The Apprentice's Companion for ADVANCED BIOLOGY

WITH EMPHASIS ON BIOCHEMISTRY

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The Apprentice's Companion for Advanced Biology

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Contents

Activity 1 Making Observations

Today's Date ____________________

General Information

Advanced Biology text reference: Chapter 1, Sections 1.1.1–1.1.3

Estimated time: 30–60 minutes

Introduction

In Chapter 1 of *Advanced Biology*, you learn about the Cycle of the Scientific Enterprise. Take a few minutes to review the corresponding sections in your book before beginning this activity. An important part of the Cycle of Scientific Enterprise is learning to make careful observations. To make a good observation, you must pay close attention to noticing and recording details.

Objectives

- Practice making detailed observations.
- Develop a greater appreciation of the created world.

Materials (per student)

- pen or pencil for sketching
- colored pencils (optional)
- magnifying glass (optional)
- tree or flower identification book for local area (optional, for class use)

Procedure

Go outside and find a tree or shrub near your home or school. Spend 10–15 minutes closely observing this plant. Use the space provided on the opposite page to make some sketches and provide descriptions of the plant. On the following page, draw and color in a sketch that includes all the features you described in the previous questions.

Begin by looking at the plant as a whole. How big is it?

What colors do you observe?

What is the basic shape of the plant?

Does the plant have any distinguishing features?

Next begin to focus on some of the parts of the plant. Describe the stem/trunk. (Does it have a woody stem? A thick trunk? A tender stem?)

Describe the leaves. What do they look like? Describe their shape (make a sketch). How big are they? How are they attached to the plant? Are they in clusters?

How do you think this plant might reproduce? Are there fruits? Seeds? Or flowers on the plant? What do they look like?

Optional: If you have access to a local tree/flower identification book or website, try to determine the common and scientific names of the plant.

— Sketches —

— Sketch —

Extensions of this Activity

- Before beginning this activity, read Samuel H. Scudder's famous essay about learning to observe well, "In the Laboratory With Agassiz." You can find it at https://philosophy.lander.edu/intro/introbook2.1/x426.html
- Keep a Nature Journal. Here are a few resources to get you started.
    1. https://www.lilyandthistle.com/how-to-start-a-nature-journal-today/
    2. Leslie, Clare Walker & Charles E. Roth. Keeping a Nature Journal: Discover a Whole New Way of Seeing the World Around You. Storey Publishing, LLC. 2003. ISBN: 978-1580174930.
- Conduct a Phenology Study throughout the school year. Phenology is the study of the timing of recurring biological events along with the causes and consequences of these events. For example, every fall the leaves on trees begin to change color and then fall off. In the spring buds begin to form and produce flowers. The flowers, after being pollinated, produce fruits. New leaves begin to grow on the trees. Many phenological events are tied to environmental cues such as changes in temperature or day length. Throughout the year use the plant you observed in this activity as your subject. Every week spend two 30-minute sessions to make careful observations of the tree. Here are two resources to help you with your study.
    1. https://www.usanpn.org/files/shared/files/Haggerty_Mazer_ThePhenologyHandbook_v3Aug2009.pdf
    2. https://www.usanpn.org/

— Commonplace Space —

What do you think about sketching? Is there any reason why you shouldn't try to develop this skill? Have you come across any new words, authors, scientists, or quotes during this activity that you should document? Take the time.

