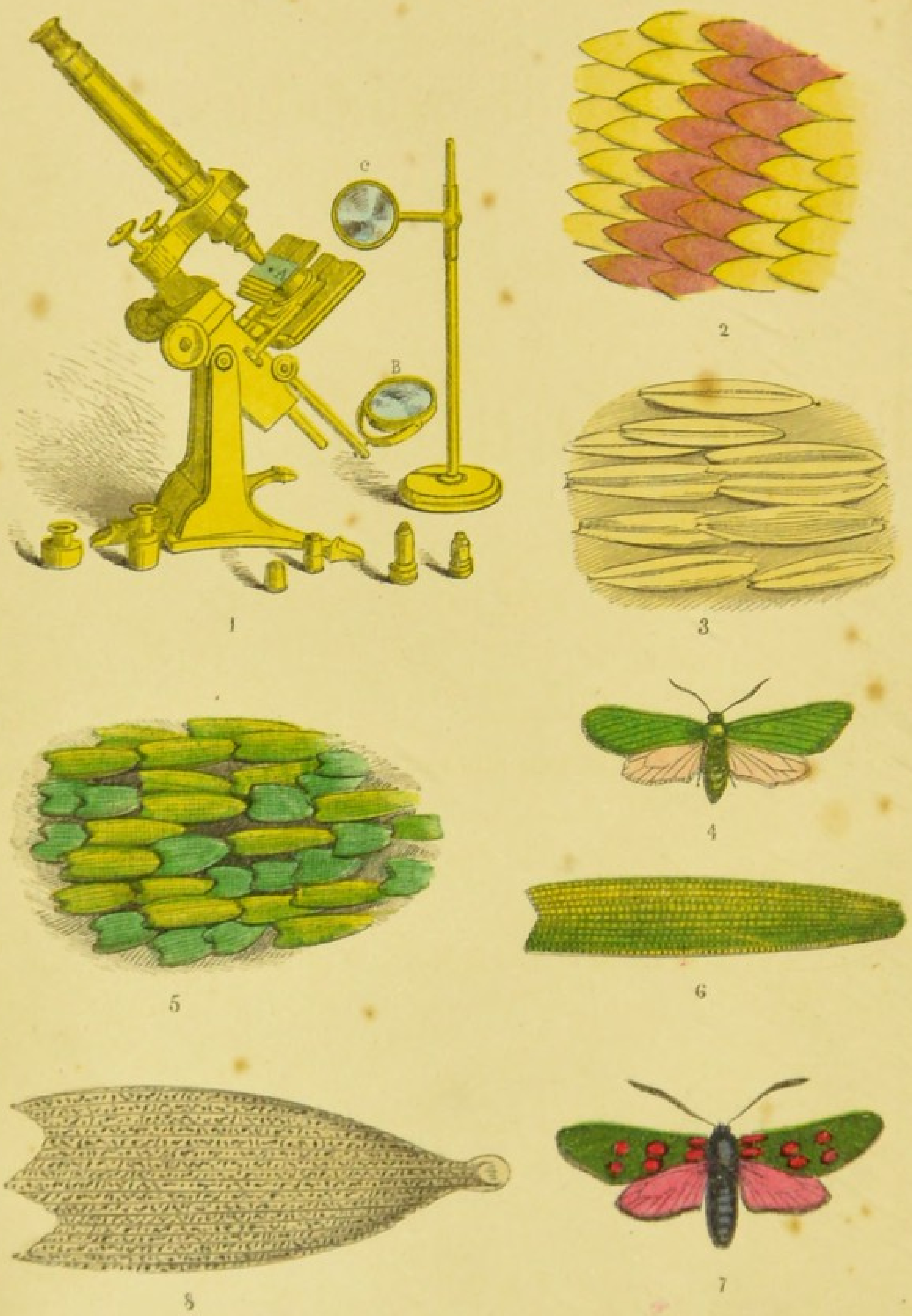
A WORLD OF WONDERS REVEALED BY THE MICROSCOPE



1. The Microscope. 2. Scales of Ghost Moth, magnified 80 diameters.
3. Scales on the under side of Ghost Moth's wing, magnified 100 diams. 4. Green Forester Moth.
5. Scales of Green Forester Moth, magd. 100 diams. 6. Scale, magd. 300 diams.
7. Six-spotted Burnet Moth. 8. Scale of Burnet Moth, magnified 420 diameters.

A WORLD OF WONDERS

REVEALED BY

THE MICROSCOPE.

A BOOK FOR YOUNG STUDENTS.

WITH COLOURED ILLUSTRATIONS.

BY THE HON. MRS. WARD.

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PREFACE.

The following account of Microscopic Objects was written, as it professes, in a letter to a friend. This will account for the familiar style employed. Some few additions and alterations have, however, been made. The Microscope used in these researches is one of Ross's beautiful instruments, equal in magnifying powers to any which have yet been constructed. Many of the wonderful objects, however, which are described in these pages, can be examined with a Microscope of far lower power.

A WORLD OF WONDERS REVEALED BY THE MICROSCOPE.

MY DEAR EMILY,

YOU have expressed a wish to receive tidings from the world of wonders which surrounds us, and which is revealed only by the microscope. The instrument stands on the table before me, and I proceed to select from among the prepared objects which are placed beside it those which I should probably exhibit to you were you here.

They are not, perhaps, so striking a series as those which I should show you in summer, when wonderful *living* things abound in every brook, and every little standing pool; when minnows or tadpoles can be gently placed below the microscope's magic tube, so as to exhibit the wonders of circulation and of breathing, their temporary thraldom seeming forgotten or compensated in a merry leap into the water when the observation is over. We must wait for the season of mild air and sunny skies before we can see these sights.

Meanwhile we shall, I hope, find much to interest us in the prepared objects, which are mounted on slips of glass, and can be shown in all seasons.

Wings of Insects.

Here are a few preparations of the wings of insects. Have you ever remarked how beautiful they are, how various, and how well adapted to each insect's mode of life?

There are very few insects without wings. This was a surprise to me when I first began to examine them. It is easy to see the wings of moths and butterflies, of flies, bees, and wasps, and of the dragon-flies which are so common every summer; but we shall find, if we look for them, that most beetles, water-insects, all full-grown crickets and grasshoppers, and even *earwigs*, have wings. Beautiful and delicate wings they are, often rainbow-tinted from their almost filmy lightness, and yet they are uninjured while their owner boldly plunges into water, or gropes his way through the muddy ground, for they are neatly folded up under the horny wing-cases which, in general, conceal them from view.

My astonishment was not small when I first succeeded in spreading out the wings of a dead earwig, having read in some book that such appendages were to be looked for.

These wings are extremely delicate and thin. When spread out they are the size represented in plate I., fig. 3, completely altering the appearance of the insect. The folding of these wings is a perfect model of neatness—they are not only closed up like a fan, fig. 1, (*b*,) but also twice bent (*c*,) laid along the insect's back, and partly covered by the wing-cases.

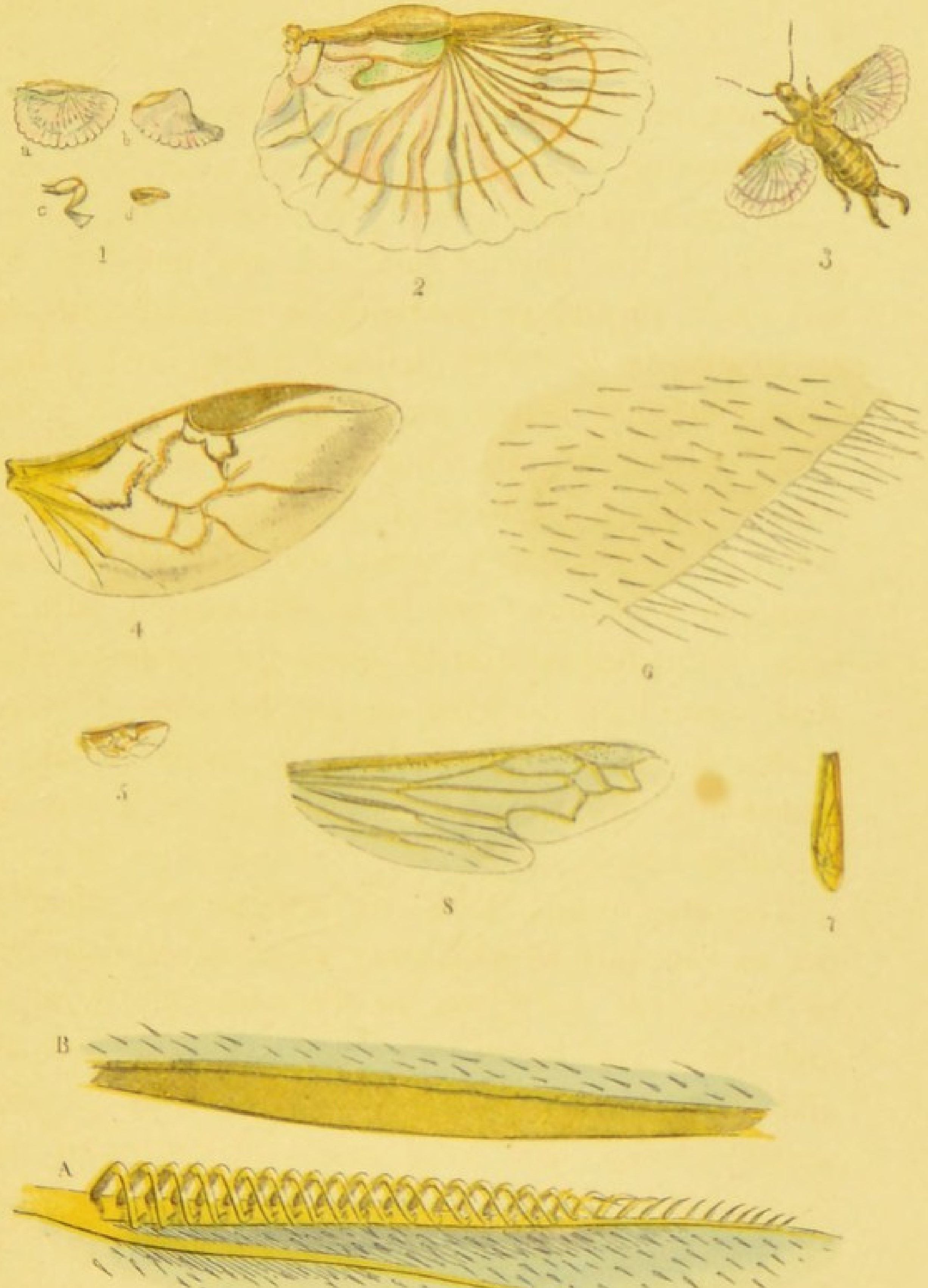
Beetles do not fold up their wings in quite so small a compass, and accordingly they have not so many ribs to strengthen them; they have a few strong ones instead. Fig. 5 represents the wing of a little water-beetle, remarkable for its habit of whirling round on the surface of ponds and brooks. With a magnifying power of about five diameters* (fig. 4) we can see the strong ribs or nervures of the wing, and can just detect on

* See Note on magnifying power at the end of this book.

the rest of its surface some pattern or graining of surpassing delicacy and minuteness.

To examine this, we apply one of the highest powers of the microscope; and we now see that the whole surface of the wing is covered with tens of thousands of short delicate hairs, and fringed with somewhat longer ones. I have drawn a very small portion of the wing as seen with this high power, (fig. 6.) Were I to represent the entire wing on this scale I must make it rather more than *ten feet long;* yet it is ornamented with the same beautiful regularity over the entire surface. And were I to describe all the beauties of insects' wings, devoting myself only to those which are folded up, my letter would stretch to a similarly gigantic length.

The wasp, too, folds its wings, but they are not so carefully stowed away as those of the earwig or beetle, as it wants to fly so much more frequently. Yet wasps often go into the ground—and bees (whose wings much resemble those of wasps) creep into very small flowers and very narrow openings in their hives—therefore a pair of large broad wings would be in their way. The contrivance they are supplied with is very curious. They have four wings, two on each side, and the



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. 3. 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.

upper wings fold once, lengthwise (fig. 7) when the insect walks, but when it prepares to *fly* it straightens this wing by the act of raising it, and the same action hooks the lower wing to it firmly, giving it all the force of a single broad wing. Fig. 8 represents the two wings thus joined, and slightly magnified. To show the minute hooks which are on the top edge of the lower wing (fig. 9, A,) I must take my specimen in which the wings are prepared separated from each other, and will magnify them 60 diameters. The part of the wing on which the hooks are placed is very small, not more than one-twentieth of an inch in length. Some one to whom I once showed these hooks, asked where the *eyes* were? However, a projecting ledge on the upper wing is a more convenient fastening, and with this it will be seen that the wing is supplied, (fig. 9, B.) The dragon-fly's wings, which never require to be folded up or reduced in size, are formed for strength and lightness, and evidently for beauty too. Plate II., fig. 1, represents one of the small dragon-flies, so common through the greater part of summer, with bright blue, or oftener red, bodies. Their wings are beautifully transparent, consisting of a delicate membrane, stretched, as it were, to a sort of ornamental network. A small portion of one wing, magnified seven diameters, is shown in fig. 2. The shaded compartment represents the single dark spot, so prettily placed near the tip of each wing. Another dragon-fly, rather larger, and with a metallic-looking bluish-green body, has more minute divisions in its wings, and in each wing a brownish patch of shading, producing a very soft appearance. It has not the little black spot in each wing; it seems as if that ornament would not be in keeping with its softer shades, (figs. 3, 4.)

But the wing which I have always thought the most curious in my collection is that of an exceedingly small beetle, represented of the natural size at fig. 5. It is a very lively, active little creature, common under moss in spring. I looked for its wings because it was the smallest beetle I had ever seen, and they turned out to be most extraordinary wings indeed. They are unusually narrow, and each fringed with hairs half the length of the wing itself. This long fringe surrounds it except in two places, where the wing doubles up so as to allow it to fold easily; here it is replaced by short hairs.

Fig. 6 represents the little beetle in the act of flying, magnified 30 diameters; but when we magnify it 420 diameters, we see that each one of these tiny hairs is fringed again like a feather, (fig. 7.) This appears very clearly when we view the hairs with a magnifying power of 900 diameters —the highest with which this microscope is supplied. The same high power brings out the wonderful fact that at the base of each of the little wing-cases—which measure at their broadest part only 1-62nd. of an inch—there is a delicate little *comb*, formed with beautiful regularity, and having 120 teeth! I have drawn an outline of the wing-case to show the position of this comb, which extends from A to B, (fig. 8,) a space scarcely more than the hundredth part of an inch.

