SCIENCE STANDARDS OF LEARNING
ENHANCED SCOPE & SEQUENCE

LIFE SCIENCE

Commonwealth of Virginia
Department of Education
Richmond, Virginia
2008

Virginia Department of Education
P.O. Box 2120
Richmond, Virginia 23218-2120
http://www.doe.virginia.gov

Superintendent of Public Instruction
Dr. Billy K. Cannaday, Jr.

Chief Deputy Superintendent of Public Instruction
Dr. Patricia I. Wright

Assistant Superintendent for Instruction
Dr. Linda M. Wallinger

Office of Middle and High School Instructional Services
Dr. Felicia D. Dyke, Director
Paula J. Klonowski, Science Coordinator

Edited and designed by the CTE Resource Center
Margaret L. Watson, Administrative Coordinator
Bruce B. Stevens, Writer/Editor
Richmond Medical Park
2002 Bremo Road, Lower Level
Richmond, Virginia 23226
Phone: 804-673-3778
Fax: 804-673-3798
Web site: http://CTEresource.org

The CTE Resource Center is a Virginia Department of Education
grant project administered by the Henrico County Public Schools.

Table of Contents

Preface

The *Science Standards of Learning Enhanced Scope and Sequence* is a resource intended to help teachers align their classroom instruction with the Science Standards of Learning that were adopted by the Virginia Board of Education in January 2003. The *Enhanced Scope and Sequence* contains the following:

- Units organized by topics from the 2003 *Science Standards of Learning Sample Scope and Sequence.* Each topic lists the following:
  - Standards of Learning related to that topic
  - Essential understandings, knowledge, and skills from the *Science Standards of Learning Curriculum Framework* that students should acquire
- Sample lesson plans aligned with the essential understandings, knowledge, and skills from the *Curriculum Framework.* Each lesson contains most or all of the following:
  - An overview
  - Identification of the related Standard(s) of Learning
  - A list of objectives
  - A list of materials needed
  - A description of the instructional activity
  - One or more sample assessments
  - One or more follow-ups/extensions
  - A list of resources
- Sample released SOL test items for each Organizing Topic.

School divisions and teachers can use the *Enhanced Scope and Sequence* as a resource for developing sound curricular and instructional programs. These materials are intended as examples of ways the essential understandings, knowledge, and skills might be presented to students in a sequence of lessons that has been aligned with the Standards of Learning. Teachers who use the *Enhanced Scope and Sequence* should correlate the essential understandings, knowledge, and skills with available instructional resources as noted in the materials and determine the pacing of instruction as appropriate. This resource is not a complete curriculum and is neither required nor prescriptive, but it can be a valuable instructional tool.

Acknowledgments

We wish to express our gratitude to the following individuals for their contributions to the *Science Standards of Learning Enhanced Scope and Sequence* for Life Science:

Charlotte Davis
Norfolk City Public Schools

Jason Gibson
Danville City Public Schools

Beth Jewell
Fairfax County Public Schools

Becky Hill
Rockbridge County Public Schools

Eric Rhoades
Stafford County Public Schools

Susan Walton
Gloucester County Public Schools

Organizing Topic — Investigating Cell Theory

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include
- a) cell structure and organelles (cell membrane, cell wall, cytoplasm, vacuole, mitochondrion, endoplasmic reticulum, nucleus, and chloroplast);
- b) similarities and differences between plant and animal cells;
- c) development of cell theory; and
- d) cell division (mitosis and meiosis).

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• describe and sequence the major points in the development of cell theory;	____________
• identify the three components of cell theory;	____________
• distinguish among the following: cell membrane, cytoplasm, nucleus, cell wall, vacuole, mitochondrion, endoplasmic reticulum, and chloroplast;	____________
• correlate the structures of cell organelles with their jobs and analyze how organelles perform particular jobs;	____________
• compare and contrast examples of plant and animal cells, using the light microscope and images obtained from microscopes;	____________
• differentiate between mitosis and meiosis;	____________
• design an investigation from a testable question related to animal and plant cells. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. An example of such a question is: “Do onion cells vary in shape or structure depending on where they are found in the plant?”	____________

- analyze and critique the experimental design of basic investigations related to animal and plant cells, focusing on the skills developed in LS.1 and emphasizing clarity of predictions and hypotheses, organization of data tables, use of metric measures, adequacy of trials and samples, identification and use of variables, identification of constants, use of controls, displays of graphical data, and support for conclusions. ____________________________

Cell Theory

Organizing Topic Investigating Cell Theory

Overview Students observe cork cells under the microscope and investigate the development of cell theory.

Related Standards of Learning LS.1j; LS.2c

Objectives

The students will
- describe and sequence the major points in the development of cell theory;
- identify the three components of cell theory.

Materials needed

- Cork cell slides
- Microscopes
- Copies of the attached "Cell Theory Graphic Organizer"

Instructional activity

Content/Teacher Notes

This lesson focuses on the discoveries leading to the development of cell theory. Students complete the attached graphic organizer, which may be altered to vary the degree of completeness. Instead of using prepared cork slides, you may have students prepare their own slides to practice the technique of slide preparation.

Introduction

Hold a think-pair-share activity to activate students' knowledge from grade five science about plant- and animal-cell structure. Tell students to list five things they know about plant or animal cells and then compare what they wrote with their partner. Have partners choose two of their answers, write each on a sticky note, and post them on the board. Go through the posted answers with the class, categorizing them appropriately as you discuss each one. For example, you might have three categories: plant-cell, organelle, and animal-cell. Lead the discussion around to the development of cell theory, and use students' responses to assess their current understanding.

Procedure

1. Have students work in pairs at the microscope. Provide each pair with a sample of cork cells, but do not tell them what they are looking at. Have students draw and make observations about what they see through the microscope. It helps to have students draw a circle to represent the field of view when they are drawing, including a title line above the circle and a line below the circle to document the magnification.
2. Once students have made observations, have them make an educated guess about what they are looking at and give their reasons for this supposition.

   Move students away from the microscopes, and lead a discussion about what they saw and what they thought they were looking at. The discussion should then lead into a conversation about cork cells, Robert Hooke, and the development of cell theory. This would also be a good time to include a discussion about a scientific theory.

3. Distribute copies of the “Cell Theory Graphic Organizer.” If students have access to this information in their textbook, they may complete the organizer on their own; otherwise, present the material to them, and have them fill in the information in the appropriate boxes.

Observations and Conclusions

- Students sketch what they view in the microscope and draw conclusions from their sketches.
- Students complete the attached “Cell Theory Graphic Organizer.”

Sample assessment

- Have students describe important discoveries leading to the development of cell theory.
- Have students list the three components of cell theory.

Follow-up/extension

- Have students create baseball-style cards for Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow, with one side showing a picture of the scientist, and the other side showing his statistics.
- Have students research and report on the history of the microscope.
- Have students calculate or estimate the size of an individual cork cell, based on the magnification being used.
- Have students develop a Webquest to lead others to the information about each scientist and his discovery about and/or contribution to cell theory.

Cell Theory Graphic Organizer

Name: ________________________________ **Date:** ___________________

Year	Scientist	Discoveries	Cell Theory
1665		Looked at a cork slice under the newly developed microscope. Noticed that it was made up of "boxes," and named these *cells*.	
1673		First person to see bacteria; made observations of various blood cells in fish, birds, frogs, and humans.	
1838		Concluded that all plant parts are made up of cells.	
1839		Concluded that all animal tissues are made up of cells; wrote the first two parts of the cell theory.	1. All organisms are composed of one or more cells. 2. The cell is the basic unit of life in all living things.
1858		Saw that cells come only from existing cells; wrote the third part of the cell theory.	3. All cells come from existing cells.

Answer Key – Cell Theory Graphic Organizer

Year	Scientist	Discoveries	Cell Theory
1665	Robert Hooke	Looked at a cork slice under the newly developed microscope. Noticed that it was made up of "boxes," and named these *cells*.	
1673	Anton van Leeuwenhoek	First person to see bacteria; made observations of various blood cells in fish, birds, frogs, and humans.	
1838	Matthias Schleiden	Concluded that all plant parts are made up of cells.	
1839	Theodor Schwann	Concluded that all animal tissues are made up of cells; wrote the first two parts of the cell theory.	1. All organisms are composed of one or more cells. 2. The cell is the basic unit of life in all living things.
1858	Rudolf Virchow	Saw that cells come only from existing cells; wrote the third part of the cell theory.	3. All cells come from existing cells.

Plant and Animal Cells

Organizing Topic Investigating Cell Theory

Overview Students investigate plant and animal cells, using the microscope, and study the functions of the cell organelles.

Related Standards of Learning LS.2a

Objectives

The students will
- distinguish among the following: cell membrane, cytoplasm, nucleus, cell wall, vacuole, mitochondrion, endoplasmic reticulum, and chloroplast;
- correlate the structures of cell organelles with their jobs and analyze how organelles perform particular jobs;
- compare and contrast examples of plant and animal cells, using the light microscope and images obtained from microscopes.

Materials needed

- Copies of the attached "Organelle Function Cards" handout
- Microscopes
- Prepared slides of plant and animal cells
- Highly magnified images of plant and animal cells
- Diagrams of plant and animal cells with arrows pointing to the various organelles

Instructional activity

Content/Teacher Notes

The animal cell is a eukaryotic cell. It is surrounded by a cell membrane, which forms a selective barrier that allows nutrients to enter and waste products to exit. The cytoplasm contains a number of specialized organelles, each of which is surrounded by a membrane. The nucleus contains all the genetic information necessary for cell growth and reproduction. The other organelles carry out the different functions of the cell, allowing it to survive and participate in the functioning of the larger organism. The other organelles (vacuole, mitochondrion, endoplasmic reticulum) are found throughout the cell in more than one copy.

The plant cell is a eukaryotic cell, but is unique among the eukaryotes because it contains chloroplasts, which are able to produce food for the organism. The plant cell contains the other organelles present in the animal cell, as well as a cell wall, which provides structure and support for the cell. The vacuole in the plant cell is generally much larger than in the animal cell.

This is an introductory lesson to cell organelles, but you may want students to learn about addition organelles. This lesson focuses on the ones mentioned in the Life Science Curriculum Framework, but within the context of the class, it may be appropriate to include more.

Introduction

Have students complete a KWL chart about cells. Then, focus class discussion around cell organelles.

Procedure

1. Provide students with prepared slides of plant and animal cells, and have them make observations of each.
2. Distribute copies of the "Organelle Function Cards" and diagrams of plant and animal cells with arrows pointing to the various organelles. Go over each organelle, its function, and where it is in the cell. Have students label their diagrams and verify the labels with their own observations of the actual cells.
3. Encourage students to make notes on the backs of their function cards to help them remember the functions. At a later time, have students cut the cards apart.

Observations and Conclusions

- Students observe the differences between plant and animal cells, using diagrams and microscopic images.
- Students conclude that the cell organelles have different functions that are integral to the cell's activities, and they explain this conclusion.

Sample assessment

- Have students compare and contrast plant and animal cell organelles, using diagrams.
- Have students articulate the different plant and animal organelle structures and functions.

Follow-up/extension

- Use the "Cell Investigations" lesson from the MathinScience.info Web site: http://mathinscience.info/teach/612_science/biolife_envisci/cell_investigations/cell_invest.htm. This lesson on cell parts and functions also includes useful diagrams and images.
- Provide students with plant and animal cell outlines, and have students cut out the organelles, label them, and paste them in the proper cell.
- Give a demonstration on the permeability of the cell membrane, using an egg and vinegar. This could lead into a lesson on the differences among diffusion, osmosis, and active transport.
- Have students compare the cell organelles to the functions of the organs in the body (e.g., the skin is similar to the cell membrane).
- Have students create a clay model of a plant or animal cell.

Sample resources

- *The Biology Project: an online interactive resource for learning biology*. The University of Arizona. http://www.biology.arizona.edu/.
- *MathinScience.info. Mathematics and Science Center*. University of Virginia. http://www.mathinscience.info/OnlineLessons/index.htm.
- "Plant, Animal, and Bacteria Cell Models." *CELLS Alive!* http://www.cellsalive.com/cells/3dcell.htm.

Organelle Function Cards

Cut out the 8 cards below on the heavy lines. Fold them along the dotted line so that the words are on the outside. Use the outsides as flash cards and the insides for additional notes, drawings, or anything that will help you remember the meaning of each term. Store cards in an envelope or zip-top bag to use for studying.

Cytoplasm	A constantly moving gel-like substance that surrounds the cell's organelles.	**Nucleus**	Contains the cell's DNA and serves as the control center for the cell.
Cell membrane	Covers the cell's surface and controls the materials that enter and exit the cell.	**Vacuole**	Serves as a storage container for water and other materials.
Mitochondria	Supplies, stores, and produces energy for the cell.	**Chloroplast**	The place in plant cells that contains chlorophyll and where photosynthesis occurs.
Endoplasmic reticulum	Produces proteins and lipid components for the cell.	**Cell wall**	A structure found in plant cells that provides strength and support to the cell membrane.

Plant Cells Compared

Organizing Topic Investigating Cell Theory

Overview Students observe plant cells and compare and contrast different types of onions.

Related Standards of Learning LS.1d, j; LS.2a, b

Objectives

The students will
- observe plant cells;
- make field-view drawings;
- observe and identify organelles of the plant cell.

Materials needed

- Compound microscopes
- Slides
- Cover slips
- Flat ended toothpicks
- Water
- Eyedroppers
- Different types of onions (red, white, and yellow onions compare nicely)
- Iodine or methylene blue stain (optional)
- Copies of the attached "Onion Cells Compared" worksheet

Instructional activity

Content/Teacher Notes

Observing onion cells is a classic life science activity. Expanding this to include a comparison of different types of onions allows students to make the standard observations while conducting a controlled experiment. Students will be able to see the cell wall, nucleus, and cytoplasm. While they can tell where the cell boundary is, they will not actually observe the cell membrane because it is too small to be seen with a light microscope. Students will need previous experience using a compound microscope and making a wet mount slide to complete the experiment. Onions should be cut into approximately centimeter-square cubes before class. You may want to add a cellular stain, such as iodine or methylene blue stain, to improve the visibility of the nucleus; however, most students will be able to see the nucleus without stain.

This activity can be adapted for use with prepared slides of animal cells. Once students have completed both labs, they can then identify similarities and differences between plant and animal cells.

Introduction

Review the structure and function of cell organelles. Remind students of the correct procedures for carrying and using a microscope. If methylene blue stain is used, be sure to warn students that because it is a cellular stain, it will stain the cells of their hands; thus, they should be careful not to get the stain on their hands, or they should wear protective gloves.

Procedure

1. Give students clean glass slides, cover slips, water, and onion pieces, and have them prepare slides of each type of onion, using standard procedure for making wet mount slides. Make sure they peel off the thin layer of skin on the *inside* curve of the onion piece.
2. Have students place each prepared slide on the microscope stage and observe the onion under low power.
3. Have students describe a cell seen, indicating its general shape, inside appearance, and other features, and making a labeled field-view drawing on the attached "Onion Cells Compared" worksheet.
4. After observing and describing each type of cell and making comparisons of the patterns they observe, have students clean up all slides.

Observations and Conclusions

- Students observe the cell wall, nucleus, and cytoplasm.
- Students compare and contrast the patterns they see in the different types of onions.

Sample assessment

- Have students complete a reflection on the onion observation, labeling lab sketches and explaining similarities and differences among the types of onion cells.
- Assess students' lab skills, using a performance rubric.

Follow-up/extension

- Have students make and observe wet mounts of other plant cell sources, such as lettuce or *elodea* leaves. Emphasize that because light must pass through their specimen, they must peel off a very thin layer of the epidermis.

Sample resources

- "Inside a Cell." *Learn.Genetics: Genetic Science Learning Center*. The University of Utah. http://learn.genetics.utah.edu/units/basics/cell/.
- "Observing Cells, Using Stains." *Antibiotics in Action: Pharmaceutical Achievers.* The Chemical Heritage Foundation. http://www.chemheritage.org/educationalservices/pharm/antibiot/activity/stain.htm.
- "Plant, Animal, and Bacteria Cell Models." *CELLS Alive!* http://www.cellsalive.com/cells/3dcell.htm.

Onion Cells Compared

Name: ___________________________________ Date: ____________________

Draw a field view of each type of onion cell observed through the microscope, and label the cell wall, nucleus, and cytoplasm.

Identity of specimen: ______________________

Magnification: 100 × _____

Identity of specimen: ______________________

Magnification: 100 × _____

Identity of specimen: ______________________

Magnification: 100 × _____

Modeling Mitosis

Organizing Topic Investigating Cell Theory

Overview Students observe, draw, and model the various stages of mitosis.

Related Standards of Learning LS.2d

Objectives

The students will
- identify and model the various stages of mitosis.

Materials needed

- Colored chalk
- Colored pencils
- Microscopes
- Onion root tip slides
- Poster board
- Diagrams of mitosis and meiosis
- Scissors
- Yarn in five different colors
- Rulers
- Glue
- Textbooks
- Copies of the attached "Mitosis Posters" handout

Instructional activity

Content/Teacher Notes

Cell division perpetuates life and allows for growth and reproduction of organisms. When introducing mitosis to the students, remind them that all cell organelles are present and performing their usual tasks; however, for this study, they will focus on only those organelles directly involved with mitosis. Make sure to point out what is and what is not part of mitosis. Technically speaking, mitosis is nuclear division plus cytokinesis. Mitosis produces two identical daughter cells during its stages—i.e., prophase, prometaphase, metaphase, anaphase, and telophase. Interphase is often included in discussions of mitosis; however, interphase is technically not part of mitosis, but rather encompasses stages G1, S, and G2 of the cell cycle. These stages of the cell cycle precede the M stage during which mitosis occurs.

Introduction

Ask students what might trigger a cell to divide. Then, inform them that cell biologists have determined that the size of the cell seems to be the signal for the cell to divide. Also, other cells supply such triggers.

Procedure

1. Use colored chalk to draw the stages of mitosis on the board, using different colors for the chromosomes. Label each stage and the structures you have drawn. Then, go through each stage with the students, describing the changes from one stage to the next.
2. Have students use colored pencils to draw each stage of mitosis as seen in your drawing. Have them write a description of what happens at each stage.

3. Divide the class into pairs of students, and have each pair look at the onion root tip slide through the microscope and locate the different stages of mitosis. Have students use colored pencils to draw and label these actual stages of mitosis that they observe.
4. Divide the class into groups of three or four students each, and give each group a piece of poster board, a circle pattern or compass, colored pencils, scissors, yarn in five different colors, rulers, and glue. Have each group create a poster depicting mitosis, using the instructions found on the attached "Mitosis Poster" handout and the textbook and/or class notes on mitosis. (For a less directed activity, you may want to provide students with the materials listed on the handout and have students devise a way to use the materials to represent mitosis.)
5. Discuss the difference between mitosis and meiosis, having students define each term and differentiate between them. Show diagrams of the stages of meiosis to compare to the stages of mitosis.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
  - Why must your body make new cells?
  - What is the cell cycle?
  - What is mitosis?
  - Where does mitosis fit into the cell cycle?
  - Where along the onion root tip do the cells undergo mitosis?
  - Which stage of mitosis is seen most frequently in a cell undergoing mitosis? Why?
  - What is the difference between mitosis and meiosis?

Sample assessment

- Have students identify the stages of mitosis in the context of a lab practical.

Follow-up/extension

- Design an experiment that answers the question: "How long does a cell spend in interphase?"

Sample resources

- "The Cell Cycle & Mitosis Tutorial." *The Biology Crisis – Cell Biology*. University of Arizona. http://www.biology.arizona.edu/Cell_bio/tutorials/cell_cycle/main.html.

Mitosis Poster

Name: ________________________________ Date: ____________________

Follow the procedure below to create a poster showing mitosis.
Then, complete the “Conclusions” section.

