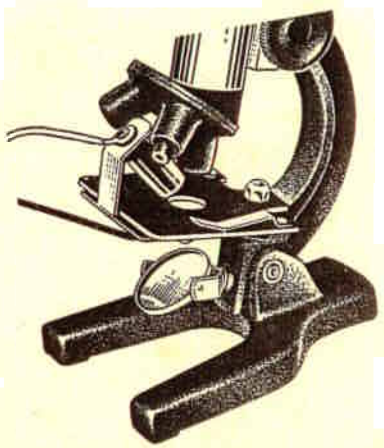
How to Use the GILBERT MICROSCOPE

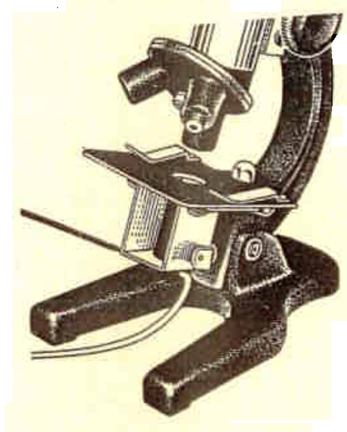
pp 20 - 37

By now you will wish to see some of the objects magnified more than the hand lens or simple microscope can do and you will have found that it is hard to find, or make, and use simple lenses of high power. Could one use several lenses together to get greater size? Yes, when the lenses are held close together they give more magnification. You may have seen groups of two or more lenses in the same holder so hinged that they could swing out and so one or more could be used at the same time. They increase the size of the object looked at, but a different arrangement gives a great deal more power and leads to the discovery of the compound microscope.



TOPSTAGE SPOT LIGHT

The Topstage Spot Light provides a type of lighting which illuminates the top surface of opaque objects. With it you may view the surface of coins, minerals, stamps, metals and all types of opaque objects. By its light you will secure clear and beautiful views which will give an entirely new idea of the appearance of opaque objects.

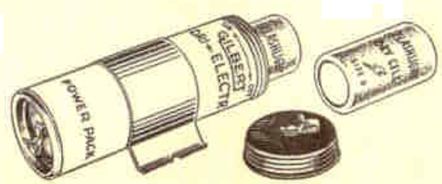


SUBSTAGE SPOT LIGHT

The Substage Spot Light is intended to replace mirror lighting with a brilliant, concentrated beam of light which will pass through semi-transparent objects which are too dense to be satisfactorily viewed by mirror lighting.

Dri-Electric Power Pack

The Dri-Electric Power Pack provides a simple means of connecting two Size "D" flashlight batteries in series, with a switch to either the substage or topstage lights.



CHAPTER 2
The Compound Microscope

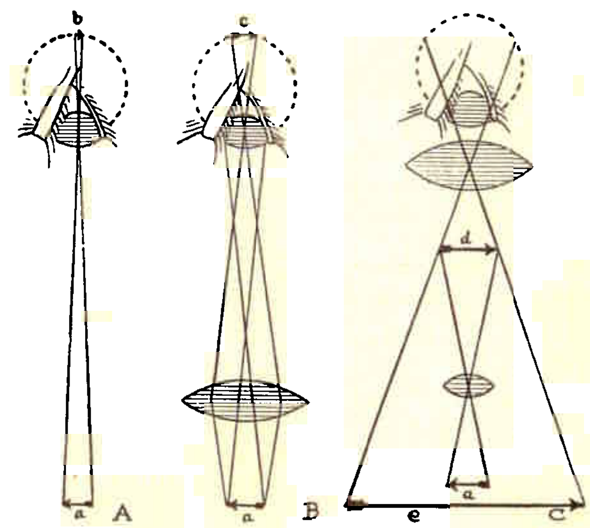


Fig. 4

The Jansser brothers discovered in 1590 that a second magnifying glass might be used to magnify the image of the first lens and the combination of lenses is the compound microscope. You found how a lens gives an image in experiment 4. In this case the image was smaller than the object because the object was far away from the lens. When the object is closer to the lens the image is larger. The image of the first lens becomes the object of the second lens in the compound microscope and the doubly enlarged image of the second lens is seen by the eye.

An object such as the arrow a in fig. 4A is visible because it reflects light into the eye and the eye forms an image b on the retina or sensitive region inside the eye. This image b is not very large and we would say that the object seen was small. Now if we look at the same arrow a with a magnifying glass as in fig. 4B the image of the arrow c on the retina of the eye is larger and the greater size is the amount it is magnified. With the compound microscope the arrow a is magnified by the first lens to an image of size d. The image d is further magnified by the second lens and because this lens is close to the eye the image appears to be located below and of the size e.

Two lenses, both thicker at their centers than at their edges, properly arranged at the right distances in a tube make the compound microscope; and in fact, the first one did look more like a telescope. However, it was tiring to hold this kind of a microscope in the hand because the least movement caused the image to disappear. Many improvements have given us the present microscope and different kinds of microscopes are made for special purposes.

