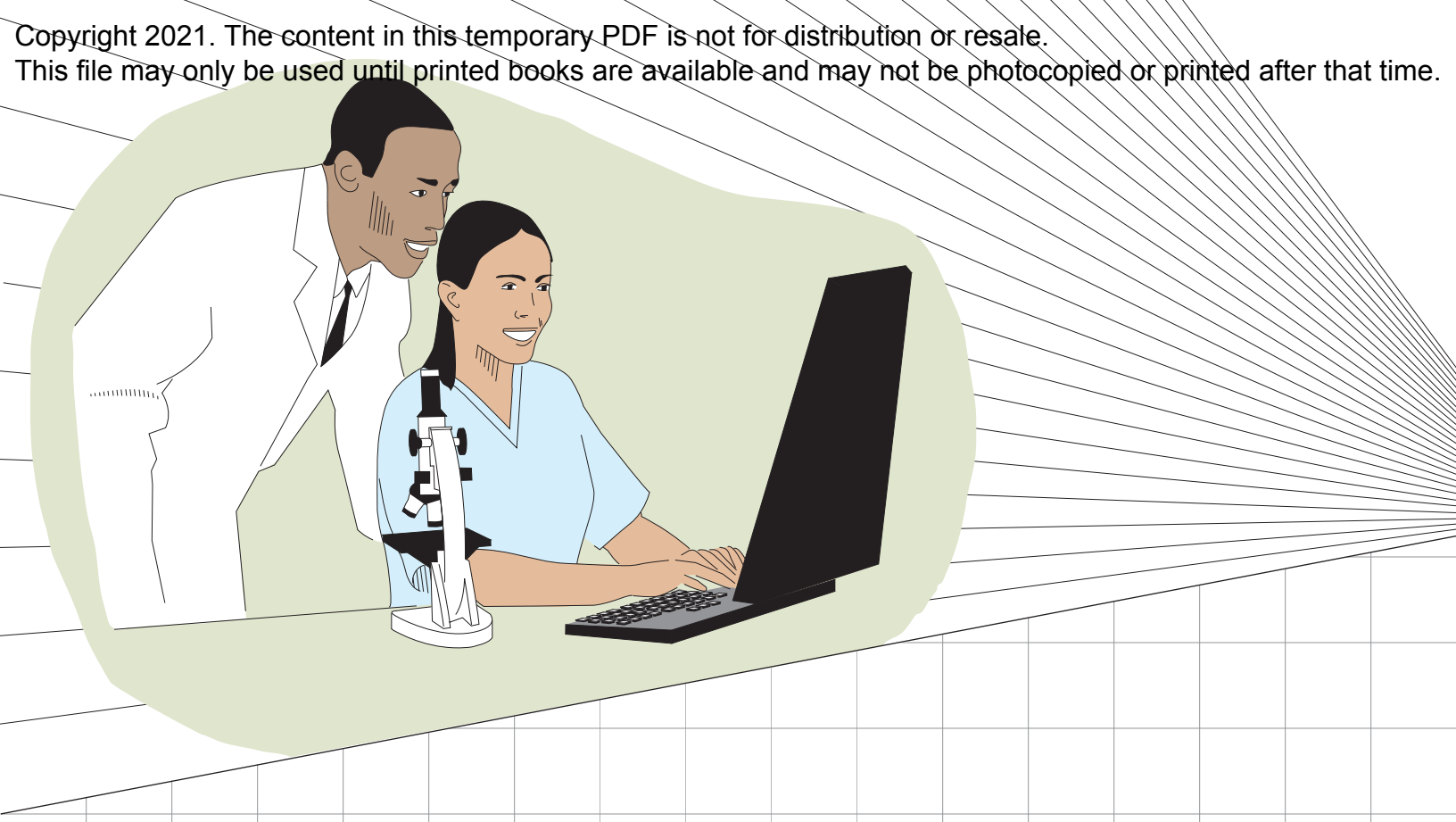

The Apprentice's Companion for General Biology

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2020

The Apprentice's Companion for General Biology

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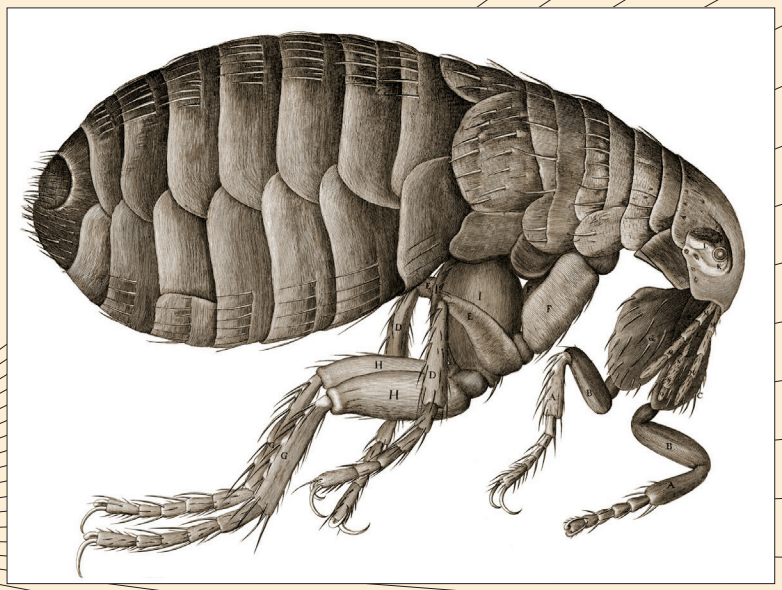
Introduction

Some things cannot be learned easily—or at all—from books. This is what apprenticeships are for—to provide learners a context in which skills and knowledge are acquired by direct modeling, mentoring, and practicing. Everyone knows about the apprenticeships that were part of the system of guilds back in the Middle Ages. Some of the terminology from those times survives in the trades today. Plumbers and electricians are rated in terms of Apprentice, Journeyman, and Master. But today, even some professional careers include apprenticeships: attorneys obtain clerkships to gain the experience needed to become judges. Medical school graduates obtain residencies to acquire the hands-on experience of caring for patients that cannot be transmitted through books.

In a similar way, science classes can convey the principles, concepts, and mathematical models associated with scientific inquiry and scientific theories. But laboratory skills, which are so important for understanding how science works and how scientific hypotheses are put to the test in experiments, must be acquired through hands-on laboratory work. This is why it is appropriate to think of the lab activities associated with a science class as an apprenticeship in which students acquire knowledge and skills that are not easily acquired by reading books.

Thinking of labs as apprenticeship one of the reasons why this book is called *The Apprentice's Companion*. The other reason is that in conceptualizing this manual of experiments and lab activities, we decided to depart from the formatting and content typically found in books of experiments. We thought it would be more interesting and more consistent with the tenets of classical education to create a multi-disciplinary *environment* in which students could enjoy literature, poetry, history, and art right along with their science and mathematics. Accordingly, we have integrated into these pages items from across the arts and sciences that we hope students will find amusing, fun, and intellectually stimulating.

Part of making the book a *companion* was enhancing its value to the student. This volume combines the functions of experiments manual, lab journal, sketchbook, and commonplace book:



Robert Hooke's exquisite drawing of a flea, from his 1665 treatise, ***Micrographia: or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses. With Observations and Inquiries Thereupon.***

- Experiments Manual. This book includes the procedures students need for conducting over 30 laboratory activities during their study of biology.
- Lab Journal. A lab journal is the place to record scientific observations and data collected during laboratory exercises. It can also be used for setting up graphs of data that can reveal underlying patterns in the data that help us interpret what the data tell us about how nature works. Students won't need a separate lab journal to accompany this course—it's built right into this book.
- Sketchbook. A sketchbook is a place to draw, practice drawing, and refine one's drawing. As depicted in the movie *Master and Commander* a few years back, there is a long tradition in which naturalists (those engaged in what used to be called natural history) develop refined drawing skills and put those skills to use documenting the natural world around them—the bugs and buds, leaves and leeches, trees and turtles in the world that we can marvel at and study.
- Commonplace Book. A commonplace book is a place to record thoughts, discoveries, questions, observations, quotes, events, mysteries, conundrums, meditations, references, words, witticisms, riddles, prayers, queries, and all the other strands that weave themselves around in an active and developing student's mind. The keeping of a commonplace book is a tradition central to classical education, dating back centuries. Hundreds of famous authors kept commonplace books, trained to do so at institutions such as Harvard College and Oxford University. For help understanding what a commonplace book is all about, check out the YouTube video by Jordan Clark entitled "you should start a commonplace book." At the end of that video, Jordan shares this quote from Jonathan Swift:

  > A commonplace book is what a provident poet cannot subsist without, for this proverbial reason, that 'great wits have short memories' and, on the other hand, poets, being liars by profession, ought to have good memories; to reconcile these, a book of this sort is in the nature of a supplemental memory, or a record of what occurs remarkable in every day's reading or conversation. There you enter not only your own original thoughts, (which, a hundred to one, are few and insignificant) but such of other men as you think fit to make your own, by entering them there.

Supporting Text

The Apprentice's Companion for General Biology is designed to accompany our text *General Biology*, published by Novare Science and Classical Academic Press (2020).

Teacher Notes

To accompany *The Apprentice's Companion for General Biology*, Classical Academic Press has available a downloadable PDF of Teacher Notes. This document is part of the Digital Resources download available online for purchasers of this book. The Teacher Notes contains information about preparing solutions, time requirements, and supply substitutions, and other items. It also contains photos obtained during our pilot runs of the experiments so that instructors unfamiliar with these experiments will know what to expect.

Materials and Equipment

The Digital Resources download mentioned above also contains a spreadsheet itemizing all materials required for these laboratory activities, as well as costs and suggested suppliers.

Equipment Substitutions

We recommend that students use actual lab apparatus, whenever possible. However, for those on a tight budget, many substitutions may generally be made: you can substitute plastic spoons for glass stirring rods and scoopulas; glasses, glass jars, or bowls for beakers; cupcake paper liners or coffee filters for weigh trays; small bowls or saucers for Petri dishes; a kitchen stove for a hotplate; and so on. You will still need a graduated cylinder, a weigh scale, a microscope, a thermometer, and a few other items. You will also need to procure specimens for the dissections. Most of the other materials used in these activities may be procured at a grocery store. Note that kitchen-type Pyrex containers should never be used for heating. When heating any liquid, always use a borosilicate-glass container.

Scales

For weighing substances precisely in this course, students require a mass scale with resolution of at least 0.1 g. However, studies in chemistry typically require a scale with 0.01 g resolution. These days, there is not much cost difference between the two, so we have recommended a 0.01-g scale in the materials list. (See the Materials spreadsheet referenced above.)

Microscopes

The most expensive item in an introductory biology course is the microscope. We provide two recommendations in the materials list. Either is acceptable for this course, but the one with a mechanical stage is a bit nicer. The mechanical stage enables easier positioning of the specimen under the lens. The maximum objective-lens power required for this course is 40×.

Thermometers

Digital thermometers with resolution to 0.1°C are preferred. However, glass alcohol thermometers with 1°C resolution are also acceptable.

Writing Lab Reports

Does the creation of this *Apprentice's Companion* mean that students don't need to write lab reports? Absolutely not!

The Apprentice's Companion is not a substitute for writing lab reports—an important skill students must continue to practice, year by year. Novare Science has consistently recommended that students write five or six full lab reports each year. The same applies to *General Biology*. Instructors should simply select three of the activities performed during each semester and designate these as the activities for which full lab reports will be written. The essential guide for writing lab reports is *The Stuident Lab Report Handbook* by John D. Mays, available from Novare Science and Classical Academic Press.

— Commonplace Space —

As you begin this course of study, take time to pause and reflect. Embrace this educational experience as your own journey. What might you gain? What questions do you have going in that you would like to find answers for? What stories have you heard about the study of biology that inform your own goals? In what ways can this study help you to grow at this particular time in your life? (When will you take time to reflect on these things if not now?)