Its use probably is to remove all particles of dust from the long feathery wings before the wing-cases close over them. Fig. 9 represents a few of these teeth as seen with a power of 900 diameters. The thinly-scattered strong bristles on the wing-case contrast with the regular appearance of the tiny comb.

It must have been at the sight of some object such as this that Boyle, the eminent philosopher, remarked that "his wonder was greater at Nature's watches than at its clocks." So wonderful are the minuter parts of God's creation! But they are the works of One who judges not as we do of great and small; who "taketh up the isles as a very little thing," and counts the nations as "the small dust of the balance;" and yet promises to *each individual* of those nations—to any man who loves Him, and therefore keeps His words—that He will "come to him, and make His abode with him!"

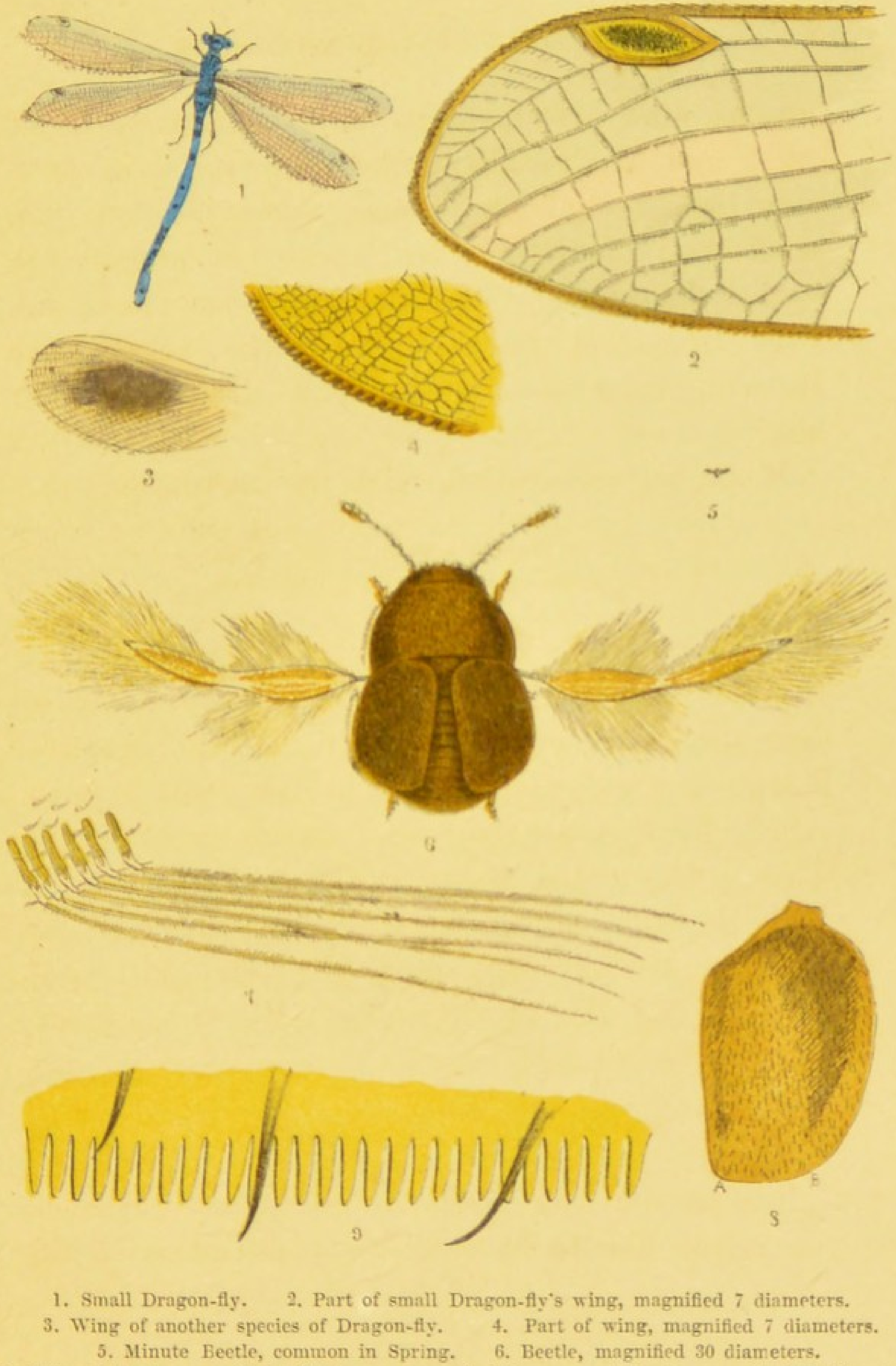
While we are enabled, with the microscope,—

> "To trace in Nature's most minute design
> The signature and stamp of power divine,—

we may profitably follow up the thought our Lord Himself suggested. He will much more clothe *us* than the grass and the lilies of the field, beautiful though they be; and we are in His sight of more value than many sparrows, though not even a sparrow falls to the ground without His knowledge. And He will not fail to order the events of our lives in the very best way, when His skill is so unerring and His providence so kind in the formation of the smallest insect.

Description of the Microscope.

Before you hear about the rest of my collection, you might like to have a short description of the



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 Beetle, magnified 420 diameters. 8. Wing-case of Beetle, magnified 50 diameters.
9. Teeth at the base of wing-case, magnified 900 diameters.

microscope, which shows me all these things. Plate III., fig. 1, represents it. When upright, it is about one foot ten inches high, but it has a joint that enables it to lean back, so that I can look through it and draw what I see quite conveniently.

You can see the various glasses I use. There are five object-glasses of different magnifying power, and three eye-glasses. The figure represents one of the object-glasses screwed in its place at the bottom of the tube, and an eye-glass is slid on at the top; and one of the microscopic objects is placed for observation at A.

There is a little looking-glass under at B, to reflect the light of a window or of a candle, if the object is partly transparent; for the most important thing in managing a microscope is to place the objects in the clearest light, or else we cannot find out the truth about them. And when we get a new object which we have never before examined, we "illuminate" it in different ways, till we find out how to show it best.

Suppose you wanted to examine some leaf—I mean without a microscope—you might hold the leaf between your eyes and the candle, and then you would see its veins very nicely. That would be making a "transparent" object of it.

If you wanted to get an idea of the surface and general colour of the leaf, you would hold it below the candle or beyond it, or on one side; then the leaf would be an "opaque object." We cannot bring our microscopic objects close enough to a candle; therefore, when we use the microscope in the evening, we place the glass C (which is like a bull's-eye or burning-glass) between the candle and the object, so that a very bright light image of the candle is thrown on the latter.

In that way I am going to illuminate the very beautiful set of objects of which I will tell you next.

Scales of Moths and Butterflies.

I HAVE not yet done with the WINGS OF INSECTS, for there is a great deal to be said about the wings of butterflies and moths, or rather the exquisite scales with which they are covered.

The wings are actually very like those of flies and wasps, etc. They are thin and transparent in themselves, but covered on both sides with beautiful scales, laid in rows like the feathers on a bird; sometimes these are nearly alike in general character on both sides, sometimes totally different.

The microscope shows that these scales are of very different shapes, and that they are frequently covered with exquisitely minute lines. I should not omit to say that not only the wings, but also the whole bodies of these insects, are clothed with scales.

Fig. 2 shows the scales of a moth very common on fine evenings in June, called the "ghost moth;" they are very like bay leaves in shape. The scales on the inside of the wing are different, and thinly scattered, (fig. 3.) The wings of this moth are yellowish, having (on the upper sides) what look like delicately-painted streaks of pink; these are red scales.

Some of the scales of moths and butterflies are beautiful for their delicate hues; others shine with a brilliant metallic lustre, to which the best painted representation could scarcely do justice. The little "green forester moth" (fig. 4) is one of these; it has scales of two different shapes on its wings (fig. 5,) the longer being brilliant yellowish green, and the shorter bluish green. When highly magnified, the scales of this moth are seen to be covered with a sort of ornamental carving; each of the larger scales has six or seven ridges on it, and rows of hollows between (fig. 6.) The smaller scales are very similarly ornamented, with a pattern not quite so much raised.

This little moth is common in the beginning of June. There is another, somewhat like it in shape, and still commoner at the same time of year; it is called the Burnet-moth, (fig. 7.) Its upper wings are of a beautiful, very dark green, with round red spots; its lower wings red, edged with bluish black. The dark green scales are glossy like satin, and the red very bright in colour, but dull like cloth or flock paper. This variety of surface forms a very striking contrast. The dark scales of the Burnet-moth are sculptured in a way similar to those of the green forester. When these scales are viewed as transparent objects, they no longer appear green, but the pattern on them, when viewed with a high magnifying power, assumes a strange and almost startling appearance.

It must be remembered how small these scales are. They are only like the finest dust or powder, and a single one could scarcely be seen with the naked eye. Yet every scale may be seen (with a magnifying power of 420) to be marked with some dozen lines, clear and sharp as staves of music, and between them are rows of characters wonderfully resembling some old Babylonish inscription, (fig. 8.)

The scales of the green forester moth are somewhat similarly inscribed, but not with equal distinctness.

Let us again adjust the microscope to view "opaque objects," and feast our eyes on a few more specimens of Nature's mosaic work. The wings of butterflies and moths have been compared to patterns in mosaic; though of course there is this great difference, that the pieces of mosaic are *inlaid;* whereas the scales of insects lie over each other like feathers, fishes' scales, or tiles on a roof. Still their general flatness, and the fact of their delicate shades being usually caused by hundreds of minute scales—the dark or light ones in greater or less number according to the hue required—originated the comparison.

I have examined some, however, in which the effect of the shading is heightened in a way inadmissible in mosaic work, but sometimes employed by *painters*.

I have heard that when an artist is painting,—for instance, a landscape,—and wishes to bring out a rock or tree very vividly, he sometimes finds it necessary to make a roughness on that part of his canvass. A friend of mine actually made the surface of his picture rough with a handful of sand stuck to the paint, and it had the desired effect of giving brightness to what was then painted over it.

Now there is a yellowish-brown insect called the Herald-moth, with one conspicuous white spot on each of its upper wings, shining like a star, or with the peculiar brightness that this representation of it (Plate IV., fig. 1) would exhibit if we were to *prick it with a pin* and hold it up to the light. On examining it with the microscope, I found that this spot consisted of a thick tuft of white scales, almost like a little brush, and standing up much higher than the surrounding parts of the wing, (fig. 2.)

In like manner the scales of the Emperor-moth, a large insect with an eye-like spot in each wing, are rendered much more ornamental by being set sloping upwards instead of nearly level. There is a beautiful semi-transparency in the wings of this moth; but the sloping arrangement of the scales gives brilliancy at the same time. It is, of course, difficult to represent it on a flat piece of paper. The eye-like spots are each about the size of fig. 3, and fig. 4 is intended for a small part of one of them, magnified 60 diameters. The colours are white, morone crimson, a sort of straw-colour, and black, a beautiful and harmonious mixture.

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 diameters.
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. 250 diameters.

I have noticed another deviation from the plan of mosaic work in the wing of a moth—one of the tribe of "Yellow Underwing." The wing is rather dingy, but with a silvery gloss in some parts, which induced me to examine it. I found that the *scales themselves* were shaded. In one place, for instance, where the wing is brown and white, the microscope showed that instead of having rows of white scales and of brown ones, the *same* scale was white and brown, and a very curious and pretty effect it has, (fig. 5.)

The *edges* of moths' and butterflies' wings are highly ornamented. The scales are long, and generally shaped like fig. 6.

There is a yellow butterfly (fig. 7) which appears in spring, and rather resembles a withered lime-leaf. You may observe some spots on the edge of this butterfly's wings; they are very small, and appear a sort of rust-colour, but through the microscope they are white scales tipped with pink, shaded like those of the moth described last. Fig. 8 represents a few of them magnified 150 diameters. I once showed them to a friend who had visited Switzerland, and she said, in great surprise, "Oh, what can this be? unless it is the Alps at daybreak, when the sun is just beginning to shine on the mountains covered with snow!"

I believe I must not take up your time with any more scales of moths and butterflies, except one group, from the under side of the Red Admiral butterfly's wing, (fig. 9.) They are of a different shape from the others which I have drawn; and each scale is covered with a number of lines, which look as if they were ruled on it with the utmost precision, (Fig. 10.) These fine lines are observed on the scales of many butterflies and moths. A very high magnifying power generally shows them to be slightly waved, and, what is very wonderful, frequently *crossed* by a second set of lines of extreme minuteness.

Scales of Beetles.

Several beetles, and some other insects, are ornamented with scales. In fact, whenever I see an insect, however bright its colour, presenting the peculiarly powdery soft appearance of a moth or butterfly's wing, I always guess that it has scales, and generally find my supposition correct.

You may have noticed a remarkably dingy, slow-moving, heavy-looking, little brown beetle (Plate V., fig. 1.) When it is magnified a little, we can see that it is covered, or rather sprinkled over, with round scales of a brownish yellow colour. But when we magnify them 100 diameters, each scale looks like a scallop shell of burnished gold, or as some one said, "an officer's epaulette"—(they *are* like that also)—and placed on the dark shell of the beetle, they are quite splendid, (fig. 2.)

There is another beetle, somewhat similar in shape to this one, but smaller, and more promising in appearance, as it is of a silvery green colour. It is very common in April and May; I have seen hundreds on our large beech trees. Its body is really *black*, with green scales of surpassing brilliancy. I can give an idea of their shape by sketching them (fig. 3;) but they must be SEEN to make you understand their lovely colour, their lustre, in short their magnificence, and I have kept the word "magnificence" to be used in describing this object!

Every one views it with delight. I showed it to a lady who had often had opportunities of seeing *regal* magnificence, perhaps as splendid, or, at least, as suited to the taste of modern times, as the splendour of Solomon in all his glory, and she had scarcely words to express her admiration of the little green beetle. And a few weeks ago, after exhibiting to one of our maid-servants all my pet objects, which she had viewed with interest, but composure, I put in this one, and she exclaimed, "Oh, Miss M., I feel that I want to shout!"

Scales of Fishes.

I MENTIONED the *scales of fishes* just now. They have long been favourite objects for the microscope, though their beauty can be made out with a much smaller magnifying power than that which must be employed to discover the lines on the scales of moths and butterflies.