Most of the objects that one wishes to see in detail are either transparent or may be prepared thin enough to be clear. Therefore, the microscope must have a stage to hold the object with a hole through the stage so that light may be thrown onto the object by an adjustable mirror placed below the stage, fig. 5. The tube containing the lenses of the compound microscope is held above the center of the stage in a ring so that it may be raised and lowered. In the larger microscopes the tube with the lenses, called the

SIMPLIFIED INSTRUCTIONS FOR THE USE OF YOUR MICROSCOPE

1. **Light and Mirror** — Place your microscope on a table so that daylight (not bright sun light) will shine on the mirror. Or arrange an electric light, not too high so that its light shines on the mirror of your microscope. Look down through the scope. Without any attempt to focus on an object, move the mirror up and down and from side to side. When you see a clear, bright circle of light the mirror is properly adjusted.

2. **Focusing on an object** — Place the feather slide on the Microscope table, directly lined up under the objective lens of the microscope.

3. **Focusing** — The following give you the approximate focus (distance from objective lens to slide) on each of the lenses contained in the S6, and S15 Microscopes.

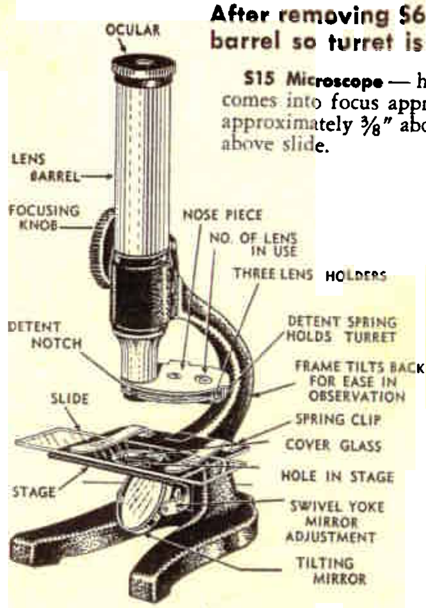
S6 Microscope — has three objective lenses. No. 1 lens comes into focus approximately ¾" above slide. No. 2 lens approximately ⅜" above slide. No. 3 lens approximately ⅛" above slide.

CAUTION

After removing S6 Microscope from package, turn barrel so turret is moved to front of microscope.

S15 Microscope — has three objective lenses. No. 1 lens comes into focus approximately ¾" above slide. No. 2 lens approximately ⅜" above slide. No. 3 lens approximately ⅛" above slide.

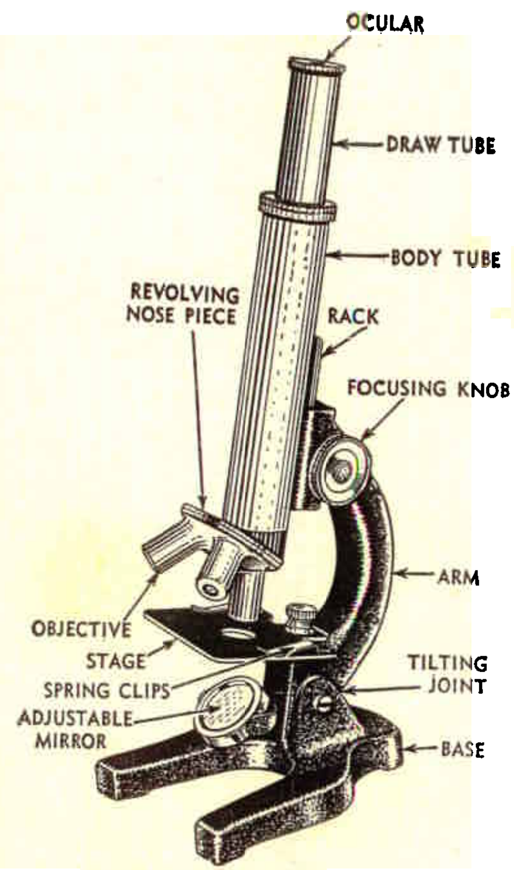
When you have adjusted your Microscope to the approximate distance as given above, you should then raise or lower the lens carefully and slowly by turning focusing knob until object comes in view. Your microscope is so powerful that it takes in but a part of even a very small object so it may be necessary to move the slide around to see different sections of it or in fact to find the object. You may from time to time find it necessary to try to see if you can improve the focus by slowly raising or lowering the barrel as already described and perhaps improve the light by changing the angle of the mirror. Patience and practice is required. But if you follow these simple directions you should be able to focus your Microscope without difficulty.



S6 MICROSCOPE WHICH IS INCLUDED IN THE NO. 8 SET

Fig. 5

Fig. 5



S15 MICROSCOPE WHICH IS INCLUDED IN THE NO. 20 SET

Fig. 5

body tube, is moved up and down by a rack and pinion gear turned by the wheels at the side. This gives smoother movement and better control.