Procedure

1. On a piece of poster board, draw, in correct order, the outline of a cell at each of the five stages of mitosis.
2. Label each stage, and give the poster a title.
3. Cut a 44-cm length of each of five colors of yarn. Then, cut each of these five strands into 11 pieces, each of which is 4 cm long.
4. Using the yarn pieces, glue, colored pencils, and your class notes and/or textbook, make a representation of the appearance of the cell contents at each stage of mitosis. Glue pieces of yarn to represent the chromosomes, chromatin, and/or chromatids at each stage. Use two pieces of each color of yarn at each stage except the first, where there should be just one piece of each color.
5. Label the following cell contents directly on each cell:
   - chromosomes
   - chromatin
   - chromatids
   - centromeres
   - centrioles
   - spindle
   - nuclear membrane
   - nucleolus
   - nucleus
   - cytoplasm

Conclusions

1. Write a brief description of what happens at each stage of mitosis.

2. Why does mitosis occur?

3. What is the difference between chromosomes, chromatin, and chromatids?

4. Why do you think cells at the end of stage six are called “daughter cells”?

5. Most of the time is spent at which stage?

6. Describe the similarities and differences between the following stages:

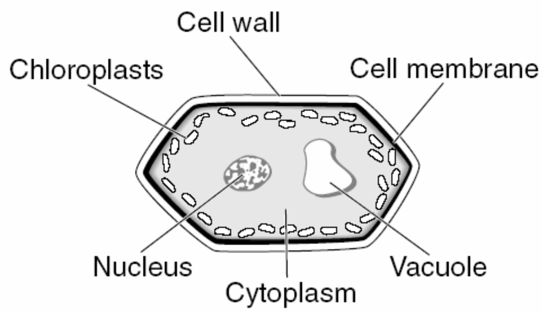
   1 and 2: ____

   5 and 6: ____

   1 and 6: ____

   3 and 4: ____

Sample Released SOL Test Items



In this plant cell, which cellular structure is responsible for storing food, water, and wastes?

F Cytoplasm
G Vacuole
H Nucleus
J Cell membrane

Which of the following do typical plant cells have that typical animal cells do not?

A Cytoplasm
B Nuclei
C Mitochondria
D Chloroplasts

Organizing Topic — Investigating Patterns of Cellular Organization

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include
- a) cells, tissues, organs, and systems; and
- b) life functions and processes of cells, tissues, organs, and systems (respiration, removal of wastes, growth, reproduction, digestion, and cellular transport).

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• differentiate between unicellular organisms and multicellular organisms, and name common examples of each;	______________________
• compare and contrast how unicellular and multicellular organisms perform various life functions, including the application of knowledge about systems in organisms;	______________________
• compare and contrast the various basic life functions of an organism, including respiration, waste removal, growth, irritability, and reproduction, and explain the role that each life function serves for an organism;	______________________
• model how materials move into and out of cells in the processes of osmosis, diffusion, and active transport, including creating and interpreting three-dimensional models and/or illustrations demonstrating the processes involved;	______________________
• differentiate among cells, tissue, organs, and organs systems;	______________________
• analyze and critique the experimental design of basic investigations related to understanding cellular organization, with emphasis on observations of cells and tissue. This analysis and critique should focus on the skills developed in LS.1. and emphasize clarity of predictions and hypotheses, organization of data tables, use of metric measures, adequacy of trials and samples, identification and use of variables,	

identification of constants, use of controls, displays of graphical data, and support for conclusions. ______________________________

Levels of Organization in Multicellular Organisms

Organizing Topic Investigating Patterns of Cellular Organization

Overview Students learn about the levels of organization found in unicellular and multicellular organisms.

Related Standards of Learning LS.3a

Objectives

The students will

- differentiate between unicellular organisms and multicellular organisms, and name common examples of each.

Materials needed

- Pictures of various multicellular organisms, showing levels of organization

Instructional activity

Content/Teacher Notes

This is a basic introductory or review lesson, which some students may not need.

All organisms are organized at both the molecular and cellular levels. In multicellular organisms, cells are organized into tissues, tissues are organized into organs, and organs are organized into systems. It may be helpful to students to point out other levels of organization that they have studied in grades five and six, such as those of atoms, molecules, and compounds. When selecting the pictures of organisms to use in this activity, be sure to include some showing all of the various levels of organization.

Introduction

Ask the students what the word *alive* means—that is, what it means to "be alive." Ask them to list the characteristics that something must exhibit in order to be considered alive. Most people can differentiate between living and nonliving, but defining what it means to be alive is not as simple.

Procedure

1. Provide several pictures of unicellular and multicellular organisms to each student. Ask students to list the similarities and the differences they see among the organisms, and ask them to list one or two reasons why these organisms might be different.
2. Divide the class into groups of three or four students each, and have each group make a list of the functions of life. When they are finished, ask a spokesperson from each group to share the group's list with the class. Write the functions on the board, and discuss them with the class. Have students use the displayed list to complete a data table comparing unicellular and multicellular organisms.
3. To help students identify the similarities and differences between unicellular and multicellular organisms, have them draw one of each. Ask them to compare each cell organelle in the unicellular organism to a body part in the multicellular organism. Have them use one color to designate similarities and another color to indicate differences.
4. Hold a class discussion on levels of organization. Have students arrange the pictures from step 1 from the simplest organism to most complex. Ask students how they determine that one organism is more complex than another. Discuss with students the levels of organization, using the pictures to show the various levels.

Observations and Conclusions

- Students produce an appropriate drawing in which they record their observations and explanations.

Sample assessment

- Have students list the multicellular and unicellular organisms from the activity.
- Have students respond to the following prompt: "Suppose you were a biologist who has found an object that looks like an organism. How can you determine what it is?"

Follow-up/extension

- Have students draw or cut out photographic examples of the levels of organization of life and paste them on poster board. Then, have them connect the levels and write a sentence for each level, explaining the connection.
- Have students describe how a biologist who has discovered a new organism can determine the level of organization in this organism. Have them describe the observations that should be made and how the organism could be classified.

Sample resources

- "BioEd Online Slide Sets." *BioEd Online. Biology Teacher Resources from Baylor College of Medicine.* http://www.bioedonline.org/slides/. Offers collections of peer-reviewed and annotated PowerPoint slide sets on topics of interest to biology teachers.

Osmosis, Diffusion, and Active Transport

Organizing Topic Investigating Patterns of Cellular Organization

Overview A cell exists in a constantly changing environment. By adjusting to changes, a cell maintains balance with its environment.

Related Standards of Learning LS.3b

Objectives

The students will

- model how materials move into and out of cells in the processes of osmosis, diffusion, and active transport, and create and interpret three-dimensional models and/or illustrations demonstrating the processes involved;
- analyze the components of these models and diagrams, and communicate their observations and conclusions.

Materials needed

- Large, clear container of water
- Food coloring
- Warm popped popcorn (optional)
- Beakers (250 ml and 300 ml)
- Salt
- Potato slices
- Elodea (*anacharis*) sprigs
- Microscopes
- Slides
- Cover slips
- Eyedroppers

Instructional activity

Content/Teacher Notes

Homeostasis is the result of the processes that living things use to maintain a constant internal environment as the external environment changes. Obtain sprigs of elodea (*anacharis*), which can be purchased at pet stores. When *anacharis* is subjected to water, the chloroplasts are spread throughout the cells. Before the lab, keep the plants in water under light for 12 hours to spread out the chloroplasts. Students may even see them moving about the cell; this is known as cytoplasmic streaming. Upon the addition of salt water, the fresh water in the cell moves out of the cell through the cell membrane, causing the cell membrane to shrink away from the cell wall and forcing all of the chloroplasts to the center of the cell.

Introduction

Explain to students that if a cell were like an impermeable bag, practically nothing would be able to enter or exit the cell. Sitting inside such a cell would be like sitting in a sealed house without doors or windows; nothing could come in or go out.

Procedure

1. Begin the activity with a demonstration of diffusion. Set a large clear container at the front of the room. Fill the container with water, let the water become still, and then place a few drops of food coloring on the surface. The color must be very intense to ensure that it will be visible at the end of the demonstration. Have students record their observations after set intervals of time and describe the process of diffusion as seen in this demonstration. Hold a class discussion of the students' observations. (An alternative diffusion demonstration would be to place a bag of freshly popped popcorn at the back of the room, and time how long it takes for the odor of the popcorn to reach a small group of students located in the front of the room.)
2. Have students do a lab activity concerning osmosis in slices of potato, as follows:
    - Students measure and record the size (circumference, diameter, thickness, mass) of each of two thin slices of potato.
    - They place each slice in a beaker and cover the slice in beaker A with distilled water and the slice in beaker B with salt water.
    - They make a diagram of what happens in the beakers, using arrows to show the direction of water movement between the water and each potato slice. They look for similarities and differences between the two potato slices and report their findings in a data table.
    - They again measure and record the size of each potato slice.
    - They list one or two reasons why sizes of the potato slices have changed.
3. Have students do a lab activity concerning osmosis in *anacharis*, as follows:
    - Students prepare a wet mount slide of an *anacharis* leaf.
    - They use a microscope to make observations and draw the leaf.
    - With an eyedropper, they place a drop of salt water at the edge of the cover slip and then place a paper towel at the opposite edge of the cover slip to pull the salt water through.
    - They draw the results, using arrows to show the direction of water movement.

Observations and Conclusions

- Students create an appropriate data table in which they record their observations and explanations.
- Students produce drawings of the potato and *anacharis* activities.
- Students make conclusions from their answers to the following questions:
    - Which way did water move in the potato slice when salt water was added? How do you know this?
    - Which way did water move in the *anacharis* when salt water was added to the slide? How do you know this?

Sample assessment

- Have students use their understanding of osmosis to explain why putting salt on a pork chop before cooking it is likely to result in a dry, tough piece of meat.

Follow-up/extension

- Have students research and report on how cell membranes of some cells of living organisms become modified to be more efficient.
- Design an experiment that would test factors that may affect the rate of diffusion.

Sample Released SOL Test Items

Which of these shows the correct sequence of development?

A Organs → cells → tissues → systems

B Cells → tissues → organs → systems

C Systems → tissues → cells → organs

D Tissues → cells → systems → organs

Which of these processes helps extract energy from food?

A Reproduction

B Digestion

C Excretion

D Circulation

Organizing Topic — Investigating Heredity and Genetics

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.13 The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include
- a) the role of DNA;
- b) the function of genes and chromosomes;
- c) genotypes and phenotypes;
- d) factors affecting the expression of traits;
- e) characteristics that can and cannot be inherited;
- f) genetic engineering and its applications; and
- g) historical contributions and significance of discoveries related to genetics.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• recognize the appearance of DNA as double helix in shape;	____________________
• explain that DNA contains coded instructions that store and pass genetic information on from one generation to the next;	____________________
• demonstrate variation within a single genetic trait;	____________________
• explain the necessity of DNA replication for the continuity of life;	____________________
• differentiate between characteristics that can be inherited and those that cannot be inherited;	____________________
• distinguish between dominant and recessive traits;	____________________
• distinguish between genotype and phenotype;	____________________
• use Punnett squares to predict the possible combinations of inherited traits resulting from single trait crosses;	____________________
• identify aspects of genetic engineering, supply examples of applications, and evaluate the examples for possible controversial aspects;	____________________

- describe the contributions of Mendel, Franklin, and Watson and Crick to our basic understanding of genetics. ______________________________

The DNA Model

Organizing Topic Investigating Heredity and Genetics

Overview Students build a DNA model out of candy, and explain the structure.

Related Standards of Learning LS.13a

Objectives

The students will

- recognize the appearance of DNA as double helix in shape;
- explain that DNA contains coded instructions that store and pass genetic information on from one generation to the next.

Materials needed

- Licorice ropes
- Small colored gumdrops
- Toothpicks
- Copies of the attached "The DNA Model" worksheet

Instructional activity

Content/Teacher Notes

Chromosomes contain deoxyribose nucleic acid (DNA). Each chromosome contains one strand of DNA. DNA contains all of the information necessary to create an organism and is found in the nucleus of the cell.

DNA is made up of a long chain of molecules resembling a twisted ladder. This is referred to as a double helix shape. The "rungs" of the ladder are made up of four bases: adenine, guanine, cytosine, and thymine. These are often referred to as the nitrogen or nitrogenous bases in DNA. Each base is attached to a sugar molecule on each side, and the sugar is attached to a phosphate group. This sugar and phosphate make up the "sides" of the ladder. The nitrogen bases pair up only in certain ways: adenine will combine only with thymine, and guanine will combine only with cytosine.

The University of Utah Web site listed on the next page under "Sample resources" presents a very good description and animation regarding the structure and function of DNA.

Introduction

Introduce students to the term *deoxyribose nucleic acid*, commonly known as DNA. Lead into a discussion about what DNA is, where it is found in the cell, and what it does. Then, review and discuss the stages of mitosis.

Procedure

1. Introduce the structure of DNA by having the students build a model of the molecule as you explain the structure.
   - Students select different colors of gumdrops, two licorice ropes, and a handful of toothpicks to use to build the model. The two licorice ropes represent the sugar/phosphate backbone of DNA, while the gumdrops represent nitrogen bases.
   - Students construct the DNA molecule, making sure to match the bases appropriately. The toothpicks make up the "rungs" of the ladder, with two gumdrops on each rung and a licorice

rope at each side. The gumdrop colors identified with adenine and thymine must be paired, and the colors designating guanine and cytosine must be paired.
  - After the ladder is complete, students can twist it to show the double helix model.

2. Upon completion, students should have their own model of DNA as well as a reference sheet to go along with it.

Observations and Conclusions

- Students complete the attached "The DNA Model" worksheet.

Sample assessment

- Give students a sequence of bases to pair up with their complement.
- Have students describe the relationships among bases, DNA, genes, and chromosomes.

Sample resources

- *Learn.Genetics: Genetic Science Learning Center.* The University of Utah. http://gslc.genetics.utah.edu/.

The DNA Model

Name: ___________________________________ **Date:** ____________________

Key Points

- DNA is Deoxyribose Nucleic Acid.
- DNA is made up of nitrogen bases, phosphate, and sugar.
- The sequence of the bases makes up a gene: for example, a a t t g c c a a t g g g c c c t t t a g a g c t a g g g a t c g a t g c t a g c t a g t t t t c t a g a t c t could be the gene for a certain trait.
- Nitrogen bases→DNA→genes→chromosome (Nitrogen bases make up DNA, which makes up genes, which group together to form a chromosome.)
- The chromosomes are passed on to offspring, who carry on the genetic information.

DNA Structure	Purpose/Location	Model Key
Phosphate	Makes up side of DNA ladder	Licorice rope
Sugar	Makes up side of DNA ladder	Licorice rope
Adenine	Nitrogen base, pairs with thymine	Green gumdrop
Guanine	Nitrogen base, pairs with cytosine	Red gumdrop
Cytosine	Nitrogen base, pairs with guanine	Orange gumdrop
Thymine	Nitrogen base, pairs with adenine	Yellow gumdrop

Analysis

1. Draw a model of DNA.

2. If you know that one of the bases is adenine, do you automatically know what the other side is? Why, or why not?

3. How can only four bases make up so many different traits, characteristics, or sets of instructions for an organism? Explain.

Heredity

Organizing Topic Investigating Heredity and Genetics

Overview Students investigate dominant and recessive traits and Mendel's historical contributions to genetics.

Related Standards of Learning LS.13b, c, d, g

Objectives

The students will
- differentiate between characteristics that can be inherited and those that cannot be inherited;
- distinguish between dominant and recessive traits;
- distinguish between genotype and phenotype;
- use Punnett squares to predict the possible combinations of inherited factors resulting from single trait crosses.

Materials needed

- Graphic organizer for notes
- Copies of the attached worksheets

Instructional activity

Content/Teacher Notes

Heredity is the passing of traits from parents to offspring. Some characteristics can be inherited, such as eye color, hair color, and height, and other characteristics cannot. Gregor Mendel is considered to be the father of genetics. Working with pea plants, he discovered how traits are passed on from one generation to the next. He determined that a trait that seems to occur most often is called the dominant trait, while the opposite trait that is not as common is the recessive trait. He also showed that each parent donates sets of instructions, or *genes*, to determine which traits will be present in the offspring. Each gene is a segment of DNA that codes for a certain trait. Multiple genes grouped together form a chromosome. Each form of the gene is known as an *allele*. For example, the pea plant may have two alleles for size—short and tall—one of which is dominant and the other of which is recessive.

A Punnett square is a diagram used to show the possible combination of alleles inherited from the parents. A dominant allele is symbolized by an uppercase letter, while a recessive allele is symbolized by a lowercase letter. Offspring are likely to inherit any of the alleles equally, as the process is completely random. However, the likelihood of the combination that the offspring will inherit can be determined by using a Punnett square.

The *genotype* represents the actual pair of alleles, dominant or recessive, that an offspring inherits. The *phenotype* is what is expressed by these inherited alleles. For instance, if T is the dominant allele for tall and t is the recessive allele for short and an offspring has the genotype Tt, the phenotype of the offspring will be tall. The term *heterozygous* refers to a genotype of different alleles, while *homozygous* refers to a genotype with the same alleles.

Introduction

Have students do a think-pair-share of five characteristics they think are inherited, or passed down from their parents. Have students share some of these as a class, and list them on the board. Lead into a discussion of what it means for a trait to be inherited.

Procedure

1. Distribute copies of the "Heredity" graphic organizer. Hold a class discussion of heredity, and have students use the organizer to compile some key concepts related to heredity, inheritance, genetics, and Mendel. Use the notes provided on the attached "Answer Key," and/or your own notes.
2. Introduce students to the Punnett square, using examples from Mendel to show how the pea plants expressed different traits. Work through several practice examples with students, emphasizing the key terms *heterozygous, homozygous, genotype,* and *phenotype* and demonstrating how to determine the percentage of offspring showing a trait.
3. Have students complete the attached "Punnett Square" worksheet activity.

Observations and Conclusions

(Refer to worksheets.)

Sample assessment

- Given the parent's genotypes, have students use blank Punnett squares to predict the ratios of phenotypes that will occur and identify what traits the offspring will have.
- Have students describe the relationships among DNA, genes, chromosomes, and alleles.
- Have students identify which given traits are inherited and which are not.

Sample resources

- *DNA from the BEGINNING: an animated primer on the basics of DNA, genes, and heredity*. Cold Spring Harbor Laboratory. http://www.dnaftb.org/dnaftb/.
- *Gene Almanac: The source for timely information about genes in your life.* Cold Spring Harbor Laboratory. http://www.dnalc.org/home.html.
- *Learn.Genetics: Genetic Science Learning Center.* The University of Utah. http://gslc.genetics.utah.edu/.

Heredity

Name: ___________________________________ Date: ____________________

Gregor Mendel	**Dominant** **Recessive**
Genotype **Phenotype**	**Homozygous** **Heterozygous**
Gene **Chromosome** **Allele**	**Punnett square**

Answer Key – Heredity

<table>
<tr>
<td>Gregor Mendel
• Born in 1822 in Austria.
• Bred plants in a monastery and studied how plants passed traits from parent to offspring.
• Realized that each plant has two sets of instructions (genes) for each characteristic and that each parent donates a set.</td>
<td>Dominant
• The name that Mendel gave to traits that occurred more frequently.

Recessive
• The name that Mendel gave to traits that occurred less frequently.</td>
</tr>
<tr>
<td>Genotype
• The actual pairs of alleles that an offspring inherits, e.g., Tt or tt.

Phenotype
• The trait that the offspring shows because of the genotype, e.g., tall (Tt) or short (tt).</td>
<td>Homozygous
• A genotype with the same alleles (tt or TT).
• For a recessive gene to be expressed, it has to be homozygous.

Heterozygous
• A genotype with different alleles (Tt).</td>
</tr>
<tr>
<td>Gene
• Segment of DNA that codes for a certain trait.

Chromosome
• Multiple genes grouped together.

