Pirouzé and Khaleda, in the other Zobeide and Badoura: two on the east side and two on the west. Each respects the other; for although Pirouzé and Khaleda are strong females, and could each wring the neck of my dear Badoura, Zobeide is stronger than both of them put together, and protects her. Thus the opposing elements are, as it were, neutralized: the combatants respect one another, and I am the head of a united house. I got letters from all of my four wives this morning, each of them most characteristic and interesting: Badoura forgot to pay the postage—she has a soul above pecuniary details—and her letter was the dearest of all."

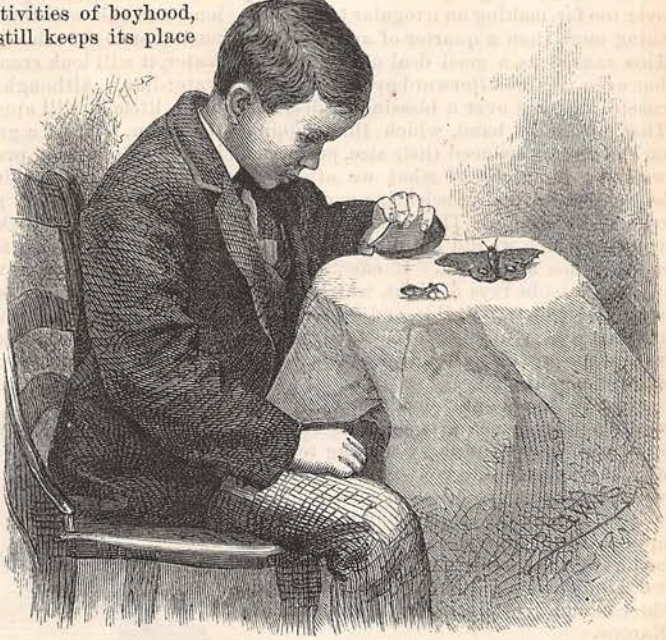
"Don't cry, Simpson," said I—"don't cry, old fellow. The steamer goes on Tuesday, and then you will see all your wives again. They will welcome you with outstretched arms—eight outstretched arms, like the octopus." I confess I was affected by my friend's artless narration, at that time, though, since I have reflected upon the matter, my moral sense has once more asserted itself, and is outraged. I state the matter as fairly as I can. I have been to picnics myself, as a married man, and made myself agreeable to the ladies. Well, in Persia this might have cost me my life, or the expense of a second establishment. So far, there is every excuse for Simpson. But, on the other hand, the astounding fact remains that there are four Mrs. Simpsons at Bussora. Whenever I look at his quiet, business-like face, or hear him talking to my wife and the girls about Persian scenery, this revelation of his strikes me anew with wonder. Of course I have not told *them* about his domestic relations; it would be too great a shock to their respective systems; yet the possession of such a secret all to myself is too hard to bear, and I have, therefore, laid it before the public. The whole thing resolves itself into a rule-of-three sum. If even a quiet, respectable fellow like Simpson, residing at Bussora, has *four* wives, how many wives—well, I don't mean exactly *that;* but how much queerer things must people do who are not so quiet and respectable as Simpson, and who live still further off?

THE MICROSCOPE.

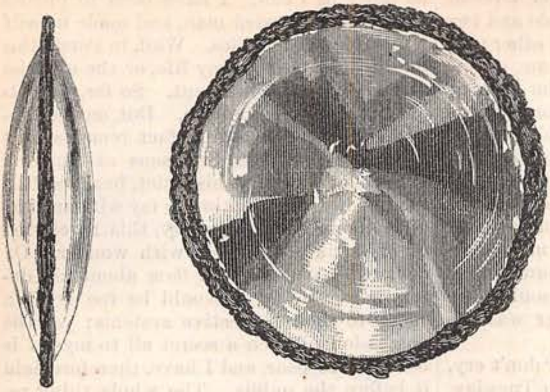
By Professor Samuel Lockwood.

I.—ITS ORIGIN.

Of the mental activities of boyhood, one especially still keeps its place in memory. It was a certain aspiration, more evinced than acknowledged, to grow up into a philosopher. Comporting with this was a lively juvenile inquisitiveness concerning experiments. We had read of the great Sir Isaac Newton, who blew soap-bubbles in the interests of science, and we came to feel an awful reverence for the earliest analyst of light. It is even yet remembered what a strain was put upon our boyish thinking at sight of a magnifying-glass. It was a crude affair, composed merely of two watch crystals set edge to edge, and filled with clean water. The thing was in itself so simple, and yet it gave results that seemed to us mysterious. To our question, so often put, *why* it did so, the one unvarying answer was sure to come, "Because it magnifies." "Yes, I know that.



THE YOUNG MICROSCOPIST.



OUR FIRST MICROSCOPE.

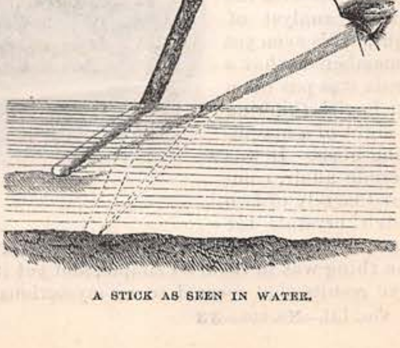
But *how* does it magnify?" "Oh, you are too inquisitive!" And so this little optical experiment too long remained a mystery. However, ignorance was not allowed to become a bar to the bliss of enjoyment. We determined to have a magnifier of our own. Having obtained from the jeweler a pair of old bull's-eye watch crystals, and a lump of shoe-maker's wax from the cobbler, the two glasses were set together, and secured at the edges by a band of wax. To be sure, the job was a bungling one, for, do the best we could, the unsightly dark wax would lap over too far, making an irregular band something more than a quarter of an inch wide. This caused us a good deal of annoyance; but even this, as afterward appeared, was a case of fretting over a blessing in disguise. That unsightly band, which thus lapping on the glasses reduced their size, performed well the functions of what we afterward learned was called in scientific parlance an optical diaphragm. Thus it afforded an advantage which we did not understand until a long time afterward. It effectually cut off the outside rays of light, which are always the most refrangible, and even in magnifying-glasses of high excellence are not without a provoking tendency to beget indistinctness of image.

Such was our first magnifier. It was really a microscope in its simplest and perhaps most ancient form. Speaking technically, it was a double convex lens. As the word lens occurs so often in microscopy, it will be in order to say that it had its first application in this sense to certain spherical bodies of glass made for optical uses. The word indicates a resemblance to the seed of the common lentil, the *Ervum lens*, eaten in Europe.

It is amusing now to look back on the time when the boy played the *rôle* of the young philosopher. Verily there was some pride over that magnifier, as he showed its power on a butterfly, or its effect on the scale of a gold-fish. And surely that was an allowable pleasure which was enjoyed at the surprise of the rustic admirers when a gnat was made to look as large as a flesh-fly. Though not conscious of the fact, there was a smack of the pride of science. And that was a peculiar sensation when, for the first time, we read in English an extract from the philosopher Seneca to the effect that "writing, even if very small and obscure, becomes larger and clearer when looked at through a small glass globe filled with water." Somehow this seemed to make our home-made magnifier loom up into the high respectability of a scientific antique; in fact, it seemed to establish a relationship to an antiquity of not less than two thousand years.

Still that old mystery kept confronting us, How did the thing magnify? And in this wise the mist began to break:

Though the "weakly boy" was never much at athletic games, there was one sport in which he excelled his playmates. It was in throwing stones at objects under the water. And the boy had a theory in the case, which was often expounded to his companions, and this was the drift thereof: If you push a straight stick slantingwise into the water, it will look crooked, or broken at the water-line. Although the stick may slant but a little, it will appear, as to the part in the water, to slant a great deal. The meaning of this is that practically we see that part of the stick which is in the air just where it is, but the part which is in the water is really seen where it is not. And it is precisely so with a fish in the water. To the beholder it seems to be farther off than it actually is, and also nearer the surface of the water than it really is; so that a stone aimed where the fish seems to be will strike in advance of its object, because the actual



A STICK AS SEEN IN WATER.

fact in the case is, we are not aiming at the fish at all, but simply at its image; and hitting the image would be no more hitting the fish than would striking a man's shadow be striking the man himself.

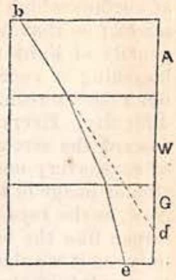
It is not averred that such was the preciseness of the boy's method, only that such was its logic. Generally these boyish lectures were accepted as demonstrations. But on one occasion particularly these dialectics were wofully dashed by a discharge of casuistry of the *reductio ad absurdum* sort, which possessed in a high degree the merit of that ancient method, in that its own absurdity made it positively unanswerable. Our neighbor Donald had listened with such respectful attention that we supposed he was all along assenting to all we said. But the following logic struck us dumb:

"That's all very fine, my lad—very fine! But it's contrary to common-sense, seeing it's against one's own senses, and *therefore* against all sound reason. You tell me that I look where the fish is, and it isn't there; but if I look where it isn't, why, then, that's just where it is! Now all that is impossible; and *therefore* it's a farlacy, my lad—a farlacy. Moreover, it's against sound logic. Seeing is believing; and that's what your Maker intended; *therefore*, to say contrarywise is to deny the faith, my lad, and to contend against the truth."

In order to apprehend the fact that an image of an object may be seen entirely distinct and separate from the object itself, let such as have not already done so try the following for themselves. Place a nickel cent at the bottom of a bowl; after looking, so as to be sure where the coin is, withdraw gently backward until the coin is lost to view, being concealed by one side of the vessel; while you are keeping your eyes steadily fixed in that position, let some one pour water slowly into the bowl. The image of the coin immediately appears forward of the real coin, and higher up in the water.

THE COIN IN THE BOWL.

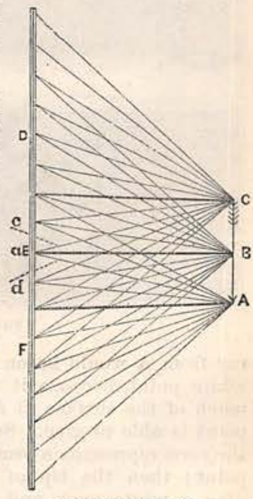
Donald's logic only caused us a temporary uneasiness. In due time Ferguson's *Optics* fell in our way, which, despite its formidable mathematics and geometry, all dark to us as Egypt, came like a revelation. We then learned with delight that the fish phenomenon gave the key to unlock the mystery of the magnifier. It proved that rays of light, when passing from one medium into or through another medium of different density, have the quality of being bent, or refracted. Look at the little diagram of a ray of light passing through different media. Let A, W, and G respectively represent air, water, and glass, three media of different density, and hence of different refrangibility, or capacity to bend the rays of light. The air is the least refractive medium of the three, the water is more so, and the glass is the most. Hence the ray of light, *b*, is differently refracted as it passes through these several media, being the most bent as it passes through the glass, which it leaves at *e*; whereas, were it not refracted in its passage, it would, after entering at *b*, leave at *d*; that is, it would pass through in a straight line.



A RAY OF LIGHT PASSING THROUGH DIFFERENT MEDIA.

Let us now take up the question, How does a lens magnify?

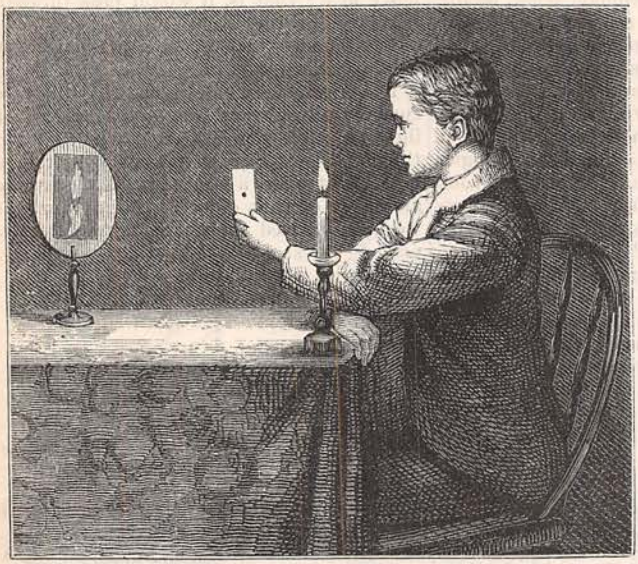
Doubtless every one knows that in these considerations every image is the result of light reflected from some real object. Why, then, does not light, when thrown from a real object upon a screen, in all cases give an image of that object? To answer this we have devised the little diagram of dispersed or scattered light. Suppose the long upright line to represent a screen upon which light is reflected by the arrow. From every surface point on that side of the arrow which is presented toward the screen are shed little bundles of rays, called pencils of light, which spread out into cones of light. The letters A, B, C are meant to indicate three reflecting points on the arrow, namely, one at the middle and one at each extremity. From each of these points is projected a pencil or cone of light of the same size and form, and containing the same number of rays. Of necessity these rays cross and intercross one another; hence they give no image on the screen, but simply a circular spot or blur of light. Now it is not merely from the points marked A, B, C on the surface of the arrow that light is reflected on the screen, but from every conceivable point



DISPERSED LIGHT.

of surface which the arrow presents to the screen; so that from points beyond number pencils of light are projected, each pencil becoming a cone whose base is received upon the screen. Here, then, is the real difficulty. Every surface point of the arrow toward the screen reflects a large number of rays, every one of which gives a reflection or image of that point upon the screen. Now, as the rays from this point fall on the screen like the base of a cone, if we could only see it we should behold this single surface point of the arrow represented in an image infinitely small, and that image repeated by the tip of every ray which entered into the cone of light whose base was on the screen and whose apex was at the point of reflection from the arrow. Suppose the color of the barb of the arrow to be white; then the reflected point represented by a ray from A would be on the screen a tiny white point, because it represents just so much of the surface at A as the reflecting point is able to give. Suppose, again, that the cone represents a brush dipped in white paint; then the tip of every hair would give a white spot, and every white spot would exactly represent the reflected spot; but the combined white spots would give a circular dab actually representing nothing. And this is done from every point of reflection along the arrow, since every point of reflection sheds a pencil of light, and this pencil diverges into a cone of rays whose base falls upon the screen. Hence, as respects the shape of the reflected object, there is no delineation, for the result is a confused circular blur of light.

But the above is a confusion of form. The same result will follow as to color. Please look again at the little diagram. If you will trace the course of the rays from their reflecting points, you will observe that many of them have the same points of impingement. By looking at these points on the screen it will be noticed that the rays strike these spots in triplets; for instance, a ray from A and one from B and another from C all meet at the one precise point on the screen. Now if the color of the arrow-head be white, and of the shaft yellow, and of the feather red, then at the point marked D on the screen an outer ray from the pencil A would deposit the tiniest tip of its proper pigment; at the same spot a tip of paint of another color comes from B; again, at the same place, a spot of color differing from both is brought from C; and thus for the places E and F; and so on for any spot on the screen within the circle of light. Thus, in fact, the screen receives a dab of color from the entire brush or pencil A, and another in like manner from the brush or pencil B, and in the same way another from the pencil C. And so the colors become indistinguishable.



THE PERFORATED CARD.

How, then, can we obtain an image of an object by reflected light rays? By cutting off all unnecessary rays, or even pencils of rays, that leave each reflecting point of the object. The thing that is to be accomplished is to get on the screen just so many representative rays as there are reflecting points of surface on the object whose image is desired. Let us take a common visiting-card and pierce it with a large pin, making a clean smooth hole in the centre of the card. We will now hold the perforated card between a candle and a screen. The result is a true image of the candle on the screen. To understand how this is done let us make a diagram of the card. Let A, B, C represent so many points on the side of the candle toward the screen. From A are thrown a number of rays, just as at A in the figure of dispersed light. But the little hole in the card plays the part of a strict utili-

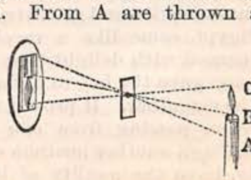
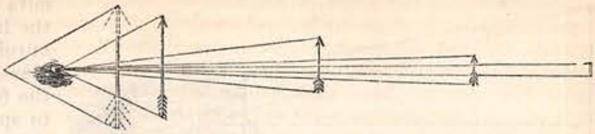


DIAGRAM OF PERFORATED CARD.

tarian, and, as if on principle, rigorously refuses admittance to every irrelevant or superfluous ray, as, for instance, from the point A only a tiny representative ray is admitted. Having passed through, it moves on in a straight line, and takes its proper place on the screen just where that line impinges, which place, from this very regulation, is not contended for by any other ray that enters. Hence the point thus illuminated on the screen exactly represents the point A of the object. And what is true of the point A is also true of the point B and the point C, and, in fact, of every conceivable point on the side of the object toward the screen; so that every point, although it sheds a large number of rays into space, as do the points A, B, C in the figure of dispersed light, can only get in its one representative ray.

