

MINIATURE ART OF NATURE AND SCIENCE.

THE BEAUTY REVEALED BY THE MICROSCOPE.

BY DR. V. GRAFE.

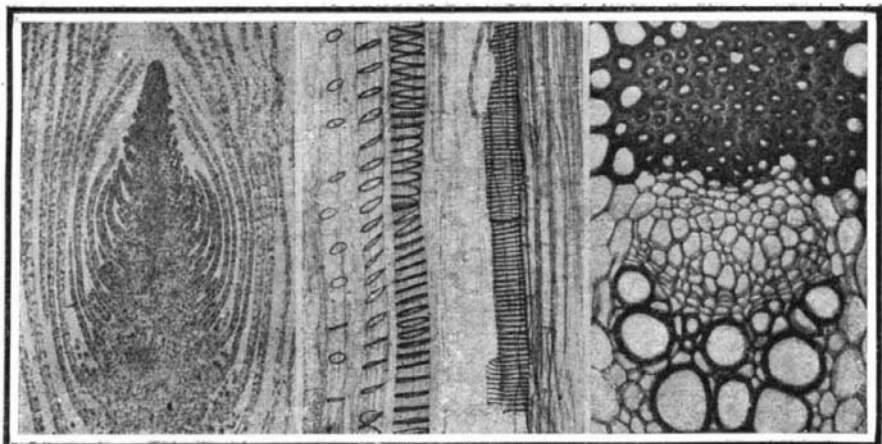
THE improvements of the microscope of Leewwenhoek opened to our view a world of miniature marvels, and the subsequent development of the instrument and of the methods of microscopic research enable us now to recognize exceedingly fine and remarkable details

ous objection. Although great improvements have been made in the method of making such drawings, it is still impossible to reproduce every detail of the microscopic picture. Furthermore, every such drawing is affected by the personal error of the draftsman,

interesting problems which are here presented to the draftsman, the sculptor, and the goldsmith. Many microphotographs of these objects contain ideal designs for carpets, wall paper, jewelry, and embroidery.

The making of such photographs is not easy. The sections, which are always difficult to make in the case of embryos, leaf buds and numerous other objects, must for this purpose be executed with especial care, in order to give prominence to the particular detail which it is desired to reproduce. The staining requires special knowledge and skill, which differ with almost every preparation. Not the smallest hair or grain of dust must be permitted to mar the distinctness of the picture. In photographing, the microscope is placed horizontally and in exact alignment with the bellows camera and the source of light—self-regulating arc lamp. The degree of enlargement must be chosen with careful reference to the sharpness of the picture. The time of exposure depends on the thickness and transparency of the object. It is also necessary to employ taste and discrimination in the choice of objects for, while the draftsman can correct nature here and there, the camera reproduces every defect with ruthless accuracy. The photographic operations require good scientific training as well as technical skill, in order that the anatomical and photographic details may harmonize. From the negative are made positive lantern slides which can be projected on screens to exhibit all the microscopic details to large numbers of spectators.

The photographs here reproduced were made in Hinterberg's laboratory from objects prepared by Dr. Jencic of the University of Vienna. One of the pictures (Fig. 5) shows a cross-section of a linden stem. In the center and occupying most of the section is the



Left-hand picture—Terminal bud. Middle picture—Longitudinal section of stem, showing water tubes of various forms. Right-hand picture—Cross-section of a vascular bundle (more highly magnified). The thick-walled dark cells at the top are bast cells, the thin-walled cells below them are phloem, and the large circles at the bottom are water tubes.

FIG. 1.—THREE MICROPHOTOGRAPHS OF THE WATER WEED (ELODEA CANADENSIS.)

in the anatomical structure of animals and plants, and thus to gain an insight into the processes of life. Many anatomical preparations are masterpieces of technical art and skill, showing all details which are resolvable by the microscope and which, in many cases, are present only in particular stages of the development of the organism. Every living cell is a microcosm in which an infinity of events is transpiring. In the first place, there is the living protoplasm, with its mysterious structure, then the nucleus, which plays so important a part in reproduction and heredity and which possesses the power to subdivide itself according to regular laws, after it has transformed itself into a structure of amazing complexity. All these wonders of life are laid bare by the knife of the expert anatomist and are made more conspicuous by the application of various dyestuffs, each of which stains only certain parts of the cell. Hematoxylin, for example, colors only the nucleus and thus brings it into prominence. The phenomena of the division of the nucleus are made distinctly visible by a triple staining with safranin, gentian violet and orange yellow. With the instrument known as the microtone it is possible to make a long series of successive thin sections of an object, which has previously been saturated with paraffin by a complicated process. The preparation is imbedded in Canada balsam to protect it from external influences.