The early microscope makers soon found that if a third lens is placed near the eye lens the object appears to be brighter. The third lens is usually placed in a tube with the second lens which is called the draw tube. Both lenses together are called the ocular, or the eyepiece, to distinguish them from the first lens. The first lens nearest the object is called the objective. The different parts of the microscope are marked on fig. 5. The magnification of the microscope can be increased by pulling out the draw tube so that the eyepiece lenses are farther away from the objective or decreased by pushing in the draw tube.

To have greater power the objective lens must be made more curved so that it will magnify more. Instead of having several microscopes with objectives of different powers two or more objective lenses are placed on a nosepiece so that one or the other may be turned into place at the end of the body tube of the microscope. Such a microscope, Fig. 5 No. 20 is essentially complete. The large professional microscopes have additional equipment and conveniences. Lenses are placed between the mirror and the stage to concentrate the light on the object. The objective lenses may be composed of as many as five separate lenses and attachments are available for measuring and drawing.

You may ask why two compound microscopes should not be combined to get a still greater magnification by letting each magnify the image of the one in front of it? This may be done but each lens takes some of the light passing from the object to the eye so that if too many lenses are used the object becomes invisible due to a lack of light. Occasionally two microscopes are used together as a stunt but for greater magnification it is better to use a microscope with stronger lenses.

What is the limit of magnification you will ask now? The limit is set by the nature of the light that is reflected by or passes through the object, and the sensitivity of the eye. With the best microscopes the smallest object that may be seen as it is, would be about one one-hundred and thirty thousandths of an inch (1/130,000). The practical limits seeing with the microscope are about 1500 to 2000 times magnification. By the use of ultra violet light and special photographic plates a greater magnification may be obtained. To use these high powers one must have expensive instruments but they are only required for special work and the ones in your set will show you many of the wonders of the world of small objects.

Now it is time to use the microscope. Take it out of the set and unwrap it carefully. Dust off the mirror, the bottom of the objective and the top of the ocular with lens paper or very soft cloth, being careful not to scratch their surfaces. Glass used in microscopes is softer than that used in windows and must be treated carefully. Place the microscope in front of you on a table of convenient height facing a window and turn the mirror until you can see an even, bright field as you look into the ocular. Tear out a few letters of a newspaper and put them on the stage above the opening. Lower the body tube until it nearly touches the object as you look at it from the side of the microscope, and then as you look through the microscope gradually raise the body tube until you see a letter or part of a letter clearly. As you raise the body tube it will first be blurred and then gradually clear. If you raise it a little too far it will become blurred again and you will have to lower it until it becomes clear. Moving the tube until the object is seen at its clearest is called focusing the microscope.

EXPERIMENT 13. Reversal of Image by the Compound Microscope

Focus the microscope, as described in the last paragraph, on a letter. Move the letter to the left and see whether it seems to be moving to the right. Move it away from

you and it appears to move toward you. Is the letter upside down and wrong-side-to? The compound microscope reverses the image. This is shown by the reversed arrow image in fig. 4C e. You note that the least movement will push the object so far that it disappears from view. A little practice will soon teach you how to move the object yet keep it where you wish it.

EXPERIMENT 14. Making a Temporary Slide

Clean one of the large glass slides and one of the small cover glasses with a little soap and water and wipe dry with a clean cloth that does not leave lint. The cover glass must be handled very carefully as it must be made thin and is easily broken. If you put it on a cloth on a flat surface it may be rubbed without breaking. Should you break the first one save the pieces for use later. Pick out a bit of newspaper which has small letters printed on only one side of the page and just large enough to have a few letters. Place this at the center of the slide and a drop of uncolored oil on the paper and then place the cover glass on by gradually laying it down from one edge so as not to get in air bubbles. If air bubbles should form take off the cover glass and clean it, add a little more oil and try again. Examine this slide with the hand lens and note how large the letter appears. The oil makes the paper translucent so that the light passes through it easily.

EXPERIMENT 15. The Number One Objective

Put the same slide on the microscope stage and focus the number one objective on it. If the number one objective is not in front of the body tube turn the nose piece until it is. You will again see the letter reversed and the ink will seem uneven because you can now observe that the fibers of the paper begin to show and that the paper is not smooth.

EXPERIMENT 16. The Number Two Objective

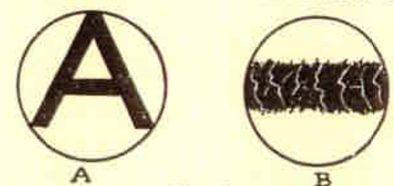


FIG. 6

The appearance of a letter, A) under low magnification; B) of part of the letter under high magnification.

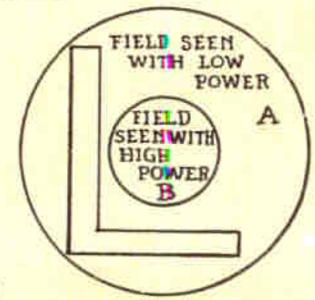


FIG. 7

A. The large field seen with the low power objective and B. the small field seen with the high power objective. The letter "L" was not properly centered and was entirely missed by the high power objective.

