How to Use the GILBERT MICROSCOPE

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CHAPTER 24

The Use of the Microscope in the Paper Industry

The use of the microscope in the paper industry is as important as it is in the textile industry. We use tremendous amounts of paper every day. It takes tons to print the daily newspapers, and a great deal is used for advertisements, magazines and as writing paper. Each use requires a different kind of paper and the microscope is used to identify the kinds of paper and to study their surfaces to see how they take ink and how they may be improved.

Much of the paper is made from wood pulp by chemical or mechanical treatment. The chemical method uses chemicals to separate the cells of the wood and to bleach them. The cells are then pressed into paper with rollers. Other materials may be added to obtain special kinds of paper and the spaces remaining on the surface between the cells may be filled with a sizing. Mechanically prepared fibers are obtained by grinding the wood between stones under water.

To examine paper one takes a small bit, about ¼″ square, and places it in a drop of water on a slide. It is gently rubbed from the center toward the edge with a dissecting needle to separate the fibers. When enough fine fibers have been separated the preparation is covered with a cover glass and studied under the microscope. For positive identification one must use special stains but we can learn much by looking at samples from different kinds of papers.

The mechanical process is the cheaper and is often used for making newspaper. The wood cells are badly broken and frayed by the process. The chemical process separates the cells without quite so much injury to them and is used in making better grades of paper.

EXPERIMENT 223. Chemical and Mechanical Paper Pulp

Examine several paper samples and try and decide whether the cells were separated by the mechanical or chemical method.

Two types of wood are used, the coniferous such as spruce, fir, pine and hemlock; and the non-coniferous like the bass, beach, birch and maple. The cells from the coniferous wood are tracheid cells like fig. 27A with thin walls and have a single or double row of dots, bordered pits, irregularly spaced on the surface. In cross section they are polygonal. The non-coniferous wood pulps have long tapering fibers with no surface markings and vessels, fig. 27B which are several times larger in diameter than the fibers and more or less covered by rows of pits or perforations. Sometimes they look like fine sieves.

EXPERIMENT 224. Coniferous and Non-Coniferous Paper Pulp

Which of the paper samples that you have prepared are from coniferous and which from non-coniferous wood? Papers from non-coniferous wood are less common and usually feel to be of a better grade as you handle them. If you look at a number of different papers you will find some of the non-coniferous pulp.

Brown wrapping paper is not bleached as much as white so that the fibers are not weakened and the finished paper is stronger. You will see on examining it that the fibers are not so completely separated from each other and the brownish color is due to the woody nature of the cell walls.

EXPERIMENT 225. Unbleached Paper

Are paper bags and brown wrapping paper of the same composition?

Heavy, yellow pasteboard often contains cells from the walls of grass stems which have been ground. The cells are thin and tapering with hollow centers. Sometimes you will find groups of a dozen or so flat cells fitted together just as they were in the plant stem.

EXPERIMENT 226. Cardboard and Strawboard

Look at yellow and dark cardboards from packing cases and see whether some of them contain straw.

The better papers are made from old linen and cotton rags. If you examine some good writing paper you can make out the linen and cotton fibers, fig. 35 although you will find that they are badly broken and frayed from the process of breaking up the cloth into fibers. These longer textile fibers make a stronger paper, and do not rapidly turn yellow with age or with exposure to light.

EXPERIMENT 227. Linen Paper

Look at some good writing paper or at a bit taken from the corner of a bookkeeper's ledger and estimate how much of it is linen fibers and how much cotton. Do you find any wood pulp fibers present?

The fine, glossy papers used by the better magazines for fine halftone pictures are sized to give them a good surface. Some papers are sized with starch and this is easily determined by noting whether or not the surface turns blue when you add a very small drop of iodine.

EXPERIMENT 228. Paper Sizing

To examine the surface coating scrape it off very carefully with a sharp razor blade and mount the scrapings in water for microscopic examination. If they look like starch granules test by running a little iodine under the cover glass. The sizings of starch are usually cooked so that you cannot easily recognize the grains. (Chapter 17). If the particles look like regular crystals they may be gypsum, if they are irregular they may be talc or clay.

The fillers used with the fibers in the paper are harder to study but you can see them in your preparations of the fibers. It takes an experienced microscopist to be able to identify them, but that is part of the training of a chemist for the paper industry.