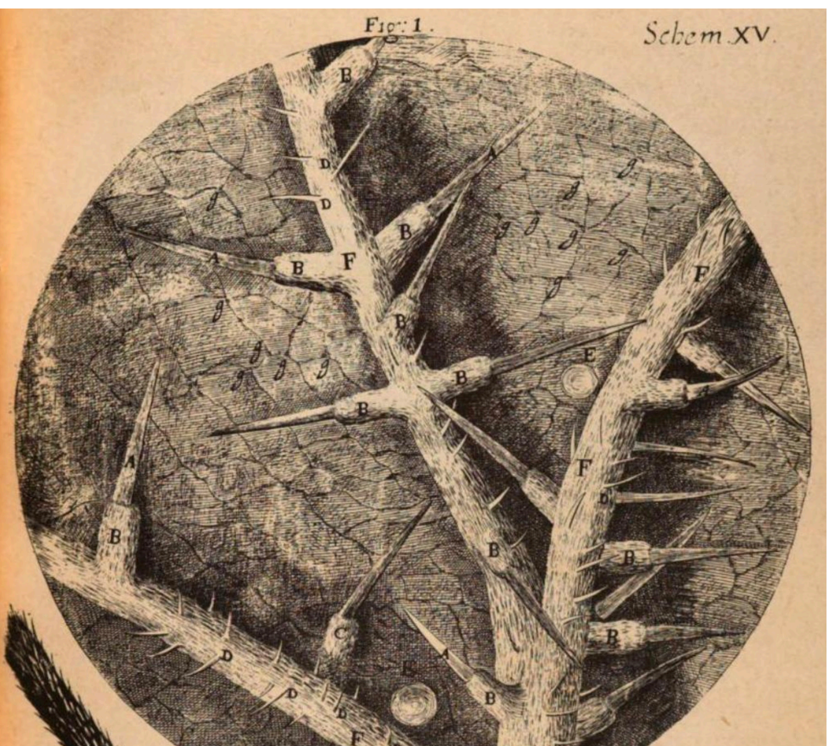
Phenology Study 1 — Sketches —

Today's date___________

Return to the plant you observed in Activity 1.

Describe the features of the plant in terms of stem, leaves, flowers, seeds, and fruits. How has the plant changed since your last observation?

Create one or more sketches highlighting the changing features of the plant.



Phenology Study 2

— Sketches —

Today's date____________

Return to the plant you observed in Activity 1.

Describe the features of the plant in terms of stem, leaves, flowers, seeds, and fruits. How has the plant changed since your last observation?

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Create one or more sketches highlighting the changing features of the plant.

> A Nettle is a Plant so well known to everyone, as to what the appearance of it is to the naked eye, that it needs no description; and there are very few that have not felt as well as seen it; and therefore it will be no news to tell that a gentle and slight touch of the skin by a Nettle, does oftentime, not onely create very sensible and acute pain, much like that of a burn or scald, but often also very angry and hard swellings and inflamations of the parts, such as will presently rise, and continue swoln diverse hours. These observations, I say, are common enough; but how the pain is so suddenly created, and by what means continued, augmented for a time, and afterwards diminish'd, at length quite extinguish'd, has not, that I know, been explained by any.
> And here we must have recourse to our ***Microscope***.
>
> —Robert Hooke, ***Micrographia***

Phenology Study 3

— Sketches —

Today's date____________

Return to the plant you observed in Activity 1.

Describe the features of the plant in terms of stem, leaves, flowers, seeds, and fruits. How has the plant changed since your last observation?

Create one or more sketches highlighting the changing features of the plant.

— Commonplace Space —

Phenology Study 4 — Sketches —

Today's date____________

Return to the plant you observed in Activity 1.

Describe the features of the plant in terms of stem, leaves, flowers, seeds, and fruits. How has the plant changed since your last observation?

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Create one or more sketches highlighting the changing features of the plant.

Activity 2 The Cycle of Scientific Enterprise

Today's Date ____________________

General Information

Advanced Biology text reference: Chapter 1, Sections 1.1.1–1.1.3

Estimated time: 45–60 minutes

Introduction

In Chapter 1 of *Advanced Biology*, you learn about the Cycle of the Scientific Enterprise. Take a few minutes to review the corresponding sections in your book before beginning this activity. In this activity you will practice putting the steps of the Cycle of Scientific Enterprise into practice.