Microscopic preparations are absolutely necessary for the study of natural history, and it is also necessary to give the student opportunity to examine them very thoroughly, for the unpractised eye often fails

for no two observers see the same object alike. During the last ten years attempts have been made to solve the problem with the aid of photography.

Until recently only special students of natural history have experienced any great need of microscopic

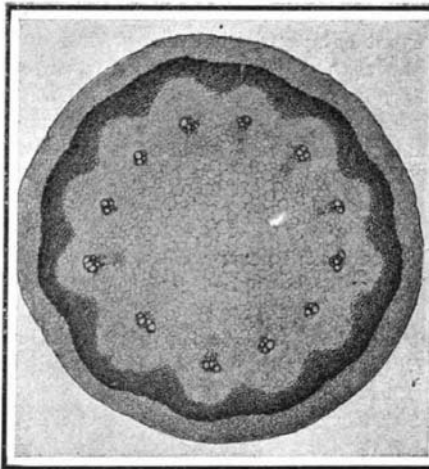


FIG. 4.—CROSS-SECTION OF EXOGENOUS ARISTOLOCHIA.

Showing vascular bundles arranged in a circle.

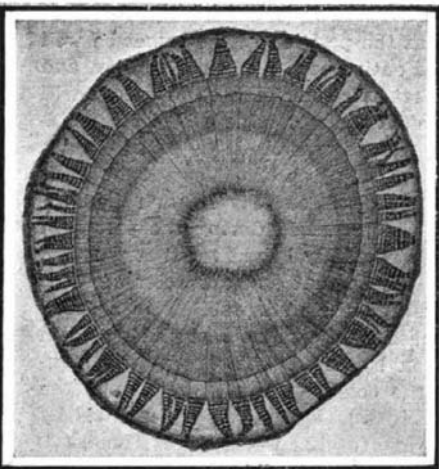


FIG. 5.—CROSS-SECTION OF THREE YEAR OLD STEM OF LINDEN.

Showing three annular rings and an encircling ring of bark.

objects or representations of them, but with the increasing popularity of the natural sciences this need is becoming felt by the schools and the general public. Artists, also, find here an inexhaustible source

vascular tissue of woody cells of large diameter, which is called the xylem and serves for the transport of water. Surrounding this is the thin cambium layer in which the growth of the stem in thickness takes place. Next comes another vascular layer, the phloem,

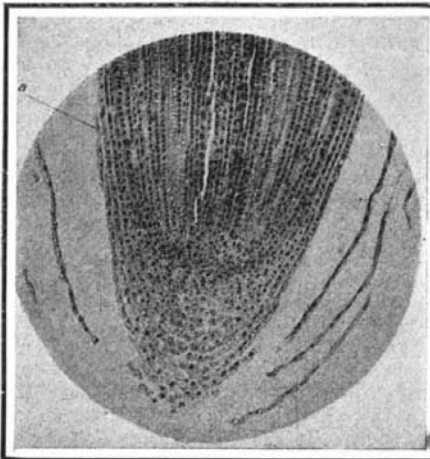


FIG. 2.—THE TIPS OF A ROOT.

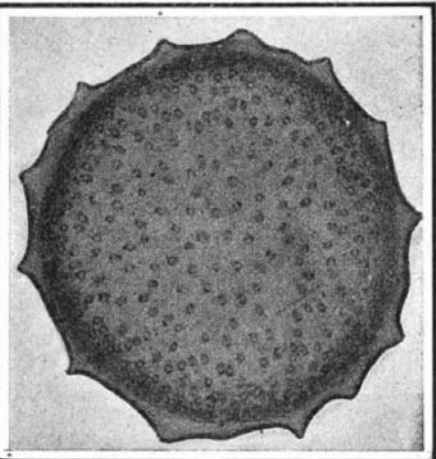


FIG. 3.—CROSS-SECTION OF ENDOGENOUS DRAGON TREE.

