Biology with a Microscope

Lab Manual

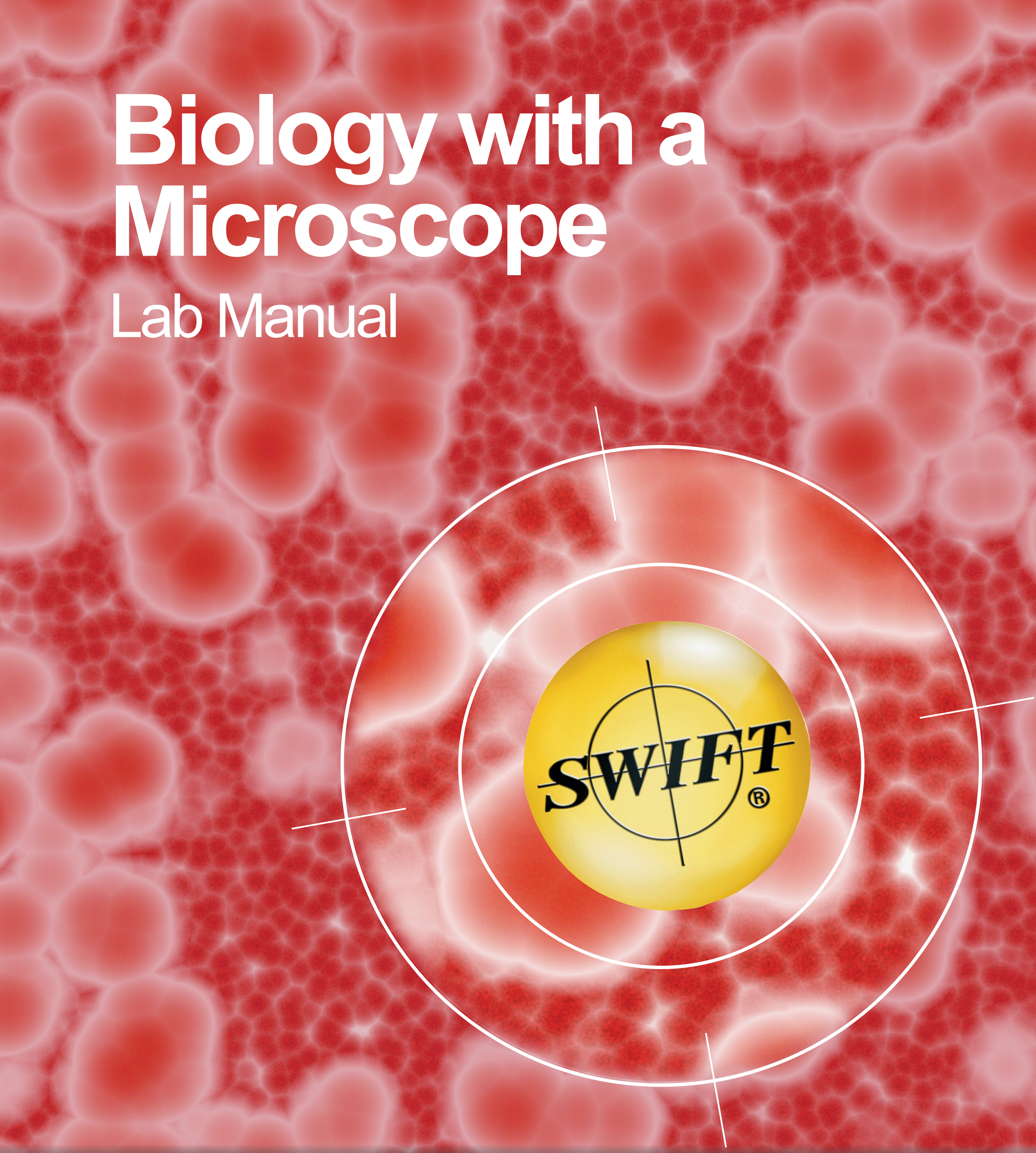

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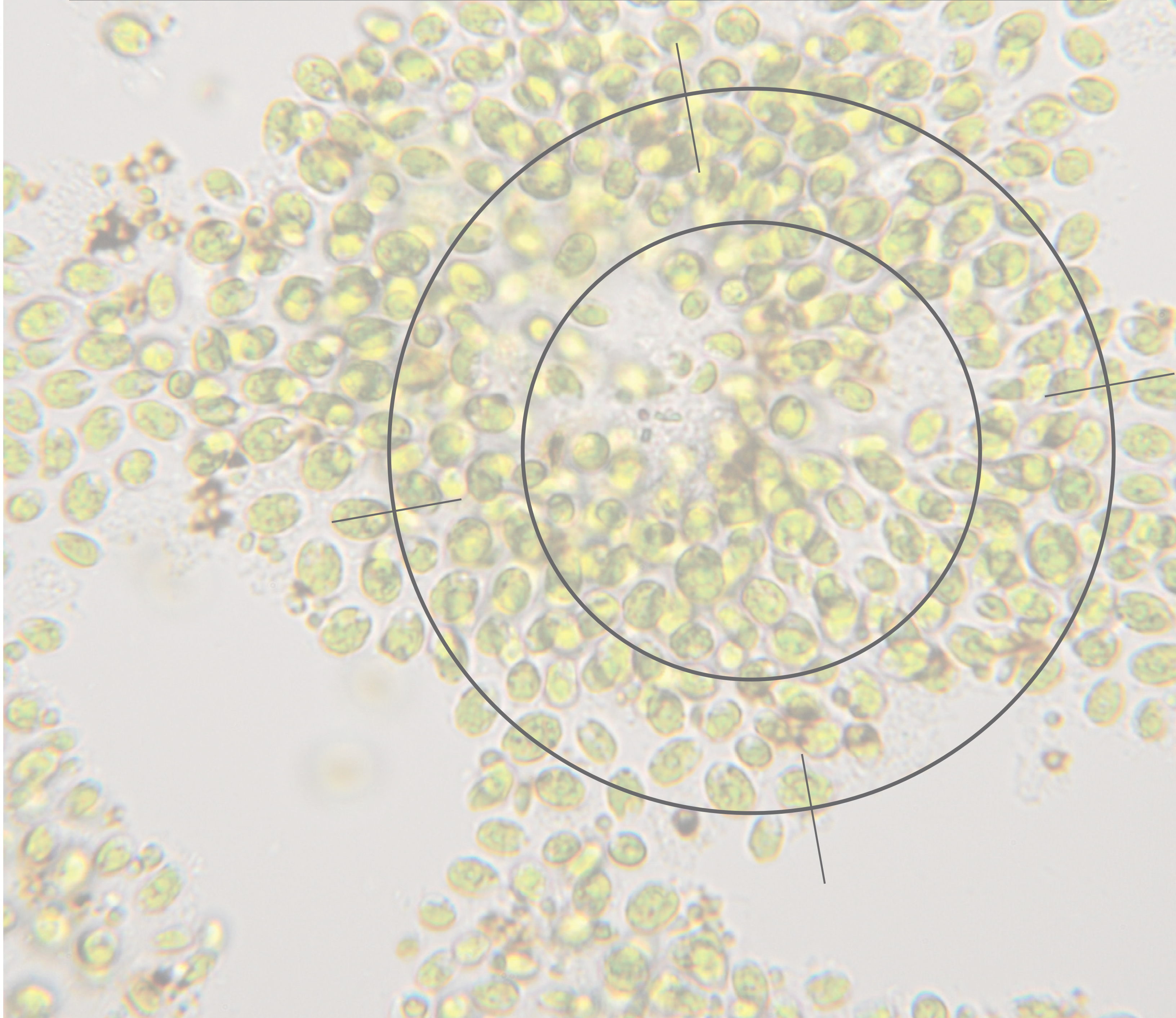
Table of Contents