If you wish to keep your preparations, dry and mount them in balsam. It is interesting to stain them with the dyes that come with your set, or with colored inks or any other dyes that you may have about the house.

CHAPTER 25

Other Applications of the Microscope

Only a few of the interesting uses for your microscope have been mentioned in the chapters of the manual. You can do many more experiments with the subjects of each chapter and many other objects may be examined. Nearly everything in your house and yard can be looked at and many of them will be surprisingly interesting. Here are a few suggestions:

EXPERIMENT 229. Sound Groove in a Phonograph Record

How are the grooves formed in a phonograph record? Are the grooves of low toned parts of the record the same as those of high tones? those of a tenor and a bass singer? those of a violin and a band?

EXPERIMENT 230. Spices and Their Adulteration

Examine the spices in the pantry and see how they look. You will find some of them contain your old friends the starches. Cheap spices are diluted more with starch than expensive ones. Is your mother getting the best buy in each for the price she pays for them? The use of oil cleared preparations (Chapter 11) and staining with iodine will aid your examination of spices.

EXPERIMENT 231. Parts of Insects

A collection of slides showing the different kinds of insect mouth parts, wings and legs is very entertaining and quite easily prepared.

EXPERIMENT 232. Designs of Diatoms

One can make designs on a slide by carefully arranging different kinds of diatoms from the diatomaceous earth in your set by means of the forceps and needles. Some people have made these designs with over a hundred diatoms and they look very nice when viewed under the low power of the microscope.

EXPERIMENT 233. Cigar and Cigarette Ash Collections

Some boys make collections of cigar and cigarette ashes either keeping them in boxes or making permanent mounts with balsam and other boys make sets of soil samples. Perhaps you remember how Sherlock Holmes used cigar ashes to trace the culprit.

EXPERIMENT 234. Snow Flakes

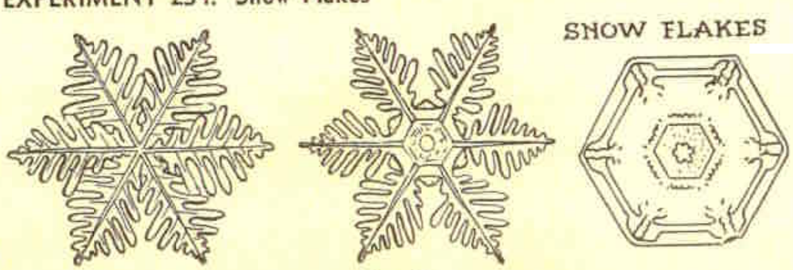

FIG. 37

On a winter day take your microscope out doors and catch snowflakes on slides as they fall. You will find that they are beatuiful and often each one is different, fig. 37. Mr. W. A. Bentley made a hobby of photographing the forms of snowflakes and you will find an interesting, illustrated article by him in the January 1923 National Geographic Magazine.

Another interesting way of discovering other things to do with your microscope is to ask your family doctor, or a chemist friend how they use their microscope. A teacher of biology or natural science will be able to show you a great many uses of the microscope and tell you of many interesting objects.

CHAPTER 26

Detective Work With the Microscope

Right now the most spectacular use of the microscope is in detective work and almost everybody has read of how the police have solved by this means crimes that would otherwise never have been solved. A woman was found dead in New York City and it was suspected that she was murdered. The only clue was a bit of cord which was taken to the laboratory, identified as a kind used by upholsterers, traced to the manufacturer and finally to where it was sold. The police then found out who had used it and ultimately found and convicted the murderer. The microscopic examination of the cord helped solve the crime which otherwise might have gone as a perfect crime. Another interesting case was the identification of a burglar because on his clothes were found the burrings made from drilling a safe and the microscope showed that these were the same as those left near the safe.

Successful detective work requires the detective to know how to use the microscope, all of the methods for preparing objects for study with it, and to have such a wide knowledge of how materials look under the microscope that he can recognize the unknown quickly and then prove that he was right by comparing the unknown material with known material. Your study of starches, hair, pollen, fibers and fish scales is good training for detective work.

There are many experiments you can do of this kind.

