How to Use the
GILBERT MICROSCOPE

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EXPERIMENT 171. The Digestion of Starch

Mix a small amount of starch with about ten times as much saliva in a test tube. If you have trouble getting the saliva chew gum or paraffine. About every 5 minutes place a sample drop on a slide with your glass rod or medicine dropper and look at it under the microscope. The starch swells and gradually is dissolved as it is digested by the saliva. Each time test it with iodine. At first the starch turns blue, later it will only turn red as it is partly digested and finally there will be no starch left and the iodine will only be diluted in color. The starch has turned to sugar. If you chew a cracker for some time it will begin to taste sweet as the saliva digests the starch in the cracker.

Fig. 29

Starches. A. Potato starch in polarized light; B. Boiled potato starch; C. Corn starch; D. Wheat starch; E. Sprouted wheat starch; F. Rice starch.

CHAPTER 18

The Many-Celled Animals

All of the processes of life such as eating, reproducing, moving, etc., have to be done by a single cell in the single celled organisms that we examined in Chapter 16. The larger number of animals are built up of a great many cells of different kinds. They are larger and only the smaller ones can be studied with the microscope. The different tissues must be prepared and studied separately from the ones too large to go on the microscope. The biologists divide these animals into some fifteen main groups and we can only look at a few of them now, but you can use the same methods with other animals and extend your information almost without limit during your life time. If you would like to read more about the animals there are books listed on Zoology in the appendix which may be borrowed from your library or bought at a book store.

You have seen some of the smaller many celled animals when you looked at your collection from a pond. After your collection has settled for a while you may see *Hydra* attached to a bit of plant or to the side of the container, fig. 30. When it is expanded it may be from 1/8" to 3/4" long. If it is disturbed it contracts into a small round ball. The mouth is on the raised part between the arms. The arms have stinging cells on them.

EXPERIMENT 172. Hydra

Watch a Hydra in a small clean dish and then gently place it on a slide and cover with a cover glass. You will see that the body is made of two layers of cells. Run a little thionine under the cover slip and it will stain the animal and will also cause the stinging cells to discharge their fine lances.

You have probably seen round worms wiggling on some of your slides like those in fig. 30.

EXPERIMENT 173. A Round Worm

Examine a round worm closely. Its digestive system may be seen through the body wall.

EXPERIMENT 174. A Flat Worm

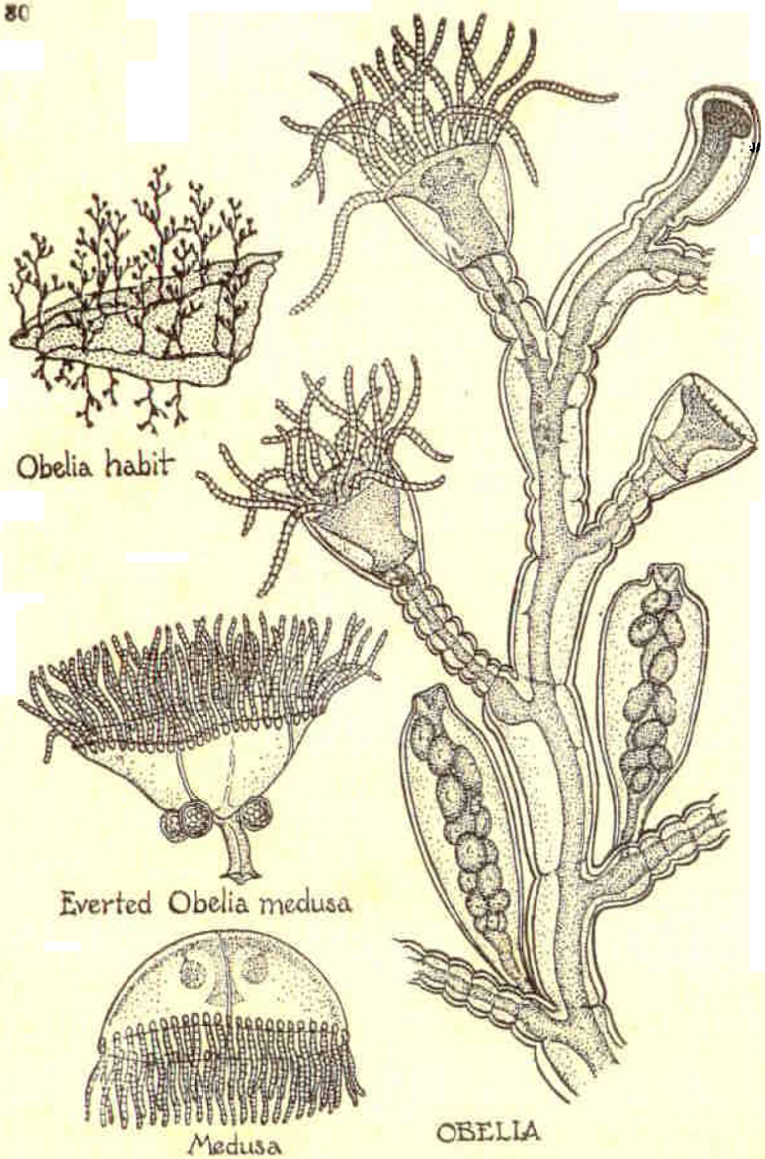
Watch a flat worm, fig. 30 to see how it moves. The surface of it is covered with cilia similar to those you saw on *Paramecium*.

Flatworms like *Planaria* can grow new parts in case they have an accident and this ability is called *regeneration*.

