CHAPTER XIII.

MICROSCOPY.

The world of the minute existing beyond the range of the unaided vision is little realized by those who take no interest in microscopy. The beauty and perfection of the smaller works of nature can never be fully known through the medium of literature or art; the objects themselves must be observed by the student personally.

In every pond and stream may be found microscopic forms of life. In every plant and flower, upon leaves and stalks, among the sands and rocks, almost everywhere in all seasons, may be found objects of absorbing interest to the student of microscopy. Animals and insects, food and manufactured articles, yield objects which may be examined microscopically with pleasure and profit. Chemistry and mineralogy afford attractive fields, and the physicist finds the microscope a necessity in his investigations. In fact, one so inclined cannot fail of finding interesting and instructive objects with little difficulty.

Microscopical investigations may be carried on by the aid of an ordinary inexpensive microscope, but this, in the natural course of things, will give place to a more perfect instrument and a complete list of accessories, provided the student becomes interested in the subject. A fine instrument is desirable on account of its wider range of usefulness, its superior optical powers, and the facility with which it may be adapted to different classes of objects. It has the further important advantage of being less fatiguing to the eyes.

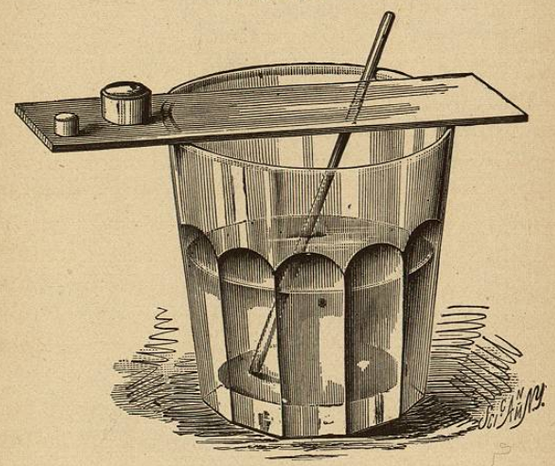
The simplest and cheapest of all microscopes is represented in Fig. 291. It consists of a thin piece of glass, having attached to it one or two short paper tubes, which are coated with black sealing wax, and cemented to the glass with the same material.

By aid of the small stick water is placed, drop by drop, in the cells until the lenses acquire the desired convexity. Objects held below the glass will be more or less magnified, according to the diameter and convexity of the drop.

A convenient stand for the water lens is shown in Fig. 292. The detail views are vertical sections of the lenses, showing the screw for adjusting the convexity of the drop.

The stand is made of wood. The sleeve that supports the stage slides freely upon the vertical standard. A wire having a milled head passes through the upper end of the

FIG. 291.



Simple Water Lens Microscope.

standard, and has wound upon it a strong silk thread, one end of which is tied to a pin projecting from the stage-supporting sleeve. An elastic rubber band is attached to the lower end of the sleeve, and to a pin projecting from the standard near the base, to draw the table downward. The stage is raised or lowered by turning the milled head.

Two standards project from the bed piece for receiving the corners of a rectangular piece of silvered glass which forms the reflector.

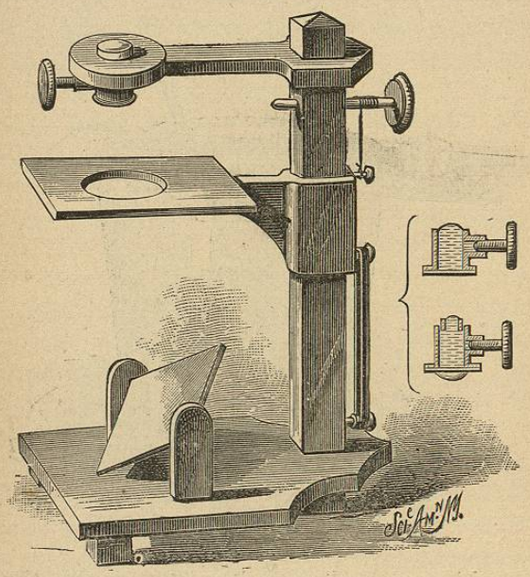
The water cell consists of a brass tube about $\frac{3}{8}$ inch long and $\frac{1}{8}$ to $\frac{3}{16}$ inch internal diameter, having in one side

a screw for displacing the water to render the lens more or less convex. A thin piece of glass is cemented to the lower end of the tube, and the inside of the tube is blackened.