Activity 1 Making Observations

Today's Date _____

General Information

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

Estimated time: 15–30 minutes

Introduction

In Chapter 1 of *General 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

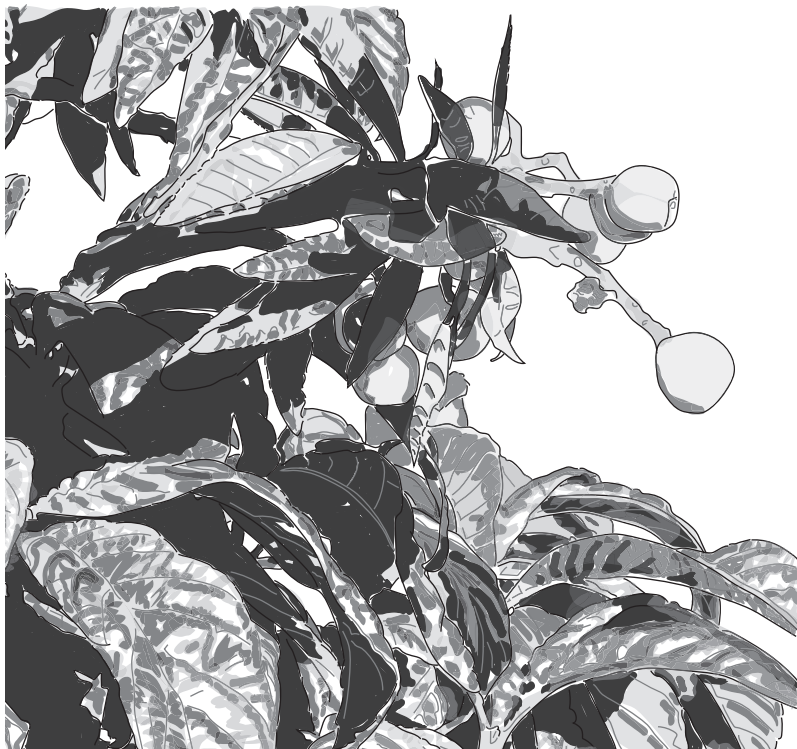
- Practice making detailed observations.
- Develop a greater appreciation of the created world.

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.



To see a World in a Grain of Sand
And a Heaven in a Wild Flower
Hold Infinity in the palm of your hand
And Eternity in an hour
—William Blake

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 —

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. A 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.

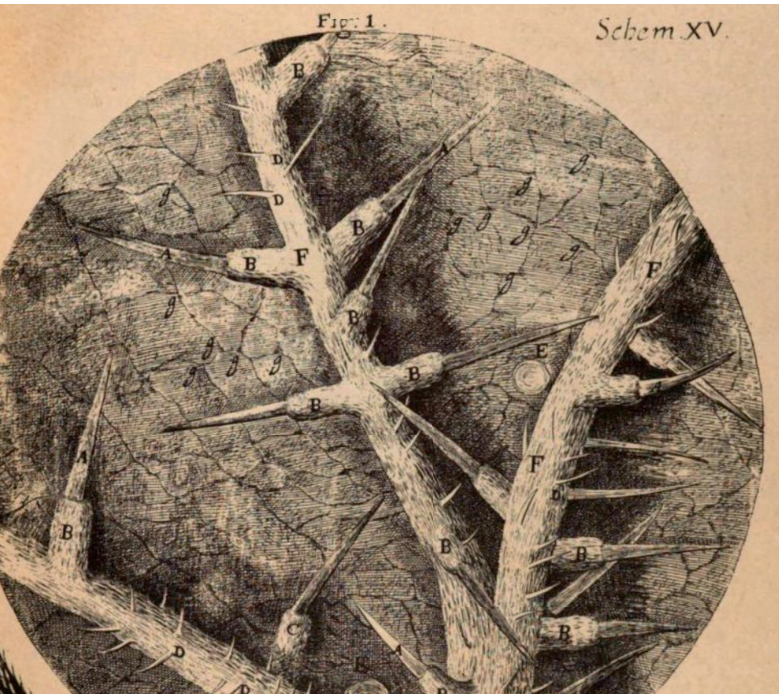
Phenology Study 1

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.



— Sketches —

Phenology Study 2

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.

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*

— Sketches —

Phenology Study 3

Today's date_____

Return to the plant you observed on 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.

— Sketches —

Phenology Study 4

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.

— Sketches —

Activity 2 The Cycle of Scientific Enterprise

Today's Date _____

General Information

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

Estimated time: 45–60 minutes

Introduction

In Chapter 1 of *General 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

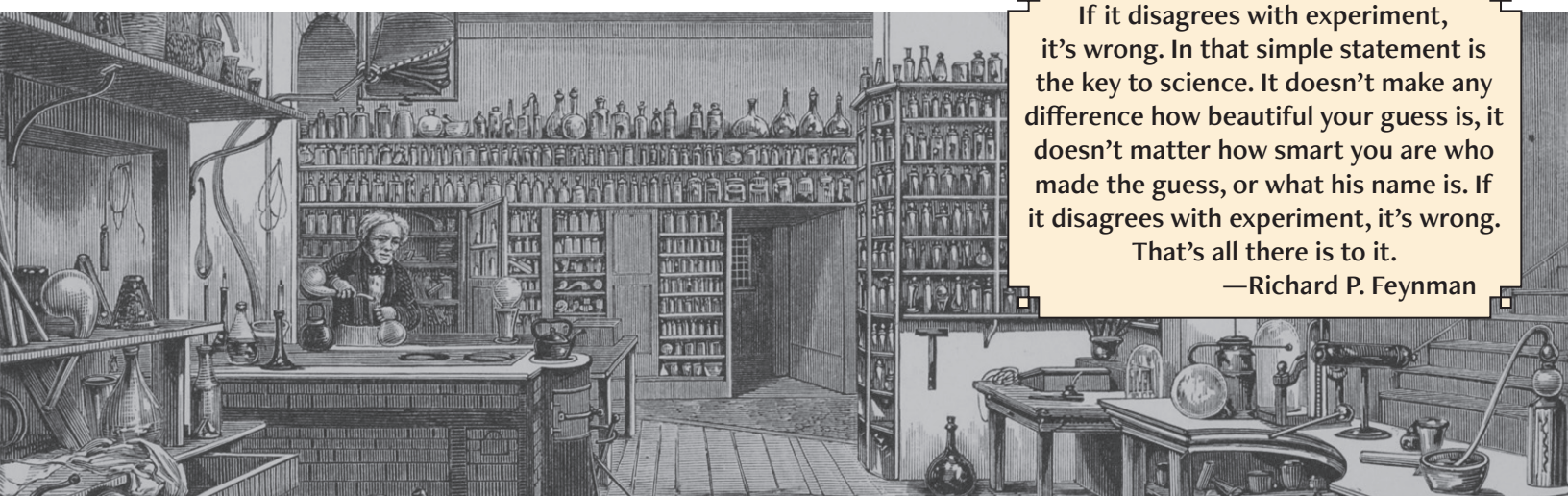
- Practice using the Scientific Method.
- Form a testable hypothesis and design an experiment.
- Make conclusions based on data collected.

Materials (per group of 2–4)

- paper towel rolls, 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
- weigh 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"

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

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 exactly 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

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

General Biology text reference: Chapter 1, Section 1.1.4

Estimated time: 15–30 minutes

Introduction

In Chapter 1 of *General 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 basic microscopy skills.
- Use the microscope to view a slide.

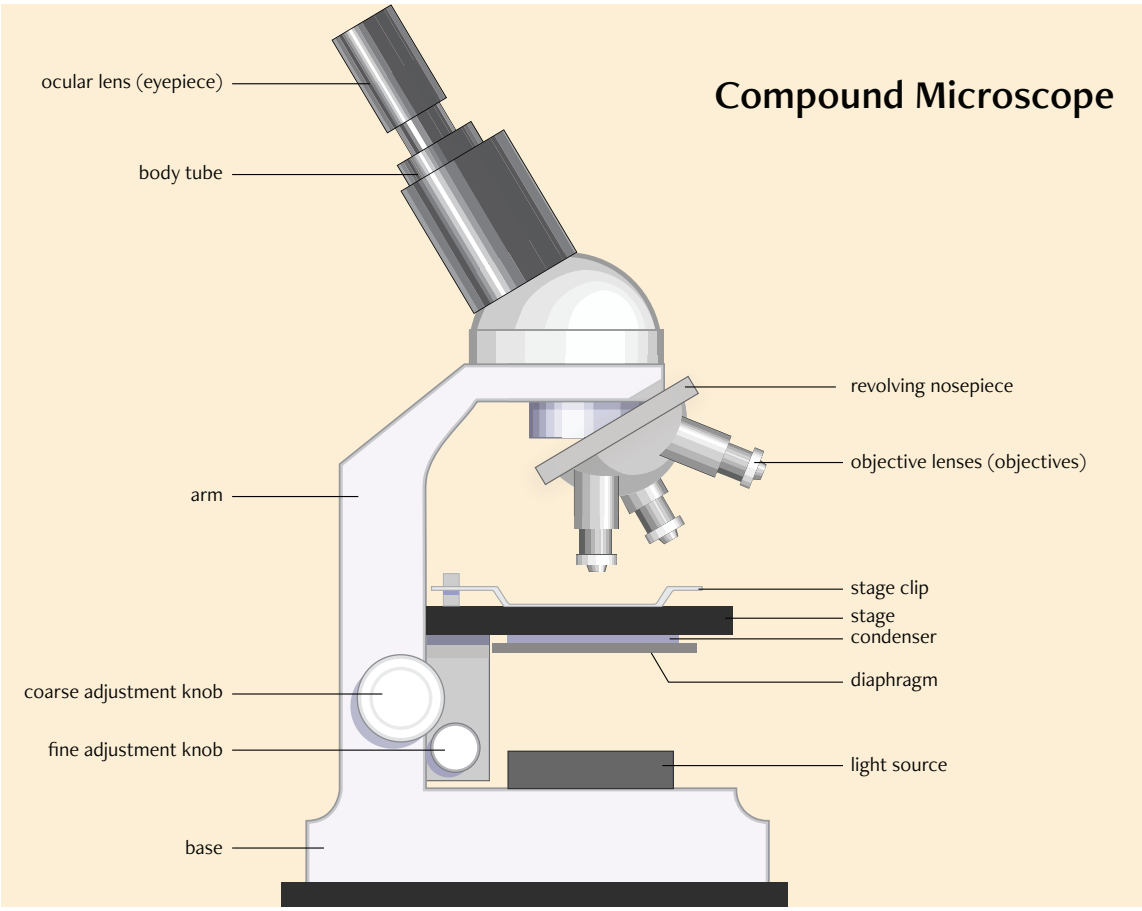
Materials (per group of 2)

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

Basic 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 will begin by learning the basic 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 magnification 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.

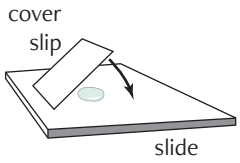
To begin using the microscope, the scanning objective should be pointing down. Place the slide on the stage, holding it in place using the slide clips. Turn on the microscope light and look through the ocular lens(es) to view the slide. Initially, you might not be able to see anything. Slowly turn the 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.

The 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

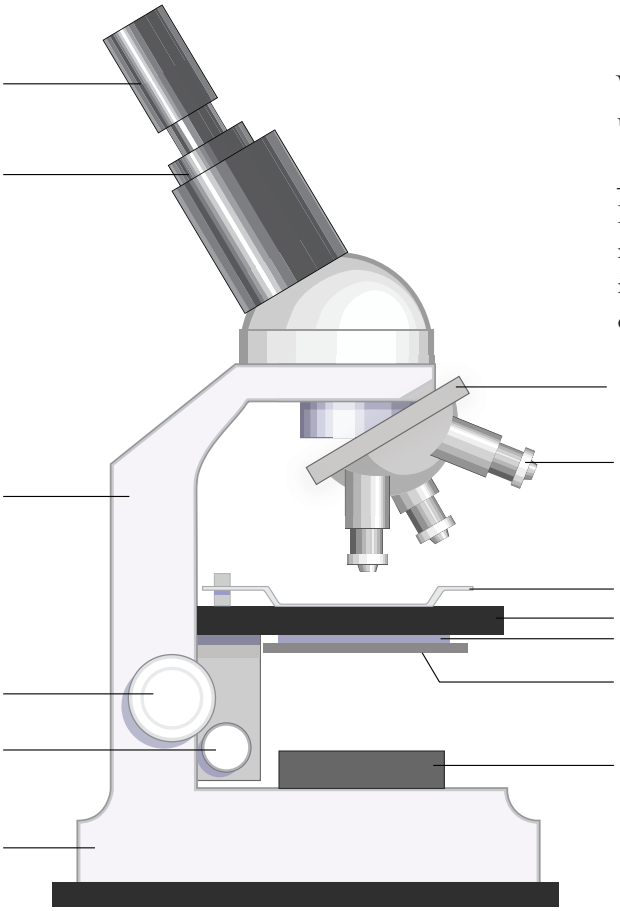
For those in classrooms, work in groups of two students for this lab activity.

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.