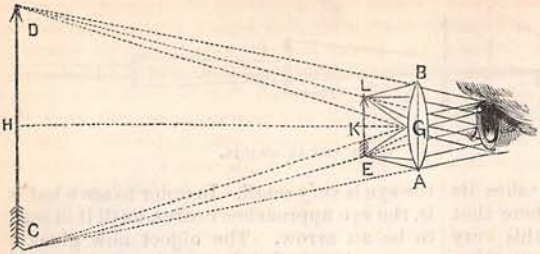


THREE VISUAL ANGLES.

To make this automatic eclecticism of the rays perfectly clear, let reference again be made to the figure of dispersed light. Suppose that for the nonce the line D E F, which represents a screen, shall here represent the card, and that E represents the pin-hole. Then of all the rays from A only the eclectic one shown by the dotted line from *c* can pass through; of all the rays from C only the one indicated by the dotted line from *d* can get in; while B is only allowed to get in its central ray. What a beautiful economy is this exclusiveness of Nature, wherein so many seek to enter, but are not able! In the thronged movement of those dispersed rays, how motiveless the way, and how many there are that go in thereat! but the narrow gate of purpose, how few there be that find it!

Every one knows that when looking at a carriage approaching from the distance, it becomes sensibly larger as the distance is lessened; also that a retreating carriage decreases in size as the distance increases. What is the reason of all this? The optician would say that both phenomena are due respectively to the enlarging and diminishing of the visual angle. Now as we are not supposed to be opticians, this very answer forces upon us two questions: What is a visual angle? and What is meant by its increase or diminishment? A visual angle is the angle made by two rays of light which proceed from the extreme parts of an object and terminate in a point at the eye of the beholder. Hence the size of the object seen, if seen distinctly, is really the measure of the angle of vision. In the cut (three visual angles), suppose the spot at the greatest extremity from the eye to be an arrow so far off that its true form is indistinguishable. It is, to all appearance, a mere spot. The angle which this makes to the eye is very small. In order to see what it is, the eye approaches nearer, until it is seen to be an arrow. The object now gives a new angle, which is larger than before. On a nearer approach the arrow becomes still larger, and now a new and larger angle of vision is obtained. Still the eye approaches the object until the large arrow is seen. The object is now brought as near to the eye as is compatible with distinct vision, and it has now obtained the largest visual angle of which that object is capable. Let the eye approach the object still nearer; the latter now becomes indistinct. The truth is, the object now fills an angle altogether too large for the eye, as its lines, instead of meeting in a point at the eye, actually meet far behind it. All that the eye does really see is just so much of the shaft of the arrow as is contained within the two lines of the largest of the true visual angles. So that we have two angles in the diagram that are not true angles of vision, because the object when embraced in or subtending either one is not distinct to the eye; and we have three angles that are true angles of vision, because the object as measured by any one of them is distinctly seen. Hence the angle of vision can be lost in two ways—either when the object is too near the eye, or too remote from it. It is noticeable also from the above that the nearer an object is to the eye, providing it is within the angle of vision, the larger it will appear.

It was plain in the diagram of the visual angles that an object may be indistinct because it is contained in too small an angle. Suppose some object entirely too minute to be distinguished by the unaided eye or natural sight, however near that object might be brought; it would, in spite of nearness, still be indistinguishable, for the reason that its angle is too small. Suppose a thin plate of glass could be placed between the eye and the object; practically nothing is gained, as the rays of light pass through the glass unchanged. Supposing that object to be a diminutive specimen of the arrow so often used already, remove the thin plate of glass and put a double convex lens in its place; now the arrow is magnified. Look at the two outermost or peripheral rays, namely, the one which starts by reflection from the point of the arrow, and the one which in like manner leaves the tip of the feather. Just as they enter the lens, on the side farther from the eye, they are bent inwardly, that is, toward the central or thickest part



THE MAGNIFIED ARROW.

of the lens, so that when they emerge on the side next to the eye, they converge until they meet at a point in that organ. But here it is evident a new angle is formed by these rays, which is wider or more obtuse than was the angle which they made when they left the object which reflected them. Now, as already mentioned, to make any object seem larger to the eye, it is only necessary to bring it nearer to the eye, or to set it in a larger visual angle. To make it plain that this new angle is wider, let its two sides be prolonged, as by the dotted lines A C and B D, until they inclose the enlarged image C D, which is the magnified image—that is, the virtual image—of the object E L. Now this enlarged angle is really the angle of vision, or the visual angle, produced in this instance by the refraction or bending of the rays which pass from the object through the double convex lens. Opticians call such an image the *virtual* image, in distinction from the *real* image, which is always inverted, in whatever way produced, as seen in the cut of the perforated card. It is the real image which is at last thrown upon that delicate screen or curtain within the eye known as the retina.

How, then, does a lens magnify? It brings the object, that is, its image, nearer to the eye, that is, to distinct vision, than was possible without this aid, and this it does by enlarging the visual angle.

In regard to our home-made microscope, in what way was that wax band advantageous? This requires that a moment be spent in considering what is meant by the expression "the aberration of lenses." Our statements have all along assumed that the rays leaving a single point, after passing through a convex lens, will all meet at a point which we have called the focus. This is not, strictly speaking, true, except of lenses having a very small aperture. We are now quite familiar with the fact that all rays (except the central or axial rays) passing through a convex lens are bent or refracted toward the axial ray. Those passing through the nearest to the edge of the lens are the most refracted, and those passing through the nearest to the axial or central ray are the least refracted, while the axis itself, being a straight or unbent line, admits of no refraction. Now at the luminous point, that is, the burning point in a burning-glass, which is usually called the focus, there are actually, so to speak, two foci, because the outer or peripheral rays all come to a point at a definite distance from the centre of the lens, while those rays near to the axial ray come to a point a little farther distant from the centre of the lens than is the point made by the meeting and crossing of the external rays. To this departure from exact concurrence has been given the name *spherical aberration*. Because of this difference of focus it often happens that the image obtained of an object is sharp at the edge but indistinct at the centre, or distinct at the centre and blurred at the edges. On this account the photographer often uses a diaphragm or stop. It may be simply a card with an annular opening, by which he covers over the edges of the lens, thus shutting off, or "stopping out," as he says, the peripheral or most refrangible rays. It was in this way that the wax binding on our first magnifier reduced the spherical aberration, and so secured a sharper outline to the image.

A PHOTOGRAPHER'S STOP.

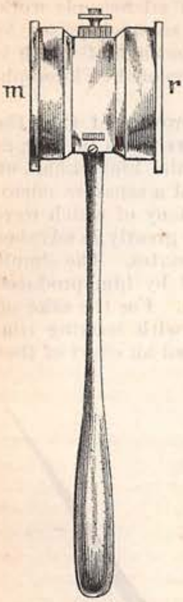
Doubtless the earliest, and for many ages the only, microscope was the double convex lens. A rock-crystal obtained in the ruins of Nineveh was pronounced by Sir David Brewster to be a lens prepared for optical purposes. There does not seem to be any evidence that the ancient lens was devoted to the acquisition of knowledge; hence science—what there was of it then—was probably in no way indebted to this little instrument. It was far otherwise, however, with art. A seal once belonging to Michael Angelo, "and believed to have been made at a very remote epoch, has fifteen figures engraved in a circle of fourteen millimeters in diameter." Just to think of it! a hard gem containing, in a circular space but a trifle over half an inch in width, fifteen delicately executed figures. Some of these figures are not even visible to the naked eye!

Among our early scientific microscopists the best work was done by the simple microscope, barely consisting of a double convex lens. But it was earnest work, and done by devoted men. The famous Leuwenhoek made his own lenses; and for each object deemed worthy of real study and preservation he made a separate and specially adapted microscope, which, when focused to his liking, was not permitted to be disturbed, but was carefully set aside, always ready for inspection. His cabinet thus became not only a collection of specimens, but also a collection of microscopes—a formidable matter, truly, and highly expensive, as, except the lens, every one was constructed entirely of silver. As he says in his inelegant but quaint Latin, "*Mihi quidem sunt centum centumque microscopia*" (Indeed, I have hundreds upon hundreds of microscopes). He left by will to the Royal Society twenty-six of these little instruments, with their objects permanently focused. These were all intrusted to the learned microscopist Henry Baker, with instructions to report on them. In 1740, after devoting three months to their examination, he made his report, which was published in the Philosophical Transactions, No. 458. His words elsewhere are, "Of the twenty-six microscopes I examined, one magnifies the diameter of an object 160, one 133, one 114, three 100, three 89, eight 80, two 72, three 66, two 57, one 53, and one 40 times." We give a drawing of a Leuwenhoek's microscope. It consists of two silver plates secured together by six rivets. The two plates are represented in the cut, each being a side of the instrument. Let us mark the two sides respectively F and B, and call them the front and the back of the microscope, meaning by the back the side kept toward the observer. At the bottom of the back is the handle, with a little screw in the upper part to secure it to the plate. High up on the plate, near the top, is a little hole. It is here where the lens is secured between the plates, and where the eye of the observer is applied. On the plate F, representing the front side, the handle is again seen, which now is shown to be a long screw, by turning which between the thumb and finger is adjusted the height of the stage at the upper end of the screw. On the stage is a short, thick, upright pin, not unlike a tenpin. On this the object to be examined is secured, usually by some adhesive substance. The base of this upright fits snugly into a little hole in the stage, in which it can be turned by the little projecting lever. In front of the stage is a small screw. By turning this the stage can be pressed a little from the plate, if necessary, when focusing. With such instruments, Leuwenhoek made those discoveries which made him famous, and a few of which, after his nearly half a century of microscopic work, constituted that legacy so much prized by the Royal Society, an account of which is given in two of the papers of the Philosophical Transactions.

LEUWENHOEK'S MICROSCOPE.

But the greatest improvement that the simple microscope received was in 1740, at the hands of Dr. Nathaniel Lieberkühn, of Berlin. He also adapted a separate microscope for each object, many of which were anatomical preparations greatly in advance of the labors of his associates. The simple microscope, as improved by him, produced some sensational results. For the sake of those who are pleased with striking contrasts, we have reproduced an effort of that venerable man, in which he attempted to show how greatly more finished Nature is in her works than it is possible for man to be in his. It is Nature *versus* Art—a wasp's sting and the point of a cambric needle. If you look along the sides of this needle point, here shown to be coarser apparently than a sailor's marline-spike, you will see an appearance like that of a margin. If this be correct (for it is taken from a copy), then it would seem as if a delicate film of the steel had been rendered transparent by the excellence of the illumination. And, in fact,


NATURE VERSUS ART—WASP'S STING AND POINT OF A CAMBRIC NEEDLE.

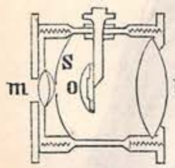


LIEBERKÜHN'S MICROSCOPE.

it was just here wherein Lieberkühn's little microscopes excelled all others in their day. We refer to the small cut showing the interior of Lieberkühn's microscope. At *r* is shown a large convex lens, which condenses the light upon the silver mirror or spectrum, *s*, which throws a brilliant light upon the little object, *o*, which is magnified by the magnifying lens, *m*, which is placed, as is seen, between a hole in the centre of the spectrum and the hole at which the eye is applied when viewing the object.

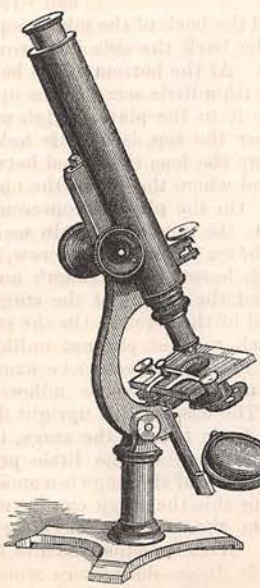
In those days microscopy, whether looked at in consideration of the work involved or the expense incurred, was nothing less than a serious business. Happily, both as to cost and efficiency, the microscope of to-day puts matters in a much more manageable shape.

A word on the compound microscope. In this instrument the observer does not look really at the object, but at an image of it, which image is given to the eye as the magnified condition of another image. An enlarged picture or image of the object is projected up the tube of the instrument from a lens, or set of lenses, and that image is again enlarged, or what is in effect the same thing, it is committed to a larger visual angle. The modern compound microscope consists essentially, as respects the lenses, of two parts—the lens or lenses next the object, and the two lenses next the eye. The lens or, if more than one, the lenses next the object are called the objective. This objective may consist of but one lens. It often, however, consists of three, and is then called a triplet. These three lenses are screwed the one to the other. If the two bottom lenses are taken off, and the upper one used, usually an inch focus is obtained. If now the middle lens be screwed on to this one, perhaps a half-inch focus will be got, which of course is a greatly increased power. If now the third lens be screwed on, and all three used as an objective, likely a quarter-inch focus will be had, and the highest power will then be obtained of which this particular triplet is capable. So that with every increase of power in the objective there is a shortening of the focus and a lessening of the area of the real field of observation. For instance, the one-inch focus objective might take in the whole of a fly at one view. But suppose it is desirable to so enlarge a single organ of that insect as to be able to inspect all its peculiarities, it would have to be done with a higher power, and when done this particular organ would itself fill the field. It is a little curious how general the difficulty seems to be to comprehend this point. Suppose an artist be required to paint in life-size the portrait of a babe, and a spread of canvas just large enough be furnished for that purpose. But the patron has changed his mind, and now requests the artist to paint on the same canvas a life-size likeness of the child's father. It is plain that the thing is impossible. We have a friend who is very skillful with the microscope. A neighbor one day brought in a dead gold-fish, some three inches long. He said he had been so delighted by thinking on that animalcule that was magnified a thousand times, that he had often thought how splendid a gold-fish would look when so enlarged; and "Now," said he, "wouldn't you be so good as just to put your very strongest magnifier on this fish?" Only to think, he expected to see inside that narrow tube, all clad in golden armor, an ichthyic monster 250 feet long, every scale of whose plate-armor would be ten feet broad; and these, too, fluted with grooves into any one of which a man might lay his right arm!



INTERIOR OF A LIEBERKÜHN'S MICROSCOPE.

Nor is all that has been just narrated to

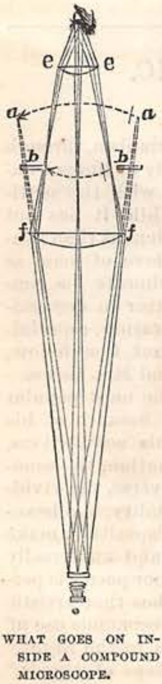


A STUDENT'S MICROSCOPE.

be charged subjectively to pure ignorance. A good deal of it is begotten of the intentional misstatements of persons who have wares to sell, and not a little of the carelessness of statement too often found in popular books. In one of these, devoted to optics, we read: "The surface of the object appears to occupy four million times its natural extent. Under such a power, a hair would appear six inches thick, a fine needle would look like a street post, and a grain of sand like a mass of rocks." Alas, what becomes of that cambric needle enlarged to the respectable dimensions of a marlinespike? O shade of Leuwenhoek! But there is not a shadow of you left!

The upper part of the tube in the compound microscope is occupied by the eyeglasses. These are two plano-convex lenses; that is, lenses that are convex on one side and flat on the other. The flat surfaces are toward the eye. The lens immediately next the eye is called the eyeglass, or ocular; the one more remote is called the field-glass; while the term eye-piece is often used to mean the two glasses and that part of the tube which contains them, and which part can be put into or taken out of the long tube of the microscope, as the better sorts of instruments have usually more than one eye-piece.