This *Swift* Digital Microscope lab manual is geared towards high school (grade 9-12) biology courses; it is adaptable to other grade levels. The activities, divided into four, theme-based units, are designed to be done in order; however, they can be done individually with appropriate preparation.

The manual concludes with tables that match the activities with national and key-state biology/life science standards and with four high school biology textbooks.

Getting Started

This guide, which is geared toward high school biology, contains a series of activities on various aspects of biology under the microscope. In Getting Started, there are several preliminary activities that set the stage for the later units.



Activity 0:
Calibrating Your Microscope

Swift Digital Microscope—
Swift M10L Series

Before you begin any of the activities in this guide, you need to first set up and learn to use your microscopes. (Information on how to do this is provided along with your microscopes.) You also need to calibrate your microscopes and the SwiftCam Imaging system.

Calibrate with Calibration Circle

1. To calibrate with a calibration circle, select the Calibration Wizard command, under “Measure,” to display the Calibration Wizard window. Click on the “Calibrate with Calibration Circle” tab to display the corresponding panel. Click “Load Image” to display the Open Image files dialog box from which calibration circles may be selected for calibration. Click “Open” to load the selected image.
2. Confirm the objective lens used to capture the selected image, then input the diameter of the calibration circle. Click “Calibration” to complete the calibration process. (Note: Use the appropriate calibration circle slide and magnification suited to your microscope.)
3. The Save Sign dialog box will display after you’ve clicked “Calibration.” Click “Save” in the dialog box to save the calibration results and use them for measuring.
4. When calibration is complete, click “Close” to close the Calibration Wizard window.

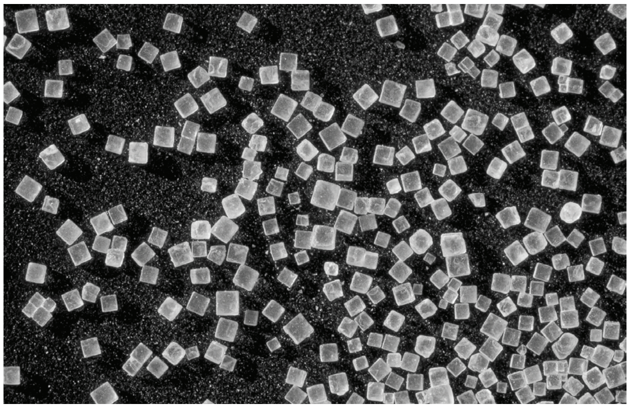
Calibrate with Scale Cross

1. To calibrate with a scale cross, select the Calibration Wizard command, under “Measure,” to display the Calibration Wizard window. Select the “Calibrate with Scale Cross” tab to display the corresponding panel. Click on “Load Image” to display the Open Image files dialog box from which scale crosses may be selected for calibration. Click “Open” to load the selected images.
2. When an image is loaded, a circle will appear on it. (You can modify its color by clicking on the Circle Color button to display the Color Palette.) Place the center of the circle (set as “O”) in the middle of the scale cross. Next, place a point (set as “A”) that is horizontal with the center of the circle on the horizontal line, and place a point (set as “B”) that is vertical with the center of the circle on the vertical line. The magnifier window under the image window will help you accurately place the points.
3. Confirm the objective lens used to capture the selected image and then input the actual length of “OA” in the “Width” bar and the actual length of “OB” in the “Height” bar. Click “Calibration” to complete the calibration process.
4. The Save Sign dialog box will display after you’ve clicked “Calibration.” Click “Save” in the dialog box to save the calibration results and use them for measuring.
5. When calibration is complete, click “Close” to close the Calibration Wizard window.

Calibrate with Scale Line

1. To calibrate with a scale line, select the Calibration Wizard command, under “Measure,” to display the Calibration Wizard window. Select the “Calibrate with Scale Line” tab to display the corresponding panel. Select the Horizontal tab to load horizontal scale lines. Click on “Load Image” to display the Open Image files dialog box from which horizontal lines may be selected for calibration. Click “Open” to load the selected images.

   Select the Vertical tab to load vertical scale lines. Click on “Load Image” to display the Open Image files dialog box from which vertical lines may be selected for calibration. Click “Open” to load the selected images.
2. When an image is loaded, a line will appear on it. (You can modify its color by clicking on the Line Color button to display the Color Palette.) Drag the two ends of the line (set as “A” on the horizontal line and as “B” on the vertical line) to two different scales. The magnifier window under the image window will help you accurately place the points.
3. Confirm the objective lens used to capture the selected image and then input the actual length of “A” in the “Width” bar and the actual length of “B” in the “Height” bar. Click “Calibration” to complete the calibration process.
4. The Save Sign dialog box will display after you’ve clicked “Calibration.” Click “Save” in the dialog box to save the calibration results and use them for measuring.
5. When calibration is complete, click “Close” to close the Calibration Wizard window.