Now turn the number two objective in front of the body tube, lower it until it nearly touches the slide, and then raise it until it is clearly focused. This time you will not have to raise it quite as far. How much larger is the letter? The paper now seems to be quite rough and fibrous and you may not be able to see all of the letter at one time.

To see any object larger would either require a larger microscope or else we must look at a part of the object which then seems to be as large as the whole object was with the lower magnification. It would cost too much to have several microscopes each larger than the other, so instead we have to be content with seeing a smaller part of the object each time we increase the magnification. The comparative views, or fields, seen with two different lenses are shown in fig. 6. If the object is not in the center of the low power field it may not be seen at all with the high power which has a smaller field as indicated in fig. 7. So if you fail to see your object with a higher power turn back to the lower power, focus it by raising the body tube, and move the object to the center of the circular field and then turn to the high power again. Since the high power field is so much smaller there is little use trying to find something with it. To find an object we always use the lowest power (No. 1 objective) and then after it is found we turn to the high power. Occasionally the draw tube is twisted in raising it or lowering it so the center of the field is changed. This is more apt to happen with the smaller microscopes which are raised and lowered by hand without the rack and pinion gears and a gentle moving of the tube sidewise or up and down will bring the center of the field to where it was with the lower powered lens.

EXPERIMENT 17. The Number Three Objective

Now turn objective number three so that it is in front of the body tube and focus it on your letter. This time you will have to focus very carefully because of the high magnification. The object will be so magnified that you will only see a small part of the letter at a time and to see the whole letter you will have to move the slide. Now you will see that the ink is on only the higher fibers of the paper. This will be explained later in Chapter 20 under the use of the microscope in printing.

EXPERIMENT 18. Adjusting the Mirror

Each of the three objectives gives a different magnification and the greater the magnification the smaller is the glass lens of the objective and the closer it must be to the object. Also with greater magnification the object may appear less bright. With the high power lens the mirror must be turned so that the light is brightest. You may have to move nearer the window to get enough light or you may need to place your electric microscope light, fig. 3H in front of the microscope and then turn the mirror so that the light from the lamp lights the object on the slide. Turn the mirror slightly to one side and notice that the object appears to sway from side to side as you focus the microscope. The light should always be centered so that the object does not sway as you focus up and down. Always have enough light to see with clearly but not so much light as to glare. Never use direct sunlight as it is much too bright. With clear objects you will need less light and with dense objects more light.

EXPERIMENT 19. The Draw Tube

Focus the low power No. 1 objective on the letter and note how large it appears. Now pull out the draw tube with a twisting motion almost as far as it will go and you will find that with a slight amount of refocusing the letter appears clear and larger. If you do not pull the tube out quite so far the magnification will be less. Try the effect of changing the draw tube with the two other objectives. The adjustable draw tube gives you a wide range of magnifications.

What magnification should be used for any given object? The answer to this is the lowest power that will show you the details you wish to see. The lower powers give brighter views so that one can sometimes see more in a smaller bright field than with the less bright greater magnification. For fine detail the higher powers are necessary. You remember that you saw more and more of the detail of the ink making the letter as you used the higher power of the lenses.

EXPERIMENT 20. Magnification

A hair placed on a slide makes a good object to show the apparent size as you use the different lenses. However, with the highest power you may not see all of the hair at one time. No easy method like that used with the simple microscope or hand lens can be used with the compound microscope. A method will be given for measuring the magnification later.

EXPERIMENT 21. The Importance of the Cover Glass

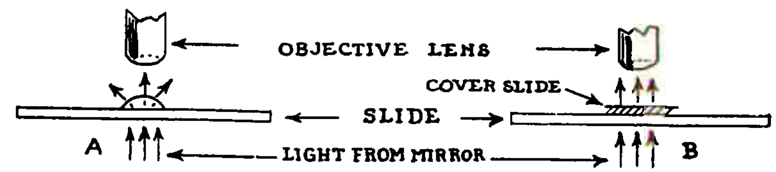


Fig. 8

The importance of the cover glass. With a round drop the light is mostly refracted away from the objective, A; but with a cover glass, B, the light goes through the object into the objective lens.

Put a hair in a drop of water on a glass slide and look at it with the lowest power (No. 1 Objective) and you will not see it as clearly as you will after putting on a cover glass. The reason for this is shown in fig. 8. The round drop acts like a lens and turns some of the light away from the objective so that it is lost. With a cover glass the light goes straight to the objective so you can see with it.

EXPERIMENT 22. Locating Dirt on the Microscope Lenses

When the mirror is dirty you cannot get enough light to see well. Place a piece of paper over the mirror and you will see how much light you lose. When the objective is dirty you cannot focus the microscope clearly and everything looks like it was in a fog. The same happens in case a drop of water gets on the objective lens from a wet preparation. Should this happen carefully wipe the lens dry with a soft paper. Dirt on the ocular appears as specks and you can easily determine this, because if you turn the ocular around as you look through it the specks will turn too. Wipe off the top of the ocular and if they still show wipe off the bottom. It is better not to leave the draw tube out because dust gets onto the back of the objective. When through working for the day clean the microscope and either cover it with a clean cloth or put it into the case so that it will keep clean.