Allele
• A form of the gene, e.g., tall or short.</td>
<td>Punnett square
• Diagram used to determine the possible combination of alleles from the parents.

<table><tr><th></th><th>T</th><th>t</th></tr><tr><th>T</th><td>TT</td><td>Tt</td></tr><tr><th>t</th><td>Tt</td><td>tt</td></tr></table></td>
</tr>
</table>

Punnett Squares

Name: ___________________________________ Date: ____________________

Introduction

In this activity, you will make predictions by means of Punnett squares. You will then use pennies to simulate the crosses and compare the actual ratios with the predicted ratios.

The trait you are looking at is the color of fur in rabbits. **W** represents the dominant allele for white fur, and **w** represents the recessive allele for black fur. Remember that for the recessive trait (black fur) to show up, the genotype must be **ww**; any combination with the dominant gene will make the dominant trait (white fur) show up.

Fill in the phenotypes, white fur or black fur, for the following genotypes:

Genotype	Phenotype
WW	______________
Ww	______________
ww	______________

Part One

1. Use the Punnett square at right to predict the ratio of offspring in a cross where the genotype of both parents is heterozygous (**Ww**).

	W	**w**
W		
w		

2. What proportion out of 4 offspring will have white fur? ___**:4** What proportion will have black fur? ___**:4** These are your *predicted ratios*. Write these ratios in the chart in step 5 below.
3. Determine the actual ratios by using two pennies to show the crosses. Use a pencil or marker to mark one side of each penny with a **W** and the other side of each penny with a **w**. Each penny now represents a parent with the genotype **Ww**. Toss both pennies, and record the results in the appropriate space in the chart below to represent the genotype of the offspring.
4. Repeat the toss-and-record 100 times to represent 100 offspring.

Genotype	Tally	Total
WW		
Ww		
ww		

Phenotype	Total
White fur (**WW** or **Ww**)	
Black fur (**ww**)	

5. Compare your predicted ratios with your actual ratios in the chart below.

Phenotype	Predicted ratio	Actual ratio
White fur (**WW** or **Ww**)		
Black fur (**ww**)		

6. Were the actual ratios similar to your predicted ratios? ______ Explain why below.

Part Two

1. Repeat the experiment in part one but with the genotypes of the parents **Ww** and **ww**. You will need to set up your own Punnett square and data charts on a separate sheet of paper. Compare your predicted ratios with your actual ratios in the chart below.

Phenotype	Predicted ratio	Actual ratio
White fur (**WW** or **Ww**)		
Black fur (**ww**)		

2. Were the actual ratios similar to your predicted ratios? ______ Explain why below.

Analysis

1. Why are the predicted ratios and the actual ratios not the same?

2. What do the pennies represent in the simulation?

3. In what instance could parents predict with 100-percent accuracy a trait that the offspring would show?

4. If a rabbit has four bunnies, will the phenotypes match the Punnett-square ratios exactly? Why, or why not?

5. Would it be an advantage or a disadvantage for a mother and a father to know the genes they have for certain traits or diseases before they have children? Explain why.

Passing Traits On

Organizing Topic Investigating Heredity and Genetics

Overview

Related Standards of Learning LS.13c

Objectives

The students will
- differentiate between characteristics that can be inherited and those that cannot be inherited;
- distinguish between dominant and recessive traits;
- distinguish between genotype and phenotype;
- use Punnett squares to predict possible combinations of inherited traits resulting from single trait crosses;
- identify aspects of genetic engineering, supply examples of applications, and evaluate the examples for controversial aspects.

Materials needed

- Petri dishes
- Dried green and yellow peas
- Copies of the attached "Passing Traits On" worksheet

Instructional activity

Content/Teacher Notes

Parents pass their characteristics, e.g., hair color, nose shape, skin color, on to their offspring. Not all of the parents' characteristics will appear in the offspring, but the characteristics that are more likely to appear can be predicted. Such predictions are based on the work of Gregor Mendel. DNA technology allows researchers to produce offspring with specific characteristics or abilities. Students should understand that gene technology is a powerful tool and is controversial. The industry prefers the term *biotechnology* to *genetic engineering.*

The transmission of characteristics from parents to offspring is called *heredity*, and the characteristics that are *inherited* can be predicted. Reginald Punnett contributed much to the science of genetics when he designed a method of predicting traits as he was studying poultry genetics. The Punnett square, originally called the checkerboard or chessboard method, is a diagram that is used to predict the outcome of all possible offspring that could result from crossing the genes of two parents. Genes are portions of DNA that code the instructions to build bodies in certain ways. Scientists know much about how genes work; they know how to "snip" genes out of one place and "stick" them into another. This is the hi-tech world of genetic engineering.

Introduction

Review with students what it means for a trait to be inherited and the meaning of the word *heredity.* Include a review of the contribution of Reginald Punnett, the use of the Punnett square, and the basic process of genetic engineering.

Procedure

1. Discuss basic terminology with students: *P1 generation, F1 generation, F2 generation, allele, dominant, recessive, phenotype, genotype, homozygous,* and *heterozygous.*

2. Model for students how to complete a Punnett square, showing the result of crossing a homozygous dominant (BB) black guinea pig with a homozygous recessive (bb) guinea pig: Determine the possible gametes from the test parents—i.e., BB = B and B; bb = b and b—and label the columns and rows of a Punnett square with these letters, as shown at right:

	B	B
b		
b		

3. Complete the square by determining the possible gamete combinations, as shown at right.

	B	B
b	Bb	Bb
b	Bb	Bb

4. Ask students to complete a Punnett square of a cross between two of the offspring in step 3—i.e., a cross between Bb with Bb—as shown at right:

	B	b
B	BB	Bb
b	Bb	bb

5. Distribute copies of the "Passing Traits On" worksheet. Divide students into pairs. Have each pair put 25 green peas in a Petri dish and 25 yellow peas in another Petri dish and mark one dish "male gametes" and the other "female gametes." Each parent randomly contributes one allele to the offspring for each trait. To model this, have students take one pea from each Petri dish, put the two peas together as a pair, and record the pairings in the genotype column on their worksheet, using a *G* for a green pea and a *g* for a yellow pea.
6. Have students repeat the previous step 24 times for a total of 25 trials.
7. Have students complete the phenotype column of the chart and then determine the genotype and phenotype ratios of the offspring.

Observations and Conclusions

- Students explain why gene technology is controversial.
- Students discuss current advances in testing for genetic conditions. (For example, a reasonably reliable test now allows people to find out whether or not they have a gene for Huntington's disease [HD]).
- Students produce an appropriate data table in which they record their observations and explanations.

Sample assessment

- Have students describe two advances in genetic engineering that have made large-scale farming more profitable.
- Have students respond to the following questions:
  - How many traits are involved in a monohybrid cross?
  - In the lab activity above, what are the genotypes and phenotypes of the parents? What does each seed represent?

Follow-up/extension

- Read aloud each item from the "Controversial Gene Technologies" list shown at the bottom of the worksheet. Ask students to choose the one item they think is the most controversial and/or unethical and write a response as though they were a scientist *defending* that particular use of genetic engineering.
- In many dog breeds, inbreeding has resulted in certain genetic disorders being common to a particular breed, such as cataracts in Boston terriers. Have students research other disorders that are common to highly inbred animals, such as domestic dogs and horses.

- Have students research various regulations in the United States on genetic experimentation. Have them compare and contrast the regulations as they apply to genetic manipulation of prokaryotes, plants, and animals.
- Have students find out the current status of allowing DNA evidence in the courtroom and investigate a recent trial that has involved use of DNA evidence.
- Ask students how they could model a dihybrid cross of two parents, using the seeds.

Sample resources

- *DNA from the BEGINNING: an animated primer on the basics of DNA, genes, and heredity.* Cold Spring Harbor Laboratory. http://www.dnaftb.org/dnaftb/.
- *Gene Almanac: The source for timely information about genes in your life.* Cold Spring Harbor Laboratory. http://www.dnalc.org/home.html.
- *Learn.Genetics: Genetic Science Learning Center.* The University of Utah. http://gslc.genetics.utah.edu/.

Passing Traits On

Name: ________________________________ **Date:** ____________________

Data Table 1: Gamete Pairings

Trial	Genotype	Phenotype
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		

Data Table 2: Offspring Ratios

Genotype	Total	Genotype Ratio
Homozygous Dominant (GG)		:
Heterozygous (Gg)		:
Homozygous recessive (gg)		:
Phenotype		**Phenotype Ratio**
Green peas		:
Yellow peas		:

Controversial Gene Technologies

1. Cloning sheep
2. Producing a seedless watermelon
3. Inserting copies of a normal gene into individuals whose copy of the gene is defective
4. Producing genetically engineered drugs
5. Grafting multiple fruits onto one tree
6. Using recombinant DNA to synthesize vaccines
7. Testing for Tay Sachs
8. Making crops resistant to herbicides
9. Using DNA fingerprinting to solve crimes
10. Introducing a growth hormone into the diet of dairy cows to improve milk production

Sample Released SOL Test Items

Mendel proposed that traits observed in pea plants resulted from a combination of "factors" inherited from each parent. His description of these "factors" can be considered the first scientific definition of the role of —

F ribosomes

G meiosis

H genes

J cell nuclei

Many complex genetic experiments have been performed on plants. One of the very successful ones crossed wild wheat with a fungus-resistant wild grass. This ultimately produced a variety of wheat that was resistant to a very destructive parasitic fungus which kills nonresistant plants. Why would such experimentation benefit humans?

A The fungus is also dangerous to humans.

B Wheat is one of the most important food crops worldwide.

C The fungus could spread to all other plants.

D Wheat products made from infected plants would taste bad.

Organizing Topic — Investigating the Classification of Organisms

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.5 The student will investigate and understand how organisms can be classified. Key concepts include
- a) the distinguishing characteristics of kingdoms of organisms;
- b) the distinguishing characteristics of major animal and plant phyla; and
- c) the characteristics of the species.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• compare and contrast key features and activities between organisms;	______________
• classify organisms based on physical features;	______________
• arrange organisms in a hierarchy according to similarities and differences in features;	______________
• categorize examples of organisms as representatives of the kingdoms and recognize that the number of kingdoms is subject to change;	______________
• recognize scientific names as part of a binomial nomenclature;	______________
• recognize examples of major animal phyla;	______________
• recognize examples of major plant phyla (divisions).	______________

Classy Critters

Organizing Topic Investigating the Classification of Organisms

Overview This lesson introduces students to the classification of living things and allows them to make decisions about features that can be used to group organisms.

Related Standards of Learning LS.1j; LS.5a

Objectives

The students will
- classify organisms based on physical properties;
- arrange organisms in a hierarchy according to similarities and differences in features.

Materials needed

- Pictures of organisms representing each of the major kingdoms and phyla, with identification written on the backs

Instructional activity

Content/Teacher Notes

Plants exhibit needs for sunlight, nutrients, water, and gases. Animals exhibit needs for food, water, gases, shelter, and space. Students will first sort the organisms into groups that they choose. Then, they will sort the organisms into groups that lead to biological classification.

Introduction

Review the needs of living things and the process of life. Tell students that during the course of this activity, they will learn about the six kingdoms of living things and the major plant and animal phyla.

Procedure

1. Divide the students into teams of four or five students each. Distribute a set of pictures to each team, and ask each team to sort their pictures into groups. Have a team reporter make a chart of the groups the team members choose, listing the organisms in each group.
2. Have teams share their groupings with the class. Discuss the points of each grouping scheme.
3. Ask the students to sort the organisms by what the organisms need to live, such as those that need sunlight and those that do not or those that need carbon dioxide and those that do not.
4. Ask the students to sort the organisms by how they conduct certain processes, such as how they move or how they get energy.
5. Introduce biological classification to the students, including the six kingdoms and their attributes. Ask them to sort the organisms into the six kingdoms. Have students record the groups and organisms on their charts, including the major features of each group.
6. Introduce the major plant and animal phyla to the students. Ask them to sort the plants and animals into these groups. Have students record the groups and organisms on their charts, including the major features of each group.

Observations and Conclusions

- Students make decisions and draw conclusions about the organisms during each sort.

- Students draw conclusions from their answers to the following questions:
  - How are the organisms alike?
  - How are the organisms different?

Sample assessment

- Have each student choose one of the organisms and describe the ways this organism was grouped.
- Give each student an organism that was not in the original group, and have him/her classify it in the correct kingdom and phylum.

Follow-up/extension

- Have students research further classification levels of their organism.
- Give students pictures of a few very similar organisms (e.g., a wolf, dog, fox, coyote), and ask students to group them into smaller and smaller levels.
- Have students classify organisms they have found in their local area.

Sample resources

- *Animal Diversity Web.* University of Michigan Museum of Zoology. http://animaldiversity.ummz.umich.edu/site/index.html.
- *eNature.com. Bringing nature to life. Field Guides.* http://www.enature.com/home/. Offers online field guides of the National Wildlife Federation.

The Six Kingdoms

Organizing Topic Investigating the Classification of Organisms

Overview Students are asked to identify one organism from each of the major phyla in each of the six kingdoms.

Related Standards of Learning LS.1j; LS 5a, b, c

Objectives

The students will
- compare and contrast key features and activities between organisms;
- classify organisms based on physical features;
- classify organisms in a hierarchy according to similarities and differences in features;
- categorize examples of organisms as representatives of the kingdoms and recognize that the number of kingdoms is subject to change;
- recognize scientific names as part of a binomial nomenclature;
- recognize examples of major animal phyla;
- recognize examples of major plant phyla (divisions).

Materials needed

- Computers with Internet access and/or library resources
- Listing of animal phyla
- Sample project slideshow

Instructional activity

Content/Teacher Notes

If access to the Internet is not readily available, this activity can be completed using only print resources about the kingdoms of organisms. Students will have already studied basic classification and the six-kingdom system. In this activity, students will be asked to identify one organism from each of the major phyla. Any group of living organisms in one of the kingdoms can be substituted to make this activity shorter.

Introduction

Review the purpose of classification and the seven levels of classification. Ask students to list the six kingdoms. Then, ask them to list all the animal phyla they can recall. Allow them to gather in small groups to share and expand their lists. Hold a class discussion to list on the board the complete list of animal phyla.

Procedure

1. Have students use the Internet and/or print resources to find information on the six kingdoms. They should include the following:
   - Protists: three slides listed by phyla or locomotion
   - Archeobacteria: one slide listed by phylum
   - Eubacteria: one slide listed by phylum
   - Fungi: three slides listed by phyla
   - Plantae: six slides, including non-seed plants, two conifers, and two flowering plants (one dicot, one monocot)

   - Animalia: eight slides, including phyla of invertebrates and one each of the following vertebrates: fish, amphibians, reptiles, birds, and mammals
2. Have students use the Internet and/or print resources to find information about one organism in each phylum. Images can usually be found via a Google search, using the image search section. Students must record citation information for all images, including the following:
   - Title (phylum)
   - Name of organism
   - Prokaryote or eukaryote
   - Autotroph or heterotroph
   - Unicellular or multicellular
   - Type of locomotion
   - Type of reproduction
   - General characteristics of the organisms in this phylum
   - Picture of organism
   - References and citations for research and photo
3. When the students have completed their research, have them create a multimedia presentation or a "book" showing the results.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
  - What characteristics do all plants share? All animals? All protists? All fungi? All eubacteria? All archaebacteria?
  - How are scientific names created?

Sample assessment

- Have students explain the purpose of the modern classification system, including the advantages of the modern classification system over those presented by Aristotle.
- Use rubric for grading guidelines for the multimedia student presentations.

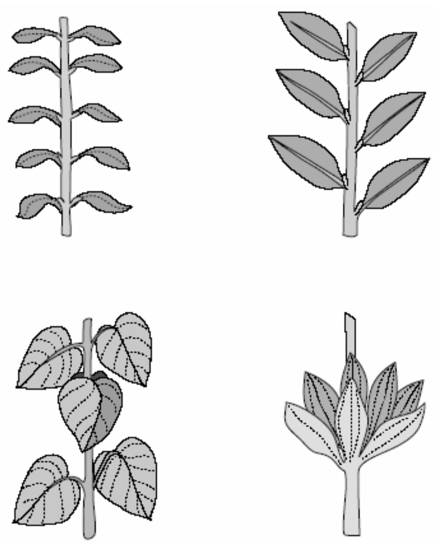
Follow-up/extension

- Have students put their multimedia presentations on a CD, and present a copy of the CD to the media center as a tool for student research.
- Have students select an ecosystem and identify the organisms in that ecosystem.
- Have students focus on land or marine organisms and then present their organisms to the class.

Sample Released SOL Test Items

Sponges are classified as animals because they cannot —

A move from place to place
B make their own food
C get rid of waste products
D catch their own food



Botanists often use leaves to identify plants. Which trait of the leaves shown would be *most* useful in identifying the plants they came from?

F Color of the leaf
G Function of the leaf
H Arrangement of leaves on a stem
J Presence or absence of veins

Organizing Topic — Investigating Plants

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.4 The student will investigate and understand that the basic needs of organisms must be met in order to carry out life processes. Key concepts include
- a) plant needs (light, water, gases, and nutrients);
- c) factors that influence life processes.

LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include
- a) phototropism, hibernation, and dormancy;
- b) factors that increase or decrease population size; and
- c) eutrophication, climate changes, and catastrophic disturbances.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• identify the basic needs of all living things;	____________________
• explain that there is a specific range or continuum of conditions that will meet the needs of plants;	____________________
• explain how plants obtain the materials and energy that they need;	____________________
• understand that plants may respond to light by growing toward it or away from it (a behavior known as phototropism);	____________________
• relate the responses of organisms to daily, seasonal, or long-term events;	____________________
• create plausible hypotheses about the effects that changes in available materials might have on particular life processes in plants;	____________________
• design an investigation from a testable question related to plant life needs. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis;	____________________

- analyze and critique the experimental design of basic investigations related to animal and plant needs, focusing on the skills developed in LS.1 and emphasizing clarity of predictions and hypotheses, organization of data tables, use of metric measures, adequacy of trials and samples, identification and use of variables, identification of constants, use of controls, displays of graphical data, and support for conclusions.

A-Mazing Plants

Organizing Topic Investigating Plants

Overview Students conduct an experiment that tests a plant's response to light.

Related Standards of Learning LS.1; LS.4a; LS.11a

Objectives

The students will
- explain that there is a specific range or continuum of conditions that will meet the needs of plants;
- analyze and critique the experimental design of basic investigation related to plant needs.

Materials needed

- Seedlings of a fast growing plant, such as beans
- Soil
- Small pots or cups
- Rectangular boxes (half-gallon milk containers or shoe boxes with lids work well)
- Cardboard
- Tape
- Black paint
- Scissors
- Rulers
- Graph paper
- Copies of the attached data sheet, "The Effect of a Maze on Phototropism"

Instructional activity

Content/Teacher Notes

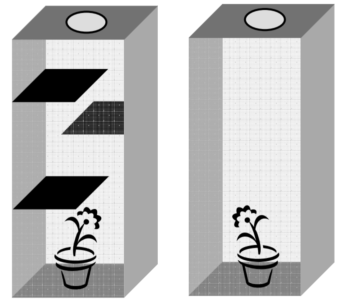
There are many experiments that can be conducted to test the needs of plants. Students may test the effects of varying such things as light source, light intensity, soil type, water amounts and ingredients, and fertilizer. These experiments provide data suitable for making continuous line graphs. In this activity, students need to be aware of the needs of plants and take steps to keep food, water, nutrients, and ambient light levels constant when conducting experiments on phototropism. Students will measure plant growth as the plant grows toward a light opening in a box or a box with a maze inside, as compared to control plants grown outside a box.

Introduction

Review the needs of plants. Ask students to brainstorm ideas of experiments that could test these factors. Discuss how plants can move; for example, roots grow toward the earth or seeds may fly in the wind or be carried by animals. Plants also grow toward their energy source. Point out examples of rapidly growing plants, such as kelp (which can grow a foot each day) and kudzu. Ask students whether they have noticed how plants grow toward the light—whether they have ever turned the pots of houseplants to maintain even growth. Brainstorm with students ways to test *phototropism*, which is the tendency of growing plant organs to move or curve under the influence of light. Suggest a maze box, and brainstorm maze patterns.

