RECOMMEND THE FOLLOWING OBJECTS AS THE CONTENTS OF A GOOD EDUCATIONAL BOX:

Cuticles of Lily, Candytuft, and one or two others, to show cells and stomata.

Cuticle of Indian Corn, or Equisetum, to show siliceous cuticle.

Cuticle of Hyacinth, to show raphides.

Cells of spiral fibre.

Scalariform vessels.

Starch grains.

Hairs of Deutzia leaf.

Scales on leaf of Elæagnus or Tillandsia.

Pollen of Hollyhock or Mallow.
Stamens.
Sections of Wool, Endogens and Exogens.
A capsule of Moss.
Spore-cases of Fern.
Elaters of Equisetum.
Elaters of Jungermannia.
Leaf of Moss or Jungermannia.
Specimens of Fungi.
Mould, Arsyria, Phragmidium, or Puccinea, blight of Wheat.
Heads of Insects.—Bee, Wasp, Beetle, Butterfly, Hymenoptera, Blow-fly, Panorpa, Tipula, to show the tongues and eyes, and study them comparatively.
Antennæ of Syrphus, of Cockchafer.
Leg of Dytiscus, Gyrinus, a Fly, a Beetle, a Saw-fly.
Wing of Wasp, for hamuli; wing of Syrphus, of Hemiptera, of Moth, to show scales.
Spiracles of Dytiscus; Trachea of ditto, or Silkworm; Aërating leaflets of Libellulæ, or Ephemera.
Sting of Wasp or Bee, of Gnat, of Horse-fly.
Elytra of Diamond-beetle, of Hemiptera.
Saws of Saw-fly.
Egg of Breeze-fly.
Acarus of Sugar.
Palate of Whelk and Helix, Limpet, Doris.
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