Objectives

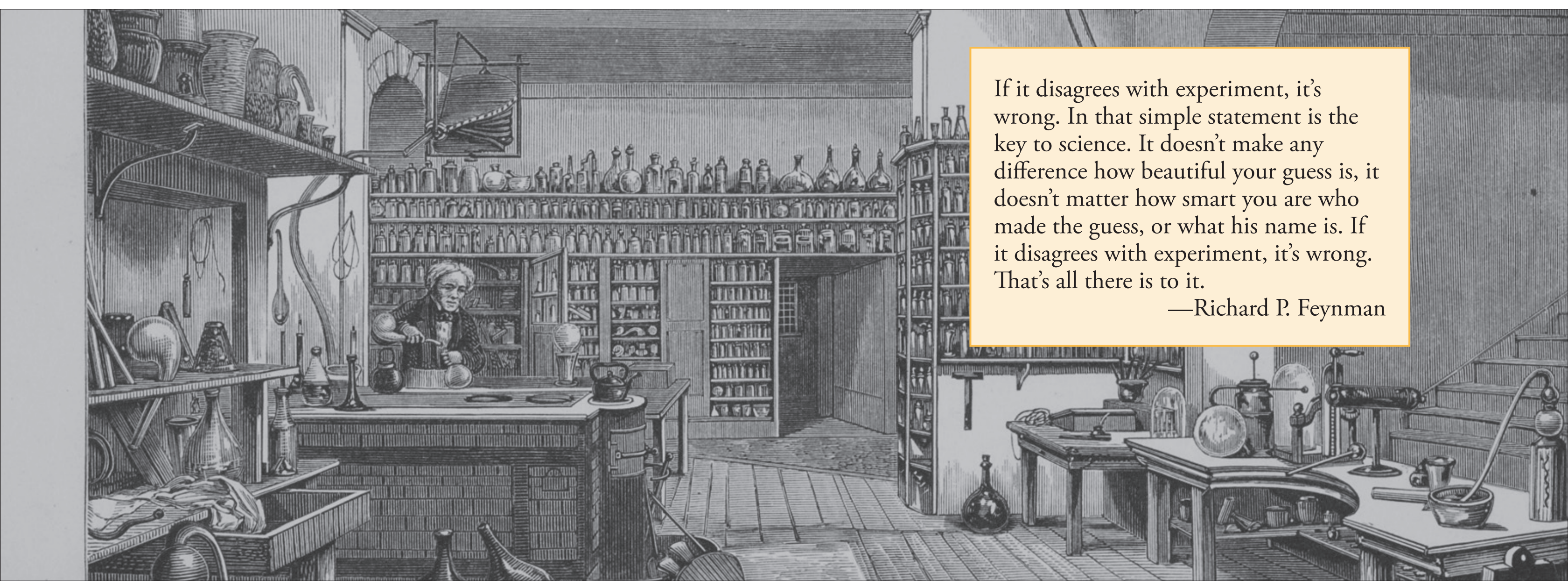
- Practice using the Scientific Method.
- Form a testable hypothesis and design an experiment.
- Make conclusions based on data collected.

Materials (per group of 2–4)

- paper towel (3), of different brands, with prices shown
- graduated cylinder, 100 mL
- beaker, 600 mL
- weights (or pennies or other coins used as weights), at least 75–100 pennies per group
- scissors
- mass scale (optional)
- water

Procedure

If you are part of a class, work in teams of 2–4 students for this activity. Your task is to use the Cycle of Scientific Enterprise to determine which brand of paper towels is best. The first thing you must do as a team is define the term "best" as it applies to paper towels. Does it mean the strongest? The most absorbent? Does price matter? Work out your own definition and describe it below. Note that if your definition involves more than one factor, you must develop a simple weighting formula to combine the factors quantitatively so that the factors can be measured and combined according to your formula to establish which paper towels are best.