Salt Crystals

Activity 1: Understanding Magnification and Scale

Understanding magnification and scale is vital to the use of a microscope and the analysis of what is observed. In this activity, you will explore magnification and scale using the digital capabilities of the Swift *Digital Microscope and by building models. You will refer back to this activity and build upon it in subsequent activities.*

Safety Note:

Remember to practice proper safety techniques in all science laboratory activities and to teach your students how to conduct themselves responsibly in the lab or classroom. *Swift* Optical Instruments, Inc. supports proper safety techniques and practices. We hope these activities and proper adherence to safety guidelines give you and your students the opportunity to teach, learn, and practice responsibility in the science lab.

Purpose:

To explore scale and magnification for the purpose of preparing for the following activities, and to understand that things viewed under a microscope might look two-dimensional but do actually have depth. This will lay the groundwork for later activities

Overview:

Students observe and measure salt crystals at various magnifications and as viewed at different scales, including with the naked eye, through the various lenses of the microscope, on the microscope's mini-digital screen, on a computer screen, and projected in front of the class. They consider physical models of salt crystals at various scales. They consider how the field of view decreases with an increase in magnification.

Time:

One (50 minute) session—Note: If students are new to the use of the *Swift* Digital Microscope, this activity may take longer.

Materials:

- *Swift* Digital Microscopes
- Computers
- Transparent ruler (with microns)
- Table salt
- Clay
- Microscope slides and cover slips
- Projector (for one computer)
- Meter stick or ruler
- Dark paper

Background:

The eyepiece (including for the camera) on the *Swift* Digital Microscope magnifies objects 10 times. Each lens then further magnifies the objects: 4X (or 4 times magnification), 10X, and 40X, as marked on the lens used. These magnification numbers combine to give the actual magnification of the object. For example, using the eyepiece plus the 4X lens, the magnification is 10 x 4 or 40 times or 40X. Any object viewed this way will appear 40 times its actual size.

Eyepiece Magnification	10X	10X	10X	10X
Lens Magnification	4X	10X	40X	100X
Total Magnification	**40X**	**100X**	**400X**	**1000X**

Also, as the magnification increases, the field of view, or total area that can be seen, decreases. At 40X, the field of view is a circle about 4.5 mm in diameter. The change in the field of view is inversely proportional to the magnification increase. It's like zooming in: the closer you go, the less area you see.

4.5 mm x 40 / ___ = ___

For example, the field of view at 100X is:

4.5 mm x 40 / 100 = 1.8 mm

Total Magnification	40X	100X	400X	1000X
Field of View	4.5 mm	1.8 mm	0.45 mm	0.18 mm

Notes:

In this activity, students make physical models of the salt crystals at the various magnifications. Table salt is approximately 0.3 millimeters on each side, so a 40X salt crystal model would be about 0.3 x 40, or 1.2 cm in each dimension.

Actual	40X model	100X model	400X model	1000X model
0.3 mm	1.2 cm	3 cm	12 cm	30 cm*

Under a microscope, things typically look only two dimensional, but it is important for your students to understand that—just like the salt crystals look like squares, while they are actually cubes—other items viewed under a microscope are also (typically) three dimensional.

* Making an actual clay model of this is obviously not practical. Even for the 400X model, you might want to simply have a few examples available for your class.

Preparation:

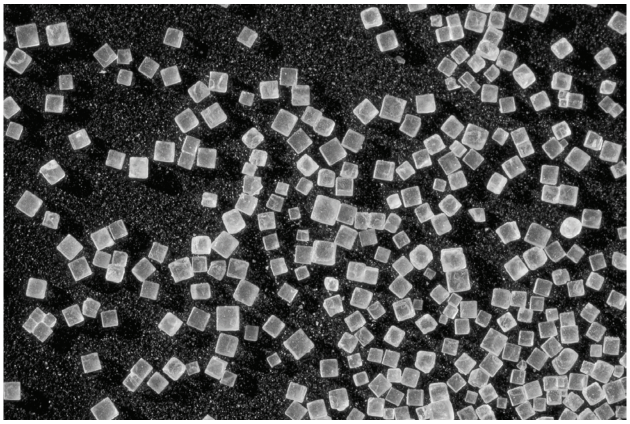
Gather the necessary materials, set up the microscopes and computers, and prepare one computer to project in front of the class. NOTE: *These general preparation instructions will not be included in future activities, as they are appropriate for all the activities in this guide.*

Procedure:

1. Have students work in pairs or small teams to complete the activity.
2. Toward the end of the activity, when the class is ready, project a view of salt crystals at 40X magnification and have students measure the size of the image.
3. Lead a discussion on the size of the salt crystal, the magnification of the crystal, and the size of the image.
   - The 4X objective results in a 40X magnification; the 10X objective a 100X magnification, and the 40X a 400X magnification.
   - The salt crystals are 3-dimensional, despite how they appear under the microscope.
   - The scale at which an image is viewed (mini-screen, computer screen, projector) doesn't change the magnification of the microscope.

Assessment:

Have your students prepare a summary of the various magnifications and their implications. What is the magnification using each lens of the *Swift* Digital Microscope? What is the field of view at each magnification? What is gained by going to a higher magnification? What is lost? How does magnification relate to image size?


Salt Crystals

Student Sheet

Activity 1: Understanding Magnification and Scale

Understanding magnification and scale is vital to the use of a microscope and the analysis of what is observed. In this activity, you will explore magnification and scale using the digital capabilities of the Swift *Digital Microscope and by building models. You will refer back to this activity and build upon it in subsequent activities.*

1. Examine crystals of table salt using your naked eye. (Try pouring a small amount of salt onto a dark piece of paper.)
   - Describe a salt crystal.
   - Draw a picture of a salt crystal.
   - Measure the size of a salt crystal, in millimeters, as best you can and record this information.
2. Place a number of salt crystals on a microscope slide.
3. Working with a partner, examine the salt at 40X magnification (i.e., the 4X lens) using the eyepieces on the microscope. Do NOT use the mini-digital screen or computer screen.
   - Describe a salt crystal as viewed under the microscope at 40X. Focus on what details you can see at this magnification that you could not see before.
   - Draw a picture of a salt crystal as viewed at this magnification.
   - Draw a picture of the entire field of view of the microscope at this magnification. The field of view is the entire circle, or area, that can be seen.)
   - Measure the size of a salt crystal, in microns, using a transparent ruler, and record this information.