CHAPTER 3
Care of the Eyes When Using the Microscope

You have two eyes so do not expect one to do all the work of looking through the microscope. Use one a while and then the other. All skilled microscopists keep the eye that is not looking through the microscope open, because it does not tire one nearly so much as when the eye muscles must work to keep that eye tightly closed. Learn to keep both eyes open and to see with only one through the microscope. At first it seems hard but you will very soon learn not to notice what the other eye sees. Sometimes it helps to hold the hand in front of the eye and gradually take it away. When using mounted objects the microscope may be tipped back at the joint just below the stage to a convenient angle.

Plan to be comfortable when you work. Have a table of the proper height so that you do not need to stretch your neck or try to fold yourself up like an accordion. If the table is not the right height place a box on it, or better, set the legs on boxes to raise it. With the electric lamp you may work anywhere that you can connect it into an electric outlet. When you are using daylight it is better to use a north window out of the direct sun and arrange the window shade so that the light is kept from hitting you in the eye.

If you habitually wear glasses it is better to keep them on when you are using the microscope for any length of time. It is not as convenient but many people learn to do it. It is especially important if you have any astigmatism. If you are just near or far sighted you may take your glasses off safely and correct for them by focusing the microscope to your own eye.

EXPERIMENT 23. Determining Whether or Not Your Glasses Are to Correct for Astigmatism

Take your glasses off and hold them a half to an arms length away and look at a window, a picture or other square object. Turn the lens around and note whether the object remains square or whether it seems to become lopsided as you turn the lens. If it does not remain square it will be better to wear your glasses when you use the microscope.

When one is in a comfortable position, both eyes are open, the lenses are clean, and the light is adjusted so that clear vision is possible with no glare, you may use a microscope for several hours at a time without discomfort. Most people like to get up and move about for a few minutes rest during long periods. The eyes should be changed at regular intervals. The microscope properly used never gives one a headache, but if one gets a headache it suggests that the reason for it should be found and corrected.

CHAPTER 4
Observations and Records

Microscopists keep records of their observations and experiments, so that they can use them at a future time. The detective must have records as he cannot remember the appearance of everything he has examined. The best way to keep a record of what you do with the microscope is to have a note book which is used for nothing else. Loose-leaf books can be bought very cheaply with ruled pages for notes and plain pages for drawings. Or a bound book may be your choice.

The first thing to do in making a record is to write the date and where you are working. Then an answer to the question why did you decide to look at that particular thing with your microscope. How did you prepare it and use it? wet or dry preparation? natural or stained with dyes? What did you see?

The answer to the last question may be done more easily with a simple drawing or sketch. At first you may think drawing is difficult but simple sketches, like many of the illustrations in this manual, are easily made. At first it may help to make a circle about two or three inches in diameter in your book and then to draw into that the appearance of the object. A circle may be made with a compass or tracing around a small glass jar or other round object. First, what is the general shape of the object? A hair would be outlined by two lines. A small animal might be like an oval, in which case you would lightly draw an oval and then change the outline to look like the animal. Usually only enough detail is drawn to show the character of the object—perhaps filling in only a strip across the drawing. For the hair a narrow strip shows how it is made and as the rest of the hair is just the same there is no use drawing any more. If a pattern, or kind of structure is just repeated, we usually only draw the pattern once and then indicate by crosses where it appears also. Note the features that are characteristic. They are the details you will want to know later. All hairs look much alike to the eye but just how do they differ when seen under the microscope? Those differences will be necessary in case you are given or find a hair and must find out with your microscope whether it is a human hair or a dog's hair. These special features may be indicated by drawing them in heavier line, pointing an arrow to the critical features or writing a brief description of them.

The object of making the record is its use tomorrow or perhaps a year from now. Before you stop, read your record through and ask yourself, is this information all that I will need to know later, or when I read this later will I be puzzled by its not being quite complete enough? A good record contains the story of your experiment with enough detail so that you can refresh your memory from the story without having to find and look at the object again.

CHAPTER 5
Collecting and Storing Material

You may collect material to look at with the microscope everywhere. If you are near a pond or creek, a cleaned screwcap bottle, like mayonnaise comes in, will be useful for bringing back some of the material. Dry materials may be put in tobacco tins, envelopes, small paper bags or boxes. When it is raining you may collect in the house. A little dust from the vacuum cleaner, starches, flour, etc. from the pantry, bits of different kinds of paper, etc. The important thing is to label each specimen clearly as to what it is and where and when you collected it. Sometimes you can write on the outside or stick a label on the outside of the container and write on that. When that is not possible, write the label on a bit of white paper and put it in with the sample. A soft pencil should be used rather than ink because the pencil will not blot should it get wet.

