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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 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

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Organizing Topic — Investigating the Structure and States of Matter

Standards of Learning

5.1 The student will plan and conduct investigations in which
   b) estimations of length, mass, and volume are made;
   c) appropriate instruments are selected and used for making quantitative observations of
      length, mass, volume, and elapsed time;
   d) accurate measurements are made using basic tools (thermometer, meter stick, balance,
      graduated cylinder);
   e) data are collected, recorded, and reported using the appropriate graphical representation
      (graphs, charts, diagrams);
   f) predictions are made using patterns, and simple graphical data are extrapolated;
   g) manipulated and responding variables are identified; and
   h) an understanding of the nature of science is developed and reinforced.

5.4 The student will investigate and understand that matter is anything that has mass, takes up
   space, and occurs as a solid, liquid, or gas. Key concepts include
   a) atoms, elements, molecules, and compounds;
   b) mixtures including solutions; and
   c) the effect of heat on the states of matter.

Essential Understandings, Knowledge, and Skills

The students should be able to

- construct and interpret models of atoms, elements, molecules, and compounds;
- design an investigation to determine how heat affects the states of matter (e.g., water), including in the design the ways information will be recorded, the measurements that will be made, the instruments that will be used, and the ways the data will be graphed;
- construct and interpret a sequence of models (diagrams) showing the activity of molecules in all three states of matter;
- compare and contrast mixtures and solutions, elements and compounds, and atoms and molecules.

Correlation to Textbooks and Other Instructional Materials

Virginia Department of Education
What’s the Matter?

**Organizing Topic**  Investigating the Structure and States of Matter

**Overview**  Students construct various models of atoms, elements, molecules, and compounds. They then interpret each other’s models.

**Related Standards of Learning**  5.4a

**Objectives**
The students should be able to

- construct and interpret models of atoms, elements, molecules, and compounds.

**Materials needed**

- Drawing paper
- Markers, crayons, or colored pencils
- Computer program, such as AppleWorks Draw, that allows students to create pictures, using basic shapes (optional)
- Copies of attached data sheet and worksheet

**Instructional activity**

**Content/Teacher Notes**

At the beginning of this lesson, students may need direct instruction to help them define and explain the nature of atoms, elements, molecules, and compounds. Make sure students understand these concepts before beginning the activity.

**Introduction**

1. Begin by finding out what students already know about matter. They will probably know that it occurs in three states — solid, liquid, and gas. Ask students what the building blocks of matter are.

2. Define and explain the characteristics of atoms, elements, molecules, and compounds. Hand out the attached datasheet and/or display drawings to help students visualize each term.

   - **Atoms.** All matter is made up of atoms, which are so small that they can be seen only by using a very strong microscope. (For an activity to show students the size of atoms, go to [http://www.miamisci.org/af/sln/phantom/papercutting.html](http://www.miamisci.org/af/sln/phantom/papercutting.html).) All atoms have the same basic parts, including protons, neutrons, and electrons. Protons and neutrons form the nucleus in the middle of the atom, while electrons orbit quickly around the nucleus. The majority of the mass of an atom is in its nucleus: atoms of different elements differ in the number of electrons and protons they have, and this affects their mass.

   - **Elements.** One atom of an element is the smallest unit of an element that retains the properties of that element. Atoms combine to form elements. Each element is given a name, such as hydrogen, gold, silver, helium, and iron, along with a symbol. The element’s name and symbol identify it. Most, but not all, of these symbols are taken from the first or first and second letters of the name of the element, such as H for hydrogen and Ca for calcium. Each atom of a particular element is alike in having the same number of protons in its nucleus; this number is the element’s **atomic number**. For example, any atom that contains exactly 47
protons in its nucleus is an atom of silver; any atom that contains only one proton is an atom of hydrogen, the lightest element.

- **Molecules.** Two or more atoms that are held together form a molecule. Two atoms of the same element can join together to form a molecule of that element. Molecules are always in motion in each of the three states of matter, and the speed of the molecules determines the matter’s state. For example, if the molecules are spread far apart and are moving very fast, bouncing off one another, the matter of which they are a part is a gas. If they are packed close together and barely moving, they are a part of a solid. If the molecules are moving freely around each other, they are a part of a liquid, which can be poured.

- **Compounds.** Atoms of two or more elements join together to form a compound. Water is an example of a compound, since it is made up of hydrogen and oxygen atoms.

3. Have students take notes on these concepts. Access Internet resources (see two examples under “Resources”) to help illustrate these terms. Strategies for taking notes, including graphic organizers, can be found in the *English Enhanced Scope and Sequence, K–5* at [http://www.doe.virginia.gov/VDOE/EnhancedSandS/englishK-5.doc](http://www.doe.virginia.gov/VDOE/EnhancedSandS/englishK-5.doc).

**Procedure**

1. Divide the class into groups of four. Assign each student in each group one of the four terms discussed above. You can also assign them a specific element, if you are concerned about duplicates.

2. Tell students that they are to create a visual representation of the term they have been assigned. They may use paper (see attached worksheet) and markers, crayons, or colored pencils, or they may create their drawing on the computer, using a drawing program. Encourage them to use color and to add a key that identifies each part of their drawing (protons, neutrons, etc.), but emphasize that they should *not* label the drawing as to which of the four terms it represents. Give students time to find pictures of atoms, elements, molecules, and compounds, either in their science books, on the Internet, or in books from the library.

3. When the students are finished, hang the drawings on the wall and label each of them with a letter of the alphabet.

4. Have the groups identify each picture as an atom, molecule, compound, or element, including the reasons for their decisions.

**Observations and Conclusions**

1. By looking at a variety of pictures created by the class, students should observe and understand the physical differences between atoms, molecules, elements, and compounds. Make sure that as they complete the activity, they observe that atoms are the building blocks of matter.

**Sample assessment**

- Give students pictures of atoms, molecules, elements, and compounds, and have them identify each.
- Evaluate the students’ identifications of the drawings for accuracy.
- Evaluate the students’ drawings for required elements.

**Follow-up/extension**

- Have students build three-dimensional models rather than make drawings. Alternatively, they could build models from their drawings.
• Have students build a variety of element models from marshmallows to extend this lesson and help students become acquainted with the periodic table of elements.

Resources

• *Matter Is the Stuff around You.* Rader’s CHEM4KIDS.COM.  

• *The Phantom’s Portrait Parlor: Mighty Molecule.*  
What’s the Matter?

Atom

An atom is made up of three kinds of particles — protons, neutrons, and electrons.

Molecule

A molecule is made up of two or more atoms that are held together. Two atoms of the same element joined together form a molecule of that element.

Compound

A compound is made up of atoms of two or more elements joined together. For example, water is a compound formed from joining two hydrogen molecules and one oxygen molecule.
An Atom of My Element

Name: ___________________________ Date: __________________

In the circle below, draw a picture of one atom of your element, including the protons and neutrons in its nucleus and the electrons in orbit around its nucleus. Use a different color for each part of the atom.

Fill in the basic information about the atom:

Name of element: ___________________________
Number of neutrons in the nucleus: ______
Number of protons in the nucleus: ______
Number of electrons: ______
Atomic symbol: ______
Atomic number: ______
Atomic mass: ______
Uses of element: ____________________________________________
Molecule Motion in the Three States of Matter

Organizing Topic  Investigating the Structure and States of Matter

Overview  Students enact the three states of matter by “becoming” molecules in three different arrangements and three different degrees of motion. Based on this experience, students construct diagrams that depict the arrangements and activity of molecules in the three states.

Related Standards of Learning  5.4a

Objectives
The students should be able to
- construct and interpret a sequence of models (diagrams) showing the activity of molecules in all three states of matter.

Materials needed
- Overhead projector
- Teacher-generated overhead that represents the three states of matter
- Masking tape
- Computer program, such as AppleWorks, Imageblender, or Kids Pix, that allows students to insert pictures and draw
- Teacher-generated “molecule sheet,” photocopy machine, scissors, glue (optional)

Instructional activity

Content/Teacher Notes
Students should know that molecules in all matter are always in motion, and they should be able to visualize how molecules in the three states of matter are arranged and how they move. Allowing students to demonstrate these ideas physically will enable them to make their drawings of the three states with thorough understanding.

Use of a computer drawing program enables students to draw one molecule, copy/duplicate it many times, and arrange the many duplicated molecules to represent the different states of matter with their different numbers of molecules, different distances between the molecules, and different molecule-movement patterns.

If you do not have access to such a computer program for use by each student, you can use a photocopy machine to make multiple copies of a “molecule sheet” (i.e., a page with numerous small, duplicate drawings of a molecule) and have the students cut out the molecules and paste them into the three appropriate patterns.

Introduction
1. Ask students to name the three states of matter. Tell them that what makes these states different are the different ways the molecules in them are arranged and move. Discuss the following facts:
   - Molecules in a solid are very close together and only vibrate in place because they are so close to each other.
   - Molecules in a liquid are farther apart and move freely around each other, which allows the liquid to “flow” and be poured.
• Molecules in a gas are very far apart and move very fast, bouncing off one another, which allows the gas to expand to fill all the available space. (This concept will be more thoroughly explored in the next activity.)

2. Show students the overhead to help them visualize this concept. Ask students to identify which drawing is the solid, which is the liquid, which is the gas.

3. Tell students that they are now going to “become” the molecules in one of these states of matter.

Procedure

1. Tape out a small square (about 4 x 4 feet) on the classroom floor or playground. Place as many students (molecules) into the square as will fit comfortably. It should be quite crowded but still have enough room for the molecules to move back and forth in place slightly and bump each other. Ask students what state of matter this represents. (solid)

2. Take a few students out of the space, and have the remainder move around. Ask the students how the molecules are moving differently now, and have them predict whether this represents a solid, liquid, or gas. (liquid) Take out even more students, and have the few who remain move around faster, bumping into each other but still not leaving the marked-off space. Students should observe that because the molecules have more room to move around, they can move faster, bump off each other more frequently, and spread out more to continue to occupy all the available space. (gas)

3. Put students into groups, and secretly assign each group a state of matter to enact. As each group acts out its state of matter, have the other students identify which one it is.

4. Have students make a drawing of each state of matter. They can use a computer program to insert a picture of a solid, liquid, or gas into their document and draw a representation of multiple molecules in that state through a “magnified view” showing how the multiple molecules are arranged and moving. Alternatively, they can cut out and paste duplicated molecule drawings to depict each state on paper.

Observations and Conclusions

1. Through class discussion, encourage the students to observe that the number of molecules in a specified area (concentration) and the degree of motion differ with each state of matter. They should conclude that the states of matter can be identified through diagrams or models that represent the concentration and movement of molecules.

Sample assessment

• Assess the students’ diagrams of the different states of matter.

Follow-up/extension

• Have students hypothesize what happens to molecules in a liquid when it is frozen or when it is boiled to form steam. This discussion can lead to the next lesson on changing states of matter.

Resources

• *Matter Is the Stuff around You*. Rader’s CHEM4KIDS.COM.

• *The Phantom’s Portrait Parlor: Mighty Molecule*.

Does Air Take Up Space?

Organizing Topic  Investigating the Structure and States of Matter

Overview  Students determine whether air takes up space. They then form a hypothesis and design an experiment to prove their hypothesis, concluding that all matter takes up space regardless of its state.

Related Standards of Learning  5.1c, h; 5.4

Objectives
The students should be able to
• design an investigation to determine whether air takes up space.

Materials needed
• Materials (e.g., balloons, gram scales, bowls, water, cups, paper towels) as needed for the investigations

Instructional activity
Content/Teacher Notes
Even at the fifth grade level, students may have a hard time conceiving that air takes up space. This investigation shows students that air does take up space and, therefore, is matter. Before beginning this activity, it is important that students understand the definition of matter. This activity necessitates that students draw on prior knowledge and previous lessons on matter.

In this investigation, you will play the part of the nonbeliever, stating that you do not believe that air takes up space and asking students to prove to you that it does. Give the students a class period for planning their experiments and submitting their materials lists to you. Use another class period for students to conduct their experiments, and another to present them, or combine these last two activities into one class period.

Because this activity is inquiry-based with students designing their own investigations, you may find that they need more direction. If that is the case, lead them through specific steps to come to the desired outcome.

Introduction
1. Begin a whole-class discussion by asking students whether they believe air takes up space. If they answer yes, say that you don’t believe them, and ask them why you can walk through it, why you don’t have to push it out of the way when you walk, why you can’t feel it pushing down on you from above, or why you can’t drink a glass of it. Try to get them a little exasperated about your not believing that air takes up space. Of course, students who might agree with you will need to change their hypothesis as they design their experiment.
2. Tell students that they are to design an experiment to prove to you that air takes up space.

Procedure
1. Place students into small groups, and have the members of each group discuss their ideas about whether air takes up space. Have them decide how to prove their hypothesis.
2. Give the groups time to research their hypotheses, using the Internet, their science textbooks, or materials you have gathered from the library. Make it clear that each group should form a hypothesis before continuing the investigation.

3. Have each group write out the experimental procedure they will follow to do their experiment. Have them submit to you a list of the materials they will need. If necessary, prompt creative thought by listing on the board objects like those shown under “Materials needed” on the previous page.

4. Sign off on each group’s experimental procedure before allowing them to proceed. Make suggestions to correct/improve their plan, as necessary.

5. Have groups perform their approved experiments, using the materials they listed. Emphasize that they must record their observations and data as they proceed.

6. Have each group present their experiment, their data, and their conclusions to the class and explain how they proved that air takes up space. Be sure to address any misconceptions that may come up during the presentations.

**Observations and Conclusions**

1. Discuss with the class the fact that nonbelievers will now have to change their original hypotheses because all the experimental data proves that air does take up space.

2. Help students recognize that because they have proved that air takes up space, air is matter. Emphasize this fact over and over as the groups share their experiments with the class. Based on this lab, students will be ready to investigate matter, coming into the activity with the understanding that all matter takes up space.

**Sample assessment**

- Evaluate student reports of their experiments to determine whether the conclusion was truly based on the data.
- Evaluate the group presentations.

**Follow-up/extension**

- This is a good opportunity to help students differentiate between weight and mass by holding a discussion about the differences between them, either as students get ready to perform their experiments or after the experiments are completed. You might wish to include a discussion of volume, too, and to introduce the appropriate metric units for these three units of measure.

**Resources**

Things Are Heating Up

Organizing Topic Investigating the Structure and States of Matter

Overview Students design an investigation to determine the effect of heat on the state of matter. They record the information they collect, make measurements, and graph results.

Related Standards of Learning 5.1c, d, e, h; 5.4c

Objectives

The students should be able to

• design an investigation to determine how heat affects the states of matter (e.g., water), including in the design the ways information will be recorded, the measurements that will be made, the instruments that will be used, and the ways the data will be graphed.

Materials needed

• Pictures of concrete sidewalks, roadways, and bridge surfaces
• Balloon
• Thermometers
• Freezer (or cooler filled with ice)
• Tape measure
• Graph paper
• Rubber bands
• Water
• Ice cubes
• Other materials as needed for the investigations

Instructional activity

Content/Teacher Notes

Changes in the states of matter are changes in the way molecules move. As matter heats up, its molecules move faster and farther apart. In this activity, students will design their own experiment to demonstrate how heat affects the states of matter. They will be given the option of showing how heat affects water, a rubber band, or a solid of their choosing. They will also design the way the information they gather will be recorded and what measurements will be made. They will graph the data they gather and present their findings to the class.

One problem in performing this activity is that for safety reasons, students are not allowed to use heat-generating appliances in the classroom. Therefore, they must create experiments that use solar energy. Keep in mind that strong solar energy is generally more available in the fall and spring than in the winter.

Because this activity is inquiry-based, with students designing their own investigations, you may find that they need more direction. If that is the case, lead them through specific steps to come to the desired outcome.

Introduction

1. Begin by asking students why sidewalks and concrete roadways are made with cracks between sections and why bridges have metal dividers with open space between them. Showing the
students pictures of these things will be helpful. After students have brainstormed a number of reasons, lead them to the understanding that concrete sidewalks, roadways, and bridges must have a little room and freedom to expand and contract as the temperature changes; otherwise, they will crack and break up as the seasons change and the temperature fluctuates.

2. Ask students how heat and cold affect the states of matter. Lead them to understand that generally speaking as matter heats up, it expands (gets bigger), and as it cools, it contracts (gets smaller). Relate expansion and contraction to the movement of molecules that make up the object: as an object heats up, the molecules that make up that object move faster and farther apart. This eventually results in a change in the matter, such as food cooking, water boiling, ice melting.

3. Explain that one exception to this rule is water, which expands when it freezes and contracts when it melts.

**Procedure**

**Activity 1: Motion and Temperature**

1. Demonstrate the effect of heat on air as follows. At least several hours prior to class, blow up a balloon, and place it in the freezer or in a cooler filled with ice. Also place a thermometer in the room. Place another thermometer in the room.

2. During class, explain that the balloon filled with air has been inside the freezer for many hours; therefore, the temperature of the air inside the balloon is the same as the temperature of the air in the freezer. Have a student read and record on the board the temperature of the air in the room and another student, the temperature of the air inside the balloon (same as temperature of the air in freezer).

3. Remove the balloon from the freezer, put it on a table, and have a student immediately measure and record its circumference on the board.

4. Continue with class, and after about 15 minutes, have the student measure the circumference again. Discuss with the class why the circumference changed as the air in the balloon warmed up.

5. Return the balloon to the freezer, and an hour later, take it out and measure and record its circumference once more. Discuss why it is again smaller, having students explain what happens to the molecules of matter when heat is removed from matter.

**Activity 2: Investigation of the Effect of Heat on the State of Matter**

1. Tell students that they will be working in small groups to design an investigation that will show a change(s) in the state of matter when it is heated, using the sun as the source of heat. They will need to write a hypothesis and then create the design of their investigation to prove their hypothesis. The design must identify the materials they will need to use, the measurement instruments they will need for measuring the changes, the data sheet they will need for recording the changes, and the graphical representation they will construct for explaining the results. Students may use materials that are in the classroom or bring materials from home.

2. Put students into small groups, and give them ample time to work on their hypotheses and designs, bring in or ask you to supply materials, and design the data sheet they will use. Give guidance and other help as needed. Approve all designs before allowing students to proceed.

3. Plan the investigations for a day that will have plentiful, intense sunshine. Have the groups carry out their investigations, gathering data and recording it on the data sheet and graphing the results.

4. Have the groups present their investigations and their results, along with their graphical representations, to the class.
Observations and Conclusions

1. Students should observe that as matter heats up, a change in the state the matter eventually takes place. They should conclude that this is because the movement of the matter’s molecules increases as the matter is heated, thus causing the change in the state.

Sample assessment

- Assess the students’ investigations, including their hypotheses, conclusions, and graphical data.
- Assess the students’ presentations to the class.

Follow-up/extension

- Have students find other examples in the construction industry in which the design allows for expansion and contraction of the materials (e.g., wood paneling in which the panels “float”).

Resources

All Mixed Up

Organizing Topic   Investigating the Structure and States of Matter

Overview     Students observe a variety of mixtures and solutions and compare and contrast them.

Related Standards of Learning   5.1e, h; 5.4b

Objectives
The students should be able to
• compare and contrast mixtures and solutions.

Materials needed
• Clear plastic cups
• Powdered drink mix
• Water
• Pepper
• Mixed fruit salad
• Marbles
• Sand
• Yogurt with fruit mixed in
• Milk
• Chocolate powder
• Salt
• Copies of attached worksheet and Venn diagram
• Overhead projector (optional)

Instructional activity
Content/Teacher Notes
In this investigation, students will rotate among different centers, observing various mixtures and solutions in clear plastic cups. See the attached worksheet for examples.

Before beginning this investigation, be sure to introduce students to the idea that a *mixture* is a combination of at least two or more different substances that do not lose their identifying characteristics when combined — for example, mud and water, or milk and cereal. Many mixtures can be easily separated.

When two substances mixed together *cannot* be easily separated because one substance *dissolves* in the others, the mixture is a *solution*. It is possible to separate the two substances, but not very easily. An example of a solution is sugar dissolved in tea: the sugar is still there, but it is dissolved, and in order separate it out, you would need to evaporate the liquid.

Students should understand at the end of the activity that all solutions are mixtures, but not all mixtures are solutions.

Introduction
1. Tell students that in their everyday lives, they frequently encounter mixtures and solutions, and give them a chance to name some mixtures and solutions and tell you what they already know about them.
2. Give students the definitions of *mixture* and *solution*, and have them record the definitions for future reference. Have the students add to their list of mixtures and solutions in light of knowing these definitions.

3. Tell the students that they are going to make observations to determine whether various liquids they examine have formed mixtures or solutions. If necessary, review the use of Venn diagrams.

*Procedure*

1. Use the attached worksheet to prepare the designated mixtures and solutions, or prepare a similar worksheet to use with other mixtures and solutions of your choice.

2. Set the prepared cups at different stations around the room. Be sure to label each cup clearly with its contents.

3. Write the definitions of *mixture* and *solution* on the board for reference. Have students work individually or in pairs to fill out the worksheet as they move from center to center. Remind students that it may be possible to check both the mixture and solution box but that they need to explain why they chose both.

4. When students have completed their observations and formed a conclusion, hand out the attached Venn diagram to each student. Have each student fill out the areas of the diagram, listing the various mixtures and solution they have identified. Place a copy of the diagram on the overhead, or make a large version on the board, and have the students fill it in during a class discussion based on their observations.

*Observations and Conclusions*

1. As the class discusses their results, lead the students to explain the similarities and differences between mixtures and solutions. Be sure they grasp the concept that all solutions are mixtures, but not all mixtures are solutions.

*Sample assessment*

- Use the completed worksheets for immediate assessment.
- Give students different mixtures and solutions to identify, using the same kind of data sheet. Evaluate the reasoning behind their answers.

*Follow-up/extension*

- Take this a step further by investigating suspensions: give the students vegetable oil and water to observe and assess without telling them whether it is a mixture or solution.
Comparing and Contrasting Mixtures and Solutions

Closely observe the contents of each cup, and decide whether its contents is a mixture and/or a solution. Explain the reason for your decision.

<table>
<thead>
<tr>
<th>Substances</th>
<th>Mixture (✓)</th>
<th>Solution (✓)</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powdered drink &amp; water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water &amp; pepper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed fruit salad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marbles &amp; sand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand &amp; water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit &amp; yogurt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate powder &amp; milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water &amp; salt</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Form a conclusion based on your observations, and write your conclusion below:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Virginia Department of Education
Comparing Mixtures and Solutions in a Venn Diagram

Name: ____________________________  Date: ____________________________
Sample Released SOL Test Items

The smallest quantity of an element is —

F a compound
G an atom
H a solution
J a molecule

Which of the following changes is possible with the addition of heat?

A Liquid water changes to ice.
B Water vapor changes to ice.
C Water vapor changes to liquid water.
D Ice changes to liquid water.

The smallest part of matter that is identifiable as an element is the —

F atom
G molecule
H cell
J compound

What will happen if the lid is removed from a container that holds helium gas?

F The gas will expand and escape from the container.
G The gas will slowly change back into a liquid.
H When light hits the gas, it will change colors.
J Gravity will keep the gas in the container.

Frequency Distribution of Backpack Mass

<table>
<thead>
<tr>
<th>Mass of Backpacks (kilograms)</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>1</td>
</tr>
<tr>
<td>2-3</td>
<td>10</td>
</tr>
<tr>
<td>4-5</td>
<td>8</td>
</tr>
<tr>
<td>6-7</td>
<td>1</td>
</tr>
<tr>
<td>8-9</td>
<td>2</td>
</tr>
</tbody>
</table>

Students in Mrs. Smith’s class are trying to find the average mass of fifth-grade students’ backpacks. The information is displayed on the chart above. The chart shows the majority of fifth-grade students have backpacks with a mass of —

F 2-3 kilograms
G 4-5 kilograms
H 6-7 kilograms
J 8-9 kilograms
Which is the *fairest* way to find out if salt water boils faster than fresh water?