EXPERIMENT 175. Regeneration of an Injured Worm

Cut a flat worm in half with a razor blade and put each half into clean pond water in clean dishes and watch the parts for a few days. They will usually regenerate the lost parts and change back to the same form as they were originally but each will be smaller. Does it make any difference whether you cut the worm in two crosswise or lengthwise?

There are many small crustaceans in pond water which have hard shells, and paired, jointed legs. Some of them are so small that you can see how their internal organs work as you look at them under the microscope.



OBELIA

Fig. 30
Courtesy General Biological Supply House.

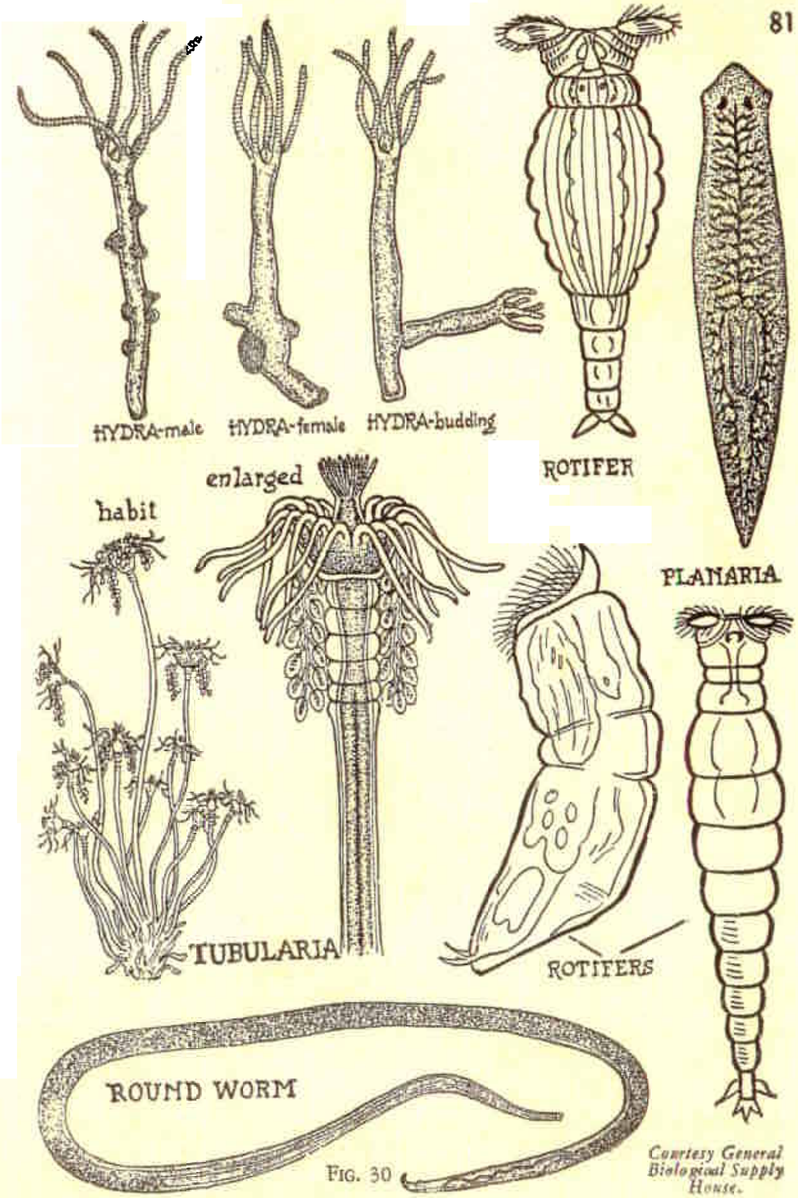


Fig. 30

Courtesy General Biological Supply House.

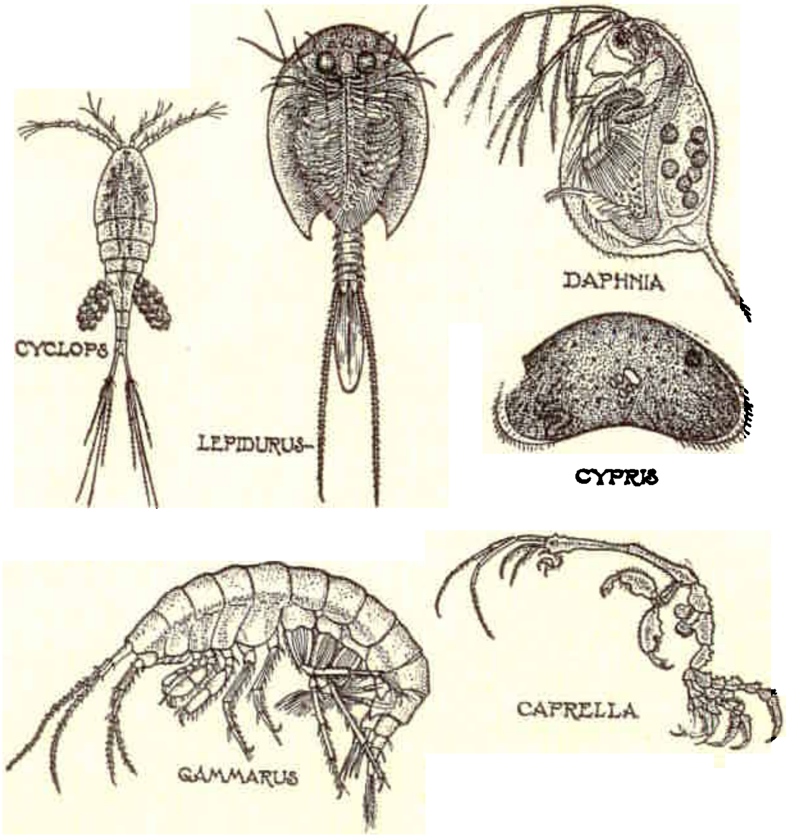


FIG. 30

Courtesy General Biological Supply House.