The microscopist keeps small amounts of materials for future reference. You probably remember reading about Sherlock Holmes' collection of soils and of cigar ashes. It is often necessary to compare an unknown object with a known one to be sure that they are the same kind. Sometimes the specimens are mounted as permanent slides, as you will be told about later, and sometimes the samples themselves are kept. Very little material is necessary for a microscopic examination. That is why the microscope is being used so much in chemistry and many industries.

A collection is more useful and looks better if the different samples are well arranged and kept in a box in one place and not scattered throughout the house. A sample is of no use unless you can find it quickly when you want to use it. Dry samples may be stored in envelopes, pill boxes or other small containers. These may be saved as they come to the house or may be purchased quite cheaply at a wholesale drug store. Many specimens may be kept in gelatin capsules with a label in each and the capsules arranged in rows in a box. They may be obtained in convenient sizes from very small to about an inch long. Chemicals that are apt to get damp should be put in small bottles or vials. Some living materials may be dried and kept that way but others must be specially preserved in alcohol or formalin and these special methods will be given as we study the specimens.

Some specimens, such as snowflakes, cannot be saved and one must depend on the record book or photomicrographs to show how many kinds there are and how they are made.

CHAPTER 6
Measuring With the Microscope

EXPERIMENT 24. The Size of the Field Seen With the Microscope

How large is the largest object that you can see under the microscope with the different objective lenses? Place the millimeter ruler across the field and count the number of millimeters making its diameter. If you have trouble seeing the lines hold your microscope lamp so that it lights the lines. Then when you know the diameter of the field you can estimate the size of the object. When the diameter of the field is one millimeter (abbreviated mm.) and the object covers three-fourths of the diameter we know that it is 0.75 mm. long. The lines marking the millimeters seem very wide when seen under the microscope but when you measure from the center of one line to the center of the next, or better from the right hand side of one line to the right hand side of the other you will have little trouble. For very accurate work one can buy slides ruled in hundredths of a millimeter and with the lines so fine that they cannot be seen by the naked eye but are very clear when seen under the microscope.

Why should we give you a ruler in millimeters rather than using an ordinary ruler? All scientific work is done using the Metric System because it is built on a simple system of tens. The unit of length is the meter which is 39.37 inches long. This length is then divided into tenths called decimeters; the decimeters are divided into tenths, called centimeters; and the centimeters are divided into tenths called millimeters. Deci—means tenth, centi—hundredth and milli—means thousandth. The same scheme is used for all measures. Liquids have the liter as the standard and a milliliter is a thousandth of a liter. It is much simpler than the English system and we believe that it will be adopted in this country for general use, as it is used in foreign countries.

The diameter of the field of view of the number 2 lens on the microscope is about 1 millimeter, or as near as I can tell 1.2 mm. What part of a meter is this? We just move the decimal point three places to the left and have the answer 0.0012 m. (three places because milli means thousandth). Suppose instead you had found that the diameter was 3/64ths of an inch and were asked what part of a yard this was? Could you tell? It is much harder than in the Metric system and shows why scientists use the simpler Metric system.

1 millimeter = 0.1 centimeter = 0.001 meter = 0.039 inch.
1 centimeter = 10 millimeters = 0.01 meter.
1 inch = 2.54 cm. = 25.4 mm.

The millimeter is a little too long a unit for measuring with the highest powers of the microscope so we use instead one-thousandth of a millimeter which we call a micron and its abbreviation is the Greek letter Mu written μ. The plural of micron is micra. Scales ruled in micra are very expensive and hard to use. Instead we know that certain objects have a definite size and we can compare other objects with them under the microscope. Our own red blood cells are about 8 micra in size as are yeast cells. We will soon see that we can compare, or measure, the size of an object with a known one even under the highest power of the microscope. The reason that we can do this is because scientists have made direct measurements with very accurate scales placed in the eyepiece of the microscope so that we know the size of some objects and also that they keep the same size and do not vary much from the average size.

EXPERIMENT 25. Measuring a Salt Crystal

Dissolve a small amount of table salt (just a few crystals) in a drop of water on a clean microscope slide and let it stand until the crystals of salt form. They are shaped like a square box. Pick out a well formed one and focus the lowest power of your microscope on it and estimate how long each side is from the known diameter of the field. Or with so low a power you may be able to place your ruler next to the crystal and measure it directly. Is it really square? Make a sketch of it in your record, or **note book, and write** the dimensions beside the edges.

EXPERIMENT 26. Vertical Measurement With the Microscope

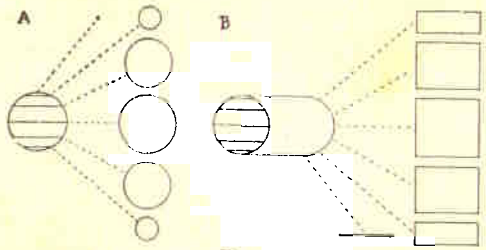


Fig. 9

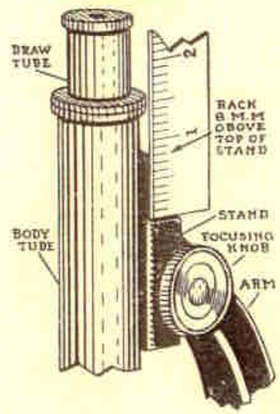


Fig. 10

You have discovered in the last experiment that if you focus your microscope on the top of the crystal you have to move the body tube downward to focus on the bottom of the crystal or on the slide on which it rests. This is a limitation of the microscope—it cannot see depth like we can with our eyes. Instead it sees only one level at a time. If we look at a round transparent object like a tiny marble we would see as we focused downward first a dot then a circle which would get larger as we approached the center until it was largest at the center. Then it would become a smaller and smaller circle until finally we would see a dot and then it would be gone. This is illustrated for a round object and for a cylindrical one in fig. 9.