- [F]
- [G]
- [H]
- [J]
**Organizing Topic — Investigating Cells**

**Standards of Learning**

5.1 The student will plan and conduct investigations in which
  e) data are collected, recorded, and reported using the appropriate graphical representation (graphs, charts, diagrams);
  f) predictions are made using patterns, and simple graphical data are extrapolated;
  g) manipulated and responding variables are identified; and
  h) an understanding of the nature of science is developed and reinforced.

5.5 The student will investigate and understand that organisms are made of cells and have distinguishing characteristics. Key concepts include
  a) basic cell structures and functions.

<table>
<thead>
<tr>
<th>Essential Understandings, Knowledge, and Skills</th>
<th>Correlation to Textbooks and Other Instructional Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>The students should be able to</td>
<td></td>
</tr>
<tr>
<td>• draw, label, and describe the essential structures of plant and animal cells and their functions. For plants, include the nucleus, cell wall, cell membrane, vacuole, chloroplasts, and cytoplasm. For animals, include the nucleus, cell membrane, vacuole, and cytoplasm;</td>
<td></td>
</tr>
<tr>
<td>• design an investigation to make observations of cells;</td>
<td></td>
</tr>
<tr>
<td>• compare and contrast plant and animal cells and identify their major parts and functions.</td>
<td></td>
</tr>
</tbody>
</table>
Plant and Animal Cells

Organizing Topic  Investigating Cells

Overview  Students use their observation skills to document the differences between an animal cell and a plant cell while also noting the characteristics the two cells have in common. The students brainstorm why cells have different functions, and therefore, different structures.

Related Standards of Learning  5.1e, f, h; 5.5a

Objectives
The students should be able to
• draw, label, and describe the essential structures of plant and animal cells and their functions. For plants, include the nucleus, cell wall, cell membrane, vacuole, chloroplasts, and cytoplasm. For animals, include the nucleus, cell membrane, vacuole, and cytoplasm;
• compare and contrast plant and animal cells and identify their major parts and functions.

Materials needed
• Copies of attached worksheet and Venn diagram
• Overhead projector and overhead transparency of the Venn diagram
• Microscopes
• Prepared slides of plant and animal cells

Instructional activity
Content/Teacher Notes
Students should already be familiar with the ways scientists classify living things, the six life processes of living things, and the five kingdoms. It is essential for students to know that a major difference between plants and animals is that plants make their own food and animals do not.

It is important that students make the distinction between the structures of animal and plant cells. Being able to visualize the parts of both types of cells will enable the students to understand better the functions of these structures. This is the reason to teach form before function. The lesson will have greatest impact if the students are allowed to find the differences through observation, then label each structure, and finally identify the functions of the various cell structures.

Introduction
1. Review with students the characteristics of plants and animals and the characteristics that set them apart from the other kingdoms. Reinforce the ideas that cells are the building blocks of all living things and that the structure of an organism’s cells is one way scientists classify living things into kingdoms. Remind students that a major difference between plants and animals is that plants make their own food and animals do not. Alternatively, have students identify the similarities and differences between plants and animals on their own.

Procedure
1. Place students into small groups of two to four, and give each group a copy of the attached worksheet and Venn diagram. (The worksheet sketches are rudimentary, so you may wish to use better representations of plant and animal cells. See “Resources.”)
2. **Instruct the students to observe the cells carefully and record their observations on the Venn diagram by noting in the outer part of one circle or the other the structures that are unique to each cell and writing in the circles’ overlapping part the structures that are found in both.**

3. **After students have had about 10 minutes to make and record their observations, ask students to make a prediction as to which is the plant cell and which is the animal cell and to back up their prediction with a reason for their choice.**

4. **Place the Venn diagram on the overhead, and fill it in as the students dictate what structures the two cells have in common and what structures are unique to one cell or the other.**

5. **Have the student groups share their predictions and their reasoning with the class. Record on the board all predictions and the reasoning behind them.**

6. **Allow students to use a microscope to look at examples of prepared slides of actual plant and animal cells to observe their structures.**

**Observations and Conclusions**

1. **Be sure that students observe that one cell has a cell wall and chloroplasts and the other cell has no unique structures. Help them conclude that both cells have a cell membrane, vacuoles, cytoplasm, and a nucleus.**

2. **After students have made their predictions, verify that the cell with the cell wall and the chloroplasts is the plant cell. Some students may have rightly concluded that because a plant cell does not have a skeletal system or other form of protection, it therefore needs to have a wall of protection. They also should have concluded that a plant needs a structure to help make its food and that an animal cell does not need such a structure.**

3. **Have students identify each cell structure and display in a graphic organizer its identity and function. An example of a graphic organizer that may be used is a two-column chart with the organelle on the left and the function on the right.**

**Sample assessment**

- Assess the students’ Venn diagrams and graphic organizers for completeness and accuracy.
- On a following day, hand out the same cell pictures with the key blocked out, and have students identify each structure.

**Follow-up/extension**

- Instead of giving the students the function of each cell structure, have students predict what each function might be. Relating each part of the cell to a part of the school building may prove helpful for students. For example,
  - Nucleus — principal or teacher
  - Cell wall — outer walls of the building
  - Cell membrane — walls of the classroom
  - Vacuoles — cafeteria, restrooms

- Follow up with the next lesson, “Building a Cell.”

**Resources**

Cell Identification Worksheet

Cell 1

Cell 2

Key
- Nucleus
- Cytoplasm
- Cell Wall
- Cell Membrane
- Vacuole
- Chloroplast
Comparing Plant and Animal Cells in a Venn Diagram

Prediction: Cell ____ is a plant cell, and cell ____ is an animal cell.
Reason for this prediction: ________________________________
Building a Cell

Organizing Topic  Investigating Cells

Overview  Students design and build an edible plant or animal cell model from a variety of given materials and construct a key to identify each structure of the cell.

Related Standards of Learning  5.5a

Objectives
The students should be able to
• identify the nucleus, cell wall, cell membrane, vacuole, chloroplasts, and cytoplasm;
• compare and contrast plant and animal cells and identify their major parts and functions.

Materials needed
• Disposable bowls, or two sizes of tight-closing plastic bags
• Soft-set gelatin in a neutral color such as orange (Two large boxes are needed for a class of 25.)
• Plastic wrap
• A variety of small foods, such as small marshmallows, grapes, strawberries, blueberries, celery pieces, banana slices, to mix into the gelatin
• Spoons
• “Cell Identification Worksheet” from previous lesson
• Drawing paper

Instructional activity

Content/Teacher Notes
In this lesson, students will design a model of a plant or animal cell, create a key that identifies each structure of the cell and the substance from which it is made, and then build the model. Gelatin will be used as the cytoplasm in which everything else floats. Students will choose to represent their cell in a bowl or plastic bag representing either the cell wall or the cell membrane. Students will identify the other students’ cell models as plant or animal cells.

Introduction
1. Review the parts of the cell covered in the previous lesson.
2. Tell students they will be creating a model of either a plant cell or an animal cell. Tell them that the gelatin will represent the cytoplasm in both kinds of cells and that they can use any of the available food materials for the cell structures, but that they will have to design the cell before building it, including in their design a diagram and a key.

Procedure
1. Place all food materials in a central location, and identify each one. Explain that cell models may be built in either bowls or plastic bags and that all parts of the cell model must be identified in a key.
2. Have the students design their cell model by drawing a diagram, adding color, and including a key that identifies the cell’s structures and their functions. Check all diagrams before allowing students to build their models.
3. Have students build their models, using the food materials listed on their diagrams. If the gelatin has not set by the end of the class period, have students refrigerate all models overnight, covering the bowls with plastic wrap, and then continue the activity on the following day.

4. Have pairs of students exchange cell models and identify the cell types based on the structures included.

**Observations and Conclusions**

1. Make sure students can readily identify a plant-cell model by the presence of a cell wall and chloroplasts. Ask students to identify the function of the cell wall and the function of the chloroplasts. Emphasize that the cell wall is needed for protection and that the chloroplasts are needed for the making of food, which is essential to the plant’s survival.

2. Lead students to understand that the nucleus, cell membrane, and cytoplasm are found in and have the same function in both types of cells, and ask students to identify the function of each of these structures.

**Sample assessment**

- Assess the students’ drawings and keys, checking to be sure all parts of the cell are identified, the function of each part is listed, and the cell is identified as plant or animal. Display some of the better drawings on the wall or bulletin board.
- Assess the students informally by having each of them describe the parts of their cell to the whole class and having the class identify the described cell as either plant or animal.
- Use the Cell Identification Worksheet as a quiz on the following day to make sure that students can identify plant and animal cells.

**Follow-up/extension**

- Have students explain in their science journals how they built their cells, what materials they used, and why they chose a particular food for each structure. Have students explain why gelatin was used for cytoplasm. Collect journals for assessment.
- Give student groups the opportunity to write a play in which the each group is a plant or animal cell and each student in a group is one of the cell’s structures. Have the groups present their plays to the class so that the audience must guess whether the cell is animal or plant.
The Mystery of the Disappearing Cells

Organizing Topic  Investigating Cells

Overview  Students apply the knowledge about cells that they have gained through the previous lessons to a “real-life” experience.

Related Standards of Learning  5.1f; g; 5.5a

Objectives
The students should be able to
- design an investigation to make observations of cells;
- compare and contrast plant and animal cells and identify their major parts and functions.

Materials needed
- Sets of cell pictures (described below)

Instructional activity

Content/Teacher Notes
In this lesson, students will be given a mystery to solve, based on their knowledge of cells. To solve the mystery, they need to know the difference between plant and animal cells. The scenario provided is just a suggestion; you may choose to write your own story to suit your students.

For each small group of students, prepare a set of cell pictures; each set should contain one zooplankton picture and multiple phytoplankton pictures. Each picture should look like it was taken through a microscope — i.e., it should be a close-up cut into a circle, resembling the view one would have through a microscope. Use only those pictures of phytoplankton that clearly show a cell wall.

Introduction
1. If necessary, review with the class the knowledge about cells gained in the previous two activities.

Procedure
1. Tell the students they are going to play the part of crime scene investigators solving a crime. Set up a scenario for them, such as the following:

Scientists have discovered evidence of a previously unknown kind of plant life. They believe this is the basis of a food chain that is very important to the survival of all human beings. They have been investigating the plant life and have found out that without this food source, human life could become extinct. It truly is a matter of life and death!

Because of the importance of this discovery, the lab in which these investigations have been taking place has been under very heavy security, including access to the lab only through palm print identification. Nevertheless, when the scientists arrived at the lab yesterday, they were shocked to find only one cell left, all the others having disappeared! There were no signs of forced entry, and there were no fingerprints that could not be accounted for. It is possible, however, that the perpetrators may have used some of the plastic gloves that were sitting on a shelf.

Were the cells stolen? If so, by whom? Was it an inside job? Or is there some other explanation for their disappearance? Are there more examples of this plant life available to the scientists, and if there are, where can they be found? Fortunately, the scientists had microscopes with digital cameras attached, and they still have pictures of the cells that were stolen.
2. Put the students into small groups, and give each group a set of cell pictures. Answer any questions they may have before allowing them to begin their investigation.

3. Have student groups decide what they will need to do in order to solve the mystery. Students should conclude that first they need to study what they have — the pictures of the cells taken by the scientists. Tell the groups that they must record in a scientific manner the information they find through their observations and they must organize their data carefully on a chart of their own design. Only then will the mystery begin to unravel.

4. Have student groups conduct observations, record data, and draw conclusions.

**Observations and Conclusions**

1. Through their investigation, students should identify the phytoplankton as plant cells. When making observations of the zooplankton, they should observe that this cell has no cell wall and that therefore, this organism is not a plant but is an animal. Some students may come up with hypotheses that are not based on their observations, and they will need to be reminded that all the evidence they need to solve the mystery is right in front of them and that inferences about what happened should be based only on observations of this evidence. From this, they should be able to infer that the animal cells ate the plant cells; thus there was no robbery!

2. List on the board all student observations about the cells. Then list the inferences they have made, making sure they go back to their observations. This may take a while because students will make inferences that are not based on their observations. When a group or two has come up with the correct answer, tell them that the plant cells are phytoplankton, the basis of the food chain in the ocean, and that the animal cell is zooplankton, which eats phytoplankton. Explain that while the scientists were collecting their specimens, they also collected the zooplankton by mistake and did not notice it until it was too late.

**Sample assessment**

- Have student groups present to the class their hypotheses of what happened as if they are presenting it to the group of scientists who are missing the cells. Be sure they back up their hypotheses with facts and use their observation chart as evidence.
- Have students write to the scientists, stating their hypotheses, their observations, and their conclusions.

**Follow-up/extension**

- If the students demonstrate interest in this activity, take it a little farther and have them investigate what food chain the plants produce. Have them hypothesize what would happen to the world’s food supply if phytoplankton really did disappear off the face of the Earth.
Sample Released SOL Test Items

What part of the plant cell is shown at the arrow?
A  Cell wall
B  Cell membrane
C  Vacuole
D  Nucleus

In plant cells, chloroplasts —
A  act as the cell's control center
B  enable plant cells to produce their own food
C  allow materials to move into and out of the cell
D  support and protect the cell

The part of a plant cell that gives the cell its green color is the —
A  nucleus
B  cytoplasm
C  vacuole
D  chloroplast

Growth of a Plant

<table>
<thead>
<tr>
<th>Date</th>
<th>Height of Plant (cm)</th>
<th>Increase in Growth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>March 7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>March 11</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>March 15</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>

Based on the information in the chart, what would be the height of the plant on March 23?
A  10 cm
B  12 cm
C  14 cm
D  16 cm
Organizing Topic — Investigating the Characteristics of Organisms

Standards of Learning

5.1 The student will plan and conduct investigations in which
   a) rocks, minerals, and organisms are identified using a classification key.

5.5 The student will investigate and understand that organisms are made of cells and have
distinguishing characteristics. Key concepts include
   b) kingdoms of living things;
   c) vascular and nonvascular plants; and
   d) vertebrates and invertebrates.

Essential Understandings, Knowledge, and Skills

The students should be able to

• compare and contrast the distinguishing characteristics of the
  kingdoms of organisms;

• group organisms into categories, using their characteristics —
  living things (kingdoms), plants (vascular or nonvascular), and
  animals (vertebrates or invertebrates) — and name and
describe two common examples of each group.
Classifying

(Adapted from an activity included in the Educator’s Guide for the NASA SciFiles™ video program “The Case of the Prize-Winning Plants.” Used by permission.)

Organizing Topic  Investigating the Characteristics of Organisms

Overview  Students investigate the way things are classified in general and the five kingdoms used to classify organisms.

Related Standards of Learning  5.1a, 5.5b

Objectives

The students should be able to

•  compare and contrast the distinguishing characteristics of the kingdoms of organisms.

Materials needed

•  Collection of assorted buttons
•  Collection of different kinds of leaves
•  Science journals
•  Cards with pictures of various organisms on one side and notes about their key characteristics on the other
•  Copies of attached graphic organizer
•  Copy paper box lids, cardboard strips, tape

Instructional activity

Activity 1: Classic Classifying

Content/Teacher Notes

It is recommended that you review the full Educator’s Guide related to “The Case of the Prize-Winning Plants” (see “Resources”).

Introduction

1. Define classify, and explain the concept of classifying as the sorting and grouping together of objects. We classify things everyday. Think about your bedroom. Do you have a sock drawer, a drawer for pants or shirts, or a drawer for toys? What about the kitchen? Are the glasses all together on one shelf or are they mixed in with the pots and pans? We classify things to organize them and, in science, to better understand them.

Procedure

1. Place a collection of assorted buttons on the table. Have the students examine the buttons and tell you how to group them according to any one characteristic they choose, e.g., size, color, number of holes, or texture.
2. Mix up the buttons again, and have the students tell you how to regroup them according to a different characteristic. Have the students illustrate the various groupings in their science journals and explain why the buttons can be grouped in different ways.
3. Place a collection of different kinds of leaves on the table. Have the students observe the leaves and instruct you in grouping them according to an observable characteristic.
4. Mix the leaves up again, and have the students regroup them according to a different characteristic. Have students illustrate the groupings and explain.

**Observations and Conclusions**
1. Ask the students which collection was the easiest to classify (group)? Why?
2. Have the students describe the common characteristics of leaves. Ask them whether these characteristics make it easier or more difficult to classify them.

**Activity 2: Classifying Organisms**

*Content/Teacher Notes*
You will need to provide students with background information on several common organisms from each of the five kingdoms of organisms. One way to do this is in a card format, each card having a picture of an organism on one side and notes about some distinguishing features on the other. Students will use these cards for part of this activity. In addition to the information on the organism cards, you may provide students with information in other ways, such as books about specific organisms and fact sheets.

**Introduction**
1. Review the prior activity with students, and discuss the ways and importance of classifying objects. Lead them into a discussion about the ways scientists classify organisms. Point out that the students will be learning the five-kingdom system of classifying, although some scientists use a seven-kingdom system, or more. Relate this idea back to Activity 1 in which the students classified the same set of objects in different ways.

**Procedure**
1. Provide each student with a copy of the “Classification of Organisms” graphic organizer, listing the five kingdoms of organisms, identifying characteristics of each, and giving examples of organisms in each kingdom. Also give each student (or group of students) a set of organism cards.
2. Have the students classify the organisms shown on their cards, using the graphic organizer.

**Observations and Conclusions**
1. Have the students (or groups) share their classification results. Have students note in their science journals the classifications of all the organisms mentioned so that their lists are complete.

**Follow-up/extension**
- Brainstorm ideas of other groups of living things to classify, such as pets, animals in the zoo, animals in the jungle, etc.
- Use a copy paper box lid and cardboard strips to make a classification box with numerous compartments of various sizes. Collect items from nature, such as leaves, seeds, and flowers, and group them together in the individual compartments.

**Resources**
- “The Case of the Prize-Winning Plants.” *NASA SciFiles™*
## Classification of Organisms

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Organisms</th>
</tr>
</thead>
</table>
| **Monera** | - Microscopic, one-cell organisms  
- No nucleus  
- Absorb their food  
- Reproduce by dividing  
Examples: bacteria, blue-green algae |
| **Protist** | - Mostly one-cell organisms  
- Have a nucleus  
- Some can produce their own food  
- Reproduce by dividing  
Examples: amoeba, paramecium, euglena |
| **Fungi** | - One- or many-celled organisms  
- Absorb their food (decomposers)  
- Reproduce by spores or hyphae  
Examples: mushroom, mold, yeast |
| **Plants** | - Many-celled organisms  
- Produce own food (photosynthesis)  
- Reproduce in different ways  
Examples: flowering plants, ferns, mosses, conifers |
| **Animals** | - Many-celled organisms  
- Eat plants and other animals  
Examples: humans, fish, birds, snakes, sea sponges |
The Animal Kingdom: Invertebrates

Organizing Topic  Investigating the Characteristics of Organisms

Overview  Students create a class set of booklets depicting the eight invertebrate phyla.

Related Standards of Learning  5.1a, 5.5d

Objectives
The students should be able to
- group organisms into categories, using their characteristics — living things (kingdoms), plants (vascular or nonvascular), and animals (vertebrates or invertebrates) — and name and describe two common examples of each group.

Materials needed
- Internet access
- Reference books
- Copies of attached note sheet
- White paper
- Colored pencils or markers
- Staplers
- Yarn
- Hole punch
- Laminating supplies

Instructional activity
Content/Teacher Notes
To study organisms, scientists first look at their characteristics and group the organisms based on the characteristics they share. Of all the kingdoms of organisms, the animal kingdom contains the organisms that are most diverse in appearance. Some animals are so small that they live on or inside other animals. Others, such as the giant squid, are many meters long and live in the depths of oceans. Animals can swim, crawl, burrow, fly, or not move at all. No matter what their size, where they live, or how they move, all animals must have some basic characteristics in common. All organisms in the animal kingdom (1) are made of more than one cell, (2) obtain their own food, and (3) are made of cells that lack a cell wall and have a nucleus.

After an organism has been classified as an animal, scientists look for other characteristics in order to place it in a phylum. More than 95 percent of all animal species are often grouped in a single, informal category called invertebrates. Invertebrates are animal that have no vertebral column or backbone. There are eight phyla of invertebrates: Porifera (sponges), Cnidaria (jellyfish, corals), Platyhelminthes (flatworms), Nematoda (roundworms), Annelida (segmented worms), Mollusca (mollusks), Arthropoda (arthropods), and Echinodermata (echinoderms). The other 5 percent of animals have a vertebral column and are grouped in a category called vertebrates. These include fish, amphibians, reptiles, birds, and mammals.

The focus of the learning at this level is being able to recognize animals as either vertebrates or invertebrates and to know some basic characteristics of each. It is not necessary for students to memorize all of the invertebrate phyla; they will study this later in Life Science.
A good introductory lesson to vertebrates and invertebrates is “Animal Antics,” which is included in the NASA SciFiles™ program “The Case of the Zany Animal Antics” (see “Resources”).

**Introduction**

1. Have students work in groups, and assign each group one or two invertebrate phyla. If you form eight groups, each group can have one phylum and produce one booklet. Give each student a copy of the “Invertebrate Note Sheet.”

**Procedure**

1. Have the students in each group research their assigned phylum or phyla, using the Internet, textbooks, reference books, and other resources.
2. Tell students that they must collect information on the note sheet provided. This will help to guide them in their research.
3. After students complete their research, have each group compile a booklet about their phylum. Each student in a group might be assigned a section to complete:
   a. Cover page: title with illustration
   b. Habitat page: picture of an animal in the phylum in its natural habitat (e.g., a spider in a web to represent the arthropods)
   c. Organism page: large, detailed picture of an organism in the phylum with its parts labeled.
   d. Poetry page: a short poem about the organism, including as many details about the defining characteristics of the phylum as possible
   e. Fact page: 5 to 10 questions about the phylum that a reader should be able to answer after reading the booklet
   f. Answer page: answers to the fact questions
4. Have the groups bind their booklets.

**Observations and Conclusions**

1. Have each group report on their phylum to the class.
2. Have groups trade booklets and complete the fact questions.
3. Lead a group discussion regarding the common, defining characteristics of invertebrates and listing some common examples.

**Sample assessment**

- Have students identify some common examples of invertebrates.

**Follow-up/extension**

- Have students compare and contrast invertebrates with vertebrates.
- Have students choose an invertebrate animal and explain how its adaptations enable it to live in its environment.

**Resources**

- Phylum Annelida. [http://www.ucmp.berkeley.edu/annelida/annelida.html](http://www.ucmp.berkeley.edu/annelida/annelida.html).
• Phylum Arthropoda.  
  www.sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Eukarya/Animalia/Arthropoda/.


• Phylum Echinodermata.  

• Phylum Mollusca.  
  www.sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Eukarya/Animalia/Mollusca/.

• Phylum Nematoda.  
  http://sidwell.edu/us/science/vlb5/Labs/Classification_Lab/Eukarya/Animalia/Nematoda/.


