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California science standards are noted at the top of activity pages. For the text of the standards, please refer to the Reference section of the California Science Student Edition.
Do different ecosystems contain different organisms?

Form a Hypothesis
Why do certain plants and animals live in certain places? How does the amount of sunlight affect different organisms? Write your answer as a hypothesis in the form “If a plant needs lots of sunlight, then . . .”

Test Your Hypothesis

1. **Experiment** With your teacher select two areas on or near your school grounds to study. Choose one area that receives plenty of sunlight and another that receives very little. Mark off a 2-by-2-meter plot in each area with stakes and string.

2. **Measure** Measure the air temperature at ground level and at 1 meter above ground level in each area.

3. **Record Data** Using graph paper record the locations of the living things in each area. What kinds of organisms do you see? Use field guides to help you identify the organisms.

Materials
- trowel or spade
- 4 small stakes
- meterstick
- string
- thermometer
- field guides
- graph paper
- safety goggles
**Draw Conclusions**

4. Compare your observations about the two areas. How do the temperatures differ? Which area contains more living things?

5. **Infer** What statement can you make about the effect of sunlight on an ecosystem?

**Explore More**

How do you think the amount of water in an ecosystem affects living things? Make a prediction about this, and design a procedure to test it. How have people affected the ecosystem?
Can you identify an ecosystem outside your school?

Make a Prediction
Can you locate an ecosystem outside your school? Write your answer as a prediction in the form “If I can find living and nonliving things interacting with each other in an area outside my school, then . . .”

Test Your Prediction
1. Walk around outside your school. Take along some paper and a pencil, and take notes on your observations.

2. Use your notes to identify an ecosystem.

3. Describe your ecosystem, and list at least two living things and two nonliving things.
Draw Conclusions

4 Classify  What criteria did you use to decide whether a location was an ecosystem?

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________________________________________________________________________

5 Does an area have to be a certain size to qualify as an ecosystem?
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________________________________________________________________________
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________________________________________________________________________

Chapter 1 • Earth’s Ecosystems
Activity Lab Book

Use with Lesson 1
Introduction to Earth’s Ecosystems

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Testing Soil pH

Purpose
Your task is to determine whether the pH differs from one soil sample to another.

Procedure
1. Put three different soil samples in separate cups.
2. Using the soil-test kits provided by your teacher, test the pH of each sample. Record the pH of each.

Materials
- pH test kit
- 3 soil samples

Chapter 1 • Earth’s Ecosystems
Activity Lab Book

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Quick Lab

Name ___________________________ Date __________

Draw Conclusions

3 Predict What do you think would happen if you added an antacid to the soil samples? Design an experiment to test your prediction.

My prediction: ____________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
My experiment: ______________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
My results: ________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
Compare

When scientists compare they look for similarities among objects, materials, and data. As scientists study a particular ecosystem over time, they can make comparisons. They can compare the way the ecosystem functions in the present with the way that it functioned in the past. With this information they can predict what the ecosystem might be like in the future.

1 Learn It

When scientists study an ecosystem, they examine every change they can. Scientists study changes because one small change in an ecosystem can affect many biotic and abiotic factors.

Charts and Venn diagrams are tools used to compare. After you have collected and recorded data, you can see at a glance whether the data, objects, or materials are similar. Line graphs and bar graphs can also be used to analyze changing conditions over time.

2 Try It

- Scientists monitor how sudden events such as floods and mudslides affect an ecosystem. In this activity you will compare a miniature landscape before and after a “flood.” You will need a dishpan, soil, rocks, small twigs, water, and a watering can.

- Build a hill landscape of soil, rocks, and twig “trees” in a dishpan. Draw a picture of your landscape on the chart on the next page. Use the watering can to sprinkle water gently on your hills. Record your observations.

- Hold the can high, and continue to let water fall down on the hills. Record your observations. Pour the rest of the water quickly over the hills. Record your observations. Draw a picture of the way your landscape looks now.
<table>
<thead>
<tr>
<th>What I Did</th>
<th>My Observations and Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>My landscape at the start of the experiment</td>
<td></td>
</tr>
<tr>
<td>Sprinkled water gently</td>
<td></td>
</tr>
<tr>
<td>Held can higher</td>
<td></td>
</tr>
<tr>
<td>Poured water quickly</td>
<td></td>
</tr>
<tr>
<td>My landscape at the end of the experiment</td>
<td></td>
</tr>
</tbody>
</table>
3 Apply It

- Now use the information from your chart to create a Venn diagram like the one on this page. Draw two overlapping ovals. In one oval list the characteristics of your hill ecosystem before the “flood.” In the other oval list the characteristics of your hill ecosystem after the “flood.” Write the common characteristics in the area where the two ovals overlap.

How did your hill ecosystem change?

- How did it stay the same?
Next, choose an ecosystem near your school or home to observe for a month. Note any changes in the ecosystem, and make a chart or Venn diagram to compare its characteristics at the beginning and at the end of the month.

Observations

<table>
<thead>
<tr>
<th>Week</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>4</td>
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</tr>
</tbody>
</table>

Beginning and End
How does light affect plants?

Form a Hypothesis

Plants need light to grow. What do you think will happen to a plant’s leaves if you cover parts of them, so that no light reaches those parts? Write your answer as a hypothesis in the form “If parts of a plant’s leaves do not receive any light, then . . .”

Test Your Hypothesis

1. Wrap small pieces of aluminum foil over parts of several leaves. Wash your hands after handling the plant.

2. Use Variables  Cover at least four different leaves of the plant in the same way.

3. Place the plant in a window where it will get lots of light. Water the plant with a measured amount of water.

4. Experiment  After one day carefully lift the foil and check each leaf. Write down your observations. Gently replace the foil in the same position.

5. Experiment  Continue your observations each day for one week. Replace the foil in the same position each time.
Draw Conclusions

6 Compare How did the areas covered by the foil differ from the other parts of the leaves?

____________________________________________________________________________________

____________________________________________________________________________________

7 Interpret Data How did the changes you observed progress after one day? After two days? After a week?

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

8 Infer How do light and darkness affect the growth of leaves?

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

Explore More
Remove the foil from the leaves. Water the plant with the same amount of water you used in the previous week, and observe it each day for another week. What happens when the leaves remain uncovered?

____________________________________________________________________________________

____________________________________________________________________________________
How do plants absorb water?

Form a Hypothesis
How does water travel from a plant’s roots to its stem, leaves, and flowers? Write your answer as a hypothesis in the form “If water travels through tubelike structures in a plant’s stem, then . . .”

Materials
- white carnation with stem split lengthwise
- 2 different colors of food coloring
- 2 glasses or narrow jars
- water

Test Your Hypothesis
1. Obtain from your teacher a white carnation that has its stem cut in half lengthwise.
2. Fill each glass with water. Add a few drops of food coloring to one. Add a few drops of food coloring in another color to the second glass. Place them next to each other.
3. Place one side of the flower stem in one glass and the other side of the flower stem in the second glass. Record your observations.

Draw Conclusions
4. Interpret Data What does this tell you about the way water is transported in plants?
Leaves

Purpose
Leaves are the food-making machines of plants, and they come in a wide variety of forms. Your task is to observe the ways in which plant leaves are alike and different.

Procedure

1. Collect a variety of leaves.

2. **Observe** Examine each leaf with a hand lens, and write down each structure that you can identify.

   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

3. Place a piece of white paper over the leaf, and rub back and forth with a crayon, making a print of the leaf.

4. **Identify** On the rubbing, identify the leaf as simple or compound, and label each structure.

   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

5. Using two different-color crayons, trace the flow of water and food through the veins.

   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
Quick Lab

Draw Conclusions

6 Infer What is the role of veins in the leaf’s food-making process?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

7 Going Further How does water move around plants? Do leaves help pull water upward through the plant? Write your answer as a hypothesis in the form “If leaves help pull water upward through a plant, then . . .”

My hypothesis: __________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
My experiment: __________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

My results: __________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
What can you see through a microscope?

Make a Prediction
What do you think you will see if you look at an onion skin, sand, or yeast under a microscope? Will you see living organisms moving? Write your answer as a prediction in the form “If I look at an onion skin, sand, or yeast under a microscope, then . . .”

Test Your Prediction

1. **Observe** Place a piece of newspaper on a microscope slide. Place the slide on the stage of the microscope, and observe it under low power. Draw what you see.

2. **Observe** Look at the newspaper again under high power. Record your observations.

3. **Observe** Select your own samples. Repeat steps 1 and 2 for each sample. Record what you see.

Materials
- microscope
- 4 microscope slides
- dropper
- water
- toothpick
- small pieces of newspaper
- onion skin
- sand
- yeast
Explore

4 **Record Data** Make a data table to record the details of what you observed. How many organisms did you observe? How big were they? What colors were they?

Draw Conclusions

5 **Observe** What did you learn about the way objects appear when viewed through a microscope?

6 **Compare** What happened to your observations as you changed from low power to high power?

7 **Observe** Describe the appearance of each of the samples you observed.

8 **Critical Thinking** Explain how your life might be different if the microscope had never been invented.

Explore More
Did you see any differences among the samples under the microscope? Research the types of cells you looked at. Analyze and present your results.
Focus on

Inquiry Skills

Alternative

Explore

What can you learn about your world through a microscope?

Form a Hypothesis

One of the joys of science is discovering the world around you. Do you think you can observe all of the organisms that you interact with every day? Do you think you will discover much larger numbers of organisms in your world if you use a microscope? Write your answer as a hypothesis in the form “If I use a microscope to examine the world around me, then . . .”

Test Your Hypothesis

1. Collect some samples from your surroundings. Using tweezers or cotton swabs, collect samples such as dust particles, carpet fibers, hair strands from a comb or brush, sand from a beach or sandbox, and potting soil from a houseplant.

2. Place each sample on a microscope slide. Use a coverslip if needed.

3. Observe Starting with low power, observe your samples. Record your observations by drawing circles on a piece of paper to outline your field of view. Label each circle with the name of the sample, and draw what you see. Switch to high power, and record your observations.

Materials

- microscope
- microscope slides
- coverslips
- tweezers
- cotton swabs
**Draw Conclusions**

4. What did you observe?

________________________________________________________________________________________

________________________________________________________________________________________

5. Do you think microorganisms are all around you? Explain your reasoning.

________________________________________________________________________________________

________________________________________________________________________________________

**Inquiry: Open** Do you think disinfectant sprays or antibacterial soaps kill microorganisms? Write your answer as a hypothesis in the form “If I use a disinfectant spray or an antibacterial soap on a surface, then . . .”

My hypothesis: __________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

My experiment: __________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

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My results: ______________________________________________________________________________

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________________________________________________________________________________________
Observing Protists

Purpose
Your task is to use a microscope to examine pond water and observe protists and other microorganisms.

Procedure

1. Slide a metric ruler onto the stage of your microscope, and focus on it, using the highest power. Measure the field of view, and record your measurement in millimeters.

2. Obtain a pond-water sample from your teacher. Put a drop of the water in the center of a microscope slide. Gently place a coverslip over it.

3. Observe Starting with the lowest power, focus the microscope until you find microorganisms. Switch to high power, and focus. Draw what you see.

4. Measure Estimate how much area one microorganism you are observing takes up. Multiply that number by the size of your field of view to estimate the size of the organism in millimeters. For example, $\frac{1}{3} \times \frac{1}{2} \text{ mm} = \frac{1}{6} \text{ mm}$.

Materials
- metric ruler
- pond-water sample
- microscope
- microscope slide
- coverslip
Draw Conclusions

5 Observe What can you learn about microorganisms by observing them under a microscope?

________________________________________

________________________________________

6 Predict How would your observations change if you used a more powerful microscope?

________________________________________

________________________________________

7 Going Further Is pond water safe for drinking? Write your answer as a hypothesis in the form “If pond water contains many microorganisms, some of which may cause disease, then . . .”

My hypothesis: ____________________________________________

________________________________________

My experiment: ____________________________________________

________________________________________

My results: ________________________________________________

________________________________________
How can you model a food chain?

Make a Prediction
What would a food chain of 20 organisms look like? Would it be linear? Write your answer as a prediction in the form “If 20 organisms were made into a food chain, then it would look like . . .”

Test Your Prediction

1 Cut construction paper into 20 rectangles. Write the names of eight producers, six animals that eat the producers, four animals that eat the plant eaters, and two animals that eat the animals that eat the plant eaters. Make a hole in each rectangle.

2 Make a Model  Cover the top of the soda bottle with construction paper. This will be the Sun. Punch eight holes around the rim. Attach a piece of yarn to each of the eight producers. Attach the other ends to the soda bottle. Using yarn, link each plant-eating animal to a producer. Continue by linking the animals that eat the plant eaters to the plant-eating animals. Only one animal may be attached to a food source.

Materials
- top half of empty soda bottle
- yarn
- construction paper
- hole punch
- scissors
Draw Conclusions

3. **Observe** How many levels are in your model? What happens to the number of organisms in each level as you move away from the Sun?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4. **Predict** What would happen to the number of plant eaters if a drought destroyed the plants? What would happen to the animal populations?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Explore More
What changes might occur in an ecosystem into which the predators move? Make a prediction and test it. Then analyze and present your results.
What food chains are needed to provide various foods?

Make a Prediction
How many food chains does it take to make a pizza? Maybe you like your pizza with extra cheese and green peppers. Perhaps you prefer ziti pizza with meatballs. Get creative! Write your answer as a prediction in the form “If I make a pizza using several ingredients, then . . .”