EXPERIMENT 176. Crustaceans

Look for some small crustacea like *Cyclops*, *Gammarus*, *Daphnia* and see how they move. Fig. 30.

When you are at the seashore look at the seaweed and if you see some fine hair like growths on the seaweed put a little on a slide with a drop of *sea water* and examine them.

EXPERIMENT 177. Sea Moss

Two of the most interesting ones are *Obelia* and *Tubularia*, fig. 30. In *Obelia* the branches end in two kinds of heads. One kind look like *Hydras* and catch the food for the whole animal. The other kind grow small jelly fish on the central club shaped part. If you have them during the summer you may see some of the small jelly fish, called medusae (me duse' e) break off and swim out the opening in the protective covering. The medusae have sex organs and the fertilized egg from them grows up into the animal with the different parts connected by a common stem.

Rotifers, fig. 30, are sometimes called wheel animalcules because they have a row of cilia around the head end. They are very common and usually found in samples of pond water like you obtained in Chapter 16.

EXPERIMENT 178. Wheel Animalcules

Examine some different kind of Rotifers.

The larger animals can be seen under the microscope part at a time. The insects are very interesting and so that you may study them at any time you wish a fly and a bee are included in your set.

EXPERIMENT 179. The House Fly

Take the fly and see how many parts it has with the aid of your hand lens. Then look at the different parts with the microscope. To do this pull the part off with the forceps and place it on a slide in some water under a cover glass. If you wish to make the preparations last longer use glycerine instead of water. Insect parts may be dried in the air, gently warmed and mounted in balsam for permanent preparations. Examine the legs and note the swelling or pad at the end. This secreted a sticky material when the fly was alive so that it could stick to the window pane and walk straight up. Examine the compound eye which is made up of a great many separate eyes all bound together, the wings, the antennae on the head and the mouth parts.

EXPERIMENT 180. Mosquito

Catch a mosquito and see how its mouth is made for sucking blood from the victim that it bites.

EXPERIMENT 181. Fruit Fly

Catch a fruit fly and compare its parts with the larger house fly.

EXPERIMENT 182. The Cause of the Cricket's Chirp

Catch a cricket and examine its legs. You may find a rough edge which has fine saw-like teeth on it. It makes its chirp by rubbing these parts together. Other insects make their noises by rubbing similar rough strips together on the edges of their wings.

EXPERIMENT 183. The Honey Bee

The bee makes one of the most interesting insects because so many of its parts are made into special tools, fig. 31. The bee has a compound eye on each side and three simple eyes on the head above and between the compound eyes. Note how the mouth parts make a sucking tube for drawing the sweet nectar from the flowers into the mouth. Notice the heavy jaws. The sting is at the other end and may be removed by taking hold of the tip of the abdomen with the forceps and gently pulling. The stinging apparatus is composed of two barbs, the poison sac and the muscles for driving the barbs into the victim. When a bee stings, the stinging apparatus is

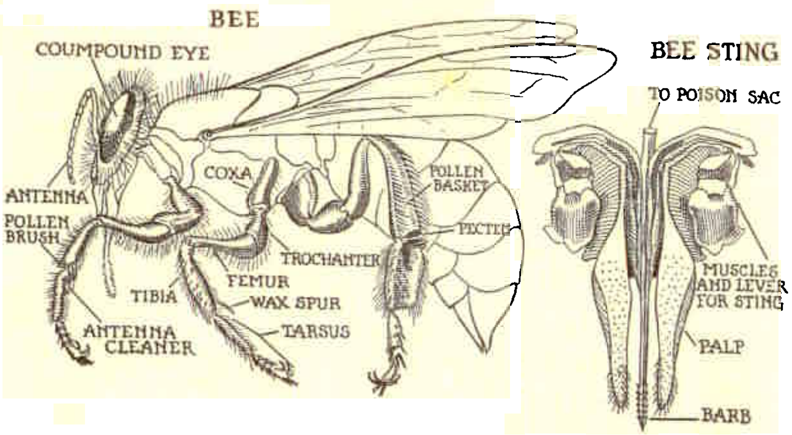


FIG. 31

usually pulled out from the bee and the muscles go on driving it into the skin. So if you happen to be stung by a bee pull the sting out as soon as you can so only a little of the poison will be injected from the poison sac into you.

The legs are each composed of five parts as labeled in fig. 31. On the front leg notice the pollen brush and the antenna cleaner. The feeler or antenna is pulled through this to clean it. Notice the pollen spur on the middle leg which is used as a pry bar in handling the pollen collected in the pollen basket which you will see on the hind leg. On the hind leg is a row of stiff hairs which serves the bee as a brush. The bee has many tools built into its body. Can you find more of them?

EXPERIMENT 184. Insect Wings

Compare the markings on the wings of different kinds of insects. Insects are arranged into groups according to their wing structures.

EXPERIMENT 185. Scales of a Butterfly's Wings

When you catch a butterfly mount a bit of the wing on a slide and see how the scales are arranged on the wing like shingles on a roof. Are the scales the same shape on different kinds of butterflies and moths?

A clam or fresh water mussel contains many interesting tissues.