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

_____

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

Activity 4 Making Solutions

Today's Date _____

General Information

General Biology text reference: Chapter 2, Sections 2.1-2.2. Appendices A.2 and A.3 are also useful to review.

Estimated time: 30–40 minutes (May be split into two short activities)

Introduction

An important part of learning to be a scientist is knowing how to make measurements and solutions. In this lab, you learn how to use a scale to measure solids, a graduated cylinder to measure liquids, and how to make a solution with a specific concentration based on mass percent. Additionally, performing accurate experiments requires meticulous attention to detail so that error is not introduced into the data. Activities 4 and 5 require you to be extremely careful and accurate in order to observe the desired effects.

Objectives

- Learn and practice basic skills used in making measurements.
- Practice measuring solids and liquids.
- Calculate the amounts needed to make a solution with a given concentration.

Materials (per group of 2–4)

- graduated cylinder, 100 mL
- beaker, 250mL or 400 mL (9 per group)
- glass stirring rod (or plastic spoon) (2 per group)
- weigh tray (or parchment paper or cupcake paper liners)
- scoopula (or plastic spoon)
- scale (precise to 0.1 g)
- distilled water
- sucrose (Table sugar. If store-bought, use white sugar, and check that sugar is the only ingredient.)
- NaCl (Table salt, make sure that store-bought salt is non-iodized. If it contains an anti-caking additive, it must not be sodium silicoaluminate, which makes the salt difficult to dissolve. The additive "yellow prussiate of soda" is fine.)
- small storage glassware or plasticware with lids, or plastic wrap for beakers
- marker for labeling
- hot plate (or stove and small saucepan)
- paper towels

Procedure

Your task is to make solutions of salt and sugar that are used in the Activity 5, Melting Points of Two Solutions. If your group has enough beakers, it would be wise to label them in advance (example: "10% salt" or "5% sucrose") and arrange them in order. Store the solutions in airtight, labeled

containers until you are ready to perform Activity 5. You may store the solutions in beakers by covering the beakers with snugly attached plastic wrap.

We begin by walking through the process of making a 10% salt solution using a mass percent. For 100 g of solution, you want 10% of the total mass to be the solute, or salt in this case. The remaining 90% of the solution is the mass of the solvent, distilled water. Measure out 10.0 grams of NaCl because this is 10% of 100 g.

First put the weigh tray (or weighing paper, parchment paper, cupcake liner, etc.) on the scale. Zero out the mass of the weigh tray with the "zero" or "tare" button. Push this button and now your scale should read 0.0 g. Next, use a scoopula or spoon to transfer the NaCl into the weigh tray until it reads 10.0 g. You need to be accurate in your measurements (See Appendices 2 and 3 in your General Biology text). Once you have measured 10.0 g of NaCl, transfer it to a beaker.

— Note —

To make the mixing the more concentrated solutions go more quickly, you can slightly heat the solution, as this helps the solute to dissolve more quickly. This can be done using a hot plate and lab-grade glassware that is heat safe. Or, if you are doing this experiment in your kitchen, simply transfer the solution to a saucepan to heat it gently on your stove. Do not allow the solution to come to a boil.

Next measure out 90.0 g of distilled water. Water has a density of 1.0 g/mL. This means that 90.0 g of water is equal to 90.0 mL of water. Pour the distilled water into the graduated cylinder until the bottom of the meniscus touches the 90.0 mL line. Pour it into the beaker to create the 10% mass-percent NaCl solution. Use a stirring rod to mix the solution until the NaCl solute is completely dissolved in the distilled water solvent.

Question: What is the appearance of the salt/water mixture before stirring? How do you know when the solution is completely dissolved? Describe the appearance of the mixture both before and after the solute has dissolved.

Question: Why might it be necessary to heat a more concentrated solution?

Now that you have made this solution, prepare the remaining solutions. In the tables below, write the amounts of solute and solvent required to make each solution. Have your instructor check your

work before you begin making the solutions. You want to make sure to use clean and dry glassware and equipment for each new solution.

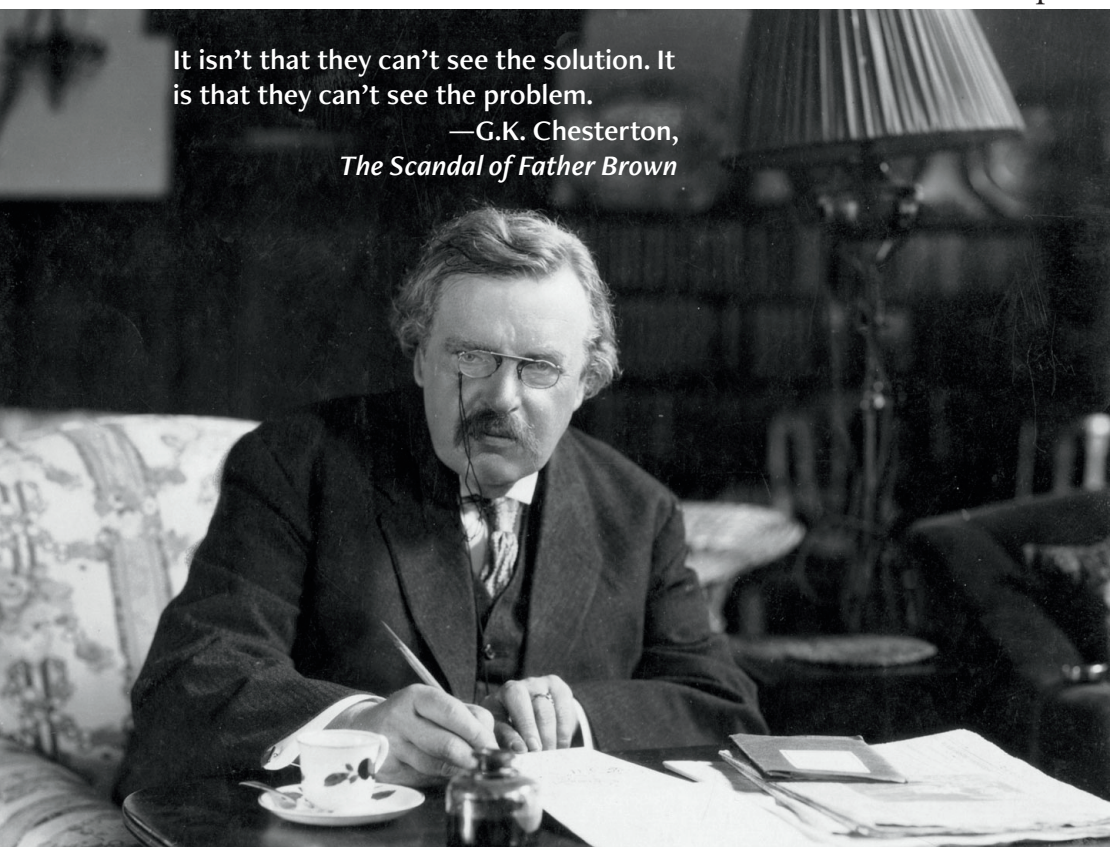
Salt Solutions

concentration (g/g × 100%)	mass of solute (salt) (g)	mass of solvent (distilled water) (g)
10%	10.0	90.0
5%		
2%		
1%		
0%		

Sugar Solutions

concentration (g/g × 100%)	mass of solute (salt) (g)	mass of solvent (distilled water) (g)
10%	10.0	90.0
5%		
2%		
1%		
(Only one 0% solution is required.)		

— Commonplace



— Space —

A Chord of Colour
G.K. Chesterton

My Lady clad herself in grey,
That caught and clung about her throat;
Then all the long grey winter day
On me a living splendour smote;
And why grey palmers holy are,
And why grey minsters great in story,
And grey skies ring the morning star,
And grey hairs are a crown of glory.

My Lady clad herself in green,
Like meadows where the wind-waves pass;
Then round my spirit spread, I ween,
A splendour of forgotten grass.
Then all that dropped of stem or sod,
Hoarded as emeralds might be,
I bowed to every bush, and trod
Amid the live grass fearfully.

My Lady clad herself in blue,
Then on me, like the seer long gone,
The likeness of a sapphire grew,
The throne of him that sat thereon.
Then knew I why the Fashioner
Splashed reckless blue on sky and sea;
And ere 'twas good enough for her,
He tried it on Eternity.

Beneath the gnarled old Knowledge-tree
Sat, like an owl, the evil sage:
'The World's a bubble,' solemnly
He read, and turned a second page.
'A bubble, then, old crow,' I cried,
'God keep you in your weary wit!
'A bubble—have you ever spied
'The colours I have seen on it?'

Activity 5 Melting Points of Two Solutions

Today's Date _____

General Information

General Biology text reference: Chapter 2, Sections 2.1–2.2. Appendices A.2 and A.3 are also useful to review.

Estimated time: 45–60 minutes. You may choose to do the data analysis on a separate day to allow for more time.

Introduction

In Chapter 2 of your General Biology text, you are introduced to basic chemistry principles as they apply to the living world. In this lab you will measure the change in the melting point of a liquid (water) after adding a solute (salt or sugar) to a solvent (water). The melting point is the temperature at which a solid becomes a liquid or the temperature at which a liquid becomes a solid. In this activity, you compare the effects of several concentrations of two different solutions on the melting point.

Objectives

- Learn and practice basic skills in used in making and graphing accurate measurements.
- Practice using the scientific method.
- Understand basic information about solutions.
- Develop a testable hypothesis and experiment.
- Make conclusions based on data collected.

Materials (per group of 2–4)

- salt and sugar solutions from Activity 4
- ice
- plastic Ziplock bags, 1- or 2-gallon size
- hammer
- clothespins or small clamps (2–4 per group)
- thermometer (2 per group) (digital thermometers are preferred, measuring to 0.1°C; alcohol thermometers measuring in 1°C increments are acceptable.)
- Styrofoam cups, 8.5 fl oz (20 per group)
- graduated cylinder, 100 mL (2 per group)
- beaker, 400 mL
- distilled water
- timer/stopwatch

Questions

Before you begin, review what you have learned about water, solutions, ionic bonds, and covalent bonds in Chapter 2. Then answer the following questions.

1. What is an ionic bond?

2. What is a covalent bond?

3. Explain how water acts as a solvent. (What unique properties of water make it a good solvent?)

4. In the compound NaCl, what kind of bond holds the two atoms together? What happens to NaCl when it is added to water? Explain.

5. Sucrose has the molecular formula $C_{12}H_{22}O_{11}$. What kind of bond holds these atoms together? What happens to sucrose when it is added to water? Explain.

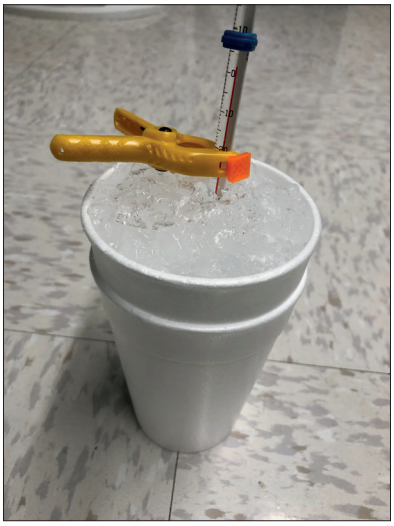
Procedure

If you are part of a class, work in teams of 2–4 students for this activity. Set up data tables on the following page for recording the temperatures in °C for the 0% solution and for the four salt solutions and four sugar solutions.

Thermometer Calibration

1. Fill a gallon-sized bag with ice and seal the bag (removing as much air as possible).
2. Use a hammer to crush the ice into pea-sized pieces (or smaller).
3. Stack two Styrofoam cups and use them to scoop out ice from the plastic bag, such that it fills the cup to the top.
4. Use your hand to gently pack the ice down, then invert the cup and ice (over a sink) so that any liquid can escape.
5. Measure out 50 mL of distilled water (your 0% solution) using a graduated cylinder. Add the water to the ice in the cup and start the stopwatch.
6. Use the thermometer to measure the temperature in °C. Gently insert the thermometer in the center of the ice/water, but do not let it touch the bottom of the cup. It should be immersed in liquid, with a "thermal barrier" of ice at the top. As shown in the images below, secure the thermometer with a clothespin or clamp to keep it from falling to the bottom of the cup and take a reading after the stopwatch reads 5 minutes. Record the value in the table below. This temperature of the 0% solution is your control.

> — Note —
> Do not stir with the thermometer. Just insert it straight down into the ice.



Melting Point Procedure

Test the eight salt and sugar solutions by measuring the temperature of each one as you did with the 0% solution.