Invertebrate Note Sheet

Name: ____________________________
Date: ____________________________

Phylum: ____________________________

Major characteristics of this phylum:

Diagram of body systems (parts) that are characteristic of this phylum:

Names of animals in this phylum:

Interesting facts about this phylum:
1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________
5. ____________________________
6. ____________________________
7. ____________________________
8. ____________________________
9. ____________________________
10. ____________________________
The Animal Kingdom: Vertebrates

Organizing Topic  Investigating the Characteristics of Organisms

Overview  Students create a class set of booklets depicting the five main subclasses of the subphylum, vertebrata.

Related Standards of Learning  5.1a, 5.5d

Objectives

The students should be able to

• group organisms into categories, using their characteristics — living things (kingdoms), plants (vascular or nonvascular), and animals (vertebrates or invertebrates) — and name and describe two common examples of each group.

Materials needed

• Access to the Internet
• Reference books
• Copies of attached note sheet
• White paper
• Colored pencils or markers
• Staplers
• Yarn
• Hole punch
• Laminating supplies

Instructional activity

Content/Teacher Notes

To study organisms, scientists first look at their characteristics and group the organisms based on the characteristics they share. Of all the kingdoms of organisms, the animal kingdom contains the organisms that are most diverse in appearance. Some animals are so small that they live on or inside other animals. Others, such as the giant squid, are many meters long and live in the depths of oceans. Animals can swim, crawl, burrow, fly, or not move at all. No matter what their size, where they live, or how they move, all animals must have some basic characteristics in common. All organisms in the animal kingdom (1) are made of more than one cell, (2) obtain their own food, and (3) are made of cells that lack a cell wall and have a nucleus.

After an organism has been classified as an animal, scientists look for other characteristics in order to place it in a phylum. More than 95 percent of all animal species are often grouped in a single, informal category called invertebrates. Invertebrates are animal that have no vertebral column or backbone. The other 5 percent of animals have a backbone and are grouped in a category called vertebrates. They are in kingdom Anamalia, phylum Chordata, and subphylum Vertebrata. There are five main classes of vertebrates: fish, amphibians, reptiles, birds, and mammals.

The focus of the learning at this level is being able to recognize animals as either vertebrates or invertebrates and to know some basic characteristics of each. Students will study the characteristics of each animal class in depth later in Life Science.
A good introductory lesson to vertebrates and invertebrates is “Animal Antics,” which is included in the NASA SciFiles™ program “The Case of the Zany Animal Antics” (see “Resources”).

**Introduction**
1. Have students work in groups, and assign each group a class of vertebrates. If you form five groups, each group can have one class and produce one booklet. Give each student a copy of the “Vertebrate Note Sheet.”

**Procedure**
1. Have the students in each group research their assigned class of vertebrates, using the Internet, textbooks, reference books, and other resources.
2. Tell students that they must collect information on the note sheet provided. This will help to guide them in their research.
3. After students complete their research, have each group compile a booklet about their class. Each student in a group might be assigned a section to complete:
   a. Cover page: title with illustration
   b. Habitat page: picture of an animal in the class in its natural habitat (e.g., a squirrel in a tree to represent the mammals)
   c. Organism page: large, detailed picture of an organism in the class with its parts labeled.
   d. Poetry page: a short poem about the organism, including as many details about the defining characteristics of the class as possible
   e. Fact page: 5 to 10 questions about the phylum that a reader should be able to answer after reading the booklet
   f. Answer page: answers to the fact questions
4. Have the groups bind their booklets.

**Observations and Conclusions**
1. Have each group report on their class of vertebrates to the class.
2. Have groups trade booklets and complete the fact questions.
3. Lead a group discussion regarding the common, defining characteristics of vertebrates and listing some common examples in each class.

**Sample assessment**
- Have students identify some common examples of vertebrates.

**Follow-up/extension**
- Have students compare and contrast invertebrates with vertebrates.
- Have students choose a vertebrate and explain how its adaptations enable it to live in its environment.
- Have students compare and contrast the classes of vertebrates by creating a Venn diagram showing their similarities and differences.
Resources

- “The Case of the Zany Animal Antics.” *NASA SciFiles™*.  

- Class Amphibia (amphibians).  

- Class Aves (birds).  

- Class Mammalia (mammals).  

- Class Osteichthyes (bony fish).  

- Class Reptilia (reptiles).  
Vertebrate Note Sheet

Name: ____________________________  
Date: ____________________________

<table>
<thead>
<tr>
<th>Class:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major characteristics of this class:</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Diagram of body systems (parts) that are characteristic this class: |
|                                                                     |

| Names of animals in this class: |
|                               |

| Interesting facts about this class: |
| 1.                                 |
| 2.                                 |
| 3.                                 |
| 4.                                 |
| 5.                                 |
| 6.                                 |
| 7.                                 |
| 8.                                 |
| 9.                                 |
| 10.                                |
Tubes for the Move

(Adapted from an activity included in the Educator’s Guide for the NASA SciFiles™ video program “The Case of the Prize-Winning Plants.” Used by permission.)

Organizing Topic Investigating the Characteristics of Organisms

Overview Students learn a way plants are classified by observing the movement of colored water through a vascular plant.

Related Standards of Learning 5.1a, 5.5c

Objectives
The students should be able to
• group organisms into categories, using their characteristics — living things (kingdoms), plants (vascular or nonvascular), and animals (vertebrates or invertebrates) — and name and describe two common examples of each group.

Materials needed
• Jars
• Water
• Blue food coloring
• Stirrers
• Celery stalks
• Scissors
• Rulers
• Paper towels
• Science journals

Instructional activity

Content/Teacher Notes
The plant kingdom is classified into major groups called divisions. A division is the same as a phylum in other kingdoms. As students saw in the “Classifying” lesson, there are various ways to group things. Another way to group plants is as vascular or nonvascular. Vascular plants have tube-like structures (xylem and phloem) that carry water, nutrients, and other substances throughout the plant. Nonvascular plants do not have these tube-like structures and use other ways to move water and other substances.

Introduction
1. Review the five kingdoms and the characteristics of each. Bring the focus of the discussion around to the plant kingdom. Have students name different kinds of plants, and list them on the board. Introduce the term vascular to students.

Procedure
1. Put the students into small groups.
2. Have each group fill a jar almost to the top with water, add 5 to 10 drops of blue food coloring to the water, and stir gently.
3. Give each group a stalk of celery with leaves intact, and have them use scissors to cut the stalk diagonally so that the stalk measures 20 cm from the tips of the leaves down to the cut end.
4. Instruct the students to put the cut end of the stalk into the colored water and observe and record their observations every hour in their science journal until they notice a change in the leaves. These observations should include measurements of how high the colored water has traveled up the celery stalk.

5. Have the students carefully take the stalk out of the water and dry it so as to not drip colored water. Tell them to observe the stalk, paying close attention to the end where the stem was cut, and record their observations.

Observations and Conclusions
1. Have the students discuss in their groups what happened to the leaves of the celery stalk and the possible reasons this happened. Ask: “What can you conclude by observing the cut part of the stem?”

2. Have the groups report their conclusions to the class. Be sure that students arrive at the fact that the water was carried up through the celery stalk in tube-like structures and that the presence of these structures make it a vascular plant. Such structures enable the plant to become large and transport water through the stems. Nonvascular plants cannot do this. Ask: “How high up do you think water in a vascular plant might go.” If the answers are too conservative, ask them to consider redwood trees, which have been known to carry water as high as 112.1 meters (367.8 feet)!

Sample assessment
- Have students explain what it means for a plant to be a “vascular plant.”

Follow-up/extension
- Have students repeat the above experiment with flowers, such as carnations, to see if the results are the same as with the celery.
- Have the students conduct the experiment again, but with three stalks, placing one in a dark room, one in the sunlight, and one in fluorescent light. Do they all behave the same? Why, or why not?
- Have the students observe a cross section of a tree trunk and compare it to a cross section of the celery stalk or a flower stem. Have them count the number of light and dark rings in the tree trunk cross section and hypothesize why the rings are different colors and sizes.

Resources
- “The Case of the Prize-Winning Plants.” NASA SciFiles™
**Sample Released SOL Test Items**

**Which of these is not a plant?**

- **F**
  ![Plant Image]
- **G**
  ![Mushroom Image]
- **H**
  ![Corn Image]
- **J**
  ![Tree Image]

Trees, wild flowers, and grasses are all considered to be —

- **F** vascular plants
- **G** nonvascular plants
- **H** woody plants
- **J** nonwoody plants

**Classification Key**

1. **1a** Body kite-like in shape.......................... Ray  
   **1b** Body not kite-like in shape ..................... Go to 2
2. **2a** Nose saw-like in shape .......................... Swordfish  
   **2b** Nose not saw-like in shape ...................... Go to 3
3. **3a** Head extended on both sides .................. Hammerhead shark  
   **3b** Head not extended on both sides .............. Go to 4
4. **4a** Body has spots ................................. Leopard shark  
   **4b** Body does not have spots ................. Nurse shark

Using the picture and classification key, what is this animal?

- **F** Swordfish
- **G** Hammerhead shark
- **H** Leopard shark
- **J** Nurse shark

**How is a fish different from a jellyfish?**

- **F** A fish has a backbone.
- **G** A fish is in the animal kingdom.
- **H** A fish can reproduce.
- **J** A fish lives in water.
What do ferns have that apple trees do not have?

A  Stems  
B  Roots  
C  Flowers  
D  Spores

START HERE
Does the creature have a round head? (go to 1)

Does the creature have a square head? (go to 2)

1 Does the creature have one big eye? (go to 3)
   Does the creature have two eyes? (go to 4)

2 Does the creature have horns? (go to 5)
   Does the creature have no horns? (go to 6)

3 The creature is a Woznat.

4 The creature is a Zapoom.

5 The creature is a Nanner.

6 The creature is an Ock.

According to the identification key, what type of creature is creature Y?

A  Woznat  
B  Zapoom  
C  Nanner  
D  Ock
Organizing Topic — Investigating the Ocean Environment

Standards of Learning

5.1 The student will plan and conduct investigations in which
   a) rocks, minerals, and organisms are identified using a classification key;
   b) estimations of length, mass, and volume are made;
   c) appropriate instruments are selected and used for making quantitative observations of
      length, mass, volume, and elapsed time;
   d) accurate measurements are made using basic tools (thermometer, meter stick, balance,
      graduated cylinder);
   e) data are collected, recorded, and reported using the appropriate graphical representation
      (graphs, charts, diagrams);
   f) predictions are made using patterns, and simple graphical data are extrapolated;
   g) manipulated and responding variables are identified; and
   h) an understanding of the nature of science is developed and reinforced.

5.6 The student will investigate and understand characteristics of the ocean environment. Key
   concepts include
   a) geological characteristics (continental shelf, slope, rise);
   b) physical characteristics (depth, salinity, major currents); and
   c) biological characteristics (ecosystems).

Essential Understandings, Knowledge, and Skills

The students should be able to

- explain key terminology related to the ocean environment;
- create and interpret a model of the ocean floor and label and describe each of the major features;
- research and describe the variation in depths associated with ocean features, including the continental shelf, slope, and rise; the abyssal plain; and ocean trenches;
- design an investigation (including models and simulations) related to physical characteristics of the ocean environment (depth, salinity, formation of waves, and currents, such as the Gulf Stream);
- interpret graphical data related to physical characteristics of the ocean;
- explain the formation of ocean currents and describe and locate the Gulf Stream;
- design an investigation (including models and simulations) related to biologic characteristics of the ocean environment (ecological relationships);
- group organisms into categories, using their characteristics: living things (kingdoms), plants (vascular or nonvascular), and animals (vertebrates or invertebrates), and name and describe two common examples of each group;

Correlation to Textbooks and Other Instructional Materials
• interpret graphical data related to the biological characteristics of the ocean, such as the number of organisms vs. the depth of the water;

• analyze how the physical characteristics (depth, salinity, and temperature) of the ocean affect where marine organism can live;

• create and interpret a model of a basic marine food web, including floating organisms (plankton), swimming organisms, and organisms living on the ocean bottom.
The Ocean Floor

Organizing Topic  Investigating the Ocean Environment

Overview  Students construct a model of the ocean floor.

Related Standards of Learning  5.6a

Objectives

The students should be able to
- explain key terminology related to the ocean environment;
- create and interpret a model of the ocean floor and label and describe each of the major features;
- research and describe the variations in depths associated with ocean features, including the continental shelf, slope, and rise; the abyssal plain; and ocean trenches;
- analyze how the physical characteristics (depth, salinity, and temperature) of the ocean affect where marine organisms can live.

Materials needed
- Drawing paper and pencils
- Chart paper and markers
- Shoe boxes
- Modeling clay
- Rocks
- Toothpicks
- Sticky notes
- Copies of the attached worksheet

Instructional activity

Content/Teacher Notes

(Background information adapted from Websites of The Office of Naval Research and Neptune’s Web [see “Resources”])

The sea bottom is described as having various characteristic types of areas — the continental shelf, continental slope, continental rise, deep ocean basin, abyssal plain, deep-sea trench, and seamount.

The continental shelf is a submerged border of a continent that slopes gradually and extends to a point of steeper descent to the deep ocean basin. The width of the continental shelf varies considerably from only a few miles to more than 900 miles, but worldwide it averages about 45 miles. It has numerous little hills, ridges, terraces, and canyons, but the water is never very deep here. When you are standing in the ocean at the beach, you are standing on the highest part of a continental shelf.

The continental slope connects the continental shelf and the oceanic crust. It begins where the bottom sharply drops off into a steep slope. It usually begins at a depth of 430 feet (130 meters) and can be up to 20 km wide.

Past the continental slope is found the continental rise. As currents flow along the continental shelf and down the continental slope, they pick up and carry sediments and deposit them just below the continental slope. These sediments accumulate (gather) to form the large, gentle slope of the continental rise.

All ocean floors except the North Pacific contain mountain ranges, several of which are higher than Mt. Everest. The largest mountain chain is the Mid-Atlantic Ridge.
Much of the deep ocean floor, especially in the Pacific, is a deep ocean basin, which is about 2.5 to 3.5 miles deep and covers about 30 percent of Earth’s surface. It somewhat resembles the surface of the moon with its features such as the abyssal plain, deep-sea trenches, and seamounts.

The abyssal plain is the flat, deep ocean floor. It is almost featureless because a thick layer of sediment has covered the hills and valleys found in it.

Deep-sea trenches are the deepest parts of the ocean. The deepest one, the Marianas Trench in the South Pacific Ocean, is more than 35,000 feet (10,668 meters), or almost 6.6 miles (10.6 kilometers) deep. A Navy-owned submarine, the Trieste, still holds the record for diving to the bottom of the deepest part of the Marianas Trench, the Challenger Deep, on January 23, 1960.

**Introduction**

1. Tell the students to imagine they are flying across the United States. Below, they see flat plains, high mountains, and deep canyons. Now, tell them to try to picture an area seven miles below the ocean’s surface. What does it look like? Surprisingly, very similar to the topography of the continental U.S.

2. Give students drawing paper, and ask them to listen to your spoken description of features of the ocean floor and to draw/diagram what you describe:

   You are walking on the beach toward the water. The continental shelf is the part or area of the ocean floor onto which you first walk out from the beach. It slopes very gently. Although it has numerous little hills, ridges, terraces, and canyons, the water is never very deep here. Continuing out, the steeper slope and drop into deeper water is the continental slope. Here you find little valleys cut by currents moving across the ocean bottom. Even farther out you come to the continental rise, where the slope again becomes more gentle and is covered with soft sediments deposited by water currents flowing down the continental slope. Finally, you see the deepest bottom of the ocean — the deep ocean basin — which has flat plains, deep trenches, and high mountains. The vast and nearly flat area is the abyssal plain. It is broken by some deep-sea trenches that are like very deep ditches or canyons. The deepest trench is deeper than the tallest mountain on land! Also, you find some tall mountain ranges, which contain a few mountains higher than Mr. Everest, and some seamounts. All in all, it is quite a varied and fantastic environment for the plants and animals that live there.

3. Repeat the diagramming exercise as a class, using a large piece of chart paper. Allow students to make suggestions about how to draw the diagram, but guide them into creating an accurate representation. Label the parts of this class diagram and post it for later reference.

**Procedure**

1. Tell students that they are now going to construct a model of the ocean floor, using the class diagram of the ocean floor as a “blueprint” or guide. (Define the word blueprint for those who are unsure of its meaning.)

2. Distribute model materials to the students, and have them create models showing the features of the ocean floor, including the continental shelf, continental slope, continental rise, abyssal plain, deep-sea trenches, and mountain ranges. Have students label the ocean features, using toothpicks and sticky notes. Circulate around the room to check the models and offer help when needed.

3. After the models are complete, provide students with a copy of the attached “The Ocean Floor” worksheet, and have them complete the graphic organizer with characteristics of each feature, including the types of organisms that would be found in each area.

**Sample assessment**

- Give students an unlabeled ocean-floor diagram, and have them label all characteristic areas.
• Have students complete a partially completed chart that lists the key characteristics of the ocean floor.
• Give students the quiz about the ocean floor found on the “Science and Technology” Website (see “Resources”).

Follow-up/extension
• Have students make an ocean-floor model in a water-proof container, such as a large, clear plastic box, and then cover the model with opaque liquid, such as very dark colored water. Then, have students determine the profile of the unseen ocean floor by taking a number of depth measurements with a ruler and plotting the measurements on graph paper.

Resources
• The Ocean Floor. http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/ocean/ocean.html. Shows a diagram of the ocean floor.
## The Ocean Floor

**Name:** ____________________________

**Date:** ______________

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Marine Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental shelf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continental slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continental rise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abyssal plain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep-sea trench</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seamount</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Salty Sea

Organizing Topic  Investigating the Ocean Environment

Overview  Students will investigate salinity.

Related Standards of Learning  5.6b

Objectives

The students should be able to

• explain key terminology related to the ocean environment;
• analyze how the physical characteristics (depth, salinity, and temperature) of the ocean affect where marine organisms can live.

Materials needed

• Salt
• Fresh water
• Large, clear plastic cups
• Food coloring
• Spoons
• Potato slices
• Ocean water
• Graduated cylinders
• Hand lenses, or microscopes
• Droppers
• Clean microscope slides
• Copies of the attached lab sheet

Instructional activity

Content/Teacher Notes

Different bodies of water can have different amounts of salt in solution — i.e., different salinities. Salinity of water is expressed as the number of grams of salt found in 1,000 grams of the water. Therefore, 1 gram of salt in 1,000 grams of water results in a salinity of 1 part per thousand (1 ppt).

Average salinity of ocean water is 35 ppt; however, rainfall, evaporation, river runoff, and ice formation cause this number to vary between 32 and 37 ppt. For example, the Black Sea is so diluted by freshwater river runoff, its average salinity is only 16 ppt.

The salinity of fresh water is usually less than 0.5 ppt. Water between 0.5 ppt and 17 ppt is called brackish. Estuaries, where fresh river water meets salty ocean water, are examples of brackish waters. The Chesapeake Bay is an excellent example of an estuary.

The salinity of water inside the bodies of most marine creatures is about the same as the salinity of the water in which they live because water seeks a balance. When an animal that normally lives in salt water is placed in fresh water, the fresh water flows into the animal through its skin. Conversely, when a freshwater animal is put into the salty ocean, the fresh water inside of it flows out. The process by which water flows through a semipermeable membrane, such as an animal’s skin, from a solution of lower solute concentration (lower salinity) into a solution of higher solute concentration (higher salinity) is called osmosis.
Introduction
1. Ask the students whether they have ever wondered why the oceans are filled with salt water instead of fresh water. Just where did all that salt come from? Is it the same kind of salt you find in a salt shaker? Explain that most of the salt in the oceans came from land. Over millions of years, water flowing in rivers and streams has washed over rocks containing salt — the compound sodium chloride (NaCl) — and carried it into the seas. Some of the salt in the oceans comes from undersea volcanoes and hydrothermal vents. When water evaporates from the surface of the ocean, the salt is left behind. After millions of years, the oceans have become more and more salty — that is, their salinity has increased.

Procedure
Experiment 1
1. Have students work in pairs to fill each of 2 clear plastic cups less than half full with the same amount of fresh water. Have one partner mix 8 teaspoons of salt into the water in one of the cups while the other partner mixes a few drops of food coloring into the other cup. Emphasize that coloring the water with a little food color does not significantly change the salinity of the water: it is still fresh water. The color simply differentiates it from the salt water.
2. Now, have one partner hold a spoon directly over the salt water and the other pour the colored water very slowly into the spoon so that it slowly drips out into the salt water. Try to keep the spoon close to the salt water when pouring the colored water in order to reduce splashing and mixing of the waters. The students should note that the two different waters do not mix. If the colored fresh water is poured slowly enough, it will float on top of the salt water. Ask why. (Salt water is heavier than fresh water, i.e., it has a greater density.)
3. Have the partners very slowly and gently lower a potato slice into their water container without stirring the water. They should note that the slice sinks through the colored fresh water and floats on the salt water.
4. Discuss the results of the experiment with the class, leading them to draw correct conclusions about what happened. Include in the discussion the layering of waters due to their different salinities and thus different densities. Does this happen on a large scale in the ocean? Does the water near the bottom of the ocean have a greater density and salinity that that near the top? How might these differences in ocean water salinity in one geographical location affect the marine life that can live there?

Experiment 2
1. Give each student a copy of the attached lab sheet and an equal quantity of fresh water and ocean water. (If you cannot get ocean water, mix salt with fresh water and let it sit overnight.) Ask students to smell both samples and describe what they smell.
2. Have students use a graduated cylinder to determine the volume of each type of water.
3. Have students put a drop of fresh water on a clean microscope slide and observe it with a magnifying glass (or a microscope, if possible). Then, have them repeat this process to observe a drop of salt water.
4. Have students fan the two drops of water until the water evaporates. Have them predict what they will see when the water evaporates and then describe the actual result.

Observations and Conclusions
1. Have students complete the lab sheet and make observations.
2. Discuss with the class the salinity of ocean water, including the normal salinity, unusual salinities, estuaries, and brackish water. Have the students research and list some examples of marine life that prefer the brackish water in estuaries to ocean water, and have them explain why. The estuaries of Virginia rivers flowing into the Chesapeake Bay are a good place to look.

3. Discuss osmosis with the students.

Sample assessment

- Assess the students’ lab sheets for understanding.
- Have students write their own definition of salinity, and assess for understanding.

Follow-up/extension

- Challenge students to create a “rainbow” of layered waters by using different-colored water of various salinities. See the following Website for directions: [http://www.lessonplanspage.com/ScienceOceanCurrents78.htm](http://www.lessonplanspage.com/ScienceOceanCurrents78.htm).
- Have the students repeat the water-layering experiment, but using two samples of the same ocean water at two different temperatures. Have them analyze how the differences in ocean water temperature in one location might affect the marine life that can live there.

Resources

- Windows to the Universe: Chesapeake Bay. [http://www.windows.ucar.edu/tour/link=/earth/Water/chesapeake.html](http://www.windows.ucar.edu/tour/link=/earth/Water/chesapeake.html).
Salinity

Name: ____________________________ Date: _____________________

1. Describe the odor of each sample of water.

   Fresh water: ______________________________________________

   Ocean water: ______________________________________________

2. Find and record the volume of each sample of water.

   Fresh water: _______ ml          Ocean water: _______ ml

3. Draw what you saw when you observed each drop under the magnifying glass or microscope.

   Fresh Water

   Ocean Water

4. Predict what you will see as the two drops of water evaporate.

   Fresh water: ______________________________________________

   Ocean water: ______________________________________________

5. Describe what you actually saw after each drop evaporated.

   Fresh water: ______________________________________________

   Ocean water: ______________________________________________
**Going Up, Going Down**  
(Adapted from an activity included in the Educator’s Guide for the NASA SciFiles™ video program “The Wacky Water Cycle.” Used by permission.)