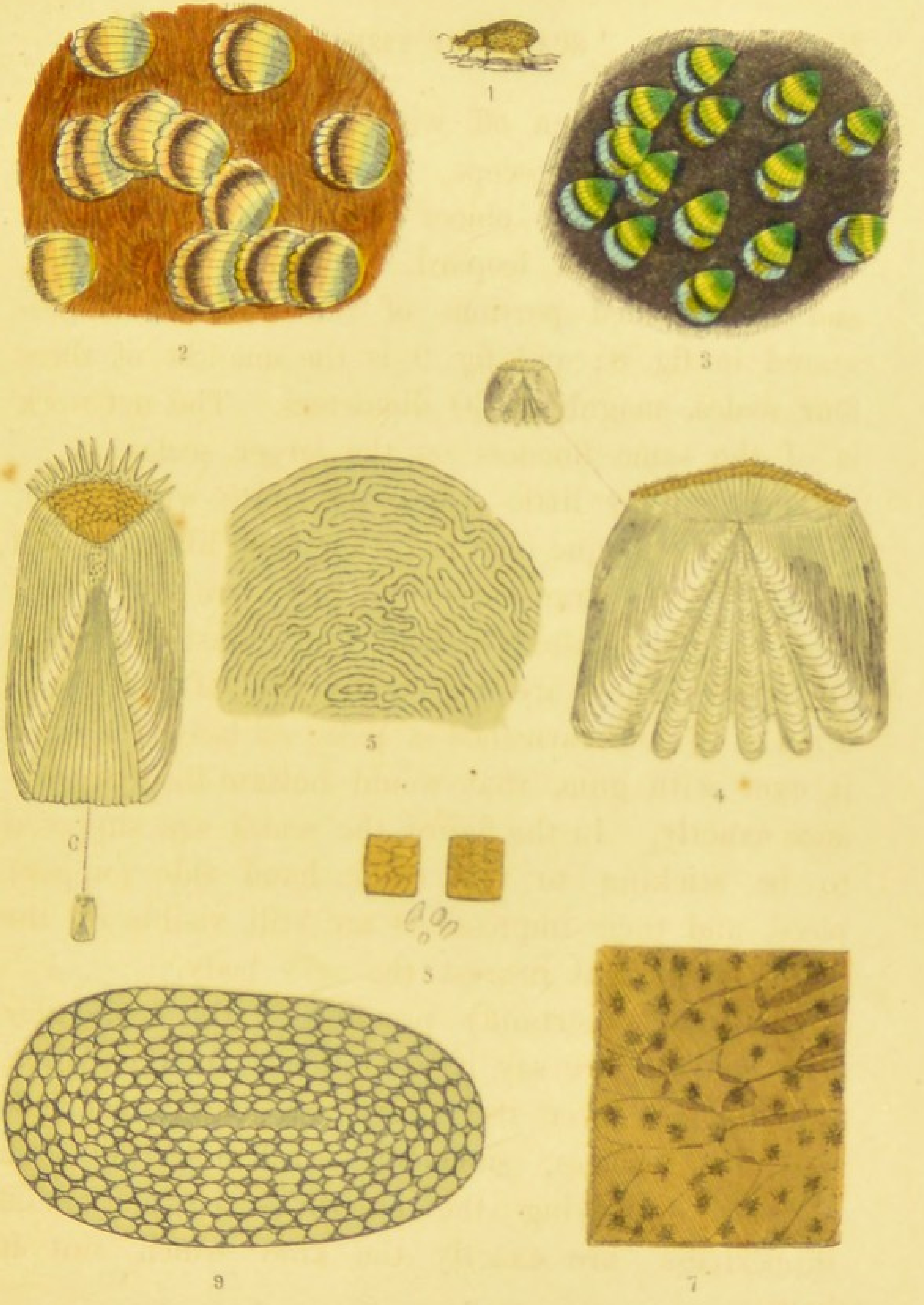
The scale of one of our fresh-water fish, the perch, is a pretty thing, even when seen without the microscope. When magnified four diameters (fig. 4) we can easily make out the graceful curving lines which cover it; these lines appear as if continuous, and parallel to each other. They are not quite so, however, in reality, and a sketch of them, when magnified 80 diameters, will best explain their appearance, (fig. 5.)

The scales of the sole, and of many other fish, are covered with similar lines. A sole's scale is represented in fig. 6. The lines on it are coarser than those in the perch's scale, except just in the centre, near the ray-like spikes, where there are some finer lines curiously arranged. These spikes are the part of the scale which are outside, and give its roughness to a sole's skin. The other end is the root of the scale, and is rather deeply sunk in the skin.

Eel's scales are concealed altogether. When I first began to prepare objects for the microscope, I read in some old book that these were worth looking at; so I procured a dry piece of eel-skin, but it was long before I could find what I was in search of. I scraped and scraped with a knife, and examined the scrapings with a microscope magnified 20 times —40 times—perhaps 100—but no scales appeared. I forget how I contrived to make them out at last. But if I take a little piece of eel-skin and view it as a transparent object, magnified about four diameters, the first thing I see is that the skin is covered with star-like spots, and next I observe *the scales* lying close together, (fig. 7.) And this is the way to get at them:—I take the little scrap of skin and tear it in two, exactly as if I were *splitting a card*, for the skin consists of two layers. I can then quite plainly see the scales sticking to the under surface of the spotted piece, that is, lying between the two layers. I can easily lift them off with a knife, and mount them for the microscope, while the skin makes another very pretty object for it, not unlike the spotted coat of a leopard. Four of the scales, and the divided portions of the skin, are represented in fig. 8; and fig. 9 is the smallest of these four scales, magnified 50 diameters. The net-work is of the same fineness on the larger scales.

These pretty little scales are quite white, and, viewed as "opaque objects," they look like beautiful lace. Viewed transparently, they are like *black* lace, or like white lace held up against the light. Of course, they are not really full of holes like a net. If you varnished a piece of lace or washed it over with gum, that would imitate their appearance exactly. In the figure the scales are supposed to be sticking to the right hand side (upper) piece, and their impressions are still visible on the lower layer, that nearest the eel's body.

The eel is certainly provided with a singular coat, and I dare say if we watched it when alive, and thought over its habits, we should conclude that these scales, sufficiently stiffening the skin without destroying the creature's elasticity and slipperiness, are exactly the kind which suit it best.



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.
5. Lines on Perch's scale, magnified 100 diameters. 6. Scale of Sole, magnified 9 diameters.
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.

Hairs of Animals.

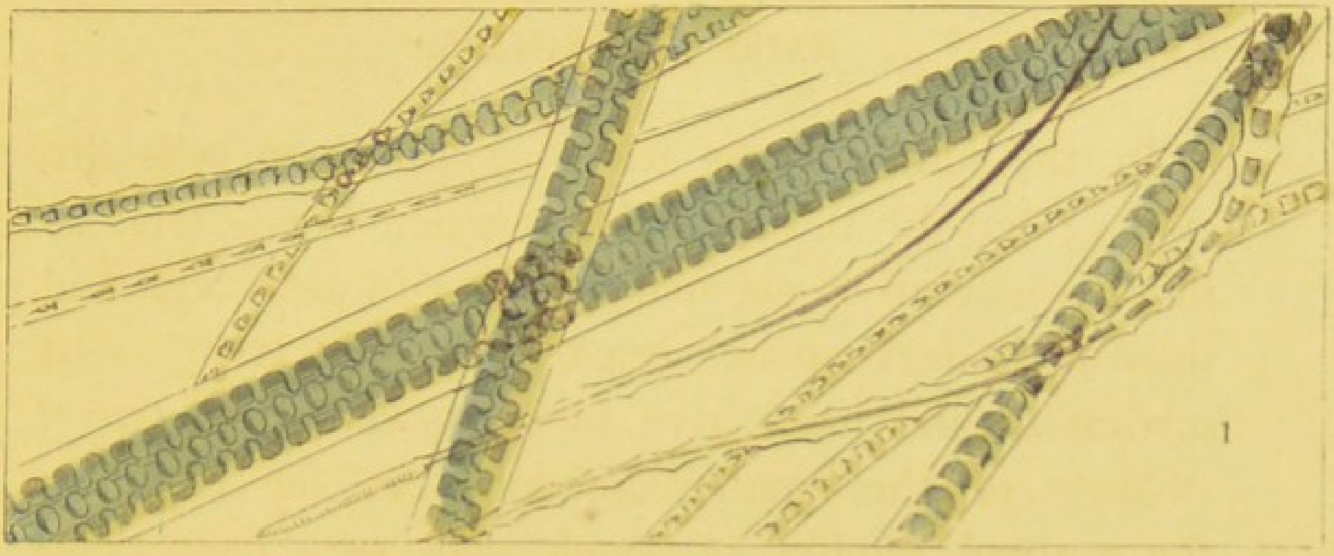
You must now hear something of the hairs of animals, or, rather, *look at* my representations of them, for I have not much to say on the subject. There is, indeed, much that is curious about the growth of hairs, springing like plants from their roots; but our present business is simply with their appearance as seen through the microscope. They require, in general, to be very highly magnified, and when they are seen to advantage observers cannot fail to admire their lovely transparency and curious regularity of construction.

Those who, for the first time, are shown one with very complicated structure, as, for instance, that of the white mouse (Plate VI., fig. 1,) are sure, after a brief survey, to look round appealingly for an explanation of what they have seen, the object is so unlike anything in their previous experience. It resembles a number of beautiful glass rods of various thickness, each containing a running pattern in its centre. These curious running patterns, resembling a sort of jointed chain in the larger hairs, and a simple row of beads in the smaller, are the internal cells of the hair, on which, in most of the smaller animals, their colour principally depends.

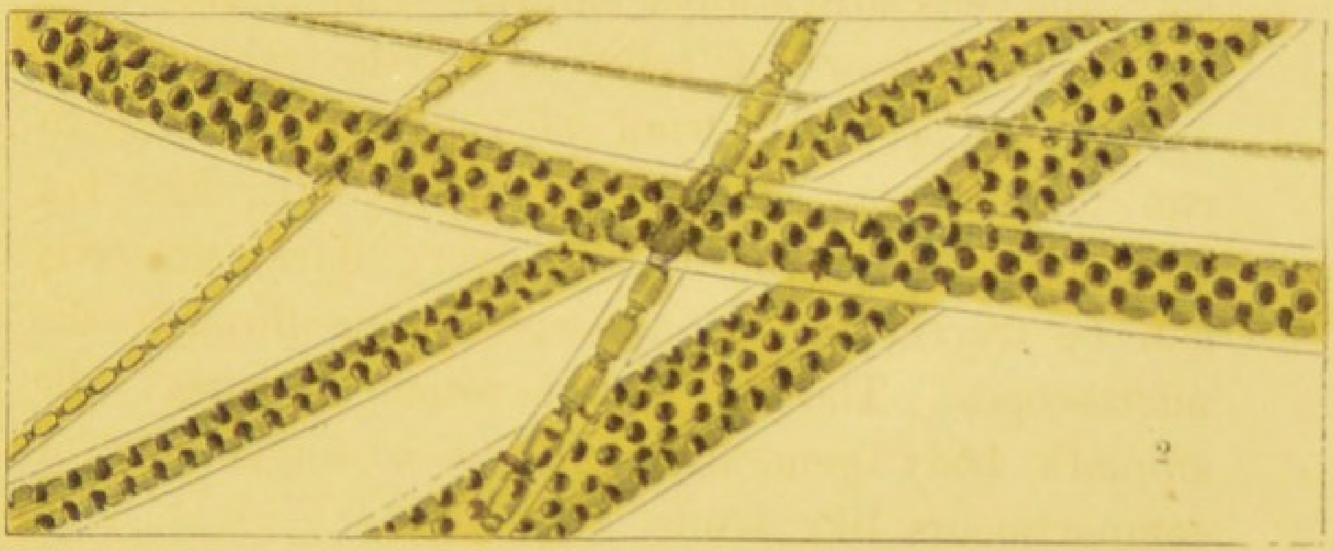
In the hairs of the white mouse these cells are empty; but in those of the common mouse (fig. 2) there is a scrap of colouring matter in each cell, and these little dark spots, seen through the transparent surface of the hair, give to it its dark colour.

Most of the smaller animals, as, for instance, the squirrel, rabbit, rat, mole, cat, etc., have these regularly placed cells in their hairs, and in white hairs the cells are always empty. The larger hairs have several rows of cells, as in the rabbit (fig. 3,) or else a broad band of cells all seeming to run together, as in the cat, (Plate VII., fig. 1.) Sometimes when the hair is very dark no cells can be traced, and it appears opaque through the microscope. The fine down which lies next the animal's body generally contains a single row of compartments like beads.

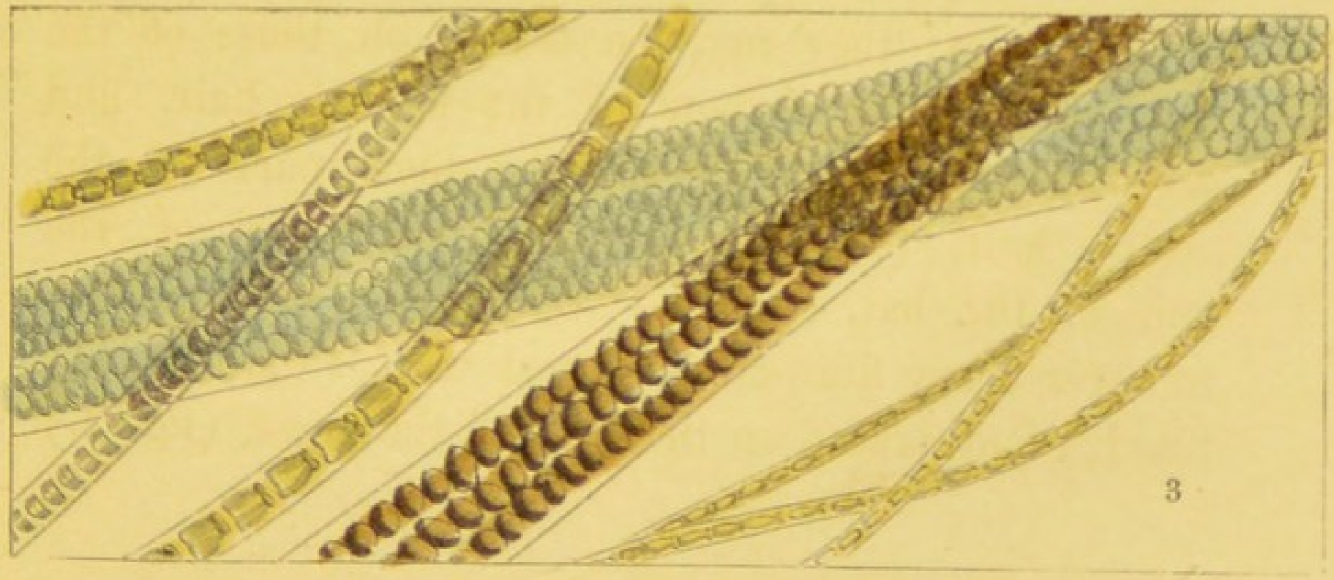
Besides these colour-cells in the interior, we may also observe curiously-arranged scales on the outside of the hairs; they may be traced on those of the cat, and near the roots of the mouse's hair, and are especially beautiful in the finer part of the otter's hair, (fig. 2,) and on every part of the hair of the bat, (fig. 3.) They may be seen, too, to cover every fibre of the finest wool, (Plate VIII., fig. 1,) and traced on the hair of the horse, (fig. 2.)