Test Your Prediction
1. Using different colors of construction paper, cut out the “ingredients” of your pizza. Begin with the crust. Add other ingredients by gluing them onto the pizza crust. You must include at least five ingredients.

2. For each ingredient in your pizza, draw on an index card a possible food chain that would provide that food, and attach the card to the ingredient.

3. Classify Look over each food chain, and classify each food as involving or coming from a producer, a primary consumer, a secondary consumer, or a tertiary consumer.
Draw Conclusions

4. From which level on the food chain did most of the ingredients on your pizza come?

5. How would you create a pizza made only of ingredients that are producers?

Inquiry: Open  How do the levels in a food chain relate to the recommended daily servings of each food group? Write your answer as a prediction in the form “If foods from producers provide fiber as well as important vitamins and minerals, then . . .”

My prediction:

My research:

My results:
Your Food Chain

Purpose
Every organism that gets energy from a food is part of the food chain involving that food. Your task is to classify where you fall along the food chains you are part of.

Procedure

1. Keep a log of everything you eat for one day.

2. **Classify** For each food, determine whether it is a producer or a consumer.

3. **Classify** Which foods did you list as producers?

4. **Classify** Which foods did you list as consumers?

Materials
- paper and pencil
Communicate  Select two foods from the consumer group, and draw a possible food chain for each. Do not forget to include yourself. Did you include decomposers in your food chain? Where do they fit?

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

Going Further  Which part of a food chain takes the most energy to feed? Write your answer as a hypothesis in the form “If each member of a higher level in a food chain eats many individuals from the level below, then . . .”

My hypothesis: _________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

My experiment: _________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

My results: ___________________________________________________________________________________________________________

________________________________________________________________________________________________________________________

________________________________________________________________________________________________________________________
How does water recycle itself?

**Make a Prediction**
All living things rely on water, yet there is a limited supply of water on Earth. Water is recycled so that it can be used again and again. What will happen to soil if it is moistened with water and then placed under a heat source? Write your answer as a prediction in the form “If moistened soil is allowed to sit under a heat source, then the water in the soil will . . .”

**Materials**
- empty soda bottle with cap (cut into halves)
- soil
- water spray bottle
- lamp or window with sunlight

**Test Your Prediction**

1. Place about 4 inches of soil in the bottom half of the soda bottle.
2. Spray the soil with water so that it is moist but not wet.
3. Secure the top half of the soda bottle over the bottom half. Use tape if necessary.
4. **Observe** Place the bottle under a lamp or in direct sunlight. Observe it every 10 minutes for a class period. Write down your observations. Observe the bottle again on the second day. Write down your observations.
**Explore**

**Draw Conclusions**

5 What did you see the first day? What did you see the second day?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

6 **Infer** What was the source of the water? What was the source of the energy that caused changes in the bottle?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

7 **Observe** What happened to the water?

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

**Explore More**

What might happen if you added some small plants to the bottle? Some small rocks? What might happen if you added more heat or placed the bottle in the shade?

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What does the carbon cycle look like?

Form a Hypothesis
Carbon is constantly cycled through living organisms and the environment. When animals exhale they are getting rid of the waste products of their own cellular activity: carbon dioxide and water. What are some other sources of carbon dioxide? Are there organisms that absorb it? Write a hypothesis in the form “If carbon is cycled through Earth’s living things and the environment, then . . .”

Test Your Hypothesis

1. Gather information about the carbon cycle. Identify sources of carbon dioxide and ways in which carbon is absorbed.

2. Cut out pictures from magazines and newspapers that represent sources of carbon and pictures of things that absorb and store carbon.

3. Use the pictures and a piece of poster board to make a collage that models the carbon cycle. Show the different pathways of carbon’s journey through living things and the environment by drawing arrows to and from each picture.

Materials
- magazines and newspapers
- poster board
- glue
- markers
Draw Conclusions

4 What role do living plants and animals play in the carbon cycle?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5 Why does the burning of fossil fuels release carbon dioxide into the atmosphere? Where does this carbon dioxide come from?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Inquiry: Open  Think of your own question related to the cycles in nature.

My question: ______________________________________________________________________

________________________________________________________________________

My research: ______________________________________________________________________

________________________________________________________________________

My results: ______________________________________________________________________
Fertilizers

Purpose
Your task is to determine whether plants given fertilizer grow faster than plants not given fertilizer.

Procedure
1. Fill two plastic cups with pond water or water from an aquarium.
2. Add a few water plants, such as elodea, to each cup.
3. Add a teaspoon of houseplant food to one cup, and label the cup. ▲ Be Careful. Always wear protective gloves when handling plant foods.
4. Observe Place both cups in a sunny window, and observe them each day for a week. Record your observations.

Materials
- 2 plastic cups
- water plants, such as elodea
- pond water or aquarium water
- houseplant food
- protective gloves
Draw Conclusions

**Interpret Data** What effect did the plant food have on the plant growth in the cups? What is the independent variable in this lab? What is the dependent variable?

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______________________________
______________________________
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**Going Further** Can a plant get too much fertilizer? Write your answer as a hypothesis in the form “*If I add too much fertilizer to a plant, then . . .*”

My hypothesis: ________________________________
______________________________
______________________________
______________________________

My experiment: ________________________________
______________________________
______________________________

My results: ________________________________
______________________________
Inquiry: Structured

**What factors affect the carbon, water, and nitrogen cycles?**

**Form a Hypothesis**
The carbon cycle is a series of events that recycles carbon through the environment. Carbon exists in many forms and can be found in the air and in plants and animals. Plants take in carbon dioxide from the air and convert it into food and oxygen. The amount of carbon found in the air is affected by air pollution, especially pollution from the burning of fossil fuels. What role do plants play in the carbon cycle? Write your answer as a hypothesis in the form “If carbon dioxide is added to a system containing a plant, then . . .”

---

**Be Careful.** Wash your hands with soap and water after the investigation. Immediately wash any area of skin that comes in contact with bromothymol blue.

**Test Your Hypothesis**

1. Use a straw to blow slowly into a small cup of bromothymol blue. Record your observations.

   △ **Be Careful.** Be sure to breathe out through the straw. Do not breathe in. Do not drink the liquid in the cup.

---

**Materials**

- small cup
- bromothymol blue
- elodea
- test tube with cap
- straw
- graduated cylinder

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2 **Measure**  Pour 10 milliliters of bromothymol blue into a test tube. Record the color of the liquid.

3 **Experiment**  Use a straw to blow gently into the test tube until the liquid turns light green. Place one piece of elodea in the test tube, and put the cap on the tube.

4 Place the test tube in a rack near a window, and check the color of the bromothymol blue every 30 minutes for 2 hours. Record the color of the liquid at each interval.

---

**Draw Conclusions**

5 **Explain**  What made the bromothymol blue change color in step 1?

6 **Analyze**  If you had continued blowing into the test tube instead of capping it, what do you think would have happened during the 2-hour experiment?

7 **Infer**  What part of the carbon cycle did you represent when you blew into the test tube?
Inquiry: Guided

What factors affect the water cycle?

Form a Hypothesis
Does temperature affect the water cycle? Write your answer as a hypothesis in the form “If the average air temperature changes over a long period of time, then the water cycle will . . .”

Test Your Hypothesis
Design an experiment to investigate how temperature affects the water cycle. Write out the materials you will need and the steps you will follow. Record your results and observations.

Draw Conclusions
Did your results support your hypothesis? Why or why not? What do you think would happen to the water cycle in a large land area if volcanic ash blocked the Sun's rays for a few months?
Inquiry: Open
What can you learn about the nitrogen cycle? For example, does pollution affect it? Come up with a question to investigate. Then design an experiment to answer your question, and carry out your experiment. Organize your experiment to test only one variable, or one item being changed. Write down the steps so that another group could complete the experiment by following your instructions.

Remember to follow the steps of the scientific process.

Ask a Question

Form a Hypothesis

Test Your Hypothesis

Draw Conclusions
What are Earth’s biomes like?

Make a Prediction
A biome is a land region that has a particular climate. Earth’s biomes include taiga, tundra, tropical rain forest, deciduous forest, desert, and grassland. Do all biomes have the same kinds of plants and animals? Write your answer as a prediction in the form “If each biome has a particular climate, then ________ plants and animals live in each.”

Materials
- long piece of white butcher paper
- crayons and color markers
- index cards

Test Your Prediction
1. Work in groups of four or five. Each group should select one biome.
2. Tape the paper to the walls of the classroom.
3. Research the biome you selected. Find out about its location, climate, soil, and its plants and animals.
4 **Make a Model** Draw a mural that represents your biome. Show at least two plants and two animals that live in the biome. Include a world map that shows the location of the biome.

5 **Communicate** List the information you collected on the index cards, and attach them to your mural. Indicate where you obtained the information.

**Draw Conclusions**
6 Compare the plants and animals in the biomes. What similarities and differences do you see?

7 Did your observations support your prediction?

**Explore More**
Compare food chains from the biomes. What are the main producers in each? What are the main consumers?
How can you recreate a biome?

Make a Prediction
When animals are kept in zoos, it is very important to recreate their native environments. Many animals come from biomes that are very different from those in which the zoos are located. Is it possible to recreate an animal's environment? Write your answer as a prediction in the form “If you know the climate and characteristics of a biome, then . . .”

Test Your Prediction
1. Select an animal from one of the world's six biomes.

2. Using color pencils draw a picture or series of pictures detailing how you would design a zoo exhibit for the animal to recreate its natural habitat.

3. Communicate On an index card, list each feature of the exhibit that helps recreate the biome from which the animal comes.
Draw Conclusions

4. Would it be easier to build your exhibit outdoors or indoors? Why?

________________________________________________________________________

5. Why do you think it is important to build zoo exhibits that are very similar to an animal’s native environment?

________________________________________________________________________

________________________________________________________________________

Inquiry: Open  How closely did your exhibit match what has been done at major zoos around the country? Visit a zoo in person or online to check out their exhibits. How did your exhibit compare?

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________________________________________________________________________
Endangered Species

Purpose
Your task is to study what happens when an animal species becomes extinct. How does the loss of its role affect other organisms in the biome?

Procedure

1. Choose an endangered animal species to study.

2. Use books, Web sites, and other sources to find information about this endangered species.

3. Identify the species' niche in its biome. Find out what it eats, where it lives, and how it interacts with plants and other animals in the biome.

4. Draw a food web that shows the interactions between the endangered species and the plants and other animals in the biome. Show how they depend on each other for resources such as food and shelter.

Materials

- books, Web sites, and other sources
- paper and pencil
Infer  What would happen if this animal became extinct?


Draw Conclusions

6  What are some reasons that the animal you researched is in danger of extinction?


Communicate  What can individuals do to help save endangered species? Design a poster to communicate your ideas.


Going Further  What animals in California are considered endangered species? How could you find out about them? Make a prediction in the form “If there are endangered animal species in California, then . . .”

My prediction: ____________________________________________


My research: ____________________________________________


My results: ____________________________________________
Sequence

Many things on Earth occur in a sequence. Think about it. You cannot be 13 years old before you are 12, and leaves do not fall off deciduous trees until the leaves have matured. The same is true about the layers of soil in a land biome. By digging down to lower layers, scientists can learn more about a biome and any changes that have taken place over time. In general, in a soil sequence, the lowest layers are the oldest.

1 Learn It

When you put things in sequence, you put one thing after another in a fixed order. When you sequence events, you put them in the order in which they happened. This order helps you see patterns.

When scientists do experiments, they record their data in a time sequence showing what happened first, next, and last. Scientists need these data not only to verify what they discovered and when but also to be able to repeat the investigation or try it in a different way. A sequence chart is a useful tool for recording these kinds of data.

2 Try It

Suppose scientists wanted to verify the soil layers in a biome. They would make a plan to dig into the ground and examine it. On the next page, there is a sequence chart they might keep, but it is not in the correct order. Write a number in front of each box to show the order in which each layer would be found. Use number 1 for the topmost layer.
Which level contained the newest soil materials?

What did scientists find at the oldest level?

How could knowing the sequence of soil and rock layers in a desert biome help scientists?

Apply It

In this activity you will build a grassy environment. As you do this activity, make a sequence chart to show each step in your project and your observations. The overall growth of the plants will show whether you have built a healthy environment. You will need a 10-gallon fish tank, gravel, charcoal, sand, topsoil, grass seed, small seedlings, a plastic spoon, a mixing bowl, a watering can, plastic wrap, tape, a measuring cup, and a ruler.
1. Spread a 1-inch layer of gravel on the bottom of the tank with the spoon. Mix in a little charcoal, and then spread a 1-inch layer of sand over the gravel.

2. Measure 2 parts topsoil to 1 part sand in the bowl, and mix thoroughly. Spread a 2- to 3-inch layer of the mixture over the sand and gravel.

3. Sprinkle grass seed on half of the soil. Plant seedlings in the other half. Be sure to cover the roots and leave space between plants. Water the landscape gently until it is moist on top.

4. Cover the tank with plastic wrap. Use tape to secure the plastic tightly over the top. Place the tank in a sunny place.

5. Check the tank each day for a week, and record what you observe. Then answer the questions on the next page.

### Grassy Environment Observations

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Do the layers in your environment appear to be in the same order as they were in the Try It activity?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

What did you observe in your environment?

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Use the sequence chart below to describe the process that seeds go through as they germinate and grow.

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________________________________________________________________________

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________________________________________________________________________
What are water ecosystems like?

Make a Prediction
What will you observe when you compare samples of water from different sources? Will the contents be alike or different? Write your answer as a prediction in the form “If water samples come from different sources, then . . .”