Several bushings may be fitted to the upper end of the tube to reduce the diameter of the drop, and thus increase the magnifying power of the lens.

Water containing animalcules or a solution of a salt for crystallization may be placed on the under surface of the

FIG. 292.



Water Lens Microscope Complete.

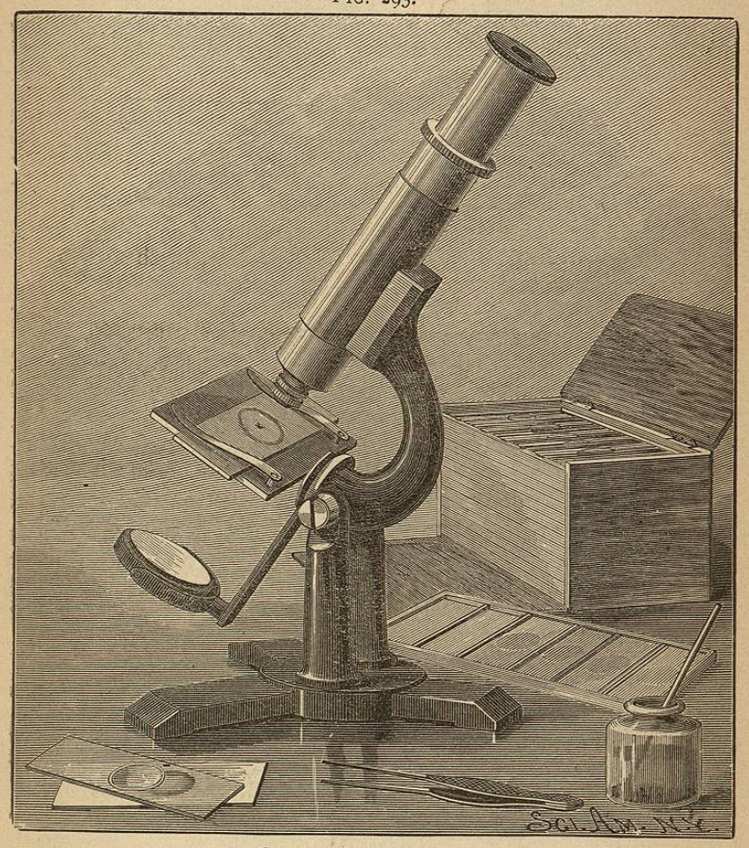
glass, when the lens may be focused by turning the adjusting screw. The lens may be adjusted to magnify objects placed on the movable stage by rendering it less convex, thus increasing its focal length.

Air bubbles forming on the upper surface of the glass may be readily displaced by means of a cambric needle.

The water lens microscope or any lens or combination of lenses through which an erect virtual image is seen, magnified, is known as a simple microscope, while a compound

microscope is an instrument in which a lens, or system of lenses, known as an objective, forms a real and greatly enlarged image of the object, and in which this image is itself magnified by a second lens or system of lenses, known as the eyepiece or ocular.

FIG. 293.

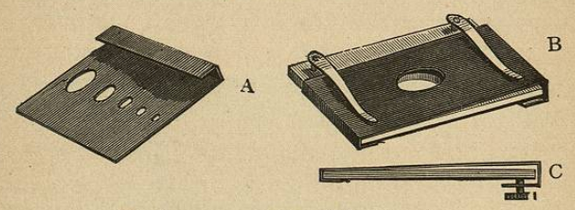


Compound Microscope.

An inexpensive compound microscope is shown in Fig. 293. This instrument, when closed, is 8 inches high, and has a draw tube which permits of extending it to a height of 11 inches. The foot and arm are of japanned iron. The tubes are well finished and lacquered. It has an

achromatic objective divisible into two powers. The mirror may be swung over the stage for the illumination of opaque objects.

FIG. 294.



Diaphragm and Fine Adjustment.

To the instrument as received from the manufacturer is applied a home-made diaphragm, as shown at A, in Fig. 294, and a fine adjustment, as shown at B C, in the same figure. The diaphragm consists of a piece of perforated thin sheet metal, extending along the under surface of the stage, and neatly bent over the outer edge of the stage, so as to be

FIG 295.