Our engraving shows a compound microscope. It is really a portrait of the kind used professionally, that is, in the laboratory, and hence is known as the student's microscope. It is with such an instrument that the main part of professional work is done; and, comparatively speaking, it is seldom that a better instrument is required. Let us now inspect the interior of a compound microscope; that is, let us see what goes on inside such an instrument. With a few words the diagram will make this whole matter plain. From *e e*, where the eye is placed, to the little object at the other end, is the entire length of the tube of the instrument. From *e e* to *f f* is the short tube, called the eye-piece, which is put into the top of the long tube. It contains two glasses; the one, *e e*, is the eyeglass, the other, *f f*, is the field-glass, and both are plano-convex lenses; that is, convex on one side and plane on the other, the flat side being toward the eye. At *b b* is a constricted aperture in the tube, between the two glasses. This is the diaphragm, or annular opening, which shuts out all unnecessary or disturbing light. From each end of the object and from the centre of it are projected three rays of light. By following each outside triplet of rays from the object, we notice that if there were no obstruction they would form an image at *a a*; but meeting the field-glass, *f f*, they are bent from their course, and compelled to pass through the constricted passage of the diaphragm at *b b*. Here they form a magnified image of the object. Now the eyeglass, *e e*, further magnifies this image, just as if it were an original object; for the rays leave *b b*, and pass through the lens or eyeglass exactly as they do in the case of the simple microscope.

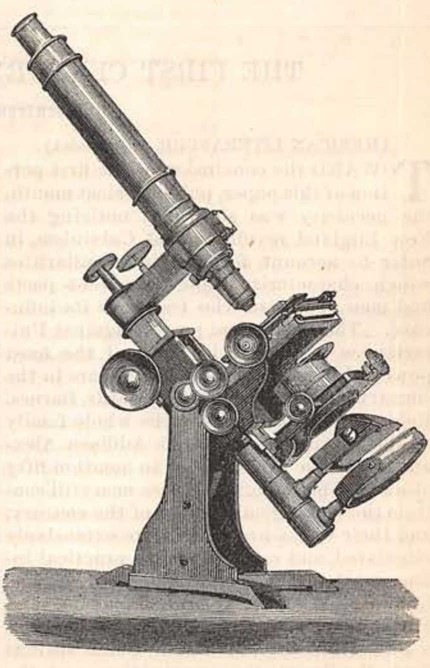


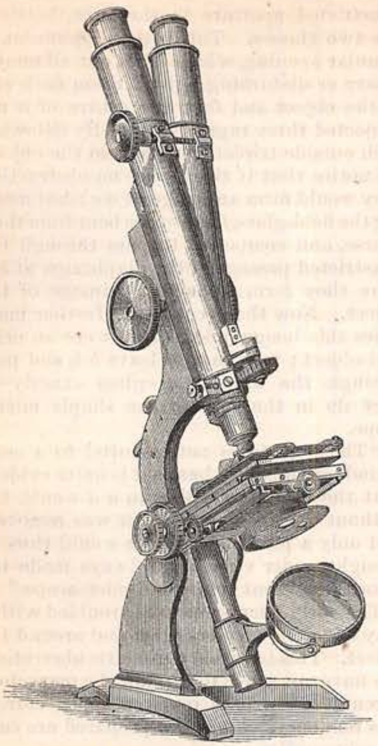
WHAT GOES ON INSIDE A COMPOUND MICROSCOPE.

"The lens *f f* is not essential to a compound microscope; but as it is quite evident that the rays proceeding to *a a* would fall without the eyeglass, *e e*, if it was removed, and only a part of the light would thus be brought under view, it is always made use of in the present compound microscope."

The early microscope was troubled with a play of rainbow colors upon and around the object. This is called chromatic aberration. We have not space to explain the marvelous ingenuity which is resorted to to correct this tendency. Lenses so prepared are called achromatic.

So the microscopist of to-day has at his service, in the modern microscope, one of


A HIGH-CLASS MICROSCOPE.



A BINOCULAR MICROSCOPE.

the highest achievements of human genius. What fertility of invention and high skill in execution! How wonderfully blended are the rigid mathematics and the severest optical science and the nicest mechanism of constructive skill! The microscope is really the crystallization of large scientific experience. Nay, we prefer to regard it as an organism of thought, the clustered fruitage of the busy, active thinking of two hundred years. Such is the modern high-class achromatic compound microscope; while the last achievement, the binocular microscope, seems to leave nothing to be desired.

So much for the genesis and growth of the microscope. And shall we not indulge one thought on its conceptional origin? As if destined to the status of a noble organism, it began existence as a mere globule, a spherical cell. And who knows—but is it not likely that the conception took place in the mind of an inchoate optician when observing the effect of the morning sunlight on a drop of dew? There, to his astonishment, appeared in clear enlargement the hitherto indiscernible—the delicate nervures of the wing of a drowned midge. Thus in the beginning, perhaps, was prefigured that *ultima thule* of modern microscopy, the immersion lens.

And now, after such a genesis and such an unfolding, in how much is our world the better for the microscope? To what extent is science its debtor? Does it add to the sum of knowledge? Does it increase human happiness or lessen human misery? In subsequent papers we shall answer these questions.

THE FIRST CENTURY OF THE REPUBLIC.

[Seventeenth Paper.]

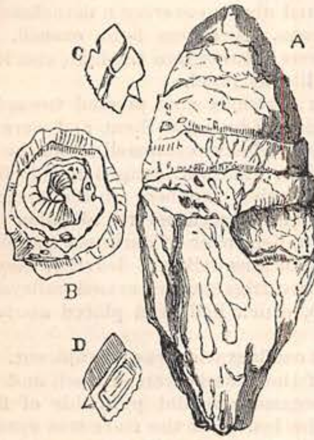
AMERICAN LITERATURE.—(*Concluded.*)

TOWARD the conclusion of the first portion of this paper, published last month, the necessity was shown of noticing the New England revolt against Calvinism, in order to account for certain peculiarities which characterize some prominent poets and men of letters who testify to its influence. The theological protest against Unitarianism was made by some of the most powerful minds and learned scholars in the country—by Stuart, Park, Edwards, Barnes, Robinson, Lyman Beecher, the whole family of the Alexanders, of which Addison Alexander was the greatest, not to mention fifty others. The thought of these men still controls the theological opinion of the country, and their works are much more extensively circulated, and exert a greater practical influence, than the writings of such men as Channing, Norton, Dewey, Emerson, and Parker; but still they have not affected in a like degree the literature which springs from the heart, the imagination, and the spiritual sentiment. Unitarianism, through its lofty views of the dignity of human nature, naturally allied itself with the sentiment of philanthropy. While it has not been more practically conspicuous than other denominations for the love of man, as expressed in works to ameliorate his condition, it has succeeded better in domesticating philanthropy in literature, especially in poetry. Witness Bryant, Longfellow, Whittier, Holmes, Lowell, and Mrs. Howe.

Longfellow is probably the most popular poet of the country. The breadth of his sympathy, the variety of his acquisitions, the plasticity of his imagination, the sonorousness and weight of his verse, the vividness of his imagery, the equality, the beauty, the beneficence of his disposition, make him universally attractive and universally intelligible. Each of his minor poems is pervaded by one thought, and has that artistic unity which comes from the economic use of rich material. The "Hymn to the Night," "A Psalm of Life," "Footsteps of Angels," hills. These features of the event, with the booming of the loaded cannon on the burning vessels when the fire reached them, answered by echoes from a hundred hills, produced a scene of awful grandeur never witnessed before nor since on the borders of the Hudson. It was a wild and fearful romance, that ended in the breaking of the boom and chain, and the passage up the river of a British squadron with marauding troops. These laid in ashes many a fair mansion belonging to republicans as far north as Livingston's Manor, on the lower verge of Columbia County.

THE MICROSCOPE.

By PROFESSOR SAMUEL LOCKWOOD.



COPROLITE AND FISH SCALES.

II.—ITS WORK.

IT was about forty years ago when the following incident occurred in England. Large quantities of "petrified cones," as they were called, which the sea kept washing up out of the lias formation, were constantly collected and carried to the mills, where, on account of their richness in phosphate of lime, they were ground into powder for agricultural uses. They were called in science "coprolites," for they proved to be, under the microscope, the fossil excrements of extinct reptiles. Thus examined, these fossil ordures were found to contain scales, teeth, and other *indigesta* of fishes. One of these, an unusually interesting specimen, contained on one side a perfect scale, which Dr. Buckland submitted to a young naturalist who had just attained some reputation for his knowledge of fishes. The young man took out his pocket microscope, and, to the astonishment of the veteran geologist, promptly answered that the scale belonged to the *Pholidophoros limbatus*. The astonishment of the elder *savant* grew into amazement when the young man further added, in the confidence of positive knowledge, that the scale was from the left side of the fish's neck. Usually on each side of a fish is a row of perforated scales. Each scale in the row has a little channel or duct. The union of these ducts makes a lateral tube, whose use is to convey the mucus evolved by certain glands in the head along the sides of the fish. By looking at the cut representing the coprolite and fish scales, this is easy to be understood. Here A is a coprolite of a great extinct lizard. B is a section of the upper end, showing scales and sundry other *indigesta*. C is the under side of the magnified scale, with the little mucous duct. D represents the upper side of the scale. There is a little spike-like point on one side, which fits into a slot in the adjoining scale. The slot to receive a similar point is shown on the opposite side of the same scale. Surely all that was most deftly done. But the young man? Oh, it was Agassiz.

However, the above was not high-class microscopic work. It rather evinced first-rate knowledge as an ichthyologist than particular skill in the use or *technique* of the microscope.

There is a story that an eminent microscopist had a bit of substance submitted to him to decide what it was. To an unaided eye it might be a morsel of skin which a baggage-smasher had knocked off the corner of a smoothly worn hair trunk. The *savant* appealed to his microscope. Entirely ignorant of this tiny bit of matter, except as he had taken counsel with his instrument, the wise man declared that it was the skin of a human being, and that, judging by the fine hair on it, it was from the so-called naked portion of the body, and, further, that it once belonged to a fair-complexioned person. The strange facts now made known to the man of science were these: That, a thousand years before, a Danish marauder had robbed an English church. In the spirit of the old-fashioned piety the robber was flayed (let us hope that he was killed first), and the skin was nailed to the church door. Except as tradition or archæological lore had it, the affair had been forgotten for hundreds of years. Time, the great erodent, had long ago utterly removed the offensive thing. Still, however, the church door held to its marks of the great shame, for the broad-headed nails remained. Somebody extracted one, and underneath its flat head was this atomic remnant of that ancient Scandinavian malefactor's pelt—that fair-skinned robber from the North.

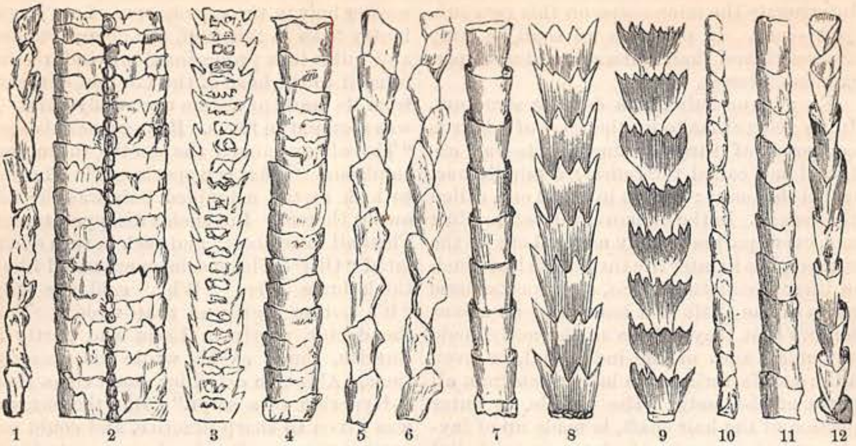
Let us now, with becoming confidence,

interrogate the microscope on this very subject—hair. In doing so we shall be truly answered, and shall learn something of permanent interest.

Every true hair has a definite structure. In its general make-up the *shaft* of a hair is composed of three distinct parts—an external one, called the *cuticle;* a middle one, called the *cortex;* and an internal one, called the *medulla.* In the human skull, before adult age, every part is sharply mapped out by the sutures, but in later life these lines lose much of their distinctness. So, as respects these parts of the shaft of a hair, it by no means follows that they will be as distinctly made out at all ages of the individual, or even alike satisfactorily from hair taken from all parts of the body. The cuticle, or outer portion of the hair shaft, is made up of layers, and these again of plates or epithelial scales. To the position of these plates is due the singularly beautiful ornamentation of many hairs, the pattern of the sculpture depending on the shape of each plate, and the angle at which it leans to or stands from the shaft. In the human hair these plates lie so closely upon the shaft as to give it scarcely any ornamentation, though under a very high power a slightly serrated aspect is presented. Still, under even a good glass of moderately high power, a human hair usually disappoints a *dilettante* at the microscope, presenting as it does to such pretty much the appearance of a large wire. We remember well an amusing instance of this sort of disappointment, amounting almost to chagrin. One of the parties was an eminent microscopist, since deceased. We had together spent the day collecting at the shore. It was evening, and the professor with his "Spencer" was working out his "finds." Some young ladies came in on a call. The professor had just made a fine slide of a bit of a red hair-like callithamnia. Under that superb lens this delicate alga came out in great beauty; for lo, instead of continuous, homogeneous hairs, the thread-like fronds looked as if they were made up of many series of ruby bugles. After gazing in admiration on the exquisite vision, the ladies were shown a mass of this pretty sea-weed as it lay in a saucer of water. This evoked the remark that it looked like red hair, and how wonderful it was that it should appear so beautiful in the microscope. Now it so happened that one of the ladies had a highly sanguine temperament, and hair of an equally ardent hue. "If a bit of red-haired sea-weed be so beautiful, what should not be expected of a human hair of the same hue?" Such was thought, although not said. The doctor had begun the preparation of a new slide for his microscope. It was a cluster of live Bryozoa, and he was somewhat impatient lest the specimen might die. But the ardent damsel would *so* like to see her hair in the microscope. Less in gallantry than in mischief, the doctor yielded, and quite in a professional way addressing himself to the head of the fair one, detached from its lambent sisters one ruddy hair. It was soon put in focus. Rising from his seat, "There!" exclaimed the doctor, in dubious emphasis. "*That* is a specimen!" The first to look at the magnified hair was the fair owner thereof. But such a disappointment! Then all must look; and each in turn ejaculated "Oh!" The specimen appeared like a thick brass wire. "Why," said the lady, "it's not so pretty as that weed!" Said the doctor, partly in Latin and partly in English, much as he wrote his prescriptions, "Alga non est vilior quam coma flava—Hyperion to a satyr." But the surgeon was given to sharp practice, and could say cutting things. Besides, he was a professor in a medical college.

In the hair of many animals the cuticle presents a very remarkable appearance. The plates or scales, according to the species, being set at varying angles to the axis of the shaft, their projecting edges give rise to the most elegant sculpturings of the surface. In this respect the hair of the domestic mouse is a pretty object, also that of the squirrels; but for a certain quaint elegance and variety of pattern, none equal the bats. Indeed, in many of these animals the hairs are suggestive of exquisitely carved columns. And as respects the special sculpture of the shaft, there is a rich diversity among the different species of the bats, and even the same pattern which may distinguish a species may have its own modifications in the pelt of the same animal, as characterizing the long coarse hair and the short fine hair.