1. Add crushed ice to a fresh pair of Styrofoam cups (labeled) by repeating the previous steps 3 and 4.

2. Add 50 mL of the salt solution you are testing. Start with the lowest concentration. Start the stopwatch as soon as you pour in your solution.
3. Measure the temperature using the thermometer, making sure not to touch the edge or bottom of the cup with the thermometer. As before, secure the thermometer with a clothespin or clamp. After 5 minutes, record the value in the table below.
4. Repeat steps 1–3 for the remaining salt solutions.
5. Repeat steps 1–3 for the sugar solutions. Take care not to contaminate your sugar solutions with salt. Either use a separate thermometer for each set of solutions, or carefully rinse and dry the thermometer in between each set.

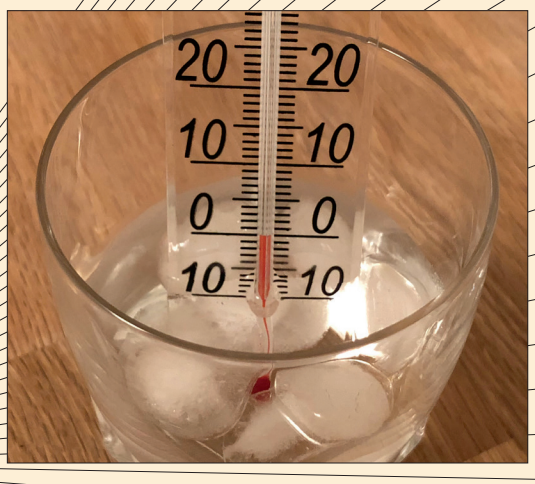
— Experimental Data —

Data Analysis

What temperature did you read for your 0% solution? What temperature would you expect it to be? If there is a discrepancy between your expected value and your measured value, explain why.

Graph your data on the grid provided on the opposite page. Graph the melting point (°C) against concentration (mass of solute / mass of water) from your experimental data. Put the salt data and the sugar data on the same graph. Use different colors for the different solutes and make a legend to indicate which is which. The concentration of the solution is the independent variable and is read on the horizontal axis. The melting point temperature is the dependent variable and is read on the vertical axis.

Interpret the graphs and describe what the graphs indicate about the effect of concentration on melting point and the difference between the two solutes.



The melting point is the temperature at which a substance undergoes the change of state from solid to liquid. At the melting point, the solid and liquid states exist together in equilibrium. This is why ice water always has a temperature of 0°C after the ice and water have reached equilibrium.

— Graphs for Data Analysis —

Challenge Data Analysis

For a more revealing look at the data, try this data analysis exercise!

Using your experimental data, you will now do some simple calculations to standardize your data. The salt and sugar behave differently when they are dissolved in water. The NaCl crystal separates not into molecules of NaCl, but into its two ions, Na^+ and Cl^-, while the sugar separates into individual molecules of $C_{12}H_{22}O_{11}$.

A standard way of comparing solutions uses a quantity called *molarity*, a measure related to the number of particles of solute per liter of solvent. To obtain the molarity, we calculate the number of moles of solute there are in the solution in each case. A *mole* (mol) of a substance is simply a particular number of particles of the substance, just as a dozen and a score are a particular number of things (12 and 20, respectively). In the case of the mole, the number is Avogadro's number, which is approximately 6.022×10^{23}. If you have taken chemistry, you already know how to use the periodic table and Avogadro's number to compute the number of moles of solute involved in each of your solutions. If you have not yet taken chemistry, use the equations given in the examples below to calculate the molarity in moles of solute per liter of solvent (mol/L, or *M*) for each solution. Enter the molarities in the tables on the opposite page.

1. One mole of salt is 58.44 g of salt, so to determine the number of moles of salt in the solution, divide the number of grams of salt by the value 58.44 g/mole. For example:

$$\frac{1.0\ \text{g}}{58.44\ \frac{\text{g}}{\text{mol}}} = 0.01711\ \text{mol}$$

2. Recall that 1.0 g of water has a volume of 1.0 mL, so the masses of water in your in your data tables in Activity 4 correspond to the volumes in mL as well. Divide each of these by 1000 to convert them to volumes liters and enter the values in the tables.
3. To determine the molarity of the salt solution, divide the total number of moles of salt by the volume of the water in liters. Notice that the volume of water is different for each of the different solutions. For example:

$$\frac{0.01711\ \text{mol}}{99\ \text{mL}} = \frac{0.01711\ \text{mol}}{0.099\ \text{L}} = 0.173\ \frac{\text{mol}}{\text{L}} = 0.173\ M$$

4. To determine the molarity of ions in the salt solution, multiply the molarity of the solution by 2. This is because the NaCl crystal dissociates into two types of individual ions in water, Na^+ and Cl^-. For example:

$$\frac{2\ \text{mol ions}}{\text{mol salt}} \cdot \frac{0.173\ \text{mol salt}}{\text{L water}} = 0.346\ \frac{\text{mol ions}}{\text{L water}} = 0.346\ M$$

5. Repeat the same set of calculations for the sugar solutions and record them in the next table. For sugar, you divide the number of grams of sugar by 342.3 g/mol. You do not need to multiply the final number by 2 because sugar does not dissociate into ions in water.

Salt Solutions

concentration (g/g × 100%)	mass of solute (salt) (g)	moles of solute (salt) (mol)	volume of solvent (water) (L)	molarity of salt solution (mol/L)	molarity of ions in salt solution (mol/L)
0%	0.0	0	0.1	0	0
1%	1.0				
2%	2.0				
5%	5.0				
10%	10.0				

Sugar Solutions

concentration (g/g × 100%)	mass of solute (sugar) (g)	moles of solute (sugar) (mol)	volume of solvent (water) (L)	molarity of sugar solution (mol/L)
0%	0.0	0	0.1	0
1%	1.0			
2%	2.0			
5%	5.0			
10%	10.0			

6. Now graph molarity (*x*-axis) versus temperature (*y*-axis) on the grid provided on the following page. These are the values you calculated and recorded in the tables above. You will have three data series on the graph: a) molarity of salt vs temperature, b) 2× molarity of salt vs temperature, c) molarity of sugar vs temperature.

— Graphs for Data Analysis —

Answer the following questions.

1. What happens to the melting point of a solvent when a solute is added? See if you can propose a theory explaining why this is the case.

2. Describe the differences between salt and sugar in the way they affect the melting point of water. Which solute lowers the melting point more dramatically? Seek to relate the differences to the new molarity graphs you made. See if you can expand your theory to account for the fact that the effects for salt and sugar solutions are different.

3. Based on your observations and measurements, formulate a hypothesis predicting the change of the melting point of a solvent as a result of adding a solute. Then describe how well your own test results support your hypothesis.

Activity 6 Properties of Water

Today's Date _____

General Information

General Biology text reference: Chapter 2, Section 2.2

Estimated time: 30 minutes

Introduction

In Chapter 2 of your General Biology text, you read bout the different properties of water. In this lab activity, you observe three of water's properties—cohesion, surface tension, and its behavior as the "universal solvent." Review these properties in your text before you begin.

Objectives

- Observe some of the unique properties of water.
- Develop hypotheses/explanations based on your observations.

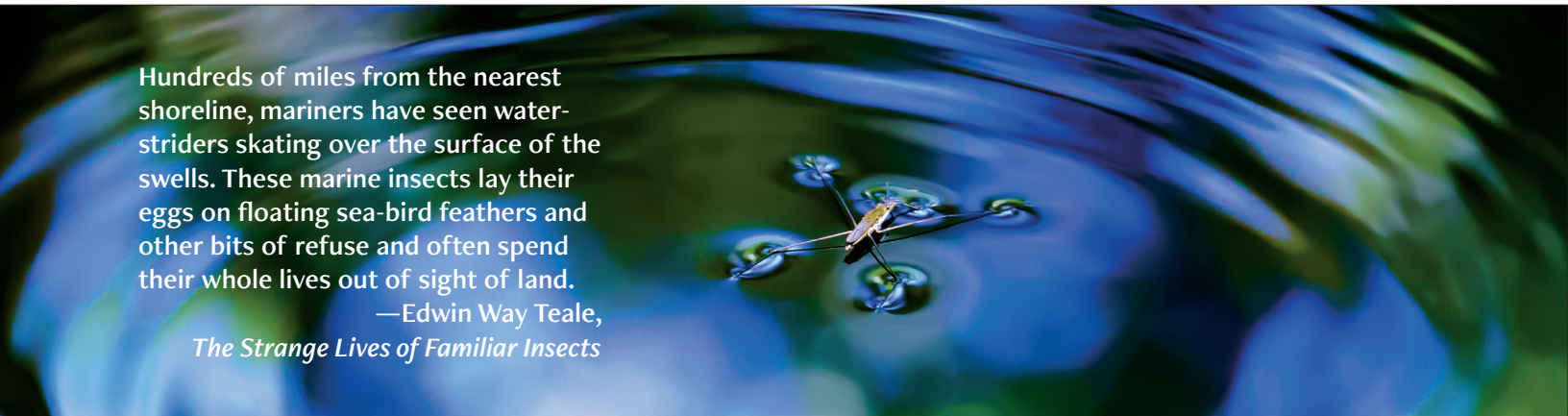
Materials (per group of 2)

- Petri dish or small bowl (at least 3 per group)
- medium-sized plate or additional bowl
- cotton swabs
- distilled water
- dish soap
- cooking oil
- food coloring
- whole milk
- small metal paper clip
- filter paper (or white coffee filter)
- scissors
- test tube
- test tube rack
- water-soluble ink pen (or bottle of water-soluble ink), black and one or two other colors
- ruler

Procedure

If you are part of a class, work in teams of two students for this activity.

Draw a water molecule in the space provided on the next page. Include the partial charges that are present on the different atoms. Below, describe what it means for water molecules to be polar.



Hundreds of miles from the nearest shoreline, mariners have seen water-striders skating over the surface of the swells. These marine insects lay their eggs on floating sea-bird feathers and other bits of refuse and often spend their whole lives out of sight of land.

—Edwin Way Teale,
The Strange Lives of Familiar Insects

— Sketch —

Part 1. Observation of Surface Tension

1. Write definitions for the following terms:

cohesion

surface tension

2. Fill a Petri dish or small bowl with distilled water. Add 2–3 drops of food coloring. What do you observe? What happens to the food coloring? What do you think causes this to happen?

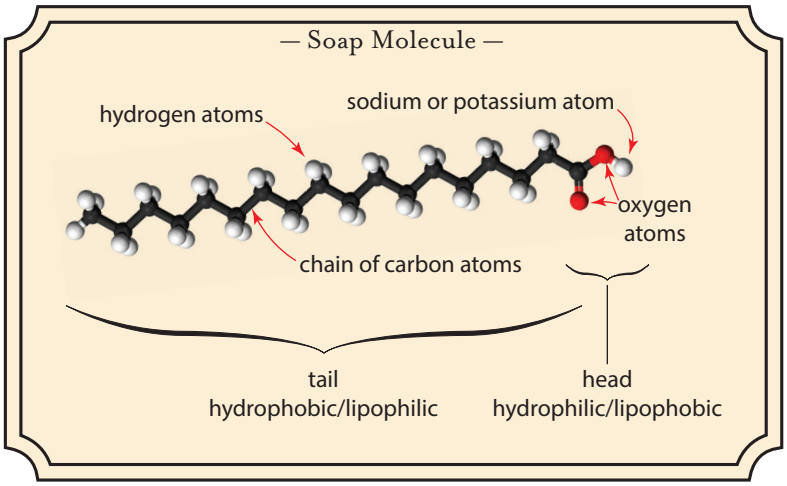
3. Obtain a clean Petri dish or small bowl. Fill it with distilled water. Add some cooking oil to the water so that it forms a small circle with a diameter of about one inch. The oil should float on the surface of the water. Next add 2–3 drops of food coloring onto the surface of the oil. What do you observe? What happens to the food coloring? Is it the same or different than what you observe when you add the food coloring to the water? What do you think causes this to happen? (Save the water with the oil and colored drops undisturbed for step 4.)

4. Using the water with the oil and colored drops from step 3, add a drop of dish soap onto the oil near the food coloring. You may need to add a few more drops of dish soap before a change takes place. What do you observe? What happens to the food coloring? What do you think causes this to happen?

5. Obtain a shallow plate or dish. Pour some whole milk into the plate to make a shallow pool. Next add a few drops of food coloring to the surface of the milk. Use multiple colors and scatter the drops around over the entire surface of the milk. What do you observe? What happens to the food coloring? Is it similar to or different from what you observe in step 1 with the water? Why do you think that is? (Save the milk with the food coloring undisturbed for step 5.)