Substitute for Revolving Table.

self-supporting—the perforations of the metal being respectively one-sixteenth, one-eighth, three-sixteenths, one-fourth, and five-sixteenths inch diameter, all arranged on a longitudinal line of the metal plate intersecting the axial line of the microscope tube, so that the centers of the holes of the diaphragm may be made to coincide with the center of the hole in the stage.

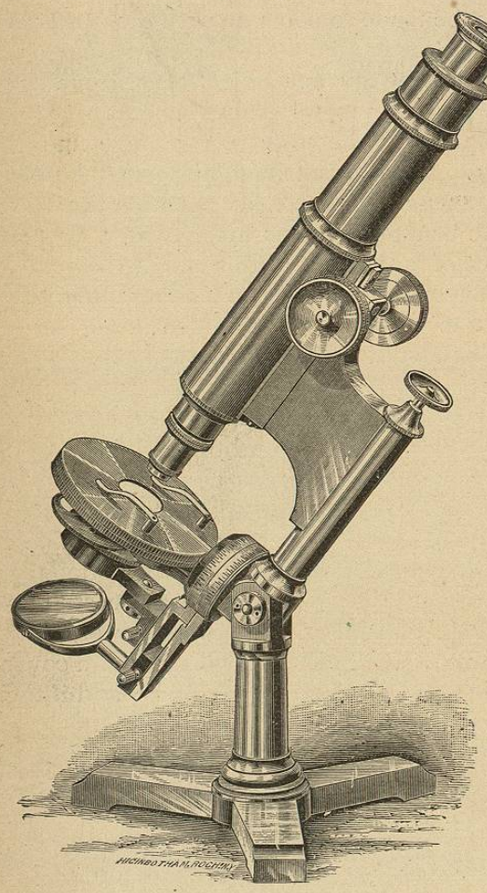
The attachment for fine adjustment is made by bending one end of a thin metal plate twice at right angles, so that it will spring on the edge of the stage and clamp the stage tightly. The opposite end of the metal plate is bent in a similar manner, but the space between the body of the plate and the bent-over end is made wider, to permit of a small amount of movement of this end of the plate. In the portion of this end of the plate extending under the stage is inserted a fine screw with a milled head, by means of which the free end of the plate may be made to move either up or down through a small distance. The body of the plate is inserted under the stage clips, and the object slide is inserted between the clips and the movable plate.

The instrument has no rack adjustment, but the main tube slides easily and smoothly in the guide tube, so that little or no difficulty is experienced in focusing. Besides the instrument and accessories, only the following articles will be required to begin in earnest the study of microscopic objects: A small pair of spring forceps, a bottle for objects, a few concaved glass slides, a few thin cover glasses, a glass drop tube, a small kerosene lamp; and if the investigator desires to entertain his friends with the microscope, he will need a Japanese or tin tray, large enough to contain both microscope and lamp, as shown in Fig. 295, so that the relation of both may be preserved while the tray is moved to bring the instrument into position for different observers, by simply sliding the tray on the table.

A little caution as to illumination is necessary, as the beginner is generally unsparing of his eyes, using far too much light. A blue glass screen placed between the mirror and source of light, or between the mirror and the stage, modifies the light so as to greatly relieve the eyes.

The lamp should be provided with a shade of some sort to prevent the light from passing directly from the lamp to the eyes. A small Japanese fan suspended from the chim-

FIG. 296.



A Modern Microscope.*

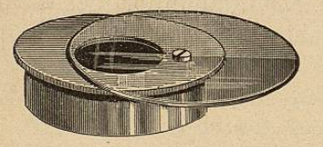
ney by a wire, as shown, forms a very desirable shade. Most objects viewed by transmitted light in an instrument of this class require an absolutely central light, that is,

* Bausch & Lomb Optical Co.'s "Universal."

the light must be reflected straight upward through the object and through the tube.

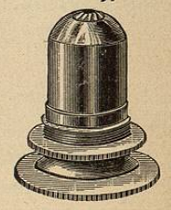
When opaque objects are examined, the mirror is raised above the stage and made to concentrate the light on the object. Different angles of illumination should be tried, as some objects are greatly relieved by their shadows, while

FIG. 297.



Light Modifier.

FIG. 297*a*.