Showing vascular bundles distributed irregularly.

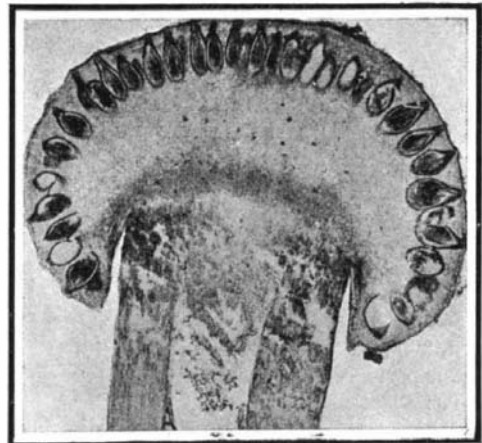


FIG. 6.—ERGOT.

to observe important details, at the first glance, unless attention is especially called to them. For this reason it has long been customary to make drawings, which can be studied at leisure, of objects as seen with the microscope. But this method is open to seri-

ous objection, as Haeckel and Boelsche have pointed out. It is only necessary to glance at the drawings of Hinterberg, the first eminent artist to enter this field, or to examine some of the botanical and zoological objects themselves, in order to appreciate the in-

in which flow the currents of elaborated sap, and on the outside is a layer of long and thick bast cells, which give flexibility and toughness to the stem. The water conduits of the xylem are formed by the coalescence of cells in the young roots, stem, branches and leaves into long tubes, the walls of which are stiffened by many rings, spiral and interlacing ridges, and

which extend from the roots to the leaves.

The vessels of the phloem which serve for the conveyance of elaborated sap are of very different construction. They are called sieve tubes and are formed by the partial coalescence of cells, the transverse walls of which have not, like those of the component cells of the water tubes, nearly or quite vanished, but have merely become perforated like sieves. The sieve-tubes begin in the leaf where, together with the water tubes, they form the so-called "veins," and, like the water tubes, they continue down through the leaf stalk, twig, branch and stem or trunk, to the root. The sieve-tubes and water-tubes constitute the vascular bundles. The coarse water-tubes are nearer the axis, the fine sieve-tubes nearer the bark. The two great classes of flowering plants, endogens or monocotyledons and exogens or dicotyledons, are distinguished from each other by the structure and arrangement of the vascular bundles. In endogens, which include palms, lilies, etc., the vascular bundles are very numerous and are distributed irregularly through the entire cross-section of the stem, though more closely near the circumference (Fig. 3). New bundles appear among the old ones as the stem increases in size. In exogens (Fig.

4), which include our common timber trees and many other plants, the vascular bundles are arranged in a circle which increases in size with the stem. Between the sieve-tubes and the water-tubes is a ring of soft cells, the cambium, which continually increase in number by cell-division during the growing season, from April to September, and thus cause the stem to increase in girth. The cambium layer surrounds the wood and is surrounded by the thin bast layer, which lies immediately beneath the bark. The wood of our common forest trees, when sawn crosswise, shows a number of concentric rings from which the age of the tree can be determined, for each ring represents the result of the activity of the cambium during one annual period of growth. The new wood formed in spring contains more numerous and larger tubes than the wood formed in autumn. The wood of spring is deposited next to the wood of the preceding autumn, and the sharp contrast between them produces the conspicuous annual ring. Most tropical woods, being endogenous, show no annual rings, and are thus easily distinguished from native woods.

The contrast in the manner of growth of aerial and underground parts of the plant is also instructively

shown by microphotographs. The terminal bud is composed of a number of leaves and scales of which the older and harder inclose and protect the younger and softer. This formation is especially well marked in the water weed (*Elodea Canadensis*, Fig. 1). The rootlets, on the contrary, grow directly from the interior of the root. The tip of every root is protected by a cap of harder cells and contains starch grains, the weight of which, according to Haberlandt, causes the root to grow downward. These starch grains are organs of equilibrium, like the otoliths, or grains of carbonate of lime, in the ears of higher animals.