Procedure

1. Obtain and pot three fast growing seedlings, making sure to maintain constant conditions for all three—e.g., the same type of plant; same type of pot (volume); same quantity of soil (mass); same quantity, kind, and temperature of water (ml or l); same air temperature.



2. Paint the inside of two boxes black.
3. Draw a circle on the end of each box, and cut out the two circles. The boxes will be placed with the long ends vertical, as shown at right.
4. Cut pieces of cardboard about half the width of a box, and tape them inside one box to make a maze. (You can cut slits into the side of the box and insert the cardboard through them.)
5. Place the boxes in the same window or at the same distance from a light source.
6. Place a plant inside each box and a third plant near the boxes to serve as a control. Measure the height of each plant and record on a class data chart. Close the boxes.
7. Measure the height of each plant at regular time intervals, such as at the same time every day or every two days. Record all data on the class data chart. A ruler can be taped to the side of each box so that the plants will not be disturbed by measuring. Water the plants with the same quantity, kind, and temperature of water as needed.
8. After a week or two, have students use the resulting data to make a continuous line graph with three lines, each with a different color to represent the heights of the three plants. Have students also make comments on the direction of the plants' growth.

Observations and Conclusions

- Students observe and describe plant responses.
- Students draw conclusions from their answers to the following questions:
  - Why do the plants respond this way?
  - How does this experiment show phototropism?
  - How does this experiment simulate the way plants might grow in natural habitats? (Hint: Think about plants on the forest floor or seedlings growing in the shade of other plants.)

Sample assessment

- Have students complete the attached data sheet, "The Effect of a Maze on Phototropism."
- Have students use the worksheet and line graph to make predictions. Assess predictions as reasonable or unreasonable.

Follow-up/extension

- Have students design and carry out other mazes to test how a plant responds to light.
- Have students look for examples of phototropism and make a photo journal of their findings.
- Have students make a time-lapse video of phototropism.
- Have students design and carry out experiments on other tropisms, such as the response to gravity. (Place seeds on a damp paper towel inside a plastic bag. Tape the plastic bag to the wall or other vertical surface. Observe the root and shoot response as the seedlings germinate.)

Sample resources

- *American Society for Gravitational and Space Biology*. http://asgsb.org/index.php. Provides information and experiments about plant response to gravity.

- *ASGSB Slide Sets.* http://asgsb.org/slidesets/slidesets.html. Each slide set consists of a set of PowerPoint slides and a script describing each slide in the set.
- *Fast Plants.* http://www.fastplants.org/. Offers plant experiments and information for science teachers.
- *NASA: Exploration Systems Mission Directorate.* http://www.nasa.gov/directorates/esmd/home/index.html. Allows visitors to search experiments on phototropism and plant response to gravity in space.

The Effect of a Maze on Phototropism

Name: ________________________________ **Date:** ____________________

Independent variable:

Levels of the independent variable:

Control:

Dependent variable:

Constants:

Observations: Make a sketch of the appearance of each plant at the end of the experiment.

Control	**Plain Box**	**Maze Box**

Data:

Day	Height of Control Plant	Height of Plant in Plain Box	Height of Plant in Maze Box
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
12			
13			
14			

Conclusions:

Predictions:

Nutrient Pollution

Organizing Topic Investigating Plants

Overview Students observe the effect of fertilizers on the population in a pond.

Related Standards of Learning LS.1; LS.11c

Objectives

The students will
- simulate nutrient population in a pond and record their observations on the biotic components of this ecosystem;
- predict the effects nutrients would have on full size water habitats.

Materials needed

- Jars
- Wax pencil
- Distilled water
- Graduated cylinder
- Fertilizer
- Spoon
- Pond water
- Plastic wrap
- Gloves
- Microscopes
- Slides
- Cover slips
- Eyedroppers
- Copies of the attached data sheet, "The Effect of Fertilizer on Pond-Water Organisms"

Instructional activity

Content/Teacher Notes

Although plants require nutrients such as phosphates and nitrates, an overabundance of these can seriously damage aquatic ecosystems. When large quantities of fertilizers enter the water, algae and other plants grow quickly and die. Decomposers eat this dead matter and use up the oxygen in the water, killing the fish and other animals.

Introduction

Define *succession, nutrient pollution,* and *eutrophication.* Stress that eutrophication is continually occurring and is a natural process. Explain that fertilizers speed up this process.

Procedure

1. Label three jars "Unfertilized (Control)," "Fertilized," and "Over-Fertilized."
2. Put 1 liter of distilled water in each of the jars. Add the recommended amount of a fertilizer to the "Fertilized" jar and 10 times that amount to the "Over-Fertilized" jar. Stir well to dissolve.
3. Pour 100 ml of pond water into each jar after stirring the pond water to ensure that the organisms are equally distributed.

4. Have students observe a drop from each jar and draw four observed organisms on a data table like the one shown at right. Have them describe the appearance of the water and determine whether the organisms are algae or consumers.

	Sketch 1	Sketch 2	Sketch 3	Sketch 4	Color	Odor	Other Observations
Unfertilized (Control)							
Fertilized							
Over-Fertilized							

5. Cover the jars with plastic wrap, and place them in a well lit place but not in direct sunlight.
6. Have students make a prediction based on knowledge of succession, predicting how the various kinds of pond organisms will grow in the jars.
7. Have students observe the jars every three days for three weeks, noting and recording in a new data table each time the color, odor, and visible presence of organisms. They may need to use microscopes to make observations, but try not to disturb the water when drawing water samples with the eyedropper.

Observations and Conclusions

- After three weeks, students draw conclusions from their observations, answering the following questions:
  - Which jar had the most algae after three weeks?
  - How were the consumers affected as time progressed and the algae grew?
  - How can such succession be prevented?
  - How would this affect the health of an estuarine ecosystem?

Sample assessment

- Have students complete the attached data sheet, “The Effect of Fertilizer on Pond-Water Organisms.”

Follow-up/extension

- Have students discuss the effect on agriculture of reducing fertilizer-use. Have them offer some solutions to the problem of nutrient pollution.
- Have students design and carry out a controlled experiment to test the effect of detergent on pond-culture life.
- Have students research laws and other restrictions on fertilizer use, or the use of nutrients such as phosphorus and nitrogen in detergents.

Sample resources

- “Eutrophication.” *Toxic Substances Hydrology Program*. U.S. Department of the Interior: U.S. Geological Survey. http://toxics.usgs.gov/definitions/eutrophication.html.
- “VIMS Chesapeake Bay Model – The Primary Domain (coarse grid).” http://www.vims.edu/physical/WEB/Bay1.htm. Provides a Hydrodynamic Eutrophication Model of the Chesapeake Bay.

The Effect of Fertilizer on Pond-Water Organisms

Name: ________________________________ Date: ___________________

Independent variable:

Levels of the independent variable:

Control:

Dependent variable:

Constants:

Prediction:

Data:

Sample Released SOL Test Items

Hypothesis: The addition of a fertilizer to soil will increase plant growth.

Which of these experimental designs would best test this hypothesis?

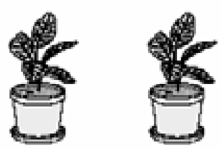
F

No Fertilizer No Water | No Fertilizer Water

G

Fertilizer Water | Fertilizer No Water

H



Fertilizer Water | No Fertilizer Water

J

Fertilizer Water | No Fertilizer No Water

Organizing Topic — Investigating Photosynthesis

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.6 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include
- a) energy transfer between sunlight and chlorophyll;
- b) transformation of water and carbon dioxide into sugar and oxygen; and
- c) photosynthesis as the foundation of virtually all food webs.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• describe the process of photosynthesis in terms of raw materials and products generated;	________________
• identify and describe the organelles involved in the process of photosynthesis;	________________
• describe that chlorophyll is a chemical in chloroplasts that can absorb or trap light energy;	________________
• explain how organisms utilize the energy stored from the products of photosynthesis;	________________
• relate the importance of photosynthesis to the role of producers as the foundation of food webs;	________________
• design an investigation from a testable question related to photosynthesis. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis;	________________
• analyze and critique the experimental design of basic investigations related to photosynthesis, focusing on the skills developed in LS.1 and emphasizing clarity of predictions and hypotheses, organization of data tables, use of metric measures, adequacy of trials and samples, identification and use of variables, identification of constants, use of controls, displays of graphical data, and support for conclusions.	________________

Carbon Dioxide and Photosynthesis

Organizing Topic Investigating Photosynthesis

Overview Students conduct an experiment to determine whether carbon dioxide is necessary for photosynthesis.

Related Standards of Learning LS.1i, j; LS.6b

Objectives

The students will

- describe the process of photosynthesis in terms of raw materials and products generated;
- describe chlorophyll as a chemical in chloroplasts that can absorb or trap light energy;
- explain how organisms utilize the energy stored from the products of photosynthesis;
- analyze and critique an investigation from a testable question related to photosynthesis.

Materials needed

- Small glass jars
- Collecting trays large enough to hold three jars
- Test tubes
- Boiled and cooled water
- Tap water
- Elodea plants
- Sodium bicarbonate
- Lamp with grow bulb (optional)
- Copies of the attached "Experimental Design Rubric" (optional)

Instructional activity

Content/Teacher Notes

Photosynthesis comes from two words: *photo*, meaning "light," and *synthesis*, meaning "to make." Photosynthesis nourishes almost all life on Earth directly or indirectly, for the path of the food chain leads from plants up through animals. Photosynthesis is a two-part process—the light and dark reactions. The conversion of carbon dioxide, water, and light into nutrition and oxygen is represented by the following chemical equation:

$$6CO_2 + 12H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

carbon dioxide + water + light energy → glucose + oxygen + water

Plants absorb carbon dioxide from the air through *stomata*, and they absorb water from the soil through their roots. Inside the chloroplasts of the leaves, *chlorophyll* absorbs light waves (energy) in the blue and red ranges. White light is a blend of colored light of differing wavelengths. The wavelengths of light are measured in units known as nanometers (nm). The colors of light that humans can see are called the visible spectrum. The light waves range from 400 to 700 nm. Humans cannot see light outside this range. Plants appear green because they reflect most of the green wavelengths. The light energizes the electrons' release from water. Plants produce glucose, sugar, and oxygen, but the oxygen is not used by the plant, and it is released into the environment.

Notes: This lab can be messy because water will be spilt; be prepared with a mop and towels. The "No CO_2" plant should be dead or dying after 3 to 5 days due to lack of carbon dioxide.

Introduction

Ask each student to complete a KWL chart on photosynthesis, emphasizing the things that are necessary for it to take place. Share the results, and create a class KWL chart. Review lab safety procedures related to cleanup of spills. Review with the class the background information given on the previous page under "Content/Teacher Notes."

Instruct each student to keep a lab journal of this experiment, including an illustrated log of events diagramming the experiment.

Procedure

Group students into lab teams. Distribute lab supplies, and have teams perform the following steps:

1. Label the glass jars "No CO_2," "CO_2," and "Water." Place the jars in a collecting tray, as water will spill.
2. Fill the "No CO_2" and "CO_2" jars with boiled and cooled water. Boiling removes the gases (including the carbon dioxide) that are dissolved in the water. Fill the "Water" jar with plain tap water.
3. Fill test tube #1 three-fourths full with boiled and cooled water. Place an Elodea plant in the tube with the cut stem pointing up toward the mouth of the tube. Fill the tube to the top with water so that a little spills over. Put your finger on the top of the test tube, flip it over, and place it mouth-down in the "No CO_2" jar.
4. Fill test tube #2 three-fourths full with boiled and cooled water. Add 500 mg of sodium bicarbonate, and stir until all of the powder is dissolved. Place an Elodea plant in the tube with the cut stem pointing up toward the mouth of the tube. Fill the tube to the top with water so that a little spills over. Put your finger on the top of the test tube, flip it over, and place it mouth-down in the "CO_2" jar.
5. Fill test tube #3 three-fourths full with the tap water. Repeat the process of placing an Elodea plant in the tube, and place the tube in the "Water" jar.
6. Place all three jars in bright light. Sunlight is best, but a plant grow bulb will work. Examine the test tubes, and record your observations.
7. Wait 30 minutes, examine the test tubes again, and record your observations. If bubbles form in any tube, observe the Elodea stem to see whether it is producing the bubbles. The bubbles are oxygen, and the production of oxygen signals that photosynthesis is taking place. Observe what happens to any bubbles that form, and record your observations.
8. Wait 24 hours, examine the test tubes again, and record your observations. Again, observe the Elodea stem to see whether it is producing any bubbles. Observe what happens to any bubbles that form, and record your observations.
9. Continue the observation every other day for a week, and record your observations.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
  - What was the independent (manipulated) variable in this experiment? The dependent (responding) variable?
  - What was the purpose of the sodium bicarbonate?
  - What process produced the bubbles you observed?
  - What was the purpose of test tube #3?
  - How did the reactions of the plants in the three jars compare?
  - Based on your results, is carbon dioxide necessary for photosynthesis?

- What did you learn about photosynthesis from this experiment?
- Was your experiment a controlled experiment? Explain.
- Did you identify any flaws in the experimental design? Explain.
- If you found no flaws in the experimental design, what is at least one way you could improve on or expand this experiment?

Sample assessment

- Have students complete a formal lab report for the experiment, including
  - identification of the independent and dependent variables, the control, and the constants
  - the daily observations and drawings
  - a conclusion comparing the three test tubes and discussing the results of the experiment.
- Have students exchange lab reports and complete peer reviews of them, using the attached “Experimental Design Rubric.”
- Have students explain the following major concepts:
  - Photosynthesis is the necessary life process that transforms light energy into chemical energy. It involves a series of chemical reactions in which the light energy is used to change raw materials (carbon dioxide and water) into products (sugar and oxygen). The energy is stored in the chemical bonds of the glucose (sugar) molecules.
  - Energy is a basic need of all living things. Photosynthesizing organisms obtain their energy from the sun. Plants and other photosynthesizing organisms are often called “producers” because of their ability to produce glucose (sugar).
  - Chlorophyll is a chemical in chloroplasts that can absorb or trap light energy.
  - Photosynthesizing organisms are at the base of the energy pyramid.

Follow-up/extension

- Have students complete an experiment using various levels of sodium bicarbonate. Exactly how much is necessary for healthy plant growth?
- Have students collect samples of water released near treatment plants, power plants, or other industrial sites that heat the water before releasing it. Have students use that water in the experiment, and based on the results, determine how plants will grow in those areas.

Sample resources

- “What Is Photosynthesis?” *Center for Bioenergy & Photosynthesis.* Arizona State University. http://photoscience.la.asu.edu/photosyn/education/learn.html.

Experimental Design Rubric

	4	3	2	1
Variables	Independent variable, levels of the independent variable, and dependent variable are described in detail.	Independent variable and dependent variable are described with most details.	Attempt is made to describe independent variable and dependent variable, but it is not accurate.	Variables are not described, OR they lack sufficient detail.
Control	Control is described in detail as the normal or zero level of the independent variable.	Control is included and described in some detail as the normal or zero level of the independent variable.	Attempt is made to control the experiment, but it is not accurate.	No control is used in the experiment.
Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable. Hypothesis uses the "If…then" format.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results is stated, but it appears to be based on flawed logic.	No hypothesis is stated.
Constants	All possible constants are given for the experiment.	Most constants are given for the experiment.	Some constants are given for the experiment.	No or few constants are given for the experiment.
Analysis	The relationship between the variables is discussed, and trends/patterns logically and graphically analyzed.	The relationship between the variables is discussed, and trends/patterns logically analyzed and/or graphed.	The relationship between the variables is discussed, but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.
Safety	Lab is carried out with full attention to relevant safety procedures. The setup, experiment, and cleanup is conducted safely.	Lab is generally carried out with attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but several safety procedures need to be reviewed.	Safety procedures are ignored and/or some aspect of the experiment poses a threat to the safety of the student or others.
Conclusion	Conclusion clearly states the effect the independent variable had on the dependent variable and discusses possible sources of error.	Conclusion states the effect the independent variable had on the dependent variable.	Conclusion describes the results.	No conclusion is included in the report, OR conclusion shows little effort and reflection.

Photosynthesis and Transpiration

Organizing Topic Investigating Photosynthesis

Overview Students grow seedlings and measure the length and mass of the seedlings each day. They observe seedlings that have been enclosed in a sealed, lighted container for 24 hours. They explain the appearance of condensation in the container as a result of transpiration, and they relate photosynthesis and transpiration.

Related Standards of Learning LS.1; LS.6b

Objectives

The students will
- describe the process of photosynthesis in terms of raw materials and products generated;
- complete an investigation focused on systematic observation, description, measurement, and/or data collection and analysis from a testable question related to photosynthesis;
- analyze and critique an investigation from a testable question related to photosynthesis.

Materials needed

- Pea seeds (or other fast-growing seeds)
- Petri dishes
- Warm tap water
- Egg cartons (plastic or foam) or seeding starter trays with at least 12 seed wells
- Dry potting soil
- Balance scales
- Clear glass jars large enough to hold one eggcup section
- Lids for jars
- Digital camera (optional)

Instructional activity

Content/Teacher Notes

Photosynthetic organisms, like plants, form the base of almost all food webs. Plants provide a renewable source of food energy for many forms of life. Green plants use sunlight and gases in the atmosphere to produce sugar (glucose) through the process of photosynthesis. They release gases (water vapor) into the atmosphere in the associated process of transpiration.

Seeds hold energy stored as a result of photosynthesis. The stored energy is released and used during germination and growth of the seedling. After the initial growth, the plant must begin to photosynthesize to continue to survive. Lack of light during this process will adversely affect the growth of the plant. Use of the stored energy can be physically measured by charting the weight change in the seed. After the initial growth, the seedlings will begin to photosynthesize and then gain weight.

Helpful hints: Cardboard egg cartons will mildew or mold, so use plastic or foam egg cartons instead. Seedling trays are also perfect and can be reused many times. “Fast grow seeds” have a short germination time and will show significant changes in the given time. Timing can be tricky for this experiment, so start the germination on a Monday. If growing space is limited, have each group do a single tray, and then pair them up with another group to share their observations. Warn students to be very careful if they plan to replant the seeds, because initial root growth can be very delicate.

Introduction

Ask students where the energy for seed growth comes from. Explain that students will be growing seeds in light and dark locations and measuring the length and mass of the seedlings each day. Ask students to identify the independent and dependent variables and the control in this experiment. Review proper lab procedures, especially cleanup and disposal. Review the proper format for quantitative (numerical) and qualitative (written observations) data.

Instruct each student to keep a lab journal of this experiment, including an illustrated log of events diagramming the germination of the seedlings throughout the experiment.

Procedure

Group students into lab teams. Distribute lab supplies, and have teams perform the following steps:

1. On a Monday, start the germination of the pea seeds by placing them on damp paper towels in the Petri dish and covering them with warm tap water. Place the dish in a location with indirect sunlight. The seed coats should split, and the first growth should be visible in two or three days. After the seeds begin to sprout (on Wednesday or Thursday), they are ready to be planted in the egg-carton "pots" or seeding starter trays.
2. Prepare the egg-carton pots by cutting the carton in half lengthwise to yield two strips with six cups each. Cut one cup off the end of each strip and discard it. Put a small hole in the bottom of each cup for drainage. Label one strip "Light" and the other "No Light." Number the cups in each strip from 1 to 5. Fill each cup with soil up to 1/2 in. from the top.
3. Weigh and record the mass of each seedling. Place one seed on the soil in each cup, and cover it up with 1/4 in. more of soil.
4. Sprinkle water over the top of the soil until the soil is well-saturated and water comes out of the bottom of each cup. Photograph each tray.
5. Place one planter strip in a well-lit place and the other in the designated dark area. Try to select areas where the temperatures will be similar.
6. Allow both sets of seeds to grow for two to four days. Water each day as necessary for the soil to remain slightly damp but not wet.