6. Use the milk with the food coloring from step 4. Obtain a cotton swab and soak the end of it in dish soap. Carefully touch the soapy cotton swab to the center of the milk. What do you observe? What happens to the food coloring? What do you think causes this to happen?

7. Soap is an *amphipathic* molecule. These means it is both hydrophilic (water-loving) and hydrophobic (water-fearing). It is also lipophilic (fat-loving) and lipophobic (fat-fearing). An illustration of a soap molecule is shown below. Knowing what you do about the properties of water, describe how the properties of water and soap molecules explain what you observe.



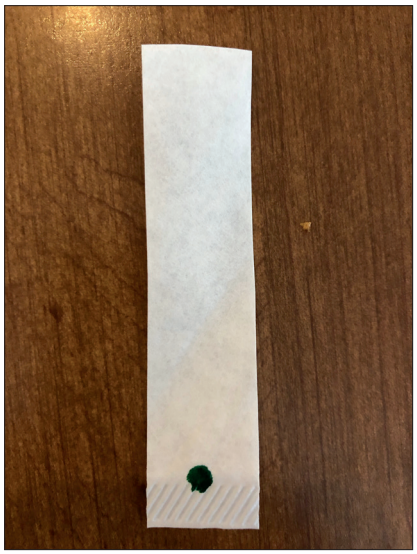
— Commonplace Space —

8. Obtain a clean Petri dish or small bowl and fill it with distilled water. Obtain a small, metal paper clip and bend one of the metal ends up to be used as a handle as shown in the image to the right. Hold the paper clip by its "handle" and gently set the paper clip down horizontally on the surface of the water. The paper clip should stay on the water's surface. Now add one drop of dish soap. What do you observe? Provide an explanation for why this happens using what you know about the properties of water.

Part 2. Water as a Solvent

In this section, you use a technique known as *chromatography* to separate the different components of a mixture. There are many different types of chromatography. Today, we make use of paper chromatography to separate different ink colors from black ink. In chromatography, a solvent (in this case water), dissolves the solute (black ink), and carries it up the filter paper. As the water moves up the filter paper, smaller particles move faster than larger particles. As a result, the smaller particles travel farther than the larger particles and they become separated on the filter paper.

1. Obtain a test tube and a test tube rack. Cut a strip of filter paper (or coffee filter) that fits into the test tube, extending all the way to the bottom of the test tube. You may want to cut the corners off the bottom of the filter paper so that it makes a U-shape, enabling it to fit better into the base of the test tube.
2. Using a pencil, mark a line across the filter paper strip, about 1 cm from the bottom of the strip. Now, using the water-soluble black ink pen (or ink from a bottle), ink in a solid dot on the line of the filter paper, as shown in the photo at the right.
3. Add a small amount of distilled water to the test tube. You want enough that the filter paper sits in the water, but you do NOT want the water to be deep enough to touch the ink dot.
4. Place the marked filter paper into the test tube and place the tube in the rack. Allow the water to soak up through the filter paper. This takes a few minutes. Once the water has soaked up through most of the filter paper, remove it from the test tube and allow it to air dry.



— Sketch —

5. Make a sketch of the filter paper in the space on the next page. You should see several different pigment marks on the filter paper.
6. Measure the distance from the pencil line at the bottom to each of the different pigment marks on your filter paper. Record these distances and the colors of pigments observed.

— Measurements and Colors —

7. For fun, try using some different pens and see if they result in different colored pigments on the filter paper. Record your observations.
8. Based on your knowledge of the properties of water, explain how the water moves upward through the filter paper. Then extend your reasoning to explain how the ink moves and why you see the pigment pattern that you do.

Activity 7 Introduction to Cells

Today's Date _____

General Information

General Biology text reference: Chapter 3, Section 3.2

Estimated time: 20-30 minutes if you choose to use the prepared slides. If you choose to prepare your own slides and stain them, then you will want to plan for more time, about 30–45 minutes.

Introduction

Chapter 3 of *General Biology* introduces cells. Review the information in Section 3.2 about the basic structures of all cells, as well as the specific structures found in plant and animal cells. It may also be helpful to review the basic microscope etiquette presented in Activity 3.

Objectives

- Observe the basic structures of a cell.
- Compare different types of cells.
- Practice basic microscopy skills.

Materials (per group of 2)

- compound light microscope
- lens paper
- prepared slides
  - *Elodea* leaf
  - human epithelial tissue
  - amoeba or paramecium
- blank glass slides (optional)
- cover slips (optional)
- materials to prepare slides (optional)
- water (optional)
- dropper (optional)
- saline solution (0.9% NaCl) (optional)
- elodea or similar aquatic plant leaf (optional)
- toothpick (optional)
- dyes (optional)
- methylene blue

Procedure

Work in pairs for this activity.

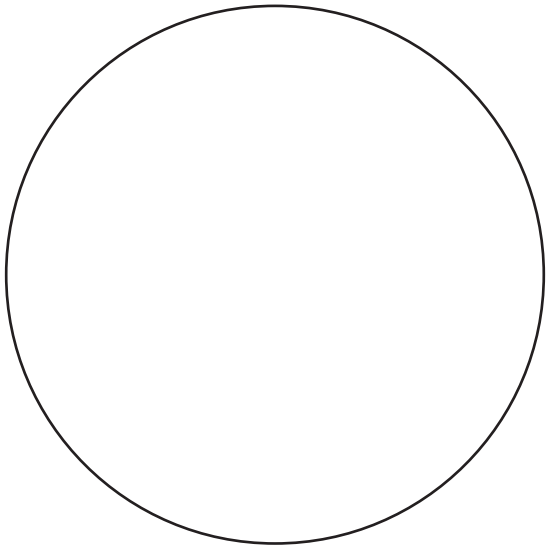
Observation of Plant Cells

1. Obtain a prepared slide of an *Elodea* leaf and observe it under the microscope using the skills you practiced in Activity 3. In the circle at the top of the next page, make a sketch of the *Elodea* cells you are viewing. Note the total magnification you are using here: _____

— Note —

If you do not have a prepared slide, you can make one of your own. Cut off about a 1 mm from the tip of a leaf of an *Elodea* or similar aquatic plant. Place it on the slide with a drop of water and add a cover slip as described in Activity 3.

— Plant Cell Sketch —



2. Plant cells are surrounded by a cell wall giving them a very distinct shape. Describe the shape of these cells.

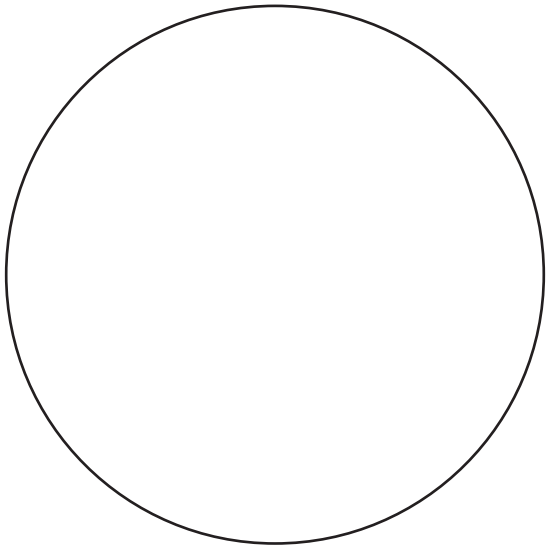
3. Some organelles are especially prevalent in plant cells. Which organelles would you expect to observe in the above sample?

4. Are you able to observe these plant-specific organelles? If so, point them out on your sketch above.

— Note —

If you do not have a prepared slide available, you can make your own. First prepare a saline (0.9% NaCl) solution by dissolving 0.9 g of salt into 99 g of water. Add a drop of saline solution to the slide. Gently use a toothpick to scrape the inside of your cheek. Stir the toothpick in the drop of saline solution to release the cells. Add a cover slip as described above. View the slide under the microscope. Epithelial cells are very light in color and may be difficult to observe. This is a great opportunity to practice using the diaphragm on your microscope. While looking through the microscope, move the diaphragm lever to increase the contrast. This help you to see the cells more easily.

— Animal Cell Sketch —



Observation of Animal Cells

1. Obtain a prepared slide of human epithelial tissue and observe it under the microscope using the skills you practiced in Activity 3. Note the total magnification you are using here: _____
2. Make a sketch of the cells in the circle above.
3. Optional staining: If you prepared your own slide, you may choose to add a stain to improve the contrast. Remove the prepared slide from the microscope and place it on your bench top or table. Place a drop of methylene blue on the edge of the cover slip. Take a piece of lens paper and hold it to the cover slip edge opposite of where you put the drop. The lens paper will absorb the water and draw the water and dye across the cheek cells underneath the cover slip. Once the dye has moved across the slide, put the slide back on the microscope stage and view it using proper microscope technique.
4. If you added the stain, describe your new observations in the space below. What is different? Are there any structures you can see that you did not see before?

5. Animal cells do not have a cell wall. What general shape do these cells have?

6. Animal cells are eukaryotic. What features do eukaryotic cells possess that prokaryotic cells do not?

7. Are you able to observe any of these features? If so, point them out on your sketch above.
8. The human mouth is also host to many bacteria (prokaryotic organisms). What kind of size difference do you expect between human cheek cells and bacterial cells?

9. Are you able to observe any bacteria in your slide? If so, label them in your sketch.

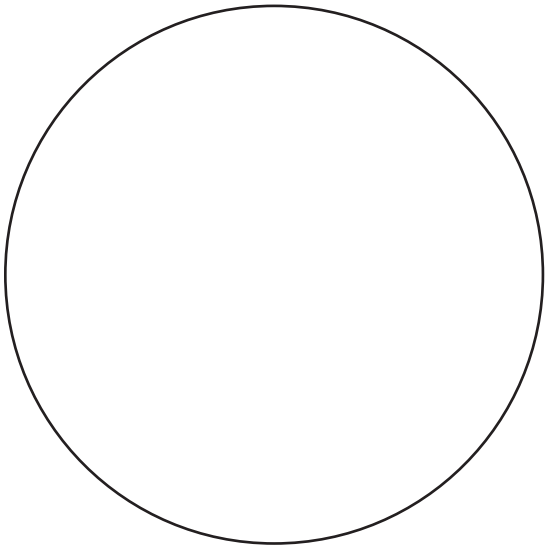
Observations of Protozoans

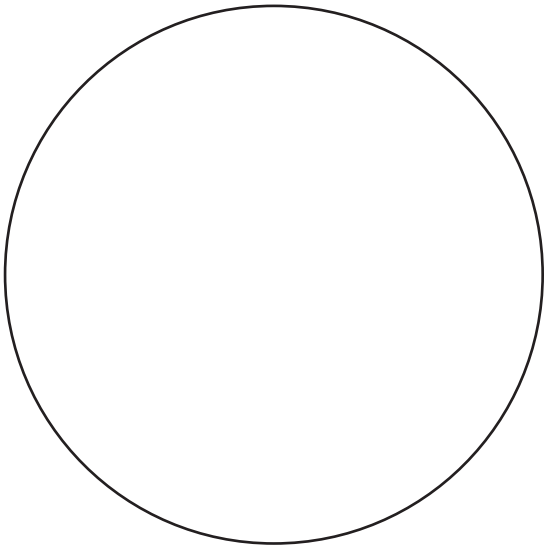
There are many microscopic organisms that live in our world. You will learn more about a specific group of animal-like unicellular organisms called protozoans in Chapter 8 of *General Biology*.

1. Obtain one or two prepared slides of protozoans such as a *Paramecium* or *Amoeba*. (Both are genus names.) Look at them under the microscope. Note the total magnifications here:
   _____ _____
2. Make sketches of the organisms in the circles on the next page. Describe their general appearance.

English botanist John Hill coined the term ***Paramecium*** in 1752. It is based on the Greek word ***paramekes*** ("oblong"). Back then, microorganisms were known by the charming name ***animalcules***.

— *Paramecium* and *Amoeba* Sketches —





3. Increase the magnification and see if you can observe any structures inside the organisms or on the outside? Include these in your sketch and description.
4. *Paramecia* and *Amoeba* both have specific structures that help them move through the water. Study your sketch and form a hypothesis as to which structures help your observed organisms to propel through water. Explain how your observations support this hypothesis.