> If it disagrees with experiment, it's wrong. In that simple statement is the key to science. It doesn't make any difference how beautiful your guess is, it doesn't matter how smart you are who made the guess, or what his name is. If it disagrees with experiment, it's wrong. That's all there is to it.
>
> —Richard P. Feynman

Our Team's Definition of "Best"

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Next, you must form a hypothesis to address the question of which is the "best" brand of paper towels. Remember that a good hypothesis is a predictive statement that is both testable and falsifiable. Testable means that you can perform an experiment that will produce data to support your hypothesis; falsifiable means that it is possible for the data not to support your hypothesis. A good hypothesis is also based on a theory. You may need to make some quick observations of the differences between your paper towels in order to make your hypothesis. Your statement should read something like, "Brand A is superior to brand B because ..." Write your hypothesis in the space provided below. (The "because" phrase is essentially a statement of your theory about paper towels.)

Our Team's Hypothesis

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Now you must determine how you will test your hypothesis by designing an experiment. Below are some questions to think about as you develop an experimental protocol.

1. What variables are you going to test? These depend on how you have defined "best." A variable is one parameter that you can manipulate for each set of trials, while holding everything else constant. For example, a variable could be the volume of water you add, or the number of pennies (or other weights) you add.

2. What conditions are you going to keep the same between your experimental groups? (Conditions or factors not being tested must be held constant across all trials and all experimental subjects. Such constant conditions are one form of experimental *controls*.)

3. How many times will you repeat each set of trials? (Experimental trials are always repeated and the results combined or averaged.)

4. What data will you collect?

Discuss your experiment with your teacher before proceeding. Write out the experimental protocol in the space on the next page. List carefully the measurements you will make, the conditions that must be prepared or arranged, and the data you will collect. Write out your experimental design clearly so that someone else could read it and know exactly how to conduct the experiment.

Our Experimental Protocol

— Commonplace Space —

Now it is time to conduct your experiment. As you conduct your experiment, collect data and record them in tables you construct the space below. You must write down all your results as you see them. Do not discard, change, or fudge your results in any way.

— Experimental Data —

Once you have completed collecting data, assess your findings. If you developed a formula of some kind to combine results of testing different factors, work it out and make your conclusion. Then assess what the data tell you. Do they support your hypothesis, or suggest something different? Does "best" depend on how you defined the term? If you are part of a classroom with other student teams, find out what their results are and compare them to your own.

Assessment and Conclusions

Check your Understanding

Upon completing the lab activity, answer the following questions.

1. List and briefly describe the stages in the Cycle of Scientific Enterprise.

2. What three qualities are necessary in a good hypothesis?

3. How many times does an experiment need to be repeated? Why?

4. What is a control? Why is it important in a good experiment?

5. The purpose of the Cycle of Scientific Enterprise is to develop theories that explain the natural world. Look back at the reason you gave for your hypothesis. Did the results of your experiment strengthen that reason or weaken it? Based on the results of your experiment, write a theory statement below, explaining what determines the best brand of paper towels.

Activity 3 Introduction to Microscopes

Today's Date ____________________

General Information

Advanced Biology text reference: Chapter 1, Section 1.1.4

Estimated time: 15–30 minutes

Introduction

In Chapter 1 of *Advanced Biology*, you are introduced to the microscope. This is a most useful instrument in biology because it allows us to study things too small to be seen by the unaided eye. Review Section 1.1.4 in your text, which describes the different kinds of microscopes and their respective resolutions. In this activity, you are introduced to using the compound light microscope.

Objectives

- Learn the different parts of a compound light microscope.
- Understand basic safety and care in using the microscope.
- Practice microscopy skills.
- Use the microscope to view a slide.