     A micron, or micrometer (symbol μm), is one millionth of a meter or one thousandth of a millimeter: 1000 microns = 1 millimeter.
   - Measure the diameter of the field of view, in millimeters or microns, and record this information.
4. Make a physical model of a 40X magnification salt crystal.
   - Calculate the dimensions of a model crystal that is 40X the size of an actual crystal.
   - Use clay and a ruler to make a 3-dimensional model of the appropriate size.
5. Repeat the observations and model-making for 100X (i.e., the 10X lens) and 400X (i.e., the 40X lens).
   - Notice and record additional details about the crystals as the magnification increases.

! REMEMBER to practice proper safety techniques in all science laboratory activities!

6. Repeat the observations for 1000X (i.e., the 100X, oil immersion lens).
   - Why are you not asked to make a physical model of a 1000X magnification salt crystal?

7. Compare your drawings and the physical models at each magnification.
   - Compare the level of detail visible at each magnification.
   - Compare an actual salt crystal to your clay models. Think about how much they increase in size and what this means about what can be viewed at each magnification.
   - Compare the fields of view. Think about how much they decrease in size and what this means about what can be viewed at each magnification.
   - In later activities, keep in mind that what you are viewing under the microscope is almost always 3-dimensional, just like the salt crystals.

8. Calculate the field of view when using each lens.
   - At 40X, the field of view of the *Swift* Digital Microscope is approximately 4.5 mm.
   - The field of view is inversely proportional to the increase in magnification:

     4.5 mm x 40 / ___ = ___

     For example, the field of view at 100X is 4.5 mm x 40 / 100 = 1.8 mm.
   - Compare these calculated values to your measured diameters of the field of view. *How closely do they match?*

9. Return to 40X magnification and examine the salt crystals again, this time using the mini-digital screen that is on top of the *Swift* Digital Microscope.
   - Using the transparent ruler, again measure the size of the salt crystal. (This is the same measurement you made earlier.)
   - Compare the level of detail you can see this way to what you see using the eyepieces. This view is comparable to looking through the eyepieces, in terms of the magnification and the level of detail you can see (though sometimes the digital view isn't quite as crisp).
   - Take the transparent ruler, hold it in front of the mini-digital screen, and measure the size of the salt crystal image. *How does the size of the salt crystal on the mini-screen compare to the size of a salt crystal? Is it 40X as large?*

10. Examine and measure the salt crystals on your computer screen.
    - Using the software's measurement tool, again measure the size of the salt crystal. You are using a different tool, but the measurement is the same one you've made several times now.
    - Take the transparent ruler, hold it in front of the computer screen, and measure the size of the salt crystal image. *How does the size of the salt crystal on the computer screen compare to the size of a salt crystal? Is it 40X as large? How does it compare to the size of the image on the mini-screen?* Image size is distinct from level of magnification.

- Under Tools, access the Magnifier option.
- Observe your image of the salt crystals at 2X, 4X, 8X, and 16X magnification using this tool. Note: Despite the term used by the software, you haven't changed the microscope's level of magnification, just the size of the image. The image is larger, but you aren't getting additional details.

11. Examine and measure the salt crystals that are projected in front of the class, and discuss what you see in terms of the size of the crystal, the magnification of the crystal, and the size of the image.
    - Take a ruler or meter stick, hold it in front of the projection screen (trying to stay out of the way as much as possible), and measure the size of the salt crystal image. *How does the size of the salt crystal on the screen compare to the size of a salt crystal? To the sizes of the salt crystal as viewed on the other screens?* Again, image size is distinct from level of magnification. If you want to see additional details, you need to go to a higher level of magnification.

Pond

Activity 2: Exploring Microscopic Pond Life

Before beginning focused explorations on various aspects of microscopic biology, it is useful and interesting to simply experience some of the abundance and diversity of life within the microscopic world. In this activity, you will consider the diversity of life found in pond water by searching for specific organisms and by identifying other organisms. You will refer back to this activity and build upon it in subsequent activities.

Purpose:

To become familiar with some the diversity of microscopic life found in pond water, such that you have a "touchstone" for later investigations

Overview:

The teacher presents an image of a microscopic organism, projecting it in front of the class, and challenges students to use hardcopy and/or online resources to (1) identify the organism and (2) look for the organism in their own sample of pond water. Students then locate other organisms within their pond water, photograph and/or take brief movies of the organisms, identify them if possible, and present their own challenges—e.g., identify and look for this—to other student in the class.

Time:

One to two (50 minute) sessions

Materials:

- *Swift* Digital Microscopes
- Microscope slides and cover slips
- Computer(s)
- Projector (for one computer)
- Pond water (and means of collecting, such as a turkey baster and jars; see *Preparation*)
- Toothpick (optional)
- Pipettes or eyedroppers
- Textbooks and other resources
- 3% Methyl cellulose solution (optional; see Activity 10)

Textbook Matching:

A summary of the textbook alignments is provided at the end of this guide.

BSCS Biology: An Ecological Approach

- *Chapter 23: Aquatic Ecosystems; 23.1 — Ponds Are Shallow Enough for Rooted Plants*
- *Appendix Four: A Catalog of Living Things*

Glencoe Science Biology (National Geographic)

- *Chapter 3: Communities, Biomes, and Ecosystems; Section 3.3 — Aquatic Ecosystems: Freshwater Ecosystems*
- *Reference Handbook (Six-Kingdom Classification)*

McDougal Littell Biology (Stephen Nowicki)

- *Chapter 15: The Biosphere; 15.5 — Estuaries and Freshwater Ecosystems*
- *Appendix A: Classification*

Prentice Hall Biology (Miller and Levine)

- *Chapter 4: Ecosystems and Communities: 4-4 — Aquatic Ecosystems*
- *Appendix E: Classification*

Notes:

- Microscope slides dry out. And, exposed to the microscope light source, they dry out faster and heat up. The light source on the *Swift* Digital Microscope is an LED, or Light-Emitting Diode. It is very bright, at 3 watts, but also relatively cool; this minimizes, but does not eliminate, the drying and heating problems. Thus, whenever organisms are studied, it is important to prepare slides shortly before they are examined and not leave the slides on the microscope for too long.
- When students challenge each other, you can have them swap slides; this ensures that the searchers do actually have the organisms they are searching for, though it also precludes any learning related to how common the organisms might be.