<u>Monday Observations</u>

7. After two to four days (on the following Monday), remove the planter strips from their designated areas. Photograph each tray. This step should be done on a Monday to allow for observations over five consecutive days.
8. Carefully separate cup #1 from each set, and return the remaining cups to their designated areas.
9. Compare the two seedlings. Remove the seedlings from the soil, and rinse them gently to remove all soil. Measure and record their length (straighten gently to measure from tip of root to tip of seedling), and write a physical description comparing their roots, stems, and leaf development, as well as their colors. Weigh each seedling, and record the two masses. Photograph the seedlings, and then discard them (or replant them for further use: see suggestion under "Follow-up/extension").

<u>Tuesday and Wednesday Observations</u>

10. Repeat steps 7–9 with the second and third cups. On Wednesday, do not return the "No Light" cups to the dark location, but leave them in the light.

<u>Thursday Observations</u>

11. Repeat steps 7–9 with the fourth cups. Place the fifth cups in glass jars and seal the jars. Leave the jars in the light.

Friday Observations

12. Observe the jars, and record all observations. Photograph the jars with the seedlings.
13. Remove the seedlings from the jars and repeat steps 7–9. All observations are now complete.

Observations and Conclusions

- Students construct a line graph showing the growth of the seedlings (their length) over five days.
- Students draw and label a diagram explaining the process of photosynthesis, including both “light” and “dark” stages.
- Students construct a line graph showing the mass of the seedlings (weight) from the start to the finish of the experiment. They describe the change in mass and explain how it was caused.
- Student draw conclusions from their answers to the following questions:
  - What was the purpose of starting the germination in water? How might a low water level affect seedling germination?
  - Compare the growth of the seedlings in the light and the dark. Were there any differences? If so, explain.
  - Did the “dark” seedlings change their growth patterns when they were placed in the light? Explain.
  - What might explain the difference in the data collected from each group?
  - Were there any inconsistencies in your data, e.g., dead seedlings, unexpected growth spurts? If so, describe them. Did other students have similar inconsistencies? What might have caused these inconsistencies?
  - What did you observe in the jar on the final day? What caused it? Draw and label a diagram explaining this process.
  - Did you identify any flaws in the experimental design? Explain.
  - If you found no flaws in the experimental design, what is at least one way you could improve on or expand this experiment?

Sample assessment

- Have students complete a formal lab report for the experiment, including
  - identification of the independent and dependent variables, the control, and the constants
  - a quantitative analysis showing the charts of plant length and plant mass
  - a qualitative analysis with the daily observations and the photographs
  - a conclusion comparing the light-dark growth and discussing the mass change.
- Have students exchange lab reports and complete peer reviews of them, using the attached “Experimental Design Rubric.”
- Have students explain the following major concepts:
  - Photosynthesis is the necessary life process that transforms light energy into chemical energy. It involves a series of chemical reactions in which the light energy is used to change raw materials (carbon dioxide and water) into products (sugar and oxygen). The energy is stored in the chemical bonds of the glucose (sugar) molecules.
  - Energy is a basic need of all living things. Photosynthesizing organisms obtain their energy from the sun. Plants and other photosynthesizing organisms are often called “producers” because of their ability to produce glucose (sugar).
  - Chlorophyll is a chemical in chloroplasts that can absorb or trap light energy.
  - Photosynthesizing organisms are at the base of the energy pyramid.

Follow-up/extension

- Get permission to dig up a small piece of turf grass on the school property so that students may examine the depth of the roots and their structure. Discuss the differences between the pea seedling roots and the grass roots. Have students compare the physical characteristics of the two types of plants.
- Have students conduct the experiment with an altered variable —i.e., the level of fertilizer. Levels should include no fertilizer and at least two other groups: one-half dose and full dose, or full dose and double dose. Many students are surprised that the double dose can actually damage the plants.
- Save the seedlings after the observation, and replant them for use in a later experiment. They can be great terrarium plants.

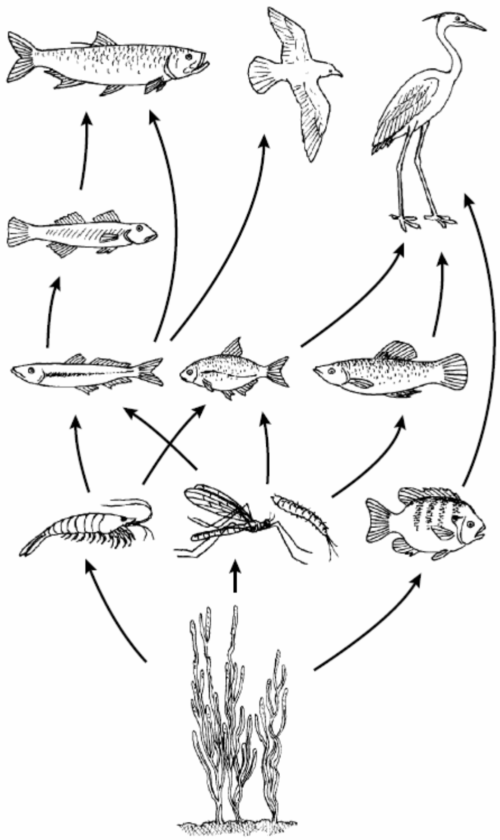
Sample resources

- "What Is Photosynthesis?" *Center for Bioenergy & Photosynthesis.* Arizona State University. http://photoscience.la.asu.edu/photosyn/education/learn.html.

Experimental Design Rubric

	4	3	2	1
Variables	Independent variable, levels of the independent variable, and dependent variable are described in detail.	Independent variable and dependent variable are described with most details.	Attempt is made to describe independent variable and dependent variable, but it is not accurate.	Variables are not described, OR they lack sufficient detail.
Control	Control is described in detail as the normal or zero level of the independent variable.	Control is included and described in some detail as the normal or zero level of the independent variable.	Attempt is made to control the experiment, but it is not accurate.	No control is used in the experiment.
Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable. Hypothesis uses the "If…then" format.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results is stated, but it appears to be based on flawed logic.	No hypothesis is stated.
Constants	All possible constants are given for the experiment.	Most constants are given for the experiment.	Some constants are given for the experiment.	No or few constants are given for the experiment.
Analysis	The relationship between the variables is discussed, and trends/patterns logically and graphically analyzed.	The relationship between the variables is discussed, and trends/patterns logically analyzed and/or graphed.	The relationship between the variables is discussed, but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.
Safety	Lab is carried out with full attention to relevant safety procedures. The setup, experiment, and cleanup is conducted safely.	Lab is generally carried out with attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but several safety procedures need to be reviewed.	Safety procedures are ignored and/or some aspect of the experiment poses a threat to the safety of the student or others.
Conclusion	Conclusion clearly states the effect the independent variable had on the dependent variable and discusses possible sources of error.	Conclusion states the effect the independent variable had on the dependent variable.	Conclusion describes the results.	No conclusion is included in the report, OR conclusion shows little effort and reflection.

Sample Released SOL Test Items



Which process is the foundation for the food web?

F Evaporation

G Condensation

H Photosynthesis

J Movement

Plants release oxygen into the air as a result of photosynthesis. Which of these do plants need for photosynthesis?

A Carbon dioxide

B Nitrogen

C Methane

D Hydrogen

Organizing Topic — Investigating Animals

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.4 The student will investigate and understand that the basic needs of organisms must be met in order to carry out life processes. Key concepts include
- b) animal needs (food, water, gases, shelter, space); and
- c) factors that influence life processes.

LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include
- a) phototropism, hibernation, and dormancy;
- b) factors that increase or decrease population size; and
- c) eutrophication, climate changes, and catastrophic disturbances.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• distinguish between the needs of plants and animals;	____________
• identify the basic needs of all living things;	____________
• explain that there is a specific range or continuum of conditions that will meet the needs of animals;	____________
• explain how animals obtain the materials that they need;	____________
• relate the responses of animals to daily, seasonal, or long-term events;	____________
• explain that animals may respond to cold conditions with a period of lowered metabolism (a behavior know as hibernation);	____________
• create plausible hypotheses about the effect that changes in available materials might have on particular life processes in animals;	____________
• design an investigation from a testable question related to animal life needs. The investigation may be a complete	

experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis; ______________________________

- analyze and critique the experimental design of basic investigations related to animal needs, focusing on the skills developed in LS.1 and emphasizing clarity of predictions and hypotheses, organization of data tables, use of metric measures, adequacy of trials and samples, identification and use of variables, identification of constants, use of controls, displays of graphical data, and support for conclusions. ______________________________

Curious Crickets

Organizing Topic Investigating Animals

Overview Students observe how living things react to stimuli in their environment and understand how an animal's space must meet all of the animal's needs.

Related Standards of Learning LS.1; LS.4b, c

Objectives

Student should be able to
- design and conduct a controlled experiment;
- observe an animal react to environmental stimuli;
- perform tests to determine which environmental spaces provide for an animal's needs.

Materials needed

- Copies of the attached "Cricket Observations Student Activity Sheet"
- Aquarium (10-gallon)
- Sand or soil to line aquarium
- Crickets or other small, easily obtained animals
- Large bug boxes or magnifying containers
- Rulers
- Empty paper-towel tube
- Timer, clock, or stopwatch
- Dog or cat kibble (optional)
- Damp and dry sponges (optional)
- Shallow tray filled with water and frozen (optional)

Instructional activity

Content/Teacher Notes

Animals exhibit the need for food, water, gases, shelter, and space. These needs may be met in a range of conditions, but too much of some things may be as harmful as too little. When these needs are adequately met, the animal is able to carry out the life functions and processes of respiration, removal of wastes, growth, reproduction, digestion, and cellular transport. This series of experiments allows the student to test and observe an animal as it reacts to changes in environmental conditions that fulfill its basic needs.

Introduction

Review the needs of living things and the process of life. Remind students how to care for classroom animals humanely. You may wish to read a story about someone who learns how to take care of a pet's needs.

Procedure

1. Prepare a habitat for the crickets by lining the bottom of a clean 10-gallon aquarium with sand or dirt. The sand should be spread evenly and be of consistent color and particle size.
2. Obtain crickets from a bait or pet store. (An alternate species would be the sowbug, or "roly poly," which is easily found under garden rocks and flower pots.)

3. Place a cricket in each of the bug boxes, and distribute them to lab groups. Remind students to not shake the box or otherwise harm the insect.
4. Have students observe their crickets. Ask them to include a labeled sketch and description in their lab notes. Descriptions should include a measurement of the cricket's length, which students can make by placing a ruler under the box. Point out that the female crickets are the ones with a tube (the ovipositor) extending from the abdomen.
5. Return the crickets to their home container. As the bug boxes are sealed, students will need to work quickly so the cricket can be returned to an environment that provides continuous air.
6. Place an empty paper-towel tube in the aquarium. Ask students to predict whether the crickets will prefer the light environment outside the tube or the dark environment inside it. Make sure all other conditions in the habitat are held constant.
7. Place 10 crickets in the aquarium. Allow the crickets three minutes to adjust to the habitat and go to the preferred area. Record the number of crickets found in each condition.
8. Conduct repeated trials by removing and replacing the crickets. Hint: A good way to transport the crickets from the experimental habitat to their cage is to allow them to gather in the paper tube and then gently tap them out of the tube into their cage.
9. Brainstorm with students other experiments that can be conducted with the cricket habitat. These might include water—i.e., their reaction to a damp sponge and a dry sponge. (The response to water can also be tested by adding moisture to the sand in one half of the tank; however, this also alters another variable—the color of the sand.) To test the response to food, provide an area with kibble and an area without kibble. Response to temperature can be tested by placing a tray of ice under one half of the aquarium and an empty tray under the other half. Students may suggest changing the color or texture of the surface the crickets use, which can be easily tested by laying sheets of construction paper on the sand.

Observations and Conclusions

- Students discuss the behavior of the crickets under each condition.
- Students draw conclusions from their answers to the following questions:
  - Did the crickets respond to the amount of light, or were they seeking shelter in the tube? Explain.
  - What was the independent variable in the experiment? The dependent variable?
  - Which conditions were the control conditions?
  - What factors in the habitat were kept constant?

Sample assessment

- Have students complete a lab report on the cricket experiment, defining variables, identifying control and constants, and drawing conclusions.
- Have students use the data in the data table to find the mean for the cricket responses. Have them make a bar graph showing Habitat vs. Number of Crickets Responding.
- Apply the attached "Experimental Design Rubric" to the lab reporting process.

Follow-up/extension

- Have students test additional factors of the cricket habitat.
- Have students test the responses of other small species.

Sample resources

- “Acheta domesticus (house cricket).” *Animal Diversity Web.* University of Michigan Museum of Zoology. http://animaldiversity.ummz.umich.edu/site/accounts/classification/Acheta_domesticus.html. Shows house cricket classification.
- *Breeding and Raising the House Cricket.* Melissa Kaplan’s Herp Care Collection. http://www.anapsid.org/crickets.html.
- *House Crickets: Acheta domesticus: Order Orthoptera, Family Gryllidae.* Louise Kulzer. http://crawford.tardigrade.net/bugs/BugofMonth31.html.

Cricket Observations Student Activity Sheet

Name: ___________________________________ Date: ____________________

Procedure

1. Sketch and describe your observations in the space below.
2. Write responses for the factors listed.

The Effect of ____________________ on Cricket Habitat Choice
(habitat factor tested)

Sketch	**Description**

Hypothesis:

Independent variable:

Levels of the independent variable:

Control:

Dependent variable:

Constants:

Prediction of cricket response to change of the habitat factor:

Data:

Trial	Control Number of crickets in the unchanged habitat area	Experiment Number of crickets in the changed habitat area
1		
2		
3		
total		
mean		

Graph of means:

Conclusion:

Experimental Design Rubric

	4	3	2	1
Variables	Independent variable, levels of the independent variable, and dependent variable are described in detail.	Independent variable and dependent variable are described with most details.	Attempt is made to describe independent variable and dependent variable, but it is not accurate.	Variables are not described, OR they lack sufficient detail.
Control	Control is described in detail as the normal or zero level of the independent variable.	Control is included and described in some detail as the normal or zero level of the independent variable.	Attempt is made to control the experiment, but it is not accurate.	No control is used in the experiment.
Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable. Hypothesis uses the "If…then" format.	Hypothesized relationship between the variables and the predicted results is reasonable, based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results is stated, but it appears to be based on flawed logic.	No hypothesis is stated.
Constants	All possible constants are given for the experiment.	Most constants are given for the experiment.	Some constants are given for the experiment.	No or few constants are given for the experiment.
Analysis	The relationship between the variables is discussed, and trends/patterns logically and graphically analyzed.	The relationship between the variables is discussed, and trends/patterns logically analyzed and/or graphed.	The relationship between the variables is discussed, but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.
Safety	Lab is carried out with full attention to relevant safety procedures. The setup, experiment, and cleanup is conducted safely.	Lab is generally carried out with attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The setup, experiment, and cleanup poses no safety threat to any individual, but several safety procedures need to be reviewed.	Safety procedures are ignored and/or some aspect of the experiment poses a threat to the safety of the student or others.
Conclusion	Conclusion clearly states the effect the independent variable had on the dependent variable and discusses possible sources of error.	Conclusion states the effect the independent variable had on the dependent variable.	Conclusion describes the results.	No conclusion is included in the report, OR conclusion shows little effort and reflection.

Sample Released SOL Test Items

One way plants and animals are alike is that they both —

A move to get their food

B make their own food

C use carbon dioxide

D use oxygen

Which of these has the greatest influence over how big a baby elephant will grow?

F The amount of oxygen in the air

G The amount of food available

H The size of the trees in the jungle

J The type of grass on the plains

Organizing Topic — Investigating Energy Flow

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.7 The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include
- a) the carbon, water, and nitrogen cycles;
- b) interactions resulting in a flow of energy and matter throughout the system;
- c) complex relationships within terrestrial, freshwater, and marine ecosystems; and
- d) energy flow in food webs and energy pyramids.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• observe and identify common organisms in ecosystems and collect, record, and chart data concerning the interactions of these organisms (from observations and print and electronic resources);	______________________
• classify organisms found in local ecosystems as producers or first-, second-, or third-order consumers. Design and construct models of food webs with these organisms;	______________________
• observe local ecosystems and identify, measure, and classify the living and nonliving components;	______________________
• differentiate among key processes in the water, carbon, and nitrogen cycles and analyze how organisms, from bacteria and fungi to third-order consumers, function in these cycles;	______________________
• determine the relationship between a population's position in a food web and its size;	______________________
• identify examples of interdependence in terrestrial, freshwater, and marine ecosystems;	______________________
• apply the concepts of food chains, food webs, and energy pyramids to analyze how energy and matter flow through an ecosystem;	______________________

- design an investigation from a testable question related to food webs. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis; ____________________________
- analyze and critique the experimental design of basic investigations related to food webs. ____________________________

Freshwater Food Chains

Organizing Topic Investigating Energy Flow

Overview Students analyze the energy relationships in a drop of pond water.

Related Standards of Learning LS.1; LS.7

Objectives

The students will
- observe freshwater pond micro-organisms;
- observe and identify common organisms in ecosystems.

Materials needed

- Pond-water samples
- Slides
- Cover slips
- Gloves
- Droppers
- Microscopes
- Field guides to pond life
- Copies of the attached "Pond-Water Activity Sheet"

Instructional activity

Content/Teacher Notes

Review basic microscope skills and how to make a wet mount slide. Select a sample of pond water containing much green, scummy algae. Preview the pond culture to make sure you are familiar with the organisms present. While identifying the organisms may be useful, the main point of the activity is to analyze the relationships present.

Introduction

Review the components of a freshwater community. Make sure students are aware that the micro-organisms they see are only a small piece of the pond ecosystem. Review or introduce food chains and food webs, making sure students understand the difference between them. Show sample pond-water food webs to increase understanding and engage the students in the activity. Review or introduce energy pyramids.

Procedure

1. Have students make a wet mount slide of a sample of pond-water. *Safety Note: Have students use gloves.* Remind students to include some of the green algae in their sample because just like animals hide among plants in the woods, animals take shelter in the plant material in the pond water.
2. Have students observe their pond-water sample through the microscope. Encourage students to view multiple locations on their slide or more than one slide.
3. Distribute copies of the "Pond-Water Activity Sheet." Have students take notes on and make field-view drawings of the organisms they see in the pond water. Field guides may be used to identify the organisms present, or students may use short descriptions of organisms they cannot identify.

4. Have students determine what energy relationships would be possible among the organisms and then analyze this information to develop food chains. If enough data is available, students can generate a food web from it, or they may share information with classmates to gain more data.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
  - What organisms are present in the sample of pond water?
  - Which ones are producers? Which are consumers?
  - What are the possible relationships between these organisms?
  - What are examples of interdependence in the sample?
  - Which organisms are more numerous?
  - What is the relationship between a population's position in a food web and its size?

Sample assessment

- Have students complete lab sheets, including observations from their sample.
- Have students complete a food web or food chain that represents their sample accurately and shows relationships correctly.

Follow-up/extension

- Have students use the data from the pond water to make a three-dimensional energy pyramid.
- Have students complete more (or fewer) trials and compare the accuracy when having more (or less) data. How does the number of trials affect the estimation of population size?
- Have students research the classification of specific pond organisms.
- Have students create a field guide to the class pond-water sample.

Sample resources

- *eNature.com. Bringing nature to life. Field Guides.* http://www.enature.com/home/. Offers online field guides of the National Wildlife Federation.
- *Pond Life Identification Kit: A simple guide to small and microscopic pond life with links to Micscape resources.* Microscopy UK. http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/.
- "Pond Life." *Molecular Expressions.* http://micro.magnet.fsu.edu/moviegallery/pondscum.html.