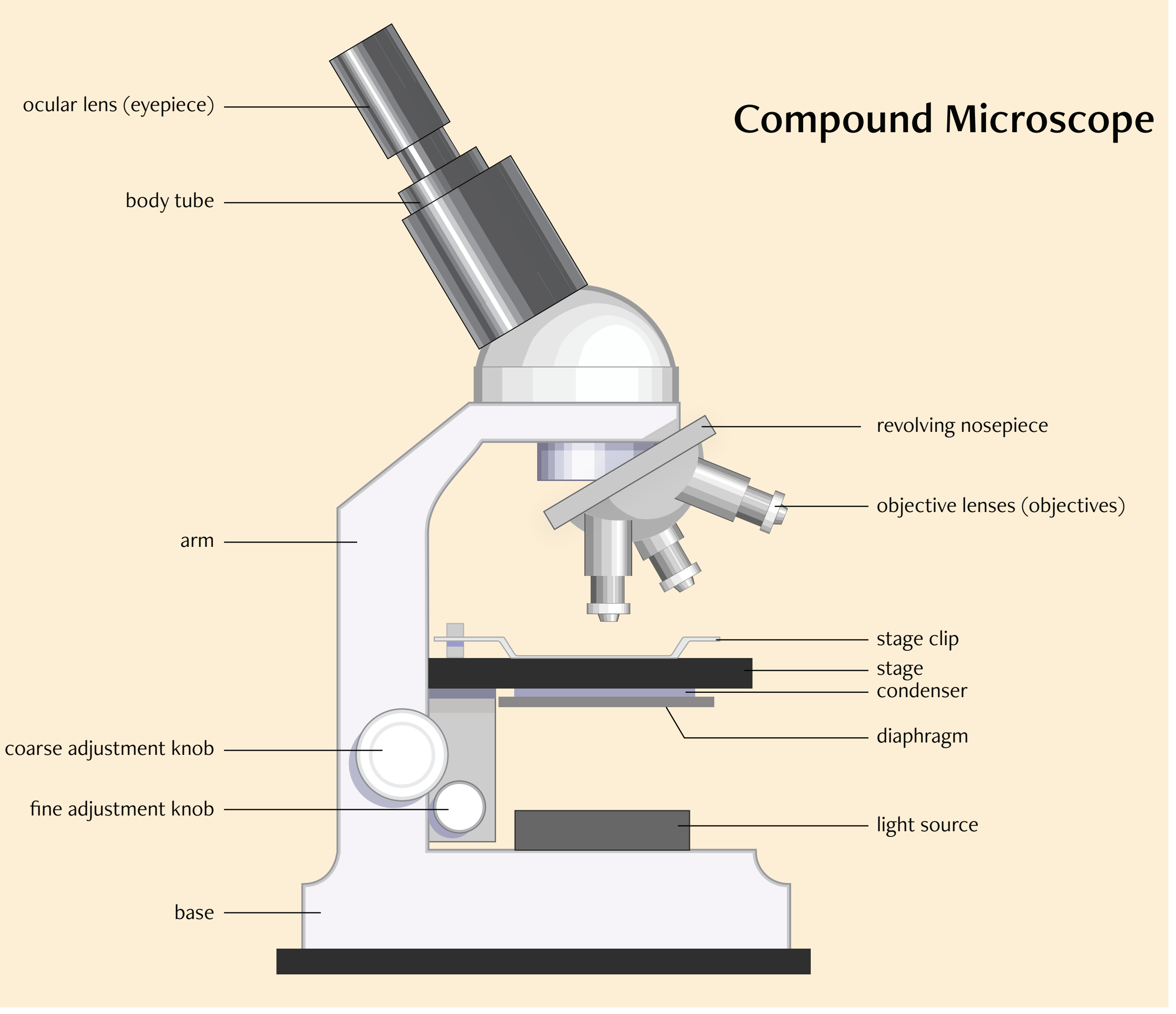
Materials (per group of 2)

- compound light microscope
- medicine dropper
- glass slides
- cover slips
- lens paper
- paper and pencil
- scissors

Care and Use of the Microscope

A microscope works by passing light through a series of lenses. A compound light microscope has two lenses. The lenses are positioned in such a way that the image is magnified as it passes through the lenses. The arrangement of the lenses produces an image that is upside down and backward, compared to the actual object you are looking at.

