microscopical work. If he knows not by previous study of the fresh tissues, what nature puts in them, he will not be successful in revealing them best in mounted preparations.

Biological science is not to be studied from microscopical slides, no more than from stuffed animals or dead shells in our museums. Botanists do not get best education by poring over mounted specimens, however beautiful they may be, no more than they do by daily browsing on the desiccated vegetation in herbaria or haystacks. We must go to the living for the best use of our instruments, and a knowledge thus obtained of structural detail is essential before any attempt should be made to preserve such details in mounted preparations. Some post-centennial work in botany, aiming at that result, has been exhibited before the Section, in which every cell showed the cell anatomy; the nucleolus, nucleus, protoplasmic contents, and cell-wall were all apparent at one view. Demonstration which falls short of this is unsatisfactory, because important morphological details are not brought out, and such work, like fossils in the rocks, belongs to a past era in microscopical technology.—*The Cincinnati Medical News*, March.

VI.—*Opaque Objects with High Powers.* By G. W. MOOREHOUSE.

A FEW words, giving experience in the use of opaque illumination with the highest powers of the microscope, may not prove entirely without interest. Some of the powers now successfully used in this way have even been thought extraordinary when used with transmitted light, and this may have led some persons to doubt the practicability of this method, and so prevented their giving it a trial. There are no natural tests yet known to have been well defined by the best microscopes that may not be seen with a power of 500 diameters. Of course it is often necessary, in order to understand the structure—say to distinguish circular markings from hexagonal—to resort to an amplification of 2000 to 4000. Can such powers be profitably used with illumination from above the object?

Many errors of interpretation arising from the use of transmitted light might be avoided if we could view all microscopic objects by light reflected from them, as we do almost everything we see with the naked eye. Yet with careful and practised use of transmitted light the same results may be obtained on suitable objects.

Place a thin leaf of honeycomb between your eye and a lamp, and mark the varying appearances and shadows as you increase the distance between the object and the eye, and as the position of the lamp is changed from central to oblique. Something of an

idea of the difficulties of interpretation accompanying ordinary methods of illumination may thus be obtained, both as produced by changes in focal adjustment and in position of mirror.

Attempts have been made to use high powers on opaque objects by making pointed-nosed objectives, and also by constructing conical front lenses, and these methods have met with some degree of success with objectives as high as dry $\frac{1}{4}$ ths; but as the finest views of the smaller objects and minute structural peculiarities can only be got with immersion objectives of wide angle of aperture, that necessarily have short working distances, other plans had to be invented. One proposition was to throw the light down one tube of a binocular instrument and view the object in the other tube, thus making the instrument its own illuminator. Previously, Professor Smith had devised a plan by which the objective itself was made the illuminator, light being reflected downward into it by means of a small silver speculum. The light was admitted to the speculum through an aperture in the tube, or an adapter above the objective. As all are aware, several opticians have made more or less important modifications of this device. The one I have used is described in Carpenter, fifth edition, page 153, under the name of Beck's Vertical Illuminator. It is simple, cheap, easily removed and cleaned, and admirably suited to the purpose for which it was made. It consists of a disk of thin glass attached to a milled head, and placed in an adapter fitted with the Society screw, and placed between the objective and the body of the instrument. The light entering the aperture is reflected by the glass disk downward into the objective, and by it concentrated upon the object.

In using the instrument, as a general thing, the lamp should be placed about eight inches from the aperture, and opposite it, but, on some objects, it is desirable to change both distance and position. The German student's lamp is poorly adapted for this work, and I have found the ordinary flat wick or sun-burner to serve a much better purpose. The lamp should be placed with the flame edgewise toward the aperture, and the narrowest possible image of the flame brought to the centre of the field of view. The image of the flame as seen in the instrument should be so perfect that any flickering of the blaze may be distinctly seen. A small bright image of the flame may be seen on the under surface of the slide with a pocket magnifier. The mirror under the stage may be used with advantage to find and centre the object, and at times illumination, both from above and below, may be used advantageously in determining the character of the study.

Dr. Carpenter speaks of the vertical illuminator being "specially applicable to diatoms, Polycystina, minute foraminifera, and the scales of insects, viewed under objectives of from $\frac{1}{10}$ ths to $\frac{1}{3}$ th

of an inch." Evidently this means dry-working objectives. A few gentlemen have used it with immersion objectives. When an immersion lens is used, the whole aperture of the objective is available, both as a condenser and an objective, for the light passes through the glass cover to the object without reflexion from the upper surface of the cover, as would be the case with all rays striking the cover at an angle of total reflexion, if a dry front was used.