EXPERIMENT 235. Identifying Soil Samples

Take a little of the dirt from the edge of a shoe and see what it looks like under the microscope. Look at different specimens of soil from different places and see if you can find out by comparing them with that on the shoe where the owner of the shoe had been.

EXPERIMENT 236. The Vacuum Cleaner Detective

Take a little of the dust from the vacuum cleaner bag and see how many different things are recognizable in it and then see if you can figure out where they came from. You may find parts of insects, textile fibers, hairs, etc. Would the use of a vacuum cleaner at the scene of a crime be helpful in finding clews?

Handwriting is always different because each person makes the letters in a peculiar manner. Each typewriter has slight differences in the form of the letters. Different typewriter ribbons give slightly different impressions. Sometimes the dot on the *i* is of different size or worn so that it is not round or may barely show. Different machines have the period so that it may have a slightly higher or lower position in the line. Some people habitually strike one letter harder or less hard so that you can recognize their writing even though they use different machines.

EXPERIMENT 237. The Handwriting Expert

Examine different kinds of handwriting with your hand lens and with the lowest power of your microscope until you can find the peculiarities that would permit you to say two samples were, or were not, the same. Have a friend try to disguise or change his writing and see if there are not still some telltale peculiarities that will show whose it is. Do you think that anyone could completely change his writing?

EXPERIMENT 238. Typewriter Detection

Study different kinds of typewriting until you can tell whether two samples were made with the same machine.

The microscope may be used to determine whether a document has been changed. Erasures that could not be seen with the naked eye roughen the surface of the paper so that you can see the difference with the microscope. Hold the microscope lamp above the paper so that the rays of light fall on the paper at an angle.

EXPERIMENT 239. Can Hand Writing Be Disguised?

Try and make a very careful change in some writing and then see how easily it can be discovered with your microscope.

EXPERIMENT 240. Safety Paper

Examine a safety check with the over all printed surface to see the design. Note how the least change or erasure shows up when you look at it with the hand lens or the lowest power of the microscope.

Artists using oil paint make strokes with their brushes which show their own styles. These are as different as handwriting.

CLASSIFICATION OF FINGER PRINTS

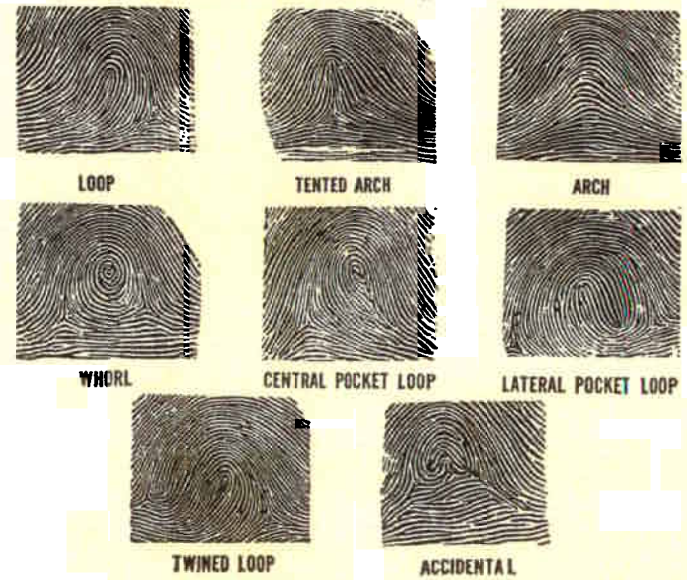

FIG. 38

EXPERIMENT 241. Oil Paintings

Examine some oil paintings and note the brush marks and see if different painters may be recognized by this method. If you are very careful you will not injure the painting.

Fingerprints are very important and fascinating. Put your finger on a piece of paper. Now if you shake a little black powder on it it will stick to the print and you can blow off the excess and find a reversed print of the ridges of your finger looking like those of fig. 38. You may use a little charcoal or very fine shavings from a soft pencil for black powder. If the fingerprint is on a dark object use white talcum powder to develop, or bring out the print. No two people have the same fingerprints, therefore, the prints make identification certain as many lawbreakers have learned to their sorrow. You may make prints of your own and your friends fingers as you did in experiment 7. Many people are having their fingerprints filed with the Department of Justice in Washington so that they may be certainly identified in case they have an accident anywhere in the world. They can then make sure of documents if they sign them with a fingerprint as well as their signature. Such fingerprints are filed separately from those of criminals at Washington.