Preparation:

1. Collect samples of water from a pond or other body of water. Look for water that appears greenish or contains dead and decaying vegetation. Also, as possible, collect samples from different locations and/or depths within the body of water, as different organisms will live in different places. For example, *Amoeba* are more likely to be found near the bottom of a pond. If you are unable to obtain pond water for any reason, appropriate samples can be cultured or ordered. (Note: Pond water will be used again in later activities; it can be kept, with proper storage and care, or you can gather new samples.)
2. Prepare a slide of pond water. Using the microscope, find several organisms that you are able to identify, and collect images and/or movies of them. Do this for your various samples. You will be challenging your students to identify these organisms for themselves and to look for them on their own slides, so select and label accordingly.
3. Locate hardcopy and/or electronic references with information on the microscopic life found in pond water. An example is the “Pond Life Identification Kit “ Web site from Microscopy-UK.

Procedure:

1. Have students work in pairs or small teams to prepare and label slides from each sample of pond water you collected.
2. Project an image or movie of an organism in front of the class, have the class briefly discuss what they'd look for in order to identify this organism, and then challenge your students to (a) try to locate one like it in their slides and (b) try to identify it using the available resources.
   - When pairs or teams think they've located and/or identified one of the organisms, check their find to see if you can confirm this.
3. Challenge your students with 1 to 3 other organisms.
4. Have students complete the activity.

Extension:

Have your students count how many of each identified species they have on a slide or within the field of view. They can consider the diversity of life in the pond water and how populations differ at different locations.

Assessment:

Have students submit an image, details on the organism in the image, an explanation of how the organism was identified, and any other information that seems pertinent for several identified organisms.

Pond

Student Sheet
Activity 2: Exploring Microscopic Pond Life

Before beginning focused explorations on various aspects of microscopic biology, it is useful and interesting to simply experience some of the abundance and diversity of life within the microscopic world. In this activity, you will consider the diversity of life found in pond water by searching for specific organisms and by identifying other organisms. You will refer back to this activity and build upon it in subsequent activities.

1. Prepare a slide of pond water.
   - Optional: Using a toothpick, put a small ring of methyl cellulose solution on a slide. (Note that methyl cellulose solution is very viscous.)
   - Using a pipette or eyedropper, place one drop of pond water on the slide (in the ring).
   - Add a cover slip.
   - Label the slide with information about its source.

2. An image or movie of an organism will be projected in front of the class. Working with a partner, (a) try to locate one like it on your slide and (b) try to identify it using the available resources.
   a. Search your slide for the projected organism, using the microscope's eyepieces and mini-digital screen (and/or the computer screen). *NOTE: Your slide may or may not have this organism.*
      - Whenever you find an organism that you think might be the one projected, discuss it with your partner, compare it to the projected organism, and take an image or short movie to document your find. Alert your teacher to have your find confirmed.
      - Along the way, if you see any other organisms of interest, take images and/or movies of them for use later in this activity. Include information on the sample in and the magnification at which you found the organisms.

   b. Search the available resources for the identity of the projected organism. Consider such factors as structure (internal and external), size, color, motion, etc.
      - When you and your partner think you have identified the organism, record details about that organism and how you identified it. Alert your teacher to have your identification confirmed.

3. Repeat this for other organisms projected in front of the class and for other slides made from various water samples.

! REMEMBER to practice proper safety techniques in all science laboratory activities!

4. Prepare your own “Find and/or Identify the Organism I Am Showing You” images and/or movies.
   - Start with any organisms you photographed or took movies of earlier in this activity. Use the resources to try to identify them.
   - Search for, photograph and/or make a movie of, and try to identify other organisms that are common in your samples or that you find particularly interesting.
   - Select three organism images and/or movies to use for challenging other students. This can include organisms that you have not (yet) managed to identify, as long as you share this fact.
5. Present your challenge organisms to other students, and work on their challenge organisms in turn.

Standards Matching

This section presents biology/life science standards from the National Science Education Standards (NRC) and the standards of several key states—California, Florida, New York, and Texas—that are addressed within the activities of this guide. Some of these standards are thoroughly covered, while others are only partially covered. Standards simply touched upon are not included.

Also, the activities in this guide are laboratory experiences. This means that they address many of the Science as Inquiry and Science Process standards, as well, though these are not listed here.

National Science Education Standards

National Research Council (1996). *National Science Education Standards*. Washington, DC: National Academy Press. Science Content Standards, Grades 9-12: Life Science (Content Standard C).

THE CELL	
1. Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization ***Structure and Function—From Functions to Structures*** Activity 10: *Paramecium* on the Move—Cilia Activity 11: Digestion in Protists ***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis Activity 15: *Amoeba* and Salt Water Activity 17: Immediate Reactions to Light—Chloroplasts
2. Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.	***Structure and Function—From Functions to Structures*** Activity 11: Digestion in Protists Activity 12: *Hydra* Eating
4. Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.	***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis Activity 15: *Amoeba* and Salt Water Activity 17: Immediate Reactions to Light—Chloroplasts Activity 18: Immediate Reactions to Light—*Amoeba*

5. Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.	***Structure and Function—Comparing and Contrasting Cells*** Activity 5: Plants—*Elodea* Leaf Cells ***Behavior—Responses to Environmental Conditions*** Activity 17: Immediate Reactions to Light—Chloroplasts
6. Cells can differentiate, and complex multi-cellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multi-cellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.	***Structure and Function—Comparing and Contrasting Cells*** Activity 7: Cell Specialization
BIOLOGICAL EVOLUTION	
5. Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization
THE BEHAVIOR OF ORGANISMS	
1. Multi-cellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.	***Behavior—Responses to Environmental Conditions*** Activity 15: *Amoeba* and Salt Water Activity 16: *Daphnia* Heart Rate and Temperature Activity 18: Immediate Reactions to Light—*Amoeba* Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations
2. Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.	***Structure and Function—From Functions to Structures*** Activity 12: *Hydra* Eating ***Behavior—Responses to Environmental Conditions*** Activity 15: *Amoeba* and Salt Water Activity 16: *Daphnia* Heart Rate and Temperature Activity 17: Immediate Reactions to Light—Chloroplasts Activity 18: Immediate Reactions to Light—*Amoeba* Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations

California: State Standards

Science Content Standards for California Public Schools, Kindergarten through Grade Twelve (2003). California Department of Education. Grades Nine Through Twelve—Biology/Life Sciences.