EXPERIMENT 186. Ciliated Cells from a Clam

Break the shell so that you can see the living animal inside. There is a fold of tough membrane on each side just inside the shell. Inside this membrane are the gills—two pair on either side. Take a little of the gill material out with the forceps and tease it out so you can see the cells of which it is made (Chapter 11). On the cilia cause the water to flow over the gills so that the clam can breathe. Staining the cells will show the cilia better but will kill them so that they will no longer move. You can study the tissues of many kinds of animals by teasing them with the dissecting needles in a similar manner.

Fish scales are very interesting and those from each kind of fish are different, fig. 32. A few scales are furnished with your microscope set. You may get others from fish you catch or from a fish market. Those from a fresh fish will have to be cleaned with water and a good rubbing and may be looked at dry or in water mounts. Try staining some. When they are thoroughly dry they may be made more transparent by soaking for a few minutes in xylene and then mounting in balsam as permanent mounts. More detail may be seen in the mounted scales.

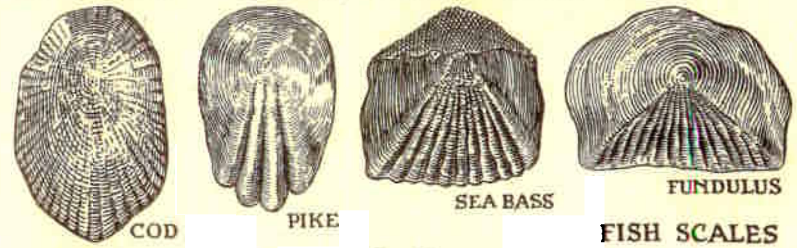


FIG. 32

EXPERIMENT 187. Fish Scales

Look at the scales that come with your set and at other scales and make sketches in your note book so you will be able to name the fish from a scale you may pick up later.

The animals which contain back bones are grouped according to their skin structures. The scale characterizes the fish. The Amphibia, frogs, toads and salamanders have moist skins with no scales. The Reptiles have dry skins with scales which are quite different from those of the fish as you will see if you have a chance to examine a snake or a lizard. The alligator and the turtle have bones in the skin for protection and the bones in the turtle join to make its shell. The feather defines the birds and should be examined by the microscopist. The mammals have hair as described in Chapters 8 and 23.

The small down feather is made of a central shaft and small branches as you see in the feather slide that comes with your set. A larger feather has side branches from the center shaft and further branches from these which hook into those of the next one as shown in fig. 33. It is this locking which gives stiffness to the feather and if the feather parts are separated it is not possible to put them back unless you do it under a microscope.

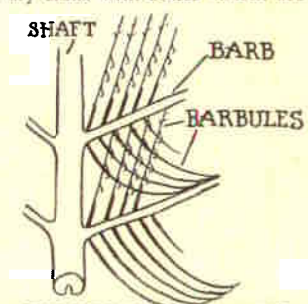
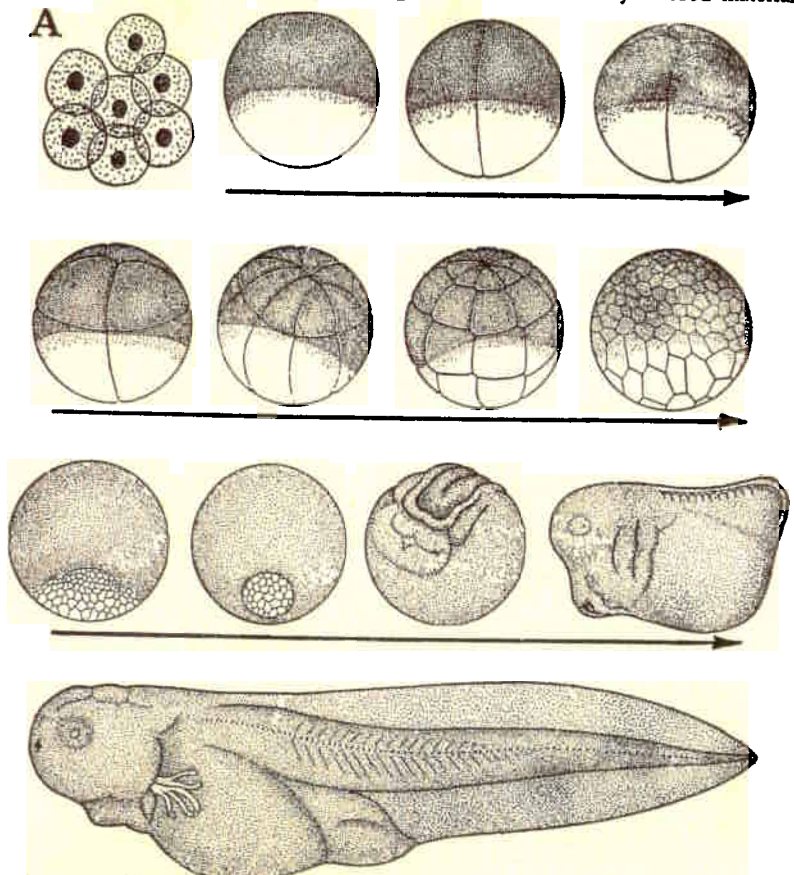


FIG. 33

EXPERIMENT 188. Why Feathers Are Stiff

Note the hooking arrangement of the finer branches of a feather. Is the color in a feather due to pigment granules or to diffraction patterns as described in Chapter 10?

Some morning in the spring go out early and look for frog or salamander eggs layed in small ponds. They are usually in masses looking like small dark spots in a jelly case, fig. 34. When you carefully pull the jelly off with your forceps and dissecting needles and look at the egg in a small glass dish you will see that the upper part is dark and that the lower part is light colored due to the yolk food material.