EXPERIMENT 242. Kinds of Finger Prints

Examine different fingerprints to see how they are similar and how different. The hand lens and the lower powers of the microscope will help you.

EXPERIMENT 243. The Home Detective

Examine the icebox, the door knobs, etc., to see which members of your family have used them.

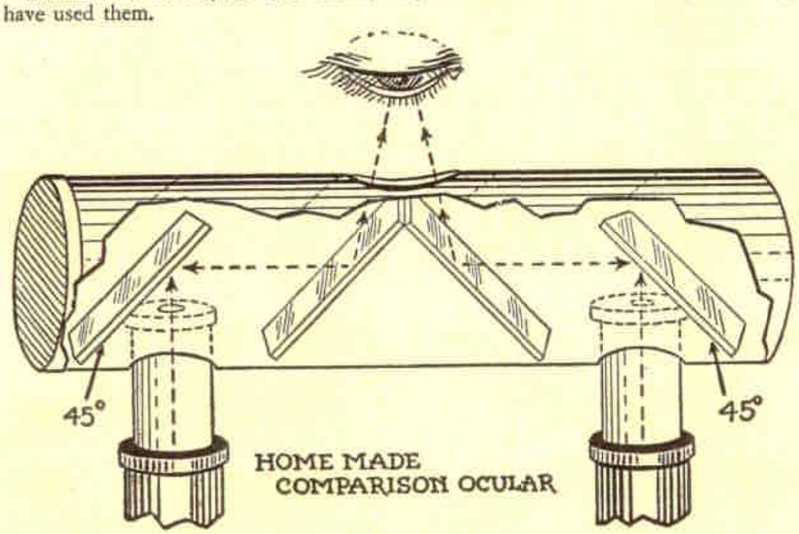

FIG. 39

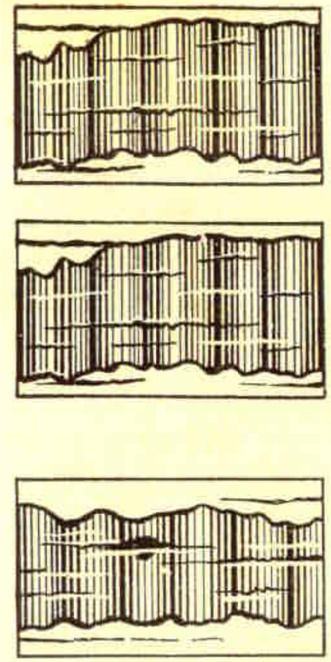

FIG. 40

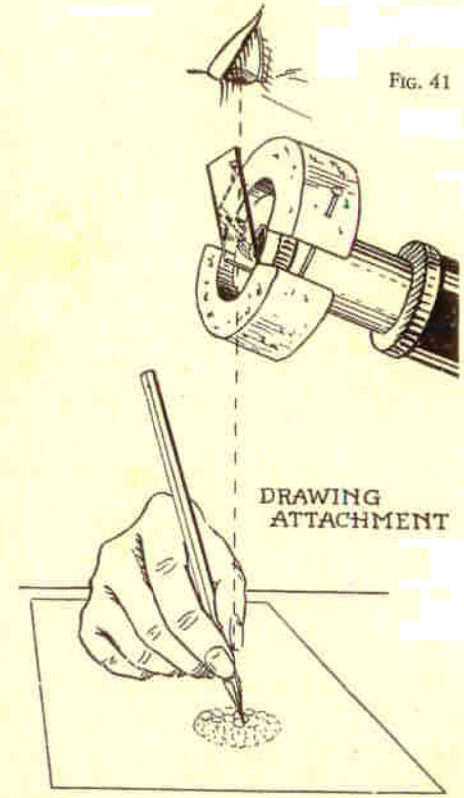

FIG. 41

When a bullet is shot out of a gun the barrel of the gun makes marks on the surface of the bullet and each gun barrel makes a different signature. By comparing the unknown bullet from the scene of the crime with one known to be shot in a particular gun it is possible to determine whether or not the same gun was used. For this work two microscopes are used with each bullet on a microscope. A comparison eyepiece is fitted to both microscopes so that the images of both bullets are seen side by side. By turning the bullets one can see whether or not the grooves are the same. If you can borrow another microscope from a friend, you can make a comparison eyepiece similar to that shown in fig. 39. The round cardboard tube may be rolled up from stiff paper or a mailing tube may be used. It should be long enough to permit the two microscopes to stand side by side. Cut the holes just big enough for the eyepieces of the microscopes to pass through and set the two end mirrors at 45° like those in the picture. The ends are then covered with stiff dark paper to keep out light not coming from the microscopes. A single hole is cut on the opposite side of the tube from that of the two holes, and the two mirrors are fastened together and tilted until you can see the image from both microscopes side by side. With such a comparison piece you can easily compare any two objects such as bullets to see if the markings are exactly the same. The telltale markings on three bullets are shown in fig. 40. Two of the bullets were shot from the same gun and the other from a different gun.

You will wish to have some method for making drawings directly from your microscope both for permanent record and for making comparisons in case you do not have access to two microscopes. A simple drawing attachment, or camera lucida, is illustrated in fig. 41. Cut a large cork in two lengthwise and hollow out the two flat surfaces until they fit closely around the eyepiece of your microscope. They may be held together on the microscope by two long pins or nails. Cut a groove in the cork so you may put a clean slide which is first broken in half into it so it will hold the slide at 45° to the body tube of the microscope, as shown in fig. 41. A more simple method would be to attach the slide with adhesive tape.