Test Your Prediction

1. Obtain from your teacher samples of pond, lake, and ocean water. Place each sample in a different container. Label each container.

2. Observe  Note the appearance of each water sample, and record your observations.

3. For each sample, place a drop of the water on a slide, and carefully place a coverslip over it.

4. Observe  Examine the slide under a microscope at low power and at high power.

Materials
- microscope
- slides with coverslips
- water samples from ponds, lakes, and the ocean
- safety goggles

California Standard
6 IE 7.b., d.
Communicate  Record what you see on each slide.

________________________________________

________________________________________

________________________________________

________________________________________

Draw Conclusions

Interpret Data  Compare the samples. How are they alike and different? What do your observations tell you about water ecosystems?

________________________________________

________________________________________

________________________________________

________________________________________

Did your results support your prediction?

________________________________________

________________________________________

________________________________________

________________________________________

Explore More
What organisms did you observe in the water samples? Where do the organisms fit in the food chain? Draw a possible food chain for each sample.

________________________________________

________________________________________

________________________________________

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________________________________________
How on Earth do we use water?

Make a Prediction
Water covers about 75% of Earth’s surface. How much of that is available for use by humans and other animals? Write a prediction in the form “If only about 3% of Earth’s water is fresh water, then . . .”

Materials
- seven 1-liter clear soda bottles
- blue food coloring
- water
- labels
- graduated cylinders
- calibrated droppers

Test Your Prediction
1. Add food coloring to 2.5 liters of water until the water is clearly blue.

2. Label the seven bottles as follows: All of Earth’s Water, All Salt Water, All Fresh Water, Fresh Water Locked Up in Ice Caps and Glaciers, Fresh Water in the Ground, Fresh Water on the Surface, and Water in Soil and Air.
3 **Use Numbers** Add colored water to each bottle, using the volumes specified in the chart below.

<table>
<thead>
<tr>
<th>Type of Water</th>
<th>Percent of Earth’s Water</th>
<th>Amount of Water in Bottle</th>
</tr>
</thead>
<tbody>
<tr>
<td>All of Earth’s water</td>
<td>100%</td>
<td>1000 mL</td>
</tr>
<tr>
<td>All salt water</td>
<td>97.2%</td>
<td>972 mL</td>
</tr>
<tr>
<td>All fresh water</td>
<td>2.8%</td>
<td>28 mL</td>
</tr>
<tr>
<td>Fresh water locked up in ice caps and glaciers</td>
<td>2.3%</td>
<td>23 mL</td>
</tr>
<tr>
<td>Underground fresh water</td>
<td>0.4%</td>
<td>4 mL</td>
</tr>
<tr>
<td>Fresh water on Earth’s surface</td>
<td>0.05%</td>
<td>0.5 mL</td>
</tr>
<tr>
<td>Water in soil and air</td>
<td>0.01%</td>
<td>0.1 mL</td>
</tr>
</tbody>
</table>

4 **Observe** When you line the bottles up, what do you observe?

________________________________________________________________________

________________________________________________________________________

**Draw Conclusions**

5 **Infer** How can you relate your observations in this activity to the need for water conservation?

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________
Plants as Water Filters

**Purpose**
Your task is to study what happens when water containing various pollutants moves through the soil of a potted plant.

**Procedure**

1. Set four small potted houseplants, with their pots, into the tops of four clear containers.

2. Slowly pour clean water into one of the pots and watch it trickle through the pot into the container. Observe the liquid that comes out.

3. Add about 1 g of soil to a cup of water and stir. Pour this mixture into a second pot. Again, observe the liquid that leaves the pot.

4. Add some colored, powdered drink mix to a cup of water and stir. Slowly pour the mixture through a third pot. Note the color of the water that drains from the pot.

**Materials**

- 4 small potted houseplants with holes in the bottom of the pots
- 4 clear containers
- water
- soil
- colored, powdered drink mix
- plastic cups
- liquid soap
Mix about 30 mL of liquid soap with a cup of water. Pour this mixture through the fourth pot. Does the soap flow through the soil?

Observe Empty the containers under the third and fourth pots. Then pour some clean water over both plants. What drains out?

Draw Conclusions

Based on your results, what can you conclude about the role of plants in wetlands?

Going Further What do you think would happen if the concentration of pollutants were greater in this procedure? How could you test your prediction?

My prediction:

My experiment:

My results:
Inquiry: Structured

What is an estuary?

Form a Hypothesis

Fresh water and salt water have many similarities and differences. Both saltwater ecosystems and freshwater ecosystems have food webs that exist because of the Sun’s energy. Both types of ecosystems have animals and plants that thrive in all types of temperatures. Estuaries are areas where fresh water flows into the ocean. This creates an area that has a different salt content and is a haven for many types of creatures. What are some unique characteristics of estuary waters? Write your answer as a hypothesis in the form “If estuary water is different from salt water and fresh water, then buoyancy . . .”

Materials

- plastic cups
- plastic spoons
- salt water made from ocean mix
- waterproof markers
- eggs
- graduated cylinder

Be Careful. Wash your hands with soap and water after the activity.

Test Your Hypothesis

1. Label three cups Fresh Water, Ocean Water, and Estuary Water.

2. Measure Pour 200 milliliters of tap water into the cup labeled Fresh Water. Pour 200 milliliters of salt water into the cup labeled Ocean Water.
3 Place an egg in the salt water. Record your observations, and mark the egg with a marker at the water level.

4 Place the same egg in the fresh water, and mark the egg again. Record your observations.

5 Remove 100 milliliters of water from each cup, and pour it slowly into the cup labeled Estuary Water. Record what happens to the water as you pour the two together.

6 Place the egg in the estuary water, and record your observations.

Draw Conclusions

7 Explain What happened when you placed the egg in the salt water? In the fresh water?

8 Analyze Based on your experiment, what can you determine about water found in estuaries? What can you determine about the animals and plants in estuaries?
Inquiry: Guided

How do ocean salt levels affect living things?

Form a Hypothesis
What would happen to sea life if the ocean's salt levels changed? Write your answer as a hypothesis in the form “If the ocean's salt levels change, then the organisms will . . .”

Test Your Hypothesis
Design an experiment to investigate what effect salt levels have on organisms such as brine shrimp. Write out the materials you will need and the steps you will follow. As you follow your plan, record your results and observations.

Draw Conclusions
Did your results support your hypothesis? Why or why not? Present your results to your classmates.
Inquiry: Open

What else can you learn about estuaries and their inhabitants? For example, what types of animal life can be found in estuaries? Think of a question to investigate. Then design an experiment or write out a research strategy to answer your question. Carry out your experiment or your research, and present your results to your classmates.

Remember to follow the steps of the scientific process.

Ask a Question

________________________________________________________________________

Form a Hypothesis

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Test Your Hypothesis

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Draw Conclusions

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
What are California’s ecosystems?

**Purpose**
What are California’s ecosystems like? How are they similar or different? Write a prediction in the form “If California’s ecosystems have different ________, then they will have different ________.”

**Materials**
- modeling clay of different colors
- sturdy cardboard
- index cards

**Procedure**
1. Work in groups of four or five. Find various ecosystems on the map provided.

2. **Make a Model** Outline a map of California on a piece of cardboard. Using different colors of modeling clay, construct a state map showing the state’s ecosystems. Include landforms and bodies of water.
3 **Observe**  Create an index card for each ecosystem. Use your clay map to find landforms and bodies of water that might affect plants and animals in the region. Record this information on the index cards. Think about the types of plants and animals you might find in each ecosystem.

---

**Draw Conclusions**

4 **Analyze**  Using the information on your index cards, compare the ecosystems. How do the regions differ?

---

5 **Did your observations support your prediction?**

---

**Explore More**

Choose one ecosystem on your state map. What adaptations do you think plants and animals in that region would need to survive?
How do California biomes compare with biomes around the world?

Form a Hypothesis
Distance from the equator is a major factor in determining which biomes are likely to occur in a particular location. How do California biomes compare with biomes around the world? Write your answer as a hypothesis in the form “If a California biome is located at a particular latitude, or distance from the equator, then . . .”

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Test Your Hypothesis

1. Study the world biome map. Review the key, and identify each type of biome.

2. For each California biome, locate other areas around the world that are at about the same distance from the equator, both to the north and to the south. Identify any similar types of biomes in these locations.

Draw Conclusions

3. Did your observations support your hypothesis?

4. Can you explain why biomes do not simply occur in bands surrounding Earth at specific distances from the equator?

Inquiry: Open Which two biomes are virtually limited to the Northern Hemisphere? Why do you think this is so?
A California Food Web

Purpose
Your task is to identify what a desert or chaparral food web might look like.

Procedure

1. Choose a large predator that lives in a desert or chaparral ecosystem in California.

2. Do research to identify some of the prey, or animals that this predator eats.

3. Choose one of the prey. Find out what organisms it eats.

4. Draw a food web that shows where the organisms you identified belong.

Materials

- books, Web sites, or other resources
- paper and pencil
Quick Lab

Name ___________________________ Date __________________

Draw Conclusions

5 Infer What types of organisms would you expect to find at the base of this food web?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6 Predict How do you think food webs would differ in other California ecosystems? Give an example.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7 Going Further What do you think would happen if one of the organisms in this food web were wiped out by disease? How could you test your prediction?

My prediction: __________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

My experiment: __________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

My results: __________________________________________________________________
How can you measure heat flow?

Make a Prediction
Do you think heat flows between warm objects and cool objects? What will happen if a jar of cool water is set into a bowl of room-temperature water? Write your answer as a prediction in the form “If a jar of warm water is set into a bowl of room-temperature water, then . . . If a jar of cool water is set into a bowl of room-temperature water, then . . .”

Materials
- 2 large bowls
- 2 jars
- 4 thermometers
- watch or stopwatch
- water

Test Your Prediction
1. Fill one jar with 30°C water. Fill second jar with 10°C water.

2. Measure Place each jar into a separate bowl of room temperature water 22°-24°C. Record the starting temperatures of the water in the bowls and jars.

   starting temperatures: warm jar 1 _____ bowl 1 _____
   starting temperatures: cool jar 2 _____ bowl 2 _____
3 Experiment Record the temperatures of the containers every 2 minutes for 20 minutes. Record your observations. When do you think the temperatures will stop changing?

Draw Conclusions

4 Analyze Make a line graph that shows how the temperature of the water in each jar and each bowl changed over time.

5 Analyze What happened to the temperature of the jar with warm water? Where did the heat go?

Explore More

What do you think would happen if you place a jar of warm water in a bowl of ice water? Make a prediction and test it. Then analyze and present your results.
How can you save a snowman?

Form a Hypothesis
What would you do if you lived in a colder climate and wanted to send a snowman to your friend in a warmer climate? Can you design the ultimate insulation to keep your snowman from melting during the trip? Write your answer as a hypothesis in the form “If I insulate a container efficiently, then . . .”

Test Your Hypothesis

1. Working in pairs, make a snowman from shaved ice, or snow if available.
2. Pack your snowman in a small container, and seal it with a lid.
3. Select an outer container that is larger than the small container holding your snowman. Place the small container inside the larger container, leaving space for insulation.
4. Decide which type of insulation you will use, and stuff it in between the large container and the small inner container. Close your package tightly, but do not seal it.
5. **Observe** Open the outer container every hour and check on your snowman. Do not keep the container open for long. Record your observations.
6. Record the amount of time it took for your snowman to become a puddle. Share your results with the class.

Materials
- containers of different materials: cardboard, polystyrene foam, metal
- small containers with lids
- shaved ice or snowballs
- foam peanuts, air-bubble packaging, paper, cotton
Draw Conclusions

7 **Use Numbers**  How long were you able to keep your snowman “alive”?

________________________________________________________________________

8 **Observe**  Which materials used for insulation and packaging worked best for keeping the snowmen frozen?

________________________________________________________________________

9 **Infer**  What kinds of materials would work best if you worked delivering pizzas and wanted to keep them hot?

________________________________________________________________________
Different Objects, Different Temperatures

Purpose
Your task is to show whether objects made of different materials have different temperatures if they are in the same room.

Procedure

1. **Observe**  Touch a metal object, such as a stapler. Then touch a wooden object, such as a ruler or a desk. What do you notice?

   
   
   

Draw Conclusions

2. **Predict**  Do you think that the metal and the wood are the same temperature? How could you determine whether they are the same temperature?

   
   
   

3. **Analyze**  How would you explain what you observed?
4 **Infer** Why do you think wooden objects feel warmer and metal objects feel cooler?

__________________________________________

__________________________________________

__________________________________________

__________________________________________

5 **Going Further** What other materials could you classify as warm to the touch or cool to the touch?

My hypothesis: ______________________________________

__________________________________________

My experiment: ______________________________________

__________________________________________

My results: ______________________________________

__________________________________________
Experiment

Scientists **experiment** by performing procedures under controlled conditions that help them test a hypothesis, discover an unknown effect, or illustrate a known effect or scientific law.

Sometimes an experiment does not produce the expected result. Does this mean it was a failure? No. It just means that you have new data to lead to more experiments.

1. **Learn It**

   When you **experiment** you perform a test that supports or does not support a hypothesis. You need to plan a procedure, make observations, and record data. Once you have enough data, you can draw a conclusion about whether or not your data supports your hypothesis. It may, or it may not. Either outcome is good. However, the more data you collect, the more accurate your conclusion will be.