Courtesy General Biological Supply House

FIG. 34

A. Frog eggs. B. Frog eggs magnified. Reading to right shows early stages of development.

Some of the eggs may be divided by a groove into two parts. Later another groove may be seen going around the egg at right angles to the first to divide it into four parts. The third groove divides the four into eight, etc., fig. 34. After a time the cells are so small that they cannot be seen as separate cells and you will see that the

dark cells gradually cover the lighter colored ones until finally only one spot of light ones may be seen. About this time a groove bounded by folds forms and at the end away from where the last light cells are seen, the head will gradually form. To see this the egg must be kept covered in water in a glass dish small enough to go under the microscope and you will use the low power of your microscope.

This process of the egg developing into the tadpole is fascinating and should be seen. The study of the development of animals is called embryology (em' bry ol'' o gy). Other eggs may be studied in a similar manner.

EXPERIMENT 189. The Development of a Frog Egg

Collect some frog eggs and watch them develop. Keep a record of how long it takes for each stage. Unless you get the eggs early in the morning they will have developed beyond the first stages and you can only see the later stages. The frogs lay the eggs in the very early morning. The rate of development depends on the temperature; they develop faster on warm days or in a warm room.

CHAPTER 19

Making Permanent Mounts of Moist Tissues

Tissues that can be dried in the air without injuring them can be easily mounted as described in Chapter 9. When we have moist tissues such as a teased bit of tissue or sections of tissues it is necessary to remove the water with alcohol instead of letting them dry in air. Place the bit of tissue into about five times as much alcohol as its volume. In about 15 minutes pour off the alcohol and put on fresh alcohol. The alcohol furnished with your set is suitable for this even though it is denatured. Change the alcohol at least five times letting the tissue soak in each change at least 15 minutes. A half or an hour is better if the bit of tissue is more than 1/8" in size. This should take out all of the water. Pour off the alcohol and blot the tissue gently with soft paper to nearly dry it and then pour on about the same amount of xylene. The tissue should become translucent so that light passes easily through it—it will have the same appearance as an oil spot on a bit of paper. If the xylene becomes milky or the specimen does not clear it means that the water is not entirely removed and it will have to be soaked in a few more changes of alcohol.

When it clears well it can be arranged on a clean slide with the forceps and the needles and then covered with balsam and a cover glass. If much xylene is on the slide it is well to blot it very gently to remove the excess before adding the balsam. After the slide is dry it should be cleaned and labeled as you did in Chapter 9.

Should you wish to make a permanent mount of a stained bit of tissue, stain it until it is properly colored and then remove the water with alcohol and mount as above. The same method may be used with both plant and animal tissues. Plant tissues stained in thionine will not be permanent and the saffranin should be used instead.

EXPERIMENT 190. Prepare Some Slides of Stained Tissues

Animal tissues are usually too soft to be sectioned in the microtome without first imbedding the tissue in celluloidin or paraffin. These methods are too detailed to describe here but you will find how to do them in books listed in the appendix.

For the examination of animal tissues careful teasing apart of the cells with the dissecting needles will do until we become quite skillful microscopists.

CHAPTER 20

Printing

Printing depends on the nature of the raised type used to carry the ink and the nature of the surface on which the ink is pressed in the printing press. The microscope is used to examine the impression and to determine what kinds of paper are suited to different reproduction purposes. With real engraving the space for the ink is cut into a metal plate, the plate is inked and all of the ink on the surface of the plate is rubbed off and then the plate is pressed against the card or paper so that the remaining ink sticks to the paper and is left as a raised letter. With imitation engraving ordinary type is used with a special ink which is heated after printing so that it swells to resemble engraving. With real engraving the letters will show some variation because they are cut by hand, while the letters of artificial engraving are uniform.

EXPERIMENT 191. Engraving

Examine some engraved calling cards, party or wedding invitations with the hand lens and the low power of the microscope to see whether they are real hand engraved or made by the imitation process.

Simple illustrations are usually made as line cuts by a combined photographic and chemical process and the cut printed along with the reading matter.

EXPERIMENT 192. A Line Cut Impression

Look at a printed line picture and notice whether the lines are continuous or whether they are made of dots. If the lines are continuous and not made of dots it was printed from a line cut.

To print pictures with intermediate shades of gray rather than just black and white the pictures must be photographed through a screen of diagonally crossed lines when the plate is made. This breaks the picture up into masses of dots and when this kind of plate or halftone, is printed the result is a lot of dots. Light gray has fine dots and black comes out as large dots. Every intermediate stage is possible. Halftone plates for printing on rough newspaper have coarse dots because they were made with a coarse screen while pictures printed on very good paper have fine dots produced by very fine screens.

EXPERIMENT 193. A Coarse Screen Halftone Picture

Examine a picture in a newspaper with the hand lens and low power of the microscope to see how the dots are arranged and their size. To see clearly on the microscope cut out a piece small enough to put on a slide and place another slide on top to hold it flat. If it is too opaque rub a little oil, or xylene, on the paper back of the part examined to make it pass more light.

EXPERIMENT 194. A Fine Screen Picture

Examine a picture from one of the better magazines printed on good paper and compare with the newspaper picture. The microscope shows why you can see more letail in the better picture.

Many colored pictures are printed from different plates so arranged that each prints exactly on the other. Usually the three colors red, blue and yellow are used. A part having one of these colors will show just the fine dots or a smooth mass of this color while a part of another color like green will be printed from the yellow and the blue plate and will show both colors under the microscope, but because the dots are too small to see with the naked eye we see the blend, or green.