Figures are given on the next page descriptive of hairs obtained from ten species of bats, ranging in size from that of our little brown bat to that of the kalong, as large as a half-grown cat. The species here represented extend over a wide geographical range—the continents and islands of Asia, Africa, Australia, and North and South America. Each specimen is magnified considerably over 500 diameters. The one marked 2 is a hair of the kalong or flying-fox of Malay. Notwithstanding its popular name, it is a veritable bat, and a strange creature, truly, even for a bat. This curious being is a vegetarian, and makes havoc with the fruit trees in the Malayan gardens, so that the queer sight is common of trees incased in wicker-work cages made of bamboo strips as a protection from these night depredators. However, if the kalong feeds on the fruit of the Malay, the latter feeds on the kalong when he can catch him, for they all account flying-fox as very savory meat. It is noticeable that the hair of this great bat is the coarsest or thickest of them all, and that the corticu-

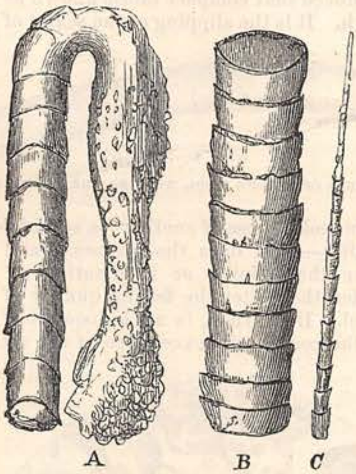


BATS' HAIRS.

lar scales are imbricated—that is, these hair scales, like the body scales of the serpent, are made to lap upon one another. No. 3 is from the margin-eared cynoptere of Northern India. This hair, naturally somewhat translucent, is made more so by the balsam in which the specimen was mounted for the microscope, so that there is a little optical illusion, by which it looks like a longitudinal section. No. 4 represents the large hair and No. 5 the small hair of Pearson's horseshoe bat, a little bat of the Sikkim Himalayas. No. 6 is the Java horseshoe bat; it is the small hair. No. 7 is a hair of the Javanese nicetris. No. 8 is a hair from the rhinopome of Egypt. No. 9 is from an Australian bat whose specific name we do not know. Nos. 10 and 11 represent the larger and the smaller hair of Pearson's bat from the Himalayas. No. 1 represents the hair of an unknown American bat.

At a time of life when one should have put away childish things comes the constraint to make full confession of a certain micro-transgression in the days of our youth. The writer had, alas! become worship-weary at an advanced stage in a long effort to comport himself well by keeping still during sermon. His endeavor had proved successful up to the "seventeenthly" of the discourse, when—for it was a summer evening—a little bat entered the church at an open window. A grateful summer air had set the chandelier into a gentle, slumberous swing. Each little curve of undulation was like a slow, somnific wink. It seemed to us that each arc exactly measured the time of a half course of this tiny bird-beast along the cornice of the ceiling. Though of a dreamy sort, there was positive poetry in that movement, rectangle and curve synchronous, each unswerving from its independent plane. And so, overhead, round and round, sailed little Vesper, timing its parallelograms of flight in an almost rhythmical measure. We watched the movement in a subdued giddiness of delight. At last the little beast made a gliding exit at an open window, and, not unlike the cadence of a weirdly pleasant sound, disappeared in the outer darkness. It was just then that the good minister was urging trust in the Divine Providence. At home a severe reprimand was administered for that unseemly gazing around the church. Not insensible to the rebuke, we were yet sleepy and speechless. Happily an aged man attempted an apology. He was deep in the polemics, and unwittingly got off a paronomasia (which is theological for pun). Said he, "Don't be too severe on the lad for gazing at that uncanny varment, as he didn't sense the fine sarmont we had." There was certainly a solid stratum of truth in that apology, such as is not always found in apologetics. But, after all, there had been a closer agreement between the communing of the boy and that of "the legate of the skies" than just then was apparent. While the minister was considering the lilies, the boy was, in a devout way of his own, thinking on that little aerial fellow, every hair in whose furry coat was not only numbered, but positively sculptured with such elegance that even Solomon had nothing comparable from the royal looms. All have seen the bugles which decorate the fringes of a lady's dress. Nothing could be more profuse in this sort of ornamentation than the raiment of little Miss Vesper, for each particular hair of her furry robe is bugled clear up to the very tip. Vesper's full name is *Vespertilio subulatus*. We must stop writing a few minutes while we take another look at one of her hairs. Now we have the pretty thing under the microscope, and before leaving it must secure a pencil portrait (see No. 12 of the bats' hairs). Its bugle-scales, though looking quite irregular, have a method in this very irregularity, and one which begets a pleasant effect, not unlike that produced by the so-called rustic-work of certain rural fences.

"Oh, this is jolly!" But that is hardly dignified. Well, we have written it because it was actually spoken. The fact is, a letter had just come from a friendly *savant* at Cambridge, and in it was a tiny envelope, with the welcome words, "Hairs from the back of a Brazilian vampire." The hair was very short, but very soft, and quite pretty. The lower part of each shaft was whitish, and the upper part of a yellowish fawn-color. We soon had some of it under a quarter-inch objective. What! Why, it looked as plain and unpretending as the maiden's hair aforesaid. It was next put under a power of about 600 diameters, and, as the boy said, that fetched it. And, for such a terrible blood-sucking night ghoul, a very pretty object it is. You will notice that the drawing gives views from three



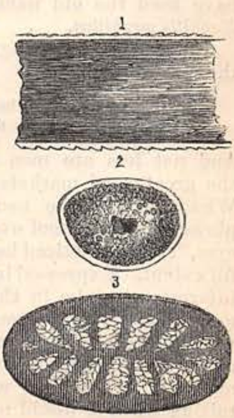
PARTS OF A HAIR OF VAMPIRE-BAT.

parts of a single hair. The entire hair was about four lines in length. Magnified 600 times linear, if it could be done all at once, it would make it 200 inches long—nearly seventeen feet. Of course the instrument can only show a very minute portion at a time. Our drawing gives three of these minute parts of the shaft. At A is shown the root, or hair bulb, which is in two parts. At the bottom it is nearly spherical, but farther up it is fusiform. The portion bent over, or turned down, is the lower part of the shaft, and is much slimmer than the upper part, which is represented at B. The extremity or tip of the hair is shown at C.

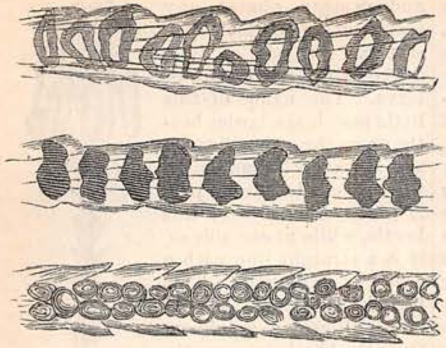
Curious as these bat hairs are, we have one still more so. There is a little beetle which greatly annoys the good housewife, and the naturalist also. It gets into her pantry and feeds on her dried meats, also destroys furs and wool. To the naturalist it is a terror, for it will eat up his insects, and destroy almost any specimen of animal substance. It has a little dark-colored hairy grub or larva. The name of this little pest is the larder beetle, or, as the scientific men say, *Dermestes lardarius*. In the cut of the larder pest is given a picture of this beetle, while at one side of it is a straight line with a cross at each end. This line is the exact length of a full-grown specimen. Over the beetle is a greatly magnified representation of a hair of its grub or larva. It will be seen that this singular hair is made up of a round shaft with whorls of sharp spines, like small leaves, clasping the shaft or stem. Each whorl seems to have four or five of these spines. High up is a whorl of much thicker projections, each somewhat egg-shaped. Top of all is a cluster of quite large appendages, each of which seems to be hinged at its middle to the central shaft, which is quite thick at this spot. Indeed, these appendages look wonderfully like abortive petals of a columbine. Nor does it need much imagination to see in the entire make-up of this hair the similitude of a flower—the continuous bracts on the stem, the calyx of thick sepals, and the corolla of spur-like petals. It is truly an oddity, the heavy part of the hair being at the distal end, much as if in a whip the snapper and the stock should change places. If one might believe in fays of microscopic stature, a hair of Dermestes might well serve as the mace of elfin nobility.

THE LARDER PEST, AND A HAIR FROM GRUB OF SAME.

It is noticeable that in all over which we have gone the microscope has simply dealt with the external character of the hair, as determined by the form, size, and position of the epithelial scales on the shaft. But this is the easiest part of the problem. Important differences occur in the dissection of hairs. This is often seen in a simple section. In the cut



SECTIONS OF HAIRS.



HAIRS OF CAT, MOLE, SABLE.

of sections of hairs, 1 shows a longitudinal section of a human hair, in which the fibrous character appears; 2 gives a cross section of the same hair, and shows the cylinder of medullary substance. Compare this with 3, which is a cross section of the hair of the peccary, or South American hog, and the great difference of internal structure is at once observable.

To many these details are interesting simply because they are curious. Some may dignify them with the epithet scientific; others will ask, "Of what use is all this?" The true answer is, "Much, every way." Herein even the commercial value of the microscope is very great. While from defective or insufficient knowledge the expert in animal hairs might occasionally be at fault, yet he could, to the extent of his practice, identify the genuine and the false among the furrier's wares. The ladies need hardly be told that the Alaska sable furs, so fashionable the last season, were the sheerest shams. Alas, these Alaska sables were only the metamorphosed pelts of the very vilest of our indigenous animals, even the one known as the skunk! Pardon the vulgar word; we might have used the old name of Shaw, *Mephitis mephitica.*

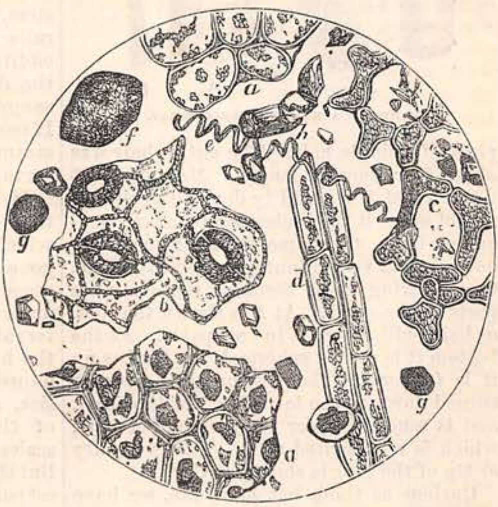
Among the sporting fraternity there is an old adage,

> "Fur, feathers, and hair
> Make many a man swear."

And not less are men tempted in the great wool markets of Europe. Whatever may be meant by the phrase "pulling wool over another's eyes," it was practiced here to a fearful extent. Expressed in figures, the interests at stake in this one commodity are simply amazing. Last year California alone clipped nine and a half million pounds of wool; and yet if California were to stop raising wool, it would not very sensibly affect the markets of the great wool-manufacturing districts, for the wool crop of the world last year was not less than one billion eight hundred and eighteen million three hundred thousand pounds (1,818,300,000). In those great marts of England, known respectively as the Wool Exchange, fraudulent sales were frequent until the microscope was summoned unto judgment. Let us make this plain. It is not the weaving alone, however skillfully done, that gives the fine body to the esteemed English broadcloth. This is due to the quality of the fibre of the wool employed in the fabric, and this excellence in the fibre is known as its felting quality. Felt hats are usually made of wool and rabbits' hair. Not by weaving at all is felt made; but by soaking in hot water and beating and pressing, thus causing the several fibres or hairs to become locked and entangled together, is produced that compact fabric known as felt cloth. It is the slipping of the scales of one

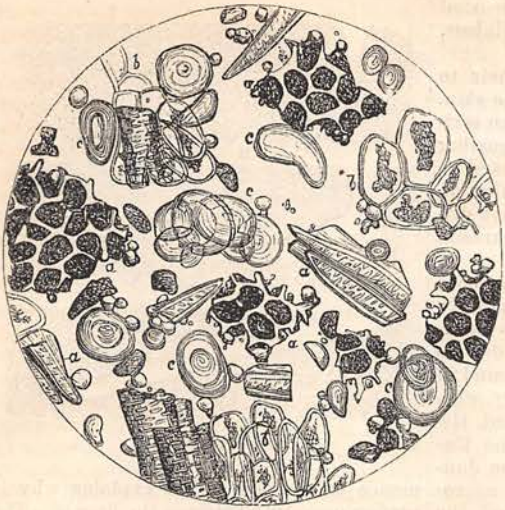
A FIBRE OF SHEEP'S WOOL, SHOWING THE IMBRICATION.

fibre under those of another—a sort of dovetailing—that does the business; and the finer the lapping or imbrication of the scales, the better the felting quality of the wool. Here, then, is an indisputable test of the commercial excellence of the article.



TEA ADULTERATED.

a. Upper surface of leaf. *b.* Lower surface, showing cells. *c. Chlorophyl* cells. *d.* Elongated cells found on the upper surface of the leaf in the course of the veins. *e.* Spiral vessel. *f.* Cell of turmeric. *g.* Fragment of Prussian blue. *h.* Particles of white powder, probably China clay.



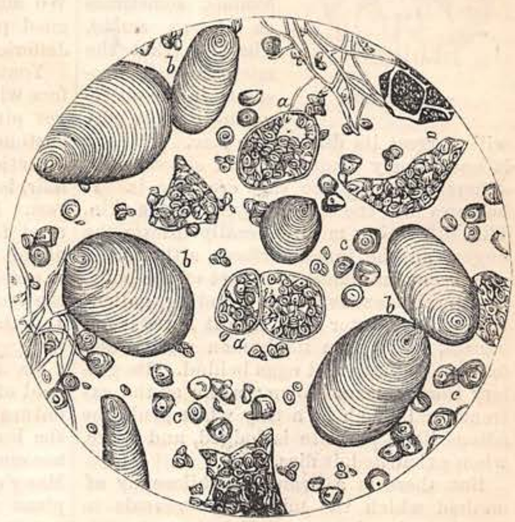
COFFEE ADULTERATED.

a, a, a. Small fragments of coffee. *b, b, b.* Portions of chiccory. *c, c, c.* Starch granules of wheat.

As facts in the form of figures are generally of easy comprehension, let us borrow a few words from Gosse. "When first the wool fibre was submitted to microscopical examination, the experiment was made on a specimen of merino; it presented 2400 serratures in an inch. Then a fibre of Saxon wool, finer than the former, and known to possess a superior felting power, was tried; there were 2720 serratures in an inch. Next a specimen of South-Down wool, acknowledged to be inferior to either of the former, was examined, and gave 2080 serratures. Finally, the Leicester wool, whose felting quality is feebler still, yielded only 1850 serratures per inch. And this connection of good felting quality with the number and sharpness of the sheathing scales is found to be invariable." Elsewhere the same writer says, "Examples selected from fine flannel and from coarse worsted vary in diameter from $\frac{1}{2000}$ to $\frac{1}{700}$ of an inch."

And it is so for all fabrics and staples of a fibrous sort. Each is stamped with its own pattern, thus impressing upon it a specific character, which skill, with a good microscope, may read. So it is with all those articles which constitute our food, and which are capable of being adulterated. Take, for instance, coffee and tea and the different kinds of starch. But all this is notoriously true of drugs. So much is this the case that salaried experts in this reprehensible business are employed in the great drug establishments, whose specialty is adulteration. And this art of the druggist is a very ancient one. An old book now lying before me is entitled *The Elaboratory laid open; or, the Secrets of Modern Chemistry and Pharmacy revealed.* It is dated London, 1758. In it much stress is put on exposing the "practice of sophistication." And how often, when too late, does the modern physician find that the very medicine with which he is doctoring his patient has itself been "doctored!" The test in some of these cases would need to be a chemical one, but generally the microscope is the best detective.

A few years ago the British Parliament instituted an inquiry into the adulteration of foods. "The opinion of three distinguished chemists was actually quoted in the House of Commons," to the effect that it was impossible to detect the presence of chiccory in coffee. The microscopist regards this as a simple matter. The adulteration of chocolate is "diabolical." "It is accomplished with brick-dust, ochre, iron rust, and animal fats of the worst description." The example given in the cut of adulterated cocoa, on health considerations is perhaps harmless. The last three cuts are from Hassall, of the British Parliament Commission of Inquiry as to Adulteration of Drugs. The tea is shown to be mixed with other leaves, drugs, and minerals. The coffee is shown



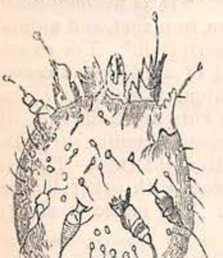
COCOA ADULTERATED.

a, a, a. Granules and cells of cocoa. *b, b, b.* Granules of canna starch, or *tous-les-mois.* *c.* Granules of tapioca starch.

to be mixed with chiccory and roasted wheat. The cocoa is simply fraudulent, not dangerous.