   In the following experiment, you will collect data to test the following hypothesis: **If a rubber band is thick, then it will get hotter than a thin rubber band when both are stretched the same amount.**

2. **Try It**

   - You will need a thick rubber band and a thin rubber band for comparison. Without stretching either rubber band, hold each to your forehead. Do the rubber bands feel warm or cool? Are they the same temperature as your skin? Record your observations in the chart on page 71.

   - Hold the thin rubber band away from your face, and quickly stretch it and let it relax three times. Let it relax, and touch it to your forehead. Record your observation about its temperature in the chart. Repeat this procedure with the thick rubber band.
Rubber Band Experiment

<table>
<thead>
<tr>
<th>Rubber Band Position</th>
<th>Thin Result</th>
<th>Thick Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stretched</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In an experiment variables are the things that change. To determine what caused the experiment’s results, you need to change one variable at a time. The variable that changes is the independent variable. A dependent variable is one that changes because of the independent variable. In this experiment what is the independent variable? What is the dependent variable?
3 Apply It

Now analyze the results of your experiment. Do they support or refute the hypothesis: *If a rubber band is thick, then it will get hotter than a thin rubber band when both are stretched the same amount?* From your results, can you draw a conclusion about why the stretched rubber band felt warmer than, cooler than, or the same temperature as your skin? If you used a thicker rubber band, would the heat flow felt by your skin be greater, less, or the same?

---

Can you predict what would happen if you used a thinner rubber band? A thicker one? A longer one? If you stretched it five times before feeling it? Ten times? Plan and carry out an experiment that would prove or disprove one of your predictions. Share the results with your classmates.
My prediction: __________________________________________

________________________________________________________________________

________________________________________________________________________

Rubber Band Experiment

<table>
<thead>
<tr>
<th>Rubber Band Position</th>
<th>Thinner Result</th>
<th>Thicker Result</th>
<th>Longer Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relaxed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stretched 3 times</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stretched 5 times</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stretched 10 times</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How can you change the sound a string makes?

Form a Hypothesis
What do you think will happen when you stretch a string out across a desk and use pencils to lift the string off the desktop? Can you change the pitch of the sound by moving the pencils? Write your answer as a hypothesis in the form “If the pencils are moved closer together, then the pitch of the sound will . . .”

Test Your Hypothesis

1. Cut a length of string about twice as long as your desk. Place the string across the desk, and tie each end to the handle of a bucket so that the buckets hang freely. Insert the pencils under the string at each edge of the desk. Fill each bucket one-quarter full with stones.

2. Near the center of the desk, pluck the string with your finger. Record what you hear.

3. Move the pencils closer together, and repeat step 2. Record your observations.

Materials

- 2 small buckets
- stones to fill each bucket
- 2 pencils
- string or fishing line
- safety scissors
- safety goggles
**Draw Conclusions**

4 Analyze  How would you explain what you observed? Did your observations support your hypothesis?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5 Infer  How does the tightness (tension) of a string affect the sound?

________________________________________________________________________

Explore More

What will happen to the sound if you fill each bucket half full with stones and repeat step 2? Develop a hypothesis and test it. Then analyze and present your results.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Why are men’s voices lower pitched than women’s voices?

Form a Hypothesis
Why do you think men’s voices are lower pitched than women’s? Does the length of a rubber band affect the highness or lowness of the sound it makes when plucked? Write your answer as a two-part hypothesis in the form “If a rubber band is short, then the sound it makes when plucked will be . . .” “If a rubber band is longer, then the sound it makes when plucked will be . . .”

Be Careful. Use sharp instruments with care.

Test Your Hypothesis

1. Cut a rubber band into 2 pieces, one shorter than the other.

2. Place the longer piece over the center of the opening of the cup, and hold it in place on the outside of the cup, just below the rim. Pluck the rubber band, and record your observations.

3. Repeat step 2 with the shorter piece of rubber band, placing it across a smaller section of the opening. Record your observations.
Draw Conclusions

4 **Analyze** How would you explain what you observed?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

5 Did your observations support your hypothesis?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

6 **Infer** Based on your observations, how can you explain the difference between men's and women's voices?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Traveling Sound Waves

Purpose
Your task is to show how sound waves travel, causing objects to vibrate and move around.

Procedure
1. **Make a Model** Stretch a piece of plastic wrap over a large bowl or pot. Make sure the plastic is stretched tightly over the container.
2. Place 20–30 grains of uncooked rice on top of the plastic wrap.
3. Hold a tin cookie sheet close to the plastic wrap. Hit the sheet with a spoon to make a loud noise. What happens to the rice?

Materials
- plastic wrap
- large bowl or pot
- uncooked rice
- tin cookie sheet
- spoon

Draw Conclusions
4. **Infer** What do you think caused the results you observed?

5. **Predict** What might happen if you hit an object that makes a sound different from a cookie sheet?

6. **Analyze** How would you explain what you observed?
7 Infer  What does this experiment suggest about how people hear sounds? How does the eardrum work?


8 Going Further  Sound waves travel from their source in all directions. How could you prove this using several bowls with rice on top?

My hypothesis: 


My experiment: 


My results: 


How can we use the energy of the Sun?

Purpose
The Sun gives off light and heat. Light is used by plants to make food and by people to see during the day. The heat of the Sun warms Earth. Can this heat be used as a source of energy?

Procedure

1. Line the outside of one paper cup with black construction paper. Tape the paper to the cup. Insert this cup into the second paper cup. The black construction paper should be between the two cups. Place three small pieces of peeled apple in the bottom of the first cup.

2. Place a piece of aluminum foil on top of a piece of white construction paper. Tape the foil to the paper. Roll the paper and foil into a cone, with the paper on the outside. The narrow end should fit into the first paper cup. Insert the cone into the cup, and tape it in place.

3. Put three small pieces of peeled apple into a third paper cup. Place the cups in direct sunlight.
Draw Conclusions

4 Observe  Look at the pieces of apple every half hour for 2 hours. Note your observations.

5 Analyze  What caused the differences you observed?

Explore More
In this activity you made a simple solar cooker. How can you make your solar cooker more efficient? Compare your design with solar cookers that are available in stores. Write a report about your findings, and present it to your class.
How can you measure calories used?

### Materials
- pencil and paper
- scale
- calorie rate chart (calories burned per hour per kilogram of body mass)

### Table: Activity and Average Calorie Rate

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average Calorie Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeping</td>
<td>1.1</td>
</tr>
<tr>
<td>Quiet activity (sitting, reading, playing chess)</td>
<td>1.5</td>
</tr>
<tr>
<td>Mild activity (washing dishes, brushing teeth)</td>
<td>3.1</td>
</tr>
<tr>
<td>Moderate activity (walking, cleaning your room, gardening)</td>
<td>4.4</td>
</tr>
<tr>
<td>Strenuous activity (dancing, roller skating, jogging, aerobics)</td>
<td>7.5</td>
</tr>
<tr>
<td>Very strenuous activity (running or swimming competitively, tennis)</td>
<td>10.5</td>
</tr>
</tbody>
</table>

### Form a Hypothesis
How can you measure the number of calories you burn in 24 hours? Write your answer as a hypothesis in the form “If you determine your body mass and use the calorie rates for your daily activities, then . . .”

```
```