We begin by describing the parts of the compound light microscope. Use the image provided on the next page to help you locate the different components of your microscope. At the bottom of the microscope is the *base*. This foundation supports the microscope as it sits on a bench or tabletop. The *light source* shines light up through the object so that it can be seen. There is usually a switch along the side of the base of the microscope that turns the light on and off. The microscope may have a knob to control the intensity of the light. Next locate the adjustment knobs along the side of the microscope. There are two adjustment knobs, the *coarse adjustment knob* and the *fine adjustment knob*. The coarse adjustment knob is used to bring the object on the slide into focus initially. Once this is done, the fine adjustment knob fine-tunes the resolution of the image. The *arm* comes up from the base and connects it to the rest of the microscope. The arm is also used for carrying the microscope when you need to move it from one place to another. Connected to the arm is the *stage*. This is a flat surface, usually black, that holds the slide. *Stage clips* are movable metal clips that hold the slide in place. Mechanical-stage microscopes have additional knobs that move the stage and slide around; microscopes without this feature require you to move the slide by sliding it around on the stage. If you look underneath the stage, you see a round structure called the *condenser*. The



purpose of the condenser is to help focus or concentrate the light on the object. Attached to the condenser is the *diaphragm*. A small lever opens and closes the diaphragm, changing the amount of light that enters the lens. Varying the amount of light affects the contrast you see when viewing the object. At the top of the microscope arm is the *body tube*. This supports the *ocular lens* or *eyepiece*. The microscope pictured in the image above has one ocular lens, making it a monocular microscope. Binocular microscopes have two ocular lenses. (If you have a binocular microscope, you do want to use BOTH eyes when looking through the microscope.) Ocular lenses usually have a magnification of 10×. Look at the side of the ocular lens on your microscope and determine its magnification. The revolving *nosepiece* descends from the body tube. The nosepiece holds the *objective lenses*, each of which has a different magnification. Most microscopes have three or four different objective lenses. The shortest lens is the *scanning objective*. It usually has a magnification of about 4×. This is the objective you always begin with. Next is the low-power objective which usually has a magnification of 10×. The longest lens is the high-power objective. Normally it has a magnification in the 40× range. Some microscopes have a fourth objective with a magnification of 100×. This requires the use of immersion oil. (We will not be using the 100× objective in this course.) The total magnification that you see when you view an object is the product of the magnifications of the ocular and objective lenses. For example, if you are viewing the object through the medium objective (10×), the total magnification is equal to the magnification of the ocular lens (10×) times the objective magnification (10×) for a total magnification of 100×.

Now that you have familiarized yourself with the basic parts of the microscope, you must learn the proper way to use and care for the microscope. When you first approach the microscope, always carry it properly so you don't accidentally drop it. Grasp the arm of the microscope with one hand and place the other hand under the base.

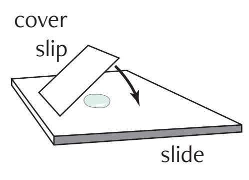
To begin using the microscope, the scanning objective should be pointing down. Place the slide on the stage, holding it in place using the slide clips. Turn on the microscope light and look through the ocular lens(es) to view the slide. Initially, you might not be able to see anything. Slowly turn the coarse-adjustment knob until an image comes into view. Next turn the fine-adjustment knob to improve the resolution of the object on the slide. Center the object in the middle of the field of view. You can increase the magnification of the object by rotating the nosepiece to put the next higher-power objective in place. Do NOT use the coarse-adjustment knob at this point, as you may lose the object you are looking at, forcing you to start over. You may use the fine-adjustment knob to sharpen the view of the object. If you need to go to the next higher-power magnification, repeat the process. Notice that as you increase the magnification of the object, the field of view decreases. Once you have finished, turn the objective lenses back so that the lowest-power objective lens is pointing downward. Turn the coarse-adjustment knob to lower the stage. This increases the distance between the objectives and the slide so that you can safely remove the slide.

Lens paper is a special paper used to help clean the lenses. Do not use other tissues as they may scratch or damage the lenses, which are expensive to replace. The lens paper helps remove dust that accumulates on the lenses or slides. Gently make a circular motion with the lens paper and then throw it away. When you are done with the microscope, turn off the light, replace the cover if there is one, and carry the microscope properly while putting it away.