1. Hair of White Mouse.



2. Hair of Common Mouse.



3. Hair of Rabbit.

This latter specimen is an example of the formation usual in the hair of the larger animals. Human hair (fig. 3) is generally without any internal cell. Like many other kinds of hair, it is not perfectly cylindrical, but more or less flattened, so that portions of the very same hair will appear of different diameters, according to the position in which they are viewed. The hair of the deer differs considerably from any other kind which I have examined. Its internal cell occupies nearly the whole width of the hair, and is enclosed in a delicate net-work resembling gothic tracery (Plate IX., fig. 1.)

I will now leave the task of description to the illustrations themselves. The portions represented are very small indeed. The black mark placed within a little frame at fig. 2, Plate IX., shows the real length of the spaces included in each of the representations of hair.

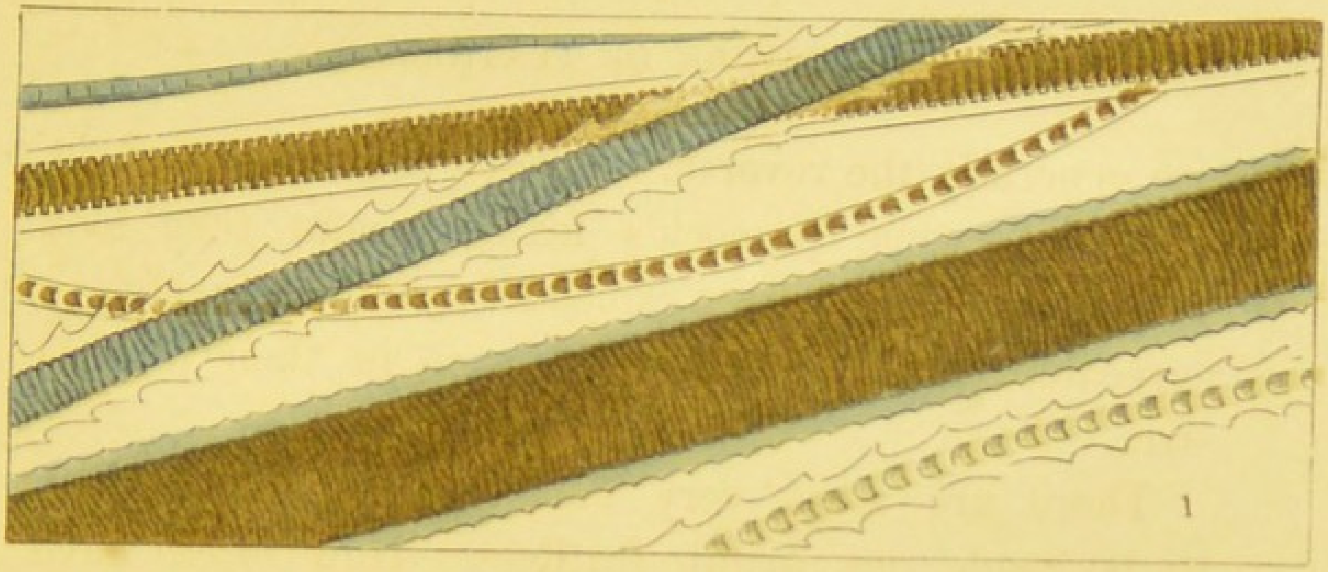
Fig. 3 represents a few of the hairs of insects.

Structure of Feathers.

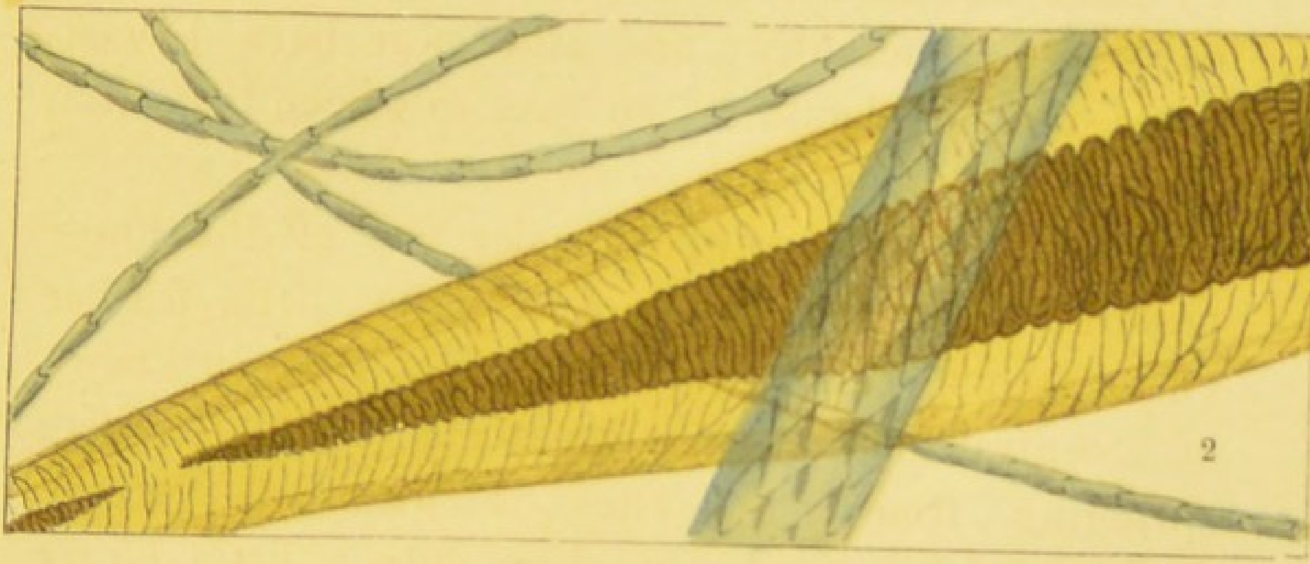
You might expect that the feathers of birds would be exceedingly pretty in the microscope. They are so; and yet scarcely so pleasing as they are without it. One reason of this is, that objects for the microscope are required to be very flat, and feathers are generally the reverse. I have been able, indeed, to flatten some peacock's feathers, and they look very large and very splendid; but scarcely so agreeable to the eye as when seen in their natural size.

There are *some* very curious things, however, to be made out about feathers. How often have I stroked the feathers of a quill (Plate X., fig. 1) back and forward, and wondered why its fibres parted so reluctantly; and still more have I wondered that it should be so easy to stroke them into their places again!

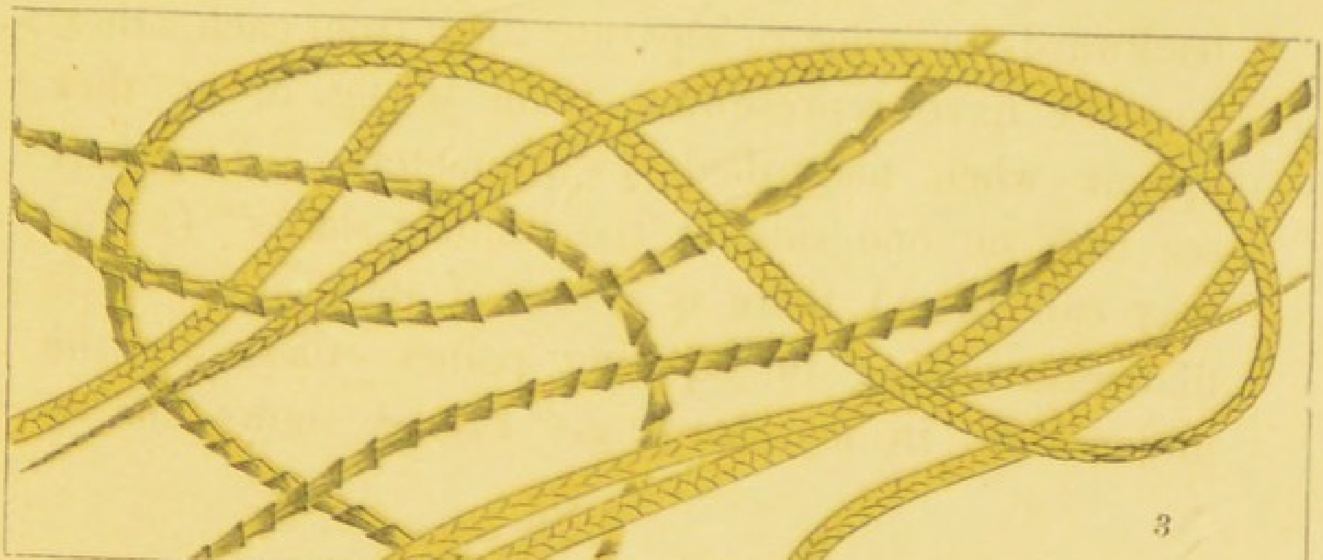
Now, I have arranged under one of the lower powers of the microscope a very flat little feather (fig. 2,) and I find that it consists (as you know) of a central shaft, with a great many small feathers springing from it. These I will call "minor feathers." I have drawn them only a little larger than the real size, and have rubbed them partly backwards in order to separate them from each other. Next I have represented them in fig. 3, as they appear when magnified 45 diameters. You may see that on one side of the "minor shafts" (as we may call them) there is a row of smooth flat little filaments ending in tapering points—these are the under rows in my drawing. Fig. 4 shows one of



1. Hair of Cat.



2. Hair of Otter.



3. Hair of Bat.

them greatly magnified. Except for the tapering point it is not unlike a blade of a knife in shape.

On the other side of each of the little shafts is a row of filaments, not ending in points, but in a series of hooks! (fig. 5.)

When the feather is smoothed down, and all the minute portions of it are in their places, it will be observed that the "minor shafts" are very close together, and the rows on each side of them overlap each other, (fig. 6.) In this way every filament ending in a series of hooks (as fig. 5) lies over three or four of the little *knife-shaped* filaments in the neighbouring row, and each of these latter is held in its place by several hooks, as shown in fig. 7. Thus they are not easily pulled asunder, and the last thing to yield is the tapering point, which the hooks pass with a jerk.

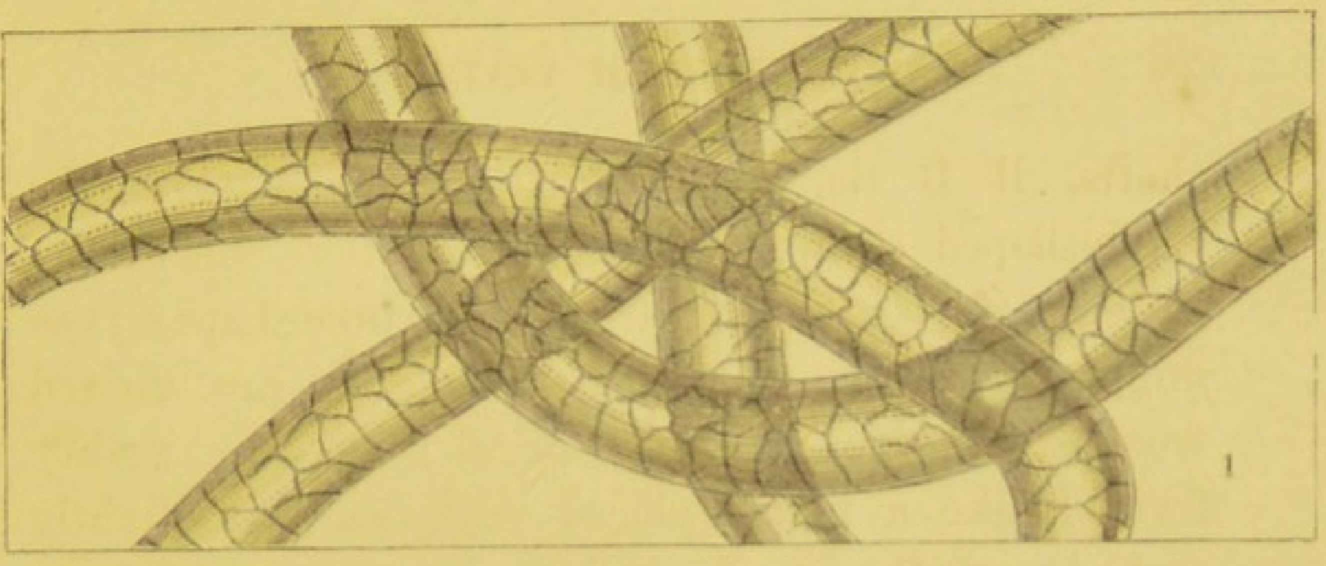
How are they joined again? Well, I must try to explain, though it would be easier to do so with a model than a drawing. I must make a *section* across the feather; that is, I must cut it with a pair of scissors in the direction S S (fig. 8.)

This is a section across what I have called the "minor shafts." Two of these, thus divided, and set edgewise, are shown in fig. 9. A A are the shafts, B B the hooked filaments, and C C the knife-shaped ones. It will be seen that the shafts, instead of being cylindrical (or tube-shaped,) as might have been supposed when they are viewed from above (as in figs. 3, 6,) are in reality formed like a plank placed edgewise and slightly arched, which is, I believe, a form of great strength.