**Organizing Topic**  Investigating the Ocean Environment

**Overview**  Students investigate the movement of warm and cool ocean currents.

**Related Standards of Learning**  5.6b

**Objectives**
The students should be able to
- explain the formation of ocean currents and locate the Gulf Stream.

**Materials needed**
- Clear glass casserole dishes
- Tap water
- Hot tap water
- Small waterproof zip bags
- Clip clothespins or small clamps
- Two different colors of food coloring
- Small rocks
- Ice cubes
- Thermometers
- Science journals
- Copies of an ocean currents map, such as that found at [http://www.physicalgeography.net/fundamentals/8q_1.html](http://www.physicalgeography.net/fundamentals/8q_1.html)

**Instructional activity**

**Content/Teacher Notes**

*Thermohaline circulation* is the name for currents that occur when colder, saltier (denser) water sinks and displaces water that is warmer and less salty and dense. In a cycle known as the *global conveyor belt*, warm water near the equator is pushed by normally strong winds toward the poles and begins to cool. In a few regions, such as the North Atlantic, cold, salty water sinks to the ocean floor. This water then travels in the deep ocean back towards the equator and begins to rise to replace the water that is being pushed away from the equator by the winds. This cool water rising to the surface is known as *upwelling*. This entire process, which may take a thousand years to complete, helps regulate the climate of the Earth as heat is transported from the equator to the polar regions and cooling water is transported to the equator.

During a period of El Niño, the winds along the equator are weaker than usual and may actually blow in the opposite direction. Warm water begins to pile up along the nearby coasts. Where the ocean is warm, more clouds form and more rain falls. Normal weather patterns around the world are therefore disrupted by this change in ocean temperature.

NASA collects satellite data to measure the sea surface and temperatures and uses the data to make maps of the ocean. From these maps, scientists can monitor the speed and direction of ocean currents.
Introduction
1. Ask students whether they have ever heard of the Gulf Stream. If so, what do they think it is? Write their responses on board. Explain to students that the Gulf Stream is a huge current and that they will be doing an activity that shows what currents are and how they are formed. The activity will also help them see why the Gulf Stream is important to people living along the East Coast.

Procedure
1. Put the students into small groups, and give each group a set of materials.
2. Have each group fill a casserole dish with room-temperature tap water and let the pan rest for a while so that the water settles and comes closer to room temperature. While this is happening, have them place a small rock in each of two plastic bags.
3. Have the groups fill one of their bags with hot water from the faucet (CAUTION: not scalding!), seal it, place it in one end of the glass dish, and use a clothespin to clip it in place (see diagram).
4. Have the groups fill their other bag with ice cubes, seal it, put it in the dish opposite the warm water bag, and use another clothespin to clip the bag to the dish.

5. Now, tell the students to carefully add 4 drops of food color to the water next to the bag of hot water and 4 drops of a different color to the water next to the bag of ice cubes. Have them observe the movement of the colors in the water for several minutes and then record their observations and illustrate them in their science journals.
6. Have a student in each group gently blow across the top of the water surface, and have all students observe what happens to the colored waters and record their observations.
7. Have another student blow across the top of the water from the other side and all students observe and record.
8. Have the groups repeat steps 2–7 and measure the temperature at the surface and bottom of the warm end of the dish at each step. Have them record the temperatures and explain what is happening.

Observations and Conclusions
1. Have the student groups explain what happened to the water near the colder end of the pan and what happened to the water near the warmer end of the pan.
2. Ask: “When you began to blow across the water, adding ‘wind power’ to the water currents, how did they change? Why?”
3. Discuss the factors that might change the flow of ocean currents. Include a discussion of how changes in the ocean currents affect the Earth.

Sample assessment
- Assess students’ knowledge on the basis of the “Observation and Conclusion” discussion and the notes and illustrations in the students’ science journals.
Follow-up/extension

• Have students use a map of ocean currents, such as the one found at http://www.physicalgeography.net/fundamentals/8q_1.html. Have them notice the difference in current flow between the northern and southern hemispheres, and discuss the reasons for this difference. To demonstrate this phenomenon and help students learn more about Coriolis effect, use the experiment “Round and Round We Go” found in the NASA SciFiles™ episode “The Case of the Phenomenal Weather” (see “Resources”).

• Have students examine satellite image maps of ocean temperatures and make their own edible ocean map by using colored gelatin and lemon sherbet. For directions, see http://spaceplace.nasa.gov/en/kids/topex_make1.shtml.

• Have students use the Websites listed below to research some key information about the ocean.

Resources


**Life in the Food Chain**

**Organizing Topic**  Investigating the Ocean Environment

**Overview**  Students investigate the links in a marine food chain.

**Related Standards of Learning**  5.6c

**Objectives**

The students should be able to

- create and interpret a model of a basic marine food web, including floating organisms (plankton), swimming organisms, and organisms living on the ocean bottom.

**Materials needed**

- Copies of the attached food-chain game cards
- Masking tape
- Open area outdoors or indoors for group play

**Instructional activity**

**Content/Teacher Notes**

This activity is designed to be used after students have been studying different organisms in the ocean food chain. Be sure to emphasize the flow of energy through the food chain and the basic fact that the sun is the original source of all food chains.

**Introduction**

1. Prior to beginning the activity, use the attached “Food-Chain Game 1 Cards” to make a complete game-set of 64 cards consisting of 8 cards of each of the 8 different food-chain organisms (plants or animals).
2. Display one complete set of cards out of sequence, and discuss with the class each organism shown.
3. Have the students help you arrange the cards in the correct sequence in the chain so that the students understand not only what the organisms are, but also how they fit into the chain. Emphasize that the sun is the beginning of all food chains and that its energy flows through the entire chain.
4. Mark out a “tidal trading pool” area on the floor with masking tape, making it large enough for 8 students at a time to be inside it.

**Procedure**

1. Divide the students into 8 teams, give each team a set of 8 cards showing the same ocean organism, and tell the teams that they will be playing a game about food chains. The object of the game is to collect all 8 cards showing the complete food chain by trading them.
2. Explain the rules. Each team has a home base on the playing field, and in the center of the field is the “tidal trading pool” — a marked-off trading area. At each turn, one student from each team runs into the pool with one card held face-down and yells, “Trade!” The students in the pool must exchange cards without looking at them; then they may run back to their home bases. All cards must be held face-down in the trading pool. If a student breaks this rule, he or she must stay in the
pool for an extra 10 seconds before going back to home base, which will reduce the team’s trading time. When the newly traded card arrives back at home base, the team looks at it and decides either to keep it or to trade it. Then, another student from the team takes one card face-down into the trading pool and trades it. Students may trade only one card at a time. The team that collects all 8 cards first yells, “Food chain!”, and trading stops.

3. Each team must create a food chain with the cards they have. They get 10 points for each card placed in the correct location in the chain.

4. Repeat the game until the students are comfortable with it. Then, have them play the game with the “Game 2” cards.

Observations and Conclusions
- Have students use their existing knowledge of the ocean zones and marine life to list the organisms from the food chain cards and the locations in the ocean where they would be found.

Sample assessment
- Give students a list of marine organisms, and have them work individually to place them into a food chain.

Follow-up/extension
- Have students create a food web, using both sets of cards.

Resources
- Chesapeake Bay Foundation: Save the Bay. [http://www.cbf.org](http://www.cbf.org).
Food-Chain Game 1 Cards

Sun → Phytoplankton → Zooplankton → Bristle Worm → Anchovy → Rockfish → Dolphin → Shark
Food-Chain Game 2 Cards

Sun → Phytoplankton → Zooplankton → Featherduster Worm → Squid → Mackerel → Sea Lion → Orca
Sample Released SOL Test Items

The ocean floor —
A is always a flat bed of sand
B has mountains, plains, and ridges like land surfaces
C is covered by the same amount of water everywhere
D covers less area than the land

Which of these is *not* considered ocean pollution?
A Dumping garbage
B Artificial reefs
C Oil spills
D Chemical runoff

Algae and other producers need lots of sunlight. Most ocean algae would be found in the water —
A on the abyssal plain
B in the oceanic trench
C above the continental shelf
D beside the continental slope

What is the length of the tadpole?
A 2.8 cm
B 3.1 cm
C 3.5 cm
D 4.0 cm
Organizing Topic — Investigating the Changing Earth

Standards of Learning

5.1 The student will plan and conduct investigations in which
   a) rocks, minerals, and organisms are identified using a classification key;
   b) estimations of length, mass, and volume are made;
   c) appropriate instruments are selected and used for making quantitative observations of
      length, mass, volume, and elapsed time;
   d) accurate measurements are made using basic tools (thermometer, meter stick, balance,
      graduated cylinder);
   e) data are collected, recorded, and reported using the appropriate graphical representation
      (graphs, charts, diagrams);
   f) predictions are made using patterns, and simple graphical data are extrapolated;
   g) manipulated and responding variables are identified; and
   h) an understanding of the nature of science is developed and reinforced.

5.7 The student will investigate and understand how the Earth’s surface is constantly changing.
   Key concepts include
   a) the rock cycle, including identification of rock types;
   b) Earth history and fossil evidence;
   c) the basic structure of the Earth’s interior;
   d) plate tectonics (earthquakes and volcanoes);
   e) weathering and erosion; and
   f) human impact.

Essential Understandings, Knowledge, and Skills

The students should be able to

- apply basic terminology to explain how the Earth’s surface is constantly changing;
- draw and label the rock cycle and describe the major processes and rock types involved;
- compare and contrast the origins of igneous, sedimentary, and metamorphic rocks;
- identify rock samples (granite, gneiss, slate, limestone, shale, sandstone, and coal), using a rock-classification key;
- make plausible inferences about changes in the Earth over time based on fossil evidence. This includes the presence of organism fossils in sedimentary rocks of Virginia found in the Appalachians, Piedmont, and Coastal Plain/Tidewater;
- describe the structure of Earth in terms of its major layers — crust, mantle, and inner and outer cores — and how the Earth’s interior affects the surface;
- differentiate among the three types of plate tectonic boundaries (divergent, convergent, and sliding) and describe how these
relate to the changing surface of the Earth, including the ocean floor;

• compare and contrast the origins of earthquakes and volcanoes and describe how they affect the Earth’s surface;

• design an investigation to locate, chart, and report weathering and erosion at home and on the school grounds, and create a plan to solve erosion problems that may be found;

• differentiate between weathering and erosion;

• design an investigation to determine the amount and kinds of weathered rock material found in soil;

• describe how people change the Earth’s surface and how negative changes can be controlled.
The Layers of the Earth

Organizing Topic  Investigating the Changing Earth

Overview  Students investigate the layers of the Earth, including its inner and outer cores, mantle, and crust. They build a model of the Earth and find objects in nature that mimic the model of the Earth.

Related Standards of Learning  5.7c

Objectives
The students should be able to

- describe the structure of Earth in terms of its major layers — crust, mantle, and inner and outer cores — and how the Earth’s interior affects the surface;
- apply basic terminology to explain how the Earth’s surface is constantly changing.

Materials needed
- Plasticene clay in different colors
- Plastic knives or wooden tongue depressors
- Copies of the attached diagram of the Earth’s layers
- Science journals

Instructional activity
Content/Teacher Notes
Students need to understand that the core is the thickest layer of the Earth, and the crust is relatively thin, compared to the other layers. Students will build a model of the Earth, using different colors of clay, and identify the different layers by drawing their model and labeling each part.

Introduction
1. Ask students what they already know about the structure of the Earth. Review that the Earth consists of three layers — the core (divided into inner and outer), the mantle, and the crust.
2. On the board, draw a picture of the interior of the Earth (see attached diagram), and have the students copy it into their science journal. Explain that the inner core is made of very hot metal that takes a solid form, while the outer core is made of molten metal, and that the mantel is made up of hot lava (molten rock) on which the relatively thin layer of crust floats.
3. Explain that scientists know the inner and outer core layers exist because of the seismograms that have been taken during earthquakes. Because the outer core contains iron, when it flows, it generates a magnetic field. This is the source of the Earth’s magnetic field.
4. Talk about the mantle, just above the core of the Earth. Explain that the mantle is rather flexible so it flows instead of cracking or breaking up.
5. Explain that the outer layer of the Earth — the one we live on — is the crust, which is about 25 miles thick beneath the continents and only about 6.5 miles thick beneath the oceans. The crust is light and brittle compared to the other layers of the Earth, and most earthquakes occur within the crust.
Procedure
1. Hand out to students the diagram of the Earth’s layers, and ask them if they can think of anything in nature that resembles the layers of the Earth. Mention a peach as an example. Help them come up with other ideas, such as a hard boiled egg or a plum.
2. Tell students that they will be creating a model of the Earth’s layers, using different colors of clay. They will be working with a partner.
3. Divide the students into pairs, hand out a small piece of gray clay to each pair, and instruct them to roll it into a small ball.
4. Hand out a piece of green clay, and have them cover the small ball with a uniform thickness of green clay to form a larger ball.
5. Hand out a piece of red clay, which they should use to cover the green with about a ½-inch thickness.
6. Give the students a piece of blue clay that is just enough to cover the red with a very thin coat.
7. Have each pair cut their ball in half. Discuss with the class what each layer of clay represents.
8. Have each student draw a diagram of the layers of the Earth and label each layer with its name and composition.

Observations and Conclusions
1. Make sure students observe the relative thicknesses of the layers — that the inner core and outer cores together form the thickest layer of the Earth and that the crust is by far the thinnest layer.
2. Lead students to conclude that the Earth has many layers and that scientists are aware of these layers through technology, including the recording of earthquakes with seismographs.

Sample assessment
- Use a quiz on the layers of the Earth to assess students’ understanding.

Follow-up/extension
- Discuss with the class the fact that the crust is not made up of a single piece of rock, but is made up of a series of plates that move and slide along the top layer of the mantle. This will lead to the next lesson on plate tectonics, earthquakes, and volcanoes.
- Have the class make a pizza representing the layers of the Earth, using the toppings to represent each layer.

Resources
The inner core is made of solid metal.  
The outer core is made of molten metal.  
Together, the inner and outer cores form the thickest layer.  
The mantle is a layer of molten rock.  
The crust is the thinnest layer.
**Plate Tectonics**

**Organizing Topic**  Investigating the Changing Earth

**Overview**  Students examine the plates that cover the surface of the Earth and differentiate among the three types of plate tectonic boundaries. They discover that the movement of these plates causes changes to the Earth’s surface, including the ocean floor, through earthquakes and volcanoes.

**Related Standards of Learning**  5.7d

**Objectives**  The students should be able to

- differentiate among the three types of plate tectonic boundaries (divergent, convergent, and sliding) and describe how these relate to the changing surface of the Earth, including the ocean floor;
- compare and contrast the origins of earthquakes and volcanoes and describe how they affect the Earth’s surface;
- apply basic terminology to explain how the Earth’s surface is constantly changing.

**Materials needed**  
- Pre-made vanilla frosting
- Graham crackers
- Wax paper
- Copies of the attached worksheet

**Instructional activity**  

**Content/Teacher Notes**  

The Earth’s crust is made up of seven large, very rigid plates, which are moving at different speeds and sometimes colliding. Plate boundaries occur where two plates meet. There are three different kinds of boundaries, which are defined by how the plates were formed and how they are moving in relation to each other:

- **Divergent boundaries.** Divergent boundaries occur along spreading centers where plates are moving apart and new crust is being created by magma pushing up from the mantle. The Mid-Atlantic Ridge in the Atlantic Ocean is such a boundary. It extends from the Arctic Ocean to the tip of Africa and is one of the longest mountain ranges in the world.

- **Convergent boundaries.** Convergent boundaries occur where plates are moving toward each other, sometimes forcing one plate to slide under the other plate and at other times pushing both plates upward. This usually takes place where an oceanic plate and a continental plate, two oceanic plates, or two continental plates come together. This type of collision of plates formed the Himalayas and the Rocky Mountains.

- **Sliding boundaries.** Sliding boundaries occur where two plates slide against each other in opposite directions. This movement is the cause of many earthquakes, such as those along the San Andreas Fault in California.
In this lesson, students will simulate the movement of the plates and observe how those movements change the surface of the Earth, including the following:

- **Volcanoes.** Volcanoes are vents in the surface of the Earth through which magma and associated gases and ash erupt. They are also the structure (usually conical) that is produced by the ejected material.

- **Earthquakes.** Earthquakes are the shaking, rolling, or sudden shock of the Earth’s surface caused by the movement of the Earth’s plates, usually the sliding of two plate boundaries against each other. Earthquakes can be measured using a Richter scale, which rates the degree of shaking on a scale from 1 to 7 with 7 being the most severe and anything a 2 or less not being felt at all.

**Introduction**

1. Start a class discussion by asking students what they already know about earthquakes. Ask them if they know what they are and where they are famous for occurring in the United States (California).

2. Ask students to think about the model of the Earth they made in the previous lesson. Explain to them that although they made the crust of their Earth models smooth and even, the actual crust of the Earth is divided into seven large plates, which move and sometimes collide with each other. Explain that there are three ways that the plates can move in relation to each other, and tell the students that they will be simulating that movement in this activity.

**Procedure**

1. Put the students into pairs, and hand out a piece of wax paper and a copy of the attached worksheet to each pair. Then, give a blob of frosting to each pair. Tell them the frosting represents the layer of lava — the mantle — on which the Earth’s crust floats.

2. Give each pair one long graham cracker broken in half, and tell them that the two halves represent two of the Earth’s plates.

3. To model the first way the plates can move in relation to each other, have the students place the graham crackers side by side gently on the frosting. Have them slide the two crackers against each other in opposite directions, slightly bumping and scraping while sliding. Explain to students that this is what happens when two plates slide and that this motion frequently causes earthquakes. Define earthquakes, and inform the students that earthquakes are frequent along the San Andreas Fault in California — a famous example of a sliding boundary. Be sure students observe that the frosting acts as a cushion but does not come up through the plates. Have students fill in the related blocks on the worksheet, citing earthquakes under “Effects.”

4. Second, have students carefully move the graham crackers apart and observe that an opening occurs and that the frosting is clearly evident. This movement is called divergent. It causes openings in the Earth’s crust out of which lava may flow or in which trenches may form. Have students fill in the related blocks on the worksheet, listing the Mid-Atlantic Ridge in the Atlantic Ocean as an example, and trenches, earthquakes, and mountain ranges under “Effects.”

5. Third, have students move the graham crackers together. Instruct some pairs of students to let one cracker slide under the other and other pairs to bring them together with some force, causing some cracking and breaking but causing them both to rise up into a mountain form. Explain to the students that this is an example of convergence, or coming together. Again, have students fill in the related blocks on the worksheet, listing the Rocky Mountains and Himalayas, as well as the Mariana Trench (created by ocean-to-ocean subduction — i.e., one plate topped by oceanic crust being subducted beneath another plate topped by oceanic crust), as examples of this kind of movement. Have students list mountain ranges, trenches, and volcanoes under “Effects.”
6. Explain that at convergent boundaries, whether the plates move under or over depends on what kind of plates are meeting. Two continental plates converging will cause both to move upward and mountains to form over time, while an oceanic plate and a continental plate converging will cause one plate to move below the other. Volcanoes can form when this occurs. Students who forced one cracker below another should be able to observe some of the frosting leaking up onto the upper cracker, which represents the formation of volcanoes from this type of action.

Observations and Conclusions
1. Make sure students conclude that these plate movements occur over long periods of time and that different kinds of plate movement cause earthquakes and volcanoes.

Sample assessment
- On another day, use the worksheet as a quiz by removing the information listed in the second column.
- Give a fresh set of graham crackers to the students, and give them an oral direction as to which movement to model — convergent, divergent, or slide. Ask them to draw the movement, describe the effect, and give an example of the movement.

Follow-up/extension
- Have the students investigate earthquakes and other disturbances, including architectural concepts that has been developed to prevent building damage. Have students create a model of a building that can resist damage during an earthquake.
- Introduce the idea of tsunamis, and explain that they are a result of two oceanic plates moving and causing earthquakes, which in turn cause tsunamis. Discuss the ways Japan has prepared to deal with the threat of tsunamis.

Resources
**Plate Tectonics**

**Directions:** Use the words below to complete the table. Some words might be used more than once, and some words might not be used at all.

<table>
<thead>
<tr>
<th>mountain ranges</th>
<th>volcanoes</th>
<th>deserts</th>
<th>Himalayas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mariana Trench</td>
<td>San Andreas Fault</td>
<td>convergent</td>
<td>tsunami</td>
</tr>
<tr>
<td>divergent</td>
<td>sliding</td>
<td>Rocky Mountains</td>
<td>trenches</td>
</tr>
<tr>
<td>glaciers</td>
<td>earthquakes</td>
<td>floods</td>
<td>Mid-Atlantic Ridge</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Direction of Movement</th>
<th>Motion</th>
<th>Type of Boundary</th>
<th>Example(s)</th>
<th>Effect(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two plates slide against each other in opposite directions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two plates come together, one sliding under the other or both rising up.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two plates move apart.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Evidence Is In

Organizing Topic  Investigating the Changing Earth

Overview  Students learn that fossils are the evidence scientists use to determine the history of the Earth. Students investigate the presence of organism fossils in sedimentary rocks found in Virginia, and they use fossil data to make inferences about the changes that have occurred to the land in Virginia and elsewhere on Earth.

Related Standards of Learning  5.7b

Objectives  The students should be able to

• make plausible inferences about changes in the Earth over time based on fossil evidence. This includes the presence of organism fossils in sedimentary rocks found in Virginia in the Appalachians, Piedmont, and Coastal Plain/Tidewater.

Materials needed  
• Plaster of paris
• Paper cups
• Plasticene clay
• A variety of small shells, leaves, and other organic objects with which to make “fossils”
• Pictures of fossils
• Magnifying glasses
• Internet access

Instructional activity
Content/Teacher Notes  
Not only does the presence of fossils tell us that certain organisms existed in a specific location in the distant past, but also their presence in particular layers of earth helps scientists determine the history of that area. A large ocean once divided the North American continent, and because of this, fossils found on the East Coast of the U.S. show a different kind of life than those found on the West Coast.

Until only recently, scientists believed that Virginia was not the home of much prehistoric life because few fossils had been found as evidence of life in our area during the age of dinosaurs. In recent years, however, scientists have discovered some significant evidence of prehistoric life in the Coastal Plain/Tidewater region of Virginia. Some of these finds are as recent as after Hurricane Isabel hit Virginia in the fall of 2003, when the fossilized bones of a prehistoric whale were uncovered by the storm.

Each region in Virginia has its own history, as evidenced through fossil discoveries. Although few dinosaur bones have been discovered in the state, enough dinosaur footprints have now been found to show that dinosaurs did exist here in great numbers. There are not many available resources on this subject, but a few are listed under “Resources.” Students need to learn that inferences about changes in the Earth over time can be based on fossil evidence found throughout Virginia. Having exact answers is not as important as the inferences that can be made, which include that the shore of Virginia has moved eastward over much time as sand and sediments have washed ashore, changing the shoreline.
Introduction

1. Define paleontologist for the students. Tell them that in this activity, they will be paleontologists trying to find out about the history of Virginia long before Jamestown was discovered. Ask students how a paleontologist could know what kind of life existed here before people were around to observe it and write it down. What kind of records do we have from the time of the dinosaurs and even before that? They should be able to tell you that scientists use fossils to find out about the history of a place before the time of recorded history.

2. Ask students: “What is a fossil?” Help them define and understand fossil as the remains, trace, or impression of an animal or plant of a past geologic age that has been preserved in sedimentary rock. Ask students how fossils are formed, and discuss with the class the process that turns part of an animal or plant into a fossil (see step 4 under Procedure below).