Because the microscope can see only one level at a time we can use it to measure the vertical height of the salt crystal. Focus the microscope on the bottom of the crystal. It may be easier to focus on a little dust on the slide beside the crystal. With your millimeter ruler measure the distance from the stand to the top of the rack, fig. 10, and write this down in your note book. With the focusing knob raise the body tube until the top of the crystal is clearly in focus and measure the height of the rack above the stand and write in your notebook. If you have trouble in reading the ruler, use your magnifying glass. The difference between the two measurements is the height of your crystal and should be added to your sketch of the crystal.

EXPERIMENT 27. Thickness of a Paint Film

Find a piece of wood that has been painted. Shave off a piece with a sharp knife and estimate with the medium power of your microscope about how thick the layer of paint is. If you examine a piece from an old house you may be able to see several differently colored layers of paint.

If you have difficulty in seeing the layer of paint hold the microscope lamp above the stage so that the light falls on the object. Another method is to put a little ink on the wood which becomes colored while the waterproof paint doesn't stain. Be sure when you make the section of the paint film that you cut it at right angles to the surface, because if you cut it at another angle you would obtain too thick a film.

EXPERIMENT 28. Estimating the Enlargement of a Drawing

Measure the length of the side of your drawing of the salt crystal and divide this by the actual length of the crystal and the result tells how many times you have made your drawing larger than the crystal. Suppose your drawing is 28 mm. and that the crystal was 0.8 mm., then $28 \div 0.8 = 35$ and you have made your drawing 35 times larger. We then record this on the drawing by writing 35x at one corner. Whenever possible the amount of enlargement of a drawing is marked beside it. Enlargement is always measured as increased length. Sometimes the lengths are called diameters. A microscope may magnify 50 diameters which means that the apparent diameter of the field seen in the microscope is just 50 times larger than the actual field seen on the slide.

CHAPTER 7
Photomicrography

Photographs taken through the microscope are called photomicrographs. (A very tiny picture that would have to be seen through a microscope would be a microphotograph.) For making very large photomicrographs elaborate equipment is necessary but smaller pictures may be made with the lower powers of your microscope and any small camera.

EXPERIMENT 29. Making Microphotographs

Focus the low power of the microscope very carefully on a crystal or other object and make sure that the light is even by moving the mirror to the best position. If you normally wear glasses you must wear them for this because the microscope has to be focused to the normal eye, or an eye corrected to normal by proper glasses. Then place the camera over the ocular of the microscope. If the camera lens may be focused, set it on 100 ft. or infinity and a time exposure of about 10 seconds should be about right. The time depends on how bright the light is, how transparent the object is and the kind of microscope, camera and film. There is no way of knowing what exposure to give until you have made some trials. A very light camera will sit on the microscope safely, but when the camera is too large to do this it must be held by a stand and, of course, this must be so solid that it cannot shake when you take the picture. If the camera lens does not fit the ocular of the microscope fairly closely a little black cloth can be arranged to keep out stray light.

Should your camera have a ground glass for focusing all you have to do is to take out the camera lens and let the light from the microscope pass to the ground glass and focus directly on it. Many records can be made in this manner. It is more difficult to make photomicrography of colored objects and if you are planning to do this you will find the books recommended on this subject in the appendix of this manual helpful.

CHAPTER 8
Hair and the Fur Industry

Hair is a convenient object with which to start microscopic study. The hair is not composed of living cells but increases in length as the living cells in the skin at the base of the hair add to it. These cells are in a sort of pocket called a follicle in the skin and as they increase in numbers the extra cells are attached to the inner end of the hair. Except for gray hair pigment is added to the cells as they change and harden into hair. Most hairs have a central canal, or medulla, and the outside of the hair is scaly when highly magnified. The size, and shape of the hair and the kind and arrangement of the scales are characteristic of each kind of mammal and make possible the identification of the fur.

At the base of the hair is an oil gland which forms an oily protective secretion which helps prevent the hair drying and cracking. The oil and any dirt that the hair may have accumulated cover up the fine markings on the hair. Before looking at the hair it should be cleaned by moving it about with the forceps Fig. 3c in a little carbon tetrachloride placed in one of the cups of the set (fig. 3d). If the hair is long it may be scrubbed in soap and water and then washed free of soap. A short piece is cut and put in water under a cover glass on a slide for study under the microscope.