To use the drawing attachment tip the microscope at the inclination joint until it is as near horizontal as possible. A weight, such as a book, may have to be placed on the stand to keep it from falling over. Place the slide you wish to draw on the stage, use the stage clips to hold it in place and look down the microscope as you have before, adjust the light with the mirror and focus the microscope. It is easier to use the low power until you become familiar with the drawing attachment. Then place your eye close to the slide, as shown in fig. 41, and you will see the object on the microscope reflected by the cover glass. You can also see through the cover glass, your pencil held on a piece of paper directly under the attachment. If the object is seen too dimly increase the light by bringing the microscope lamp nearer the mirror of the microscope, or else stand some books around your paper to keep the light of the room off the paper. With a little practice you will be able to balance the light on the mirror and that on the paper so that you can see both at once. Then you may make an accurate tracing of the object on the paper. The drawing attachment is used to get the outlines, is taken off and the details filled in as you examine the object, without the attachment.

If you wish to know the magnification of your drawing, take the object slide off and put your ruler on the stage. Focus it and make the distance on the drawing between two marks on the ruler, one millimeter apart. Of course, you must be careful not to change the distance from the drawing attachment to the paper when you place your ruler on the stage or you will change the magnification. The farther the paper from the drawing attachment, the greater the magnification will be; but unless the paper is reasonably close it will be hard to see the image and the pencil. It is better to use a higher power objective when you wish a larger drawing. Then measure the distance in millimeters between the marks. If you find that the distance between the two marks is 25 millimeters you know that the drawing is 25 times larger.

With the drawing attachment you may make careful drawings at a known magnification and your drawings may be directly compared when they are made at the same magnification. Such accurate records are important in detective work.

EXPERIMENT 244. Measuring the Magnifying Power of the Compound Microscope

You may use the drawing attachment to determine how much the low power on your microscope magnify. Arrange the microscope as you did before but so that the center of the ocular is exactly 254 mm. from the paper. Focus the microscope on the ruler and draw the position of two marks one millimeter apart on the paper. Measure the distance in millimeters with your ruler and that will give you the magnifying power of that objective at that position of the draw tube. The distance of 254 millimeters, or ten inches, is always used because it is the usual distance that reading material is held in front of normal eyes when reading and it is at this position that we imagine we see the object as we look at it through the microscope. To measure the higher power objectives a better camera lucida is required and a ruler that is graduated in one-hundredths of a millimeter on a glass slide, otherwise the method is the same. Measure the magnifying power of the low power lens of your microscope with the draw tube closed and again with the draw tube pulled out. How much is the magnification increased for each 25 mm. that you pull out the draw tube?