3. Brainstorm a list of ideas about what fossils can tell us. These should include kinds of plants and animals that lived in a region during a certain time period.

Procedure

Activity 1

1. Tell students that today they are going to make their own “fossil.” Hand out to each student, or each student pair, a paper cup and a ball of clay. Have students soften the clay and push it into the bottom of the cup so it is about 1½ to 2 inches thick.

2. Have students press a shell or other small organic object into the clay so that it leaves a clear impression, and then remove the object. At this point, the students have made clay molds of their objects.

3. Have them pour about 1 inch of plaster of paris over the impression. Set the cups aside to dry.

4. After the plaster is completely dry, have each student tear away the paper cup and gently remove the plaster from the clay mold. The students will now have both a clay mold and a plaster cast of the object. Explain that this is similar to the way many fossils are formed. Slowly, over a long period of time, an object that has fallen into soft clay or mud (the mold) fills up with minerals as it deteriorates, and the mineral-filled object becomes a kind of cast of the object while the soft clay or mud becomes sedimentary rock. Usually, the hardest parts of an organism’s body, such as bones, teeth, and shells, are the objects that last long enough to become a fossil; rarely are they skin, muscle, or fur because these deteriorate so quickly. In other cases, such as footprints, the impression in the mud or clay is left completely free to fill with sedimentary rock over time.

Activity 2

1. Tell students that they are going to be paleontologists as they identify the organism to which a fossil belongs and the time period and location in which the organism existed.

2. Give each student a picture of a fossil that was found in Virginia. Have the students use the Web site about “Early Eocene Sharks & Rays of Virginia” (see “Resources”) and/or other resources to research their fossil to find out what organism it came from and when and where that organism lived.

3. Have the students infer why fossils of ocean animals’ teeth and bones are found on land in the Coastal Plain/Tidewater region of Virginia. This is an advanced activity that will require advanced skills, such as research skills using the Internet and resources you have gathered for this purpose.
Sample assessment

- Have students fill out a log that details their “fossil find” and the information they were able to gather about it. Make sure they include their inferences about how the Earth has changed in Virginia since the time their organism lived at that place.

Follow-up/extension

- Have students create a timeline of fossils, from the oldest (the deepest) to the youngest (closest to the top soil layer). You might also have students spot on a Virginia wall map the regions in which their assigned fossils were found. Mapping the number of fossils found in each region will help students make inferences about the history of Virginia in prehistoric times by showing where life was clustered. It is important to let the students know that our knowledge of life in Virginia in prehistoric times is changing even now, as more and more fossils are found when they move towards the surface through weathering and erosion and movement of the tectonic plates.
- Have students draw a picture of their fossil on a large piece of white construction paper and include the information they gathered about it. Allow the class to hang the pictures in the hallway in chronological order from oldest to youngest, using the timeline they created.

Resources

- Bourdon, Jim and Michael Folmer. Early Eocene Sharks & Rays of Virginia. http://www.elasmo.com/paleo/fauna/va_eoc.html. This site shows a wonderful assortment of bone and tooth fossils of a variety of sharks and other fish found in Virginia.
Weathering and Erosion

Organizing Topic  Investigating the Changing Earth

Overview  Students define weathering and erosion, find evidence of erosion in the schoolyard and at home, and gather data about the erosion. They plan various methods of stopping the erosion from altering the area further, and they implement their plan.

Related Standards of Learning  5.1c, e; 5.7e, f

Objectives
The students should be able to

- apply the basic terminology to explain how the Earth’s surface is constantly changing;
- design an investigation to locate, chart, and report weathering and erosion at home and on the school grounds, and create a plan to solve erosion problems that may be found;
- differentiate between weathering and erosion;
- describe how people change the Earth’s surface and how negative changes can be controlled.

Materials needed

- Rulers (in centimeters)
- Digital or regular cameras (optional)
- Equipment for printing digital photos (optional)

Instructional activity

Content/Teacher Notes
This activity is best started near the beginning of the school year because it involves recording changes that occur over a long period of time; the longer the time period, the more noticeable these changes will be. Other science units can be incorporated into this lesson, such as observations of plants or evidence of other life in the designated area. Students will be “adopting a spot” for the school year. This spot can be in their backyard, in the school playground, in a local park, or anywhere students may have permission to mark off an area that will not be disturbed. The area chosen may already show signs of erosion. Some good possibilities may be an area under a rain spout where plants are not in evidence, a place where recent construction has been completed and plants have not yet taken root, and the sides of a stream or creek. It is not important for every student to find a place that already has erosion, because it is just as important for students to identify the factors that prevent erosion.

Students need to know the difference between weathering and erosion. Weathering is the breaking up of rocks due to chemical or mechanical changes. Chemical change can be caused by acid rain or acids emitted by some plants causing some of the minerals within a rock to change. Mechanical change is physically breaking a rock into fragments without changing the chemical makeup of the minerals within it. Erosion is the movement of rock particles by the action of wind, rain, gravity, and other forces of nature.

Repeatedly photographing (or drawing pictures) of the areas chosen is an important part of this project. Digital pictures are best because they do not require expensive processing and can readily be printed out as soon as they are taken.
**Introduction**

1. Tell students that they will be participating in a project throughout the whole school year that will document some changes in their environment. Ask students to come up with some environmental changes that are going on around them. They will probably talk about construction of buildings and roads, and they will likely mention the seasons. They may think of soil erosion from heavy rains. Lead them to the idea that those things are *causes* of changes to the Earth and that the actual changes, such as weathering and erosion, are the *effects* of those causes. Define *weathering* and *erosion*, and tell students they will be tracking some weathering and erosion in the community in which they live.

**Procedure**

1. Have each student designate a spiral notebook or journal to record the data they will collect during the year. They could also keep a video diary of the changes and/or write their entries in a computer-file diary if they have the equipment to do so.

2. Tell students that they are going to “adopt a spot” — an area about two feet by two feet that they will designate as their little corner of the world on which to focus for the school year. Help students decide where those places should be, being sure that there is a good variety of places. Some students may need to do this in the schoolyard, so you can use those students’ spots as examples for the students who choose remote areas. You must make sure that the students have permission from the owners of the land to mark off and eventually alter these spots; a signed permission form for each spot may be the best way to document permissions and avoid any problems.

3. Have the students mark off their spot in some way, for example, by using plastic builders tape. All spots need to be about the same size area.

4. Have the students take a picture (or make a drawing/diagram in their diary) of their area and date it. Have them look for and record all plant life in the area and all evidence of animal life, such as insects, animal droppings, footprints, etc. Have the students look carefully for signs of weathering or erosion and record those. If there are any large stones in the area, have the students observe and record their shapes very carefully. If there are cracks in the ground, students should measure their width and/or length and record the measurements in centimeters.

5. Designate a day every two weeks for students to go back to their spot, make the same observations again, record the same information, make notes about any changes that have taken place, and take a photo (or make a drawing/diagram in their diary) and date it. Differences occur slowly over time and are not always obvious just by looking; comparing photos or drawings/diagrams may be a better way to discover changes. As the year goes on and more changes take place, students can create a timeline of the changes by arranging the pictures or drawings/diagrams in the order they were made, which is why it is important to date each picture.

6. As the year progresses, discuss the discoveries the students are making. Have any stones in the area weathered enough to notice the change? Has there been any erosion? If no erosion is taking place, discuss why (e.g., plants are growing, roots are holding the soil, it is a protected place where weather does not affect it). If erosion is taking place, in late spring have students design a plan for stopping further erosion and repairing the eroded area. This can include planting plants with good root systems or adding pebbles or rocks to hold the soil. Pair students whose spots have not eroded with students whose spots have, and have the pairs work together to make a plan for the eroded spot.

7. Before allowing students to implement their plans, be certain to authorize the plans and to verify the permissions. Students must not make changes to land belonging to others without permission.
For those who have permission to make the proposed changes, have them continue making their observations and taking pictures after the plan has been implemented. Have them continue creating the picture timeline to help the class observe the changes.

Observations and Conclusions
1. By the end of the year, many students will have observed some real changes in the spots they have adopted. Some of these changes may be due to the change of seasons along with erosion and even some weathering. Others may be due to human impact. Students should also be able to explain conditions that prevent erosion and conditions that contribute to it.
2. Lead a discussion about the ways humans impact the environment and what people can do to be sure that they contribute to erosion as little as possible. Take the class on a walk around the school grounds and the neighborhood to look for ways humans are impacting their environment. This can include observing that builders put a black plastic fence around their work area to prevent topsoil from washing away before more plants can be planted, or that they plant grass as soon as grading on a construction site is done. Discuss ways humans help prevent erosion, from using strategies that we all can use to laws that ensure that a certain amount of land always stays in its natural state. Ask students to explain some of the possible consequences of urban sprawl in which nearly all forested areas around cities are destroyed to build houses, businesses, roads, and parking lots.

Sample assessment
- Collect and assess student journals on a regular basis to be sure correct documentation is occurring and an accurate record is being kept.
- Assess for effectiveness and creativity the students’ plans to prevent further erosion and repair erosion in their spots.
- Have students produce a PowerPoint presentation on the yearlong project in which they summarize what they learned about weathering and erosion and the ways their knowledge will impact them now and in the future.

Follow-up/extension
- Have students’ research laws in the community that directly address erosion. Have them write a letter to their representative, supporting the laws or asking for more stringent rules for builders, miners, farmers, and others who disturb the land.

Resources
What Kind of Weathered Rock Have You Found?

Organizing Topic  Investigating the Changing Earth

Overview  Students determine the amount and kinds of weathered rock that can be found in the community. They find ways to separate rocks from soil and use a classification key to determine what kind of weathered rock they have found.

Related Standards of Learning  5.1a, b, c; 5.7a, e

Objectives
The students should be able to
- identify rock samples (granite, gneiss, slate, limestone, shale, sandstone, and coal), using a rock-classification key;
- design an investigation to determine the amount and kinds of weathered rock material found in soil.

Materials needed
- Clear plastic containers
- Water
- Small spades or shovels
- Rock-classification key
- Screens for filtering, or coffee filters
- Magnifying glasses
- Vinegar

Instructional activity

Content/Teacher Notes
Before beginning this lesson, students should have learned from the previous lesson the difference between weathering and erosion. They will collect samples of soil from a little below the topsoil line and then design an investigation to separate the rocks out of the soil and identify the kinds of weathered rock that is left behind. You should make sure that students know about the different layers of soil and why it is important in this investigation to take the soil sample from an area right below the topsoil line. Because students are designing their own investigation, they may ask for materials not on the materials list. They should have a rock-classification key to help them identify their weathered rocks — either the one included in the “Rocky Road” lesson found later in this document or one found elsewhere.

Introduction
1. Begin by reviewing the definitions of weathering and erosion. Explain to students that they will be identifying weathered rock that has been found in the soil around the schoolyard or around their home.

2. Talk to the students about the layers of soil. Discuss what topsoil is and what materials it is made of. Explain to the students why they will need to find their weathered rock in the layer of soil that is below the topsoil. Discuss appropriate areas for collecting the soil containing weathered rock. Taking the sample from an area that has just been dug up and replaced during recent construction is not the best idea as the layers have been disturbed. The soil samples should come from a long-established area.
Procedure
1. Have students work in small groups for this activity. Have the groups collect their soil samples from an undisturbed area where they have permission to dig down below the topsoil and extract some soil. (Be certain that the owners of the land have given permission for this activity to occur!) Remind students to document the exact location of their area.
2. Have each group decide how to separate the weather rock from the soil and design a process for doing this. Have them describe their process in writing with each step clearly explained. Check these written explanations for effectiveness, and then allow the groups to carry out their process.
3. Give each group a rock-classification key, and have them identify the weathered rock found in their sample.
4. Instruct students to write up their investigation, describing their finding at each step. They need to identify the exact location where they collected their soil sample. For each weathered rock identification, they must explain the reasons for their decision.

Observations and Conclusions
1. Students should observe that mixing or shaking the soil in water and then straining the mixture will separate the rock from the soil.
2. Students should look carefully at the soil sediment left after straining and observe the presence of crystals and their sizes. They should be able to draw conclusions about the kind of soil in which this sediment was found (for example, if it is gritty, it is a sandy soil; if it is smooth, it may contain limestone).

Sample assessment
- Assess the procedure the students followed to complete their investigation, checking it for details and logical order.
- Assess the final rock identifications and the students’ reasons for their decisions. Ascertain whether those decisions logically follow from information provided in the rock-classification key.

Follow-up/extension
- Have the students graph the class results and draw inferences from the graph about the most common kinds of weathered rock in your community.
- Have students bring samples of soil from visits to other places, such as another part of Virginia or another state. Have them do the identification procedure with these samples. Then, have them place the identified weathered rock in clear plastic bags with identification tags and attach them to a Virginia or U.S. map, creating a display of where different kinds of weathered rock are found around the state or country. This could accompany the yearlong unit on weathering and erosion.

Resources
The Rock Cycle

Organizing Topic  Investigating the Changing Earth

Overview  Students investigate the three types of rocks found in the rock cycle — igneous, sedimentary, and metamorphic — and compare and contrast their origins. They draw and label the rock cycle as found in nature and describe the major processes.

Related Standards of Learning  5.7a

Objectives
The students should be able to
• apply basic terminology to explain how the Earth’s surface is constantly changing;
• draw and label the rock cycle and describe the major processes and rock types involved;
• compare and contrast the origins of igneous, sedimentary, and metamorphic rocks.

Materials needed
• Copies of the attached rock-cycle diagram
• Rock kit or collection (or photographs of different types of rocks)
• Construction paper, colored markers, tape, glue

Instructional activity
Content/Teacher Notes
In this lesson, students will be introduced to the three major types of rock:
• Sedimentary rocks. Sedimentary rocks are formed in layers, are found near water sources, and may contain fossils.
• Igneous rocks. Igneous rocks are formed when molten lava cools and hardens.
• Metamorphic rocks. Metamorphic rocks are sedimentary or igneous rocks that have been transformed through heat, pressure, and/or chemicals.

Students will investigate the rocks in a rock kit or collection (or photographs of rocks), classify them according to type, and put them in chronological order.

Introduction
1. Ask students to close their eyes and imagine the places they have seen, especially those with different kinds of rocks.
2. Brainstorm with students to list different kinds of rocks, noting the observations they make about the characteristics that differentiate the rocks and including places where such rocks are found.
3. Have the students brainstorm a list of places they have found interesting rocks. Tell them that rocks contain their own history and are constantly being formed and changing. Tell students that they are going to learn how scientists classify rocks into three main types.

Procedure
Activity 1: The Three Types of Rocks
1. Write the names of the three types of rocks on the board. Ask students what the root of the word sedimentary is. (sediment) Discuss the meaning of the word sediment. Explain that sedimentary rocks are formed when sediments, which are found near water sources, are highly compressed by
pressure and/or heat. Show students samples of sedimentary rocks, or, if you do not have a rock kit, photographs of sedimentary rocks. Ask students to list on paper some of the characteristics they see. They should observe that sedimentary rocks are gritty, sometimes have visible lines or layers, and can be broken pretty easily.

2. Define the words *igneous* and *lava*, and tell students that igneous rocks form when molten lava cools. Tell them that the speed at which the lava cools determines the size of the crystals within the rock. Show students samples (or photographs) of igneous rocks, and have them list their characteristics.

3. Define the word *metamorphic*, and ask students whether they know a similar word. They should know the word *metamorphosis* and that it is used to describe the change of a tadpole into a frog or a caterpillar into a butterfly. Tell students that metamorphic rock is also the product of a *change* — that is, it is rock that has been changed through intense heat and pressure into a different kind of rock. A metamorphic rock can be formed from a sedimentary rock, an igneous rock, or even another metamorphic rock. Show students samples (or photographs) of metamorphic rocks, and have them list their characteristics.

4. Use the students’ lists of rock characteristics to make a class list of the characteristics of the three different types of rocks under their names on the board.

**Activity 2: The Rock Cycle**

1. Give each student a copy of the rock cycle diagram. Explain to students that rocks are constantly changing through weathering (including that due to acid rain), pressure, heating, and cooling. This constant process is called “the rock cycle.” Be sure to emphasize that this is a *cycle*; students should be able to recognize what would come next starting with any of the three types of rock in the cycle.

2. Have students brainstorm the way one of the rocks on display has moved through the rock cycle. Where did it start? Where did it go next? Where did it end up? For example, the obsidian sample (igneous rock) started out on a volcanic island as sandstone (sedimentary rock) that was formed through the compression of sand particles. Over time, the rock was buried deep in the sand, and the pressure changed it into metamorphic rock. Eventually, the volcano that created the island erupted, and the rock was changed into igneous rock through melting and cooling. It has ended up as a shiny, black rock that is highly prized by the natives on the island.

3. Tell students that they are going to design “Extreme Makeover” brochures featuring a rock going through the rock cycle. The brochures should be colorful and attractive and designed to entice other rocks to go through the cycle and be made over. Each brochure needs to advertise three “treatments” where the rock will change during the cycle. Students may start with a rock from the rock collection or select a different one. Students should create their brochures on construction paper or on the computer and should be prepared to present their brochures to the class.

**Observations and Conclusions**

1. By designing the brochures, students should conclude that every rock has a history and is continually changing, and they should get experience comparing and contrasting the different ways rocks are formed and changed.

**Sample assessment**

- White out portions of the rock cycle diagram, and quiz students on the missing parts. Then, have them draw and label the rock cycle from scratch.
- Assess for scientific accuracy the brochures showing the three changes.
• Have students write a story about the rock that has the makeover advertised in their brochure.

**Follow-up/extension**

• Use activities from the following Web sites to reinforce knowledge of the three different kinds of rocks and the rock cycle:

• If there is sufficient time available, have students complete the crystal cooling activity found at [http://igs.indiana.edu/geology/rocks/rockcycleactivities/coolcrystals.cfm](http://igs.indiana.edu/geology/rocks/rockcycleactivities/coolcrystals.cfm). This can be done at the end of the day and kept overnight.

**Resources**

• *The Geology of Virginia*. College of William and Mary. [http://www.wm.edu/geology/virginia/](http://www.wm.edu/geology/virginia/).
• *Geology of Virginia*. Virginia Division of Mineral Resources. [http://www.mme.state.va.us/DMR/DOCS/Geol/vageo.html](http://www.mme.state.va.us/DMR/DOCS/Geol/vageo.html).
Virginia Department of Education

Sedimentary Rock

Heat & pressure

Weathering

Igneous Rock

Heat & pressure

Melting

Metamorphic Rock

Melting

Weathering

Magma

Cooling
Rocky Road

Organizing Topic  Investigating the Changing Earth

Overview  Students make observations of and perform tests on various kinds of rocks in order to classify them. They use this data to follow their rocks through a rock-classification key and identify them.

Related Standards of Learning  5.1a, e; 5.7a

Objectives
The students should be able to
• conduct investigations in which rocks are identified using a rock-classification key;
• collect, record, and report data, using the appropriate graphical representations.

Materials needed
• Rock collection, either purchased or collected by the students
• Magnifying glasses
• Safety goggles
• Nails
• Vinegar (weak acid)
• Eye droppers
• Copies of the attached Rock-Classification Key
• Copies of the attached Dichotomous-Differences Template (optional)

Instructional activity

Content/Teacher Notes
Scientists classify rocks into types by determining their reaction to an acid test and their physical characteristics, including the size and shape of their grains, the arrangement of their grains, and their color(s). In this lesson, students will use those criteria to classify rocks and create a dichotomous key that can be used to classify any rock. They will take unidentified rocks and follow them through the key to classify and identify them. You may use a labeled rock collection, available through stone supply or science supply companies, to help you determine whether the students have identified the rocks correctly. However, the objective is not necessarily correct identification, but correct classification according to observable dichotomous characteristics followed through a classification key. Building a rock collection can be easy and free, and a collection is good to have in the classroom for a variety of science investigations.

This lesson is presented as an inquiry-based lesson, but if your students need more structure, you can give them the observable dichotomous characteristics used by scientists to classify and identify rocks.

Introduction
1. Begin by asking students whether they think all rocks are alike. When they answer no, ask them how scientists can classify rocks. Then, give students time to brainstorm a list of reasons why it is important to be able to classify and identify rocks. Accept all answers. They should recognize that it is important because scientists can tell the history of an area by knowing about the rocks found there.
2. Tell students that in this lesson, they are going to be scientists who are classifying rocks that have just been found in a place you identify, such as the bottom of the ocean or a deserted island. Their job will be to determine whether these rocks are unique or whether they belong to types of rocks already known and classified by scientists.

**Procedure**

1. Group students into groups of two or three, and give each group a magnifying glass, a nail, a small amount of vinegar, an eyedropper, and eight to ten different kinds of rocks from a rock collection.

2. Have the groups list all the readily observable characteristics of their rocks, such as
   - rock color – one color or multiple colors
   - rock texture – smooth or rough
   - grain arrangement – layers or no layers
   - grain size – large or small
   - grain shape – rounded or crystal-shaped.

   Students are naturally curious about rocks, so they should come up with a list of characteristics quickly. Ask students what makes a rock smooth or rough, and lead them to attribute this feature to the size and shape of the grains that they can see through the magnifying glass. Be sure that students realize that the size of the whole rock means nothing, because rocks break and the pieces are the same whether they are large or small.

3. List on the board the observable characteristics found by the students. Explain that these are readily observable dichotomous differences — that is, a rock either has a certain characteristic or it has the opposite characteristic. These observable dichotomous differences are among the criteria used by scientists to classify rocks. Ask what other unobservable dichotomous differences scientists might be able to discover by using tests. Lead students to mention the hardness/softness of a rock by using a simple scratch test, as well as whether a rock reacts to acid or not by using an acid test. (CAUTION! Students must wear safety goggles when conducting these tests.)

4. Have each group use the nail to conduct a scratch test to determine the hardness/softness of their rocks. Then, have them use the a few drops of vinegar (acid) on each of their rocks to see if they react to acid.

5. Give each group a copy of the attached Rock-Classification Key through which any rock can be followed in order to classify and identify it. Alternatively, you might choose to instruct the students in the process of using the dichotomous differences they have observed in order to create their own classification key. Using the attached Dichotomous-Differences Template may prove helpful. If you choose to have the students make their own classification key, start them off with “Does react with acid” vs. “Does not react with acid.”

6. Give groups time to follow their rocks through the classification key to classify and identify them.

7. When the classifications are complete, have students trade rocks (and keys, if self-created) to see whether other groups will come up with the same conclusions.

**Observations and Conclusions**

1. From this activity, students will conclude that rocks can be classified according to observable characteristics, as well as according to characteristics revealed by tests.

2. Now that students have classified rocks, ask them to think about how rocks are created based on the observations they made and the groupings they used. Tell students that in the next lesson, they will investigate the how the different kinds of rocks are formed, as well as how scientists use rocks to determine the geological history of an area.
Sample assessment

- Give each group of students a different set of at least three rocks. Have them follow these rocks through their own key to decide whether the rocks are similar to the ones they have already classified. If their key is well done, they should be very similar.
- Have groups of students exchange keys and use the new keys to classify their own set of rocks. Allow users to make suggestions to creators to improve the keys and make them more workable.
- Have groups compare their key to a real rock-identification key (see “Resources”) and discuss the similarities and differences.

Follow-up/extension

- Have students use a rock-identification key available on the Web from Brooke Weston City Technology College in England (see “Resources”) to classify and identify their rocks.