Procedure

For those in classrooms, work in groups of two students for this lab activity.

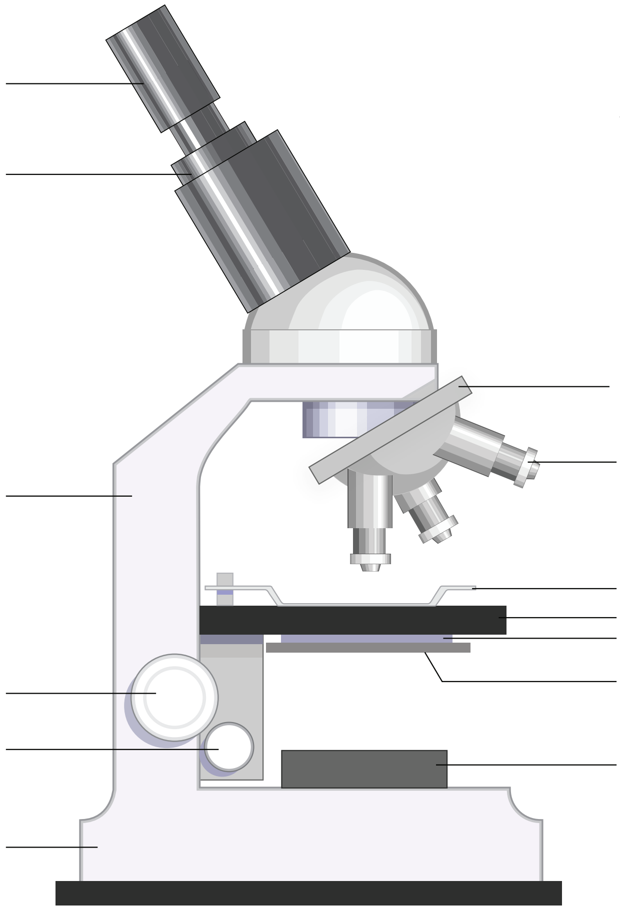
In this lab activity, you practice using the microscope by looking at a slide of a letter in the alphabet. Using a pencil with your normal handwriting, write or print the letter "e" on a sheet of paper. Obtain a blank glass slide. Cut out the letter and place it in the center of the blank slide. Using a dropper, add one drop of water to the paper. To add a cover slip, hold it at a 45-degree angle with one edge touching the slide, as indicated in the image at the right. Let the cover slip drop onto the paper. This technique helps prevent air bubbles from forming underneath the cover slip. Now that your slide is prepared, place the slide on the microscope stage as described above. View the slide underneath the microscope using the scanning (4×) objective. Once you have found the image, use the fine-adjustment knob to get a clear image. Draw what you see in the space on the following page.



Next, while looking through the microscope, slowly move the slide to the right. Describe what happens to the image.

Next, increase the magnification of the object by moving to the next higher-power objective lens. Look through the microscope and determine what part of the letter is magnified. In your sketch at right, circle the part of the letter that you are now looking at.

— Sketch —



What is the total magnification you are using to view the letter?

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Review the different parts of the microscope by labeling them on the image at the left. Try to label them without consulting the figure above.

ALIVE
Light; and water. One drop.
Under the microscope
an outline. Slight
as a rim of glass;
barely and sparely there,
a scarcely-occupied shape.

What's more, the thing's alive.
How do I recognize
in a fleck so small
no human term applies—
no word's so minimal—life's
squirming throb and wave?

Locked in the focussed stare
of the lens, my sight
flinches: a tiny kick.
The life in me replies
signalling back
"You there: I here."
What matters isn't size.

What matters is . . . form. Form
concentrated, exact,
proof of a theorem
whose lines are lines of force
marking a limit. Trim,
somehow matter-of-fact,
even matter-of-course.
But alive. Like my eyes. Alive.
—Judith Wright