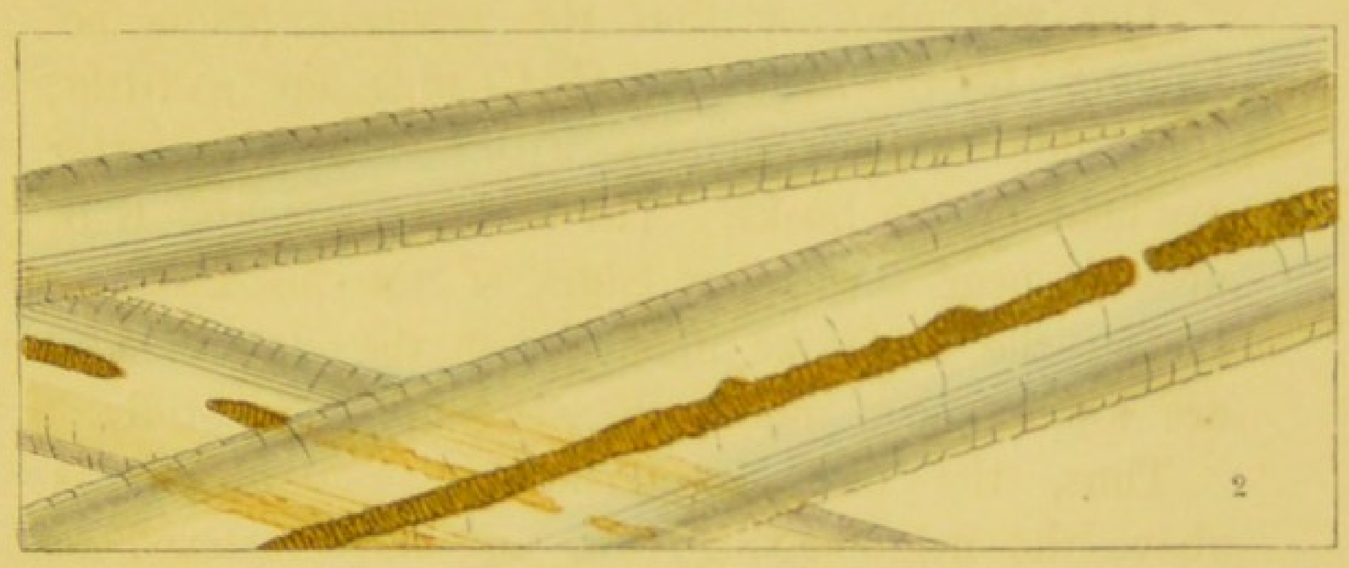
You will also see that the tapering points belonging to the filaments C C turn up a little; this adds to the firmness with which the latter are held by the hooks. The hooked filaments, B B, are set near the upper edges of the plank-shaped shafts; the knife-like filaments on the opposite sides are lower down, and both stand out very stiffly.

Thus, the natural position of these hooks is above the neighbouring row, and duly fastened to it. When we begin to smooth down the feather, the filaments cannot fail to clasp each other. They do it, like a released spring, in the act of straightening themselves, and when they have resumed their natural shape the feather has regained its beautifully level smoothness.

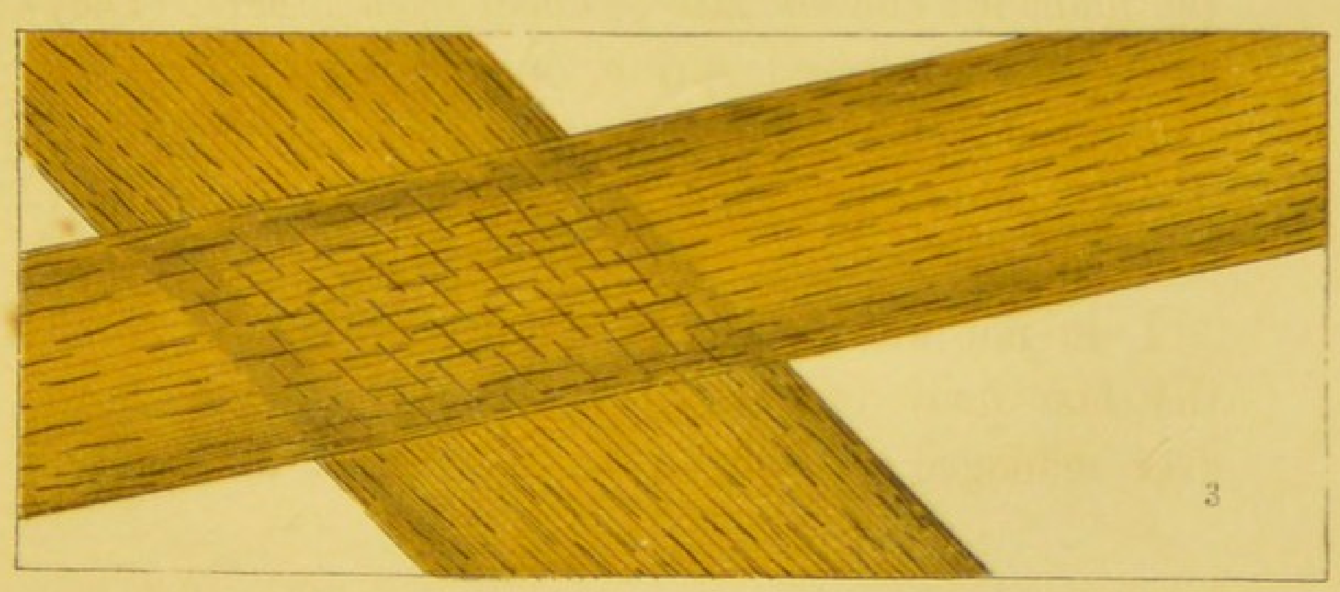
I do not know whether, in attempting to fasten the *last hook* of a rather loose dress, you have ever managed to unhook all the rest in an instant.



1. Wool.



2. Hair of Horse.



3. Human Hair.

The vexatious incident has occasionally happened to me, and I have wished it possible to *hook them all* as instantaneously.

Now, if instead of eyes one had a number of sloping bars (fig. 10) set on one edge of the dress, and a set of compound hooks on the other, and if the bars were of some springy material like whalebone, it would not be very unlike the arrangement observable on almost every feather of every bird. I should not, on the whole, recommend the plan as an ornamental fastening for ladies' dresses, but I think you will see that as the feathers are required to hook *themselves*, and as every part is at once perfectly strong and elastic, such a contrivance is admirably adapted to the end in view.

Down of Birds.

NEAR the quills of feathers—that is, next the body of the bird, there is generally some *down* placed there for warmth. This down is so fine and easily flattened that it forms a good object for the microscope. I will give three specimens, (Plate IX., figs. 4, 5, 6, 7.)

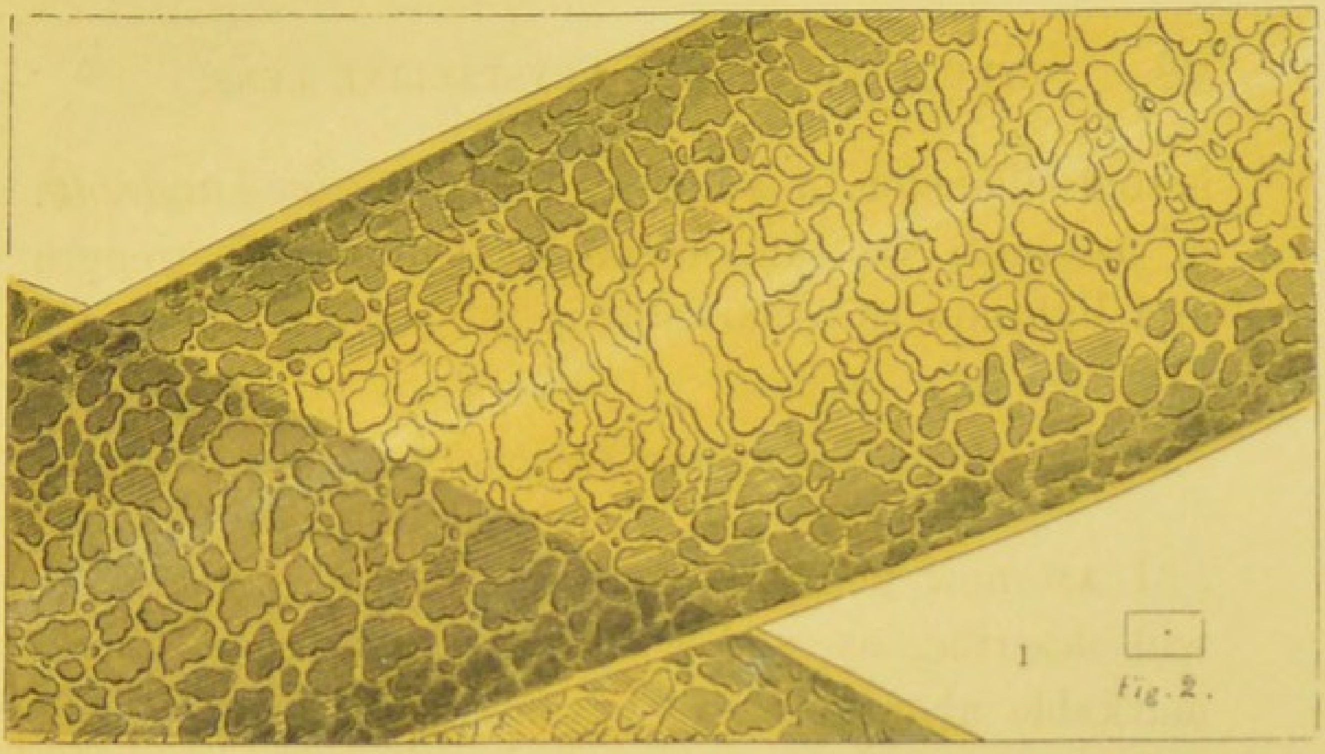
These are all magnified about 100 diameters. Fig. 5 represents one of the curious knots on the first of them—that of the duck. And even in this little thing, utterly invisible to the naked eye, and the actual diameter of which is only the *nine-hundredth of an inch*, we can observe that union of strength and lightness so remarkable in the structure of birds.

Structure of the Crystalline Lens.

I AM now going to quite a different subject. I will describe, as well as I can, what there is remarkable about the eye of a cod-fish, or any fish's eye you may choose to examine.

I believe most people in the early part of their lives, who have seen a large fish placed on the dinner-table as a head dish, have begged for *one of its eyes*—not the whole jelly-like mass, but the pretty white thing inside, the size and shape of a marble. The prize gained, they have peeled off the white brittle covering, and discovered the beautiful little transparent sphere within, (Plate XI., fig. 1.) And then they have found that they can go on peeling and peeling till it becomes almost too small to hold. Our present business is with this little sphere and its peelings. Before speaking further of them, however, I must first say something of eyes in general, even at the risk of carrying my letter to an unreasonable length.

The eyes of beasts, birds, reptiles, and fishes



1. Hair of Deer, magnified 200 diameters. 2. Natural size.

Bee. Cockchaffer. Small Water-beetle. Wasp.

3. Hairs of Insects, magnified 200 diameters.

4, 5. Down of Duck. 6. Peacock. 7. Wren. Each magnified 100 diameters.

are all formed on the same model. There are great differences in particulars, but the general plan in all is alike.

I dare say you have seen in books a diagram representing the section of an eye-ball, or the appearance it would have if cut in two, (fig. 2.) Some time ago a physician exhibited the mechanism of a cow's eye to a large party, of whom I was one. He told us all about the different coats of the eye, and showed us the "crystalline lens" and the retina, on which the image of everything we see is received.

After hearing this lecture, you may be sure I soon found out how to examine eyes for myself; I believe an *otter's* was the first on which I experimented. It was just like that of the sheep or cow, the space A (fig. 2) full of a perfectly transparent and rather liquid jelly—the "vitreous humour," and suspended in this, not in its centre, but near the front of the eye, was the crystalline lens B, firm and beautifully clear and bright, and very like one of the glasses in the microscope, (fig. 3.) This little lens is a very important part of the eye.

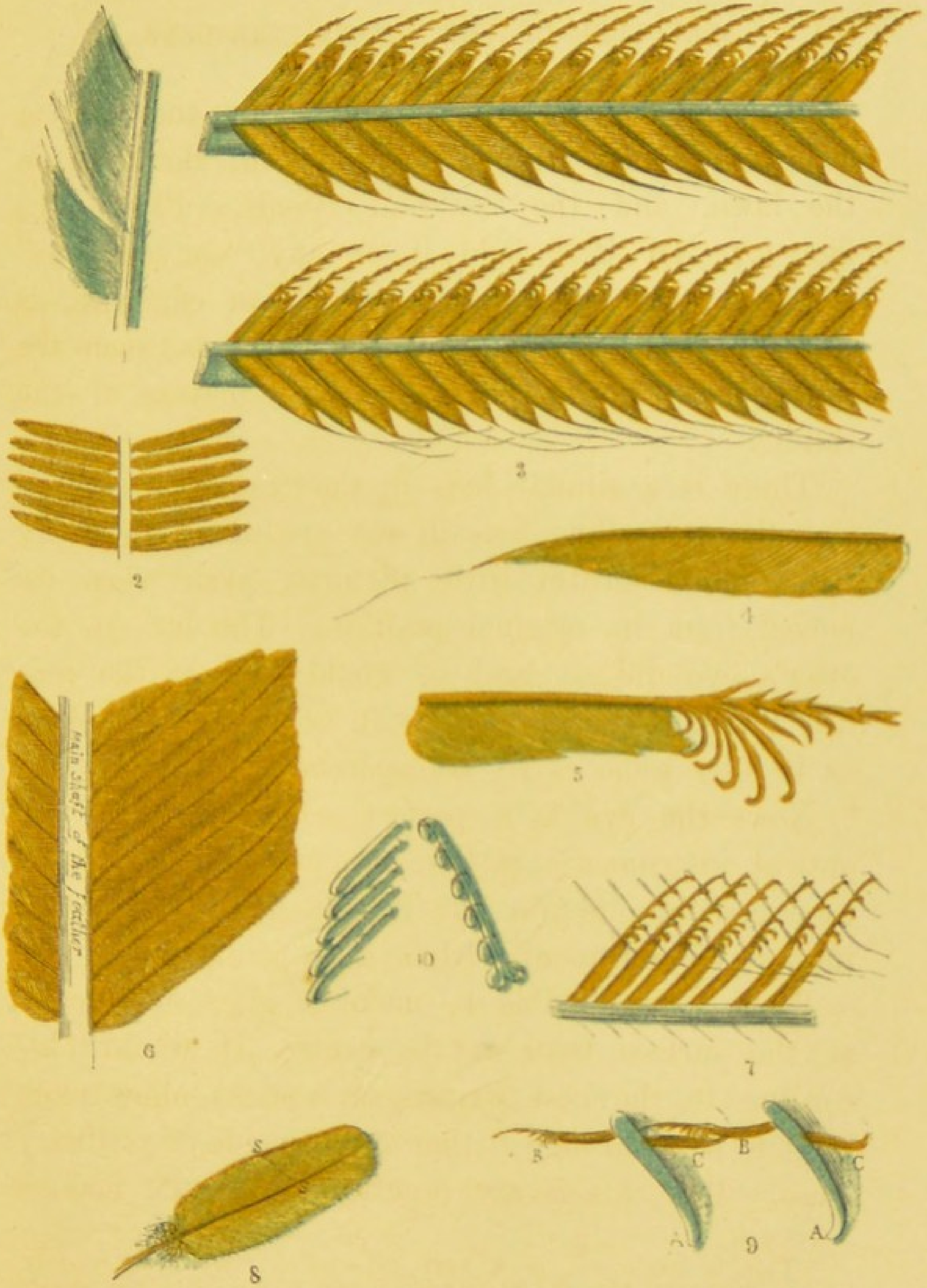
In page 10 of this letter I told you of the thick glass C (Plate III., fig. 1,) which is used for giving light to opaque objects. If I set this glass at a particular distance from the wall opposite the drawing-room window, I shall see on the wall a beautiful little picture of the window, the trees on the lawn, and the sky and clouds, (Plate XI., fig. 4.) Or if I hold it or any "convex lens" (that is, any glass which, when seen edgewise, is of either shape represented in fig. 5) between the candle and the wall, I shall see a picture of the candle.