Resources

- *Welcome to Rock Identification Science Project.* Brooke Weston City Technology College. [http://www.bwctc.northants.sch.uk/html/projects/science/ks34/rocks/list.html](http://www.bwctc.northants.sch.uk/html/projects/science/ks34/rocks/list.html). This excellent interactive site allows the student to identify rocks according to various characteristics and then name them.
Rock-Classification Key

1. Test the rock with acid (vinegar) to see whether it reacts (fizzes).
   If the rock does react with acid, it is either **SANDSTONE** or **MARBLE**.
   If the rock does not react with acid, go to 2.

2. Look closely at the grains in the rock to determine their size and relationship to one another.
   If the grains are too small to see and the rock is soft and crumbly, it is either **SHALE** or **MUDSTONE**.
   If the grains are crystals held together in a close pattern, go to 3.
   If the grains are rounded, go to 7.

3. Look closely at the grains in the rock to see whether they are arranged in layers.
   If the grains are not arranged in layers, go to 4.
   If the grains are arranged in layers, go to 5.

4. Look closely at the color of the rock.
   If the rock is a pale color and has large crystals, it is **GRANITE**.
   If the rock is a dark color and has very small crystals, it is **BASALT**.

5. Look closely at the color of the rock.
   If the rock is white or pink and very hard, it is **QUARTZITE**.
   If the rock is a gray or purple, is very hard and brittle, and splits into thin sheets, it is **SLATE**.
   If it is neither, go to 6.

6. Look closely at the color of the rock.
   If the rock is silvery with flaky grains, it is **SCHIST**.
   If the rock has dark and light bands, it is **GNEISS**.

7. Look closely at the texture of the rock.
   If the rock is made of small, sand-like grains, it is **SANDSTONE**.
   If the rock has large, rounded grains or pebbles, it is **CONGLOMERATE**.
Dichotomous-Differences Template
Do Rocks Absorb Water?

Organizing Topic  Investigating the Changing Earth

Overview  Students perform an investigation to determine whether rocks absorb water. They determine mass and volume, record their findings, and graph their results.

Related Standards of Learning  5.1b, c, d, e, h

Objectives
The students should be able to
- make plausible estimations of length, mass, and volume;
- measure length, mass, and volume, using metric measures, including centimeters, grams, and millimeters;
- collect, record, and report data, using charts and tables, and translate numerical data into line graphs;
- distinguish between observations and inferences;
- define/make observations and inferences;
- measure, record, identify, collect, and organize observations.

Materials needed
- A variety of rocks, including more porous rocks, such as sandstone, pumice, and mudstone
- Graduated cylinders or beakers (ml)
- Balance
- Chart for recording data
- Graph paper
- Tape measures
- Plastic wrap

Instructional activity

Content/Teacher Notes
This investigation, in which most students will predict that rocks do not absorb water, is extremely effective for teaching students to make scientific observations, take metric measurements, and record data. Students will find that some rocks do gain mass because of the absorption of water and yet others do not. This discovery will lead directly into a discussion about rock types and what happens when a water-absorbing rock freezes. If this investigation begins on a Monday, students can take daily measurements, thus giving them even more experience with metric measurement.

Introduction
1. Review what students already know about rocks, brainstorming a list of rock facts. It is not necessary for the students to have covered the rock unit, but it will be helpful.
2. Ask the students whether they believe that rocks can absorb water, and have them write their answers and the reasons for them.
3. Have students share their ideas in a class discussion, but if there is disagreement about the question, do not give them the answer.
4. Tell students that they will be carrying out an investigation to find out whether rocks absorb water. This investigation would be more effective if students have already been taught metric measurement. Place balances in a central location, and decide on a place to keep the rocks where they will not be disturbed.

Procedure
1. Place students in pairs or small groups, depending on how many rocks you wish to use or have available; the more rocks you use, the more effective the investigation will be. The rocks can come out of an existing rock collection to ensure a wide variety, or students can bring in their own rocks.
2. Have students use a rock-classification key to determine what kind of rock they have (see the previous activity).
3. Once they have determined what kind of rock they have, have students predict and record the mass of their rock (in grams) and how long and wide it is (in centimeters and millimeters). Then have them take careful measurements of the rock’s mass, length at the longest part, and width around the widest part, again recording all measurements on their data sheet.
4. Have students fill a ml beaker with as much water as they think it will take to cover the rock completely when it is placed inside the beaker. Have them record this amount. For rocks that are too large to fit into a beaker, students can use a bowl that will not absorb the water and carefully measure, using a beaker, enough water to cover the rock. Again, have students carefully record the amount of water they used.
5. Have students place their rocks into the water and cover their beakers or bowls with plastic wrap to prevent evaporation. Set the submerged rocks aside.
6. Each day for about 7 days, have the students take the measurements of the rocks — mass, length, and width. Measurements may change by only a few millimeters, so encourage students to measure exactly and to note changes in millimeters. The amount of water left in the beaker should also be recorded. If the rocks are placed on a sheet of plastic, any water that is dripped can be carefully placed back in the beaker. Caution students to be very careful not to spill water and to make careful and accurate measurements, or their results may not be accurate.

Observations and Conclusions
1. Students with more porous rocks will notice a distinct gain in mass, especially if pumice is being used. The mass gains of other rocks will vary. Students will also notice that rocks that gain mass do so for a number of days, and then the mass gain tapers off.
2. Have students graph all data. Then have them share results with the class. Lead a discussion about what kinds of rocks gain mass (absorb water) and why the mass gain stops after a number of days.
3. Have students predict how these discoveries apply to the “life” of the rock. What happens to water-absorbing rocks when freezing temperatures occur? What happens to water when it freezes? What happens to a rock when the water inside it freezes? Does this contribute to erosion, or changes, in the rock?

Sample assessment
- Assess the students’ graphs and charts of the data.
- Have students summarize in their science journals what they did during the investigation, what they found out through the investigation, and their conclusions based on their observations. Assess the journal entries.
• Have students write a story about the life of a rock that is found in the northeastern United States, where the seasons change. It should include the changes that take place in the rock as the seasons change.

Follow-up/extension

• Take several samples of small rocks that absorbed water and some that did not absorb water, and place them in the freezer overnight in a container. Have students observe what happens to the rocks when they freeze.
• Place a porous rock in some out-of-the-way location on the school grounds, and after securing necessary permission, have students mark the location of the rock by flagging it with a little ground marker. Have the students observe the rock through the school year, taking data at the beginning of the year and at regular intervals throughout the year. Have the class keep a rock journal, recording the changes the rock goes through, including temperature changes, the changes in the environment around the rock, and the precipitation to which it is subjected.
Sample Released SOL Test Items

Three Basic Types of Rocks

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Igneous</td>
<td>Formed from cooled and hardened magma deep inside the Earth or from lava at the surface</td>
</tr>
<tr>
<td>Sedimentary</td>
<td>Formed when layers of sediments or rock pieces are cemented together; may contain fossils</td>
</tr>
<tr>
<td>Metamorphic</td>
<td>Formed when rocks are changed by heat, pressure or chemical action; may be banded</td>
</tr>
</tbody>
</table>

According to the information in the chart, which of the following rocks is a sedimentary rock?

A  
B  
C  
D

The most common cause of earthquakes is —

F  the sinking of the ocean floor  
G  movements in the Earth's crust  
H  giant tidal waves called tsunamis  
J  unequal heating of the atmosphere

To learn about the temperature inside the Earth's crust, scientists study —

A  earthquakes  
B  fossil formations  
C  minerals on the ocean floor  
D  volcanoes

Which one of the following events occurs in the formation of sedimentary rock?

F  Crystallization  
G  Melting  
H  Cooling  
J  Weathering

The diagram shows layers of sedimentary rocks and examples of their fossils. Which layer contains the oldest fossils?
The diagrams show how a river can cause the erosion of land. Which sequence of letters best shows how the river has aged from youngest to oldest?

F C, A, B, D
G B, A, C, D
H A, D, B, C
J D, A, B, C
Organizing Topic — Investigating Sound

Standards of Learning

5.1 The student will plan and conduct investigations in which
   c) appropriate instruments are selected and used for making quantitative observations of
      length, mass, volume, and elapsed time;
   d) accurate measurements are made using basic tools (thermometer, meter stick, balance,
      graduated cylinder);
   e) data are collected, recorded, and reported using the appropriate graphical representation
      (graphs, charts, diagrams);
   f) predictions are made using patterns, and simple graphical data are extrapolated;
   g) manipulated and responding variables are identified; and
   h) an understanding of the nature of science is developed and reinforced.

5.2 The student will investigate and understand how sound is transmitted and is used as a means of
   communication. Key concepts include
   a) frequency, waves, wavelength, vibration;
   b) the ability of different media (solids, liquids, and gases) to transmit sound; and
   c) uses and applications (voice, sonar, animal sounds, and musical instruments).

Essential Understandings, Knowledge, and Skills

The students should be able to

- use the basic terminology of sound to describe what sound is,
  how it is formed, how it affects matter, and how it travels;
- create and interpret a model or diagram of a compression
  wave;
- explain why sound waves travel only where there is matter to
  transmit them;
- explain the relationship between frequency and pitch;
- design an investigation to determine what factors affect the
  pitch of a vibrating object. This includes vibrating strings,
  rubber bands, beakers/bottles of air and water, tubes (as in
  wind chimes), and other common materials;
- compare and contrast sound traveling through a solid with
  sound traveling through the air, and explain how different
  media (solids, liquids, and gases) affect the transmission of
  sound;
- compare and contrast the sounds (voice) that humans make and
  hear to that of other animals. This includes bats, dogs, and
  whales;
- compare and contrast how different kinds of musical
  instruments make sound. This includes string instruments,
  woodwinds, percussion instruments, and brass instruments.
Sound Vibrations


Organizing Topic  Investigating Sound

Overview  Students investigate basic facts about sound and sound waves.

Related Standards of Learning  5.2

Objectives

The students should be able to

• use the basic terminology of sound to describe what sound is, how it is formed, how it affects matter, and how it travels.

Materials needed

• Tuning forks
• Bowls
• Water
• Copies of the attached worksheet

Instructional activity

Content/Teacher Notes

The source of all sound is movement. Movement causes vibrations, which in turn can cause molecules surrounding the source of the movement to vibrate. These vibrations move outward in a wave-like pattern. In a sound wave, individual molecules do not move very far; they just vibrate as the vibration moves from one molecule to the next and energy, not matter, is transferred.

We hear sound after these vibrations enter our ears. The sound vibrations cause a super-sensitive membrane in our ears, the eardrum, to vibrate. The eardrum transfers the vibrations to three tiny bones — the hammer, anvil, and stirrup. These bones, called ossicles, amplify and transmit the vibrations to the inner ear where they are changed into nerve impulses. The nerve impulses are then carried to the brain, where they are perceived as sounds.

The following terms are used in this activity:

• Vibration. A back-and-forth motion
• Sound. Vibrations transmitted through a material medium, such as air, water, or metal
• Medium. A substance (gas, liquid, or solid) through which something is transmitted or carried

This activity is useful for introducing the important concept that sound waves are energy moving from one place to another through a medium, but that the molecules of the medium — for example, the air or water molecules — do not move with the wave but merely vibrate to transfer the energy along.

Procedure

1. Give each student a copy of the attached worksheet, and have them write their prediction.
2. Put the students into groups, and give each group a bowl of water and a tuning fork. Instruct the students in the proper way to strike the tuning fork on a soft object, such as their palm or knee. Stress that it should never be struck against a hard surface, such as metal, stone, or wood, because such an impact could damage the tuning fork.
3. Have the students in each group take turns striking the tuning fork, listening to it, and recording their observations on their worksheets.

4. When the water in their bowl is perfectly still, have the students in each group take turns striking the tuning fork and very carefully placing the tips of the prongs in the water while the other group members observe what happens to the water. Have the students record their observations on their worksheets.

5. Have the students complete the handout by explaining how sound travels, what it is, and whether it exists in outer space.

**Observations and Conclusions**

1. Discuss with the students that when the tuning fork is struck, the prongs begin to vibrate. The vibrating prongs cause the surrounding air to vibrate. These vibrations are transmitted through the air from molecule to molecule until the air molecules near your eardrum vibrate and, in turn, cause your eardrum to vibrate.

2. Point out that the tuning fork vibrations also caused the water to vibrate (ripple) in every direction. The ripples are visible if the vibrations are strong enough. Remember, during this process, energy, not matter, is transferred. Sound waves are energy moving from one place to another through a medium, but the molecules of the medium — for example, the air or water molecules — do not move with the wave but merely vibrate to transfer the energy along.

3. Lead the class through a short discussion of what sound is and how it travels.

4. Continue the discussion by turning to the issue of sound in outer space. Ask students whether one could hear a spaceship explode in space. (No. In space, there is no medium through which sound vibrations can travel, as space is a vacuum.) Include in this discussion mention of movies that depict huge explosions in outer space. Should these fictional explosions be shown as silent?

**Follow-up/extension**

- Have each student place one finger gently in his/her ear. Strike the tuning fork on a soft object, and touch the handle of it to each student’s elbow. Sound vibrations will travel up the arm and be heard. (Note: If students are wearing thick clothing, such as a heavy sweater, this will not work very well.)
- Have students put an ear on a table. Strike the tuning fork on a soft object, and gently touch the handle of the tuning fork to the table. The sound vibrations will travel through the table and be heard by the students.

**Sample assessment**

- Use the worksheet to assess student understanding of sound vibrations.

**Resources**

Make Some Waves!

Name: ______________________ Date: ______________________

Predict
What will happen if you strike the tuning fork and then place the tips of the prongs in the water?

CAUTION! Never strike a tuning fork on a hard surface, as this could damage the fork. Always strike it on a soft surface like the palm of your hand or your knee.

Procedure
1. Strike the tuning fork gently on your palm or knee, and then hold it close to your ear. Do you hear a sound? ______ If so, what is it like? __________________________________________
   What are the prongs doing? ______________________________ What is the air around the prongs doing? ______________________________ What is your eardrum doing? ______________________________

2. Strike the tuning fork again, and place the tips of the prongs in the water.
   What happens? __________________________________________
   Why? __________________________________________

Think
After seeing what happened in step 2 of your experiment, how do you think sound travels?

What do you think sound is?

Apply Your Knowledge
Does sound exist in outer space? ________ Why, or why not?

Could you hear a spaceship explode in outer space? ________ Why, or why not?
Model Sound Wave

Organizing Topic  Investigating Sound

Overview  Students investigate the structure of a sound wave.

Related Standards of Learning  5.2a

Objectives
The students should be able to
• create and interpret a model or diagram of a compression wave.

Materials needed
• Loudspeaker with removable cover
• Slinky
• Wrapped drinking straws
• Glue or rubber cement
• Mugs or empty soup cans
• Plastic wrap
• Rubber bands
• Dry rice grains or grains of sand
• Wooden spoons or scissors

Instructional activity
Content/Teacher Notes
Sound is a form of energy produced and transmitted by vibrating matter. Sound waves caused by such vibrations move through a material medium (a solid, liquid, or gas) in all directions from their source. However, the medium just vibrates back and forth and transfers the energy; the medium is not carried along with the sound wave.

Sound waves can be described by the wavelength and frequency of the waves. Students should know the following terms:
• Wave. A disturbance moving through a medium (solid, liquid, or gas)
• Sound. A compression wave moving outward from its source through a material medium
• Wavelength. The distance between two sound waves
• Frequency. The number of sound waves in a given unit of time, such as a second
• Pitch. The property of sound that is determined by the frequency of the waves producing it; the higher the frequency, the higher the pitch, and vice versa

Sound travels more quickly through solids than through liquids and gases because the molecules of a solid are closer together and, therefore, can transmit the vibrations (energy) faster. Sound travels most slowly through gases because the molecules of a gas are farthest apart. Some animals make and hear frequencies of sound vibrations (pitches) that humans cannot make nor hear. Musical instruments vibrate to produce sound.

Introduction
1. Ask the students whether they have ever felt a sound wave. They have heard sounds, of course, but how about feeling sounds? If they have ever been next to a loudspeaker with very loud bass tones
being emitted, such as those in some cars, then it is likely they have. Could a deaf person feel a sound?

**Procedure**

1. Show the students a loudspeaker with the cover removed. Explain that the speaker is made up of two main parts: the tweeter and the woofer. Ask why they think these names were used to name these parts. The tweeter(s) makes the higher pitched sounds and the woofer makes the lower pitched sounds. They do this by moving a membrane back and forth, in and out, to push the air and make it vibrate. If the speaker can be connected to a CD player, play some music, and let the students watch the membranes moving.

2. Model a sound wave by stretching out a Slinky on a table or desk. Hold one end, and have a student hold the other. Give your end of the Slinky a pulse by pushing it forward a little very quickly and immediately pulling it back to the starting position. Students should see the crunched coils or “compression wave” move down the Slinky from one end to the other. Explain that what the students see models (looks like) the movement of a compression wave or sound wave. Your hand is acting like the speaker diaphragm that makes the air (Slinky) vibrate.

3. Give each student a wrapped drinking straw. Tell each student to hold one end of the straw firmly in one hand and use the other hand to push the wrapper slowly from the other end along the straw to compress it. Then have them pull the wrapper back out (uncompress it) in several small areas along the straw but leave it compressed in other areas in between. Tell students that this models the compressed areas and uncompressed areas (called rarefaction) of sound waves. Have the students glue their straw models to their data sheets.

4. Put the students into groups, and give each group a mug or soup can, a piece of plastic wrap large enough to cover the top of the mug and be secured, and a rubber band. Have them make a drum-like device by stretching the plastic wrap tightly over the opening of the mug and securing it with the rubber band. Then, give each group a few grains of rice or sand to put on top of the “drum.” Ask them how they could make the rice “dance” or move without actually touching the mug or table. Have each group hold a second mug or can upside down at an angle just above the rice and tap firmly on the bottom with a wooden spoon or a pair of scissors. The smallest grains will jump. Ask student why this happens, and have them record their explanations on their data sheets. *(Tapping the mug made it vibrate, which then made the air inside and around it vibrate. As sound waves traveled through the air out of the mug, they came in contact with the “drum head” (plastic wrap), causing it to vibrate. This vibration caused the rice grains to dance.)*

**Observations and Conclusions**

1. Hold a class discussion on what the students have seen in these demonstrations. Make certain that students understand that when a sound wave travels through a medium, individual molecules of the medium (air, water, solid) do not change location; they just vibrate back and forth, transferring the vibration from one molecule to the next to the next: energy, not matter, is transferred. Put another way, sound waves are energy moving from one place to another through a medium, but the molecules of the medium (e.g., the air or water molecules) do not move with the wave but merely vibrate to transfer the energy along.

**Sample assessment**

- Have students draw a diagram of what happens in the air when a sound wave travels from a sound source to their ear. Drawings should include the source of the vibrations, an accurate illustration of the vibrations, and an ear.
Follow-up/extension

- “The Case of the Barking Dogs,” a NASA SciFiles™ episode, has some activities that correspond to the video clips (see “Resources”).

Resources

- “The Case of the Barking Dogs.” NASA SciFiles™
  http://www.smv.org/pubs/index.html
- Sound Waves and Music. The Physics Classroom.
  http://www.physicsclassroom.com/Class/sound/soundtoc.html, or
  http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u11l1c.html.
Sound Investigations

Organizing Topic  Investigating Sound

Overview  Students investigate how sound travels through different media.

Related Standards of Learning  5.2b

Objectives
The students should be able to

- explain why sound waves travel only where there is matter to transmit them;
- compare and contrast sound traveling through a solid with sound traveling through the air;
- investigate how different media affect the transmission of sound;
- explain how different media (solids, liquids, and gases) transmit sound.

Materials needed

- Copies of the attached activity sheet
- Long table
- Babywipes
- 2 pieces of string, each about 2 feet long
- Large metal serving spoon
- Large rectangular pan (metal, if possible, like a deep aluminum baking pan)
- Water
- 2 windup, ticking clocks
- Thin rubber tube or hose
- 2 large funnels

Instructional activity

Content/Teacher Notes

Sound is a form of energy produced and transmitted by vibrating matter. Sound waves caused by such vibrations move through a material medium (a solid, liquid, or gas) in all directions from their source. However, the medium just vibrates back and forth and transfers the energy; the medium is not carried along with the sound wave.

Sound waves can be described by the wavelength and frequency of the waves. Students should know the following terms:

- **Wave.** A disturbance moving through a medium (solid, liquid, or gas)
- **Sound.** A compression wave moving outward from its source through a material medium
- **Wavelength.** The distance between two sound waves
- **Frequency.** The number of sound waves in a given unit of time, such as a second
- **Pitch.** The property of sound that is determined by the frequency of the waves producing it; the higher the frequency, the higher the pitch, and vice versa

Sound travels more quickly through solids than through liquids and gases because the molecules of a solid are closer together and, therefore, can transmit the vibrations (energy) faster. Sound travels most slowly through gases because the molecules of a gas are farthest apart. Some animals make and hear frequencies of sound vibrations (pitches) that humans cannot make nor hear. Musical instruments vibrate to produce sound.
Introduction

1. Review with the students what they learned in the “Sound Vibrations” lesson. Remind them that the tuning fork vibrations caused the ripples in the water. Be certain that students understand that during the process of vibrations being transferred from air molecule to air molecule, it is energy, not matter, that is being transferred.

2. Ask each student to hold one hand against his/her throat, high up under the chin, and then hum. Ask them what they feel and what conclusions they can make about their voice and vibrations. (They should feel vibrations and should conclude that in order make sound, the throat must produce vibrations.) What does this investigation teach us about sound? What causes sound? (Vibrations cause sound. Vibrating objects transmit sound waves to other media, such as air, and they travel in all directions.)

3. Review with students the three types of media (solids, liquids, and gases) through which sound travels, and that these correspond to the three states of matter (solid, liquid, and gas). The point is that for a sound wave to happen, there must be matter in some form through which the wave can travel.

4. Review SOL 5.4c and the motion of molecules in the three states of matter. Explain that sound travels at different speeds through the three media: it travels most quickly through solids than through liquids and gases because the molecules of a solid are closer together and, therefore, can transmit the vibrations (energy) faster; it travels most slowly through gases because the molecules of a gas are farthest apart.

Procedure

1. Set up four stations, labeled A through D, as described on the attached activity sheet.

2. Put the students into pairs, and hand out a copy of the activity sheet to each pair. Allow the pairs to rotate among the various stations to investigate and compare how sound travels through the three media. Instruct students to record in their science journals their observations and the answers to the questions that accompany each station. (Safety Note: Be sure that students are instructed not to place the funnel in their ears. It is best to use a large funnel so that it will not fit into an ear.)

Observations and Conclusions

1. Randomly select student pairs to share their answers to questions. Students will have learned that sound travels best (fastest) through solids. Emphasize the reason for this: because the molecules in a solid are closer together, and, therefore, the sound wave can transfer from one molecule to another faster. Sound traveling through the air travels at a much slower rate because the molecules in a gas are farther apart.

Sample assessment

- Assess students’ participation in the activity and answers to the questions.
- Ask students to describe why sound travels faster in a solid than it does in a gas.

Resources

- **Sound Waves and Music.** The Physics Classroom.  
  http://www.physicsclassroom.com/Class/sound/soundtoc.html, or  
  http://www.glenbrook.k12.il.us/gbssci/phys/Class/sound/u1l1c.html.
## Sound Travel Through Media

### Directions

You and your partner will go to each of four stations to investigate how sound travels through a certain medium — a solid, a liquid, or a gas. As you do the experiment at each station, discuss the questions listed below, decide on the answers, and write the answers in your science journals.

### Station A

You will find a long **table** and **babywipes**.