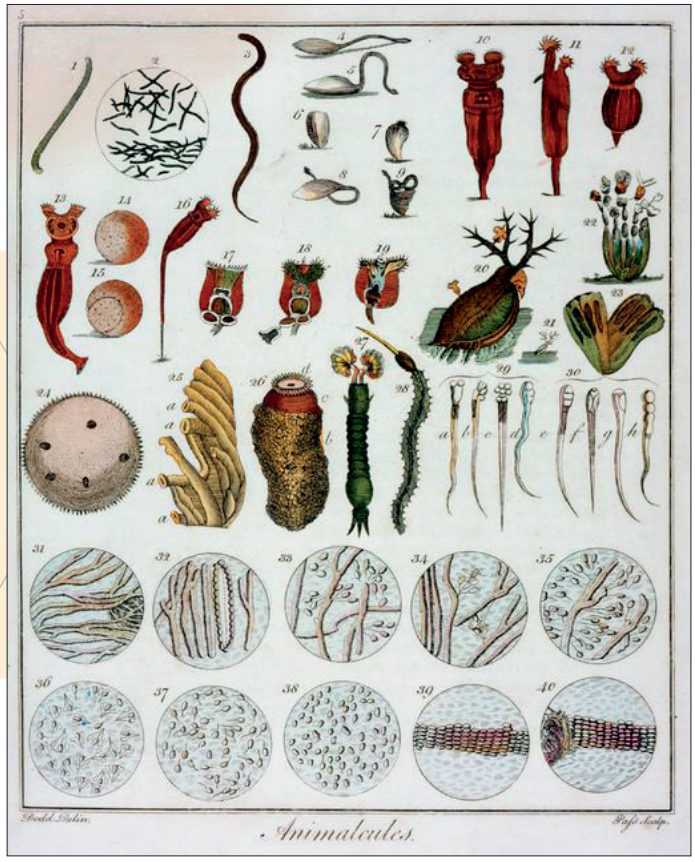
Bonus Activity

Now that you have some practice using the microscope, find other things to view under your microscope. For example, you can look for living microorganisms in a sample of pond water and make a slide (with cover slip) to view. Or you can view a hair under the microscope. Remember that in order to see detail, the object must be very thin so that light can pass through the object and to your eye. Include a sketch and description of your observations in the space provided below. Be sure to include the total magnification here: _____

— Bonus Activity Sketch —

Describe your Bonus Activity observations here:

Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas, and so ad infinitum.
—Augustus de Morgan, based on Jonathan Swift



Activity 8 Diffusion

Today's Date _____

General Information

General Biology text reference: Chapter 3, Section 3.3.2

Estimated time: 20–30 minutes

Introduction

Chapter 3 of *General Biology* addresses the various modes of transport across a cell membrane, classified as either active transport or passive transport. In this activity, you investigate the nature of one type of passive transport—simple diffusion. Review the properties of simple diffusion before proceeding. Also review the kinds of molecules that generally cross the cell membrane via simple diffusion and the definition of the term *concentration gradient*.

Diffusion occurs because molecules of liquid or gas are always zooming about because of the kinetic energy they have. This kinetic energy depends on the temperature—the higher the temperature, the faster the molecules are moving. (This is why heating can make chemical reactions occur more rapidly. At higher temperatures, molecules are moving faster and collide with each other more frequently, providing more opportunities for new chemical bonds to form.) In general, at a given temperature, lighter molecules have higher kinetic energies. Since lighter molecules are moving about at higher velocities, they diffuse more rapidly though a given medium.

Objectives

- Observe and explain the process of simple diffusion.
- Explain how the size of diffusing molecules, structure of medium, and concentration gradient affect diffusion.

Materials (per group of 2–3)

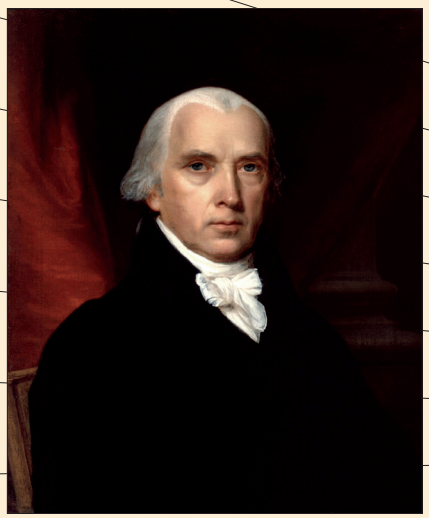
- Petri dish, pre-plated with agar
- food coloring, four colors (red, green, blue and yellow preferred)
- plastic drinking straw
- metric ruler
- timer/stopwatch
- colored pencils

Procedure

If you are part of a class, work in teams of 2–3 students for this activity.

In this activity, you study diffusion through agar of different colors of dyes. Agar is a gelatinous mix of carbohydrates that is commonly used in some Asian desserts and in the microbiology lab. The carbohydrates themselves come from the cell walls of various species of red algae. Recall that the structures of the cell wall and the cell membrane (shown in Figures 3.37 and 3.40 of *General Biology*) have different compositions.

1. Draw a quick sketch of the molecular structure of each one in the space on the opposite page.

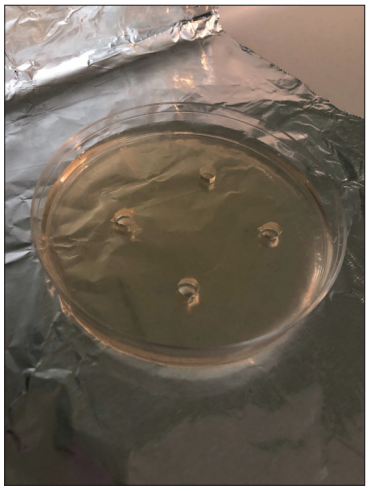


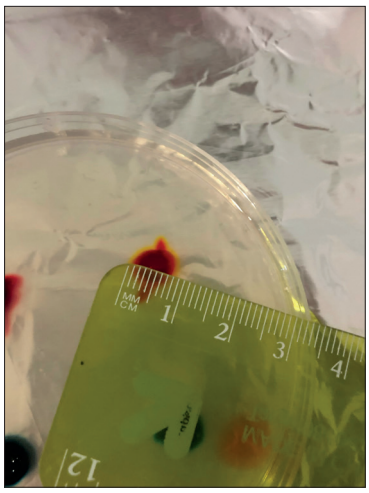
The advancement and diffusion of knowledge...is the only guardian of true liberty.
—James Madison

2. Are the molecules polar or non-polar? Would you expect it to be easier for larger molecules to pass through the cell wall or the cell membrane? Why?

3. Your instructor has poured agar into a Petri dish and let it set ahead of time. Obtain a plastic straw and use it to form four wells (holes) in the agar, as shown in the image on the left at the top of the next page. Place the straw vertically over each well location, then press it straight down, rotate it slightly, and pull it out. This removes a plug of agar to form the well.

— Sketches —





— Experimental Data —

4. Carefully place one drop of food coloring into each well (one color per well), and start your timer. Be careful not to spill food coloring in any other location.
5. The diameter of the color spot in each well will increase as the molecules in the food coloring diffuse through the agar. Your data collection task is to track the diameter of each color spot over time, making measurements every five minutes. Prepare a data table in the area provided on the next page for recording these measurements. Include rows in the data table for an initial measurement (time = 0 minutes) and additional measurements at five-minute intervals up to a final set of measurements at the 15-minute mark. Include columns for each color.
6. After five minutes, measure diameter of the dye spot for each color, as shown in the image on the right on the previous page. Measure across the circle of dye, from the edge of the color front to the other edge. It doesn't matter what the color is; so long as there is color, include it in the measurement. Repeat your measurements every five minutes and record your data in your data table.
7. The molecular mass of a molecule is the sum of the masses of the atoms in the molecule. The molecular masses of the dyes are provided in the following chart. In between measurements, use the information in the chart to respond to the questions below.

Dye Color	Major Ingredient	Molecular Mass (g/mol)
red	FD&C Reds 40 and 3	496.42, 879.9
yellow	FD&C Yellow 5	534.3
green	FD&C Yellow 5 and FD&C Blue 1	534.3, 792.85
blue	FD&C Blue 1	792.85

Questions

1. What is a concentration gradient?

2. Based on your answer, form a hypothesis as to the direction(s) you think the dyes will travel.

3. Do you expect the different dyes to travel the same distance or different distances? Form a hypothesis predicting the distances the dyes will travel relative to each other. (Refer to the molecular mass chart to help inform your answer.)

4. In the space on the next page, draw a sketch of the way your Petri dish appears after 15 minutes. Use colored pencils or shading to show differences in color intensity.

— Sketch —

5. Which dye traveled the farthest? The least distance? What aspect(s) of the dyes do you think cause the different diffusion patterns?

6. Plot your data on the grid below, using the separate data sets for each color. Use colored pencils or markers with the same colors as your dye to indicate each data set. What variable is the independent variable? How do you know?

— Graphs for Data Analysis —

What is the dependent variable? How do you know?

7. Write down any observations you made about the intensity of the color in different locations after 15 minutes. Why do you think this is the case? What do your observations teach you about diffusion?

8. Save your Petri dish for the following day, and use the space below to make further observations, sketches, measurements, or notes.

Activity 9 Osmosis

Today's Date _____

General Information

General Biology text reference: Chapter 3, Section 3.3.2.

This lab activity requires solutions and materials to be prepared 4 days in advance of the procedure.

Estimated time: 60 minutes

Introduction

Chapter 3 of *General Biology* introduces the role the cell membrane plays in controlling the molecules and ions that enter and exit a cell. Review the structure and function of the plasma membrane in Section 3.3 of your text. In particular, this activity focuses on the type of passive transport called osmosis. Osmosis is concerned with the movement of water molecules, not solute particles, across a membrane.

Objectives

- Observe the process of osmosis in a cell.
- Practice making and graphing measurements.
- Make predictions regarding the process of osmosis in a cell.
- Form conclusions based on data collected.

Materials (per group of 4)

- solutions to be prepared in advance
  - ☞ 10% sucrose (~100 mL)
  - ☞ 20% sucrose (~ 100 mL + ~2.5 L more for soaking)
  - ☞ 40% sucrose (~ 100 mL)
- distilled water
- sucrose (white baking sugar)
- de-shelled eggs (4, prepared four days in advance)
- vinegar (1 gallon)
- large spoon
- weigh tray
- mass scale
- graduated cylinder, 100 mL
- Pyrex measuring cup, 500 mL
- beakers, 250 mL (4) (or Styrofoam/ disposable cups)
- stopwatch or timer
- cake pan or Pyrex with lid to store eggs
- colored pencils

Procedure

If you are part of a class, work in teams of four students for this activity.

An egg is a single cell with a plasma membrane. In most cases, the plasma membrane surrounding the egg cell has a protective coat around it. In the case of a chicken egg, this protective coat is a shell made of calcium carbonate. Once the shell is removed, however, the plasma membrane is exposed and is the only thing holding the egg together. Solutes cannot pass through the egg membrane, but water can. Therefore, water moves into or out of an egg, depending on the type of solution in which the egg is placed. Your team has been provided with four eggs, from which the shells have been removed. These eggs have been soaking in a 20% sucrose solution. For the duration of the

I learned from admiration and osmosis.
—Joni Mitchell

experiment, each egg remains in one of four different sucrose solutions while you observe the changes it undergoes.

1. Obtain four 250 mL beakers (or disposable drinking cups). Label the four beakers as follows: 1 – 0% sucrose, 2 – 10% sucrose, 3 – 20% sucrose, 4 – 40% sucrose.
2. Fill each beaker with about 100 mL of its respective solution.
3. Obtain four de-shelled eggs. Assign one to each beaker and keep in mind which one is which. Weigh each egg and record their respective masses in the row labeled "start (0 min)" in the data table below.

> — Note —
> Distilled water contains 0% sucrose.

	Egg Masses			
egg/solution	0% sucrose	10% sucrose	20% sucrose	40% sucrose
start (0 min)				
15 min				
30 min				
45 min				
60 min				

4. Once you have recorded the mass of each egg, place the eggs in their appropriate solutions and set your timer for 15 minutes.
5. Based on what you know regarding osmosis, predict what you expect to happen for each egg. Will it increase its mass? Decrease in mass? Or remain about the same?

Our Team's Predictions

Egg 1: _____

Egg 2: _____

Egg 3: _____

Egg 4: _____

6. After each time interval, carefully remove the egg with a spoon, weigh it, record the mass value in the table, replace the egg in the same solution, and restart the timer.

7. Make a graph of your results on the grid provided below. The independent variable is read on the horizontal axis. The independent variable is the one for which we know the values at the beginning of the experiment. What is the independent variable for this experiment and what are its units?

What increments should you use on the axis for the independent variable?

The dependent variable is read on the vertical axis. The dependent variable changes in relation to the independent variable. What is the dependent variable for this experiment and what are its units?