Cell Biology	
1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept: a. Students know cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 5: Plants—*Elodea* Leaf Cells ***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis
c. Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization
f. Students know usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.	***Structure and Function—Comparing and Contrasting Cells*** Activity 5: Plants—*Elodea* Leaf Cells ***Behavior—Responses to Environmental Conditions*** Activity 17: Immediate Reactions to Light—Chloroplasts
j.* Students know how eukaryotic cells are given shape and internal organization by a cytoskeleton or cell wall or both.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells
Ecology	
6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept: a. Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.	***Behavior—Responses to Environmental Conditions*** Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations

Florida: State Standards

Sunshine State Standards: Science (2008). Florida's Student Performance Science Standards, State Board of Education. 9-12 Science Standards: Bodies of Knowledge, Life Science.

Standard 14: Organization and Development of Living Organisms A. Cells have characteristic structures and functions that make them distinctive. B. Processes in a cell can be classified broadly as growth, maintenance, reproduction, and homeostasis. C. Life can be organized in a functional and structural hierarchy ranging from cells to the biosphere. D. Most multi-cellular organisms are composed of organ systems whose structures reflect their particular function.	
SC.912.L.14.2 — Relate structure to function for the components of plant and animal cells. Explain the role of cell membranes as a highly selective barrier (passive and active transport).	***Structure and Function—Comparing and Contrasting Cells*** Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization ***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis
SC.912.L.14.3 — Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization
SC.912.L.14.9 — Relate the major structure of fungi to their functions.	***Structure and Function—Comparing and Contrasting Cells*** Activity 4: Protista and Fungi
Standard 15: Diversity and Evolution of Living Organisms	
SC.912.L.15.6 — Discuss distinguishing characteristics of the domains and kingdoms of living organisms.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization
Standard 16: Heredity and Reproduction	
SC.912.L.16.14 — Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.	***Structure and Function—From Functions to Structures*** Activity 13: Mitosis

Standard 17: Interdependence	
SC.912.L.17.1 — Discuss the characteristics of populations, such as number of individuals, age structure, density, and pattern of distribution.	***Behavior—Responses to Environmental Conditions*** Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations
SC.912.L.17.2 — Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.	***Behavior—Responses to Environmental Conditions*** Activity 15: *Amoeba* and Salt Water Activity 16: *Daphnia* Heart Rate and Temperature Activity 18: Immediate Reactions to Light—*Amoeba* Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations
SC.912.L.17.6 — Compare and contrast the relationships among organisms, including predation, parasitism, competition, commensalism, and mutualism.	***Structure and Function—From Functions to Structures*** Activity 12: *Hydra* Eating
Standard 18: Matter and Energy Transformations	
SC.912.L.18.3 — Describe the structures of fatty acids, triglycerides, phospholipids, and steroids. Explain the functions of lipids in living organisms. Identify some reactions that fatty acids undergo. Relate the structure and function of cell membranes.	***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis Activity 15: *Amoeba* and Salt Water

New York: State Standards

Learning Standards for Mathematics, Science, and Technology (1996). Albany, NY: The State Education Department. Standard 4—Science, Commencement: The Living Environment.

1. Living things are both similar to and different from each other and nonliving things. Students: • explain how a one-celled organism is able to function despite lacking the levels of organization present in more complex organisms.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization ***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis
2. Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring. Students: • explain how the structure and replication of genetic material result in offspring that resemble their parents.	***Structure and Function—From Functions to Structures*** Activity 13: Mitosis
4. The continuity of life is sustained through reproduction and development. Students: • explain how organisms, including humans, reproduce their own kind.	***Structure and Function—From Functions to Structures*** Activity 13: Mitosis
6. Plants and animals depend on each other and their physical environment. Students: • explain factors that limit growth of individuals and populations.	***Behavior—Responses to Environmental Conditions*** Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations
• explain how the living and nonliving environments change over time and respond to disturbances.	***Behavior—Responses to Environmental Conditions*** Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations

Texas: State Standards

Texas Essential Knowledge and Skills (1997). Texas Education Agency, Texas Administrative Code (TAC), Title 19, Part II. Chapter 112. Texas Essential Knowledge and Skills for Science: Subchapter C. High School, Biology.

(4) Science concepts. The student knows that cells are the basic structures of all living things and have specialized parts that perform specific functions, and that viruses are different from cells and have different properties and functions. The student is expected to: (A) identify the parts of prokaryotic and eukaryotic cells;	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells
(B) investigate and identify cellular processes including homeostasis, permeability, energy production, transportation of molecules, disposal of wastes, function of cellular parts, and synthesis of new molecules;	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization ***Structure and Function—From Functions to Structures*** Activity 10: *Paramecium* on the Move—Cilia Activity 11: Digestion in Protists ***Behavior—Responses to Environmental Conditions*** Activity 14: Changes in Salinity—Osmosis Activity 17: Immediate Reactions to Light—Chloroplasts
(5) Science concepts. The student knows how an organism grows and how specialized cells, tissues, and organs develop. The student is expected to: (A) compare cells from different parts of plants and animals including roots, stems, leaves, epithelia, muscles, and bones to show specialization of structure and function;	***Structure and Function—Comparing and Contrasting Cells*** Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization
(6) Science concepts. The student knows the structures and functions of nucleic acids in the mechanisms of genetics. The student is expected to: (E) compare the processes of mitosis and meiosis and their significance to sexual and asexual reproduction	***Structure and Function—From Functions to Structures*** Activity 13: Mitosis
(8) Science concepts. The student knows applications of taxonomy and can identify its limitations. The student is expected to: (C) identify characteristics of kingdoms including monerans, protists, fungi, plants, and animals.	***Structure and Function—Comparing and Contrasting Cells*** Activity 3: Prokaryotic and Eukaryotic Cells Activity 4: Protista and Fungi Activity 5: Plants—*Elodea* Leaf Cells Activity 6: Animals—Human Cheek Cells Activity 7: Cell Specialization