### Test Your Hypothesis

1. **Measure** Use the scale to determine your body mass in kilograms.

```
2 Make a log of your daily activities and the amount of time you were involved in each.


3 **Use Numbers**  For each activity multiply your body mass by the calorie rate given in the chart. Then multiply that number by the number of hours or parts of hours, in decimals, spent doing each. Total the amount for all activities.


4 **Observe**  How many calories did you use in a 24-hour period?


**Draw Conclusions**

5 **Infer**  How can you use this information to help develop a healthful nutrition program?
What materials can reduce friction?

Purpose
Your task is to show which of two materials—hand lotion or talcum powder—will work to reduce friction.

Procedure

1. **Observe** Rub your hands together quickly. What happens? What force causes your hands to heat up?

2. **Experiment** Put lotion on your hands, and try rubbing them together again. What happens? Do you think talcum powder will have the same effect as the lotion? Test your idea.

3. **Infer** Based on your observations, what effect does motor oil have on friction between engine parts?
Draw Conclusions

Predict  How would ice on a sidewalk affect your ability to walk? How would spreading sand on the ice affect your ability to walk? What role might friction play?

Going Further  One of the main events of county fairs used to be a contest to see who could catch a greased pig. Would it be easier to catch a greased pig or an ungreased pig? What is your reasoning? How could you demonstrate this using a coating of petroleum jelly on the palm of someone's hand?

My hypothesis:  

My experiment:  

My results:  

How does heat flow from one material to another?

Make a Prediction
What will happen when two objects of different temperatures are placed together? Will heat be transferred? Write your answer as a prediction in the form “If heat moves from hot to cold, then . . .”

Test Your Prediction
1. Hold a liquid-crystal thermometer card against the back of your hand, and observe what happens to the card as it warms up. Record color changes, if any.

2. Warm a quarter in your hands and place it on the table. Place a liquid-crystal thermometer card on top of the quarter. Record any changes.
3 Hold a liquid-crystal thermometer card above a cup of hot water. Note any changes. What shape is the colored region? How is this different from the colored regions in steps 1 and 2?

4 Hold an ice cube about 1 centimeter above a thermometer card. What happens now?

Draw Conclusions

5 **Analyze** How would you explain what you observed? Did your observations support your prediction?

6 **Infer** Does heat flow between two materials when they are touching? When they are not touching?

**Explore More**

What would happen if you repeated step 2 and placed a second card on top of the first? Make a prediction and test it. Then analyze and present your results.
How does heat travel?

Form a Hypothesis
What do you think will happen if you heat one end of a metal rod? Write your answer as a hypothesis in the form “If a metal rod is heated at one end, then the heat will . . .”

Test Your Hypothesis

1. Thread three cubes of paraffin wax onto the metal skewer or wire, positioning the cubes at 6 centimeters, 9 centimeters, and 12 centimeters from the tip. Have your teacher open the chafing dish and light the fuel.

   △ Be Careful. Use the heat-resistant glove or oven mitt to hold the skewer.

2. Hold the tip of the skewer over the flame.

3. Observe what happens to the paraffin. Record your observations.

Materials
- chafing dish
- metal skewer (or coat hanger wire) about 30 centimeters long
- cubes of paraffin wax
- heat-resistant glove or oven mitt
Draw Conclusions

4 **Analyze** How would you explain what you observed?

5 Did your observations support your hypothesis?

6 **Infer** What do you think would have happened if the metal skewer had been cut between the first and second wax cube and a piece of wood inserted?

7 **Infer** Why do you think it is a good idea to have wooden handles on metal forks used to roast marshmallows?
Which warms faster?

**Purpose**
Your task is to determine which material—water or plastic foam—will heat up more quickly.

**Procedure**

1. Write a hypothesis about which material—water or plastic foam—you think will warm up more quickly. Make a list of variables that affect how rapidly the two materials warm up.

2. Fill a beaker half full of water and another half full of plastic-foam peanuts. Place a thermometer in each beaker. Record the starting temperatures. Place both beakers under a desk lamp, and turn the lamp on.

3. **Measure** Take the temperature of each beaker after 2, 4, 6, and 8 minutes.

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Temperature</th>
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<tbody>
<tr>
<td>2</td>
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<tr>
<td>4</td>
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<tr>
<td>6</td>
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<tr>
<td>8</td>
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</tbody>
</table>
Draw Conclusions

4 **Infer**  When did you observe changes in temperature? What was the result of your experiment?

________________________________________________________________________

________________________________________________________________________

5 Do your observations support your hypothesis?

________________________________________________________________________

________________________________________________________________________

6 What factors are held constant in this experiment?

________________________________________________________________________

________________________________________________________________________

7 **Interpret Data**  How can you explain the difference in temperature changes over time for the two substances?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Inquiry: Structured

What are conduction and convection?

Make a Prediction
Heat energy can move through solids by a process called conduction. In fluids heat energy can move by conduction and through convection currents. Heat energy moves at different rates through different solids and fluids. Metals are considered good conductors because heat energy moves through them rapidly. How can you measure conduction of energy in a solid? Write your answer as a prediction in the form “If heat moves through a solid by conduction, then you can measure the movement by . . .”

Materials
- metal rod
- thermal strip
- ruler
- transparent tape
- graph paper
- marker

Be Careful. Be careful while handling warm water. Clean up spills immediately.

Test Your Prediction

1 Measure Use the ruler to measure the length of the metal rod. Use a marker to place a dot at each inch along the length of the metal rod. Record the length of the rod, and draw a picture of it.

2 Place your thumb on the thermal strip for 1 second. Record the color change.
Use transparent tape to attach the thermal strip to the rod. Line up the end of the strip with the first mark. You will need to be able to see the marks on the rod throughout the activity.

Place one end of the rod in a cup of warm water. Start a timer, and record how many seconds it takes the changing color on the thermal strip to travel to each mark.

Repeat step 4 two more times, and record your data.

**Draw Conclusions**

**Graph** Construct a line graph, and plot your three trials on the graph.

---

**Analyze** Using your data describe the process of conduction. Describe any trends or differences you saw among the three trials.

---

**Infer** What do you think would happen if the water you used were hotter?
Inquiry: Guided

What causes convection currents in water?

Form a Hypothesis
How do convection currents begin in a body of water? Write your answer as a hypothesis in the form “If warm water is added to cooler water, then . . .”

Test Your Hypothesis
Design an experiment to investigate how heat energy moves through convection currents. Write out the materials you will need and the steps you will follow. Carry out your experiment, and record your results and observations.

Draw Conclusions
Did your experiment support your hypothesis? Why or why not? Present your results to your classmates.
Inquiry: Open
What are some conductive properties of metals? For example, are some metals better conductors than others? Think of a question, and design an experiment to investigate it. Plan your experiment to test one variable, or one item being changed. Write out the steps so another group could try it by following your instructions.

Remember to follow the steps of the scientific process.

Ask a Question

Form a Hypothesis

Test Your Hypothesis

Draw Conclusions
Which material best heats water?

Make a Prediction
Which material—white paper, black construction paper, or aluminum foil—will most quickly raise the temperature of water when placed in direct sunlight? Write your answer as a prediction in the form “If I wrap three jars using white paper, black construction paper, and aluminum foil, then . . .”

Test Your Prediction

1 Experiment Fill three jars with the same amount of water. Wrap one of the materials around each jar, and secure each with a piece of tape. Place the jars on a level surface in a location that receives direct sunlight.

2 Place a thermometer in each jar, and stir the water. Record the temperature of the water in each jar. Wait 30 minutes, stir the water, and record the temperature of the water in each jar again.
Draw Conclusions

3 Use Numbers For each jar, subtract the initial temperature of the water from the temperature recorded after 30 minutes in the sunlight. In which jar was the temperature of the water most increased? Was your prediction correct?

<table>
<thead>
<tr>
<th>Wrapping Material</th>
<th>Initial Temperature</th>
<th>Temperature 30 Minutes Later</th>
<th>Temperature Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>White paper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black construction paper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum foil</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 Infer What caused the water temperature in the jars to rise?

Explore More
Set the jars in a place that does not receive direct sunlight. Which jar will lose the most heat? Wait 30 minutes, stir the water, and record the temperature. Which jar lost the most heat? Analyze the data and present your results.
How are the regions of the electromagnetic spectrum alike and different?

Make a Prediction
How can you use a model to compare and contrast each region of the electromagnetic spectrum? Write your answer as a prediction in the form “If I make a model of the electromagnetic spectrum, then . . .”

Test Your Prediction

1. Tape a long sheet of white paper horizontally along the walls of your classroom. As a class, divide into six groups. Each group should be assigned one region of the electromagnetic spectrum.

2. Working as a group, find out the following characteristics of the waves in your region of the electromagnetic spectrum: frequency range, wavelength range, sources of waves, and applications of the waves in that region.

3. Communicate Divide the white paper into six sections. Draw the information you gathered on your section of the paper. Be sure to arrange the regions in the appropriate order.

Draw Conclusions

4. How are the regions of the electromagnetic spectrum similar? How are they different?

Materials
- long sheet of white paper
- color pencils
- masking tape
Inquiry: Open  X rays can pass right through some materials but are absorbed to different degrees by others. This characteristic is what creates the image on an X-ray image. Can you use a shoe box, a screen, a cardboard bone, and sugar to model the effects of X rays? Write a prediction and test it.

My prediction: _____________________________________________________________

________________________________________________________

My experiment: __________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

My results: ______________________________________________________________

________________________________________________________
Distance and Energy

Purpose
Your task is to demonstrate how distance from an energy source affects the amount of energy received at a particular location.

Procedure
1. What happens to the light beam from a flashlight as you move the flashlight farther from a piece of paper? Tape a sheet of graph paper to the wall, and write an x in the middle of the paper.

2. **Measure**  Hold a flashlight 2 centimeters away from the paper. Turn on the light, and keep the x in the middle of the beam. Trace a circle around the spot of light. Count and record the number of squares inside the circle.

3. **Predict**  What will happen to the size of the circle if you move the flashlight to 4 centimeters and then 8 centimeters from the paper? How will this affect the brightness of the light and the size of the circle? Why?

Materials
- flashlight
- graph paper
- metric ruler
Draw Conclusions

4 Infer How does distance from the light source affect the amount of energy each square receives?

____________________________________________________________________________________

5 Infer If a planet were twice as far from the Sun as Earth is, would it receive half as much energy from the Sun as Earth does? Explain. What effect would this have on the planet’s temperature?

____________________________________________________________________________________

____________________________________________________________________________________

6 Going Further Could you use this idea of energy versus distance to help determine how far stars are from Earth? Write a prediction, and describe how you could test it.

My prediction: ______________________________________________________________________

____________________________________________________________________________________

My experiment: _____________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

My results: _________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________
Form a Hypothesis

The Sun emits a huge amount of electromagnetic radiation, including wavelengths we can see and some we cannot. Waves with shorter wavelengths have higher energy. Scientists use information like this that they read, as well as the results of experiments they do, to help them form a hypothesis, or make an educated guess, about something. Then they read more, experiment more, and draw conclusions.

1. Learn It

When you form a hypothesis, you make a testable statement about what you think is true. You can test the statement to support or disprove the hypothesis. Record all your findings and observations. You are gathering the evidence you need to support or disprove the hypothesis.

2. Try It

In this activity you will form a hypothesis about which part of the electromagnetic spectrum emits the most heat. You will test your hypothesis by measuring the temperatures in different parts of the spectrum. You will need a cardboard box, white paper, tape, a glass prism, 4 thermometers, and a watch or a clock.
Tape white paper in the bottom of the box. Attach the prism to one top edge of the box. Place the box by a window so sunlight shines through the prism to make a spectrum. Tape the thermometers in the box so you can read the numbers. Tape one on the blue band of the spectrum, one on the yellow band, one just beyond the red band, and one in a shaded area. Form a hypothesis about which thermometer will register the highest temperature and what the order of the readings will be, from highest to lowest. Record your hypothesis on the chart below. Wait 1 minute, and then read each thermometer. Record the results on your chart. Continue to read the thermometers at 1-minute intervals for a total of 6 minutes, and record the data.

<table>
<thead>
<tr>
<th>My Hypothesis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
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<tr>
<td>---------</td>
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<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<td>6</td>
</tr>
</tbody>
</table>
Now use your data to answer these questions.

- What part of the spectrum emits the most heat?
- What is the order of temperatures, from highest to lowest?
- Do your data support your hypothesis?

Apply It

Would the temperatures in this kind of experiment be the same if the box were lined with black paper? With aluminum foil? If you used a desk lamp instead of sunlight? If you had a deeper box?

- Choose one of these variables, or make up one of your own, and form a hypothesis about what you believe would happen.
- Then test your idea, and record the results to either support or disprove your hypothesis.
My Hypothesis:

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Thermometer 1: On Blue</th>
<th>Thermometer 2: On Yellow</th>
<th>Thermometer 3: Just Beyond Red</th>
<th>Thermometer 4: In Shade</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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</table>
How can light energy create motion?

Form a Hypothesis
A radiometer spins when exposed to sunlight. What do you think will happen if it is exposed to different sources of light? Write your answer as a hypothesis in the form “If a radiometer is exposed to different light sources, then . . .”

Test Your Hypothesis
1. Place the radiometer in bright, natural sunlight. Record your observations.

2. Try using different light sources and light sources with different intensities. Record your observations. Does the radiometer speed up, slow down, or stay the same?

<table>
<thead>
<tr>
<th>Light Source</th>
<th>Light Intensity</th>
<th>Observations</th>
</tr>
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<tbody>
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</tbody>
</table>
3 Place a black cloth over the radiometer. Look underneath and observe the vanes. Record your observations.

Draw Conclusions

4 Analyze How would you explain what you observed?

5 Did your observations support your hypothesis?

6 Infer Do you think there is air inside the radiometer? Why or why not?

Explore More
How do you think the motion of the radiometer would change if it were placed in direct sunlight for a whole day? Form a hypothesis and test it. Then analyze and present your results.
Can gases in the atmosphere absorb energy from solar radiation?

Form a Hypothesis
Sunlight warms Earth’s surface. However, only about half of the Sun’s energy that reaches the atmosphere reaches Earth’s surface. Some of the energy is absorbed by the gases in Earth’s atmosphere. What effect does this have on the temperature of Earth’s air? Write your answer as a hypothesis in the form “If gases in the atmosphere absorb energy from solar radiation, then trapped air in direct sunlight will . . .”

Test Your Hypothesis

1. Place two thermometers in direct sunlight. After a few minutes, record the starting temperatures.

2. Place a clear jar over one of the thermometers. Record the temperature on both thermometers every minute for 10 minutes.

Materials
- 2 small thermometers
- clear jar
- watch or clock
- location in direct sunlight
3 Use Numbers  Compare the data from both thermometers to determine which showed a greater increase in temperature.

________________________________________________________________________

Draw Conclusions

4 Infer  Why do you think the temperature inside of the jar was not the same as the temperature outside of the jar?

________________________________________________________________________

5 Infer  How can you compare the jar to the atmosphere?

________________________________________________________________________

Inquiry: Open  What do you think would happen if there were no heat-trapping gases in the atmosphere?

________________________________________________________________________
Solar Still

Purpose
Your task is to separate salt from water in a saltwater solution.

Procedure