— Graphs for Data Analysis —

What increments should you use on the axis for the dependent variable?

Plot the data for egg 1. At time zero, put a dot on the zero line at the point where it intersects with the line for the egg's mass. Repeat this for the remaining time points. Draw line segments connecting the data points. Repeat for the remaining three eggs, using different colored pencils or pens for each of the different eggs.

Questions

Upon completing this activity, answer the following questions.

1. Determine the type of solution used for each egg (hypotonic, hypertonic, or isotonic).

   Egg 1: _____

   Egg 2: _____

   Egg 3: _____

   Egg 4: _____

2. Compare your results to your initial predictions. Were your predictions correct? Explain what happened in each case.

Egg 1:

Egg 2:

Egg 3:

Egg 4:

3. What is osmosis? Explain it briefly.

4. Why did the masses of the eggs vary? What was physically different about the eggs at different times and in different solutions that made them have different masses?

5. Discuss with your group the factors that might affect the diffusion of water into and out of the eggs. Describe below all you identify.

6. What questions do you have about your observations? Write down your questions in the space below.

7. Take one of the questions from the previous question and rephrase it as a hypothesis. Remember that a hypothesis needs to be testable and falsifiable. Write your hypothesis in the space below.

Activity 10 Calorimetry

Today's Date _____

General Information

General Biology text reference: Chapter 4, Sections 4.1 and 4.2.

Estimated time: 50–60 minutes

Introduction

Cellular respiration is the process by which your body converts the food you eat into usable energy in the form of ATP. Quantities of energy are measured in units of joules or calories. In the case of food science, the energy content of food is usually measured in Calories. The "capital C Calorie" (on food labels) is equivalent to 1 kilocalorie, or 1000 calories. The "lowercase c calorie" is the amount of heat required to raise the temperature of one gram of water by one degree Celsius.

Different types of biomolecules have different energy contents, so far as metabolism goes. Carbohydrates generally contain 4 Cal/g (Calories per gram). These molecules feed directly into glycolysis, the citric acid cycle, and oxidative phosphorylation. Proteins and fats can also release energy through other pathways that feed into the citric acid cycle. Proteins also contribute 4 Cal/g, while fats contribute 9 Cal/g.

A device called a calorimeter can be used to measure the energy content of various foods. In this lab, you assemble your own calorimeter using an aluminum can containing a known quantity of water. Then you burn small amounts of various foods to determine the amount of energy they contain. The heat produced from burning warms the water in the aluminum-can calorimeter, resulting in a measurable temperature increase in the water. By measuring the change in water temperature, you can calculate the calorie content in the different foods.

There are several possibilities for supporting your aluminum can during the combustion of the food samples:

1. Use a ring stand and ring as a support.
2. Use a large-sized steel vegetable can with top and bottom removed, label removed, and several openings cut around the bottom for air flow. Place an aluminum pie tin under the steel can to elevate the soda can a bit for proper air circulation around the flame during food combustion.

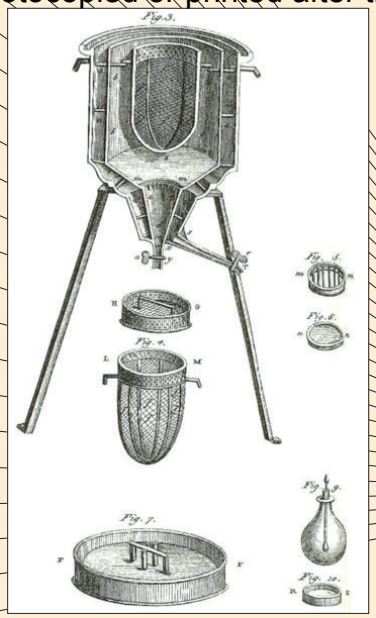
Objectives

- Measure the calorie content for foods with different carbohydrate, protein, and fat content.
- Use the principles of calorimetry to measure energy content for a biomolecule.
- Relate the law of conservation of energy to the conversion of food into other forms of energy.

Materials (per group of 4)

- safety goggles (3–4)
- aluminum soda pop can, with ring-tab attached
- glass stirring rod or wooden dowel, 1/4 in × 10 in
- ring stand with ring or large-sized steel vegetable can with aluminum pie tin
- aluminum foil
- straight pin or sewing needle
- butane safety lighter

The world's first calorimeter was constructed by French chemists Antoine Lavoisier (the "father of modern chemistry") and Pierre-Simon Laplace in the winter of 1782–1783.



- distilled water
- thermometer
- graduated cylinder, 100 mL
- puffed cheese chips (such as Cheetos or similar), with nutrition label
- small marshmallow, with nutrition label
- walnut or peanut, with nutrition label
- mass scale
- pliers
- optional: tin snips
- clothespin or small clamp
- paper towels

Questions

What is the purpose of cellular respiration?

What is the law of conservation of energy? How does this law apply to the processes of cellular respiration?

Write the overall equation for cellular respiration. Label the overall reactants and products.

Procedure

If you are part of a class, work in teams of four students for this activity.

Assemble your calorimeter as follows:

A ring stand (left) provides the simplest setup and the easiest height adjustment. Alternatively, use a large steel can and pie tin, modified to provide air circulation and to enable food to be place under the soda can.

Aluminum foil and straight pin food holder.

1. Using a 1/4-inch wooden dowel or glass stirring rod, hang the aluminum can through its tab as shown in the images above. Hang the dowel from a ring stand and ring, or by placing it across a large-sized steel vegetable can, as depicted in the images. If a large steel can is used, make sure sufficient air flow is possible by using tin snips to cut flaps in the bottom edge that can be folded out for air circulation. The photo shows an aluminum pie tin as a base, with the outer edges folded in so that the large can is sufficiently elevated and air can reach your food sample. Cut out a door or opening in the bottom part of the can in which to insert the food sample.
2. Fashion an aluminum foil food holder from a crumpled piece of foil, as shown in the image on the right, and use a pair of pliers to insert a straight pin or needle in the center. The foil food holder should enable the food to be very close to the bottom of the aluminum can, but with enough space around the flame for ventilation.
3. Measure 100 mL of distilled water and pour it carefully into the aluminum can. Do not spill any of the water—make sure it all goes into the can.
4. Insert your thermometer into the aluminum can. Use a clothespin or small clamp to suspend the thermometer so that the tip of the thermometer does not touch the bottom of the aluminum can.

— Safety Cautions —

1. Make sure the area is cleared of flammable items and that the area is well ventilated.
2. Perform this experiment under adult supervision only.
3. Always wear safety goggles while flames are present at your work area.
4. Place your calorimeter assembly on a heat-resistant surface, such as a piece of cement construction board on a lab table, or a concrete floor.
5. Use care to avoid injury from the straight pin (or needle), both when inserting the needle into the foil and when placing food samples on the pin.

— Experimental Data —

5. In the space provided above, make a data table with eight columns, labeled as follows: Food Sample, Initial Water Temperature (°C), Final Water Temperature (°C), Temperature Difference, Initial Mass of Foil + Food (g), Final Mass of Foil + Food (g), Mass of Burned Food (g), and Calories per Gram. Provide rows in the table for each of the food items you will test.
6. Place one food item (one chip, nut, or marshmallow) onto the tip of the pin or needle.
7. Weigh the aluminum foil + needle + food sample to the nearest 0.01 g and record the mass in your data table.
8. Measure the Initial Temperature of the water and record it in the table.
9. Place the food assembly near, but not under the aluminum soda can.
10. Use the butane lighter to ignite the piece of food. You may need to apply the flame for several seconds before the food ignites. Once the food is lit, quickly position it directly under the aluminum soda can containing the water.
11. As soon as the flame on the food extinguishes itself, measure the temperature of the water and record it in the table as the Final Temperature.
12. Once the flame is out and the food is cool, weigh the food/needle/foil stand assembly and record the mass in your table. Do not touch or remove the remaining charred food until after the mass has been carefully measured.
13. Dump the water and wipe the soot from the bottom of the soda can with a moist paper towel. Measure out 100 mL of fresh, room-temperature distilled water and pour it into the can. Replace the thermometer in the aluminum can as before, attaching a clothespin or clamp to the thermometer so that it does not touch the bottom of the aluminum can.
14. Repeat the previous steps for two more food items, recording the record the Initial and Final Temperatures, and Initial and Final Masses in the table.

15. Since the energy content of each food item is used to heat a quantity of water, the energy content of the food is equal to the increased thermal energy in the water after it is heated. This energy change in the water can be determined from the equation $Q = cm\Delta t$, where Q is the amount of additional thermal energy in the water (Cal), c is the specific heat capacity of water, which is 0.001 Cal/(g·°C), m is the mass of the water (g), and Δt is the temperature change (°C), which is Final Temperature – Initial Temperature. You used 100 mL of water for each food sample. Recall from Activities 4 and 5 that for water, 100.0 mL = 100.0 g. Use this information to compute the energy content (Q) in Calories (Cal) for each food item.

16. To determine the food energy content in Calories per gram, divide the number of Calories (Q) by the mass of food that is burned. Enter these values in the right-most column of your data table.

Analysis

1. For each type of food burned, use the law of conservation of energy to trace the types of energy that are present at each stage of the procedure.

2. How is burning a piece of food similar to the process of cellular respiration? How is it different?

3. Look at the nutrition labels of each of your food items. In the space below, record how many grams of carbohydrates, proteins, and fats each item contains per serving. Then look at the total overall Calories per serving and divide that by the number of grams per serving.

4. Describe how the flame burned for each food item. Was it difficult to ignite? Did it burn for a long time? What did the remaining residue look like?

5. Based on your data and observations, which food item do you think contained the most fat? Carbohydrates? Protein? Discuss your results.

6. Compare your Cal/g to the Cal/g determined from the nutrition label. Why do you think your value differs from the value on the nutrition label?

Activity 11 Enzymes

Today's Date _____

General Information

General Biology text reference: Chapter 4, Section 4.1.4; Chapter 2, Section 2.3.3; Box on p. 83

Estimated time: 20–30 minutes

Introduction

Chapter 4 introduces the topic of enzymes. *Catalase* is an enzyme that is present in nearly every organism that utilizes oxygen. Oxygen is necessary for cellular respiration, but can produce byproducts called *reactive oxygen species* that can damage the DNA of organisms. One such molecule is *hydrogen peroxide* or H_2O_2. The purpose of catalase is to convert hydrogen peroxide into less harmful molecules so that the organism's DNA is not excessively damaged.

The chemical reaction for this transformation is highly exothermic. The reaction equation is as follows:

$$H_2O_2 \xrightarrow{\text{(catalase)}} H_2O + O_2$$

Recall that enzymes are proteins that have primary, secondary, tertiary, and in some cases quaternary structure (Section 2.3.3). Review these concepts before beginning the lab.

Finally, review the "Hmm…Interesting" article on p. 83 of *General Biology*.

Objectives

- Form a hypothesis relating enzyme activity to various parameters.
- Observe enzyme activity in a biologically important chemical reaction.

Materials (per group of 3–4)

- potato, 1-cm^3 cube (5)
- beaker, 100 mL (2)
- graduated cylinder, 100 mL
- hot water, nearly boiling (>80°C) (50 mL)
- vinegar (50 mL)
- plastic knife
- small disposable cups or other small containers (5)
- sharpie marker for labeling
- hydrogen peroxide, 3%, (100 mL)
- small tongs, forceps, or plastic spoon

Questions

1. Write the definition of an enzyme.

I am and always will be a catalyst for change.
—Shirley Chisholm, first African-American woman elected to the US Congress (1968), first black candidate to run for major party nomination for US President (1972), recipient of the Presidential Medal of Freedom (2015).

2. In the space that follows, draw the reaction pathway diagram for an exothermic reaction (see Figure 4.3 in *General Biology*). Show and label the pathway of the reaction when an enzyme is present.

— Sketch —

3. How is the surface area:volume ratio important for the functioning of cells?

Procedure

If you are part of a class, work in teams of 3–4 students for this activity. Read through the procedure first, then form your hypotheses below before beginning your work.