1. Put your ear on one end of the tabletop (a solid), and plug your exposed ear with a finger. Have your partner tap lightly or scratch on the underside of the other end of the table. What do you hear? How strong is the sound?
2. Remove your ear from the table, but keep your other ear plugged. Have your partner tap or scratch the table in exactly the same way as before. What do you hear this time? How did the sound coming to your ear through the table compare to the sound coming through the air? Which of the two sounds was louder? Why?
3. Use a babywipe to clean the spot where you put your ear, and then reverse roles to repeat steps 1–3.

### Station B

You will find a **spoon** with two equal lengths of **string** tied to one end of it.

1. Wrap the end of one of the strings (a solid) around a finger of one hand and the end of the other string around a finger of the other hand. Plug your ears with your wrapped fingers. Have your partner bang the spoon against the table. How would you describe the sound you hear?
2. Remove your fingers from your ears, and have your partner bang the table with the spoon in exactly the same way as before. What do you hear this time? How did the sound coming to your ears through the string compare to the sound coming through the air? Which of the two sounds was louder? Why?
3. Reverse roles to repeat steps 1 and 2.

### Station C

You will find a windup, ticking **clock**, a large **pan** (a solid) filled with **water** (a liquid), and **babywipes**.

1. Place your ear against one end of the pan, and plug your exposed ear with a finger. Have your partner place the clock against the other end of the pan. Can you still hear the ticking sound through your ear that is against the pan? How strong is the sound?
2. Remove your ear from the pan, but keep your other ear plugged. Listen carefully to the ticking sound coming through the air. What do you hear this time? How did the sound coming to your ear through the water and pan compare to the sound coming through the air? Which of the two sounds was louder? Why?
3. Use a babywipe to clean the spot where you put your ear, and then reverse roles to repeat steps 1–3.

### Station D

You will find a ticking **clock** and a rubber **tube** (a solid and a gas) with a **funnel** attached to each end.

1. Place one funnel against your ear, and plug your exposed ear with a finger. Have your partner place the other funnel against the ticking clock. Can you hear the ticking sound coming through the tube, which is filled with air? How strong is the sound? (Safety Note: Be sure that you do not place the funnel in your ear!)
2. Now, remove the funnel from your ear, but keep your other ear plugged. Listen carefully to the ticking sound coming through the air. What do you hear this time? How did the sound coming to your ear through the tube and the air in it compare to the sound coming to your ear through the air alone? Which of the two sounds was louder? Why?
3. Use a babywipe to clean the funnel that touched your ear, and reverse roles to repeat steps 1–3.
Making Waves, Music, and Noise

(Adapted from “Making Waves, Making Music, Making Noise,” a Utah State Department of Education CORE Curriculum lesson. Used with permission.)

Organizing Topic  Investigating Sound

Overview  Students investigate the production of sound in terms of the vibration of an object creating vibration in another material.

Related Standards of Learning  5.2a, c

Objectives
The students should be able to
• explain the relationship between frequency and pitch;
• design an investigation to determine what factors affect the pitch of a vibrating object, including vibrating strings, rubber bands, beakers/bottles of air and water, tubes (as in wind chimes), and other common materials;
• compare and contrast how different kinds of musical instruments, including string instruments, woodwinds, percussion instruments, and brass instruments, make sound.

Materials needed
• Empty tin cans
• Cotton string of medium thickness
• Scissors
• Several thin sponges or baby wipes
• Large paper clips
• Duct tape
• Fishing line of three different weights or test strengths
• Wooden meter stick, cut in half
• Utility knife (for teacher use only)
• 3-inch length of a 1-inch-inside-diameter PVC pipe
• Drinking straws made of paper, not plastic
• Rulers
• Copies of attached activity sheet

Instructional activity
Content/Teacher Notes
During lunchtime in the cafeteria, when hundreds of children are eating and talking and vibrating, the air (gas), the tables (solid), and the drinks (liquid) are all vibrating too. All of these vibrations go out in all directions from each of their sources, creating a great cacophony. Children are masters at vibrating the particles around them, therefore creating sound . . . and lots of it.

Sound is a form of energy produced and transmitted by vibrating matter. Sound waves caused by such vibrations move through a material medium (a solid, liquid, or gas) in all directions from their source. However, the medium just vibrates back and forth and transfers the energy; the medium is not carried along with the sound wave.

Sound waves can be described by the wavelength and frequency of the waves. Students should know the following terms:
• **Wave.** A disturbance moving through a medium (solid, liquid, or gas)
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• **Wavelength.** The distance between two sound waves
• **Frequency.** The number of sound waves in a given unit of time, such as a second
• **Pitch.** The property of sound that is determined by the frequency of the waves producing it; the higher the frequency, the higher the pitch, and vice versa

Sound travels more quickly through solids than through liquids and gases because the molecules of a solid are closer together and, therefore, can transmit the vibrations (energy) faster. Sound travels most slowly through gases because the molecules of a gas are farthest apart. Some animals make and hear frequencies of sound vibrations (pitches) that humans cannot make and/or hear. Musical instruments vibrate to produce sound.

The frequency of the vibrations determines how high or low the pitch of the sound is. The faster the object vibrates, the higher the frequency and the higher the perceived pitch; the slower the object vibrates, the lower the frequency and the lower the perceived pitch. The size and shape of an object will affect the pitch at which it resonates.

Before beginning Activity 1, make several “Talking Cans,” using different shapes and sizes of empty tin cans; the more variety, the better. Cans should be clean and have their tops complete removed so that there are no sharp pieces anywhere. Make a small hole in the center of the bottom of each can. Cut a meter-length piece of cotton string for each can, thread it through the hole, and tie the end to a large paper clip. Secure the paper clip with a piece of duct tape to the inside bottom of the can. The other end of the string should be free to hang through the hole in the bottom of the can. Also prior to this activity, select a short story that has several characters that can be portrayed with different sounds. Stories that have animal characters work well. Make a list of the characters, and decide which Talking Cans will be used for each character.

Prior to beginning Activity 2, make several “BoJo” sound instruments, as shown at right. Drill three evenly spaced holes through the sides of the 3-inch piece of PVC pipe. Cut a meter-length piece of each of three different weights of fishing line. Using a utility knife, carefully make three slit-type notches on each end of a meter-stick half. Keep in mind the diameter of each type of fishing line, and size the notches accordingly. Tie a large knot at one end of each fishing line. Thread each line through a hole in PVC pipe, and secure the knotted end in a slit-type notch. After all three lines are secured to one end of the stick, wrap a piece of duct tape around that end to prevent the strings from slipping. To secure the other ends, pull each string to find the amount of tension it can take. Make a knot at the tension point, and secure in a slit-type notch. After all three strings have been secured, wrap a piece of duct tape around to help the strings from slipping. The PVC pipe should be able to move back and forth along the stick. The instrument can be played by plucking the strings. The “BoJo” can be used for a class demonstration about sound or, if you make multiples, with groups of students. It can also be used as an introduction to making individual musical instruments.

**Activity 1: Talking Cans**

**Introduction**

1. Demonstrate how a Talking Can works by demonstrating one. To get sound from a Talking Can, dangle the can from the attached string, and slide a small damp sponge or baby wipe along the
string to set it vibrating. The way you slide it along the string (e.g., short, jerky motions versus long, smooth motions) will yield different sound effects. Display various sizes of cans, and ask students how the sound from each can will compare to that from the first can. Encourage students to observe the shape and size of the can as they think about what sound the can will make. Ask the students why the shape and size of a can affects the sound it will make.

**Procedure**

1. Tell students that they will be performing the sound effects for a story that you will read aloud. Assign students to various Talking Cans.
2. Tell students that whenever they hear their character mentioned in the story, they are to immediately make their character’s trademark sound, using their Talking Can.
3. Before you begin reading the story, have students practice making their sounds. Instruct students in making their sound as soft and as loud as they can. Also, have them practice making it high and low.
4. Before reading the story, modify it so students are challenged to make soft, loud, high, and low sounds. As you read the story, pause briefly to allow students to perform their sounds, but keep in mind that it is a good idea to keep the pace moving along.

**Observations and Conclusions**

1. Discuss with the class exactly what is happening with the Talking Can — the science behind the sounds. Ask them to identify the source of the vibrations. *(The motion of the sponge)* Ask them what the string is doing. *(Vibrating)* Ask them what function the can has. *(Resonating)*
2. Discuss the concepts of *resonation* and *resonator* with the students, pointing out that all acoustic (non-electric, non-amplified) musical instruments involve something that vibrates and something that resonates.
3. Talk in depth about the variety of sounds produced. Select two Talking Cans that differ greatly in shape and size, and demonstrate their characteristic sounds. Have students discuss as a group the differences in the sounds, using the following questions:
   - Why do these two cans make different sounds?
   - Which one makes the higher sound, and why?
   - Which one makes the lower sound, and why?
   - Can you make the sounds softer and louder (change the volume)? How?
   - Is there a way you can make lower sounds on the smaller can? How? Why does this work?
   - Is there a way you can make higher sounds on the larger can? How? Why does this work?

**Activity 2: Making Music, Making Noise**

**Procedure**

1. Have students answer the following questions as you demonstrate (or they manipulate) a BoJo while it is lying on a table. Have them record their responses in their journals.
   - Move the PVC piece slowly back and forth, strumming or plucking the strings.
     - What does lengthening the strings do to the sound? What does shortening the strings do?
     - Why do you get higher sounds with shorter strings?
     - Why do you get lower sounds with longer strings?
   - Pluck the strings gently.
     - What happens to the volume?
     - Why is it softer?
• Pluck the strings forcefully.
  ° What happens to the volume?
  ° Why is it louder?
• Move the PVC piece three-fourths the way up the stick. Play the thinnest string, and then play thickest string.
  ° Is there a difference between the sounds of the two strings? If so, what is the difference?
  ° Since both strings are the same length, why is the sound of the thinner string higher than that of the thicker string?
  ° Is there a way you could make the pitch of both strings the same? If so, how?
• Place the BoJo on something that resonates, for example a real drumhead or one constructed for the purpose. Repeat the plucking experiments above.
  ° Does the resonator make a difference to the sounds? If so, what difference does it make?
  ° Why do the sounds seem louder?

**Observations and Conclusions**
1. Lead a class discussion focusing on students’ answers to the questions.

**Activity 3: Squawkers**

**Procedure**
1. Distribute paper straws, scissors, and copies of the attached worksheet to the students.
2. Have students measure and then flatten 1 inch of one end of their straw, using a ruler for both tasks.
3. Instruct students in making two diagonal cuts with scissors to the flattened end of their straw, as shown on the worksheet.
4. Tell the students to blow through the open end of their straw. This should create a “squawking” sound. Ask them what part of the straw is vibrating to make the sound and what part of the straw is acting as a resonator.
5. Ask students what they think will happen if the straw is shortened. Have them predict how the pitch will change.
6. Test the class prediction. Have several students cut their straws to a shorter length. Then conduct a sound comparison by having these students blow their squawkers one at a time, followed immediately by several students blowing their original-length squawkers one at a time. Have the students compare the sounds of the shorter squawkers with the sounds of the longer ones and draw a conclusion about how pitch changes with length.

**Observations/Conclusions**
1. The squawkers make sound by producing vibrations. Moving air causes the pointed ends of the straw to move rapidly back and forth — that is, to vibrate. Woodwind instruments, such as clarinets, use a reed that vibrates in a manner similar to the pointed end of the squawker. The kazoo-like sound that is created by the squawker is, in part, determined by the length of the straw. As the length of the straw is shortened, the pitch of the sound produced becomes higher. This is because the air in the shorter straw naturally resonates at a higher frequency. Sound waves with a higher frequency cause sound with a higher pitch.
Sample assessment

- Have students go through the same comparison process as that in Activity 3, but focusing on cans in a variety of shapes and sizes instead of straws of various lengths. Have them write responses in their journals to the same types of questions, and encourage them to include labeled diagrams.

- Do one of the following demonstrations for the class: resonating box and tuning fork, singing tube, popping tube. Have students explain the science behind the demonstration, using science language and the basic concepts they have learned about sound. Encourage students to include diagrams with their explanations.

Follow-up/extensions

- Have students design and make an instrument that (1) is durable and can be played, (2) can play both high and low pitches, and (3) can be played both loudly and softly. For the design process, encourage them to focus on cause/effect relationships and use a flow chart as a graphic organizer.

- Have students design an advertisement for the instrument they made, including the following: an original name, a list of features or things the instrument can do, a diagram illustrating how it works, and a scientific explanation of why it works.

Resources


Squawker: A Sound Exploration

Name: ____________________________ Date: __________________

Directions
Make a squawker from a paper drinking straw, test it, and answer the questions.

Procedure
1. Use a ruler to measure a distance of 1 inch from one end of your straw. Mark this point. Use the ruler again to carefully flatten the 1-inch of the end of the straw.
2. Make two diagonal cuts with scissors to the flat end of the straw, as shown below.

3. Test your squawker by blowing through the open end.
4. Answer the following questions:

   Which part of the straw vibrates? ____________________________

   Which part of the straw is the resonator? ____________________________

   What will happen if you cut your straw shorter?

   ____________________________

   How does the frequency of a sound wave relate to the pitch of the sound produced?

   ____________________________
Sample Released SOL Test Items

Blowing through a straw will produce a sound. Which straw will make the highest pitch?

A  
B  
C  
D  

A person will see a flash of lightning before they hear the thunder that goes with it because —

F  the eye is quicker than the ear
G  the thunder occurs much later than the lightning
H  sound travels faster through the atmosphere than light
J  light travels faster through the atmosphere than sound

Which technique is the boat using to find the distance from the surface of the ocean to the bottom?

F  Morse code
G  Radio
H  Sonar
J  Sound tracking

Which material will sound travel through the fastest?

A  Water
B  Air
C  Steel
D  Cloth
Organizing Topic — Investigating Light

Standards of Learning

5.1 The student will plan and conduct investigations in which
   c) appropriate instruments are selected and used for making quantitative observations of
      length, mass, volume, and elapsed time;
   d) accurate measurements are made using basic tools (thermometer, meter stick, balance, graduated cylinder);
   e) data are collected, recorded, and reported using the appropriate graphical representation
      (graphs, charts, diagrams);
   f) predictions are made using patterns, and simple graphical data are extrapolated;
   g) manipulated and responding variables are identified; and
   h) an understanding of the nature of science is developed and reinforced.

5.3 The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include
   a) the visible spectrum and light waves;
   b) refraction of light through water and prisms;
   c) reflection of light from reflective surfaces (mirrors);
   d) opaque, transparent, and translucent; and
   e) historical contributions in understanding light.

Essential Understandings, Knowledge, and Skills

The students should be able to

- explain the relationships between wavelength and the color of light, and name the colors of the visible spectrum;
- diagram and label a representation of a light wave, including wavelength, peak, and trough;
- compare and contrast reflection and refraction, using water, prisms, and mirrors;
- explain the terms transparent, translucent, and opaque, and give an example of each;
- analyze and describe the effects of a prism on white light, and explain why a rainbow occurs.
Let’s Make Waves


Organizing Topic    Investigating Light

Overview    Students use a creative movement exercise to model the wavelengths of light, from giant radio waves to the tiniest wavelengths of cosmic radiation. They explore polarizing filters in order to more easily visualize light as a wave.

Related Standards of Learning    5.1d, h; 5.3a, b

Objectives

The students should be able to
• diagram and label a representation of a light wave, including wavelength, peak, and trough;
• explain the relationship between wavelength and the color of light, and name the colors of the visible spectrum.

Materials needed
• Overhead projector
• 9 signs entitled: Radio, Television, Microwave, Infrared, Visible, Ultra Violet, X-Ray, Gamma Ray, and Cosmic Ray
• 1 coiled spring or coiled rope, about 6 feet long
• Glass pie plate
• Water
• Matches

Instructional activity

Content/Teacher Notes

The word light can be used to communicate a number of different concepts. One dictionary lists 57 different meanings. One of these is “electromagnetic radiation of any wavelength.” Electromagnetic radiation is energy traveling in waves. These waves travel at about 300,000 kilometers per second in a vacuum. They can be reflected or refracted (bent), or changed in other ways. The waves are three-dimensional, vibrate in all planes around a center line, and have high points, called crests, and low points, called troughs. The distance from one crest to the next is called a wavelength. The number of waves passing a given point in one second is called the frequency. The wavelength multiplied by the frequency equals the velocity at which the wave is moving: Wavelength × Frequency = Velocity.

Electromagnetic waves vary greatly in wavelength. Modern technology has measured many wavelengths, such as the tiny gamma ray, which measures 0.1 nanometer (1 nanometer equals 1 billionth of a meter) and the very large radio wave, which can measure 1,000 meters or more. As these waves move through the physical environment, they sometimes transfer some or all of their energy to the objects or systems they encounter. They may heat the ocean, provide energy that plants use in photosynthesis, or, in some cases, cause chemical changes in the retina of the eye.
Wavelengths between approximately 400 and 700 nanometers can be seen by the unaided human eye. This range of electromagnetic radiation is what most people mean when they use the word *light*. Visual perception (the process of seeing) occurs when light waves rebound from the surface of objects into the eye of a viewer. The eye-brain system uses the information contained in the waves (the number of waves, the wavelength, the direction of the wave, etc.) to interpret the physical environment.

Light is a form of electromagnetic energy that can be modeled as waves and as particles. The electromagnetic spectrum is a family of waves that are made up of electricity and magnetism. Some waves are huge and have low energy, while others are tiny and have great energy. Human senses can detect only a small portion of the spectrum: we feel infrared waves as heat; we see visible light. Visible light belongs to a spectrum of electromagnetic waves that is like a family in which all the members differ in height but share the same basic characteristics. Our eyes are “tuned” to waves of certain sizes and frequencies. Light waves are very small, but our eyes can tell them apart. When they do, we see color. Each color is a different sized wave; red is the longest and violet is the shortest. The rest of the electromagnetic spectrum is invisible to the human eye.

**Introduction**

1. You may want to start this activity with a discussion about light and vision. Tell students to close their eyes, and ask, “What is light?” As the students answer with their eyes closed, write their descriptions/definitions on the board. Then, have the students open their eyes and read the descriptions. Leave them on the board, and discuss them again after you finish the activity.

**Activity 1: A Wave Simulation**

**Procedure**

1. Select a strong student to hold one end of a long coiled spring or rope tightly with both hands braced against his/her body.
2. Pull the other end away from the student until the spring is loosely stretched between you.
3. Now explain to the class that you are going to send a message to the student. Snap the spring up and down once to send a wave of energy to the student’s hand. The spring will bounce back (*reflect*) from the stationary end. Ask for observations, and explain what you did. Relate this reflection to light being reflected, and ask the students to name some examples of light bouncing back. They should remember bright light being reflected by a shiny surface, such as the reflection of late afternoon sunlight off of the windows of a building. However, even an ordinary reflection of an image in a mirror is an example of light bouncing back or reflecting.
4. Have the student helper hold the end of the spring tightly. Create a standing wave in the spring by vigorously moving your hand rhythmically up and down slowly. Each wave is made up of a *crest* (the high part) and a *trough* (the low part). Have the class observers note that the waves are long and that your hand is moving slowly. Now model short waves by moving your hand up and down rapidly. This time observers should note that the short waves seem to have a lot more energy than the long ones. (Note: You may need to practice creating waves in the spring or rope. It’s like pumping yourself on a swing; you have to find the right rhythm to keep it going.)

**Activity 2: Waves in Action**

**Procedure**

1. Darken the room, and turn on the overhead projector. Place the glass pie plate on the overhead projector stage. Pour water into it to a depth of about ½ inch. Wait for the water to become still. Gently touch the center of the water with one finger. Students should observe waves spreading out
in all directions and then reflecting from the sides of the dish — i.e., bouncing back toward the center. Turn the overhead off.

2. Now move to the center of the room, and strike a match while the students look away from you and the match. Ask students whether they can see the light from the flame even though they are looking away from the match. Ask whether they can see the walls of the room when the match is lit. How is this effect similar to the waves in the pie plate?

**Observations and Conclusions**

1. Discuss with the class that light waves, like sound waves, travel out in all directions from the source, just as the water waves did. When light waves bounce off walls and other objects, we can see the objects with the light that is reflected to our eyes. The glowing match was the source of the light energy, and they saw everything else with reflected light coming from that source. Ask students to name some other sources of light and objects that reflect light. They should come to realize that anything that glows is a light source and nearly everything else reflects light from a light source.

**Activity 3: Act It Out! Waves Tall and Small**

**Procedure**

1. Arrange nine student volunteers according to height in a line at the front of the classroom, with the tallest student at one end. Give one sign to each student: the tallest holds the sign saying Radio, the next tallest holds Television, then comes Microwave, then Infrared, Visible, Ultra Violet, X-Ray, Gamma Ray, and finally Cosmic Ray.

2. Introduce the group as follows:

   Ladies and Gentlemen, I would like to introduce you to the family known as the electromagnetic spectrum. Yes, the members of this family are all made up of electricity and magnetism traveling together in the form of waves. How fast do you think they have ever traveled? *(Pause to get estimates.*) These waves travel through space at the speed of 186,000 miles each second! But the tall waves can take longer steps; we say they have longer wavelengths. The short ones travel just as fast, but they must take many small steps much more frequently. We can say that the long waves have lower frequency and the short waves have higher frequency. Which of these waves in the spectrum have the highest energy? *(Pause for answer: Cosmic rays.)*

   Please welcome Radio, the longest kind of electromagnetic wave, which comes from some stars and from man-made devices. These waves are in the room with us, but can you sense (see, hear, taste, smell, or feel) them? *(Pause for answer: No.*) But if we turn on a device known as a radio, it will convert radio-wave energy to sound energy.

   Next, welcome Television, shorter than radio and also used to carry messages (pictures and sound) to a special device. Without our TV sets, we cannot sense the TV waves around us.

   Now, may I introduce Microwave. Shorter than TV waves, microwaves act on the motion of molecules. They travel in a straighter line than radio waves. We can use them for communication and for cooking.

   The next member of the family is Infrared. Its common name is heat. Yes, we can sense infrared waves whenever we feel something warm. Are you a source of infrared waves? *(Pause for answer: Yes.)*

   Please welcome Visible. What special sensors do we have for detecting visible light? *(Pause for answer: eyes.*) As you see, visible light is only a small part of the entire electromagnetic spectrum. The longest wave in this part of the spectrum is called the color red, then comes orange, yellow, green, blue, indigo, and violet. To remember the order of the colors, think of the first letters of each color which together spell the name “ROY G. BIV.” Each color is a different-size wave.
Below the smallest wave in the visible spectrum is an even smaller, higher energy wave known as **Ultraviolet**. It is sometimes called **black light**. It is absorbed by our skin and can cause sunburn. It is harmful to our living tissue because it acts on the cells of our skin and can cause cancer. That is why we wear sunscreen and why we want to preserve the ozone in the air. The ozone layer screens out ultraviolet waves and protects us from these harmful rays that come from the sun.

Next we meet **X-ray**, who can pass right through our skin but not our bones. X-rays sometimes come from nature, but they can also be man-made. When they are used in medicine, the harmful X-rays pass through our skin to expose film. Thick organs, teeth, and bones leave shadows. Too many X-rays are very harmful, and it adds up. So avoid getting too many X-rays by reminding doctors of how many you have already had.

**Gamma rays**, even smaller and deadlier (because they’re more energetic) than X-rays, come from certain elements in the Earth’s crust. These elements, called **radioactive elements**, give off gamma energy as they decay. Only special devices such as Geiger counters can detect them. They can pass through thick concrete walls, but lead can stop them.