Another interesting photograph (Fig. 6) shows a section of the pileus, or reproductive part, of ergot or "smut," a poisonous fungus which grows on the grain of rye and has caused many deaths. The bottle-shaped glands are filled with the black spores which give "smutty" rye its characteristic appearance.

These few examples may serve to give some idea of the wonders which are revealed by the microscope and which it is now possible to exhibit to great numbers of spectators with the aid of photography and the projecting lantern.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Reclam's Universum.

HALLEY'S COMET.

SUGGESTED OBSERVATIONS.

THE Astronomical and Astrophysical Society of America, through its comet committee, is soliciting co-operation in the observation of Halley's comet at the present return, and has prepared a circular letter of advice that has been widely distributed among observatories with regard to such observations. A copy of this circular will be sent to any astronomer who may desire to use it, upon request being made to the chairman of the committee, Prof. G. C. Comstock, Washburn Observatory, Madison, Wisconsin. As many astronomers and other observers of Halley's comet will be interested in the suggestion made by the committee, the circular is here reprinted in a slightly abridged form.

It is desirable that the position of the comet be well observed during the entire period of its visibility, and it seems probable that extra-meridian observations will be secured in sufficient number with especial solicitation. In view, however, of possible large perturbations arising from the close approach of the comet to Venus on May 1, and to the earth on May 18, meridian observations are especially desired during the period in which the comet is sufficiently bright for that purpose. An examination of the amount and character of these comet perturbations and their adaptability to a determination of the mass of the planets producing them has been undertaken by Profs. Leuschner and Crawford, and in case the conditions prove favorable, the meridian determinations may well be supplemented by heliometer observations of the positions of the inner planets with the view of a possible determination of the mass of the comet itself.

The close approach of the comet to the earth promises unusual opportunity for a study of the physical conditions that obtain in such a body, and, as an indispensable basis for such study, the committee recommends a photographic campaign as long and as nearly continuous as possible. The comet's close proximity to the sun's direction at the time of maximum brilliance imposes serious limitations upon this programme, and widely extended co-operation will be required throughout the whole circuit of the earth if this ideal of a continuous photographic record is to be even remotely realized.

About one-third of the earth's circumference in longitude is covered by the Pacific Ocean, within which there is known to exist no observatory with proper facilities for celestial photography. To fill this gap, at least partially, the committee, aided by a grant from the National Academy of Sciences, proposes to send to the Hawaiian Islands an expedition to photograph the comet during the period of its greatest brilliance.

The ends to be served by these photographs, and others obtained elsewhere, are as follows:

To give a permanent record, as continuous as possible, of the phenomena and changes (1) in the tail of the comet, with special reference to outgoing masses; (2) in the head and nucleus of the comet, particularly as to the formation of envelopes and jets.

The following suggestions as to procedure and precaution in making the photographs have been formulated by Prof. Barnard.

PHOTOGRAPHY OF COMETS.

One of the greatest difficulties in photographing the average bright comet is its proximity to the horizon, and consequent projection on a more or less dawn or twilight sky. The effect of this illuminated background

with any considerable exposure is to fog the plate to such an extent as either to ruin it or to prevent a proper development of the image of the comet. A difference of three or four minutes in the duration of exposure when the sky is brightest may make a success or a failure of the picture. It is impossible to establish fixed rules as to when the exposure should stop or begin; so much will depend upon the condition of the sky, the position of the comet, the kind of lens, the rapidity of the plates, etc. The best rule is that of the judgment of the observer at the time, and this can only be derived from actual experience in the work.

The plates should be backed with the following to prevent halation: Cook two pounds of white sugar in a saucepan without water until nearly in the caramel stage, then add one pound of burnt sienna. Cook a little more (but not to the candy stage), stirring well. Finally, add about one-half an ounce of alcohol to each pint of backing as a dryer. This backing will keep indefinitely. When it is too hard, moisten it with a little water. This is to be applied to the back of the plate as a stiff paste with a broad camel's-hair brush, and should be applied just before using. A piece of old newspaper pressed upon this will prevent its being rubbed. The face of the plate should be very carefully dusted with a broad camel's-hair brush after it has been placed in the plate holder. The camera tube should also be frequently wiped out with a damp cloth to avoid dust. Before developing, remove the backing with moist absorbent cotton. If a little remains on the plate it will not injure the developer. In removing the backing be careful to shield the plate from the dark-room light. Do not wet the surface of the plate before pouring on the developer, as it may cause air bubbles on the film; swab it carefully with absorbent cotton at the beginning of development. Develop until the plate is almost opaque to the ordinary developing light. Fix for twenty minutes or more in the ordinary fixing bath (frequently made new), to which has been added a teaspoonful of sodium bisulphite to prevent discoloration.