EXPERIMENT 195. Printed Color Plate

Examine a colored picture from one of the better magazines to see how it was printed. Do the dots form a microscopic pattern?

The rotogravure sections of the Sunday newspapers are printed with a special ink which runs enough to fill in the spaces between the dots and gives a smoother picture.

EXPERIMENT 196. Rotogravure Pictures

Compare a picture printed in rotogravure with a picture printed from a halftone plate with your hand magnifier and your microscope.

The colored "funny paper" or comic strip is printed partly as smooth color and partly as dots which is known as the Benday process. Sometimes the blue and yellow are printed as smooth color and the red as dots. A purple would be made from the smooth blue and over printed with red dots.

EXPERIMENT 197. A Benday Picture

How are the colors printed on a colored comic strip for your Sunday newspaper?

CHAPTER 21
The Structure of the Photographic Image

The film that you place in your camera has a light sensitive emulsion of silver salts placed on a celluloid support. When you take a picture the lens focuses an image of whatever the camera is pointed at onto the film and the light changes the silver salts in accordance with the amount of light received on each part of the film. The film is developed with chemicals which change the silver salts affected by the light into metallic silver and which wash out the silver salts not affected by light. The resulting negative contains dark regions with lots of tiny silver masses in the regions which were light in the original and the shadows are registered on the negative by much lighter deposits of silver because less light was reflected from them to the film.

EXPERIMENT 198. Structure of a Photographic Negative

Look at a photographic negative with the low power of your microscope and then with a higher power until you can see that the metallic silver deposits are made up of individual grains.

Some developers like pyro produce a stain in addition to the silver grains.

For printing the negative directly onto paper by contact the fineness of the grains does not matter very much, but if the negative is to be enlarged many times the grains in the negative must be so small that they will not be seen separately by the eye after the negative is enlarged.

EXPERIMENT 199. Limitations of Enlargement

By looking at a negative with different magnifications you can decide how much it may be enlarged and still look well. Look at some different negatives and see whether they could be enlarged 3, 5 or 10 times without the grain becoming objectionable.

EXPERIMENT 200. Correspondence in Grain Between Negative and Enlarged Print

Compare the appearance of the negative and of an enlargement from it with your lenses.

For great enlargement of a picture the negative must have very fine grained particles of silver and special fine grain devolpers are prepared for this purpose. The fineness of the grain in negatives from the modern miniature cameras must be preserved and with proper processing the prints from enlarged negatives five or more times may be as good as contact prints made from larger negatives.

EXPERIMENT 201. Fine Grain Developer

Compare the grain size of negatives developed in fine grain and ordinary developers.

If you do your own developing and printing you will find that the microscope will help you to make better pictures because you can see just how they are formed. You will think of many other experiments such as the effect of the temperature of the solutions on the grain size, and you can compare the results of different kinds of developers and films. You may look at the paper prints as well as the negatives.

A drop of xylene on the back of the print will make it transparent enough for you to use the low power of the microscope with a strong light. The picture will not be harmed by the xylene which quickly evaporates.

Reversal film used in the 8 and 16 mm. motion picture cameras often has finer grain than ordinary camera film. Of course any picture will have small and large grains of silver in it so we have to make our comparisons of the average size of the grains of the pictures.

EXPERIMENT 202. Reversal Film

Do you find the average size of the silver grains different in a still camera negative from those in reversal film?

Pictures taken in natural color are produced in many different ways and it would take a large book to tell you all about them and how they work. The usual method is to separate the colors of the pictures into three primary colors red, blue and yellow by proper filters and then to combine the colors by complimentary dyeing of the images on the film or films. If you have any of these pictures look at them with your microscope to see how they are made.

The Autochrome plates have a filter of colored starch grains between the emulsion and the glass which you can see by looking through the back of the film with the low powers of your microscope. Other processes have filters of colored oil droplets in the emulsion. The Agfa color plate has a color screen of partricles and the Dufay screen is ruled on the celluloid by diagonally crossed colored lines. The Finley plate has no color screen built into it but you place such a screen in front of the plate when taking the picture and a different screen called a viewing screen in front of the finished picture when you look at it. The Kodachrome film has three color images in different layers obtained by toning the original images when the film is processed.

EXPERIMENT 203. Natural Color Films

Look at as many kinds of color films as you can get and see how the image of each is produced. Small bits of the film permanently mounted in balsam make interesting slides to show your friends. A friend of yours in a photographic store may be able to give you some small bits to mount and look at. You will find silver images in some of the color processes as well as the colored images.

CHAPTER 22

Metallurgy and the Microscope

The surfaces of different kinds of metals show quite different kinds of structure and grain, which is important as an index of rusting and wearing ability. A rough surface would not be a good metal for a bearing so a smooth surface metal mixture like Babbit metal must be used instead. The same metal finished in different ways appears differently under the microscope. Many metals used in industry are not pure but are alloys or mixtures of several pure metals and in some cases the microscopist can tell about what proportions of each were used in the mixture. The following experiments will be interesting and may suggest others. The microscope is very important when flaws in broken surfaces must be studied.

EXPERIMENT 204. Rusty Iron

Take a bit of rusty iron and polish off part of it so you can compare the surface of the metal with the part covered with the iron oxide rust.

EXPERIMENT 205. Metal Surfaces

Compare the surface markings of copper, silver, and other metals. Coins may be used.

EXPERIMENT 206. Metal Plated Surfaces

Examine different surfaces such as chromium plating, nickel plating, cadmium plating, etc., with your microscope.