Among the ills which flesh is heir to stand notably those pertaining to the skin. Though some are more unsightly than serious, others are too often both disgusting and calamitous. As the hair is rooted in and grows from the skin, there is often an intimate connection in their respective disorders. Let us adduce an animal parasite peculiar to each.

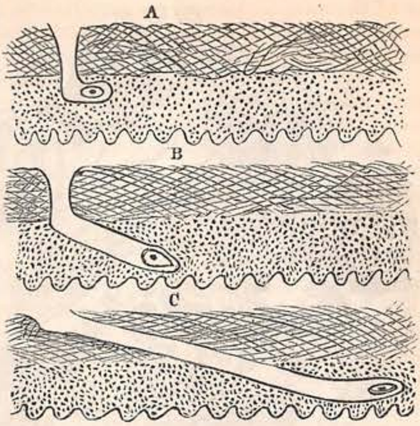
It is interesting to know that early science is indebted to a learned and saintly lady for a clear statement of the fact that the loathsome disease known as the itch is due to the presence of an insect. This is found in a work written in the twelfth century, with the title *Physica*, by Saint Hildegard, the Lady Superior of the convent on the Rupertsberg, near Bingen. In 1619 the Jansens were giving prominence to the microscope as a practical instrument, and the itch disease began to be studied with its aid. In 1687 Dr. Bonomo, of Leghorn, and Cestori, an apothecary, were able to explode the old theory that "the itch disease was due to thickened bile, drying of the blood, irritating salts, melancholy juices, and special fermentation." These observers saw the insects, and even the female laying the eggs.



THE ITCH MITE.

The itch mite belongs to the family Acarina, and is known as *Sarcoptes hominis*, sometimes as *Acarus scabiei*. The fact that the microscope is necessary in the observation of this pest will suggest its diminutive size. The cut is enormously magnified, and shows what a horrible being the tiny creature is. It burrows into the deeper layers of the skin. This disgusting mite generally infests the fingers on the inner surfaces, although it may occur on almost any part of the body. It literally excavates a winding gallery beneath the outer skin. As it bores it advances, feeding on its human victim, and leaving its *fæces* and eggs behind. Its gallery thus appears brown; while at the extreme end, much as a tiny white grub, the odious little parasite is lodged, and there, when exhausted, it dies.

But there is a beautiful philosophy of method which the microscope reveals in these acarian burrows. To illustrate this we give three cuts. When one of these mites gets upon the skin it creeps about until it finds a tender spot where it may com-



ITCH MITE BURROWS.

mence excavation. This explains why it prefers operating between the fingers. The favorable spot found, it immediately stands upon its head, and begins burrowing. In Fig. A of the acarian burrows the itch mite has got under the scarfskin. In Fig. B it is working horizontally. In Fig. C the burrow has well advanced. Now it is noticeable, especially in Fig. C, that there is a steady cell growth upward, thus a constant pushing outward of the effete or dying cells, and these, thus brought to the exterior, are easily rubbed off by the surface wear. But this operation affects the burrow, as it really pushes the burrow up at its oldest parts, that is, at its beginning. Thus it is that in Fig. C the elbow or angle in each of the other figures has disappeared. We must here confess our obligation to a good paper on this subject by Dr. B. Joy Jefferies.

Young persons are often disfigured in the face with black specks. These are the maggot pimples, or *comedones*. But an uglier customer by far, as its secretions beget obstructions which cause degeneracy of the hair, is the hair-sac mite, *Demodex folliculorum*. It is generally found on the face, and most frequently on the sebaceous follicles of the nose. Rarely numerous, it is not often serious. It lives "in the space between the hair shaft and the root sheath, and deposits its eggs in its dwelling-place."

THE HAIR-SAC MITE.

As a canebrake offers a novel field of exploration to a Northern naturalist, so to the microscopist the human hair is interesting on account of its peculiar parasites. Many of these are of a fungous or plant nature. Some of these engender quite serious forms of disease. That one might be instanced which is known as the barber's itch. But as this is an affair solely of the men, let us address ourselves to a matter which alone concerns the ladies, namely, the chignon malady.

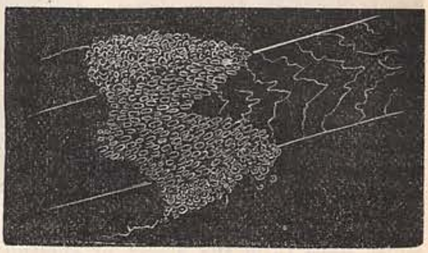
In 1867 a Hamburg paper, with an apparent scientific authority, issued an announcement that fell like a bomb-shell into the great circle of fashion. A Mr. Lindemann was credited with the discovery of a new microscopical parasite, which he had named *Gregarina*. He announced that it existed parasitically in the human blood, that it swam in this life-stream, and was nourished by it, much, we suppose, as a fish in the river. He said, also, that each head-louse had in it enormous numbers of these gregarines. He told of his having interviewed a hair-dresser at Nizhni-Novgorod, and of his finding lots of these dreadful protozoic animalcules infesting his stock in trade. Very naturally the Russian ladies became greatly alarmed when he told them that their chignons were obtained from the caputs of filthy peasants. But more, and worse: he declared that in the ball-room even the dead of these parasites on the false hair, under the influence of the light, heat, and moisture of perspiration caused by dancing, revived, grew, multiplied, became disseminated in millions, and got into the lungs, and thence into the blood, where they attained their specific gregarine nature, and thus induced disease. Just think of it! But it well-nigh dazes sober thinking—a parasite in a parasite—for he tells us that these infinitesimal pests commence existence as an internal parasite of the *Pediculus humanus*. Nay, do not scratch behind thine ear, or hint at "bully Bottom's" "auricular assurance," or make doubting pantomime, or scoff, for, according to Mr. Lindemann, this dreadful gregarina is not only begotten in, but lives in, and dies in, the body of this vermin; and,

"last scene of all,
That ends this strange eventful history,"

is its resurrection. It revives, and, quitting its living coffin on the human head, enters the human blood. Of course what less could "gentle blood" do than tingle at the recital! The entire *bon ton* of St. Petersburg were filled with dismay, and the ladies of Berlin and Paris caught the alarm, and even London was startled from its stolid propriety. Next the fair of America heard just enough of the rumor to suffer a sort of Bald Mountain scare.

All this was one side of the famous chignon controversy. At such a juncture a humble appeal was taken in behalf of the devotees of Fashion to the stern judgment of a stricter science than that of Mr. Lindemann; and again the microscope was called to preside at the tribunal.

Against the German Lindemann, Dr. Tillbury Fox, a skillful English microscopist and eminent specialist in diseases of the skin and the hair, took up the onus of the investigation. The doctor avers that he never found a true gregarina on the hair. He did, however, find a fungous growth on a specimen of German false hair, which, he says, is possibly the supposed gregarina of Lindemann. Such an infested hair, if drawn between the thumb and finger, will feel rough. This roughness is caused by the presence of a number of dark knots, each knot being about the size of a pin point. The figure represents a very minute portion of the shaft of a hair thus surrounded with a mass of these microscopic fungi. It would take hardly less than 4000 of them set closely together, like beads, to make just

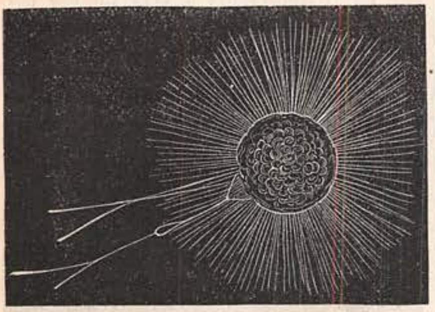


FUNGIFEROUS HAIR FROM A CHIGNON.

one inch in length. And yet they are really plants, and the hair thus infested may be called fungiferous hair. By looking at the figure very closely, you will observe that the middle portion of this fungous mass is made up of small bodies, considerably elongated. These forms may be called filamentous, while the parts on each side are composed of cellular and more spherical forms. These are but different stages in the life history of the same individual plant.

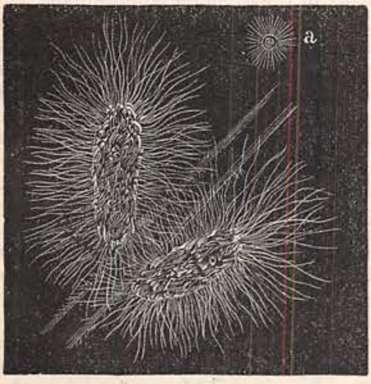
Now we must appear for a moment to digress; for it must be mentioned just here that the lower one gets down in the two realms of life, the animal and the vegetable, the more perplexing becomes the resemblance between them. Even the spawn of an oyster, when just emitted from the parental shell, is provided with *cilia*, or fleshy hair-like organs. With these propellers, like banks of oars, this microscopic being is really an active traveler in the sea. And it is similar with the spores of a seaweed. At maturity the cell containing them bursts, and out rush the sporules, and each one enters upon its travels, just as if it were not only an animate but a sentient thing.

To return to our chignon fungus, as shown in the figure, "Fungiferous Hair." Each plant here may be considered as a simple cell. After a little while, around each cell a groove or depression is noticeable. This keeps on deepening. There is some hidden force at work, as if an invisible thread were being drawn around each cell, until the constriction cuts it through. The one cell now becomes two cells, and each is a perfect one—that is, the one plant has really become two plants. Thus is the species multiplied by this division of each individual. But there were noticed in the mass some cells that were larger than the others, and it was observed that these large cells were filled with small ones. Some of these large ones had two *cilia*, or thread-like organs, extending from them, with which they moved along the hairs quite rapidly. Other cells had a bristling array of projecting organs,



A BUR-LIKE CELL OF CHIGNON FUNGUS.

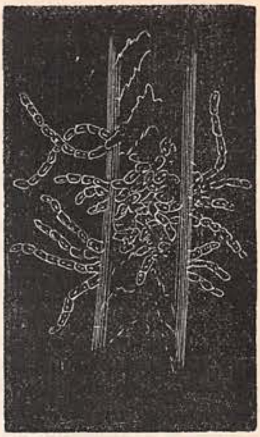
which gave them the aspect of chestnut burs. They had also a pair of organs very much longer than the other projections, and these were bifurcated at their farther ends. Doubtless all these threads may be regarded as serving like functions with the *cilia* of the oyster spawn. The figure shows this bur-like cell, with its young all in motion within the parent cell, and the numerous projecting threads, with the two long bifurcated ones. Another figure gives this chignon fungus in two masses when four-



CHIGNON FUNGUS FOURTEEN DAYS OLD.

teen days old. It is not very highly magnified. The remaining figure of this fungus is very much enlarged, and shows the structure of a mycelial portion next to the hair.

We may add that Dr. Tillbury Fox did not see any ground for much alarm in the facts he developed from this chignon parasite. He says the hair shafts, even though infested, seemed perfectly healthy after the pest was removed. He mentions, however, one stage of this torula-like fungus, at which, if it fell on the tender skin of an infant, it might beget a certain kind of scalp disease.



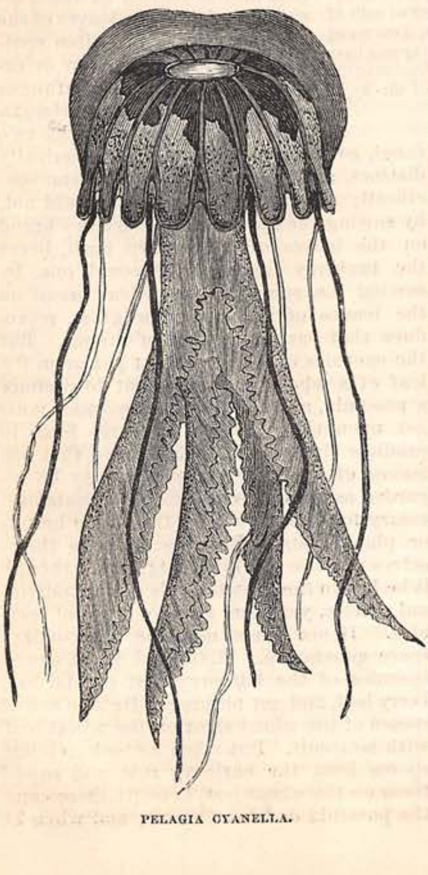
MYCELIA, OR THREADS OF CHIGNON FUNGUS, VERY GREATLY MAGNIFIED.

Thus ended the great chignon scare. After this verdict of the microscope every one breathed freely again; and each devoted fair, charitably blind to these foibles of her favorite, cherished as lovingly as ever her costly and charming back hair.

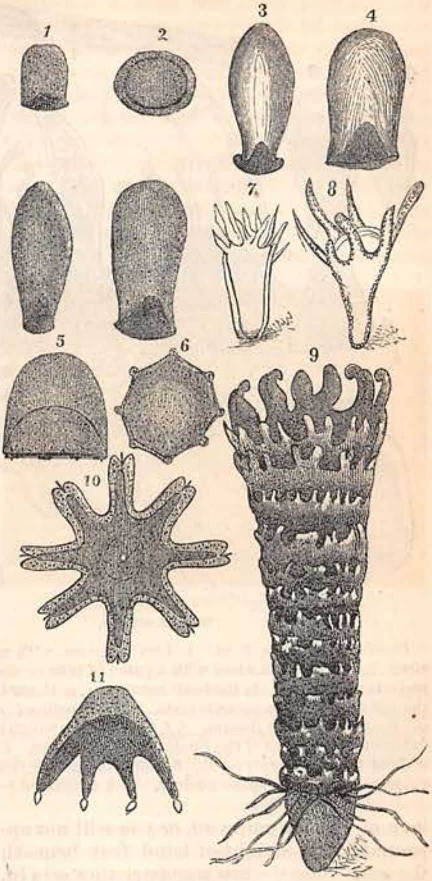
Although a complemental necessity to man's highest nature, did it not stagger Nicodemus when the great Teacher said, "Marvel not that I said unto thee, Ye must be born again?" And is this second genesis in the spiritual more wonderful than a certain analogous phenomenon which the microscope has made known in the material realms of life? Let us see.

Steenstrup and Sars, those wonderful Northern lights, by their discoveries made almost a new science of marine zoology. From his Norway home the latter announced things which seemed not lawful to utter, for he seemed to speak scientific heresy. But he spoke with the authority of a discoverer, and his words erased from the books whole troops of genera as facts not found in nature, but myths made of men. Certain curious creatures, long supposed to be adult forms of life, and bearing their generic names, were declared to be but different stages of a cycle of life through which the individual must pass ere it reached its adult form. There was the tiny planula, a mere speck, a jelly sphere, moving in the water by its *cilia*. And there were the hydroids, a community of polyp forms, minute beings fixed to the ground or a stone, anchored like little sea-plants. And they called this last by the name of scyphistoma. And there was a quaint little creature that seemed like a nest of baskets with ornamental borders. This also was anchored at its smaller end, and its name was strobila. Then there was a merry little being swimming in the sea. It was very small, and like a fruit dish with deeply cleft edges. Its name was ephyra. And, as every body knows, there was the acaleph, or medusa, the animate Montgolfier of the sea. And, fabulous as it may seem, all these were shown to be but temporary life phases in the life cycle of one individual, whose adult form was the medusa; and having attained this form, it produced eggs, and so the mystic cycle of life was run again. Now planula came of an egg; thus, strange though it seems, the fact is that Medusa begat the egg which begat Planula, and Planula begat Scyphistoma, and Scyphistoma begat Strobila, and Strobila begat Ephyra, and Ephyra begat Medusa—which also is to say, that Medusa is the parent of them all, and seems to be the great-great-grandparent of itself. Herein comes the hard word parthenogenesis, while to this series of phenomena is given the name alternate generations.