(10) Science concepts. The student knows that, at all levels of nature, living systems are found within other living systems, each with its own boundary and limits. The student is expected to: (A) interpret the functions of systems in organisms including circulatory, digestive, nervous, endocrine, reproductive, integumentary, skeletal, respiratory, muscular, excretory, and immune;	***Structure and Function—From Functions to Structures*** Activity 9: Methods of Locomotion in Pond Water Activity 10: *Paramecium* on the Move—Cilia Activity 11: Digestion in Protists Activity 12: *Hydra* Eating Activity 13: Mitosis
(11) Science concepts. The student knows that organisms maintain homeostasis. The student is expected to: (B) investigate and identify how organisms, including humans, respond to external stimuli;	***Behavior—Responses to Environmental Conditions*** Activity 15: *Amoeba* and Salt Water Activity 16: *Daphnia* Heart Rate and Temperature Activity 18: Immediate Reactions to Light—*Amoeba* Activity 19: Reactions to Light—Pond Protozoans Activity 20: Long-Term Reactions to Light—Populations
(12) Science concepts. The student knows that interdependence and interactions occur within an ecosystem. The student is expected to: (B) interpret interactions among organisms exhibiting predation, parasitism, commensalism, and mutualism;	***Structure and Function—From Functions to Structures*** Activity 12: *Hydra* Eating

Textbook Matching

This section aligns the activities in this guide with four high school biology textbooks: BSCS Biology: An Ecological Approach, Glencoe Science Biology (National Geographic), McDougal Littell Biology (Stephen Nowicki), and Prentice Hall Biology (Miller and Levine). The activities address or otherwise relate to ideas and concepts presented in the referenced chapters and sections.

BSCS Biology: An Ecological Approach

BSCS Biology: An Ecological Approach (2006). Tenth Edition, BSCS Green Version. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Chapter 2: Populations; 2.1 — Populations Are Made Up of Individuals, 2.4 — Abiotic and Biotic Factors Work Together to Influence Population Size	Activity 19 Activity 20
Chapter 3: Communities and Ecosystems; 3.4 Organisms May Benefit or Harm One Another	Activity 12
Chapter 4: Matter and Energy in the Web of Life; 4.5 — The Sun and Photosynthesis: How We Get Energy	Activity 5
Chapter 5: The Cell; 5.2 — Biologists Use Microscopes to Study Cells, 5.3 — Cells Are of Two Basic Types, 5.4 — Membranes Organize Eukaryotic Cells, 5.5 — Eukaryotic Cells Contain Various Organelles, 5.6 — Cell Activities Require Energy, 5.7 — Substances Enter and Leave Cells by Diffusion, 5.8 — Cells Move Substances in a Variety of Ways, 5.9 — The Cell's Life Is a Cycle. 5.10 — Mitosis Is a Continuous Process, 5.11 — Cells Become Specialized during Development	Activity 3 Activity 4 Activity 5 Activity 6 Activity 7 Activity 13 Activity 14 Activity 15 Activity 17
Chapter 6: Continuity Through Reproduction; 6.1 — Reproduction Is Essential for the Continuity of Life, 6.2 — Reproduction May Be Sexual or Asexual	Activity 13
Chapter 7: Continuity Through Development; 7.1 — A Zygote Gives Rise to Many Cells, 7.2 — Cell Differentiation Is a Major Part of Development	Activity 7 Activity 13
Chapter 9: Evolution: Patterns and Diversity; 9.1 — Living Organisms Are Both Similar and Varied	Activity 7
Chapter 10: Ordering Life in the Biosphere; 10.5 — Cell Structure Is Evidence for Relatedness, 10.6 — Organisms Are Grouped into Five Kingdoms, 10.7 — Classifications Can Change	Activity 3 Activity 4 Activity 5 Activity 6 Activity 7
Chapter 11: Prokaryotes and Viruses; 11.1 — Prokaryotes Are Structurally Simple but Biochemically Complex	Activity 3
Chapter 12: Eukaryotes: Protists and Fungi; 12.5 — Flagellates May Be Consumers or Producers, 12.6 — Many Sarcodines Use Pseudopods, 12.8 — Ciliates Have Two Types of Nuclei	Activity 4 Activity 9 Activity 10 Activity 11
Chapter 13: Eukaryotes: Plants	Activity 5

Chapter 14: Eukaryotes: Animals; 14.1 — Animals Are Adapted to the Demands of Their Environment, 14.3 — Sponges and Cnidarians Are the Least Complex Animals, 14.8 — Digestion May Be Intracellular or Extracellular, 14.11 — Nervous Systems Control Responses to Stimuli and Coordination of Functions, 14.12 — Muscles and Skeletons Provide Support and Locomotion	Activity 6 Activity 9 Activity 11 Activity 12 Activity 16 Activity 18 Activity 19 Activity 20
Chapter 19: The Flowering Plant: Maintenance and Coordination; 19.1 — Photosynthesis Takes Place in Chloroplasts, 19.2 — Photosynthesis Requires Light	Activity 5 Activity 17 Activity 20
Chapter 20: Behavior, Selection, and Survival; 20.1 — Behavior Usually Falls into Two Categories, 20.7 — Animals Adjust to Environmental Changes in Several Ways	Activity 15 Activity 16 Activity 18 Activity 19
Chapter 23: Aquatic Ecosystems; 23.1 — Ponds Are Shallow Enough for Rooted Plants	Activity 2
Appendix Four: A Catalog of Living Things	Activity 2 Activity 4 Activity 7

Glencoe Science Biology (National Geographic)

National Geographic (2009). *Glencoe Science Biology*. New York, New York: McGraw-Hill Companies, Inc.

Chapter 2: Principles of Ecology; 2.1 — Organisms and Their Relationships (predation)	Activity 12 Activity 16
Chapter 3: Communities, Biomes, and Ecosystems; Section 3.3 — Aquatic Ecosystems: Freshwater Ecosystems	Activity 2
Chapter 4: Population Ecology; Section 4.1 — Population Dynamics	Activity 19 Activity 20
Chapter 7: Cellular Structure and Function; Section 7.1 — Cell Discovery and Theory: Microscope Technology and Basic Cell Types, Section 7.2 — The Plasma Membrane, Section 7.3 — Structures and Organelles, Section 7.4 — Cellular Transport	Activity 3 Activity 4 Activity 5 Activity 6 Activity 7 Activity 9 Activity 10 Activity 14 Activity 15 Activity 17
Chapter 8: Cellular Energy; Section 8.1 — How Organisms Obtain Energy, 8.2 — Photosynthesis	Activity 5 Activity 17 Activity 20
Chapter 9: Cellular Reproduction; Section 9.1 — Cellular Growth, The Cell Cycle, Section 9.2 — Mitosis and Cytokinesis	Activity 13
Chapter 10: Sexual Reproduction and Genetics; Section 10.1 — Meiosis (Table 10.1)	Activity 13
Chapter 12: Molecular Genetics; 12.4 — Gene Regulation and Mutation	Activity 7
Chapter 18: Bacteria and Viruses; Section 18.1 — Bacteria, Diversity of Prokaryotes, Prokaryote Structure, Prokaryote Characteristics	Activity 3 Activity 9
Chapter 19: Protists; Section 19.1 — Introduction to Protists, Section 19.2 — Protozoans—Animal-like Protists, Section 19.3 — Algae—Plantlike Protists	Activity 4 Activity 9 Activity 10 Activity 11 Activity 15
Chapter 20: Fungi; Section 20.1 — Introduction to Fungi, Section 20.2 — Diversity of Fungi, Section 20.3 — Ecology of Fungi	Activity 4
Chapter 21: Introduction to Plants	Activity 5
Chapter 22: Plant Structure and Function; Section 22.1 — Plant Cells and Tissues, Section 22.2 — Roots, Stems, and Leaves	Activity 5 Activity 7 Activity 17