EXPERIMENT 207. Flaws in a Broken Surface

Examine the broken surface of the next bit of broken metal you find to see whether it was a clean break or whether there was a flaw in the metal which weakened it so that it broke at the place.

Brass is an alloy of copper and zinc, although a little tin is sometimes added. It is one of the more interesting metals for examination with the microscope.

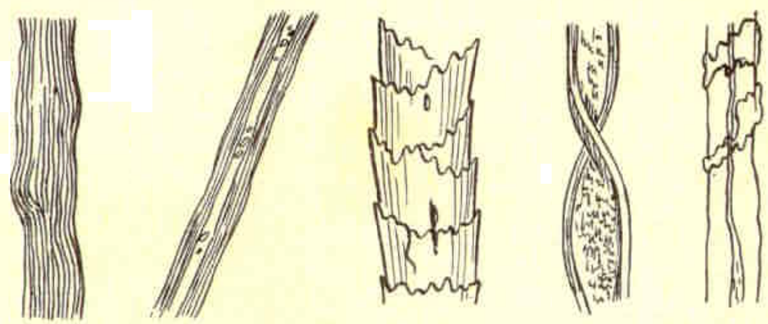
EXPERIMENT 208. Alloys and Its Components

Compare tin, zinc and copper with brass. Are all brass objects made of the same kind of brass? What happens to the surface of brass when it becomes dark and when you polish it. You will find tin as a plating over iron on tin cans and boxes, the outside of dry batteries, such as are used in flashlights, are made of zinc. Copper can be found on the top of the center of the battery or you may find some copper wire around the place.

CHAPTER 23
Textile Microscopy

The nature of cloth and its ability to be colored with different dyes depends on the kind of fibers from which it is made. Much of our knowledge of the fibers has come from experimenting with them under the microscope. The microscope is necessary in some cases to know from what material a cloth was made and to determine the quality of the goods. The microscope shows us whether the cloth was made with new fibers or whether part of the fibers were reclaimed from some used cloth, it shows whether the fibers are in good condition or whether they have been damaged by molds and mildew or by careless handling in manufacturing. From this knowledge we can tell whether they will wear well and whether they are what they are claimed to be.

One needs only a small bit of thread for a microscopical examination so you can get a sample from garments near a seam without damaging them. It is well to take one piece of thread about ½" long from the warp fibers running one way in the cloth and another from the woof fibers which cross the former ones, because sometimes they are of different material. Put the thread into a drop of water on a slide and tease the fibers apart at one end with a dissecting needle while you are holding the other end with the forceps or the other needle. It may be easier to do this under the hand lens on the dissecting microscope stand. When the individual fibers that make up the thread are well separarted add a cover glass and examine with your microscope.



FLAX MANILLA-HEMP WOOL COTTON SILK

Fig. 35

Wool is the hair from the sheep (Chapter 8) and shows definite scales on its surface, fig. 35. These scales permit the fibers to felt together and give wool its springy feeling. Wool fibers burn slowly and the burning end tends to form a rounded glowing ball. Wool dissolves in moderately strong lye (sodium hydroxide) while cotton does not. When the wool fibers have been dyed a dark color it may be difficult to see the surface markings, but if you have some hydrogen peroxide in your family medicine chest this may bleach the fiber enough to see its structure. Experts can tell from what part of the world the wool comes from the pattern of the fiber.

EXPERIMENT 209. Wool

Examine some wool cloth and compare the fibers with your observations on other animal hairs.

EXPERIMENT 210. Shoddy

Notice in samples of wool whether the fibers seem to be all of the same color or whether there seems to be a mixture of fibers of different colors. Sometimes wool is reclaimed from old cloth and some of this second-hand wool is mixed with fresh wool to make it cheaper woolen cloth. The old fibers usually have mixed colors and this kind of cloth is called shoddy.

There are other hairs from animals related to the sheep which are used to make fabrics. Mohair comes from the Angora goat and is used in making upholstery material and in some heavy, winter, outer clothing.

EXPERIMENT 211. Mohair

Examine a bit of thread from the cloth on a cloth covered chair. The fibers are straighter than those of wool, the scales are smaller and the fibers seem to have a brighter luster than those of wool.

Cotton fibers come from the hairs on the seeds of the cotton plant and are used more in textiles than any other kind of fiber. The fibers are composed of cellulose and they burn quickly with an odor like that of burning leaves rather than the odor of burned hair you noticed with burning wool. The fiber is ribbon shaped and is a flattened or collapsed tube, fig. 35. The fibers are usually more or less twisted.

EXPERIMENT 212. Cotton

Look at cotton fibers from different samples of cotton cloth and thread.

EXPERIMENT 213. Part Wool Cloth

Examine a number of threads from a suit of woolen clothes to see whether or not some cotton was used with it. If you have any lye in the house make a strong solution of it in one of your test tubes and put some wool cloth in it with the forceps. If it is all wool it will completely dissolve, but if any cotton is present it will remain. Wash it with water and look at it under the microscope to make sure that it is cotton. Caution—do not get any of the lye on your skin and be sure you wash all the dishes you use with lots of water because lye burns.

EXPERIMENT 214. Mercerized Cotton

If your mother has some mercerized cotton thread be sure to examine it. It is cotton that has been treated with a lye solution to give it a higher luster. Other methods with chemicals, heat and pressure are used to make cotton look like silk but you can usually tell under the microscope by noting the twisted ribbon like cotton fibers.

Linen is made from a vegetable fiber found in the stems and leaves of the flax plant. The parts are reted by soaking in water until the softer parts break up and then the long fibers are washed free from the other parts of the plant, dried and twisted into thread. The fibers are round and smaller in diameter than those of cotton. At the ends they appear frayed showing that they are made up of finer fibers, fig. 35.