Look a moment at the cut of the pretty medusa, *Pelagia cyanella;* and the next cut, which figures the principal stages in the transformations of this medusa. Nos. 1, 3, 4, and the two figures over 5 and 6, are profiles of planula at different ages; No. 2 is No. 1 seen from underneath; 5 and 6 are planula farther advanced; 7 and 8 are scyphistoma at different stages; 9 is strobila; and 10 and 11 are ephyra from different



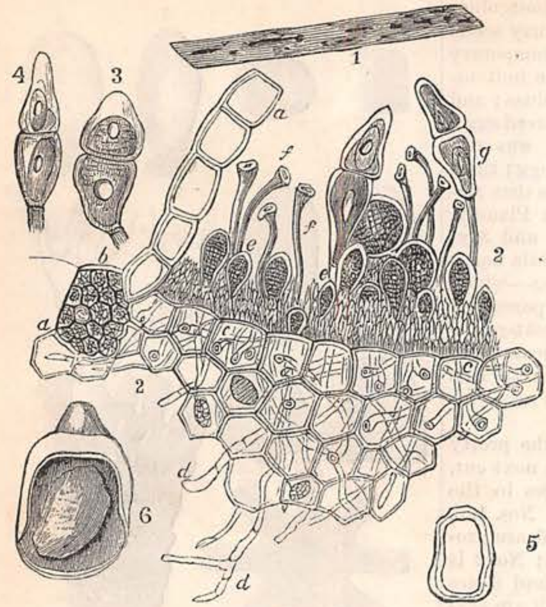
PELAGIA CYANELLA.



TRANSFORMATIONS OF A MEDUSA.

views. The last is one of the tiny dish-like or basket forms set free from strobila. It is already a floating being, and at its next change will become the elegant medusa, *Pelagia cyanella.*

This begetting must be taken, however, in a sense of its own. It is a sort of growth which may be called a "turning into." Thus planula turns into a scyphistoma, and that into a strobila, and this not into one other single thing, but a good round dozen at least of "othernesses" called ephyræ, much as a rocket ends in a constellation of distinctive stars. Indeed, this halt or stage in this singular life course looks very much as if nature might sometimes indulge in a bit of necromancy of her own. The feat is so bewitchingly like that of a juggler that one stands not a little astounded at the sight. Now there is no trick in the thing whatever, for although seemingly impossible, it is actual, and real planula, as we have seen, becomes transformed into a scyphistoma, and this again into a strobila, with its structure so like a nest of baskets. Just



WHEAT BRAND.

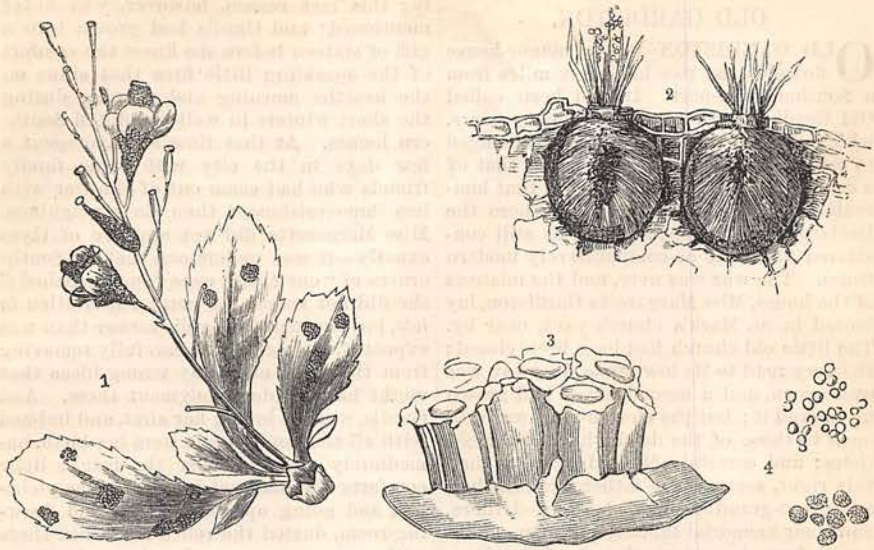
Puccinia graminis, Pers. 1. Leaf of grass, with mildew, natural size. 2. Section of the leaf with a patch of mildew and rust. *a*. Epidermis of the leaf. *b*. Bast-cell nerves. *c, c*. Outer layer of cells of the leaf on which the parasite rests. *d, d*. Mycelium. *e, e*. Young and old spores of *Cæoma lineare*. *f, f*. Stalks from which the spores have fallen off. *g*. Spores of the *Puccinia*. 3, 4. Spores. 5. Section of the wall of the lower spore-cell. 6. Longitudinal section of the upper spore-cell with the spore-nucleus. (2–6 magnified.)

look at what is going on, or you will not appreciate this sleight-of-hand feat beneath the sea. Near the top a constriction sets in, and the topmost basket is cut off, and drops dying upon the sea-bottom. By another constriction the one that now is the topmost is in like manner cast off, and lo! it sails away a living merry little ephyra, and it soon becomes a full-formed medusa. And so with the rest of this nest of basket-like forms: strobila casts them off one by one, each becoming an ephyra, and that becoming a true medusa, until the bottom basket is reached, and so strobila is used up, or has gone off into some dozen other forms, which become so many great-great-great-grand-ancestors to as many future cycles of medusan or acalephan life.

Does the biologist, whose functions are with the whence, the what, and the whither of all living things, fully comprehend this seeming legerdemain of strobila? He does not pretend to. Why should it be a law inflexible that strobila's first begotten shall inevitably fall still-born to the floor of the sea, while for the rest of her numerous offspring each shall receive a fair start in life? Well, the microscopist is still doggedly set at his task of investigation, and, depend upon it, we shall yet learn even this medusan mystery of life and death.

The reader has noticed what singularly like processes the microscope has revealed as at work in plants and animals respectively in the lower ranks of life. And lately it has brought out the very interesting fact that even in plant life there is an analogue of that strange phenomena, alternate generations.

In 1774, over a hundred years ago, it was that Krünitz's *Encyclopedia* mentioned the injurious effect which the contiguity of the common barberry bush had upon the wheat. Even then and ever since *savants* enough have been who have snubbed what has proved to be a common-sense conviction of the tiller of the soil. The farmer declared that with the barberry near his fields it was impossible to raise wheat without the brand. This brand or smut is a brownish stain or rust on the grasses and the grains. It is really a fungus, and is known as the *Puccinia graminis*. The leaves of the *Berberis vulgaris* are often spotted with a bright yellow or orange rust. This is the fungus known as the *Æcidium berberidis*. It now turns out that the two fungi, so long supposed to be generically distinct, are actually, generically, and specifically identical. And yet you could not, by sowing the spores of the barberry brand on the leaves of a barberry bush, beget the barberry fungus; nor could one, by sowing the spores of the wheat brand on the leaves of the wheat or grass, reproduce that particular kind of fungus. But the sporules of æcidium must get upon the leaf of a wheat or grass plant to produce a puccinia, and the puccinia sporules must get upon the leaf of a barberry bush to produce the æcidium. It is true that the leaves of the different plants may be regarded as the different soils or habitats necessary for the growth of these two brands or plant rusts. But the sporules themselves must be also different; that is, though it be but in the growth cycle of one individual species, yet there are two kinds of sporules. Hence there must be a secondary spore generation. M. Gauriel Rivet sowed sporules of the barberry rust on the barberry leaf, and got nothing. He also sowed spores of the wheat smut on the wheat leaf with no result. But when he took æcidium spores from the barberry rust and sowed them on the wheat leaf, behold! there came the puccinia or wheat brand; and when he



BARBERRY BRAND.

Æcidium berberidis, Gmel. 1. Branch of barberry with spots of rust, natural size. 2. Spermagonia. 3. A group of Peridia with their orifices dentated. 4. Sporidia. (2, 3, and 4 magnified.)

sowed sporules of puccinia from the wheat on the leaves of the barberry, behold! there came the true æcidium or barberry blight. For the patient development of these phenomena under the microscope we are indebted to Oerstedt and De Bary.

That is always a grand moment in experience when Truth enters the mind and illumes it with a new conviction. The writer well remembers the quiet awe that fell upon a class of youths when, in a lecture on the marsupials, he laid upon the table a live female opossum, and with an almost religious sense, gently opening, exposed to view her soft warm pouch, or secondary womb, in which, soon to be ready for their second birth, were the fœtal little ones, each adhering to its own lacteal font. And even here, in this unpretending spot of plant rust, this orange stain on this barberry leaf, are we confronted with the amazing mystery of a second generation in the one life of so lowly an individual.

In the cut of the "Barberry Brand" the spermagonia of the fungus is shown. They are upright vesicles, each prettily margined at top, and suggestive of so many little mantel-piece match safes. These spermagonia are literally vegetable wombs, in which the seeds or sporules are generated. The cut also represents the sporidia, or compound sporules.

Honor to whom honor is due. This instance of parallelism between the plant and the animal of corresponding grade or rank was seen, in advance of observation, so early as January, 1847, by an English clergyman, Rev. J. M. Berkeley, who has delved in quietness for more than forty years in this obscure field of microscopic labor. In a published article he then said, "It is quite possible that in plants as well as in the lower animals there may be an alternation of generations."

So here again the microscope shows its kindly human bias as eyes to the blind. It will with patience peer into that which a supercilious science will not so much as condescend to look at. In this instance, having got at nature's secret, it vindicates the plain common-sense of sensible men, and confirms beyond controversy that which could only be asserted in the confidence of conviction. In the words of the late Professor Joseph Czermak, one must not "remain standing at an event viewed unequally." But if it be an observation in which eyes and ears and perception have been true, and a conscientious testing of results has followed, why should one hesitate to contend for that which our eyes have seen and our hands have handled as the truth? In scouting the common-sense convictions of men, when based upon observations so often and trustworthily made, those *savants* were found flouting at a great principle in nature—that sublime activities are not limited to the so-called high fields of her operations. Does not their conduct stand painfully parallel with that of those philosophers of that ancient cultus to whom an even grander truth seemed "foolishness?"

THE MICROSCOPE.

By PROFESSOR SAMUEL LOCKWOOD.

PRYING INTO THINGS.

III.—ITS WORK.—(*Concluded.*)

MOTHERS know too well what is meant by the word "thrush," or "sprew," that mouth malady too common with little children. To the profession it is known as an aphthous ulceration of the tongue, aphtha being the name of the disease, and signifying a burning. The tongue "is swollen, tender, and furred." There are excoriated spots, sometimes true ulcers, varying in size, perhaps, from that of a pin's head to that of a half pea, and these are severally capped with a white curd-like mass. However diminutive these pustules may be, they are in truth hummocks of tiny plants, for each one contains many thousands of parasitic fungi, often called *torula.* These fungi attach themselves to the mucous membrane, and burrow among the epithelial cells. They are "composed of threads matted together like felt," whose basal ends intertwine among the epithelia, like hair in the prepared mortar of the plasterer. At a recent meeting of the Academy of Natural Sciences, Professor Leidy exhibited a mouse with little curdy patches on its ears, face, and nose. Mr. Indifference would have passed the matter by as a stupid trifle; and a spurt of insapience escaped one of the wise men, who wished to know "what the muss was." However, little *Mus musculus* was regarded as an abnormal case, and a proper subject of scientific inquiry. The query was now, "What ailed the little fellow, and where had he been?" At this juncture the microscope spoke out in meeting, declaring with authority that the white spots were colonies of a parasitic fungus; and, strange to tell, they were as much like the thrush fungus as one pea is like its fellow in the same pod. The truth told, Mousie was captured in the children's department of Blockley Hospital, where he had picked up the crumbs that had fallen from the mouth of a child patient. The diagnosis now seemed natural and direct. Mousie had been and got it—namely, the thrush—and, strange to say, he had got it bad, for it was on his ears and nose and face. Soon, in all probability, it would have entered the mouth, even if it had not already. A minute portion of one of these white spots was subjected by skilled hands to a lens of very high power, and lo! there were the morbid parasites, tiny sporular bodies, some single, some double, and others "in chains of a dozen or more." The fungus was pronounced to be a *torula,* or *oidium,* like that found in the disease known as thrush or aphtha. A drawing of it would simply be like a number of elongated beads strung together. But how diminutive these beads or cells were! A single one was the

$\frac{1}{650}$ of a line in length, that is, it would take 7800 of them in line to make an inch.

It is not in our limits to go into that interesting subject, "disease germs." Herein, however, it is fair to say that the microscope is making benevolent, because admonitive, revelations. Let it suffice to remark that these germs are not mysterious intangibilities, but real entities, of a material, and generally of an organic nature. For the most part they are plants—algæ and fungi. Once when away from home the writer was thrown upon the hospitality of a stranger for the night. Sitting with our host by the side of that homestead, we enjoyed the shade of an old *Pinus alba.* The noble evergreen grew close up to the house, and, summer and winter, its thick fasciculate foliage, like a curtain, shut out the hygienic smiling of the sun. The following conversation occurred:

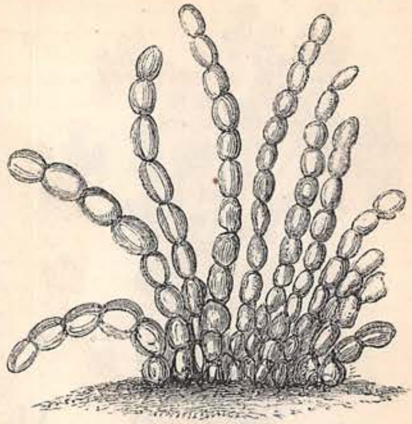
SELF. "Sir, does any one sleep regularly in that room which is so shaded by this tree?"

HOST. "Oh yes. Myself and wife have occupied that room many years—in fact, ever since we were married."

SELF. "*I* should not think it safe to sleep there. I venture to say that the walls are covered with invisible fungi, and that the atmosphere abounds with their floating sporules. I would not dare occupy such a room for any great length of time."

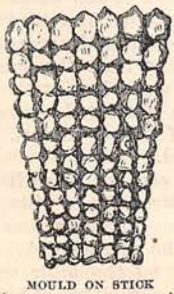
HOST (*in astonishment*). "Sir, now I see into it. Why didn't the doctor tell me? That's where my wife has lost her health. That tree's got to come down, and I'll let the sunlight into those windows like a flood!"

Thus the microscope reveals the ease and the method of spreading disease. It is literally a dissemination. In our mind there is not the least doubt that the common house fly is often a propagandist of dire and loathsome diseases. Take the thrush, for instance; for its communication what more is necessary than that a solitary cell of a torula or oidium should be transferred to a suitable nidus? For such an end, although accidental, how efficient an agent is the sucking tube of a fly, or the adhering disk of each foot! After feeding on the pustules of some disease, what is to hinder that some should adhere to the insect, and be conveyed over the threshold of some unconscious household, and thus that the mysterious disorder should obtain a foot-hold?



GRASS BLIGHT (OIDIUM MONILIOIDES).

Under the name of mould, these fungi, as torula and oidia, are almost every where. A red species is often found on very old cheese, another on glue, the several animal dungs when dry seem to have each its own species.



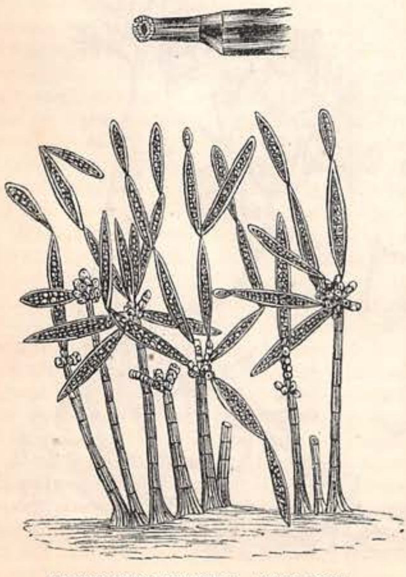
MOULD ON STICK (TORULA HISTERIOIDES).

DACTYLIUM DENDROIDES.—AFTER COOKE.

POLYACTIS FASCICULATA.—AFTER COOKE.

Also the fruits which fall to the earth and decay; and, in a word, as decay and fungus growth are often associated, so decayed fruit should not be eaten.

But it is well-nigh past belief what quaint yet beautiful objects many of these moulds become under the microscope. A mere vegetable stain, which when touched leaves a smut upon the finger, is thus unfolded into a jungle of plants, whose forms are of the most *recherché* character and wholly defiant of verbal description. In proof, look at the elegant mucedine, or vegetable mould, *Dactylium dendroides.* Again, examine the pretty hummock named *Polyactis fasciculata,* from the mould on the outer husk of a horse-chestnut.