Pond-Water Activity Sheet

Name: ___________________________________ **Date:** ____________________

Field View	**Identity of Specimen**	**Description**
	_______________ **100 ×** ____	
	_______________ **100 ×** ____	
	_______________ **100 ×** ____	

Conclusion

What are the energy relationships among the pond-water microscopic organisms?

Cycles of Nature

Organizing Topic Investigating Energy Flow

Overview Students diagram and explain the water cycle, carbon cycle, and nitrogen cycle.

Related Standards of Learning LS.1j; LS.7a

Objectives

The students will
- diagram and explain the water cycle, carbon cycle, and nitrogen cycle;
- describe how living organisms fit into each of these cycles.

Materials needed

- Poster paper
- Markers
- Magazines
- Scissors, glue, and other craft materials.
- Copies of the attached labels for posters of the three cycles of nature

Instructional activity

Content/Teacher Notes

Matter has been on the Earth since it was formed billions of years ago. It is used over and over again in cycles. Each type of matter has its own cycle. In cycles, matter moves through living organisms and the environment.

Introduction

Have students read in their text or other reference about each of these three cycles. Review the terms *precipitation, evaporation, ground water, condensation, decomposition, combustion, respiration,* and *photosynthesis.*

Procedure

1. Hold a class discussion on the three cycles to review the information the students have read about them.
2. Divide the students into groups of three to participate in the following cooperative learning “Jigsaw” activity. Number each student in each group one, two, or three.
3. Have all number one’s meet together to create a poster of the water cycle, number two’s create a poster of the nitrogen cycle, and number threes create a poster of the carbon cycle. Magazines and other craft material may be used to depict the environment and organisms involved. Distribute copies of the attached labels to the appropriate groups so that they can place them in appropriate places on the posters.
4. Have students discuss answers to questions listed below that address their particular cycle.
5. Have students then return to their original groups and teach their peers about the cycle on which they have just focused.
6. After all students have presented, allow each group time to discuss the answers to all the questions listed below.

7. Have each student write the questions and answers on his/her own response sheet and list the names of the other two members of his/her group at the top of the sheet.
8. Display the posters for future reference.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
    - Why are cycles important to living things?
    - Where does water travel as it moves through the water cycle?
    - How does the water cycle serve to clean water?
    - What role do bacteria play in the nitrogen cycle?
    - What is nitrogen fixation?
    - What kinds of organisms are involved in decomposition?
    - How does carbon enter plants from the nonliving parts of the environment?

Sample assessment

- Assess each group's poster and each student's answers to the seven questions.
- Ask students to explain what would happen if water were to stop evaporating.
- Ask students how the carbon cycle would be affected if decomposers were to be removed from the environment.

Follow-up/extension

- Have students explain how the pollution cycle is influenced by the water cycle.

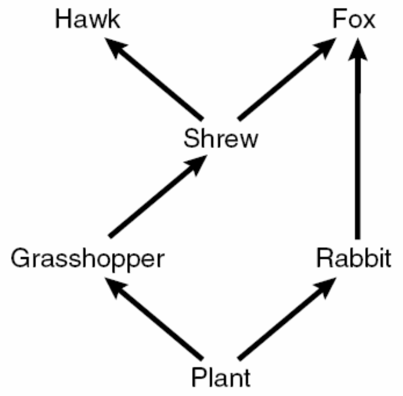
Sample resources

- *Around and around you go; where you'll stop nobody knows. The Carbon, Nitrogen, and Water Cycles.* Gary Strickland and Sherri Merrill. http://my-ecoach.com/online/webresourcelist.php?rlid=4115.
- "Cycles." *REAL TREES 4 Kids!: The story and science of REAL TREE farming: Grades 6–8.* http://www.realtrees4kids.org/sixeight/cycles.htm.
- "Environmental Cycles." *GreenFacts: Facts on Health and the Environment.* http://www.greenfacts.org/glossary/def/environmental-cycles.htm.

Labels for Cycles of Nature Posters

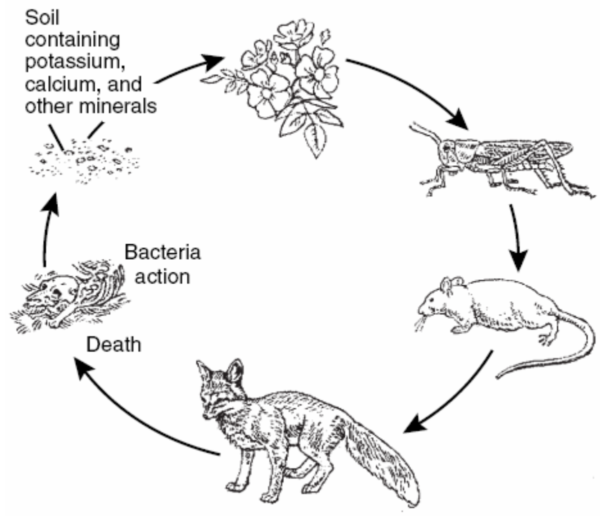
The Water Cycle
Runoff
Condensation
Precipitation
Transpiration
Evaporation
Groundwater
The Nitrogen Cycle
Nitrogen in the air
Animals get nitrogen from plants
Dead animals and plants
Decomposers release nitrogen
Nitrogen uptake by plant roots
Bacteria change nitrogen back into a gas
Nitrogen-fixing bacteria in plant roots
Nitrogen fixation by lightening
The Carbon Cycle
Carbon dioxide in the air
Photosynthesis
Combustion
Respiration
Burning fossil fuels
Fossil fuels in the Earth
Death and decomposition

Sample Released SOL Test Items



The primary producer in the ecosystem above is the —

F plant
G rabbit
H hawk
J fox



Which concept is best illustrated by this diagram?

A The exchange of CO_2 and O_2 in an ecosystem
B The effect of limiting factors in a biome
C Cycling of nutrients in a community
D Environmental pressures on a population

Organizing Topic — Investigating Communities

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.8 The student will investigate and understand that interactions exist among members of a population. Key concepts include
- a) competition, cooperation, social hierarchy, territorial imperative; and
- b) influence of behavior on a population.

LS.9 The student will investigate and understand interactions among populations in a biological community. Key concepts include
- a) the relationships among producers, consumers, and decomposers in food webs;
- b) the relationship between predators and prey;
- c) competition and cooperation;
- d) symbiotic relationships; and
- e) niches.

LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include
- a) phototropism, hibernation, and dormancy;
- b) factors that increase or decrease population size; and
- c) eutrophication, climate changes, and catastrophic disturbances.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• identify the populations of producers, consumers, and decomposers and describe the roles they play in their communities;	____________________
• comprehend that in a community, populations interact with other populations by exhibiting a variety of behaviors that aid in the survival of the population;	____________________
• comprehend that organisms or populations that rely on each other for basic needs form interdependent communities;	____________________

- interpret, analyze, and evaluate data from systematic studies and experiments concerning the interactions of populations in an ecosystem; ____________________
- predict the effect of population changes on the food web of a community; ____________________
- comprehend that energy resources of a community are shared through the interactions of producers, consumers, and decomposers; ____________________
- comprehend that the interaction between a consumer that hunts another consumer for food is a predator-prey relationship; ____________________
- generate predictions based on graphically represented data of predator-prey populations; ____________________
- comprehend that populations of one species may compete with populations of other species for resources. Populations of one species may also cooperate with populations of other species for resources; ____________________
- generate predictions based on graphically represented data of competition and cooperation between populations; ____________________
- comprehend that symbiotic relationships include mutualism (in which both organisms benefit), commensalism (in which one organism benefits and the other is unaffected), and parasitism (in which one organism benefits and the other is harmed); ____________________
- differentiate between the types of symbiosis and explain examples of each; ____________________
- comprehend that each organism fills a specific role or niche in its community; ____________________
- infer the niche of organisms from their physical characteristics; ____________________
- predict the effect of large scale changes on ecosystems, communities, populations, and organisms (fire, drought, flood, etc.) on populations; ____________________
- predict the effect of climate change on communities; ____________________
- design an investigation from a testable question related to interactions among populations. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. ____________________

A Salt Marsh Ecosystem

Organizing Topic Investigating Communities

Overview Students observe what happens to food webs when the physical environment changes.

Related Standards of Learning LS.1j; LS.8b; LS.9a; LS.11b

Objectives

The students will
- identify the populations of producers, consumers, and decomposers, and describe the roles they play in their communities;
- demonstrate the effect of environmental changes on a food web;
- construct a salt marsh food web.

Materials needed

- Scissors
- Tape
- Yarn
- Multiple copies of the attached "Salt Marsh Organisms Cards," representing 15 salt marsh organisms their food or energy source

Instructional activity

Content/Teacher Notes

Make sure students understand the abiotic factors of a salt marsh ecosystem. Review the terms *producers, consumers, herbivores, carnivores,* and *omnivores.*

Introduction

A salt marsh is a complicated ecosystem made up of different food chains that overlap to form a food web. The data on the attached "Salt Marsh Organisms Cards" can be modified if you want to add or substitute examples from your local ecosystem.

Procedure

1. Give each team of three or four students a pack of the 15 cards, each card representing an organism of the salt marsh and the foods it eats or the source of its energy. Also, display the following questions on the board or chart paper:
   - What are the producers in this community?
   - What is the source of their energy?
   - Which three organisms are strictly herbivores?
   - Which two organisms are strictly carnivores?
   - Which three organisms are omnivores?
   - Which organisms are first-order consumers? Which are second-order? Which are third-order?
   - How would the predator-prey relationships be described?
   - How does the size of an animal affect its position in the food web.
2. Direct students to place the cards representing the producers of this community at the bottom of their desk or table. Then, have them place the cards representing the grasshopper, snail, fish, and small crustaceans in a row above the plants and to connect each animal to its food source(s) with a piece of yarn. Have them tape the ends of each piece of yarn to a card. Next, have them place the

hawk and the owl at the top edge of the desk and scatter the remaining organisms in the space between the herbivores and the hawk and owl. Again, have them use the yarn and tape to connect each of the organisms to all the other animals that will eat it, using the food list on each card to help determine the food each organism eats.

3. Ask students to identify the organisms in the food web which are eaten by the rat. Ask students which organisms depend directly on the marsh plants for part or all of their diet. Have students answer the questions listed above in step 1.
4. Have each team member hold one of the producer cards or the heron, hawk, or owl cards and carefully lift the food web off the table. It should be supported by the yarn attached to these five cards. Have students observe the web carefully, noting the connections.

Observations and Conclusions

- Students predict what would happen to the food web if insecticides were to enter the salt marsh and kill the grasshoppers and snails. Students draw conclusions from their answers to the following questions:
  - Which animals would be affected by the loss of these foods?
  - What might these animals do to replace the lost food sources?
  - How might this affect their other food sources?
  - Which organism would be affected if pollution of the water were to reduce the population of fish?
  - What might happen to this food web if the salt marsh were filled in to make room for a new housing development?
- Have students cut the yarn leading from the marsh plants and algae to the herbivores. Ask: “Was the prediction correct?”

Sample assessment

- Have students construct a simple food web with the following organisms: grass, weeds, worm, grub, beetle, robin, starling, and cat. Have students identify the producers and first-, second-, and third-order consumers.
- Have students create a food web from another ecosystem.

Follow-up/extension

- Have students research other food chains. They may investigate how toxins travel through the food chain in the salt marsh. Why should all members of the larger watershed be concerned about a salt marsh that is hundreds of miles away. How do salt marshes benefit humans? Have students research other ways to control pests.
- Have students complete a bioaccumulation simulation.

Salt Marsh Organisms Cards

MOUSE *eats* **grasshoppers** **snails** **marsh plants**	**RAT** *eats* **sparrows** **grasshoppers** **snails** **marsh plants**	**OWL** *eats* **rats** **sparrows** **ducks** **sandpipers**
DUCK *eats* **crustaceans** **marsh plants** **algae** **grasshoppers** **snails**	**SANDPIPER** *eats* **crustaceans** **algae**	**SPARROW** *eats* **crustaceans** **marsh plants** **grasshoppers** **snails**
SMALL CRUSTACEAN *eats* **algae**	**FISH** *eats* **crustaceans** **marsh plants** **algae**	**HERON** *eats* **fish**
SALT WATER ALGAE *energy source:* **sunlight** **CO_2** **water**	**SALT MARSH PLANTS** *energy source:* **sunlight** **CO_2** **water**	**SNAIL** *eats* **marsh plants** **algae**
HAWK *eats* **shrews** **mice** **rats**	**SHREW** *eats* **grasshoppers** **snails** **mice**	**GRASSHOPPER** *eats* **marsh plants**

Succession in a Community

Overview Students observe the changes in a community over time.

Related Standards of Learning LS.1; LS.11c

Objectives

The students will
- collect observations of the changes in a community over time;
- describe what happens in succession.

Materials needed

- Debris from a pond
- Boiled pond water
- Clear 1-liter jar with lid
- Microscopes
- Droppers
- Slides
- Cover slips
- Invertebrate guide book
- Copies of the attached "Succession Data Chart"

Instructional activity

Content/Teacher Notes

Succession is the change in a community over time. During succession, plant and animal populations are gradually replaced over time by different plant and animal populations.

Introduction

Review the concept of succession with the students. Also, review the care and use of a microscope, as needed.

Procedure

1. Fill the jar to a depth of 3 cm with debris from a pond. Add boiled, cooled pond water until the jar is filled to a depth of 1 cm from the top. Place the lid on the jar, and shake to mix the water and the pond material. Place the jar in a lighted area where it will not be disturbed.
2. Distribute copies of the "Succession Data Chart." Have each lab team use a dropper to take a sample of water from the jar, place a drop of the water on a microscope slide, and add a cover slip. Have teams examine the drop of water through the microscope and record their observations on the chart.
3. Have students observe the contents of the jar by holding the jar up to the light every day for nine days and record their observations in the chart. Have lab teams examine a new drop of water under the microscope each day, make drawings of any organisms found, and identify the organisms, using an invertebrate guide book. Have them record their observations in the chart.

Observations and Conclusions

- Students draw conclusions from their answers to the following questions:
  - Why was the water boiled?
  - How many kinds of organisms did you observe on days 1, 3, and 9?

  - What organisms appeared first?
  - From where did the organisms not present on the first day come?
  - After nine days, were there still large numbers of the organisms that had appeared at first?
  - What ecological process is demonstrated by the change of populations that occurred in the jar community? How can this change be explained?

Sample assessment

- Ask students to explain how this experiment shows succession.
- Have students write a reflection on what happens in succession.

Follow-up/extension

- Have students describe what happens in pond succession and explain the causes of pond succession.
- Have students explain how the biotic and abiotic elements of the community change in succession.

Sample resources

- *Ecological Succession.* Offwell Woodland & Wildlife Trust. http://www.countrysideinfo.co.uk/successn/intro.htm.

Succession Data Chart

Day	Appearance of material in the jar	Organisms present in a drop of water
1		
2		
3		
4		
5		
6		
7		
8		
9		

Predator-Prey Simulation

Organizing Topic Investigating Communities

Overview Students use a simulation to generate data on the interactions between predator and prey populations.

Related Standards of Learning LS.1i, j; LS.8a; LS.9b

Objectives

The students will
- conduct a simulation that models predator-prey interaction;
- use continuous line graphs to interpret data and make predictions;
- comprehend that populations of one species may compete with populations of other species for resources.

Materials needed

- Large pieces of construction paper or student desks marked off as habitats
- Construction paper cut into large and small squares
- Copies of the attached "Predator-Prey Simulation Data Sheet" worksheet
- Graph paper
- Colored pencils

Instructional activity

Content/Teacher Notes

While it is not feasible to experiment with real predator and prey populations, it is possible to generate data through simulations that model the interactions that occur within a population, particularly between predator and prey. Students often feel that predators are "bad" because they kill smaller, weaker animals for food. Modeling the effects that predators have on habitats can help students realize that predators are not bad and that they play an important role in maintaining stable communities. You may substitute any predator or prey animal in the simulation. Coyotes make an interesting choice as this species has made a reappearance in Virginia in recent years. If your students have been studying other species, such as owls and voles in an owl pellet dissection, these species would be a good choice for this simulation.

Introduction

Review population dynamics—factors that influence the numbers of births and deaths and the amount of immigration and emigration. If focusing on coyotes, ask students to brainstorm what they know about this species. Tell students that this predator is making a comeback in Virginia, and give more details about the species. Have students prepare by generating food chains that include the predator and prey species. Ask students their opinions of predators, and have them discuss the importance of predators to communities. You may want to include a reading of a story about a predator and prey relationship.

Procedure

Group students into teams, and have each team use a large piece of construction paper or a desktop to represent a habitat, such as a grassy field. The small squares of construction paper represent rabbits, and the larger squares represent coyotes. Have teams perform the following steps:

1. Place three rabbits on the habitat. Toss a coyote into the habitat by tossing it up and allowing it to fall on the habitat. It should not slide across the habitat into the rabbits, but it might land on top of

one or more of them, meaning that it “eats” them. The coyote needs to eat three rabbits to survive. As the coyote square will not land on three rabbit squares in this generation, the coyote will starve and die. Remove the dead coyote, and remove any rabbits that are “eaten.” Record on the attached “Predator-Prey Simulation Data Sheet” the number of remaining rabbits as generation 1.

2. For generation 2, double the number of rabbits left from the previous generation. Put all the second-generation rabbits around the habitat. The first generation coyote starved, but another will now migrate into the habitat. Record the number of prey and predators at the beginning of generation 2. Toss a coyote into the habitat, as before. If the predator lands on less than three prey, it will die. Remove the eaten rabbits and the dead coyote, if necessary, as before.
3. Begin generation 3 by doubling the number of remaining rabbits and allowing a third-generation coyote to migrate into the area, if necessary. Record the data at the beginning of generation 3.
4. Continue with the following generations. Eventually the rabbit population, which continues to double each generation, will be large enough to sustain a coyote, but whenever a coyote starves, a new coyote migrates into the habitat. There should always be at least three rabbits in the prey population at the beginning of a generation. If the rabbits should be decimated or eliminated, new rabbits will migrate into the habitat. Once a coyote survives, it also reproduces. The coyote will produce a pup for every three rabbits it eats. For example, if the coyote eats six rabbits, it will produce two pups.
5. Continue the simulation, making predictions at the end of each generation, until you have worked through 25 generations.
6. When finished, make a double-line graph of the data, with one color line representing the rabbit population and another color line representing the coyote population.

Observations and Conclusions

- Students use the graphed data to make a prediction about what might happen in future generations.
- Students summarize the population dynamics observed in the simulation.

Sample assessment

- Assess students’ line graphs.
- Assess students’ predictions as reasonable or unreasonable.
- Assess students’ summaries of the population dynamics in the simulation.

Follow-up/extension

- Have students repeat the simulation, introducing other factors that affect population. This could be done by making event cards for students to draw for each generation. Cards could include unfavorable events such as harsh weather or disease that kill a certain percentage of the rabbits. Favorable events could improve rabbit reproduction rates or increase immigration. Human interaction could include unfavorable events (e.g., hunting, habitat destruction) that reduce population, and favorable events (e.g., reduction in numbers of other predators) that would increase population.
- Have students create their own population simulation.
- Have students use a computer-generated predator-prey simulation, such as one found on the Internet.
- Have students research predator-prey species that interest them.

Sample resources

- *eNature.com. Bringing nature to life. Field Guides.* http://www.enature.com/home/. Offers online field guides of the National Wildlife Federation.

- *Pond Life Identification Kit: A simple guide to small and microscopic pond life with links to Micscape resources.* Microscopy UK. http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/.
- "Pond Life." *Molecular Expressions.* http://micro.magnet.fsu.edu/moviegallery/pondscum.html.

Predator-Prey Simulation Data Sheet

Generation	Rabbits at Start	Coyotes at Start	Rabbits Surviving	Coyotes Surviving
1	3	1		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Fungal Friends: Lichens

Organizing Topic Investigating Communities

Overview Students investigate lichens as an example of a fungal symbiosis.