Lumière Sigma dry plates are recommended, because of their rapidity. Seed 27 Gilt Edge and Cramer Crown are both beautiful plates, but are not now so rapid as the Sigma.

Hydrochinon developer gives a good strong negative, and for astronomical work is excellent. Rodinal in a weakened form, say 1/60 or 1/70 of water, with a longer development, will give a soft and more transparent negative, especially suited for showing the details of the head of the comet on large-scale photographs.

The doublet, or portrait lens, such as is made in America by the Brashear Optical Company and the Alvan Clark Corporation, on account of its wide field, is the best form of instrument for showing the general features of the comet and its tail, and especially for following any outgoing masses that may appear in the tail. One of about 6 inches (15 centimeters) aperture will be the most generally used, because of the expense of such instruments. It should be supplemented by several smaller lenses. A "lantern" lens of 1 3/5 inches (4 centimeters) aperture and about 6 inches (15 centimeters) focus, made by McAllister, of New York, is recommended for showing the extent of the tail. The cost of one of these lantern lenses is seven dollars. It gives a good field of twenty to thirty degrees, espe-

cially when diaphragmed down to 1 inch. It is extremely quick for comet work. Its focus should be carefully determined by star trails.

In comet work it is important in all these lenses that the camera should be so adjusted on the mounting with respect to the guiding telescope that the head of the comet can be displaced to one side of the field to secure a greater extension of the tail. Two of the small lenses may be so arranged by a mutual adjustment as to cover the full length of the tail, even though it should be fifty degrees long or more. Although it would thus be in two sections—the head and part of the tail on one plate, and the rest of the tail on the other—there would be no serious objection if the whole tail could thus be secured. The large reflectors will be of the utmost importance in dealing with the detail and structure of the head and envelopes, as has been recently shown at Greenwich.

Until something further is known of the spectrum of the comet, it would be unwise to attempt to give any specific directions as to the duration of exposure required with any telescope. Daniel's comet of 1907, and Morehouse's of 1908, were very different in respect to their photographic activity. The latter was relatively many times more actinic in its light, and hence required much shorter exposures to show the same strength of tail. This information must come from actual experience with the comet. It would seem, however, that the circumstances of the comet's visibility when brightest will make short exposures necessary.

The committee will be pleased to receive from every astronomer who may co-operate in the matter copies (glass positives) of his negatives of Halley's comet, and it will undertake the comparison and discussion of the material thus collected.

SPECTROSCOPIC OBSERVATIONS.

For spectroscopic observations of the comet the committee makes the following suggestions, formulated by Prof. Frost. While it may be possible to make visual observations of the comet's spectrum with ocular spectroscopes attached to large telescopes, it is likely that most of the photographic records of the spectrum will be obtained by the objective prism or the slit spectrograph, and reference will be made in what follows to the use of these two types of instrument.

These methods of observation are mutually complementary; for the accurate measurement of wavelength, effect of motion in the line of sight, and analysis of structure of lines or bands (if sufficiently sharp), the slit spectrograph has all the advantages, but for study of distribution of elements in different parts of the comet, and for reaching faint details, the prismatic camera, or objective prism, with its much greater light-power, is essential. The prismatic camera may be employed, with a fair possibility of success, when the comet's brightness is equivalent to that of a ninth or tenth magnitude star; the slit spectrograph cannot be hopefully applied before the comet is two or three magnitudes brighter. The size and kind of telescope employed, of course, make such statements relative rather than absolute, and uncertain at best. Too much here depends upon the comet; if its light is chiefly reflected rather than intrinsic, and the continuous spectrum is predominant, then the comet will have to be much brighter for satisfactory spectroscopic analysis than if the light is largely intrinsic and