I have used this illuminator with excellent results with $\frac{1}{10}$ th and $\frac{1}{20}$ th immersion objectives, with lamp as described above. Improved effects may sometimes be produced by introducing the hand or a diaphragm between the lamp and reflector, cutting off a portion of the light, and such tests as *Pleurosigma Spencerii* and *Navicula rhomboides* may be well resolved.

The object should be mounted dry, and in close contact with the covering glass, so that the extreme oblique rays will pass to it, and not be reflected from the lower surface of the cover. The usual care must be taken in correcting the objective for thickness of cover.

I append selected memoranda of observations to show the utility of this mode of using the microscope, and venture to presume that no one will deny the general trustworthiness of illumination by reflected light, or the fact that errors of interpretation are less likely to creep in with it than with ordinary transmitted light. Objects are seen in their natural colours, and the views obtained of such specimens as the scales of insects are indeed beautiful. This is also true of numerous other objects.

The scales of *Macrotoma major*, *Lepisma saccharina*, *Deegeria domestica*, and *Lepidocyrtus curvicolis*, I have been able to see better, and the true character of the markings more satisfactorily indicated, than by any other method of illumination. It may not be out of place to state the fact that no semblance of the so-called beading is to be seen on any of them. The *Macrotoma* and *Lepisma*, like the scales of the gnat, show only the longitudinal, or, as the case may be, radiating ribs, with the transverse and often irregular and waved corrugations or wrinkles. The smaller scales of any of the insects named show almost as easily and distinctly as the larger, the resolution is so much superior to that ordinarily employed. With the Tolles immersion, $\frac{1}{20}$ th powers of x2500 and x4000 were employed; and with Tolles' four-system $\frac{1}{10}$ th, x500, x1000, x2000, and x4000, the last two by using $\frac{1}{2}$ -inch and $\frac{1}{4}$ -inch solid eye-pieces. The objects were well defined, with enough light, even with the highest powers used.

The *Deegeria* scales are covered with short or interrupted ribs, or long spines, adhering to the surface of the scale; a structure intermediate between the true ribs of the *Macrotoma* and the short

spines of the Podura scale. It must be remembered that these three insects are very closely allied. That Podura scales are really armed with projecting spines I consider as proven by the experiments of Dr. Arnold, of New York, a few years ago; but if any further proof was needed, the *demonstration* is complete by this method of illumination. Both on the scales of the American Podura and the British *Lepidocyrtus* Podura, the spines are seen distinctly projecting anywhere on the surface of the scale, and also over beyond the end of the scale farthest from the body of the insect. The inference would appear to be that the scales are undeveloped hairs, and the spines secondary hairs, and that the latter are in some species modified, or imperfectly developed, so as to form ribs.

Of the many diatoms examined I only mention one, the *Pleurosigma angulatum*. Some of the specimens of this test were mounted by Möller, and others by Wheeler. All are seen in hexagons, and with great distinctness; not, however, surpassing results obtained by other illumination. I send with this communication a slide of broken specimens of a coarsely marked variety of this diatom, found in Nottingham earth. I think it will readily be seen that the line of fracture runs through the hexagonal areolæ, often leaving the points of the network projecting. The vertical illuminator confirms this idea of the structure. It will be noticed that some of the fragments of *Angulatum* on this slide are split into two layers or plates; the two plates are quite distinct, and the line of fracture of each may be easily traced in some of the pieces. With the $\frac{1}{10}$, and a $\frac{1}{2}$ -inch eye-piece, with either the opaque illuminator or an objective used as an achromatic condenser, the edges of the fractured specimens are clearly defined. Although the *Angulatum* is made up of two plates like *Coscinodiscus*, the two plates are much nearer alike than they are in *Coscinodiscus*.

The coarsely marked diatoms are displayed with great beauty under this reflected light, and one can have but little doubt in regard to their true structure; and this in a still greater degree is true of insect scales. On the whole, then, opaque illumination, with high powers, cannot be said to be a failure, but, on the contrary, almost or quite keeps pace with the easier problem (as far as construction of accessories is concerned) of illumination by transmitted light, and proves itself a valuable aid, even when the most difficult and strongly controverted questions are attacked.—*A paper read before the Dunkirk (U.S.A.) Microscopical Society.*