Related Standards of Learning LS.1; LS.9d

Objectives

The students will

- comprehend that organisms or populations that rely on each other for basic needs form interdependent communities.

Materials needed

- Samples of lichens collected from rocks or tree bark (If lichens are available in the school yard, students can collect their own lichens to study; not much matter is needed for viewing the organisms.)
- Microscopes
- Slides
- Cover slips
- Droppers
- Water
- Large pins

Instructional activity

Content/Teacher Notes

Lichens are an easily found but often overlooked example of symbiosis that can be readily studied in the classroom. Lichens demonstrate the mutual relationship of fungi and algae or fungi and cyanobacteria. The algae carry out photosynthesis, while the fungi absorb and hold water and nutrients and provide a place for the algae to live. Other easily found fungal symbioses are the mychorrhizal associations between fungi and the roots of plants. The study of lichens can be extended into comparing species by taking samples from various sites and doing an assortment of related field activities.

Introduction

Review the needs of plants and the needs of fungi and how they live. Review the classifications of algae and fungi. Ask students to brainstorm ways fungi and plants could work together. Introduce the lichen as an example of symbiosis. Point out that the plant helps the fungi meet their needs and vice versa. (Care should be taken not to confuse students with the fact that algae are no longer classified as plants.)

Procedure

Group students into lab teams. Distribute lab supplies, and have teams perform the following steps:

1. Place a drop of water on a microscope slide.
2. Using a large pin, tease apart a small piece of lichen into the drop of water. Add a cover slip.
3. Observe the slide under the microscope. The green algal cells can be seen in the filaments of the fungi.
4. Make a field view sketch of the algae and fungi. Describe how they appear.
5. Use print or online field guides to identify the lichens.

6. If time and materials allow, compare and contrast samples of different lichens.

Observations and Conclusions

- Students observe and describe the interaction between the algae and the fungi.
- Students explain the role of lichens in food webs.

Sample assessment

- Have students complete a lab sheet, including observations from their sample.
- Have students describe the symbiotic relationship between the algae and the fungi.
- Have students compare and contrast the appearances of different lichen specimens.

Follow-up/extension

- Have students collect their own samples, noting location and conditions at the point of collection.
- Have students find out more about lichens by using the Internet.
- Have students design and carry out controlled experiments on a lichen assembly. One idea might be to attempt to grow some lichen indoors in various conditions of light, moisture, and temperature.

Sample resources

- *Introduction to Lichens: an alliance between kingdoms.* University of California Museum of Paleontology. http://www.ucmp.berkeley.edu/fungi/lichens/lichens.html.
- *Lichen determination keys available on INTERNET.* Botanischer Garten und Botanisches Museum Berlin-Dahlem, Freie Universität Berlin. http://www.bgbm.org/sipman/keys/default.htm.
- *Lichenland: Fun with Lichens from Oregon State University*. http://ocid.nacse.org/lichenland/.
- *Loveable Lichens.* Earth-Life Web Productions. http://www.earthlife.net/lichens/intro.html.

Student Activity Sheet

Name: ________________________________ **Date:** ____________________

Source of Lichen 1: ____

Field View **Description**

100 × _____

Source of Lichen 2: ____

Field View **Description**

100 × _____

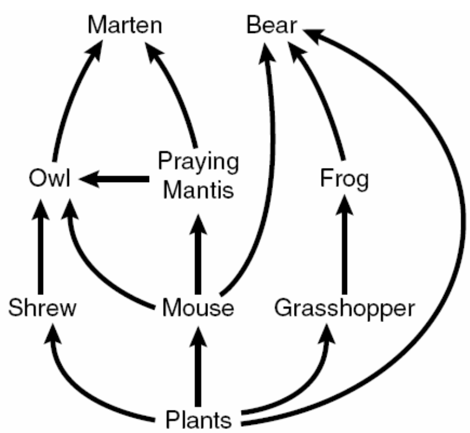
Conclusion

Describe and name the relationship between the algae and the fungi in the lichens.

Sample Released SOL Test Items

A tick that feeds on the blood of animals is a —

A predator
B host
C competitor
D parasite



Which of these populations is most likely to increase if the number of grasshoppers decreases?

A Plant
B Frog
C Praying mantis
D Owl

Organizing Topic — Investigating Adaptation and Change

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.10 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include
- a) differences between ecosystems and biomes;
- b) characteristics of land, marine, and freshwater ecosystems; and
- c) adaptations that enable organisms to survive within a specific ecosystem.

LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include
- a) phototropism, hibernation, and dormancy;
- b) factors that increase or decrease population size; and
- c) eutrophication, climate changes, and catastrophic disturbances.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• differentiate between ecosystems, communities, populations, and organisms;	______________________
• differentiate between ecosystems and biomes;	______________________
• comprehend that each of the Earth's major biomes is associated with certain conditions, including a range of climate and ecological communities adapted to those conditions;	______________________
• compare and contrast the biotic and abiotic characteristics of land, marine, and freshwater ecosystems;	______________________
• recognize and give examples of major biomes: desert, forest, grassland, and tundra;	______________________
• comprehend that organisms have specific structures, functions, and behaviors that enable them to survive the conditions of the particular biome in which they live;	______________________

- observe and describe examples of specific adaptations that organisms have which enable them to survive in a particular ecosystem; ________________________
- comprehend that organisms adapt to both biotic and abiotic factors in their biome; ________________________
- analyze specific adaptations of organisms to determine how they help the species survive in its ecosystem (see LS.5 - external and internal structures, method of locomotion, obtaining nourishment of species, etc.); ________________________
- predict the effect of large scale changes on ecosystems, communities, populations, and organisms; ________________________
- predict the effect of climate change on ecosystems, communities, populations, and organisms; ________________________
- design an investigation from a testable question related to how organisms adapt to biotic and abiotic factors in a ecosystems. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis; ________________________
- analyze and critique the experimental design of basic investigations related to how organisms adapt to biotic and abiotic factors in ecosystems. ________________________

A Designed Organism

Organizing Topic Investigating Adaptation and Change

Overview Students apply their knowledge of life science and ecosystems to create a new creature.

Related Standards of Learning LS.1; LS.10c

Objectives

The students will
- comprehend that organisms have specific structures, functions, and behaviors that enable them to survive the conditions of the particular biome in which they live;
- observe and describe examples of specific adaptations that organisms have which enable them to survive in a particular ecosystem;
- comprehend that organisms adapt to both biotic and abiotic factors in their biome;
- analyze specific adaptations of organisms to determine how they help the species survive in its ecosystem.

Materials needed

- Reference texts
- Graphic organizers
- Colored pencils or markers
- Copies of the attached “Designed Organism Rubric” handout

Instructional activity

Content/Teacher Notes

Adaptations are structures, functions, or behaviors that allow an organism to survive in its habitat or biome. This project is meant to be a culminating activity that allows for creativity and the application of technical knowledge. After the introductory review, students will prepare a concept map or other graphic organizer showing a plan for their newly designed creature.

Introduction

Briefly review the needs of living things, features of biomes, the niche concept, and symbiosis. Review the meanings of the terms *ecosystem, biome, habitat*, making sure the students understand the distinctions among these terms (see lesson on page 109). Review examples of specific adaptations of organisms. You may want to read a story about an imaginary creature, pointing out its adaptations to specific factors. Demonstrate labeling of a lab drawing, if necessary.

Procedure

1. Have each student select an ecosystem, biome, or habitat he/she would like to use in this activity.
2. Distributed copies of the “Designed Organism Rubric,” and go over the steps for designing a new creature.
3. Have students brainstorm the imaginary creature’s features that could enable it survive in the chosen ecosystem. Adaptations should be specified for feeding, movement, and protection. A symbiotic relationship should be included.
4. Go over the ratings in the rubric so that students understand the task.

5. Have students perform steps 1 through 5 on the rubric, using a concept map or other graphic organizer as they organize their thoughts.
6. Have students draw and label a diagram showing the organism's adaptations (step 6).
7. Have students write a summary describing ecosystem, the adaptations of their designed creature, and exactly how the adaptations enable it to survive.

Observations and Conclusions

- Students present information and drawings to their classmates, who determine whether the new creature is reasonable or not. They defend their positions.

Sample assessment

- Assess the designed organisms, using the rubric.
- Assess students' summaries for accuracy and completeness.

Follow-up/extension

- Have students share their designed creatures with classmates and try to classify each creature into kingdom and phylum.
- Assign students to create a herbivore and provide information about a new plant and a new predator for the designed creature.
- Have students analyze their designed creature for similarities and differences to real organisms.
- Have students create the classification scheme for their designed organism.
- Referring to the variety of the designed creatures, discuss with students the concept of biodiversity.

Sample resources

- *Animal Diversity Web*. University of Michigan Museum of Zoology. http://animaldiversity.ummz.umich.edu/site/index.html.
- *The Biodiversity Project. Life. Nature. You. Make the connection.* http://www.biodiversityproject.org/. Presents explanations and offers links to many organizations concerned with the study of biodiversity.
- *Kratts' Creatures*. http://www.pbs.org/kratts/world/index.html.

Designed Organism Rubric

Design a new organism that is adapted to an ecosystem, biome, or habitat of your choice.

1. Choose and describe an ecosystem, biome, or habitat.
2. Describe the needs of your organism and how these needs are met in its ecosystem.
3. Design and describe three adaptations that allow the organism to survive within its ecosystem. Adaptations should be specified for *feeding, movement,* and *protection.*
4. Describe the niche of your organism and how the organism interacts with other things.
5. Describe a symbiotic relationship for your organism.
6. Make a labeled diagram of the organism you have designed and described.

Category	Exceptional (4)	Very Good (3)	Acceptable (2)	Poor (1)
Biome Description	Ecosystem description totally accurate; all details included	Ecosystem description mostly accurate; a few details missing	Ecosystem description somewhat accurate; several details missing	Ecosystem description very weak on details
Needs of Organism	How needs are met completely realistic; all details included	How needs are met mostly realistic; a few details missing	How needs are met unclear; several details missing	How needs are met not included; very weak on details
Three Adaptations to Biome	Adaptations completely described; all details included	Adaptations mostly described; a few details missing	Adaptations somewhat described; several details missing	Adaptations not or poorly described; how this organism would survive is unknown
Niche	Niche descriptions accurate; all details of interactions included	Niche descriptions mostly accurate; a few details of interactions missing	Niche descriptions somewhat accurate; details of interactions missing	Very weak on niche descriptions; no interactions described
Symbiosis	Partnership is reasonable; details of relationship well described	Partnership is reasonable; details of relationship partly described	Partnership is possible; details of relationship not identified	Partnership not possible; details of relationship not identified
Creativity	Unique details make organism stand out.	Some details about organism are unique.	A few details are unique, but organism is much like an existing organism.	Organism is like an existing organism, with few or no new features.
Diagram	Detailed; in color; adaptations labeled and described	Detailed; adaptations labeled and described	Labeled drawing	Basic sketch

Heat Loss from a Fur-Insulated Animal

Organizing Topic Investigating Adaptation and Change

Overview Students conduct a controlled experiment to test the effect of insulation on heat loss from a simulated animal.

Related Standards of Learning LS.1j; LS.10c

Objectives

The students will
- analyze the specific adaptations of organisms to determine how they help the species survive in its ecosystem.

Materials needed

- 50-ml plastic graduated cylinders
- Pieces of fake fur, cut to fit as tube-shaped "gloves" for cylinders
- Rubber bands
- Hot water
- Thermometers
- Thermometer keeps, or paper clips if short thermometers are used
- Clock or timers
- Copies of the attached lab sheet, "The Effect of Fur Insulation on Heat Loss"
- Graph paper
- Colored pencils

Instructional activity

Content/Teacher Notes

As students investigate adaptations, they can observe how fur insulates. Fur or feathers are an adaptation possessed by warm-blooded animals to protect against too hot or too cold ambient temperatures and help maintain constant body temperature. This experiment shows how fur protects against a too cold ambient temperature by preventing/delaying heat loss. The experiment also provides students with continuous data, which can be used to create graphs that, in turn, can be used to practice extrapolation. *Safety Note: Be sure the hot water used in this experiment is not boiling or* ***too*** *hot. As students pour the hot water into the cylinders, caution them to be very careful and not spill the hot water on themselves.*

Introduction

Review adaptations of living things to various environmental factors. Discuss the difference between biotic and abiotic factors.

Procedure

Group students into lab teams. Distribute lab supplies, and have teams perform the following steps:

1. Wrap a piece of fake fur around a cylinder, and secure it with rubber bands. The wrapped cylinder will simulate a warm-blooded, furry animal. Place the fur-wrapped cylinder beside an unwrapped cylinder.
2. Fill both cylinders with hot water, being careful not to spill the water on yourself.

3. Immediately place a thermometer into each cylinder. If short thermometers are used, they can be hung from the lip of the cylinder by a paper clip. Allow the thermometers to equilibrate, and when their readings reach the highest point (time zero), begin timing.
4. Read and record the temperature of the water in each cylinder every two minutes for 20 minutes. (The time can be extended, but 20 minutes should be long enough to collect useful data.)
5. After 20 minutes, remove thermometers and pour out the water.
6. Plot on graph paper a double-line graph of the collected data.

Observations and Conclusions

- Students form conclusions from their results.
- Students extrapolate their data to predict what would happen after another 10 minutes.

Sample assessment

- Assess students' completed graphs, lab worksheets, and extrapolations.

Follow-up/extension

- Have students design and carry out an experiment to test another animal's adaptations, such as using feathers to simulate a bird.
- Have students compare the insulating capacities of fur or fabric of varying thicknesses.
- This experiment shows how fur protects against a too cold ambient temperature by preventing/ delaying heat loss. Students are often amazed to discover that fur can actually be beneficial when the temperature of the air is very hot. Have students design and perform a similar experiment to test the effectiveness of fur insulation against a too hot ambient temperature by preventing/ delaying heat *gain*. Ask students how furry animals lose excessive heat when the ambient temperature is very hot. Ask: "How do humans lose heat under such conditions?"

Sample resources

- "Adaptation to the Cold." *Gateway Antarctica.* http://www.anta.canterbury.ac.nz/resources/adapt.html.
- *Caribou Survival Adaptations: Learn and Build Your Own.* Journey North. http://www.learner.org/jnorth/tm/caribou/BuildACaribou.html.
- "How Do Animals Survive the Cold Weather of the Tundra?" *iwebquest.com.* http://www.iwebquest.com/alaska/webquest/shape/animals.htm.
- "The Structures & Adaptations to Marine Living." *MarineBio.org.* http://marinebio.org/Oceans/StructuresAdaptations.asp.

The Effect of Fur Insulation on Heat Loss

Name: ___________________________________ Date: ____________________

In this experiment, you will compare heat loss from a furry (insulated) mammal with heat loss from a non-furry (uninsulated) mammal. A hot-water-filled, fur-wrapped graduated cylinder will represent the furry mammal, and a hot-water-filled, unwrapped cylinder will represent the non-furry mammal.

Hypothesis:

Independent variable:

Levels of the independent variable:

Control:

Dependent variable:

Constants:

Prediction:

Data:

Time (minutes)	Temperature (° Celsius) unwrapped cylinder	Temperature (° Celsius) fur-wrapped cylinder
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

On a piece of graph paper, plot a double-line graph of the data, using two different colors. Attach your graph to this worksheet for assessment.

Conclusion:

Biomes of the World

Organizing Topic Investigating Adaptation and Change

Overview Students research unique characteristics of the world's biomes, using the Internet and other resources.

Related Standards of Learning LS.1; LS.10a, b, c

Objectives

The students will
- explain that each of the Earth's major biomes is associated with certain conditions, including a range of climate and ecological communities;
- determine some human and natural actions that may influence the health of biomes.

Materials needed

- Access to Internet and other resources
- Copies of the attached "Biomes Graphic Organizer" and "Checklist for Biome Poster"
- Poster board
- Markers or crayons

Instructional activity

Content/Teacher Notes

A *biome* is a geographic area with certain unique characteristics and unique animal and plant communities. Biomes contain smaller *ecosystems*. Rainfall and temperature (and types of organisms) are the main factors that determine the type of biome found in a specific region. This activity is meant to be a culminating activity for students. After defining *biome* and *ecosystem* and the relationships that occur in each, students will prepare a graphic organizer and poster.

Introduction

Review a map of the world's biomes, and brainstorm some unique characteristics of each. Review the terms *biome, ecosystem, habitat, community, population, biotic, abiotic, carnivore, herbivore, omnivore, consumers, producers, decomposers, food web,* and *food pyramid.* Make sure each student has a working knowledge of each term.

Procedure

1. Distribute copies of the two attached handouts. Have students use the Internet and/or other resources to research and complete the "Biomes Graphic Organizer."
2. Next, have students choose one biome and prepare a poster illustrating a food web from this biome, using the "Checklist for Biome Poster."
3. Have students write an analysis of their food web or energy pyramid and the biome with which it is associated.
4. Have students present their posters to the class.

Observations and Conclusions

- Students discuss projects as they are presented and reflect on possible human or natural actions/events that can or are affecting these biomes. Events such as deforestation and drought should be included in the discussions.

Sample assessment

- Assess completed graphic organizers.
- Assess students' posters as they are presented to the class.

Follow-up/extension

- Have students research how human activity is affected by the biome they live in.
- Have students design a zoo with animals from each biome. Ask students to explain the kinds of things zoo designers have to consider to ensure that the ecosystems are appropriate for the animals and plants being kept.

Sample resources

- *Mission: Biomes. Earth Observatory Experiments.* NASA. http://earthobservatory.nasa.gov/Laboratory/Biome/index.html.
- *WorldBiomes.com.* http://www.worldbiomes.com/. Covers five of the world's major biomes.

Biomes Graphic Organizer

Use the Internet and/or other resources to complete the following chart.

Characteristics	**Temperate Deciduous Forest**	**Coniferous Forest**	**Tropical Rainforest**	**Grasslands**	**Deserts**	**Tundra**
Rainfall						
Temperature						
Climate						
Abiotic Factors						
Five Animals						
Five Plants						
Location						
Natural or human factors that can or are affecting this biome						
Terms to Know	deciduous	conifers	canopy	savanna temperature		permafrost

Checklist for Biome Poster

3 = Excellent
2 = Good
1 = Present but poor quality
0 = Not present

_____ Biome and food web or pyramid are clearly depicted on poster.

_____ Poster is colorful and neatly done.

_____ Food web is ecologically correct.

_____ Spelling is correct.

_____ A predator-prey relationship is depicted and identified.

_____ A carnivore, a herbivore, and an omnivore are shown and identified.

_____ A symbiotic relationship is shown and identified.

_____ An example of cooperation is shown and identified.

_____ An example of competition is shown and identified.

_____ Summary of poster is written clearly and describes the poster in detail.

Sample Released SOL Test Items

Which amphibian is most aquatic?

F

H

G

J

In which of the following environments would you expect to find the greatest number of different species of plants and animals per square mile?

F An island near the South Pole
G A wheat field in North Dakota
H A pasture on a Virginia farm
J A tropical rain forest in Panama

Organizing Topic — Investigating Biologic Evolution

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.14 The student will investigate and understand that organisms change over time. Key concepts include
- a) the relationships of mutation, adaptation, natural selection, and extinction;
- b) evidence of evolution of different species in the fossil record; and
- c) how environmental influences, as well as genetic variation, can lead to diversity of organisms.