There is a similar lens in the "camera obscura," and the crystalline lens in the eye also forms very clear and beautiful little pictures, even when removed from its original position. The lens in the otter's eye did so, and so would that of the cod-fish if we were to examine it before it is cooked, as it loses some of its transparency by boiling.

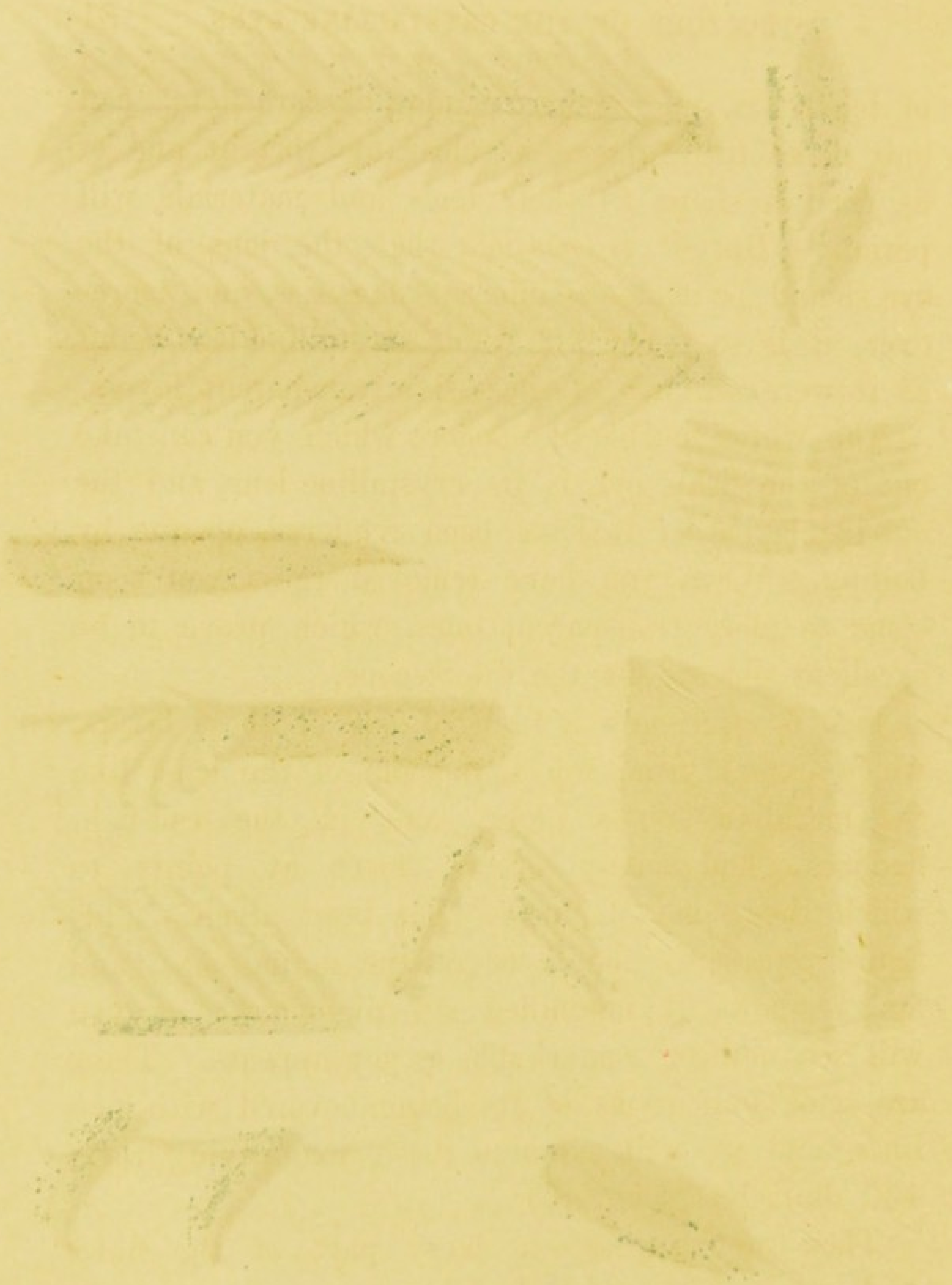
Now, the eye is a perfect and beautiful little optical instrument; it has, in fact, been compared to a camera obscura, but it is a *great deal better* than any instrument with a glass lens.*

If it were possible to make a glass lens softer at the surface than at the centre, it would (according to the best writers on optics) allow more light to pass through it than a lens made of ordinary glass. But this is *not* practicable; so the makers

*This is explained in a very interesting way in a modern edition of Paley's Natural Theology, in the Appendix, vol. 4, p. 96.



1. Feather of a quill. 2. Part of feather, with minor feathers separated, magnified 4 diameters.
3. Two minor feathers, magnified 45 diameters.
4. Knife-shaped filament, magnified 150 diameters. 5. Series of hooks, magnified 150 diameters.
6. Part of feather, with minor feathers smoothed down, magnified 15 diameters.
7. Diagram to shew the crossing of the filaments. 9. Section through two of the minor shafts.
10. Imaginary bars and hooks.



of telescopes, microscopes, camera obscuras, etc., can only make their glasses as clear and bright and of as good a shape as their tools and materials will permit. But *it is possible* that the lens of the eye should be made of different densities, and, moreover, it is so made, the whole crystalline lens being as it were *built up* of successive transparent layers.

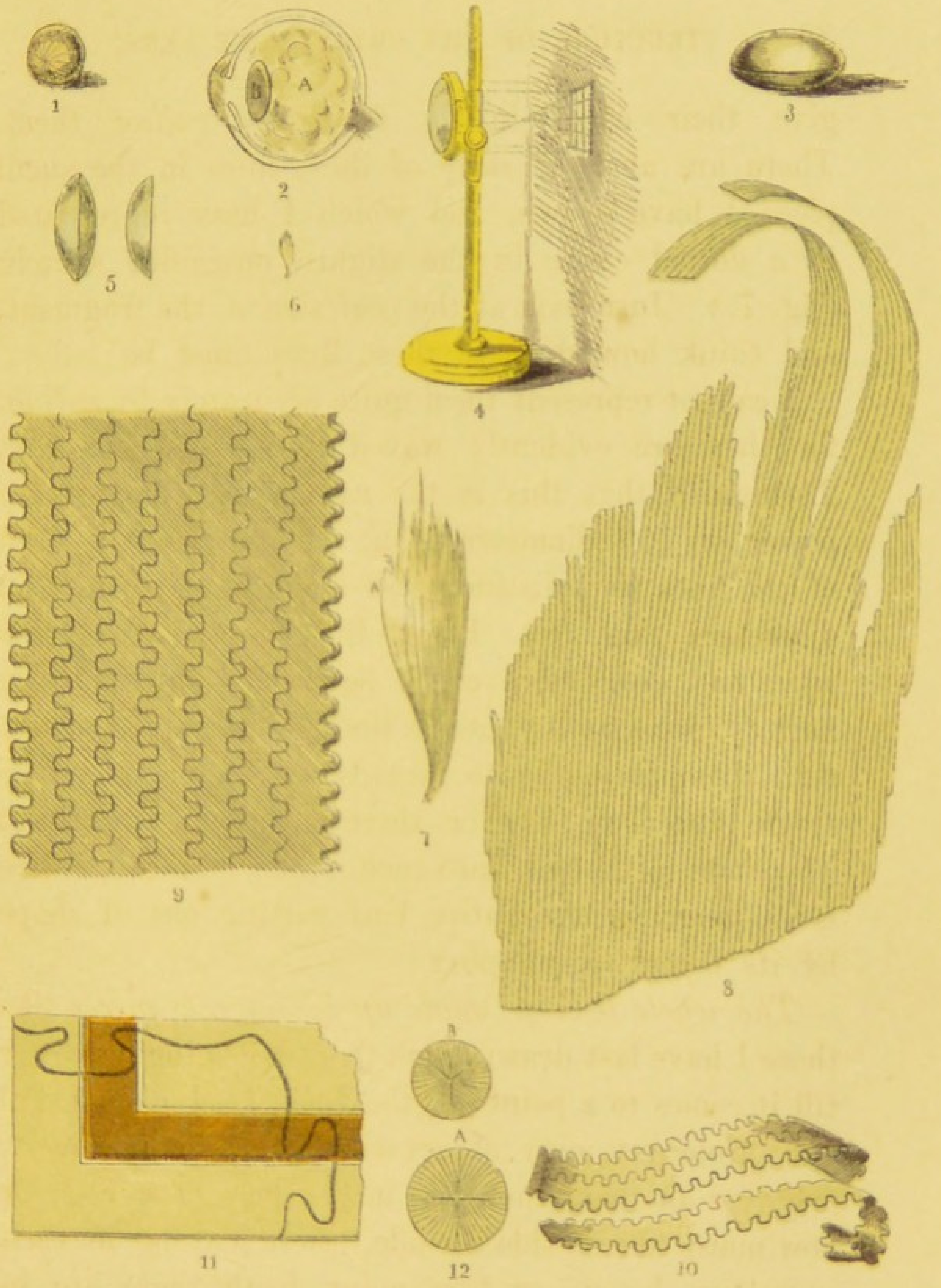
The white marble-like sphere which you can take out of the fish's eye is its crystalline lens, and the outside layers of it have been rendered opaque by boiling. When you have removed these you soon come to more transparent ones, which prove to be excellent objects for the microscope.

Fig. 6 represents a fibre of one of these layers, which extend from top to bottom of the lens, like the meridians on a globe, and in the cod-fish, haddock, and many others, meet at points to which the name of "poles" has been given. This figure represents the layer of the actual size, and fig. 7 shows it magnified six diameters; as you will see, nothing remarkable as yet appears. There are some indications of its being covered with fine lines, and we will examine these, magnifying them 130 diameters, (fig. 8.)

They now appear on every part of the fibre, and are so beautifully regular that I can only give their effect in the figure by *ruling* them. There are at least *sixty* of these lines in the small piece I have drawn, and which I have represented by a dotted curve in the slightly magnified sketch, (fig. 7.) Just look at the *real* size of the fragment, and think how delicate these lines must be!

I cannot represent them quite accurately by *ruling*, for they are evidently waved lines. We can just distinguish that this is the case with a magnifying power of 100 diameters; but we see the real form of the lines very distinctly on magnifying them 670 diameters, (fig. 9.) Every line is toothed in this way, and every fibre could be divided into as many narrow pieces as it contains lines. I have frequently torn them into minute threads, which proved to be single fibres, or two or three together, (fig. 10.) The little teeth lock into each other, and thus there is no danger of the entire lens getting out of shape by its layers overlapping.

The whole lens is made up of narrow pieces like those I have last drawn, each piece becoming narrower till it comes to a point at the "pole." I cannot tell you, from my own observation, how many layers, one over another, there are in the lens of a cod; or how many fibres, side by side, there may be in each successive layer; or how many teeth there are in



1. Lens of Codfish. 2. Section of the Eye.
3. Lens of Otter. 4. Condensing Lens of the Microscope. 5. Lenses (of glass) viewed edgewise.
6. Thin fibre from Codfish's Lens; natural size. 7. Thin fibre, magnified 6 diameters.
8. Small portion of the fibre, magnified 130 diameters.
9. Portion of the fibre, magnified 670 diameters. 12. Crystalline Lenses.

one fibre from pole to pole. But all these things have been calculated by others, and the result is amazing.

In the small piece I have selected there are more than 200 fibres side by side. Look again at fig. 6. Think of 200 delicate lines in this little fragment! and think of all the teeth locking so accurately into each other. It is, indeed, a wonderful specimen of "Nature's watches."

To give a rough idea as to the comparative thickness and breadth of the single fibres, I should say that they bear about the same proportion to each other that the thickness of the wood on which an ordinary "dissected map" is mounted does to the breadth of a piece two inches across. I mention a dissected map, because the kind of joint (fig. 11) with which we fasten the outside portions of one of these maps always reminds me of the teeth in a fish's eye. I dare say your little Louisa has a dissected map among her possessions. If she had a globe with all the meridians cut in teeth and separated (like the rind of a melon when you have removed the soft part,) I think it would make rather a good game to put them into their proper places; and it would certainly make a large model, which, with the exceptions of there being nothing to represent all the successive layers, and the meridians not being easily made sufficiently narrow and numerous, would be somewhat like the structure of a cod's eye.

These teeth appear more or less distinctly in the lenses of all beasts, birds, and reptiles, and of man. There are scarcely any exceptions. They are most easily seen in those of fishes, being strongly developed in them; besides, the lenses of fishes are harder and more manageable than those of other classes of animals.

The lenses of different animals differ considerably in shape, some, as in the cod-fish, being spherical, while others are flattened. The fibres do not in all cases converge to *poles;* in the salmon, for instance, the hare, and many other creatures, they terminate (as I have read) in straight lines (fig. 12 A) on each side of the lens. In others they converge to a Y-shaped line (fig. 12 B;) in others to crossed lines, etc. But I must not wander from the immediate province of my letter, which is to tell you *what I have seen myself* with this microscope.

There is a small water-insect called "Daphnia," which has a most curious eye; I say "eye" purposely, for apparently it has but *one.* This eye cannot, I believe, be preserved, but it is very easily examined without even hurting the animal. I hope to tell you about it in another letter.

Compound Eyes of Insects, etc.