EXPERIMENT 30. A Brunette Human Hair

Take a small bit of a dark hair, clean it and mount it and look at it with the low, medium and high powers of the microscope. Knowing the actual size of the hair as seen without the microscope its apparent size under the different lenses will help you realize how much the microscope magnifies. The central canal is surrounded with a layer of material containing the pigment granules which give the color to the hair. On the very outside is the layer of scales.

When you look at dark hair you will need to have plenty of light to see with. The microscope lamp will help if the daylight is not strong enough. If you still have difficulty, dry the hair with a little absorbent paper and study in a drop of xylene. The scales can be seen more clearly when the hair has been placed in a drop of the dye, saffranin, for about two minutes and then blotted dry.

EXPERIMENT 31. A Blonde Hair

Obtain a hair from a blond person and notice that there is a yellowish pigment in the layer around the canal, i.e., in the medulla.

EXPERIMENT 32. A Gray Hair

The gray hair from an older person is found to be light colored because it has no pigment, or very little pigment in the medulla. The follicle is no longer putting pigment granules into the cells as it turns them into hair.

EXPERIMENT 33. A Red Hair

In pure red hair you will find very little of the dark pigment but reddish to yellowish pigment occurs.

EXPERIMENT 34. Straight Hair

Take a piece of naturally straight, uncurled hair and cut off as thin a section as you can with a very sharp knife. A safety razor blade makes a good knife. It is better to use the kind that has only one edge so as not to cut your fingers. It may help to place the end of the hair in a drop of water on the slide and cut the sections in the water. Make a number and then place a clean cover glass on the drop. Examine one that is thin enough and so placed that you can make out the cross section. You will find that this is nearly round or circular.

EXPERIMENT 35. Curly Hair

Prepare a bit of naturally curly hair as you did in the last experiment and it will probably be flattened so its cross section will be oval.

EXPERIMENT 36. Permanent Waving of Hair

Permanent waving of hair causes the hair to curl by artificially flattening the hair strands. **When you examine thin sections of hair that has been waved you will find that they are more or less oval but that the strands are not so uniformly flattened as in naturally curly hair.**

The hair of our animal friends is just as interesting and of commercial importance. Wool from the sheep, fig. 11, is very important and will be discussed later (Chapter 23) with the textiles.

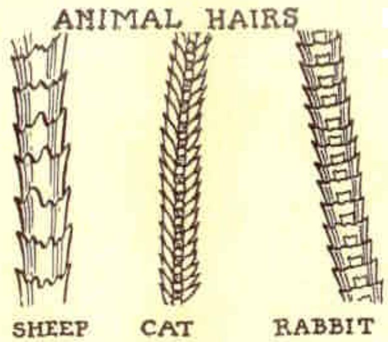


Fig. 11

EXPERIMENT 37. Examine a Bit of Wool

The central canal is less easily seen and the surface is covered with irregular scales. Different kinds of wool may be known from the nature of these scales.

Only one or two fine hairs are necessary for identification with the microscope and they may be obtained from a seam or the end of a tassel without injuring the cloth or object from which they were taken. This is one of the reasons why the microscope is so useful and important.

EXPERIMENT 38. A Cat Hair

A cat hair will look like the one in fig. 11. Different kinds of cats will have slightly different kinds of fur.

EXPERIMENT 39. A Dog Hair

A dog hair is different from a cat hair and from our own hair. Examine one. What is the chief difference? If you have looked at a number of samples of hair from different kinds of cats and dogs can you tell from which an unknown hair might come?

Your note book records are very valuable as soon as you start identifying unknown hairs. Even with a good notebook you will wish to have some samples of known hairs with which to compare any unknown ones. The bits of cleaned hair may be kept in envelopes or in small gelatin capsules. Or you may make slides of each kind and keep the slides as described in the next chapter.

EXPERIMENT 40. A Rabbit Hair

A rabbit hair should look like the one in fig. 11. Rabbit fur is cleaned and dyed various colors and sold in the stores under a lot of other names like mock-fox, lapin, imitation seal, etc. It is against the law to call rabbit fur, seal, but other names are used. Other furs are sheared to change the length of the hairs and dyed to imitate more expensive furs. However, the shearing and dyeing cannot change the structure of the hair and the microscope comes to the rescue of the fur buyer when there is any doubt. If you are interested in furs obtain small samples, a few hairs of each are plenty, from a fur dealer and learn to recognize the different kinds under the microscope. You can usually get a few hairs from the cages of animals at zoological gardens if you will tell the keeper why you want them. Good sketches in your note book will help you when you must identify an unknown hair; but a good microscopist will make a direct comparison with a known hair before giving his answer.

EXPERIMENT 41. Identifying a Hair

The next time you pick up a hair examine it with the aid of your microscope. Is it a human or an animal hair? Has it been curled artificially or is it naturally curly? etc.?

An alert policeman noticed some dirt on a dented part of the fender of an automobile. He sent the material to the laboratory and was told it contained human hairs. This one clue led ultimately to the conviction of a man who had run down and killed two children.