1. You can use the Sun’s energy to separate a solution of salt and water. Make a saltwater solution by dissolving 2 tablespoons of salt per cup of fresh water. Fill a large bowl with salt water to a depth of about 2 inches.

2. Place an empty glass in the center of the bowl. The top of the glass should be below the edge of the bowl but above the surface of the salt water.

3. Cover the bowl with plastic wrap. Use tape, if necessary, to make a tight seal.

4. Place a heavy object, such as a rock, in the center of the plastic wrap over the glass.

5. Leave the still in direct sunlight for a few hours. Then remove the plastic wrap. Has water collected in the glass?

6. **Predict** Do you think the water in the glass is salty or fresh? Why? How would you test your prediction?

Materials
- salt
- water
- large bowl
- 1 glass
- plastic wrap
- heavy object, such as a rock

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Draw Conclusions

7 Sequence Explain the role of evaporation and condensation in transferring water to the glass.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

8 Going Further Do you think that separation of fresh water from salt water occurs in nature? How? Write your answer as a prediction in the form “If there are large bodies of salt water on Earth’s surface and evaporation occurs over these bodies of water, then . . .”

My prediction: ______________________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

My research: ______________________________________________________________________________________

___________________________________________________________________________

My results: ______________________________________________________________________________________

___________________________________________________________________________
How does heat move in liquids and gases?

Make a Prediction
When an ice cube melts in room-temperature water, what do you think happens to the melted water? Where does it go? Write your answer as a prediction in the form “If an ice cube melts in room-temperature water, then . . .”

Materials
- clear plastic container
- ice cube dyed with blue food coloring
- red food coloring
- color pencils
- paper

Test Your Prediction

1 Fill the plastic container about two-thirds full of water. The water should be at room temperature and perfectly still. Gently place the blue ice cube in the water at one end of the container. Add two drops of red food coloring to the water at the opposite end of the container.

2 Observe Carefully observe where the blue water flows and where the red water flows. Use color pencils to draw the flows of the two different-color waters.
Draw Conclusions

3 Analyze How would you explain what you observed?

Did your observations support your prediction? What caused the behavior of the blue water? Why did the water in the tank appear to circulate? What happens when warm and cool water meet? Explain your answer.

Explore More
What would happen if you placed a dyed ice cube in very cold water? Form a hypothesis and test it. Then analyze and present your results. Does circulation take place in air? What examples can you find to demonstrate warm air’s rising or cold air’s sinking?
How does a sea breeze form?

Form a Hypothesis
Which heats up faster: land or water? How does this difference affect the formation of land and sea breezes? Write your answer as a hypothesis in the form “If land heats up faster than water, then . . .”

Test Your Hypothesis

1. Fill one beaker half full of sand. Fill the other beaker half full of water. Place a thermometer in each beaker.

2. Place both beakers under the lamp. Record the temperature in each beaker every 10 minutes for 1 hour. Make a chart to record your data.

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Temperature of Sand</th>
<th>Temperature of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
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<tr>
<td>60</td>
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</tr>
</tbody>
</table>
Draw Conclusions

3 Observe Which heats up faster: land or water?

4 Infer On a sunny day, how would the temperature of the air over land compare with the temperature of the air over water?

5 Can you use this information to explain how a sea breeze, which flows from the water to the land, forms?

Inquiry: Open How would a land breeze, or a breeze that flows from the land to the sea, form?
Expanding and Contracting Air

Purpose
Your task is to show what happens to air if it is heated and cooled.

Procedure
1. Place a balloon over the opening of a bottle. What do you think will happen if you heat or cool the air in the bottle? Hold the bottle for a minute or two in a pail of warm water. Observe what happens to the balloon.

Materials
- balloon
- bottle
- pail
- warm water
- ice water

2. Infer. Explain what happened to the air in the bottle. What evidence do you have for your explanation? Now hold the bottle in a pail of ice water for a few minutes. What happens to the balloon?

3. Infer. Use your observations to answer these questions. As the bottle cooled, what happened to the air pressure inside? How did the pressure outside compare to the pressure inside? What caused the changes to the balloon?
Draw Conclusions

4. Draw “before” and “after” pictures of the bottle. Use arrows to show what happened to the air pressure.

Before

After

Going Further

5. What do you think would happen if you cooled water to form ice? Would it expand or contract? Write a hypothesis and test it.

My hypothesis: 

My experiment: 

My results: 

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Inquiry: Structured

What can convection currents do?

Form a Hypothesis

Convection currents can be seen in air and in water. They even occur in Earth’s mantle. The heating and cooling of air causes convection currents. A circular pattern is created, in which warm air rises and cooler air moves in to take the place of the warm air. Convection currents cause wind and other weather patterns. How does the temperature of the air affect the movement of convection currents? Write your answer as a hypothesis in the form “If air is cooled, then . . .”

Test Your Hypothesis

1. **Experiment** Place one jar in a plastic tub filled with ice. Place the other jar in a tub of warm water. Leave the jars for 10 minutes.

2. Remove the jar from the tub of ice. Have your teacher light a match and immediately blow it out. Hold the opening of the jar over the smoking match to trap some of the smoke. Place a piece of cardboard on the opening of the jar, and turn the jar right side up.

3. **Make a Model** Place the jar from the tub of warm water over the jar from the tub filled with ice. Remove the cardboard. Make sure to keep the jars together so the smoke cannot escape. Observe the movement of the smoke, and record your observations.

Materials

- 2 jars
- small piece of cardboard
- matches
- ice
- 2 plastic tubs (1 for ice, 1 for warm water)
4 Observe  While still keeping the jars together, flip the jars over. Observe the smoke, and record your observations.

___________________________________________________________________________________________________________________________________________________________________________________________________________________________

Draw Conclusions

5 Define Based on Observations  What did the smoke do when you first removed the cardboard in step 3? Why did that happen?

___________________________________________________________________________________________________________________________________________________________________________________________________________________________

6 Communicate  What happened to the smoke when you flipped the jars over?

___________________________________________________________________________________________________________________________________________________________________________________________________________________________

7 Infer  What do you think the smoke would do if you placed the model in a hot-water bath? Try it.

___________________________________________________________________________________________________________________________________________________________________________________________________________________________
Inquiry: Guided

What happens when cold air meets warm air?

Form a Hypothesis
How do convection currents behave in the atmosphere? Write your answer as a hypothesis in the form “If warm air and cold air come together, then the warm air will . . .”

Test Your Hypothesis
Design an experiment to create and test a model that demonstrates convection currents in the air. Write out the steps you will follow. Record your results and observations.

Draw Conclusions
Did your experiment support your hypothesis? Why or why not? What did you observe in your convection-current model? Could your observations explain how wind is created?
Inquiry: Open
What else can you learn about convection currents? For example, how can convection currents be affected by the rotation of Earth? Design an experiment to answer your question. Your experiment must be organized to test only one variable, or one item being changed. Your experiment must be written so that another group could complete the experiment by following your instructions.

Remember to follow the steps of the scientific process.

Ask a Question


Form a Hypothesis


Test Your Hypothesis


Draw Conclusions


Are the continents moving?

Form a Hypothesis
Were the separate continents we know today one huge supercontinent in the past? Do the outlines of the continents fit together? Write your answer as a hypothesis in the form “If the continents were once a supercontinent, then . . .”

Materials
- world map
- tracing paper
- pencil
- safety scissors
- safety goggles

Test Your Hypothesis
1. Place tracing paper over a map of the world. Trace the coastlines of North America, South America, Europe and Asia (including India), Africa, Australia, and Antarctica.

2. △ Be Careful. Cut the traced continents along their coastlines, and label them.

3. Using the continent cutouts like pieces of a jigsaw puzzle, find ways the continents fit together. Draw a sketch showing ways you can fit them together.
Draw Conclusions

4 **Analyze** Which continents have coastlines that fit together most closely?

________________________________________________________________________
________________________________________________________________________

5 Did your results support your hypothesis?

________________________________________________________________________
________________________________________________________________________

6 **Infer** Which of your sketches shows the greatest number of continents fitting together? Do all of the coastlines in the sketch fit together equally well?

________________________________________________________________________

Explore More

What if the continents in your finished puzzle moved apart to the positions they are in today? If they kept moving, how might they be arranged in the distant future? Make a prediction and test it. Then analyze and present your results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Can clues help you piece together a puzzle?

Make a Prediction
Can clues help you piece together a puzzle more easily? Can they increase your confidence that the pieces are put together correctly? Write your answer as a prediction in the form “If clues are available, then they _______ help me put a puzzle together and ________ my confidence that the pieces are put together correctly.”

Test Your Prediction

1. On a sheet of paper, design a puzzle with at least 8 pieces. Before you cut out the pieces, make a symbol on each side of the line between the pieces. Each set of symbols should be different.

2. △ Be Careful. Carefully cut your puzzle into pieces.

3. Flip the pieces over so that your symbols do not show, and then mix up the pieces. Put the puzzle back together. Record the time it took you to put the puzzle together.

4. Now flip the pieces over so that you can see the symbols, and then mix up the pieces. Put the puzzle together again. Record the time it took you to put it together.
Draw Conclusions

5 Did the amount of time it took you to put your puzzle together when you could see the symbols differ from the amount of time it took when you could not see the symbols?

__________________________________________

6 Did the symbols help verify that you put your puzzle together correctly?

__________________________________________

7 **Communicate**  What kind of “symbols” could scientists use to support the idea that the continents once fit together like pieces of a jigsaw puzzle?

__________________________________________

__________________________________________

__________________________________________
Model Plate Movement

Purpose
Your task is to show how converging tectonic plates form a mountain range.

Procedure
1. Stack sheets of paper into two piles.
2. Slowly push the short ends of the two paper piles together.
3. Observe What happens? How is this model similar to the formation of a mountain range such as the Himalayas?

Draw Conclusions
4. Evaluate How is this model similar to a mountain range? How is it different?
5 **Going Further** When ocean plates converge, one slips under the other. How could you demonstrate what happens to two such plates?

My hypothesis: __________________________________________________________

_____________________________________________________________________

My experiment: _______________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

My results: __________________________________________________________

_____________________________________________________________________

_____________________________________________________________________
Draw Conclusions

Scientists read a lot of data and collect data themselves through exploration and experimentation. Then they study the data, analyze them, and draw conclusions, or decide what is and is not true. In the previous lesson, you learned about the evidence that helped scientists draw the conclusion that the continental drift theory was correct.

Learn It

When you draw conclusions, you have to look at all the data and facts before you can decide what is true. You have to be careful not to jump to conclusions. Here is an example: It’s time to go home from school, but you discover that your new jacket is missing. Outside you see a student you don’t know wearing a jacket just like yours. Can you draw the conclusion that this person took your jacket?

No, that assumption would be jumping to a conclusion. You need to ask questions and maybe even examine the jacket carefully to find all the facts. Suppose you do, and then you discover that the other person’s jacket merely looks like yours. The only conclusion you can draw is that the other person has really good taste, just as you do.
Try It

Use a hard-boiled egg as a model of Earth to gather evidence about moving plates. Use the evidence to **draw conclusions**. You will need a hard-boiled egg, a paper plate, and glue.

Crack the egg. Pull off the pieces of eggshell, and pile them on the paper plate. They represent Earth’s plates. Record the number of pieces on the chart below. Set the egg and the pieces of the shell aside for 20 minutes. Can you draw a conclusion at this time about whether the pieces of eggshell can be replaced to completely cover the egg?

<table>
<thead>
<tr>
<th>Number of Pieces</th>
<th>Observations</th>
<th>Conclusions</th>
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</table>

Try to glue the eggshell pieces back on the egg. Use a light dab of glue on each piece. Then pick up the egg, and squeeze gently. What happens? Record your observations on the chart.

<table>
<thead>
<tr>
<th>Number of Pieces</th>
<th>Observations</th>
<th>Conclusions</th>
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</tbody>
</table>
Apply It

Now use all the information you have gathered to draw conclusions, and answer these questions. Record your conclusions on the chart on the next page.

▲ How are Earth’s plates similar to the pieces of the eggshell?

▲ Why did the pieces of eggshell push against each other when you picked the egg up?
What might happen if Earth’s plates broke into as many pieces as the eggshell?

<table>
<thead>
<tr>
<th>Number of Pieces</th>
<th>Observations</th>
<th>Conclusions</th>
<th>Comparison</th>
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How can you make a model of Earth’s interior?

Purpose
In this activity you will make a model to compare the thickness of Earth’s layers.

Procedure

1. **Make a Model** Draw a small X on the ground. This will be your center point for making three circles.

2. **Measure** Tie one end of a string to a piece of chalk. Then measure the string to a length of 185 cm. Hold the string at your center point in the center of the X, and have a partner draw a circle around the X, keeping the string straight and taut all the way around.

3. Repeat the process two times, first cutting your string to 182 cm and then cutting it to 100 cm.

Materials
- chalk
- measuring tape or meterstick
- string
Draw Conclusions

4. **Analyze**  The scale for your model is 1 cm = 35 km. How many real kilometers are presented by each layer in your model?

________________________________________________________________________________________

________________________________________________________________________________________

5. Are the layers in your model the same thickness? According to your model, what is the distance from the surface of Earth to its center?

________________________________________________________________________________________

________________________________________________________________________________________

**Explore More**

Research different ways to travel to the center of Earth, using different modes of transportation. Determine how long it would take to travel there. Analyze and present your results.

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
Form a Hypothesis
Can you make a model of Earth’s interior? What must your model include? Write your answer as a hypothesis in the form “If I know the basic structure of Earth’s interior, then I can make a model of it by using . . .”

Materials
- oranges
- paper and pencil

Test Your Hypothesis
1. Obtain an orange from your teacher. Ask your teacher to cut the orange in half.
2. Observe Look at the cross section of the orange. Make a sketch of what you observe.

Draw Conclusions
3. Evaluate What layer of Earth does each layer of the orange represent? Label each layer as core, mantle, or crust.
Measuring Density

Purpose
Your task is to show how materials that have different densities will tend to separate into different layers.

Procedure
1. Measure 1 cup of vegetable oil, 1 cup of water, and 1 cup of corn syrup.
2. Add four drops of a different shade of food coloring to each cup. Stir each cup.
3. Observe Pour the three cups together into a large glass bowl. Record your observations.

Materials
- 3 measuring cups
- large glass bowl
- vegetable oil
- water
- corn syrup
- 3 different shades of food coloring

4. What happened? Why do you think you saw these results?

5. Which layer of Earth corresponds to the vegetable oil? The water? The corn syrup?
**Quick Lab**

**Draw Conclusions**

6 **Infer** As early Earth was forming, it was a swirling cloud of matter. As it cooled, some elements settled to the bottom, or center; other elements settled in the middle; and still others settled on the top. Can you explain why?

   ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

7 **Going Further** Saturn, a planet that is one of the outer gas giants, is less dense than water. In fact, if you could find a body of water large enough, Saturn could float on it. Can you make a model of how a planet larger than Earth could float on water? Write your answer as a hypothesis in the form “If I know Saturn is less dense than Earth and could float on water, then I can make a model of Saturn’s density using . . .”

My hypothesis: ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