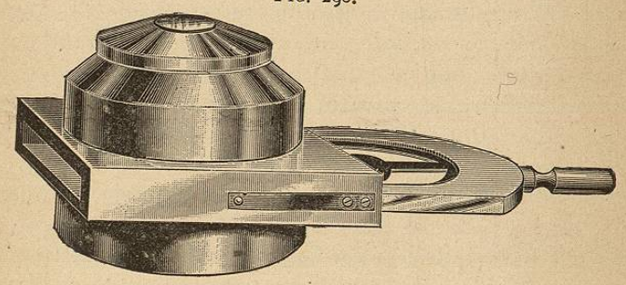


Iris Diaphragm.

others require illumination as nearly vertical as possible. Experience will soon indicate the right magnification for different objects. This may be varied by taking off or putting on the lower half of the objective, also by drawing out or pushing in the draw tube.

For truly scientific microscopical work a better instru-

FIG. 298.



Sub-Stage Condenser.

ment than that already described will be needed. The microscope shown in Fig. 296 is perfectly adapted for general use. The main tube has two draw tubes by which any desired tube length may be secured. The coarse adjustment is effected by means of a rack and pinion; and a

micrometer screw is used for the fine adjustment. The stage, which is revoluble, is made thin to allow of the greatest obliquity of illumination. The arms which support the sub-stage and the mirror turn upon the same axis, and are capable of being moved independently. The mirror may be swung above the stage for the illumination of opaque objects.

The sub-stage is adapted to receive any of the accessories, such as the light modifier shown in Fig. 297, the condenser represented in Fig. 298, and other desirable and indispensable appliances. A stand of this character is perfectly adapted to objectives of the highest class. All adjustments required to secure any angle of illumination, any position of the object, or any degree of fineness of focalizing, can be made quickly and with precision. The possessor of a microscope of this quality will always feel a degree of satisfaction which the poorer instrument can never give.

A larger, more complete, and at the same time much more expensive microscope is shown in Fig. 304, in connection with light-intermitting apparatus. This microscope has, in addition to the features already described, complete mechanism for centering the stages, a rack and pinion for the sub-stage adjustment, a graduated circle on the stage, a graduated head on the micrometer screw, graduations upon the pillars for the angle of inclination of the tube, and graduations at the base for measuring angles of objectives. A microscope of either of these grades, with a complement of fine objectives, eyepieces, and other necessary accessories, will yield all the results attainable at this stage of microscopy.

The graduated blue glass light modifier above referred to consists of a disk of flashed glass ground and polished so as to give all shades between white and dark blue, both transparent and translucent. This disk is pivoted upon an adapter (Fig. 297), so that it may be turned to receive any desired quality of illumination. It may be used in conjunction with the condenser shown in Fig. 298. This condenser is fitted to the sub-stage, and is provided with several stops

and diaphragms, by which the light may be controlled. This condenser has a very wide angle, and is adapted for use in connection with objectives of all grades; but its efficiency is specially noticeable when it is used in connection with objectives of high numerical aperture in the examination of difficult objects and the resolution of tests.

The iris diaphragm shown in Fig. 297*a* is of great value in ordinary work. As its name indicates, its aperture may be expanded or contracted to adapt it to a particular object. It shuts off much superfluous light, thus saving the eyes; at the same time improving definition of the object.

For further information regarding microscopes and their accessories the reader in referred to the literature of the subject. Of this there is an ample supply.*

GATHERING MICROSCOPIC OBJECTS.

Objects for microscopical examination are gathered by means of a wide-mouthed bottle clamped in tongs attached to a long handle, cane, or even a fishing rod. By this device mud can be removed from the bottom, the stems and leaves of aquatic plants can be scraped so as to remove animalcules, and objects can be readily dipped from pools and shallow places. The under surface of plants and of grasses hanging over into the water may be scraped with the bottle, and more or less of the matter adhering thereto will be secured. Occasionally a long leaf like that of the flag may be lifted from the water and traversed by the bottle with good results. Small twigs and dead leaves floating in the water are often found teeming with life. The thousands of animalcules and forms of minute plant life found in water will afford the most zealous student a life-long supply of objects for examination. A wide-mouthed bottle or jar is provided with a perforated cork, in which is inserted a funnel for receiving the material; and another funnel, inverted and placed within the jar or bottle, with its nozzle extending

* "The Microscope and its Revelations," by Carpenter; "How to Work with a Microscope," Beale; "How to See with a Microscope," Smith; and "Practical Microscopy," by George E. Davis, are among the excellent works on the subject.