CHAPTER 27

The Use of Polarized Light

A beam of light acts as if it were a wave of some sort in which the vibrations are at right angles or crosswise to the direction of the beam. A beam consists of many waves going together in the same path but with their vibrations in all possible directions to the path. When such a beam of light is passed through a polarizing substance the waves are so combed that only those vibrating in the same direction can pass through the polarizer, and we say that the light is then polarized. If we hold a second polarizing filter in front of our eye and look down the beam of polarized light toward the first polarizing filter and turn the filter before our eye we find the light to gradually become darker until we reach a position of the second when the light is dimmest, continuing to turn it we find the light gets brighter and then the brightening and dimming of the light repeats. When the axis of the second polarizer filter is at right angles to that of the first, the polarized light is blocked and cannot pass through. Placing the second at 45° passes half of the light and when the axes are the same the light goes through both filters.

The Nicol prism is used to separate the light rays so that only those vibrating in the same plane can pass and these prisms are very expensive. Recently E. H. Land discovered how to arrange many very small crystals of certain salts of quinine in a transparent material so that large polarizers can be made at considerably less cost. This material is called *Polaroid*. The *Polaroid Jr.* in your set will not polarize the light so completely as the more expensive Polaroid, but is satisfactory for our experiments.

Light reflected from various substances is more or less polarized. When the reflecting substance is non-metallic and at 33° to the beam of light, quite complete polarization occurs.

EXPERIMENT 245. Polarization by Reflection

Take the round element of Polaroid Jr. from your set and look at various objects through it as you hold it in front of your eye. As you look at them rotate the disc and you will notice that in certain positions the glare of reflected objects disappears and you can see them clearly. If you are near a lake or the ocean you will find that much of the light reflected from the waves is polarized, because you can cut it out by turning the Polaroid Jr. filter to the proper position.

This property of the Polaroid products is of important use in making glasses for outdoor wear and special Pola-Screens are now used in front of the camera lens to reduce the intensity of reflected light which obscures the details to be photographed.

EXPERIMENT 246. The Use of Two Polarizing Filters

Hold the long Polaroid Jr. element from your set between you and a source of light with one hand and the round element in front of your eye with your other hand. Turn the round element as you look at the long one and you will find a position of the round one which makes the long one nearly black and another position that passes the light through both. The position of the elements with their axes at right angles to each other does not block the light completely, because a little purplish light still passes through. This will not make any difference to our work and makes the material possible in our sets even though the more perfect polarizers would be too costly.

This experiment illustrates the principle that has been suggested for use on automobiles. The Polaroid over the lights of the cars would be at the proper angle to that placed in the windshields and the light of an approaching car would be barely seen from within the car instead of nearly blinding the driver.

EXPERIMENT 247. Using Polarized Light With the Microscope

Place the long Polaroid Jr. element under the stage of your microscope so that the filter is in the center of the hole in the stage. The clips under the stage will hold it in place. The light reflected from the mirror will be polarized as it passes through the Polaroid Jr. into the objective of the microscope. It does not look very different to the eye, but when you place the round element on top of the ocular and rotate it you will find that you can make the field look very dark when it is turned so that the axes of the two Polaroids Jr. are at right angles.

EXPERIMENT 248. Potato Starch in Polarized Light

Scrape off a bit of raw potato starch onto a clean slide and mount it in a little water under a cover glass. Place the Polaroids Jr. so that the field of the microscope is dark as in the last experiment and then put the potato starch under the microscope. When the microscope is properly focused you will see bright colored crosses in the potato starch grains. These disappear when you remove the filter from the eyepiece, or when you turn the filter to other positions.

The fine structure within the starch grain sets up interference of the polarized light as it passes through it and causes some of the rays of light to be differently polarized and to interfere with each other. Then they can pass through the filter on the ocular, called the analyzer, and the colors you see come from the interference of the light rays with each other. Many kinds of substances have similar effects on light because of their fine structure and such substances are said to be doubly refractive. The fine structure is too small to be resolved by the microscope but by analyzing the color patterns produced with polarized light much may be learned about them.

EXPERIMENT 249. Starches and Polarized Light

Examine the starches that you looked at in Chapter 17 with polarized light. Does cooking starch change its effect on polarized light?