My experiment: ____________________________________________
   ____________________________________________
   ____________________________________________
   ____________________________________________

My results: ____________________________________________
   ____________________________________________
Make a Model

A map is a useful tool that provides information, or data, about Earth. When scientists create a map, they make a model that shows information about a place or a region. To use a map, you need to learn how to interpret the information on it.

1 Learn It

Road maps show cities, towns, streets, roads, and highways. Other kinds of maps include different data, such as borders of states and countries or bodies of water. When you make a drawing showing streets in your neighborhood, you make a model of the area.

All maps have legends, which include additional information to help you read the maps. For example, the legend on a road map shows the map’s scale. Knowing the scale lets you determine distances.
Now you will examine two different kinds of maps. The first map is a geologic map. It shows the geological features of California, such as the kinds of rocks found in the state. A geologic map can also show features such as faults and volcanoes. Scientists include these kinds of information on maps in order to **make a model** that shows an area’s geological features.

Look at the map, and select one place to study. Use the legend to find out the meaning of the shade and pattern used in the place you chose. What information does the legend contribute to the map?
The second map is a topographic map. This map shows only a small part of California, near San Francisco. Topographic maps show the shape of Earth’s surface. They use special contour lines, which show points that are the same height. Contour lines allow scientists to make a model that tells the height of a hill above sea level or the depth of the ocean below its surface. When contour lines are far apart, they tell you that changes in altitude are gradual. When contour lines are close together, they tell you that changes in altitude are steeper.

Select a point on one of the contour lines on the map. What is the height of Earth’s surface at the point you chose?

______________________________________________________________________________

______________________________________________________________________________
Apply It

- How do geologic maps and topographic maps differ?

- Of the two types of maps shown here, which would be a good type to use when planning a hike in the mountains? Why do you think so?

- Make a model by drawing a map of the area around your school. Find ways to indicate differences in height. In your legend include the scale you used and keys to any features on your map.
What happens when Earth’s surface breaks?

Make a Prediction

What would a scientist observe if Earth’s surfaces were pushed together, pulled apart, or slid against each other? Write your answer as a prediction in the form “If Earth’s surfaces were pushed, pulled, or slid against each other, then . . .”

Test Your Prediction

1. △ Be Careful. Place the candy bar on a flat surface, and cut it in half through the center.

2. Identify which layers of the bar represent the layers of Earth.

3. Then push the pieces together. Pull the pieces apart. Take one of those pieces and pull it into two pieces. Slide the pieces past each other. Move the pieces up and down in relation to each other.
Draw Conclusions

4 Analyze  How would you explain what you observed?

5 Did your observations support your prediction?

6 Infer  What layer of the candy bar (“layer of Earth”) was deformed the most? Why do you think this happened?

Explore More

Try to relate each movement of the candy-bar pieces to an actual Earth event. Explain. Then analyze each and present your results.
Why do surface waves do more damage than body waves during an earthquake?

Form a Hypothesis
Why do you think that surface waves do more damage than body waves during an earthquake? Write your answer as a hypothesis in the form “If I know that surface waves move differently than body waves, then . . .”

Materials
• coiled spring toy

Test Your Hypothesis
1. **Observe**  Working with a partner, stretch one coiled spring toy between the two of you until it is about 5 meters long. Give a gentle push on your end of the toy. Record your observations.

2. **Observe**  Make sure the coiled spring toy has stopped moving after step 1. Remaining in your same positions, move your end of the toy up, then down. Record your observations.
Observe  Make sure the coiled spring toy has stopped moving after step 2. Remaining in your same positions, move your end of the toy to the right, then to the left. Record your observations.

Draw Conclusions

4 In which step(s) is the wave movement most similar to the movement of body waves during an earthquake?

5 In which step(s) is the wave movement most similar to the movement of surface waves during an earthquake?

6 Why do surface waves cause more damage than body waves during an earthquake?
Earthquake Safety

Purpose
Your task is to model what happens to buildings during an earthquake.

Procedure
1. Add sand to a pan, filling it deeply and evenly.
2. Add water to the sand below its surface.
3. Place a brick on the sand on its shortest side, as if it were a building.
4. Gently tap the side of the pan with the hammer one time. △ Be Careful.
5. Observe Write down what you saw happen to the brick and the surrounding sand. What would happen if you hit the pan a second time, but harder? Try it.

Materials
- sand
- deep pan
- brick
- hammer
Quick Lab

Name ____________________________ Date ____________

Draw Conclusions

6 Predict  How do you think the magnitude of an earthquake affects buildings in the area?

____________________________________________

____________________________________________

7 Going Further  How do you think the movement of a building during an earthquake is affected by the materials the building is made of? Write your answer as a hypothesis in the form “If one structure is built of craft sticks and a second is built of sugar cubes, then . . .” Conduct an experiment to test your hypothesis.

My hypothesis: __________________________________________

____________________________________________

My experiment: __________________________________________

____________________________________________

My results: __________________________________________

____________________________________________
How can you make a model volcano erupt?

Make a Prediction
What do you think will happen if you try to make a volcano with baking soda and vinegar? Will it behave like a real volcano? Write your answer as a prediction in the form “If a model of a volcano is made out of baking soda and vinegar, then . . .”

Test Your Prediction
1. Fill the plastic container with a few inches of baking soda, and place it in the middle of the tray. ▲ Be Careful. Wear goggles.

2. Build the sand up around the container, leaving the top of the jar exposed.

3. Add a few drops of food coloring to the vinegar.

4. Slowly and carefully pour the colored vinegar into the container. Observe and record what happens.
Draw Conclusions

5 Analyze  How would you explain what you observed? Was it like a real volcano?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

6 Did your observations support your prediction?

__________________________________________________________________________
__________________________________________________________________________

7 Infer  What do you think would have happened if there had been a lid on the container?

__________________________________________________________________________
__________________________________________________________________________

Explore More

What would happen if the opening of the container were larger? If it were smaller? Make a prediction, and test it. Then analyze and present your results.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
How can you model different types of volcanoes?

Form a Hypothesis

There are descriptive names for three types of volcanoes: shield volcanoes, cinder cone volcanoes, and composite volcanoes. Based on their names, how can you model these different types of volcanoes? Write your answer as a hypothesis in the form “If I know that the terms shield volcano, cinder cone volcano, and composite volcano are descriptive, then . . .”

Test Your Hypothesis

1. Using modeling clay, make a model of a shield volcano, a composite volcano, and a cinder cone volcano. Use a different color clay for each kind of material the volcanoes are made from. Use a piece of cardboard as the base for each model.

2. When you have completed each model, draw a picture of how the inside might look in the assigned space below.

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• different colors of modeling clay</td>
</tr>
<tr>
<td>• large pieces of cardboard</td>
</tr>
</tbody>
</table>

| Shield Volcano | Cinder Cone Volcano |
Why do you think each type of volcano was given its name?

Shield volcano: ____________________________

______________________________

______________________________

Cinder cone volcano: ____________________________

______________________________

______________________________

Composite volcano: ____________________________

______________________________

______________________________

Infer Other than shape, what is one way in which these three types of volcanoes differ?

______________________________

______________________________

______________________________
Cooling Candle Lava

Purpose
Your task is to show how the height from which lava falls affects the shape of the lava when it cools.

Procedure

1 Watch while your teacher holds a lighted candle about 1 ft above the tray so that a drop of melted wax falls on the tray.

2 Observe  This procedure will be repeated several times, with your teacher holding the candle at different heights. Observe the cooled drops.

3 From which height did the molten wax spatter the most? The least? What shape did the cooled wax take?

4 How does this experiment explain the cooled shapes of lava from a volcanic eruption?
Quick Lab

Name _________________________ Date __________

Draw Conclusions

5 Shield volcanoes have very broad, gently sloping sides. Use your observations of the candle wax to explain how they form.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

6 Going Further  Do you think the rate at which hot lava cools has an effect on its shape? Design an experiment to test your idea.

My hypothesis: ____________________________________________________________
________________________________________________________________________
________________________________________________________________________
My experiment: ___________________________________________________________
________________________________________________________________________
________________________________________________________________________
My results: ______________________________________________________________
________________________________________________________________________
________________________________________________________________________
Inquiry: Structured

What are some characteristics of volcanic rock?

Purpose
The cooling of lava from volcanoes is one way igneous rocks are formed. The cooling rate determines the crystalline structure and the appearance of the rocks. When lava cools immediately, there are no visible crystals, and the rocks look glassy. However, when lava takes a few days to cool, the crystals appear very small and look like grains of sand. When the lava cools over the span of a few years, the crystals become very large and create large rocks. What are some characteristics of volcanic rocks? Write your answer as a prediction in the form “If the rock is igneous, then . . .”

Test Your Hypothesis

1. **Observe**  Use a hand lens to look at each rock sample.
2. Sketch the crystals, or grains, below.

Materials
- hand lens
- igneous rock samples
- cup of water
3 Define Based on Observations  Feel each rock. Describe the texture.

4 Classify  Record the color and coarseness of the grains for each sample.

5 Experiment  Place each rock in a cup of water. Record your observations.

Draw Conclusions

6 Analyze  Are any of the characteristics the same in all of your samples? Why do you think the similarities or differences occurred?

7 Explain  What factors influenced the color of the rocks that you observed?
Inquiry: Guided

What happens when the pressure changes inside a volcano?

Form a Hypothesis
Can changes in the amount of pressure in a volcano change the force of the eruption? Write your answer as a hypothesis in the form “If the pressure in a volcano increases, then . . .”

__________________________________________________________________________

Test Your Hypothesis
Design an experiment to investigate what happens inside a volcano when there is an increase in magma or gas pressure. Write out the materials you will need and the steps you will follow. Record your results and observations.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Draw Conclusions
What changes did you make to your volcano to increase the internal pressure? Did your experiment support your hypothesis? Why or why not? Present your results to your classmates.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Inquiry: Open
What else would you like to learn about volcanoes? Would you like to know about the different types of volcanoes? Design an experiment to answer your question. Your experiment must be organized to test only one variable, or one item being changed. Record the research materials you used for your experiment.

Remember to follow the steps of the scientific process.

Ask a Question

Form a Hypothesis

Test Your Hypothesis

Draw Conclusions

Be a Scientist
How do plate movements affect California?

Make a Prediction
Can you make a model of the forces that have shaped California? Write your answer as a prediction in the form “If two plates slide past each other, then . . .”

Test Your Prediction
1. Place the pieces of cardboard on a flat surface, and cover each with a layer of sand or flour.

2. Without disturbing the sand or flour, push the two pieces of cardboard together so that the edges line up.

3. Slowly slide one piece of cardboard along the edge of the other.

4. Observe What happens as one piece of cardboard slides past the other? Record your observations.

Draw Conclusions
5. How does this model show what happens when two plates move against each other? Place two markers, such as lumps of clay or sugar cubes, on either side of the fault. Describe their relationship to each other after movement along the fault. Draw a line through the sand across the fault to represent a river. How is the river affected by movement along the fault?
Explore More
How do the effects of movement compare when the two sides slide past each other slowly and quickly? Design an experiment that would compare the effects of two plates sliding past each other at different rates.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Inquiry: Open  Ask your own questions about plate movements in California.

My question:  ___________________________________________________________________
________________________________________________________________________

How I can find out: ___________________________________________________________________
________________________________________________________________________

My results: ___________________________________________________________________
________________________________________________________________________
Can you model what happens during an earthquake event?

Form a Hypothesis
Areas of Earth’s crust along slowly moving plate boundaries are subject to increasing tension, or stored energy, that is released during an earthquake. How can you model that increasing tension and release of energy? Write your answer as a hypothesis in the form “If increasing tension in Earth’s crust along slowly moving plate boundaries is released suddenly during an earthquake, then . . .”

Test Your Hypothesis
1. Tape one piece of sandpaper around a block of wood. Tape another piece of sandpaper to a tabletop.
2. Tack a rubber band to the wooden block.
3. Place the wooden block on the table with both sides of the sandpaper in contact. Very slowly pull on the block with the rubber band. What do you observe?

Materials
- block of wood
- 2 pieces of sandpaper
- rubber band
- thumbtack

Draw Conclusions
Infer How can you compare your results with what actually happens along a fault?
**Folded Mountains**

**Purpose**
Your task is to model what happens to Earth’s surface when tectonic plates slowly move toward one another.

**Procedure**
1. Make a model by stacking three layers of clay on top of one another, placing a piece of plastic wrap between layers.
2. Place the clay stack on a tabletop between two bricks.
3. Slowly push the bricks toward each other until the clay bends, or folds.
4. **Observe** What happened? Did you create a fold?

**Materials**
- 3 different colors of modeling clay
- plastic wrap
- 2 bricks
Draw Conclusions

5 How does a fold compare with a fault?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

6 Infer What factors do you think influence whether a rock will fault or fold?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

7 Going Further Do you think temperature affects whether a rock will fault or fold? How could you use crayons and a desk lamp to test your hypothesis?

My hypothesis: __________________________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

My experiment: __________________________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

My results: __________________________________________

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Where does precipitation come from?

Form a Hypothesis
When pressure is increased on a volume of air, its temperature increases. When pressure is decreased, the volume of air expands and cools. How do temperature and humidity affect the formation of fog? Write your answer as a hypothesis in the form “If moist air in a bottle is cooled, then . . .”

Test Your Hypothesis
1. Put a small amount of room-temperature water in a plastic water bottle.
2. Have your teacher add smoke by lighting a match, blowing it out, and holding the smoking match inside the bottle.
3. After a few seconds, have your teacher take the match out and screw on the bottle’s cap.
4. **Experiment**  Squeeze the bottle to increase the pressure on the air inside. Release the pressure on the bottle.
Draw Conclusions

5 Analyze  What happened when you released the pressure on the air in the bottle? How is this related to the temperature of the air inside the bottle?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

6 Infer  How does moist air’s temperature affect a change from water vapor to water droplets? How is this model similar to the formation of fog?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Explore More
What would you see if you did this experiment first with warm water and then with cold water? Form hypotheses and then test them with your teacher or another adult. Analyze and present your results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

________________________________________________________________________
Where does water vapor come from?

Form a Hypothesis
Where do you think the water vapor that eventually condenses into rain comes from? Do you think some of it comes from plants? How could you prove this? Write your answer as a hypothesis in the form “If water vapor comes from plants, then . . .”

Test Your Hypothesis

1. Locate a tree in your schoolyard that is in leaf.
2. Tie a plastic bag around a tree branch, including its leaves, and close with a twist tie.
3. Observe  Wait a few hours, and go back to observe the tree branch and the plastic bag. Record your observations.

Materials
- plastic bag
- twist tie
- live tree branch in leaf