I HAVE, however, a few specimens of the eyes of *insects* properly so called—such as the dragon-fly, cricket, etc., as well as those of the shrimp, lobster, and crab. These eyes all resemble each other in being composed of a very great number of minute *lenses* joined into a single group, each one of these lenses being (according to the best naturalists) "a distinct organ of vision." The lenses are arranged side by side in a form that allows of their being close together without loss of room.

If they were in circles (Plate XII., fig. 1) a great deal of space would be wasted, and so there would be also were they eight-sided, (fig. 2.) But they are usually formed with *six* sides, just the same shape as the cells in a honeycomb, so that no room whatever is lost.

Fig. 3 represents the head of the larger dragon-fly—a strong, remarkable-looking insect which appears here in June and July. Those large light-coloured masses are its two eyes, or, rather, its twenty-four thousand! for naturalists have counted twelve thousand in each mass.

There is a separate little nerve for each of these lenses; this cannot easily be preserved, but the lenses themselves can be cleaned and prepared in such a way that they will keep their shape. Fig. 4 (*a*) represents a small piece taken from a dragon-fly's eye thus prepared; it contains 290 lenses.

It may sound like a difficult thing to count so great a number; but they are arranged with such extreme regularity that their amount is readily calculated. It is almost as easy as to find out the quantity of stitches in a piece of worsted-work, where you have nothing more to do than to reckon those in the height of the piece—say 110, and in the breadth—say 230—and then multiplying these together you get the whole number of stitches, 25,300, to a certainty.

Now you shall see this little collection of lenses as it appears when magnified 36 diameters (fig. 4 *b.*) Is it not a curious-looking thing? It is like a piece of lace; and there is another thing which it also much resembles—the wire-netting that is often put round garden plots to keep out rabbits, just like gigantic lace with holes about the size of half-crowns, (fig. 5.) Now, if we were to provide ourselves with several dozens of round spectacle-glasses, and set one in each of these holes, and hold the piece of wire-netting at a certain distance from a wall, we should see on the wall several dozens of pictures of whatever there was behind the lenses.

Well, I have a contrivance, by means of which I can see something very like this, with an insect's eye. I have a darkened room with a hole in the window-shutter into which a microscope can be fitted, and when the sun shines through this hole the shadow of whatever object I put into the microscope is thrown on a white screen held up to receive it. And when I put in a scrap of the dragon-fly's eye I see in every compartment of its shadow a brilliant point of light, which is a little picture of the sun!

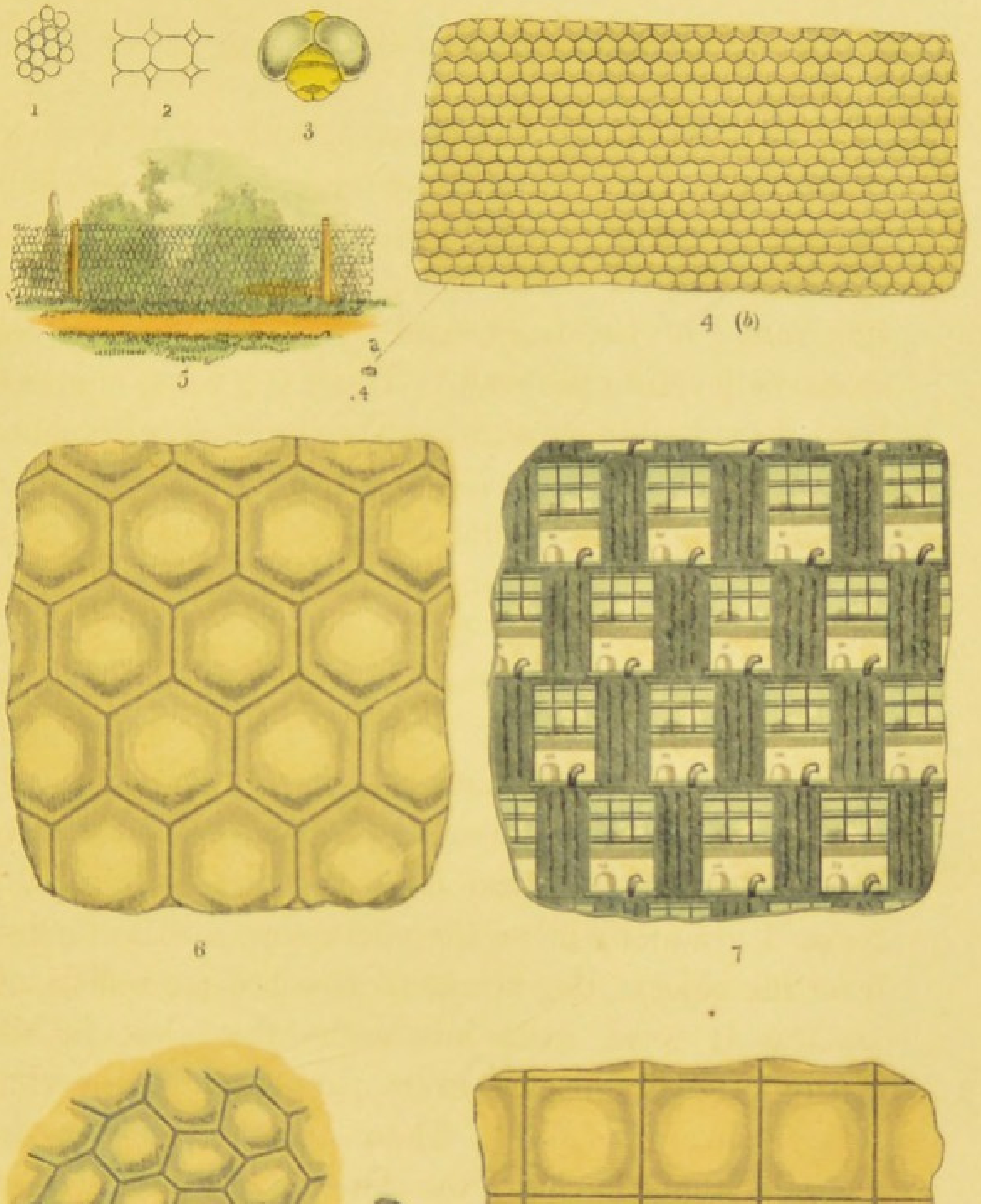
This proves them to be lenses; and it can be shown in another way. If we had a piece of wire-netting with spectacle-glasses mounted in its holes, and we held it between our eyes and a window, we should see a great number of little windows, and whatever view appeared through them, just as many as our machine contained of spectacle-glasses. If we held our eyes too close to it we could see the net-work well enough, but the view through it would be hazy. By removing our eyes farther off we should see the little pictures quite clearly.

We can imitate all this with a scrap of dragon-fly's eye; the piece I select contains about fourteen lenses.

I am sitting in a room by myself opposite a window, though at some distance from it. The window is thrown up nearly as high as it will go, and there is an old arm-chair standing close to it at the left-hand side. Through the window I can see a range of offices with a slated roof; there is an archway in this range of buildings, and over it an old carved stone is let into the wall. There is a large elm tree beyond the buildings, and I can see its leafless branches over the roof, standing out against the sky. I have the microscope on the table before me. I told you that it has a joint to enable it to lean back; and now I have it leaning back as much as if it were a telescope, and facing the window, and I am looking through it at the scrap of dragon-fly's eye, with a magnifying power of 250 diameters.

First, I screw the microscope very close to it, that I may see the beautiful hexagons clearly, (fig. 6.) Next, I gradually move the microscope a little farther from the object; the hexagons now become indistinct, and, as it were, melt into each other, but in the centre of each appears every particular of the view I have just described! There are the sashes of the window, the arm-chair, the slated roof, the archway, the carved stone, and the distant tree! (fig. 7.)

I have examined this object a very great many times, and have shown it to a number of people; yet I always view it with new wonder.



3. Head of Dragon-fly. 4. (*b*) Piece of Dragon-fly's eye, containing 290 lenses; magd. 35 diams.
6. Piece of Dragon-fly's eye, magnified 250 diameters.
7. The same, with view seen through each lens. 8. Part of Cricket's eye, magd. 250 diams.
9. Part of Lobster's eye, magd. 250 diams. 10. Eye-stalk of Crab or Lobster.

The reason why the dragon-fly (as well as other insects) has so great a number of eyes is this:—Its eyes are not capable of turning round, as ours are, but being supplied with this prodigious number, the greater portion of its head being studded over with them, it suffers no inconvenience from having them fixed and immoveable, as it is thus enabled to see at once in almost all directions.

It is believed (from an examination of the interior structure of these "compound eyes") that in looking at an object, an insect can only see clearly the point exactly opposite to the centre of each lens. "The image on the retina may be compared to a *mosaic* composed of a great number of small images, each of them representing a portion of the object seen. The entire picture is, of course, more perfect in proportion as the pieces are smaller and more numerous."*

There is a great difference in the number of lenses in the eyes of different insects. It is calculated that the ant has 50 lenses, the house-fly 4000, while as many as 34,650 have been counted by the naturalist Geoffroy in the eyes of a butterfly. The eyes of the majority of insects bear a great resemblance to those of the dragon-fly, being composed of six-sided figures, (hexagons.)

* Agassiz and Gould's Comparative Physiology, p. 70.

These hexagons, however, are not always so regular in shape as in the eye of the dragon-fly. This will appear by a sketch of part of the cricket's eye, (fig. 8.) The irregularity appears most near the edge of the eye, where it takes a sudden bend, and where a set of *regular* hexagons could not probably pack together. Some of the lenses have only *five*, or even *four* sides.

Crabs' eyes are composed of hexagons; those of lobsters and shrimps of squares. Fig. 9 shows a very small piece of a lobster's eye, magnified in the same proportion as that of the dragon-fly in fig. 6, viz., 250 diameters.

This eye forms little pictures of the window, etc., as beautifully as one with hexagonal lenses. I have observed that it requires the microscope to be removed a great way off (comparatively speaking) before it will show the pictures distinctly; that is (as opticians would express it,) *its focus is much longer* than that of an insect's eye. I should mention that the eyes of lobsters, crabs, etc., are mounted on a sort of stalk (fig. 10,) so that they are rather more moveable than those of insects. They are, however, smaller in proportion to the size of the creature's whole body than those of insects usually are.

Feet of Insects.

I MUST leave a great many curious objects without the mention of more than their names, for were I to describe them at length my letter might become tedious. So I pass over some which I have prepared myself, some which I have seen or heard of, and, no doubt, there are numerous admired microscopic objects which I have neither seen or heard of; and, again, a very great number of wonderful structures which no one has yet thought of examining, though the microscope is used very perseveringly in these days, and few scientific investigations can be pursued without it.

I had very little idea that my beetle *with the comb* (Plate II., fig. 5) had ever been heard of before I found it; but not long after I first examined this tiny insect, in choosing some microscopic objects at an optician's, I found one of the curious feathery wings duly prepared, and labelled "the wing of Trichopteryx Atomaria." I do not know whether its *comb* has ever been detected; possibly not, as the little wing-case at the base of which it is placed is a good deal arched, and it was by accidentally tilting up this wing-case that I discovered the "comb."

Among the most curious objects for the microscope, which comprise remarkable parts of insects and other living creatures, and which I have not already described, are the stings of wasps and bees, the horns of moths, etc., the beautiful spiral tongues of butterflies and other insects, the lancets of the gnat, the skins of caterpillars, the proboscis of the fly; in short, as an excellent book on the microscope says, "there is scarcely a part of the body of an insect that does not exhibit some remarkable structure." Many shells and their inhabitants are also interesting objects for the microscope.

In larger animals most curious preparations have been made of thin slices of their horns, hoofs, bones, and hair. I mean that a way has been contrived for making sections of hairs, that their real shape may be ascertained.

You may be sure that the vegetable world has supplied numerous and beautiful objects for the microscope. I have too few of these, but my letter would be incomplete without a short description of them. I will tell you about them presently, but will first finish my account of the *animal world* with three very curious feet—those of the spider, fly, and "boat-fly."

The last joint of the spider's foot generally terminates in two or three hooks or claws, with comb-like teeth, as you may see in Plate XIII., fig. 1. Fig. 2

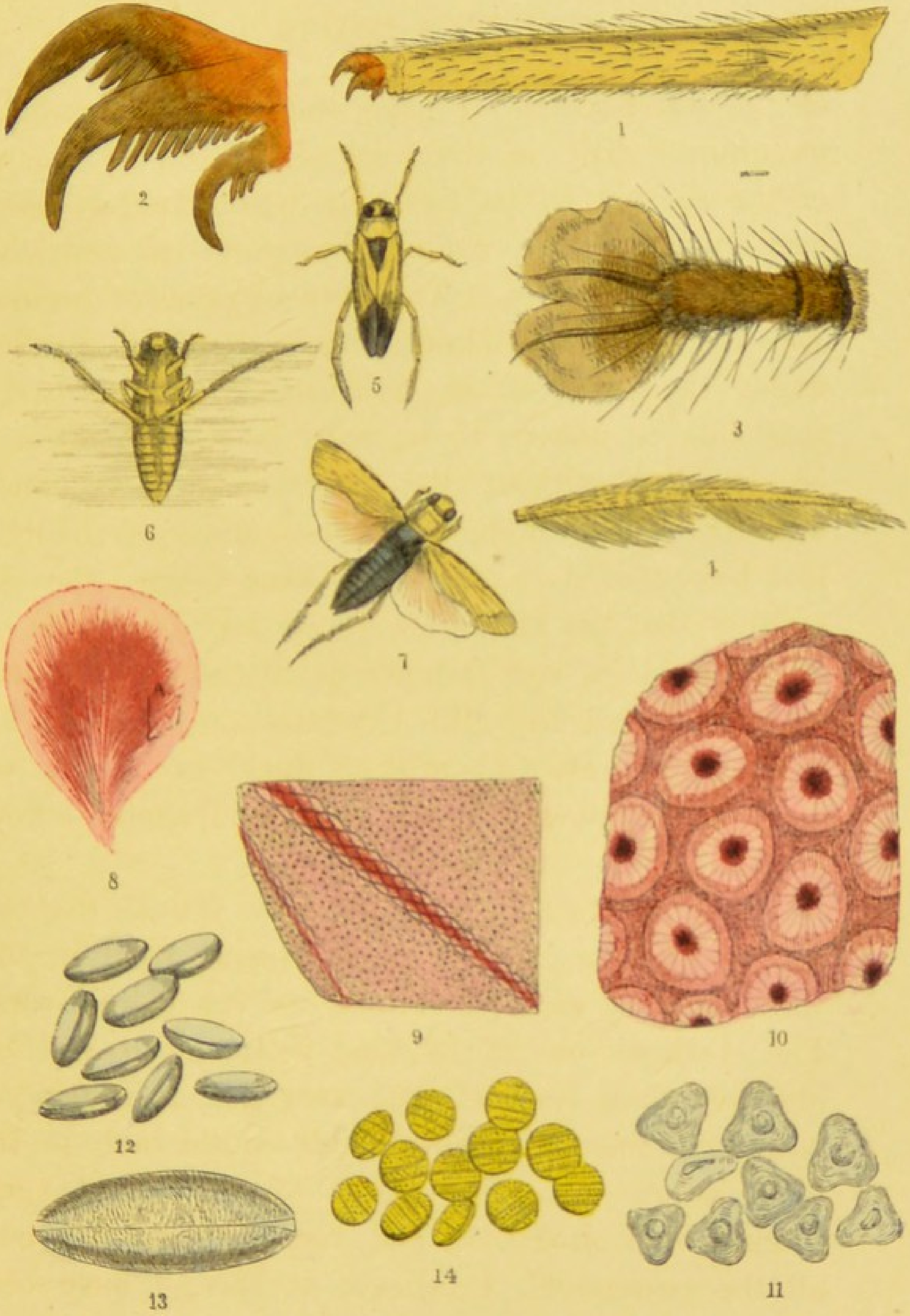
represents them on a larger scale—they are shown as "transparent objects," and for this reason you can see part of the far claw through the centre one. These teeth enable the spider to lay hold of its web and glide along it without danger of slipping. They answer the same purpose as the rough nails which are put on horses' shoes in frosty weather.