EXPERIMENT 250. Identifying Starch With Polarized Light

It is often easier to detect starch with Polarized light than without it. Starch is used in yeast cakes, some pills and often as an adulterant of coffee and spices. Repeat these experiments using polarized light to see how much easier the identification becomes with the polarized light.

Most living substances have a doubly refracting fine structure and give nicely colored images with polarized light. You will wish to examine most of the objects you have looked at before with polarized light. Here are a few experiments which will suggest many others to you. When the colors are not brilliant, try different thickness of the material until you find the best thickness for each substance examined. Placing the tint plate (Exp. 258) between the polarizer and the subject frequently enhances or changes the colors. Try various thicknesses of the tint plate.

EXPERIMENT 251. Plant and Animal Hairs With Polarized Light

Mount some fine hairs from a leaf in water and you will usually see colored images of the hair. Animal hairs show different colored patterns with polarized light. (Chapter 8).

EXPERIMENT 252. Polarization Images from Wood

Slices of wood must be extremely thin to affect polarized light in the way intended. The appearance is more readily seen if the wood is dried and mounted in balsam.

EXPERIMENT 253. Sections of Shells, Horn, Bone and Teeth

Break or cut as thin a shaving as you can from a bit of horn, shell, bone, tooth or finger nail and you will find them to be very interesting when viewed with polarized light and your microscope. To make really good preparations of these heavy materials, a section is cut with a hack saw as thin as possible and then ground smooth on one side on a carbordundum stone with water. This is dried and cemented with balsam to a slide and then the other side ground until the preparation is thin enough to show well under your microscope. It takes time and patience, but the preparations are worth it. When finished dry again, add more balsam and make a permanent preparation by adding a cover glass.

EXPERIMENT 254. Fish Scales

Fish scales give pretty colored images in polarized light especially after they are cleared in xylene and mounted in balsam.

Textile fibers require polarized light for their complete study. The artificial silks may be separated with this aid when they appear otherwise much the same.

EXPERIMENT 255. Cotton, Silk, Wool and the Natural Fibers

Examine the natural fibers mentioned in Chapter 23 with polarized light to see what kind of color patterns they show.

EXPERIMENT 256. Separating the Artificial Silks With Polarized Light

Acetate artificial silk does not polarize well, but viscose, cuprammonium and collodion silks give good colors in polarized light. The collodion giving the brightest colors.

EXPERIMENT 257. Cellulosic Wrapping Materials

Look at a little Cellophane and notice the bright colors. Try a little Kodapack and notice that it shows very little color unless you use a number of thicknesses (10-15).

Thin, transparent, doubly refractive materials like Cellophane and Kodapack create interference colors in accordance with the number of layers that the light passes through. Try one, two, three and more layers and notice the different colors produced when the Polaroids Jr. are set to give the darkest field.

EXPERIMENT 258. Retardation Tint Plates

Find how many layers of material are necessary to make a difference of just one color. The materials like Kodapack which are weaker optically are better for this experiment even though more layers are required. Standard plates are made for use with the microscope which change the color a certain amount and these are used when making analyses. You may find your material wrapped around various products or may buy small amounts of the sheets from a stationery store. Interesting designs may be made by mounting bits of Cellophane on a slide. Thin pieces of mica are useful to show colors. Try various thicknesses. Try your tint plate *with* other objects. Tint plates having a known color change are used in analytical work.

EXPERIMENT 259. Effect of Rotating the Analyzer

Look at a pattern made of several layers of Cellophane and as you watch rotate the round filter on the ocular and you will see a regular change of the colors.

EXPERIMENT 260. Examination of Minerals With Polarized Light

Small bits of minerals give beautiful colors when looked at under the microscope with crossed Polaroids Jr. Thin ground slices, made as described before with bone, are best but small broken fragments may be used. Examine them with and without polarized light. The following minerals are suitable objects: various agates, serpentine, carbonate of lime, some kinds of marble and sandstone, granite, mica, quartz containing rocks and the selenites. You may be able to find some of these near where you live.

Crystals frequently appear like jewels when you look at them with your polarizing set and as you turn the analyzer on top of the ocular you will find an unending series of colors.