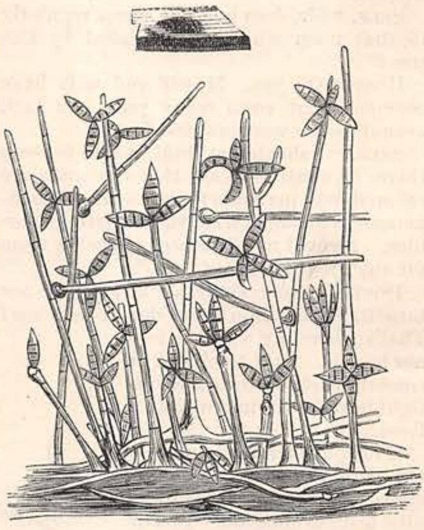


DENDRYPHIUM FUMOSUM.—AFTER CORDA.

The quaint *Dendryphium fumosum* is from a stain of black mould on the angelica; and the grotesquely eccentric *Triposporium elegans* is from a brand of a velvety black aspect on a barkless spot on an oak. But as these moulds are almost every where, these beautiful forms, which but for the microscope would be invisible and unknown, are beyond number.

Let us instance a noble service rendered our common humanity by the microscope.

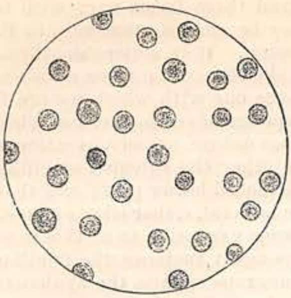
How often, like some spectacular scenes in a drama, do we find in the pages of the Old-World history passages of deep pathos and fierce passion, and both, alas! occurring as the offspring of religious superstition. So there were miraculous apparitions of blood, one while in rain from the heavens, and again in spots in the dwellings of God and of men. Of course these were portents of



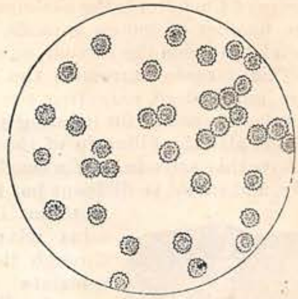
TRIPOSPORIUM ELEGANS.—AFTER CORDA.

most dire significance. The recital is too long, for even in Christian chronicles it covers a thousand years. In 1263, shocking to tell, while ministering at the altar of his church at Bolsena, a Bohemian priest was seized with the terrible temptation to doubt the transubstantiation of the wafer which he had just consecrated. Horrified at his own guilt, the celebrant of the mass beheld drops of blood oozing from the sanctified Host. All were awe-stricken at the miracle, and the Church instituted in commemoration the feast of Corpus Christi. Such was the pious legend.

In the fourteenth century, when Heinrich von Bulow had destroyed the village and church of Wilnach, as if to show that Heaven was pained at the sacrilege, eight days afterward the Host on the altar was observed to be stained with drops of blood!



HUMAN BLOOD CELLS (LIVE BLOOD).—MAGNIFIED FIVE HUNDRED DIAMETERS.



STELLATED BLOOD CELLS (DEAD BLOOD).—MAGNIFIED FIVE HUNDRED DIAMETERS.

Near the close of that fourteenth century appeared Raphael, a wonderful man, with a genius sublime, with passions groveling, and withal a religiousness that made him feel and pass for devout. In the now celebrated stanze of Raphael in the Vatican is that miracle of this painter's genius, "Miracolo di Bolsena." Its exhibition at each feast of Corpus Christi intensified the Church's conception of the so-called miracle which confirmed the faith of the Bohemian priest. Unhappily the bloody portent returned; the Host was again spotted with gore. The zeal of the ecclesiastics became insane, for, horrible to relate, thirty-eight innocent Jews were burned at the stake. For what? For crucifying the Lord afresh, for torturing the Host until it bled!

In 1824 the "blue Moselle" was horrified with a rain of supernatural blood; and again in 1848 this unnatural gore fell from heaven. And now Ehrenberg takes the matter in hand for sober investigation, and the microscope alone is to determine for the superstitions of men. This great man dissipated the miracle entirely by exciting wonder in another direction, for he announced that these bloody rain-drops were composed of real living organisms, but so minute was each individual that it would take over forty billions of them to make one cubic inch.

Thus the microscope has done away with these grim portents of a thousand years. This red snow and bloody slime have now their distinctive place and names among organic things. They are microscopic vegetables—unicellular plants. In the arctic regions Captain Ross found this encrimsoned snow extending in masses of miles. He brought some home, and the able botanist R. Brown pronounced it *Algarum genus*. It is curious to notice the controversy of so many able botanists, with their diverse judgments. But after a while all came back to the judgment of Brown; and Agardh, the able German algologist, gave this, the lowliest of the algæ, the name *Protococcus nivalis.*

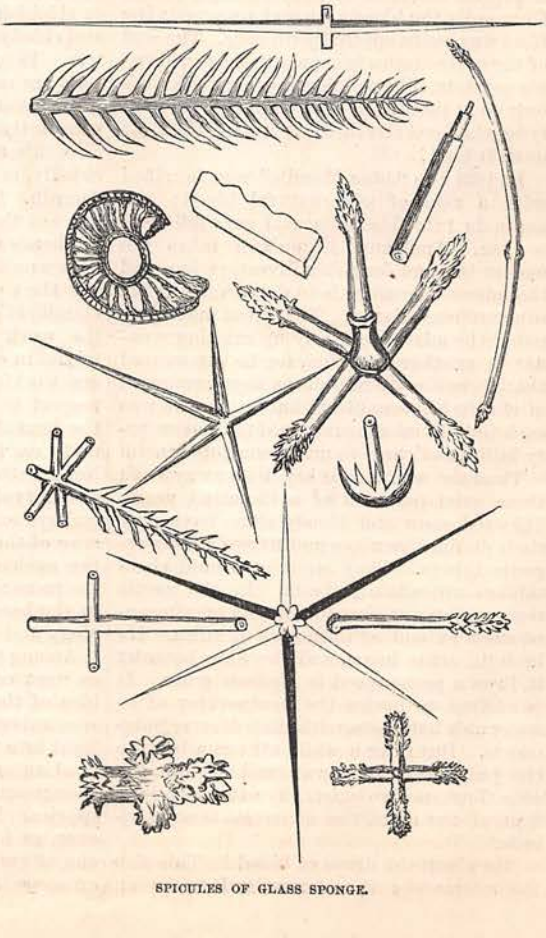
But about the drops of blood? This also the microscope has determined to be an alga, and bears the name given it by Agardh, *Palmella cruente.* Its structure is even simpler than that of an oidium. The name, though not romantic, is significant. Palmella means a vibration or quivering, and is here suggestive of that tremulous movement of which a great clot of coagulated blood is capable. The entire name indicates the significance of "quivering gore." In England the popular name of this fungous slime is "*gory dew.*" It occurs as shining red films or thickish blood-red stains on damp walls, and chiefly on the whitewashed walls of cellars. Being a unicellular plant, when the cells are mature there is a flowing together into viscous masses, which look and feel unpleasantly like clotted blood. Presenting also this aspect of gore, though not so decidedly, is the *Hæmatococcus sanguineus* of Agardh. Though moist to the touch, this has not the gelatinous character of palmella; hence the bloody illusion is not so vivid.

It would be profoundly interesting to follow the work of the microscope in scientific classification. It is beyond all question that the work of the ancient naturalists was trivial in comparison with that of those who are working the field to-day; and in this respect it can not be otherwise than that the lamented Agassiz set too high an estimate on the work of the great Stagyrite. None better than Agassiz knew the value of embryology in the work of the philosophical systematist. But embryology is a science of the present. It was not possible to the ancients. Nor is it possible to-day to the mere zoologist. It needs the microscope in the hands of him who is profound in zoology and an expert in microscopy.

Among the Japanese the sponge is known as "sea cotton." And until recently this idea of the vegetable nature of the sponge was universal. The microscope alone cast light into this darkness. The sponge is indeed an animal. It is also true that these sponge animals belong to many genera and species. The work of classification is, however, so far as the sponges are concerned, one of great difficulty, and without the microscope it is impossible. In general terms, the sponge of the toilet is the skeleton of an immense number of sponge animals. This horny skeleton holds the sarcode, or sponge flesh. This sarcode surrounds the entire structure, and, indeed, excepting the openings or tubes necessary for inhaling and exhaling, it is also the filling in of the structure. Now this sarcode is of a consistence like jelly, and would be diffluent but for the fact that it contains mixed all through it little spiculate particles of a siliceous or calcareous nature, that give to the sarcode a consistency or ability to hold together, much as the hair does to the plaster through which it is mixed. And as these minute spicules have very definite forms, and these forms vary with the species, they become of great help in their determination. It is noticeable, then, that a sponge skeleton, when alive, consists of two parts—the one with which we are familiar as the sponge of commerce, and which is of an animal nature, namely, keratose or horn, and the other the spicules, or filling in of the reticulated horny part; and these spicules are mineral, either silex or lime. Now the strange exception to all this is with the glass sponges: instance the familiar Japanese glass-rope sponge, the hyalonema. Its skeleton is all silex, the long fibres or threads which compose the rope or coil, also the finer structure called the head. The greater part of the head is made of very fine fibres or glass threads, and the filling in is with beautiful spicules of the same material. The whole skeleton, then, is composed of silex.

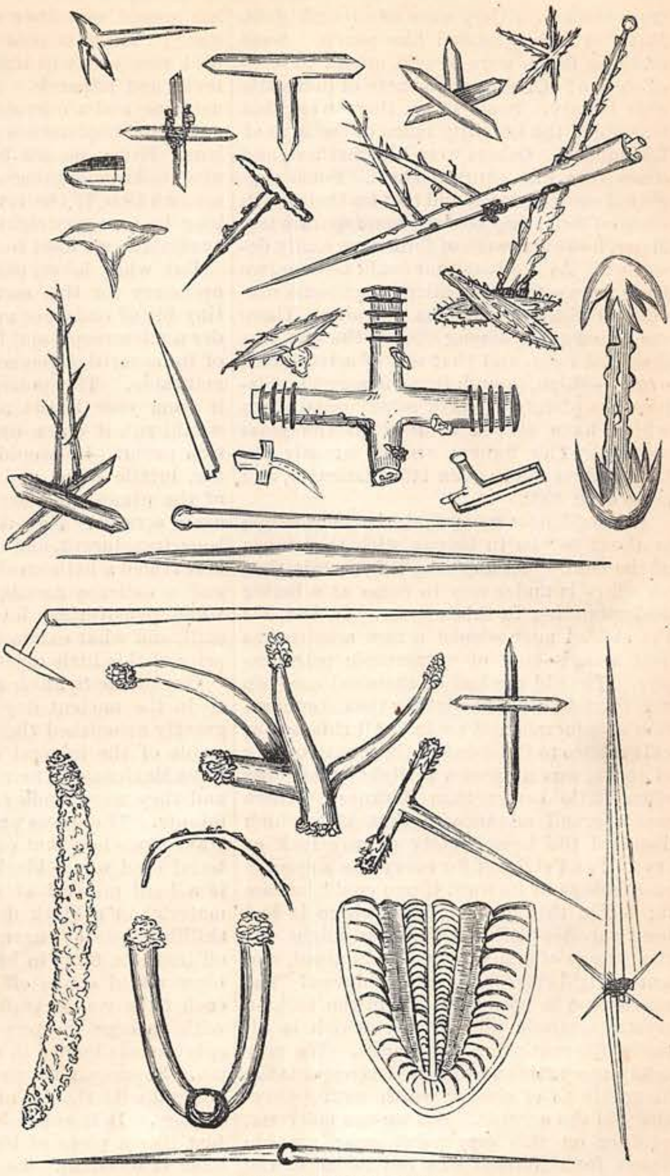
Now as showing the authority of the microscope in this connection, we must detail a bit of experience which occurred along with this writing. A scientific friend informed us that he had received direct from Japan a specimen of hyalonema which was

GLASS-ROPE SPONGE (HYALONEMA SIEBOLDI).—ONE-THIRD NATURAL SIZE.



SPICULES OF GLASS SPONGE.

a unique. We went to see it, and astonishment ensued. It was truly surprisingly fine, and as a specimen, certainly excelled any one that we had ever seen. The head was a deep thin cup, and quite symmetrical, and the whole specimen had a compactness which seemed to say that it had been selected from a thousand. Indeed, it was so fine that we became impressed with the suspicion that it was a fraud; that the head was not that of a hyalonema at all. A small portion of it was subjected to the microscope, which showed up the coarse irregular horny reticulation, such as is not to be found in the glass sponge. As to the spicules, none could be found. It was evident that a piece of the very thin yet large cup-like sponges so common in Japan had been cut out and folded just as the grocer makes a cornucopia. This was put at the top of a real glass rope of hyalonema, and by some cement the whole was so ingeniously secured as to escape observation. We then gave some attention to a true hyalonema.



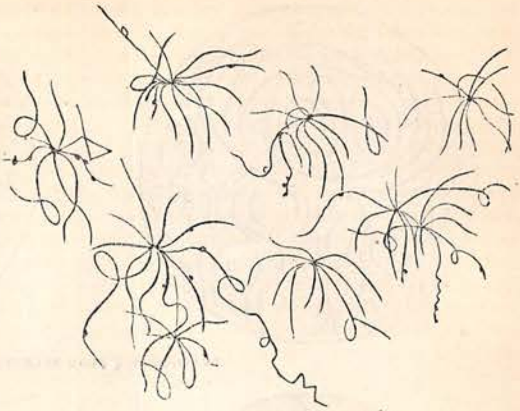
SPICULES OF GLASS SPONGE.

Taking a sheet of clean white paper, a hyalonema head was shaken over it. A little dust fell. This was carefully collected and put into a test-tube and boiled in nitric acid. This was intended to destroy every thing except the glass spicules that might be in that intangible dust. A little sediment was observable at the bottom of the tube. The acid was carefully removed, and the precious film left on the glass was now washed with scrupulous care. The water was then filtered through bibulous paper. A little stain of dust remained on the paper. When dry, some glass slips or slides were prepared for the microscope. This was simply done by touching a slide against the paper, when the merest trace of dust would adhere to the glass. The slide was next put under the microscope. The scene presented was a vision of beauty. Forms innumerable appeared as the slide was moved slowly on the stage of the instrument. The variety of these forms was endless, although nearly all could be reduced to a few patterns, of which they were modifications. And every one of these pretty figures was transparent, for they were of natural glass. Many of them gleamed like pearls. Some of these forms were so odd, others were so exquisite! Crosses were there of indescribable beauty. Some forms there were that resembled the knightly lance of the hero of La Mancha. Others were like feathers, and some were like churn-dashers. Some suggested snow crystals, and besides their similitude of form, they had the same sparkle too. Many, however, were of forms not easily described. As the best that could be done, we have drawn from the microscope some seventy of these hyalonema spicules. There are two figures among them—the one of a discoidal form, and that one of a truncated ovoid—which, though found among the spicules, are plainly shells of some foraminifera which have served as food to the glass sponge. The figures are all greatly enlarged, from 400 to even 1400 diameters, and some even 2000.