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• explain how genetic variations in offspring, which lead to variations in successive generations, can result from the same two parents;	______________________________
• comprehend that adaptations are structures, functions, or behaviors that enable a species to survive;	______________________________
• describe how changes in the environment can bring about changes in species through natural selection, adaptation, and extinction;	______________________________
• comprehend that individuals of a population exhibit a range of variations in a trait as a result of the variations in their genetic codes;	______________________________
• explain that if a species does not include traits that enables it to survive in its environment, or to survive changes in the environment, then the species may become extinct;	______________________________
• comprehend that mutations are inheritable changes because a mutation is a change in the DNA code;	______________________________
• comprehend that a mutation may result in a favorable change or adaptation in genetic information that improves a species' ability to exist in its environment or a mutation may result in	

an unfavorable change that does not improve or impedes a species' ability to exist in its environment; ______________________________

- analyze and evaluate data from investigations on variations within a local population; ______________________________
- interpret data from simulations that demonstrate selection for a trait belonging to species in various environments; ______________________________
- describe and explain how fossils are records of organisms and events in the Earth's history; ______________________________
- explain the evidence for evolution from a variety of sources of scientific data (including the fossil record, radiometric dating, genetic information, the distribution of organisms, and anatomical and developmental similarities across species). ______________________________

Variations Within a Population

Organizing Topic Investigating Biologic Evolution

Overview Students observe the variations within a natural population and use this information to interpret the process of natural selection.

Related Standards of Learning LS.1; LS.14a, c

Objectives

The students will
- observe variations within a population;
- apply the concept of natural selection.

Materials needed

- Peanuts in the shell
- Metric rulers
- Copies of the attached lab sheet, "Variation Within a Population"

Instructional activity

Content/Teacher Notes

A population may exhibit numerous variations. Humans are a good example of this fact. In this regard, peanuts are a good subject for study. Students are familiar with peanuts and foods such as peanut butter, but they may not be aware of the importance of this crop to Virginia's economy, nor know little about the peanut plant and how it grows. Peanuts are also a good example to use when discussing the nitrogen cycle.

Safety Note: Persons with peanut allergy may be so sensitive that they must not be in the room with peanuts. Therefore, check with the students as well as with your school nurse to ascertain whether any student in your class has peanut allergies. Many other seeds that are contained in husks or shells, such as acorns, corn seeds, or bean seeds, could be substituted for peanuts in this activity.

Introduction

Review and discuss the history of the peanut. Show students photos of peanut plants—how the peanut plant flowers, how the flowers grow toward the ground after pollination, and how the peanuts grow underground. Inform students that when they eat peanuts, they are eating peanut seeds.

Procedure

1. Distribute 10 peanuts in the shells and a copy of the attached "Variation Within a Population" lab worksheet to each student. For steps 1 and 2 on the worksheet, have students compare the features of their peanut shells, encouraging them to be as specific as possible in their descriptions.
2. Have students measure the length of each peanut shell at its longest point and record the measurements to the nearest millimeter on the "Variation within a Population" lab worksheet.
3. Have students find the mean, median, mode, and range of the recorded lengths.
4. Have students open the peanuts and record the number of the seeds in each shell. *Safety Note: Caution students never to eat lab materials!*
5. Combine students' data, and have students generate a class graph of the data.

Observations and Conclusions

- Students analyze their data.
- Students discuss the environmental conditions that could lead to variations, answering such questions as: What variations could result from a drought? What variations could result from an early frost?

Sample assessment

- Assess the completed lab worksheets.
- Have students analyze variations found in other populations.
- Have students write summaries that relate the experiment to real-life examples.

Follow-up/extension

- If raw peanuts were used, have students plant them to observe how peanut plants grow, flower, and bear seeds.

Variation Within a Population

Name: ________________________________ **Date:** ____________________

In what ways are the 10 peanuts shells similar?

In what ways are the 10 peanuts shells different?

Measure and record in the chart at right the length of each peanut shell at its longest point.
Find and record the mean, median, mode, and range of the lengths.

Mean: ________
Median: _______
Mode: ________
Range: ________

Peanut Shell	Length in mm	Number of Seeds
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		

Open each shell and record the number of seeds in it in the chart.
What is the most common number of seeds in the peanuts? ________

What is the relationship between the most common length of shell and the number of seeds per shell?

Suggest a reason why most peanuts have the same number of seeds.

If the environment changed to be more advantageous to a very large peanut, what do you think would happen over time to the size of peanuts? ______________________________ Explain why.

Describe an environmental change that would favor a much larger peanut.

Describe an environmental change that would favor a much smaller peanut.

In the chart at right, tally the sizes of the peanuts found by the class.

Make a bar graph comparing shell length and number of seeds.

What conclusions can you make about the trend you observed in the size of the peanut shells?

Length of Shell	Number of Peanuts
0–5 mm	
6–10 mm	
11–15 mm	
16–20 mm	
21–25 mm	
26–30 mm	
31–35 mm	
36–40 mm	
41–45 mm	
46–50 mm	
51–55 mm	

Natural Selection

Organizing Topic Investigating Biologic Evolution

Overview Students analyze the effect of natural selection on a simulated prey population.

Related Standards of Learning LS.1; LS.14a, c

Objectives

The students will
- explain that adaptations are structures, functions, or behaviors that enable a species to survive;
- explain that individuals of a population exhibit a range of variations in a trait as a result of the variations in their genetic code.

Materials needed

- Colored toothpicks (red, blue, yellow, green)
- Plastic bag or other container for toothpicks
- Green grassy area marked off into square-meter plots
- Stopwatch or timer
- Copies of the attached worksheet, "The Effect of Prey Color on the Predation"

Instructional activity

Content/Teacher Notes

Gene mutations can lead to variations within a population. If mutation results in a structure, function, or behavior that helps the organisms survive, the gene may be favored and persist through the process of *natural selection.*

Introduction

Review the relationships of mutation, adaptation, natural selection, and extinction. To help students grasp the concept of natural selection, point out that if an organism does not have the adaptations that allow it to survive and reproduce, it cannot pass its genes to offspring and will therefore die out.

Procedure

1. Mark off a square-meter of green, grassy area for each team of students—the greener the better so that the green toothpicks will be harder to find. (Note: Areas of other size will work; however, it is easier to find the remaining toothpicks after the activity is over if the area in which they were spread is clearly marked and rather limited.)
2. Distribute a copy of the worksheet, "The Effect of Prey Color on Predation," to each student. Have one team member in each team randomly spread prey animals (colored toothpicks) over the team's marked-off grassy area. Point out that each color represents a different gene frequency for the allele of the prey animal. (See lessons on pages 29 and 35.) Have each team designate one member to be the predator, who will "catch" (find and pick up) prey animals one-by-one and "eat" each one by placing it in the "stomach" (plastic bag) before catching another.
3. Give the predator in each team one minute to feed on the prey, catching as many as possible.
4. Have each team count and record on the attached lab sheet the number of each color of prey in the bag and then return the prey to the grassy area.
5. Have each team repeat the process for a total of three trials.

6. When data collection is complete, be sure lab teams clean their area by finding and storing all the toothpicks in the plastic bag.

Observations and Conclusions

- Students analyze their data and draw conclusions from their answers to the following questions:
    - Which prey color was easiest for the predator to find? What will happen to the gene frequency for this allele?
    - Which prey color was most difficult for the predator to find? What will happen to the gene frequency for this allele?

Sample assessment

- Have students complete a lab sheet and analyze their data.
- Have students explain the simulation in terms of natural selection and gene frequencies.
- Have students write summaries that relate the lab experiment to real-life examples.

Follow-up/extension

- Have students complete another experiment in which they give the *predator* various adaptations. This might include assigning the predator different beaks (e.g., tweezers, spoons). This shifts the focus to adaptations needed by the predator to survive.
- Have students design another simulation that demonstrates natural selection.

The Effect of Prey Color on Predation

Name: ___________________________________ Date: ____________________

Independent variable:

Levels of the independent variable:

Constants:

Dependent variable:

Data: Number of prey eaten

Trial	Red	Blue	Yellow	Green
1				
2				
3				
Total				
Mean				

Graph of means:

Conclusion:

Sample Released SOL Test Items

Changes in DNA are known as mutations and can sometimes produce beneficial changes in populations. A mutant form of the normally light-colored peppered moth is dark colored. The dark-colored moth blends in with soot-covered trees in heavily polluted areas. Why would the dark-colored mutation be beneficial in a polluted area?

F Dark-colored moths have a longer life span than light-colored moths.

G Dark-colored moths can't be seen well by predators.

H Dark-colored moths taste bad to most of their predators.

J Dark-colored moths produce more young than do light-colored moths.

Fossils are evidence of living things that were alive many, many years ago and often consist of the skeletons of creatures imbedded in rock. Why don't fossils contain the animal's soft tissues, as well?

A Because the soft tissues decayed before the fossil could be formed

B Because the rock breaks down soft tissues

C Because the soft tissues were always eaten by scavengers

D Because the rock always smashed the soft tissues flat

Organizing Topic — Investigating the Conservation of Living Resources

Standards of Learning

LS.1 The student will plan and conduct investigations in which
- a) data are organized into tables showing repeated trials and means;
- b) variables are defined;
- c) metric units (SI—International System of Units) are used;
- d) models are constructed to illustrate and explain phenomena;
- e) sources of experimental error are identified;
- f) dependent variables, independent variables, and constants are identified;
- g) variables are controlled to test hypotheses, and trials are repeated;
- h) continuous line graphs are constructed, interpreted, and used to make predictions;
- i) interpretations from a set of data are evaluated and defended; and
- j) an understanding of the nature of science is developed and reinforced.

LS.12 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include
- a) food production and harvest;
- b) change in habitat size, quality, or structure;
- c) change in species competition;
- d) population disturbances and factors that threaten or enhance species survival; and
- e) environmental issues (water supply, air quality, energy production, and waste management).

Essential Understandings, Knowledge, and Skills	Correlation to Textbooks and Other Instructional Materials
The student will use hands-on investigations, problem-solving activities, scientific communication, and scientific reasoning to	
• identify examples of ecosystem dynamics;	______________________
• describe the relationship between human food harvest and the ecosystem;	______________________
• describe ways that human interaction has altered habitats positively and negatively;	______________________
• explain that human input can disturb the balance of populations that occur in a stable ecosystem. These disturbances may lead to a decrease or increase in a population. As populations in an ecosystem are interdependent, these disturbances have a ripple effect throughout the ecosystem;	______________________
• debate the pros and cons of human land use versus ecosystem stability;	______________________
• compare and contrast population disturbances that threaten and those that enhance species survival;	______________________
• observe the effect of human interaction in local ecosystems and collect, record, chart, and interpret data concerning the effect	

of interaction (from observations and print and electronic resources); ______________________________

- design an investigation from a testable question related to the relationships between ecosystem dynamics and human activity. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis; ______________________________
- analyze and critique the experimental design of basic investigations related to the relationships between ecosystem dynamics and human activity. ______________________________

Water Quality Problems and Conservation Strategies

Organizing Topic Investigating the Conservation of Living Resources

Overview Students investigate Virginia's watersheds, the negative impact humans have on water quality, and water conservation strategies.

Related Standards of Learning LS.1; LS.12d, e

Objectives

The students will
- describe ways human interaction has altered habitats positively and negatively;
- describe the relationship between human food harvest and the ecosystem.

Materials needed

- Shower curtain
- Newspapers
- Shallow pan
- Watering can
- Water
- Fishing line
- Index cards
- Scissors
- Permanent markers
- Food color
- Liquid soap
- Soil
- Baking soda
- String
- Construction paper
- Paper towels
- Copies of the attached "Pollution in the Chesapeake Bay Watershed" story

Instructional activity

Content/Teacher Notes

This activity requires preparation of many materials:
- small container of water colored blue-green to represent factory discharge
- small container of water colored yellow-red to represent motor oil from car and boat
- small container of water colored red-blue-green-yellow to represent manure from barnyard
- small container of soapy water to represent car washing waste
- container of soil to represent erosion from building site
- container of baking soda to represent fertilizer from farm field
- small piece of fishing line to represent fisherman's snag
- small pieces of paper to represent picnic litter
- trees (one for each student) made from green construction paper and, optionally, laminated
- two role cards representing each of the following:
  - a builder doing construction at a building site
  - a farmer raising crops in a pasture
  - a farmer raising cattle in a barnyard
  - a manufacturer making a product in a factory
  - a driver driving car on a road
  - a son driving a motorboat on water
  - a daughter washing car at home
  - a college student fishing on a creek, river, or the Bay
  - a family picnicking in a nice spot

Introduction

Review the concept of a watershed, and have students name some of the creeks and rivers in your local watershed. Ask them where the water in your watershed goes. (Chesapeake Bay for most of Virginia)

Procedure

1. Have students study watershed maps of Virginia, which are available on the Internet and from the Virginia Department of Forestry, the U.S. Fish and Wildlife Service, the USGS, and the USDA Soil Conservation Service.
2. Have students create a watershed model on the classroom floor by draping a shower curtain over balled up newspapers to observe water sprinkled over it flow “downstream” toward the shallow pan. Have students form the watershed model so that it resembles your own “watershed address,” and have them label towns, creeks, and rivers on the model, using index cards placed on the model.
3. Lead students in brainstorming the pollution problems of your local watershed and, ultimately, the Chesapeake Bay.
4. Give each student a paper tree and a Role Card. (Create more Role Cards as needed for classes with more than 18 students.)
5. Have students stand around the watershed model and place their trees somewhere on the model. This represents the environment before being polluted.
6. Read (or have students read) the attached story, “Pollution in the Chesapeake Bay Watershed.” (You may want to adapt the story to your own locality so students connect to it more readily.)
7. In paragraph 3, at the words, “Builders…cut down trees…,” have several students take some trees off the model. At the words, “construct houses, schools, churches,…,” have students with Builder-Construction-Building Site cards put their cards on the model in places where they are constructing buildings along a creek or river and identify their building project (e.g., house, new school, subdivision). Have the builders sprinkle soil on their building sites to represent exposed soil. At the words, “Rains washed loose soil…,” sprinkle rain from the watering can to wash the soil into the creek or river. Point out to students that sediment from exposed soil runoff is now the second worst threat to water quality in Virginia.
8. In paragraph 4, at the words, “farmers cleared the trees…,” have several more students remove their trees from the model and several students with Farmer-Crops-Pasture cards put their cards on the model. Have the farmers sprinkle baking soda on their farms to represent fertilizer. Then, at the words, “Rainwater washed the fertilizer…,” again sprinkle rain from the watering can to wash the fertilizer into the water. Point out to students that nitrates in runoff containing fertilizer and animal manure are the number one threat to water quality in Virginia. Nitrates also dump into rivers (and the Bay) because of ineffective municipal and private septic sewage-treatment systems.
9. Continue the story for each role and pollutant.
10. After making a mess of the land and water, challenge the class to think of ways to prevent or ameliorate each problem. As they think of solutions for each problem, remove the Role Card from the model. The object is to remove every Role Card.
11. Lead students to realize that one of the better solutions is to protect existing trees and plant new ones. Discuss the value of trees in preventing erosion, filtering out pollutants, providing habitat for wildlife, cooling down the air and water, and adding beauty to the landscape. Have students put their trees back on the model.

Sample assessment

- Have students identify their local watershed address.

- Have students name three ways humans pollute water and explain some ways to prevent or stop these three problems.
- Have students clarify and discuss how trees are helpful to the watershed.
- Have students list some things they could do in the next 24 hours to help the water in the watershed.

Follow-up/extension

- Show the video “It’s Happening Today on the Chesapeake Bay.”
- Have the class visit the local wastewater treatment plant.
- Invite a manufacturer to visit the class to discuss ways his factory meets environmental standards.
- Have students research one of the pollutants and find out how significant its impact is and what efforts are being made to minimize its impact.
- Have students participate in a tree planting/restoration project along a waterway in your community.
- Have students conduct chemical tests in local waters for such things as nitrates, pH, and dissolved oxygen.

Pollution in the Chesapeake Bay Watershed

1. Years ago, Rockbridge County was a wilderness with very few residents. This was a time before roads and cars. Native people depended on nature to survive; they lived simply and didn't change the natural surroundings very much. The people found food in the wetlands and caught fish in the sparkling, clean waters of the Maury River and James River. There were lots of trees, and the native people hunted in the forest.

2. Eventually, more people traveled to this land from across the ocean. They found rich soil for farming, forests full of mature trees and lots of wildlife, and a river that provided plenty of clean water and fish. It was a perfect place to settle.

3. The Maury River has changed a lot since then. This is the story of those changes.

4. More and more people moved to the area. Gradually, a city called Lexington grew up around the river. Builders drained swamps and cut down trees to construct houses, schools, churches, stores, roads, hospitals, and many other buildings. Rains washed loose soil from these building sites into the river.

5. At first, Lexington was small. Upstream, farmers cleared the trees and made fields for crops. They covered their fields with chemicals called fertilizer to make their crops grow faster. Rainwater washed much of the fertilizer into little creeks near the farms, which then flowed into the river, which eventually flowed into the Bay.

6. Some farmers used trees to build barns to keep cattle in. The cows dropped much manure, and rainwater washed much manure into the creeks and river and finally into the Bay.

7. Buena Vista grew to be the second largest city in Rockbridge County. Trees were needed for new houses. Several manufacturers opened factories along the river to make things people wanted, like paper for books and carpet for homes and schools. But the factories heated the river water, which killed some fish and plants, and they leaked some chemicals into the water. These chemicals caused the fish to become sick and unhealthy to eat.

8. Trees were cleared to make roads. Traffic grew as drivers took their cars to and from work on roads. Some cars leaked oil or other fluids, which washed off the roads and parking lots into the river with every rain.

9. On nice days, many people headed to the river, where someone's son zoomed up and down the James River in a motorboat and some engine oil leaked into the water. The oil floated on the surface, coated the feathers of ducks, and made the turtles, otters, and beavers sick.

10. Someone's daughter washed her car at home. The soapy water rushed down the driveway into the storm drain by the curb, which emptied into the river. If she had used biodegradable soap (or no soap at all), the water would not have polluted the river when it reached it.

11. Some college students went fishing, and when they left, their line got tangled in a tree near the water. They were in a hurry and didn't retrieve it. Birds and other creatures got tangled in it and died.

12. A family decided to have a picnic in Goshen Pass, but guess what? They ran off to play after lunch and didn't clean up their mess. They forgot all about their trash when they went home, and it ruined the beautiful picnic site for everyone else to come.

13. As you can see, the pollution in the Chesapeake Bay watershed is an environmental disaster because of the careless, selfish behaviors of humans.

How can we clean up the water in the watershed and, eventually, the Bay?

How can we *prevent* pollution in the first place?

Brainstorm solutions to each problem in order to get your Role in this huge mess off the model. See suggestions below.

1. Builder-Construction-Building Site—Take precautions to prevent erosion.
   - Put up silt fences to catch the soil.
   - Build retention ponds to catch runoff and slow down the runoff water.
   - Plant trees and other vegetation at the conclusion of the construction job.

2. Farmer-Crops-Pasture—Take precautions to reduce or eliminate use of fertilizer.
   - Take soil samples, and test the soil to see how much fertilizer they really need.
   - Put down fertilizer when rain is *not* in the forecast so plants can use the fertilizer before it is washed into the streams.
   - Use organic methods of farming to avoid the use of fertilizer.

3. Farmer-Cattle-Barnyard—Take precautions to keep manure out of the water.
   - Put up fences to keep livestock away from springs, creeks, and rivers.
   - Build a septic system for barnyard waste.
   - Collect barnyard waste and spread it on pastures or sell it to gardeners.

4. Manufacturer-Product-Factory—Take precautions to keep chemicals out of water.
   - Install treatment systems that clean the water.

5, 6. Driver-Car-Road, Motorboat Owner-Motorboat-Water—Take precautions to prevent leaks.
   - Service the vehicle regularly to make sure there are no leaks.
   - Repair gas and oil leaks immediately.
   - Dispose of used oil properly.

7. Daughter-Car-Driveway—Take precautions to keep soap out of the river
   - Use a biodegradable cleaning solution, or only water.
   - Reduce the frequency of car washing.

8. College Student-Fishing-Water
   - Remove all fishing lines from the environment.

9. Family-Picnic-Any Locale
   - Clean up area completely.
   - Take nothing but pictures, and leave nothing but footprints!

10. Everybody-Everywhere
   - Plant trees!