Chapter 24: Introduction to Animals; Section 24.1 — Animal Characteristics	Activity 6 Activity 9 Activity 10 Activity 12
Chapter 28: Fishes and Amphibians; Data Analysis Lab 28.2	Activity 16
Chapter 31: Animal Behavior; Section 31.1 — Basic Behaviors	Activity 15 Activity 18 Activity 19
Reference Handbook (Six-Kingdom Classification)	Activity 2 Activity 4 Activity 7

McDougal Littell Biology (Stephen Nowicki)

Nowicki, Stephen (2008). *McDougal Littell Biology*. Evanston, Illinois: McDougal Littell.

Chapter 1: Biology in the 21st Century; 1.1 — The Study of Life, 1.2 — Unifying Themes of Biology	Activity 3 Activity 16
Chapter 3: Cell Structure and Function; 3-1 — Cell Theory, 3.2 — Cell Organelles, 3.3 — Cell Membranes, 3.4 — Diffusion and Osmosis	Activity 3 Activity 4 Activity 5 Activity 6 Activity 7 Activity 14 Activity 15 Activity 17
Chapter 4: Cells and Energy; 4.2 — Overview of Photosynthesis, 4.3 — Photosynthesis in Detail	Activity 5 Activity 17 Activity 20
Chapter 5: Cell Growth and Division; 5.1 — The Cell Cycle, 5.2 — Mitosis and Cytokinesis, Investigation — Mitosis in Onion Root Cells, 5.5 — Multi-cellular Life	Activity 7 Activity 13
Chapter 6: Meiosis and Mendel; 6.1 — Chromosomes and Meiosis (Figure 6.2)	Activity 13
Chapter 13: Principles of Ecology; 13.1 — Ecologists Study Relationships	Activity 20
Chapter 14: Interactions in Ecosystems; 14.2 — Community Interactions (predation), 14.3 — Population Density and Distribution, 14.4 — Population Growth Patterns	Activity 12 Activity 20
Chapter 15: The Biosphere; 15.5 — Estuaries and Freshwater Ecosystems	Activity 2
Chapter 17: The Tree of Life; 17.4 — Domains and Kingdoms	Activity 4
Chapter 18: Viruses and Prokaryotes; 18.4 — Bacteria and Archaea	Activity 3 Activity 9
Chapter 19: Protists and Fungi; 19.1 — Diversity of Protists, 19.2 — Animal-like Protists, 19.3 — Plantlike Protists, 19.5 — Diversity of Fungi, 19.6 — Ecology of Fungi	Activity 4 Activity 9 Activity 10 Activity 11
Chapter 20: Plant Diversity	Activity 5
Chapter 21: Plant Structure and Function; 21.1 — Plant Cells and Tissues, 21.4 — Leaves	Activity 5 Activity 17
Chapter 23: Invertebrate Diversity; 23.1 — Animal Characteristics, Investigation — Feeding Hydra	Activity 6 Activity 12
Chapter 27: Animal Behavior; 27.1 — Adaptive Value of Behavior, 27.2 — Instinct and Learning, 27.3 — Evolution of Behavior	Activity 15 Activity 18 Activity 19
Chapter 28: Human Systems and Homeostasis; 28.1 — Levels of Organization	Activity 7
Appendix A: Classification	Activity 2 Activity 4 Activity 7

Prentice Hall Biology (Miller and Levine)

Miller, Kenneth R. and Joseph Levine (2008). *Prentice Hall Biology*. Boston, Massachusetts: Pearson Education, Inc.

Chapter 4: Ecosystems and Communities; 4-2 — What Shapes an Ecosystem? (predation), 4-4 — Aquatic Ecosystems	Activity 2 Activity 12
Chapter 5: Populations	Activity 20
Chapter 7: Cell Structure and Function; 7-1 — Life is Cellular, 7-2 — Eukaryotic Cell Structure, 7-3 — Cell Boundaries, 7-4 — The Diversity of Cellular Life	Activity 3 Activity 4 Activity 5 Activity 6 Activity 7 Activity 14 Activity 15 Activity 17
Chapter 8: Photosynthesis; 8-2 — Photosynthesis: An Overview, 8-3 — The Reactions of Photosynthesis	Activity 5 Activity 17 Activity 20
Chapter 10: Cell Growth and Division; 10-2 — Cell Division, Exploration — Modeling the Phases of the Cell Cycle	Activity 13
Chapter 11: Introduction to Genetics; 11-4 — Meiosis	Activity 13
Chapter 18: Classification; 18-3 — Kingdoms and Domains	Activity 4
Chapter 19: Bacteria and Viruses; 19-1 — Bacteria	Activity 3 Activity 9
Chapter 20: Protists; 20-2 — Animal-like Protists: Protozoans, 20-4 — Plantlike Protists: Red, Brown, and Green Algae	Activity 9 Activity 10 Activity 11 Activity 20
Chapter 23: Roots, Stems, and Leaves; 23-1 — Specialized Tissues in Plants, 23-2 — Roots, 23-3 — Stems, 23-4 — Leaves	Activity 7
Chapter 26: Sponges and Cnidarians; 26-1 — Introduction to the Animal Kingdom, 26-3 — Cnidarians	Activity 6 Activity 7 Activity 9 Activity 11 Activity 12
Chapter 34: Animal Behavior; 34-1 — Elements of Behavior	Activity 15 Activity 18 Activity 19
Appendix E: Classification	Activity 2 Activity 4 Activity 7

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