The highest energy waves (and the deadliest) are **Cosmic rays**. They come from deep space and can pass through the Earth. They are passing through right now — but we cannot sense them.

3. For the finale, go down the line of students, starting with Radio as the tallest and slowest, and ask each to hold up his/her sign and bob up and down. Tell each student to do this up and down motion, representing his/her frequency, a little faster than the taller one beside him/her. Cosmic should be bobbing quite rapidly, portraying the highest frequency wave with the most energy. Ask the class observers to explain this model of the electromagnetic spectrum, making sure that they understand that although the longer waves have the lower frequencies and the shorter waves have the higher frequencies and therefore the higher energies, all nine waves move through space at the same rate of speed.

**Sample assessment**

- Have students sketch long and short waves and label them.
- Have students draw a diagram of the electromagnetic spectrum, including the visible spectrum and the colors in proper order.

**Follow-up/extension**

- Have students use the lesson “Really? Is Light Made of Waves?,” found in the “Light Science: A Science Museum of Virginia Activity” document (see “Resources”), to explore polarization of light.

**Resources**

**Enlightening Explorations**

(Adapted from “Enlightening Explorations,” a Utah State Department of Education CORE Curriculum lesson. Used with permission.)

**Organizing Topic**  Investigating Light

**Overview**  Students conduct investigations to explore reflective surfaces and properties of light.

**Related Standards of Learning**  5.1d, h; 5.3c

**Objectives**

The students should be able to
- compare and contrast reflection and refraction, using water, prisms, and mirrors;
- explain the terms *transparent*, *translucent*, and *opaque*, and give an example of each.

**Materials needed**

- Copies of the attached worksheets
- Shoebox
- Transparent tape
- Old magazines
- Book on the properties of light
- Bag of assorted objects (e.g., canning jar lid, foil, transparency, waxed paper, fabric, netting, square of construction paper, 3 x 5 card, penny, empty spool, plastic test tube, 1 oz. food container, clear plastic cup)
- Flashlight
- White board or white cardstock
- Sets of attached Situation Cards
- 3 x 5 cards
- Glue
- 3 flashlights that vary in intensity and size
- Laser pen (for teacher use only)
- Incandescent bulb in lamp base
- Fluorescent bulb in lamp base
- Squares of aluminum foil
- A sample of each of the following: sandpaper, white cardstock, black construction paper, stiff plastic (e.g., CD case), metal (e.g., canning jar lid), glass (e.g., small glass jar)

**Instructional activity**

**Content/Teacher Notes**

When light hits an object, it can be *absorbed*, *reflected*, or *transmitted* (pass through). All objects reflect some light, which makes it possible for us to see them, but objects that are smooth and hard are better at reflecting light than other types of objects. Mirrors are excellent reflectors because the surface is smooth and much of the light bounces off them.

The Law of Reflection states that when light hits a surface, the angle at which it is reflected is the same as the angle at which it strikes. This can be modeled by throwing a ball at a smooth surface; the angle at which it bounces off will equal the angle at which it hit (e.g., 45° going in will equal 45° bouncing off). The angle at which you throw the ball is called the *angle of incidence*, and the angle at which the ball
bounces off is called the angle of reflection. Therefore, the angle of incidence equals the angle of reflection.

Light travels at 300,000 km per second (186,000 miles per second), i.e., so fast that it seems like we see events happen at the exact moment they happen. Light travels in straight lines, but when it passes at an angle from one transparent medium to another, it can be refracted (bent). This is because the speed of light slows as it passes from one transparent object to another. Put another way, when light traveling through one transparent object, such as air, strikes another transparent object, such as water or glass, at an angle, one part of the light reaches the object and slows before the other part of the light, and this variation of incidence and slowing causes the light to bend.

The following experiments can be done either by individual students, by small groups working in three learning centers, or as a demonstration for the whole class. If you have limited materials and books, learning centers are a good way to keep everyone involved at the same time. The first two activities require students to read some background information, which might be found in their textbook. If not, other reading materials will need to be provided. Discuss with the class what should be written on the worksheets, and show a few examples of properly completed worksheets. It may be helpful for students also to see several examples of poorly completed worksheets.

**Introduction**

1. Prepare a shoebox by taping several bright pictures cut from magazines to the inner bottom. Cut a 1-inch hole in the lid, and write “Look Here” below it. Tape the lid on the box with a couple pieces of tape.
2. Pass the box around the room for students to look in through the hole.
3. After each student has looked, discuss what they saw. Ask whether they think there is anything special in the box. Most students will say that they could not see anything.
4. Have someone open the box and show what is inside. Why couldn’t they see it? *(There was no light.)* Emphasize that we cannot see anything without light. The following three activities will show why.

**Procedure**

**Activity 1: How Light Travels**

1. Distribute copies of the attached How Light Travels worksheets, and have students read background information about this topic in the textbook and/or other sources.
2. Instruct students to write at least three sentences summarizing what they learned about the ways light travels.
3. Have students complete the 3 sentences on the worksheet by filling in the blanks.
4. Have students look at each of the objects from the bag as it is placed in the beam of light that is shining on the white board. Have them identify which objects are transparent, translucent, or opaque by writing the name of each in the correct category.
5. Have students complete their worksheet by drawing each object in the correct box.

**Activity 2: Comparing Light Sources**

1. Prepare several sets of attached Situation Cards by photocopying them, cutting them out, and gluing them to 3 x 5 inch cards.
2. Distribute copies of the attached Comparing Light Sources worksheets, and have students read background information about this topic in the textbook and/or other sources.
3. Instruct students to write at least three sentences summarizing what they learned about light sources.

4. Allow students to compare the light coming from each of the six light sources. Have them complete the chart on their worksheet. (Safety Note: Closely monitor the use of laser pens, or do this part yourself as a demonstration to avoid the misuse of the laser.)

5. Have each student draw a Situation Card and write about his/her choice of light for that particular situation, as directed on the worksheet.

**Activity 3: Reflective Surfaces**

1. Distribute copies of the attached Reflective Surfaces worksheets.

2. Have the students explore reflections, using foil squares and flashlights, and have them explain their observations on their worksheets.

3. Allow students to explore reflections further by using the other six items. Have them explain their observations in the chart.

4. Have students complete their worksheet by writing their discoveries from looking at all these reflections.

**Observations and Conclusions**

1. Go over the completed worksheets to review the main concepts, check for understanding, and clear up misconceptions.

**Sample assessment**

- Use the completed worksheets to assess student understanding. The following rubric may be helpful:

<table>
<thead>
<tr>
<th>Mastery</th>
<th>Working Understanding</th>
<th>Needs Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Completed the required task at the center.</td>
<td>• Completed the required task at the center.</td>
<td>• Somewhat completed the required task at the center.</td>
</tr>
<tr>
<td>• Wrote about and drew what happened in the experiment.</td>
<td>• Included some drawings and observations of what happened in the experiment.</td>
<td>• Included few drawings and observations of what happened in the experiment.</td>
</tr>
<tr>
<td>• Explained in own words what was discovered.</td>
<td>• Somewhat explained what was discovered.</td>
<td>• Included little or no explanation of what was discovered.</td>
</tr>
</tbody>
</table>

**Follow-up/extension**

- In class discussion, challenge students to help make a list of as many different reflective surfaces as they can, trying for at least 100. Encourage them to think of extremely unusual surfaces.

**Resources**


How Light Travels

Name: ___________________________ Date: _______________________

Read about the way light travels, and then write at least three sentences summarizing what you learned.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Find out what happens to the light when you place each item found in the bag between the flashlight and the white board. Name, draw, and list four examples of each kind of object.

1. Objects that allow most light to pass through them are called _________________.
   Four examples are:
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________

2. Objects that allow some light to pass through them are called _________________.
   Four examples are:
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________

3. Objects that allow no light to pass through them are called _________________.
   Four examples are:
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________
## Comparing Light Sources

Compare the following light sources to determine the differences in light.

<table>
<thead>
<tr>
<th>Light Source</th>
<th>Color</th>
<th>Intensity (how bright)</th>
<th>Direction Light Travels</th>
<th>Temperature Change Noticed (yes or no)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashlight #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashlight #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flashlight #3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incandescent bulb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent bulb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser pen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Choose a Situation Card, and describe which light you would use for that situation. Write at least three justifications for your choice.

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________
### Situation Cards for Comparing Light Sources

<table>
<thead>
<tr>
<th>Light an entire room</th>
<th>Find a key down a tiny hole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highlight a word on the screen</td>
<td>Point to a star during a star show</td>
</tr>
<tr>
<td>Tell stories in the dark</td>
<td>Signal to a friend across the street</td>
</tr>
<tr>
<td>Decorate at Halloween</td>
<td>Carry with you in a small bag</td>
</tr>
<tr>
<td>Find shoes in a dark closet</td>
<td>Find a missing ball at night</td>
</tr>
<tr>
<td>Send a light through a tube</td>
<td>Use if you get lost</td>
</tr>
</tbody>
</table>

Virginia Department of Education
123
Reflective Surfaces

Name: ___________________________ Date: ________________________

1. Set a square of smooth foil on the table, and use it to reflect the light from a flashlight up to the ceiling.
   Do you get a good reflection? _________
   Why, or why not? ________________________________

2. Crumple the foil square, and then straighten it out. Again use the foil to reflect light up to the ceiling.
   How does this reflection compare to the first one?
   ________________________________
   Explain why this is true.
   ________________________________

3. Compare both of these reflections to the reflection of the sky on a lake, first when there is no wind, and then when there is a strong wind.
   ________________________________

4. Describe the reflection you see on the ceiling when you shine a laser light on each of the following objects lying on the table. Include the size of the reflection — large, small, none.
<table>
<thead>
<tr>
<th>Sandpaper</th>
<th>White paper</th>
<th>Black paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiff plastic</td>
<td>Metal</td>
<td>Glass</td>
</tr>
</tbody>
</table>

5. Discovery: ________________________________
   ________________________________
   ________________________________
   ________________________________

Virginia Department of Education
124
Reflection and Refraction
(Adapted from “Enlightening Explorations, Part II,” a Utah State Department of Education CORE Curriculum lesson. Used with permission.)

Organizing Topic   Investigating Light

Overview   Students investigate reflection and refraction.

Related Standards of Learning   5.1d, h; 5.3b, c

Objectives
The students should be able to
• compare and contrast reflection and refraction, using water, prisms, and mirrors.

Materials needed
• Copies of the attached worksheets
• Copies of attached Protractor and Alphabet Letters sheet
• Flat mirrors with mirror stands
• Flashlights (must have very focused beams of light)
• Hinged mirrors
• Teddy bear counters
• Targets made from 3 x 5 inch index card folded in half
• Opaque cups
• Water
• Pennies
• Clear glass jars (4 with lids)
• Broken pencils
• Graduated cylinders
• Small amounts of vegetable oil, corn syrup, and rubbing alcohol

Instructional activity
Content/Teacher Notes
The Law of Reflection states that when light hits a surface, the angle at which it is reflected is the same as the angle at which it strikes. This can be modeled by throwing a ball at a smooth surface; the angle at which it bounces off will equal the angle at which it hit (e.g., 45° going in will equal 45° bouncing off). The angle at which you throw the ball is called the angle of incidence, and the angle at which the ball bounces off is called the angle of reflection. Therefore, the angle of incidence equals the angle of reflection.

Light travels in straight lines, but when it passes at an angle from one transparent medium to another, it can be refracted (bent). This is because the speed of light slows as it passes from one transparent object to another. Put another way, when light traveling through one transparent object, such as air, strikes another transparent object, such as water or glass, at an angle, one part of the light reaches the object and slows before the other part of the light, and this variation of incidence and slowing causes the light to bend.
Introduction
1. This set of activities is a continuation of the previous lesson, “Enlightening Explorations.” If necessary, review with students the concepts learned from the previous lesson before undertaking the activities in this lesson.

Procedure
Activity 1: Light Reflections
1. Distribute copies of the attached Light Reflections worksheets, the Protractor sheet, flashlights, and mirrors.
2. Have the students complete step 1 and summarize their discoveries.
3. Have the students complete step 2. They may need help in placing the mirror correctly. Have them summarize their discoveries.
4. Distribute Alphabet Letters, and have students complete step 3.

Activity 2: Don’t Hit the Target!
1. Put the students into small groups, and distribute the Don’t Hit the Target worksheets and other materials to each group.
2. Have students play the game in their small groups and then again in larger groups. Have them summarize their discoveries on their worksheets.

Activity 3: Light Refractions
1. Distribute copies of the attached Light Refractions worksheets and other materials.
2. Have students do each activity and summarize their discoveries.

Observations and Conclusions
1. Go over the completed worksheets to review the main concepts, check for understanding, and clear up misconceptions.

Sample assessment
- Use the completed worksheets to assess student understanding.
- Use the following questions/activities to provide a quick assessment. This can help you decide whether more time needs to be spent on certain topics before moving on:
  - If the angle of incidence is 25°, what is the angle of reflection? (25°)
  - What do we call an object that allows only some light to pass through? (translucent)
  - Which object will make the best shadow — translucent, transparent, or opaque ones? (opaque)
  - Draw light hitting an uneven surface. (Light drawn reflecting in all directions)
  - List the colors in order as seen when light hits a prism. (ROY G BIV)
  - Which color of matter best reflects the colors of light? (white)
  - Draw light being refracted. (Light drawn refracting through water or a prism)
  - Draw a natural light source. (sun, fire, lightning, etc.)
  - Identify whether the following examples are refraction or reflection:
    - A prism bending light (refraction)
    - A straw seeming broken inside a glass of water (refraction)
    - A kaleidoscope (reflection)
    - The ocean looking very blue under a blue sky (reflection)
– A sea shell in the water looking closer than it really is (refraction)

**Follow-up/extension**

- Allow students to look at several kaleidoscopes, and then challenge them to recreate a kaleidoscope pattern on paper.

**Resources**

Light Reflections

Name: __________________________ Date: __________________________

1. The **angle of incidence** is the angle at which light hits an object. Explore the **angle of reflection** as follows. Put the protractor template flat on the table, and place a mirror upright at a 90-degree angle to the table with its reflective edge along the 0 line of the protractor. Use a flashlight to shine a light at the mirror from each of the following angles of the protractor to determine at which angle the light is reflected.

<table>
<thead>
<tr>
<th>Angle of Incidence</th>
<th>20°</th>
<th>60°</th>
<th>80°</th>
<th>40°</th>
<th>70°</th>
<th>10°</th>
<th>50°</th>
<th>30°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle of Reflection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discovery:**

2. Place a hinged mirror at the edge of the protractor with the reflective edge along the 0 line. Move the hinged part of the mirror to the degree specified, and place a teddy bear counter in front of the mirror. Count the number of reflected images you can see.

<table>
<thead>
<tr>
<th>Angle</th>
<th>10°</th>
<th>30°</th>
<th>50°</th>
<th>70°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Reflected Images</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discovery:**

3. Set the mirror at 90°. Place an Alphabet Letter against the mirror, and draw the letter as it is reflected (you should draw all four reflections of the letter exactly as you see them). Each reflected image will be flipped 90°.

**Discovery:**
Don’t Hit the Target!

Name: __________________________ Date: __________________

1. In your group, place a light on the table and a target somewhere behind it. Take turns using mirrors to create at least three "bounces" before the light hits the target.
   Make a diagram of how you did it:

   Discovery:

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

2. Combine with another group, and try to make six “bounces” before the light hits the target.
   Make a diagram of how you did it:

   Discovery:

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________
Light Refractions

Name: ___________________________ Date: __________________

Light travels in straight lines, called rays, at 186,000 mps (300,000 km/sec). When light passes through a transparent object at an angle, it slows down. The light waves slow down one by one, bending the light. This is refraction.

1. Place a penny in an opaque cup, and crouch down so you can see the inside of the top part of the cup but not the penny at the bottom. Without moving, slowly add water to the cup until you can see the penny in the water. Draw what you did, and write your discovery.

<table>
<thead>
<tr>
<th>Before adding water</th>
<th>After adding water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discovery: ____________________________________________

2. Fill four clear glass jars with 50 ml, 100 ml, 150 ml, and 200 ml of water, respectively. Place a piece of a pencil in each jar, and draw what you see. Write your discovery about the appearance of each pencil in the different amounts of water.

<table>
<thead>
<tr>
<th>50 ml</th>
<th>100 ml</th>
<th>150 ml</th>
<th>200 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discovery: ____________________________________________

3. Fill four clear glass jars with 100 ml each of water, vegetable oil, corn syrup, and alcohol. Place a pencil piece in each jar, and draw what you see. Write your discovery about the appearance of each pencil in the liquids of different thicknesses (viscosities).

<table>
<thead>
<tr>
<th>Water</th>
<th>Vegetable Oil</th>
<th>Corn Syrup</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discovery: ____________________________________________
The Rainbow Connection
(Adapted from “Enlightening Explorations, Part III,” a Utah State Department of Education CORE Curriculum lesson. Used with permission.)

Organizing Topic  Investigating Light

Overview  Students investigate the effect of a prism on light and the reason a rainbow occurs.

Related Standards of Learning  5.1d, h; 5.3a, b

Objectives
The students should be able to
• compare and contrast reflection and refraction, using water, prisms, and mirrors;
• analyze and describe the effects of a prism on white light, and explain why a rainbow occurs.

Materials needed
• Copies of the attached worksheets
• Books and/or other resources about color and light
• Lamp with bare bulb
• Rainbow (diffraction) glasses
• Small paintbrushes
• Red, yellow, and blue watercolors
• Water
• Assorted prisms
• Bright light (overhead projector or old filmstrip projector)
• Red apple
• Green leaf
• Orange
• Lemon
• White ball (e.g., golf ball, Ping-Pong ball)
• Blue box
• Colored filters or lenses

Instructional activity
Content/Teacher Notes
Visible light is made up of different wavelengths, and each color has its own unique wavelength. The seven colors of the visible light spectrum are red, orange, yellow, green, blue, indigo, and violet (“ROY G. BIV”). (There is disagreement as to whether indigo is really a color or not — a topic that would make a good student research project.) As light hits an object, some light is absorbed and some is reflected. The color of an object is the color of the light it reflects. Grass looks green because when light hits it, the blades of grass absorb all the colors of the light except green, which it reflects. Objects that appear white reflect all colors of light waves, while black objects absorb all colors of light waves.

White light contains all the colors of light. The colors can be separated when a bright white light is shone through a prism at an angle. Short wavelengths, such as blue and violet, are bent more than longer wavelengths, like red, so the colors always separate and appear in the same order or sequence. In nature, the color separation can happen during or after a rainstorm or when using a sprinkler, when the sun’s light shines through the water droplets in the air, which act like a prism.
The three primary colors of light are red, green, and blue (R. G. B.: “Roy G. Biv’s” initials), which are different from the three primary colors of pigment — magenta (red), yellow, cyan (blue). Light of any color can be made from these three primary light colors, and combining all three primary colors of light produces white light. When colored filters are used, only certain wavelengths pass through, and the others are absorbed. For example, when a red filter is used over a light, only red light passes through, and objects appear to be either shades of red or black.

The following experiments can be done either by individual students, by small groups working in three learning centers, or as a demonstration for the whole class. If you have limited materials and books, learning centers are a good way to keep everyone involved at the same time. The first two activities require students to read some background information, which might be found in your textbook. If not, other reading materials will need to be provided. Discuss with the class what should be written on the worksheets, and show a few examples of properly completed worksheets. It may be helpful for students also to see several examples of poorly completed worksheets.

**Procedure**

**Activity 1: Rainbows**
1. Distribute copies of the attached Rainbows worksheets, and have students read background information about rainbows.
2. Instruct students to write at least three sentences explaining why rainbows occur. They must include the color order from top to bottom.
3. Have students look at a light bulb through rainbow (diffraction) glasses, and then draw the colors exactly as they see them, including the correct width of each color and where they are in relation to the light source.
4. Have students compare what they saw through the rainbow glasses to a rainbow. How are they the same? How are they different?
5. Have students paint the rainbow on the bottom of the page, using only red, yellow, and blue watercolors.

**Activity 2: Refraction**
1. Distribute copies of the attached Refraction worksheets, and have students read background information about refraction.
2. Instruct students to write at least three sentences telling how light is bent.
3. Allow students to experiment with the effect of prisms on light as they try different ways to cause the light to bend and make “rainbows.”
4. Have the students draw at least three discoveries on their worksheet and then write what they discovered beside each drawing.

**Activity 3: What Color Is It?**
1. Distribute copies of the attached What Color Is It? worksheets.
2. Have the students look at each object through different colored filters and then fill in the chart to show what each object looks like through each filter.
3. Have the students write their discoveries from looking through the colored filters by answering the given questions.
**Observations and Conclusions**

1. Go over the completed worksheets to review the main concepts, check for understanding, and clear up misconceptions.

**Sample assessment**

- Use the completed worksheets to assess student understanding.
- Have students make a graphic organizer that displays what they know about light and color.
- Have students write two or three paragraphs about what they have learned from these activities.

**Follow-up/extension**

- Give each student an 8-inch circle made from white poster board, and have students use rulers to mark several pie-shaped sections on them. The sections do not have to be equal in size. Then have students color the sections differently. Next, have the students predict whether their “color wheels” will appear (reflect) white or black when spun around at high speed. After they have written their predictions, tape each wheel to the end of one beater of a hand mixer, and spin the wheel. Have the students compare the colors they see with their predictions and explain the results.
- Have students use fine-tipped markers in red, yellow, and blue to make a pointillist painting — i.e., they may use only small dots of these colors to create their picture, but they may apply different colors over top each other (e.g., make green by applying yellow and blue dots on top of each other).
- Have students use a magnifying glass to look closely at a television picture to see the lines of very small red, green, and blue dots.

**Resources**

- *Kaleidoscope Painter*. [http://www.permadi.com/java/spaint/spaint.html](http://www.permadi.com/java/spaint/spaint.html). This Web site is a kaleidoscope with which students can create patterns.
- *Optics for Kids*. [http://www.opticsforkids.org/](http://www.opticsforkids.org/). This Web site allows students to mix colors, learn about colors in nature, and have fun exploring with light.
Read about rainbows, and then write at least three sentences explaining why they happen. You must include a list of the colors of the rainbow in the order they appear from top to bottom.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Look at the light bulb through rainbow glasses, and draw below the colors you see.

How is this similar to a rainbow?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Using only red, yellow, and blue watercolors, paint the rainbow below with the correct colors in the correct order.
Read about refraction, and then write at least three sentences telling how light is bent.

_________________________________________________________________________________

_________________________________________________________________________________

Experiment using various prisms to bend the strong light. Draw in detail and explain beside each drawing three discoveries you made when using the prisms.

1. |

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

2. |

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

3. |

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________
What Color Is It?

Name: ___________________________ Date: __________________

Place each object listed below on the table. Look at the object through each of the colored filters, and then write what color the object appears to be through each filter.

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>Red Filter</th>
<th>Yellow Filter</th>
<th>Green Filter</th>
<th>Blue Filter</th>
<th>Violet Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red apple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green leaf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White ball</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue box</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Describe what happened when the object was the same color as the filter:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Describe what happened when the object was a different color from the filter:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Describe what the white ball looked like through each filter:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Sample Released SOL Test Items

Which of the following materials is transparent?

F Clear window glass
G Your eyelids
H Solid wood door
J White paper

Which diagram shows a wave with the highest frequency?

A

B

C

D

Which of the above waves has the longest wavelength?

A Wave #1
B Wave #2
C Wave #3
D Wave #4

When light hits an object, the rays can pass through it, bounce off it, or be absorbed by it. Light rays that bounce back are —

F radiant
G reflected
H refracted
J radar