Linen fibers may have swellings or nodes now and then along the fiber and they are straight and not twisted like you saw with cotton fibers.

EXPERIMENT 215. Linen

Obtain a small bit of linen thread or some bits from a linen handkerchief and familiarize yourself with linen fibers.

Silk used to be one of the more important kinds of cloth but the modern artificial silks are cheaper and are displacing real silk. The silk fiber is composed of two fine protein fibers cemented side by side as they are secreted from the spinning glands of the silk worm, *Bombyx maori*. The larva eats mulberry leaves and grows until it is ready to spin its cocoon which it does with the silk. Man has learned how to unwind the silk fibers, to clean them, and to twist many fibers into silk thread for making cloth. The natural silk from the cocoon is yellowish and may have masses of the fibroin cement substance on it. This is washed off in hot soapy water. The resulting fiber looks like fig. 35. The fibers are very small and smooth although the size of the fiber may vary a little and sometimes it shows the marks of other fibers which crossed it in the cocoon before it had dried hard. Other insect larvae make cocoons but the silk is not of as good quality as that from the silk worm, the cocoons may contain leaves and other material and cannot easily be unwound.

EXPERIMENT 216. Natural Silk

Untwist some silk thread and observe the individual fibers.

The artificial silks are often called rayons and because they are cheaper they have replaced natural silk to a large extent. These materials are made by dissolving the cellulose from wood pulp, cotton, and many other plants and then forcing the solution through a pin hole so that a very fine threat is formed. The thread is hardened and as many of these artificial fibers as are necessary to get the desired thread size are twisted together and the thread is woven into cloth. The artificial silks are classified according to the process used for their manufacture and it is a little more difficult to be able to recognize them than the natural fibers under the microscope.

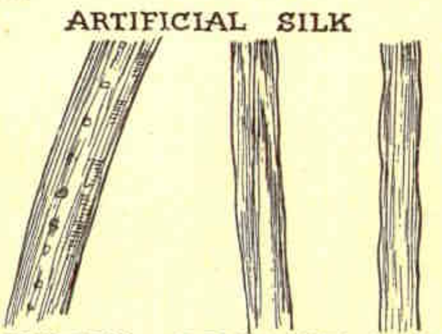


FIG. 36

In the original process bits of waste cotton were treated with nitric acid which produced gun cotton or cellulose nitrate. The nitrated cellulose was dissolved in a mixture of alcohol and ether and the viscous solution forced through pin holes to make the fibers. As the alcohol and ether evaporate rapidly and may be recovered to be used again, the fiber becomes hard. This was then treated chemically to take out the nitric acid so that the thread will not be inflammable and explosive. The fibers are twisted together to make the thread. This process is known as the Chardonnet process and the artificial silk is called collodion silk, fig. 36. The fibers are seen to be quite smooth under the microscope and marked by heavy dark lines running along the fiber and the surface may be wrinkled from the rapid drying of it in air.

EXPERIMENT 217. Collodion Silk

Look at some rayon silks and try and find some fibers that are made by this process. It helps to make thin sections of the artificial silk fibers for identification. The collodion silk has crescent, oval or irregular appearing cross sections.

Instead of using nitric acid the Cuprammonium method dissolves the cellulose in a solution of copper oxide in strong ammonia. The dissolved material is sprayed into fibers and the copper and ammonia removed leaving a brilliant fiber with fine, faint surface lines and with a round or oval cross section.

EXPERIMENT 218. Cuprammonium Silk

Try and find some rayon made by this process, fig. 36.

Viscose rayon is obtained by treating purified cellulose from wood pulp chemically to make it into cellulose xanthate and the fibers are recognized from their wrinkled appearance due to the fine lines running lengthwise. The cross sections are flattened and of irregular outline.

EXPERIMENT 219. Viscose Silk

Can you find a sample of this kind of rayon?

The fourth common process for making artificial silk turns the cellulose into cellulose acetate by means of acetic acid, which is the acid which makes vinegar taste sour and have its own odor. These fibers look much like the other artificial silk fibers but do not swell much when they are placed in water, as do the other kinds of rayon. When the fibers are burnt they have a different, rather more unpleasant odor.

EXPERIMENT 220. Acetate Silk

Look for some acetate artificial silk.

For complete identification special chemical methods are used and it takes quite a little training to become a textile microscopist. The different artificial silks stain differently with dyes which helps in their recognition under the microscope.

The transparent wrapping papers like Kodapack and Cellophane are made by a similar manner except that the solution of cellulose is forced through a narrow slit instead of a pin hole. Cellophane gives very interesting colors in Polarized light, the color depending on the number of thicknesses of cellophane used. Kodapack does not give as pronounced colors.

EXPERIMENT 221. Sheet Cellulose Products

Examine different kinds of cellophane—like wrapping materials.

Many other plant fibers are used commercially. Hemp fibers are reted out of another plant much like linen fibers were described as coming from flax. The fibers look much like linen but the center hollow shows more clearly, fig. 35. These fibers are coarse and strong and used for making rope.

EXPERIMENT 222. Rope Fibers

Examine the fibers from a rope and compare with the other fibers you have just seen. Also examine the fibers from some burlap or gunny sack and you will see that they are quite similar but they are of another material called Jute. The Jute fibers are smoother than those of linen and often sharp pointed. Nodes are not found on Hemp and Jute fibers.

It is easy to make permanent preparations of textile fibers by drying them in the air and mounting in balsam under a cover glass.