What a different foot is the fly's! (fig. 3.) I dare say you have seen representations of it in books, and may have read some rather different accounts of its nature.

Naturalists have always wished to explain how flies can walk up a window or even upside down on the ceiling of a room; and there is no doubt that the curious flat appendages at the last joint of the foot enable them to do so. These appendages appear to be of the quality of parchment, and air-tight, and almost all books on natural history tell us that they are *suckers;* that the air presses on them, and that no air can get under them, as a vacuum is formed beneath by the raising of their central parts.

There appears much to be said in support of this theory, and the *sucker* is an instrument by no means unknown in nature. The feet of a lizard —called the Gecko—are supplied with a contrivance of the kind, and this is also the case with some of the water-beetles; I have seen one of them hold on quite tightly to the edge of a basin by means of the suckers on its feet. It would appear, however, that the fly cannot "support its position" *entirely* in this way. An acute observer of nature, Mr. Blackwell, at Manchester, noticed that flies under the glass of an exhausted air-pump were still able to adhere to it, and, in fact, could not be detached without the employment of a small degree of force. Renewed investigations of the fly's foot have tended to revive, in some degree, the old opinion that the two discs at its last joint emit a sticky fluid in very minute quantities; and it has been suggested that the extreme care which a fly takes to dry its feet after a ducking in milk or water, is to allow this glutinous fluid again to flow freely.

The *third* foot I have to show you is that of the *boat-fly*, so called from its rowing itself in the water with a pair of feet much resembling oars. Fig. 4 shows one of its hind feet, and it will be observed that, besides being very flat, it is fringed with long fine hair, which adds considerably to its force as an oar. The insect (fig. 5) is a very singular one altogether, and very common in ponds all the year round, I believe; at least, I have seen



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, magd. 100 diams. 12 Pollen of Crown-imperial, magd. 100 diams.
13. Grain of the above. magd. 300 diams. 14. Pollen of Salvia patens, magd. 100 diams.

it in January composedly rowing about *under the ice.* It is very amusing to watch its movements even without the microscope. When it comes to the surface of the water, its natural position is floating on its back with its oars stretched out, (fig. 6.) It has large eyes with a *great many lenses*, and on the approach of an enemy it quickly plunges under the water with a few strokes of its oars. I have, however, contrived to catch it in my hand, and it has defended itself with a sort of beak which it possesses, and with which it can inflict a *very* sharp prick. This gave me an additional respect for the boat-fly! This insect does not move easily on dry land, but I believe it *flies* very well (fig. 7,) its wings being folded up under wing-cases which are both broad and thin. The wings are extremely beautiful and delicate, even more so than *those of the earwig.* And now (without at first intending it) I have come back to the very subject (and object) with which I began my letter.

But I have reached the end of my list of living things, and must now tell you what I have observed in *flowers and plants.*

Petals of Flowers.

I AM sorry that I have but few specimens of this, which to many persons would be the *most* interesting class of objects, and the beauty of which cannot fail to give me great pleasure, though I understand very little about them.

The petals of flowers are sometimes exquisitely beautiful when viewed as "opaque objects"—wonderfully glossy and covered with little hills and hollows. The same objects viewed transparently often present quite a different appearance.

A small piece of the petal of a geranium (fig. 8 A) which, when viewed without the microscope, appears of a beautiful shaded pink colour, may be seen when magnified to look like a delicate red net-work on a white ground. In fig. 9 I have given its general effect when magnified eight diameters, but fig. 10 shows an extremely small portion of it —such a piece as might be enclosed as in a frame *in the eye of the finest needle*—as seen through one of the higher powers of the microscope. The points in the centres of the interstices are of a very deep rich red; the rays proceeding from these points are of a lighter tint, and so also are the lines of the net-work. It is a very beautiful object.*

* It should be observed that the drawing (Plate XIII., fig. 10) was made from a dried specimen, in which the lines of the net-work are more sharply marked, and the different shades of red appear more detached from each other than in the fresh petal.

Besides the petals of flowers, there are many other parts which I have examined, but without retaining specimens. The kind of little purple tuft in the centre of the spider-wort looks like numerous strings of amethysts of oval shape—that in the centre of the scarlet verbena like a tiara of pearls.

Pollen of Flowers.

The seeds of plants are also various and wonderful; and the *pollen*, that fine powder which is to be seen on the anthers of full-blown flowers, has long been known as an excellent object for the microscope.

In the few specimens which I have examined, I have observed a great variety of forms. The pollen of "Clarkia Pulchella" looks, when highly magnified, like an immense heap of glass rings, of three-cornered form, (fig. 11.) That of the crown imperial is more like grains of wheat. Fig. 12 represents some of this, and fig. 13 shows some of the grains, magnified 300 diameters; and it is wonderful to observe that their surfaces are covered with a delicate pattern, *just perceptible* with this high magnifying power!

The pollen of "Salvia Patens" is flat and round, (fig. 14.) Shall I mention a ridiculously far-fetched comparison which always occurs to my mind in looking at it? The disc of the planet Jupiter, with its belts stretching across! only *here* there are scores of bright golden Jupiters on the deep blue ground of the lovely flower on which they are often scattered.

Besides these objects, which can be viewed with very little preparation, there are several very interesting ones not so easily procured; such as sections of stalks, roots, and various kinds of wood. I have a few of these; they look like some delicate needlework, having rays diverging from a centre.

Seed-vessels of Ferns.

THE plants which I have examined most carefully are *ferns*. My book says, in giving the names of a few, the minute seeds of which are curious objects for the microscope, "The list might well include the whole of the fern tribe, as all are more or less beautiful."

Almost all ferns have their seed-vessels on the backs of the leaves, or "fronds," as they are sometimes called. These seed-vessels are exceedingly small—smaller, indeed, than the *seeds* of most plants—and they are arranged in a great variety of ways in the different kinds of fern; but in very

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 Maiden-hair 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.

nearly all ferns they are globular, contain a number of extremely minute seeds, and grow from the back of the fern-leaf on a curiously-jointed stalk, and this stalk runs up one side of the seed-vessel, and bends round it like a ring.

This ring is elastic, and so long as the seeds are unripe and the seed-vessel soft and green it maintains its bent shape, and acts as a band round the seed-vessel. But when the latter becomes stiff, and the seeds ripe, the elastic ring suddenly straightens itself with a great jerk, tears the seed-vessel open, and scatters the tiny seeds in all directions! Plate XIV., fig. 1, represents one of the seed-vessels of a fern, called the Black Maidenhair Spleenwort; and fig. 2 a similar seed-vessel with the ring in the act of straightening itself.

Very often in autumn I have brought a number of fern-leaves into the house to examine while fresh with the microscope; and as the heat of the room hastened their drying, the rings soon began to straighten themselves, the seed-vessels to tear, and the seed to scatter about. I have shown it to friends, and been asked, "*What are those live things?*"

Fig. 3 shows you part of the leaf, of the size of the original; the slit-like marks are the groups of seed-vessels. In fig. 4 one of these groups of seed-vessels and part of another are shown magnified 12 diameters. From this you may gain some idea of the animation of the scene.

Each group of seed-vessels in the tribe of spleenwort ferns is protected on one side by a "cover," as it is called, shaped somewhat like one half of a pea-pod. Another fern, called Hart's-Tongue, a strong, large, showy plant, somewhat resembling dock, has two covers, one on each side of the group, (fig. 5.) The Common Polypody fern has no covers at all; its seed-vessels stand up in round groups, very like heaps of oranges, their colour being bright yellow. We can generally observe a few of those seed-vessels lying open like little boxes. They are some which have burst and scattered their seed.

The "Shield-fern," common in dry ditches, has its "cover" constructed not unlike a little umbrella standing up in the centre of each group of seed-vessels. Fig. 6 represents a leaflet the size of nature, and fig. 7 one of the groups of seed-vessels, magnified.

There is a very great diversity in the shape of these "covers." A beautiful book might be made of representations of these alone, in all known ferns, native and foreign.

The common Brake fern has its seed-vessels curiously concealed round the edges of the leaves—

the margins of which turn down over them. Another little native fern—the Scaly Spleenwort, has its whole stalk as well as the backs of its leaves covered with scales resembling bits of lace; and the seed-vessels lie thickly between them, like ribbons in the border of a cap!

One foreign fern I must show you; it is the Hare's Foot. Its groups of seed-vessels are on the tips of the leaflets; the covers are somewhat like little pockets, and, when filled with seed-vessels, resemble baskets of flowers. Are they not beautiful, graceful little things? (fig. 9.)

It will have occurred to you that there must be a very great number of seeds on the leaves of ferns. This is the case; and in the Hart's-Tongue fern, which has remarkably small seeds and seed-vessels, the amount is quite prodigious. Each leaf bears on an average 80 collections of seed-vessels, containing from 3000 to 6000—that is, on an average containing 4500 seed-vessels in one collection, making 360,000 on the whole leaf. And these vessels each contain about 50 seeds. So that a single leaf of Hart's-Tongue fern carries no less than eighteen millions of seeds!

Mineral Productions.

I HAVE left one class of microscopic objects still unnoticed; I mean the numerous *mineral* productions which require minute examination. Of these there are several, and perhaps among the most curious are those which help to explain the nature of the world's extinct productions. The structure of different fossil woods has been clearly made out by examining thin sections of them with the microscope, and comparing these with slices cut from modern trees. Petrified animalculæ abound in chalk, and are also found in flint and in other rocks; and with the help of the microscope, the curious fact has appeared, that *all limestone* is composed of the remains of minute shells and animalculæ. Not merely that limestone contains petrified shells, larger than snails and cockles, the stone itself is one mass of extremely minute animal remains.

Not long ago I saw an experienced geologist take a little fragment of marble or very black limestone, and after grinding it thin he mounted it with cement on a piece of glass, and then held it again to the grinding-stone till it became so very thin as to be a pale grey and partly transparent. Fig. 10 shows a small portion of this specimen from a drawing which I made at the time. The space included is only about one-twelfth of an inch in diameter.

Conclusion.

AND now, my dear Emily, shall we not lift up our hearts in humble gratitude to Him who has crowned all creation with His goodness, and manifested His glory alike in things great and small?

As a friend remarked, we who live in these days, and look through microscopes, can add very much to the list of things which were named to Job as instances of the power of God.

The microscope enables us to *consider* the lilies of the field, and to *consider* the ravens, with additional understanding of God's care of them; and the telescope enables us to "*consider* the heavens, the work of His fingers," with additional wonder that He should be mindful of man.

The *telescope* and *microscope* teach us different things; but *both taken together* give us truly vast ideas of the Creator's omnipotence.

We have examined with the microscope but a few things, and those few but slightly. What wonderful productions should we see if we thoroughly examined all the creatures of one country, or of the whole world! But the telescope shows us many planets like our own, and possibly *all* the abodes of life—of life thus various and wonderfully organized. It shows the twinkling stars to be like ours, and *they*, probably, not shining in vain, but giving light and heat to the inhabitants of an untold number of planets.

When I think of these things, I feel as the Queen of Sheba did when she realized the glory and the wisdom of Solomon—"There was no more spirit in her"—for the idea is almost overpowering. It is like seeing a faint glimpse of the meaning of "*Infinite Power.*"

How thankful should we be that one so great has been pleased to declare himself unto us by His Son, and to teach us in His revealed word those things that we could not otherwise have known.

I have enjoyed writing this account of the wonders of the microscope to you, who so truly value His blessed word; for those who know and love His word best, can study His works with the most safety and profit.

Ever yours,

M. W.

THE END.

NOTE ON MAGNIFYING POWER.

THE calculations as to the degree in which the various objects are magnified are stated in this little work by "so many *diameters*." Thus an object measuring one-third of an inch in breadth, would, if represented *one inch* across, be described as "magnified three diameters."

Its representation would, however, take up *nine* times the space occupied by the real object, being three times the height as well as three times the breadth. This latter statement of magnifying power is called the "superficial measure," that is measure of the surface, and is frequently employed in popular works on the microscope.

The measure by diameters is called the "linear measure," and at first sight conveys the idea of a much lower magnifying power than it in reality indicates. Thus, the piece of dragon-fly's eye in plate XII. is said to be magnified 250 diameters; this measure, as stated by the other rule, would be the *square* of 250, and the object would be said to be magnified sixty-two thousand five hundred times; that being a true statement of the relative sizes of the object and its pictured representation, but now always discarded in scientific works from its inconvenient length, and from a difficulty the mind naturally experiences in comparing such immense numbers.

A table of both measures is subjoined, by which the superficial measure will be found, corresponding to each linear measure used in this little book.

Linear Measure.	Superficial Measure.
3	9
4	16
5	25
6	36
7	49
9	81
10	100
12	144
15	225
20	400
30	900
36	1,296
45	2,025
50	2,500
60	3,600
80	6,400
100	10,000
130	16,900
150	22,500
200	40,000
250	62,500
300	90,000
420	176,400
670	448,900
900	810,000

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