1. Obtain five small cups and label them as follows: "control potato," "1/2-cut potato," "1/4-cut potato," "hot water potato," and "vinegar potato." Set these cups aside.
2. Obtain 50 mL of hot water (nearly boiling, or >80°C) and add it to a 100 mL beaker. Take one potato cube (1 cm^3) and place it in the 100-mL beaker of hot water to soak for 10 minutes.
3. Obtain 50 mL of vinegar and add it to a 100 mL beaker. Take another potato cube and place it in 100-mL beaker of vinegar to soak for 10 minutes.
4. Take a third potato cube and slice it in half. Set the halves aside.
5. Take a fourth potato cube, slice it in half, and then slice each half in half again. Set the potato-cube quarters aside.
6. Add 20 mL of hydrogen peroxide to each of your five labeled cups.
7. In the next step, you will add different pieces of potato to the hydrogen peroxide in each of the five cups. Before doing so, form hypotheses about what will happen in each case. Notice from the H_2O_2 reaction equation that the reaction produces oxygen gas. Thus, if the catalase enzyme is doing its job, you should see oxygen bubbles forming. In the space below, form a hypothesis for each trial. Do you expect to see oxygen bubbles, and if so, how reactive do you expect the enzyme to be compared to the control?

Cup Label	Trial	Hypothesis
control potato	1 plain potato cube	
1/2-cut potato	2 pieces of 1/2-cut potato cube	
1/4-cut potato	4 pieces of 1/4-cut potato cube	
hot water potato	1 potato cube taken from hot water soak	
vinegar potato	1 potato cube taken from vinegar soak	

8. After the soaking in steps 2 and 3 are complete, carefully place each potato piece (or pieces) into the appropriate cup of hydrogen peroxide, as indicated in the Hypothesis table above. (Do not include any hot water or vinegar as you transfer the potato pieces from the soaking beakers.) Allow the reactions to continue for at least five minutes. Record your observations in the next table.

Cup Label	Trial	Observations
control potato	1 plain potato cube	
1/2-cut potato	2 pieces of 1/2-cut potato cube	
1/4-cut potato	4 pieces of 1/4-cut potato cube	
hot water potato	1 potato cube taken from hot water soak	
vinegar potato	1 potato cube taken from vinegar soak	

9. Compare your observations to your hypotheses. Were your hypotheses supported by your observations or not?

10. Explain why you observed the results that you did. Consider the factors can affect an enzyme's tertiary structure. Consider also the surface area to volume ratio of the potato pieces.

Activity 12 Fermentation

Today's Date _____

General Information

General Biology text reference: Chapter 4, Section 4.2.3.

Estimated time: 30 minutes

Introduction

Chapter 4 of *General Biology* presents the metabolic processes of aerobic respiration and fermentation as ways in which some organisms produce energy. Before beginning this activity, review these processes, specifically fermentation in Section 4.2.3. This activity focuses on the process of fermentation in yeast. Recall that in the absence of oxygen, yeast undergo fermentation to produce some energy. In doing so, they also produce carbon dioxide as a byproduct. We can measure the output of carbon dioxide as a way of determining the relative amount of fermentation taking place.

Objectives

- Observe the process of fermentation in yeast.
- Measure carbon dioxide production due to of fermentation.

Materials (per group of 2–3)

- solutions to be prepared ahead
  - ☞ 5% sucrose (20 mL)
  - ☞ 5% starch (20 mL)
- distilled water
- yeast
- mass scale
- beaker, 100 mL (3)
- test tube rack
- thermometer
- hot plate or microwave
- timer/stopwatch
- large test tubes 18 × 150 mm or 13 × 100 mm (3)
- small test tubes 13 × 100 mm with no extended rim or 10 × 75 mm with no extended rim (3)
- rectangular plastic tub, large enough to hold the test-tube rack
- glass stirring rod
- small weigh trays (3)
- metric ruler
- sharpie or wax pencil for marking glassware

Procedure

If you are part of a class, work in teams of 2–3 students for this activity. In order to measure the carbon dioxide production by yeast, you must first learn how to set up a fermentation tube. Watch the video about making a fermentation tube, available with the Digital Resources for this book.

1. To practice the procedure with plain water, begin by putting about 20 mL of water in the 100-mL beaker.
2. Carefully pour the water into the small test tube until it reaches the very brim of the tube. Holding the small test tube in one hand, take the large test tube in your other hand and hold it upside down so that the open end is pointing downwards. Insert the small test tube into the large test tube. Using your finger, push the small test tube all the way to the bottom of the inverted large test tube and hold it in place. While holding it, quickly flip the two test tubes

— Commonplace Space —

While waiting to make measurements, try writing your own short poem about yeast!

over. The water in the small test tube should remain in place with a small bubble at the top. Practice this until you are comfortable with this procedure and can get the smallest bubble possible.

3. Obtain three, labeled 100-mL beakers with 20 mL of the following solutions: 1) distilled water, 2) 5% sucrose, 3) 5% starch.
4. Using the mass scale and three small weigh trays, measure out 0.5 g of yeast in each tray and set these to the side.
5. Label three large test tubes as 1) distilled water, 2) 5% sucrose, 3) 5% starch. Set these to the side.
6. Prepare a warm water bath by heating to 40°C a quantity of water that will fill the plastic tub about halfway. Add this to the plastic tub and place the test-tube rack in the warm water bath.
7. Take the 100-mL beaker containing 20 mL of distilled water and add 0.5 g of yeast from one of the weigh trays prepared earlier. Stir with the stirring rod. Clean the stirring rod thoroughly. Repeat this process for the sucrose and starch solutions. Carefully clean the stirring rod each time to avoid cross-contaminating the samples.
8. Obtain a small test tube and carefully fill it to the brim with the solution of yeast and distilled water. Invert the small test tube in the large test tube labeled for this solution. Using a Sharpie marker, mark a small line at the base of the air bubble. Place the fermentation tube in the test-tube rack in the warm water bath. Repeat this process for the remaining two solutions, placing all three into the water bath. Start your timer.
9. In the data area below, prepare a data table for recording the distances the small test tubes have risen in each of the three yeast solutions. Include rows for measurements every five minutes from 0 to 20 minutes. Every five minutes, carefully remove the test tubes one by one and measure the distance from your starting line to the bottom of the air bubble. (If you use the smaller set of test tubes, you may wish to measure from the starting line mark to the top of

— Experimental Data —

— Graph for Data Analysis —

the inner test tube. This will give you initial readings at 0 minutes that are other than zero.) Record the measurements in your data table and replace the tube in the water bath.

10. Make a graph of your results using the space above.

Questions

1. Which solution resulted in the most fermentation?

2. Think back to the discussion in Chapter 2 about carbohydrates. What is the molecular difference between starch and sucrose?

3. How do you think the difference between starch and sucrose affects the process of fermentation?

4. In this activity you kept the temperature of the fermentation tubes around 40°C. What do you think would happen to the rate of fermentation if the temperature was lowered to around 20°C? What if it were increased to 80°C?

5. What other factors may affect the amount of fermentation that takes place? List two.

6. Choose one of the factors listed in the previous question and formulate a hypothesis to explain how it may affect fermentation.

Extensions of This Activity

1. Design and perform an experiment to test the effect of temperature on rate of fermentation.
2. Design and perform an experiment to test the hypothesis you wrote above.

Activity 13 Extracting DNA

Today's Date _____

General Information

General Biology text reference: Chapter 5, Sections 5.1, 5.2.1, and 5.2.2.

Estimated time: 15–20 minutes

Introduction

Chapter 5 of *General Biology* addresses DNA as the genetic material of the cell and its structure. Review the information found in Sections 5.1, 5.2.1 and 5.2.2 before beginning. In this activity, you extract DNA from a strawberry using basic materials typically found around the home.

Objectives

- Isolate (extract) DNA from strawberries.
- Observe DNA in a precipitate from a solution.

Materials (per group of 3–4)

- strawberry
- knife
- Ziplock sandwich bag
- cheesecloth square, approximately 3 in × 3 in
- small funnel (optional)
- rubber band
- beaker, 50 mL
- scissors
- weigh tray (or small bowl)
- Extraction solution (prepared in advance)
  - NaCl (table salt), 2 g
  - dish soap, 1 mL
  - distilled water, 90 mL
- graduated cylinder, 100 mL
- glass stirring rod or bamboo skewer
- cold isopropyl alcohol, 91%, stored in freezer for at least 1 hr prior to experiment (approx. 35 mL)

Procedure

If you are part of a class, work in teams of 3–4 students for this activity.

1. Obtain a strawberry and cut it in half so that the green top is removed. Discard the piece with the green top into the trash. Place the other piece of the fruit into the Ziplock bag and close it, squeezing out all excess air. Use your fingers to mash up the fruit for 1–2 minutes within the bag. Be careful not to split open the bag.
2. Use the graduated cylinder to measure out 10 mL of the extraction solution. Open the Ziplock bag and pour the 10mL of solution into the bag. Close the bag, squeezing out the excess air. Mash up the fruit with the extraction solution with your fingers for another minute.
3. Set up the small beaker with cheesecloth as a "funnel" as shown in the images on the next page. Use the rubber band to hold the cheesecloth in place. You may choose to also use an actual funnel and place the cheesecloth inside it.
4. Use the scissors to cut off the lower corner of the plastic bag. Squeeze out the fruit and extract into the cheesecloth and allow the fluid to drip into the beaker. Gently remove the cheesecloth and rubber band so that no solid matter falls out, and squeeze the cheesecloth with the fruit to

allow as much fluid as possible to flow into the beaker. Discard the plastic bag, cheesecloth, and fruit pulp in the trash.

5. Measure out an amount of cold isopropyl alcohol that is roughly equal to the fluid extract in the beaker. Tilt the beaker slightly and *slowly* pour the cold isopropyl alcohol down the side of the beaker. Pour slowly so that the alcohol layer does not mix with the fruit layer. Once complete, you should see a colored bottom layer and a transparent top layer.
6. Observe the interface or boundary between the two layers. This is where the DNA will begin to collect. Write your observations in the space provided below. What do you see happening?

7. Dip a glass stirring rod or bamboo skewer into the beaker where the alcohol and fruit extract meet. Slowly turn the glass rod or skewer to spool out the precipitated DNA. Pull out the DNA and place it in a weigh tray or small bowl for observation.
8. Upon completing this activity, respond to the following questions.

Questions

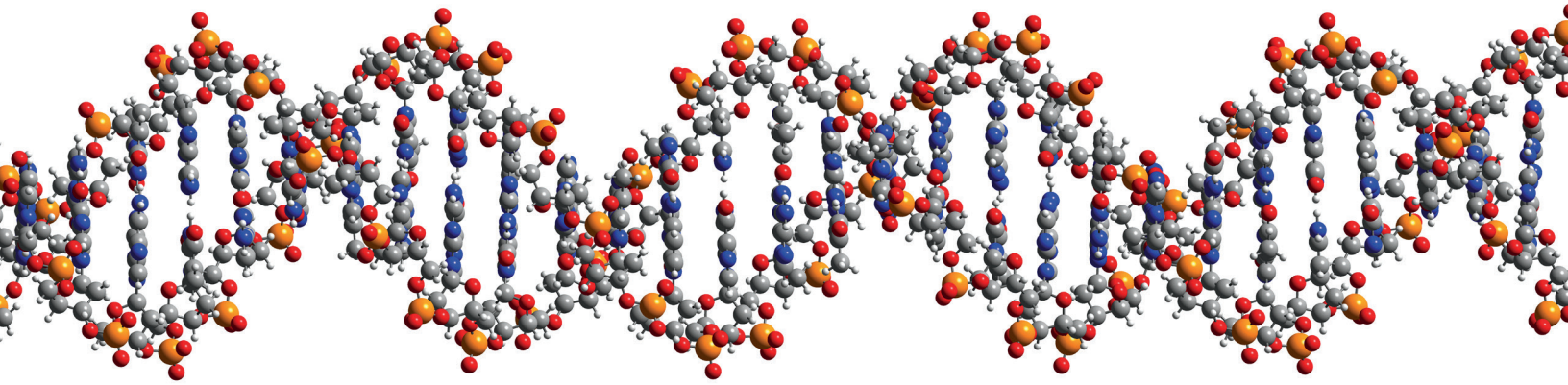
1. What does the DNA look like? What does it feel like?

2. Did you find it easy to extract the DNA? Make note of your thoughts about this DNA extraction process.

Extension

3. Describe the chemical properties of dish soap and salt water. Based on your response, what do you think happened to the strawberry pulp on a cellular level when this solution was added to it?

4. Isopropyl alcohol contains a hydrophobic end and a somewhat polar end. Based on what you know of the structure of DNA, why do you think the DNA becomes visible in the isopropyl alcohol layer? Why do you think that the isopropyl alcohol has to be cold?



It seemed almost unbelievable that the DNA structure was solved, that the answer was incredibly exciting, and that our names would be associated with the double helix as Pauling's was with the alpha helix. ...The following morning I felt marvelously alive when I awoke.

—James Watson, *The Double Helix*

— Commonplace Space —