EXPERIMENT 261. Doubly Refractive Colors of Some Crystals

Examine the following crystals from your set by growing good crystals as you did in Chapter 12: potassium nitrate, borax, and copper sulphate. You will find some of the following around the house which are very good for this purpose: alum, boric acid, washing soda, potassium chlorate, tartaric acid and many of the salts in tooth pastes and mouth washes. By all means look at sugar crystals as they are particularly beautiful. Temporary mounts show well in paraffine oil because it cuts out the reflections without dissolving most crystals. Crystals mounted permanently in balsam often show better than the same crystals in the air.

EXPERIMENT 262. Crystals from Fusion

Melt a little potassium nitrate under a cover glass as you did in Experiment 84 and watch the crystals form as it cools with polarized light.

EXPERIMENT 263. Crystals from Sublimation

Sublime a little quinine from a tablet or capsule, as you did in Experiment 101 and examine the crystals with polarized light.

Optically active substances rotate the beam of polarized light and this property is used in measuring their concentrations with an instrument called a polarimeter.

EXPERIMENT 264. Converting the Microscope into a Polarimeter

Dissolve some sugar in a small amount of water in a small glass dish that will go under the low power of your microscope. Set the analyzer so that the field of the microscope is darkest and then put the sugar solution under the scope. You will now have to turn the analyzer a little to again make the field dark because the sugar turned the beam of polarized light passing through the microscope. Dissolve twice as much sugar in the solution and see how much more you have to turn the analyzer to darken the field. By placing a protractor on the ocular it is possible to measure the actual number of degrees that the analyzer is turned and the polarimeter can be calibrated to tell how much sugar is present when special tubes holding a certain depth of solution are used. Use a strong solution and as deep a layer as you can get under the low power lens.

EXPERIMENT 265. Inverting Sugar

Add to the sugar solution some strong vinegar and watch it every five minutes and you will find that the analyzer will have to be turned a little each time to darken the field. The acid breaks up the double cane sugar into single sugars and as it is broken up it effects the light passing through the solution.

EXPERIMENT 266. Making Zinc Acetate Crystals

Put a little zinc on a slide and a little vinegar and let it stand until the solution dries. The vinegar dissolves some of the zinc making zinc acetate crystals which are doubly refractive and show colors when looked at with polarized light and the microscope.

You will find many other substances to look at with polarized light and, in fact, with the polarized light you will have nearly twice as many interesting experiments to do with your microscope.

You have now learned how to use your microscope, many of the methods used to prepare objects for microscopic examination and how a large number of materials look under the microscope. You can easily devise other experiments with objects found everywhere; around your home, at school, or work, etc. Sooner or later you may wish to learn other methods and for this purpose we are listing in the appendix some of the more useful books. These you may borrow from your Library, or, if they are not all in your library now, you and your friends can persuade your librarian to get them. In some States you may borrow the books from the large State Libraries.

Some of us use the microscope in our professional work. Many more people find that the microscope becomes their life hobby and they always find new objects to look at, or see more detail in familiar objects, thus throughout life they explore fascinating new worlds. You may do what you wish with your microscope; but if you use it carefully, as any valuable tool should be used, and follow the instructions in this manual until you are familiar with the methods, you will surely have many pleasant hours of fun and you may even make new discoveries in science or solve mysteries!

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B. Older books. Many of these can be purchased cheaply at second-hand book stores and they are of use even though the descriptions of the microscopes are out of date. Earlier or later editions are also useful.

Beale, L. S., How to work with the microscope. 4th ed. 1848. London. 383 pp
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Hogg, J., The microscope. 11th ed. 1886. London. 764 pp.
Wood, J. G., Common objects of the microscope. London. A second edition of this has recently appeared with no date. It can be obtained from Barnes & Noble, New York City. This has many colored plates and is quite inexpensive.

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Chamberlain, C. J., Methods in plant histology. 5th ed. 1932. Univ. of Chicago Press. 416 pp.
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Dale, A. B., Form and properties of crystals. 1932. Cambridge. 186 pp.
Hanusek, T. F., Trans. by A. L. Winton. The microscopy of technical products. 1907. Wiley. 471 pp.
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Strong, O. S., and A. Elwyn, Bailey's text book of histology. 7th ed. 1928. Wood. 939 pp.
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Woodruff, L. L., Foundations of biology. 5th ed. 1936. Macmillan. 583 pp

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