It would now seem that the microscope is about to "be in league with the stones of the field." At any rate, it is certain that an effort is under way to come at a better understanding in this matter. In fact, for the skilled microscopist a new science has just arisen—that of microscopic petrography. The old method of chemical analysis was thought all-sufficient for the determination of minerals and rocks. All this, so far as it relates to the constructive constituency of rocks, was a species of light which was often little better than darkness. There was a grand advance in that idea which disputed the homogeneity of any rock or crystal, and claimed for every one a specific morphology of its own, if one could but see it; for in this idea of form, where it had been supposed all was formless, might not the genesis of many rocks be explained, and a more rigid classification be achieved? The microscope is now revealing in the rocks a crystallographic idiosyncrasy which is already differentiating the species. We may safely accept this new method as respects the inorganic as of similar worth with embryology in the organic. But we can not resist quoting on this very point some graphic words from *Nature:* "In the midst of the darkness wherein the poor petrographers ticketed their specimens, carefully arranged their cabinets, and elaborated their dreary treatises, there fell among them (not from heaven, but from the hands of a worthy citizen of Sheffield) a microscope and a few glass slides, with a description of what could be done therewith. Eyes which had seen no light for so long could not at first make any thing of the apparition; but after a few years it began to take shape before them. And now the microscope promises to do as much in comparison for mineralogy and petrography as it has done for the biological sciences. From town to town this new light has spread, or rather rushed, all over Germany. There is now a sort of neck-and-neck race who will make the most slices of rocks and minerals. A cutting or rubbing machine and a microscope have become as necessary implements as a hammer and a lens. Every month brings to light some new 'mikromineralogische' contribution, insomuch that if the fever lasts we shall ere long be as overweighted with microscopic analysis as we used to be with chemical."

But what labor, skill, and patience are necessary for this sort of work! Take a tiny bit of obdurate granite and put it under a microscope, and beyond the enlarging of its asperities you see nothing that is remarkable. The petrographer would take it from your hands, and by tedious labor would rub it down until it was as thin as this paper. He would next take this tender, brittle plate, and with manipulations of the utmost delicacy, would polish away every scratch. Now it is transparent, or at least translucent, and under the microscope is revealed a little world of beautiful colors, and a delicate mosaic in structure. But what persevering labor, what matchless skill, and what exhaustive patience are the price of this little object!

One of the Spanish adventurers to Mexico in the ancient day on his return home greatly astonished the Castilians by his account of the mineral cutlery of those ancient Mexicans. Their knives were so keen, and they were made so fast—a hundred a minute. There was probably a dash of extravagance here, but only a dash. The material used was a black volcanic glass. It is a hard mineral, at sight much like the material in a black flint-glass bottle. By skillful blows long narrow flakes were struck off from the lump in hand. A single smart blow would strike off one long flake, and each flake was a knife ready for use, and with an edge unexceptionally keen. This substance is known in mineralogy as obsidian. Suppose, now, we look at a bit of this mineral with the eye of an amateur in mineralogy. It is volcanic glass, and it looks just like a piece of black flint-glass. We label it obsidian. To all appearance it is perfectly homogeneous. We put together a number of specimens from different countries, and with the exception of differences of color, we see nothing whatever to distinguish them. Well, is there really any difference worth talking about? We must put this question to some petrographist. Happily some exquisite engravings on this subject have been just given to the world by H. Rosenbusch, of Germany. Let us now follow him in his labors with his microscope. A bit of obsidian is the subject. At length it is prepared, a thin section or film. It turns out that the seemingly homogeneous mineral is full of queer objects, not unlike



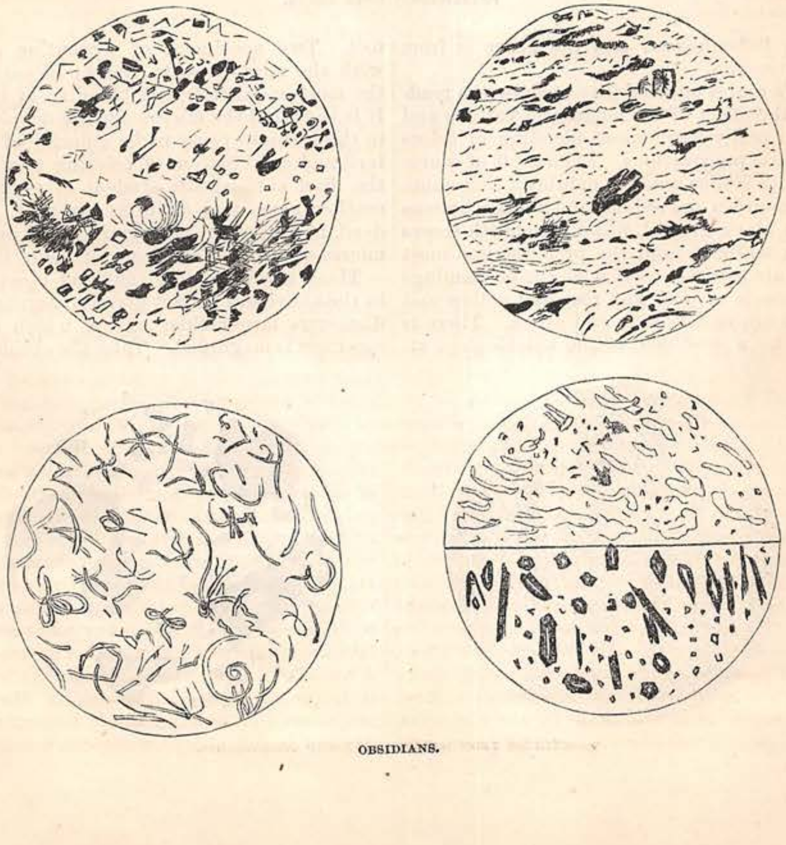
TRICHITES IN OBSIDIAN FROM TOKAY.

spiders. They are groups or rather knots of sprawling lines. To the scientist they suggest the idea of hairs; and so, drawing upon the Greek for a word, Haar calls them *trichites*, which means hairs. A similar marking pervades the mineral zircon. Let the reader now pause and look at the figure of these trichites in a specimen of obsidian obtained from Tokay; and let it be remembered that no such structure could be suspected, much less known, but for the petrographist. The little balls on the hairs are unpleasantly suggestive of the cruel loading of cat-o'-nine-tails, while the queer marking at the bottom centre of the cut must be left to some stenographer to interpret.

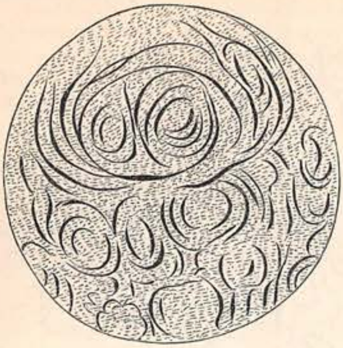
Constructively, then, a bit of obsidian differs immensely in itself. And it is even more remarkable how much a series of obsidians brought from different countries differ among themselves. The one just given, containing the trichites, was from Tokay. Here is a series of five more. The first is from Iceland. The second from the Lipari, a cluster of volcanic islands in the Mediterranean. The third is from Greenland. The fourth figure has a line through it; the upper half is a specimen of obsidian from Mexico, and the lower half one from Isle de la Réunion.

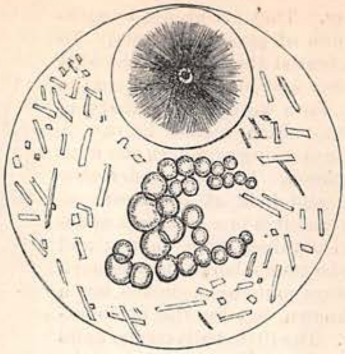
We give on the next page, from the same source, four figures illustrating specimens of perlite, or pearl-stone. Two are from Telkibanya, and two are from Arran. Their differences are astonishing, and each one has a beauty peculiarly its own.

As illustrative of the wide difference which the microscope reveals in the specimens set down as the same species, look at the two figures of tachylytes (page 820). One is

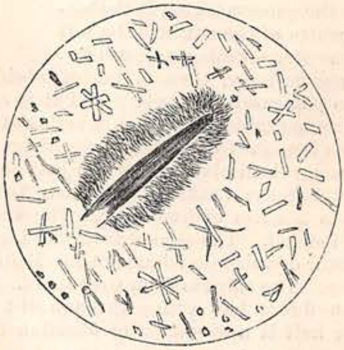


OBSIDIANS.





PEARL-STONES FROM TELKIBANYA.

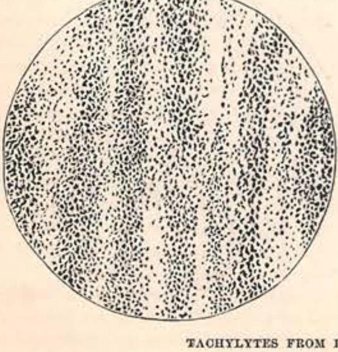


PEARL-STONES FROM ARRAN.

from Bobenhausen and the other is from Czernoschin.

We regret our inability to show the reader the effect of the singularly various and often really harmonious blending of colors in these preparations. Even a bit of coarse granite is thus made to exhibit a rich union of pea-green and reddish and pinkish browns on a black ground, while a sodalith shows on a white ground the prettiest and most delicate settings, as if it might be shadings in mosaic of pink and rose and yellow and light brown and blue and green. There is in some a good deal of the kaleidoscope effect. Two specimens of serpentine give, with the most delicate tracery of pattern, the most exquisitely soft blending of tints. It is thus that the microscope has developed in the hitherto prosy rocks a poetry of pattern and combination of coloring to which the most enthusiastic student of even the costlier gems was an utter stranger. Indeed, in this view, petrography makes the microscope the kaleidoscope of the rocks.

There would be an element of obscurity in the above did we not give the number of diameters larger than nature which each specimen is magnified. Take the obsidians.



TACHYLYTES FROM BOBENHAUSEN AND CZERNOSCHIN.

The one from Iceland is magnified 110 diameters; the one from Lipari, 150; the one from Greenland, 700; the one from Mexico and the one from Isle de la Réunion, each 150. The perlites or pearl-stones—the two from Telkibanya, the first one, 75, and the second one, 700; the two from Arran, the first one, 150, and the second one, 700. The tachylytes—the one from Bobenhausen, 700, and the one from Czernoschin, 150.

But we must bring this biography of the microscope to a close. There are broad fields of microscopic labor which we have not so much as mentioned. What a fascinating one is that of vegetable physiology! and how profound that one of animal physiology! and what a painfully interesting one that of pathology, which follows up the ravages of disease, and the many abstruse morbid phenomena of life and death! And there are those biological questions which at present are occupying the very ablest minds—the one question of spontaneous generation, and those allied ones, so profound, the beginnings of the functions of life. These and others show that the microscope is truly the one best eye of science.

To the student of the biological sciences the microscope, as the telescope to him who delves the depths of space, is absolutely indispensable. And from both realms what analogies or similitudes do these instruments find in matters material and things spiritual! The modern telescope, by resolution of the "star dust," has so multiplied these stellar bodies that we begin to forget their individual magnitude, and to regard them as spherules, or even as the organic cells of the universe, which last impresses us with the sense of infinity. And yet how very much remains unresolved! And so the microscope deals with the microcosm, man; it resolves him into cells, and it makes of these again habitable spheres. In this incomprehensibly diminutive cell dwell bacteria, vibriones, etc., to whom that cell is a universe. Organisms they are, and yet it would seem that organic species they are not. Says Professor Karsten, of Vienna: "The phenomena of animal reproduction have never been observed in them. They are pathological products, which grow in the interior of vegetable or animal cells, but which do not penetrate these when once developed as parasites." But this is just one of the profound sub-provinces of the microscope in pathology. Is it not another shadowing of infinity? for it finds the fungus, or unicellular plant, such a ubiquity in the realm of life that it would almost seem to be necessary as a fermentative or stimulative process or condition of life, as the fungi are assuredly present in the fermentative processes of disease. Perhaps every man in his microcosmic character may be to himself a faunal province, having his own specific fungi as a personal condition of harmonious vitality or otherwise. The microscope has not yet got at the bottom of these matters. In that stubborn membrane of diphtheria is there not a rank fungous growth, obtained probably from without, and lodged as in a rich soil or nidus in the purulent exudation? But like the dependence of the barberry blight and that of the wheat, may not these mycelia of diphtheria have a connection with morbid germs that have circulated in the lymph? Thus in respect to these ubiquitous little ones that swarm in the snow and the rain, in the air and the waters and the land, and inhabit the living things, both the plants and the animals of earth, that play their *rôle* in the sanative and in the morbid phenomena of things—of such is the kingdom of material life.

And in his character of a microcosm, as regards the mechanical movements of man, the microscope shows him as combining in himself representatively the movements of the very highest and the very lowest of all created forms and conditions of life. There is an animalcule known as the *amœba*. The word means "changing;" and this insignificant creature is rarely seen twice in the same form, for, like a tiny drop of viscid oil in clear water, it is always changing form. It is a little jelly globule many times smaller than the point of a pin. Though seemingly structureless, yet is it a living thing; and although one can not see any distinctive organs, yet it moves, entraps its prey, and feeds upon it. It certainly exhibits functional contractility. Its locomotion is a gliding movement, as if a tiny speck of liquid adipose a little flattened on its under side should glide almost imperceptibly along. If now an animalcule smaller than itself should happen in the way, it glides upon, envelops it, and, much as a sponge does water, absorbs its softer parts. Now in the blood of man are two kinds of cells, known respectively as the red and the white corpuscles of the blood. In the circulation of the blood the red cells flow like tiny coins through a convoluted glass tube, giving the idea of a rollicking movement, similar to that of some of the more highly organized animalcules under the microscope. But the white corpuscles move slowly and glidingly along. In fact, their movement is decidedly amœba-like. Thus the white blood cell, as Huxley says, "exhibits *contractility* in its lowest and most primitive form."

But, as already intimated, there are animalcules vastly higher in the scale of being. They are higher because they have real organs, cilia, by the lashing of which they travel in the water. This sort of movement is called "cilia locomotion." Now in man there are innumerable millions of microscopic objects known as epithelial cells.

They occupy the inner walls or lining of the mouth, the nose, and the breathing tubes, and elsewhere. Each epithelial cell has its cilia or lashes, some as many as thirty. In their several departments they are a busy crew, quite lowly, but decidedly useful, like those who clean the decks of the stately ship. Could we see them at their work in one's nose or any of the mucous passages, this is what would be seen: every one of these little things is immersed in the mucous lining; standing thus as if in the flow of a sewer, it draws its threads or lashes in a curve-like motion upward, that is, in a direction from the outlet of the nostril; then, with a more rapid movement, the lashes are brought downward in a curved position toward the outlet. As this singular activity is carried on by many millions of these epithelia, the effete mucus is driven toward and expelled at the natural outlet.

It would seem, then, from this analysis of the microscope, man is the paragon of animals in a sublimer sense than even the great poet dreamed. Indeed, the devout scientist when peering into these matters often beholds things which seem to him as visions almost unlawful to be seen or uttered. While a vulgar conception may entertain the notion of great or small in the creative works, the microscope dispels the illusion by showing the marvelous nature of the so-called small things, and the amazing fact that the one entity, whatever it may be, among material things, is itself an infinity of microscopic wonders. So that Saint Augustine, in an unscientific age, must have been moved by a scientific instinct when he wrote, "Deus est magnus in magnis, maximus autem in minimis" (God is great in great things, but He is especially great in the smallest things). In the old economy stood the Urim and Thummim. It is not clear what their precise functions were. It is plain that they were consulted in dark matters, and that the literal meaning of these stones is "light" and "perfection." So in modern science stands the microscope. Its little lenses, the ocular and the objective, are the Urim and Thummim, and for clear judgment, only the true priest of science can seek counsel thereof.

THE ROMANCE OF THE HUDSON.

[Second Paper.]

JOHN ANDRÉ.—[FROM PORTRAIT BY JOSHUA REYNOLDS.]

THE career of Major André on the borders of the Hudson River during a few weeks in the fall of 1780 has formed an attractive theme for the historian, the poet, the painter, and the sculptor. His youth and personal beauty, his mental culture and rare endowments, his social and official position, the magnitude and importance of the undertaking in which he perished ignominiously, and the tragic ending of his life have cast a glamour of romance around the deeds of one who was acting simply as a go-between in the service of two unscrupulous conspirators of high rank in the belligerent armies, plotting against the liberties of American patriots. He was sacrificed to the ambition and avarice of these two men.

John André, a captain in the British service, first appears in our history as a prisoner of war taken by General Montgomery at St. Johns, on the Sorel, in Canada, late in 1775, whence he was sent to Pennsylvania with several other captive officers, and paroled at Carlisle. The autograph order by John Hancock, then President of the Continental Congress, for taking that parole, and the parole itself, in Captain André's handwriting, and signed by him and nine fellow-officers, are in the possession of Dr. Thomas Addis Emmet, of New York, to whose kind courtesy we are indebt-