**Draw Conclusions**

4. **Infer** Where did the water droplets inside the bag come from?

________________________________________________________

________________________________________________________

________________________________________________________

**Inquiry: Open** Do our bodies give off water vapor? Write and conduct an experiment.

My hypothesis: ___________________________________________

________________________________________________________

________________________________________________________

My experiment: __________________________________________

________________________________________________________

________________________________________________________

My results: _____________________________________________

________________________________________________________

________________________________________________________
Measuring Humidity

Purpose
Your task is to demonstrate how humidity varies from one location to another.

Procedure

1. Make a map of the inside and the outside of your school. Choose places to measure the humidity in the air.

2. Obtain cobalt chloride strips from your teacher. These strips measure humidity in the air by turning pink.

3. Tape each cobalt chloride strip to a piece of white paper.

4. **Observe** Hang the papers in the chosen locations. Wait at least 30 minutes. Then collect the papers and examine the colors of the strips.

Draw Conclusions

5. Which location had the highest humidity? Which one had the lowest? Explain your results.

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
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<tbody>
<tr>
<td>• paper and pencil</td>
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<tr>
<td>• cobalt chloride strips</td>
</tr>
<tr>
<td>• tape</td>
</tr>
<tr>
<td>• white paper</td>
</tr>
</tbody>
</table>

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Going Further  If you were hanging laundry on a clothesline to dry, would it dry faster on a humid day or a drier day? Make a prediction, and design an experiment to test it.

My prediction: ________________________________________________________________
____________________________________________________________________________

My experiment: _______________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

My results: ________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Analyze Data

Scientists study weather maps and **analyze data** from them. They look at temperature patterns in order to predict future weather in an area. They also look for fronts where cold and warm air meet. Then they analyze the data to draw conclusions and explain why things happen.

**1 Learn It**

When you **analyze data**, you use information that has been gathered to find patterns, answer questions, or solve problems. It is usually easier to analyze the data if it has been organized and placed on a chart or a graph. Then you can see at a glance any patterns and any extreme changes in the data.

![July Temperatures](image)

**2 Try It**

- Look at the map. It shows high and low temperatures for six cities for one day in July. Then look at the chart on the next page. It lists the average high and low temperatures and the rainfall for these U.S. cities during July in past years. **Analyze data** from the map and the chart to help you answer the questions.
<table>
<thead>
<tr>
<th>City</th>
<th>New York</th>
<th>Miami</th>
<th>Chicago</th>
<th>Phoenix</th>
<th>Dallas</th>
<th>Bakersfield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>▶️</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>80.8°F</td>
<td>88.5°F</td>
<td>84.4°F</td>
<td>109.0°F</td>
<td>95.2°F</td>
<td>98.4°F</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>▶️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>65.7°F</td>
<td>74.1°F</td>
<td>65.7°F</td>
<td>75.9°F</td>
<td>72.0°F</td>
<td>69.4°F</td>
</tr>
<tr>
<td><strong>Precipitation</strong></td>
<td>▶️</td>
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<tr>
<td></td>
<td>3.3 in.</td>
<td>8.1 in.</td>
<td>4.0 in.</td>
<td>0.6 in.</td>
<td>2.4 in.</td>
<td>0.0 in.</td>
</tr>
</tbody>
</table>

How did the high and low temperatures for Bakersfield shown on the map differ from its average high and low temperatures?

Which city had high and low temperatures closest to its average high and low temperatures?

Which city had temperatures cooler than its average high and low temperatures?
Apply It

Now use data from the chart to create bar graphs, like the ones started here, to compare the high temperatures or the amounts of precipitation.

July Average High Temperatures for Some Cities

July Average Rainfall in Some Cities
Finally, look at a weather map from your local newspaper. Compile data from the map and make two bar graphs. Include temperatures and precipitation for cities in California. **Analyze data** in your graph to predict what the weather may be in your area tomorrow. Share your findings with your classmates.

My prediction for the weather in my area tomorrow is:

Temperature (°F)

<table>
<thead>
<tr>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
<th>95</th>
<th>100</th>
<th>105</th>
<th>110</th>
<th>115</th>
</tr>
</thead>
</table>

Rainfall (inches)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>
How does the steepness of a slope affect stream erosion?

Form a Hypothesis
A stream causes erosion by carrying sediment and other materials away. Do you think a stream in a steep streambed will cause more erosion than a stream in a level streambed? Write your answer as a hypothesis in the form "If a streambed is steeper, then . . ."

Test Your Hypothesis
1. **Make a Model** Fill the dishpan or bin with the mixture of sand, gravel, and pebbles to model a streambed.

2. Use the watering can to pour a thin stream of water down the middle of the model. What happens?

3. Smooth out the streambed, and use a book or wood block to prop up the dishpan or bin and make the streambed slightly steeper. Pour water down the middle of the model. What happens now? Stick about two dozen toothpicks into the slope to represent trees. Pour water again. Do the trees make a difference?

Materials
- dishpan or plastic bin
- mixture of sand, gravel, and pebbles
- small watering can
- books or wood blocks
- toothpicks
Draw Conclusions

4 **Analyze** Make a chart to organize your data. Did your observations support your hypothesis?


5 **Infer** What do you think would happen if there were many plants or trees along a stream’s banks?


Explore More
What would happen if you used two books or wood blocks to make the streambed steeper? Form a hypothesis and test it. Then analyze and present your results.


How do glaciers change the land?

Form a Hypothesis
How do glaciers reshape Earth’s surface? Write your answer as a hypothesis in the form “If glaciers drag loose rocks and soil with them as they move over Earth’s surface, then . . .”

Test Your Hypothesis
1. Fill one milk carton with plain water. Place a layer of sand in the other milk carton, and fill it with water. Place both in a freezer, and allow them to freeze solid.

2. Use scissors to cut open the carton and remove the ice.

3. With a paper towel, pick up the block of ice without sand. Press it against a smooth piece of clay, and rub it back and forth several times. Use firm pressure, but not too much. Record your observations.

Materials
- 2 small milk cartons
- sand
- water
- safety scissors
- modeling clay
- paper towels
4. Repeat step 3 using the block of ice with sand. Record your observations.

________________________________________________________________________

________________________________________________________________________

Draw Conclusions

5. **Observe**  What did the surface of the clay look like after you rubbed it with the second block of ice? If there were changes, what caused them?

________________________________________________________________________

________________________________________________________________________

6. **Infer**  How does this relate to the way glaciers change Earth’s surface?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Layers of Sediment

Purpose
Your task is to model the effects of different particle sizes in the formation of sediment.

Procedure

1. **Make a Model**  You can use a sediment jar to model how sediment is deposited in layers. Pour 1 cup of water into a widemouthed jar. Put another cup of water into another jar along with $\frac{1}{2}$ cup each of flour, dry rice, and dry red beans. Close the lid of the second jar, and shake the mixture you made.

2. **Observe** Pour the mixture into the water in the first jar. Record what you see. You may wish to draw a diagram. Continue recording what you see every 20 minutes for 1 hour and again in 24 hours.

<table>
<thead>
<tr>
<th>Time After Start</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 minutes</td>
<td></td>
</tr>
<tr>
<td>20 minutes</td>
<td></td>
</tr>
<tr>
<td>40 minutes</td>
<td></td>
</tr>
<tr>
<td>60 minutes</td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td></td>
</tr>
</tbody>
</table>

**Materials**
- 2 widemouthed jars
- water
- flour
- dry rice
- dry red beans
Draw Conclusions

3 Infer How does particle size affect the order in which particles settle? Why?

________________________________________________________________________
________________________________________________________________________

________________________________________________________________________

4 Going Further If you placed a mixture of different-sized particles in running water, such as a stream, how do you think the speed of the water would affect the rate at which the sediment was laid down? Write a hypothesis and test it.

My hypothesis: ____________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

My experiment: __________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

My results: ______________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
How can you map a watershed?

Purpose
What information will you need to map a watershed? Write your answer in the form “If I want to map my area’s watershed, then I will need . . .”

Procedure
1. Choose a site to map: a stream, pond, or other small body of water. Place the plastic sheet over the topographic map, and tack both to the cardboard. Mark your site on the topographic map, using the road map to help you.

2. Mark the bodies of water near your site on the topographic map. Use the map’s contour lines to find the highest and lowest points around your site. Mark each hilltop with an x.

3. Use x’s to label the directions in which the local ditches and streams flow. On your map find the highest ground between two bodies of water. Draw a line to connect highest points (the x’s) around your site, including its mouth—the place where it drains into another body of water.

Materials
- topographic map of your area
- road map of your area
- clear sheet of plastic (acetate) as large as the map
- piece of cardboard the same size as the map
- thumbtacks
- dry-erase markers
- tissues
Draw Conclusions

4 Analyze What can you tell about how water flows in the watershed? Use the topographic map to explain.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Explore More
How could this watershed map be used to serve your community? What information does it provide? Make a prediction and test it. Then analyze and present your results.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Inquiry: Open Think of your own question related to watersheds.

My question: ____________________________________________________________________________

________________________________________________________________________

My research: ____________________________________________________________________________

________________________________________________________________________

My results: ____________________________________________________________________________

________________________________________________________________________
Can humans control the natural flow of rivers?

Form a Hypothesis
Throughout Earth’s history rivers have flooded, depositing rich sediment on the surrounding lands. They have cut new paths through the land on the way to the oceans, lakes, and other bodies of water into which they drain. Humans have the ability to control the natural flow of rivers to the benefit of society. However, do these changes have other consequences? Write your answer as a hypothesis in the form “If humans control the natural flow of rivers, then . . .”

Test Your Hypothesis

1. Using a deep aluminum pan or large plastic box, create a riverbed. Lay down a layer of soil, sand, and gravel, and carve out your river in the center. At one end of your river, flatten out the area, creating a delta at the river’s mouth. Cut a hole in the end of the pan by the mouth, and place a tub directly beneath it.

2. Create a slope by placing the end of the pan opposite the mouth on a stack of two or three books.

3. Observe Starting at the high end of the pan, pour a gentle stream of water into your river for about 30 seconds. Record your observations.

Materials
- large plastic box or deep aluminum pan
- large tub
- sand, soil, and gravel
- watering can
- modeling clay
- 2 or 3 books
4 Using the modeling clay, build a wall along each bank of your river all the way down to the mouth. Repeat step 3, and record your observations.

4 Draw Conclusions

5 How did the walls affect the speed of the water flowing in your river? How did the speed affect the rate of erosion and deposition?

5 Infer How do levees affect the flow of water in a river? How does this affect the deposition of sediment in delta areas?
Changing the Land

Purpose
Your task is to model how a river flows over the land and changes the shape of the land.

Procedure

1. **Make a Model**  Model a river by placing soil or sand in a long plastic box. Make the soil or sand at one end higher than the other. Use pebbles to build up higher areas. At the other end of the box, make a large depression in the soil to model an ocean.

2. Using a hose or a watering can, pour a thin stream of water onto the “mountain.”

3. **Observe**  What happens as the water flows down from higher areas to lower areas? What happens at the river’s mouth when the river reaches the “ocean”? Report your findings.

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
</thead>
</table>
| - long plastic box  
| - soil or sand  
| - pebbles  
| - hose or watering can |
Draw Conclusions

4. How does the slope of a river affect the rate of erosion?

5. Why is sediment deposited at the mouth of a river?

6. Going Further: Does erosion occur more rapidly in a younger river or an older river? Write a hypothesis and test it.

   My hypothesis: ____________________________
   __________________________
   __________________________
   __________________________

   My experiment: ____________________________
   __________________________
   __________________________
   __________________________

   My results: ____________________________
   __________________________
   __________________________
   __________________________
What is sand?

Make a Prediction
Do you think that all beaches have the same kind of sand? Write your answer as a prediction in the form “If you look at sand samples from different beaches, then you will see . . .”

Test Your Prediction

1. **Observe** Use a hand lens to examine grains of sand from several beaches. Describe the grains in each sample. Make a chart to organize your observations.

2. **Classify** Compare the properties of the different grains of sand to the properties of the mineral samples provided by your teacher. Group the sand samples whose grains are made of the same minerals.

3. **Use Numbers** Choose one sand sample. Estimate the percent of each type of particle in the sample. Display your results in a circle graph. What is the most common type of particle in the sample?
Draw Conclusions

4 Analyze  How would you explain what you observed? Compare the grains of sand within one sample. Are they all the same size? The same shape? What might cause them to be different?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Explore More

Some beaches in Hawaii have black sand. There are beaches in the Bahamas where the sand is pink. What might you see through a hand lens if you looked at samples of these types of sand? Why do you think beach sand has different colors in different places?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Why are plants important to a dune?

Form a Hypothesis
Many beaches have beautiful dunes that look inviting to walk on. However, in most places there are signs posted asking people to stay off the dunes. There are also signs asking people not to pick the dune plants. Why do you think these plants are so important? Write your answer as a hypothesis in the form “If the dune plants disappear, then . . .”

Test Your Hypothesis

1. Using a plastic box or aluminum pan, build a sand dune. You may want to moisten the sand slightly to make it stick together.

2. **Observe** Using the watering can, pour a stream of water over your dune, and observe what happens.

3. **Observe** Rebuild your sand dune. This time add some plants. Repeat step 2, and record your observations.

Materials
• sand
• small plastic aquarium plants
• plastic box or aluminum pan
• watering can
Draw Conclusions

Why do beach communities ask people not to pick the dune plants?

Inquiry: Open Do plants protect sand dunes from erosion by wind as well as water? Write a hypothesis and test it.

My hypothesis:  

My experiment:  

My results:  

Name ____________________________ Date ______________
How Waves Affect Beaches

Purpose
Your task is to create a model that demonstrates how waves affect a beach.

Procedure

1. You can make a model of how waves affect a beach. Cover the bottom of a paint-roller pan with 4 cups of sand. Build a small “beach” at the pan’s shallow end.

2. Pour 8.5 cups of water into the deep end of the pan. Note the appearance of the sand and water.

3. Observe Hold a pencil sideways in the water at the deep end of the pan. Use the pencil to make waves. What happens when the waves hit the sand?

4. How do the height and frequency of waves affect the beach? Experiment with using the pencil to make different kinds of waves, and observe the results.

Materials
- paint-roller pan
- 4 cups of sand
- water
- pencil

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Draw Conclusions

5 Infer What affects the rate of erosion along a shoreline?

________________________________________________________

________________________________________________________

6 What other actions can change the shape of a shoreline?

________________________________________________________

________________________________________________________

7 Going Further Along many coastlines there are barrier islands. How do you think these islands affect the rate of erosion along the shoreline?

My hypothesis: _______________________________________

________________________________________________________

________________________________________________________

My experiment: _______________________________________

________________________________________________________

________________________________________________________

My results: _______________________________________

________________________________________________________
What can change a river?

Form a Hypothesis
Rivers and streams can be found all over the United States. People have changed rivers and streams to accomplish different tasks, such as irrigating fields and powering turbines for electricity. The flow of water down a stream or river can be influenced by various factors. Rain and snowfall can increase the flow of water. Drought and human-made structures can slow or stop the flow of water. What effect does the makeup of the land have on the formation of a storm? How does the size of the land particles affect how a stream forms? Write your answer as a hypothesis in the form “If the land a stream is forming in is made from soil, sand, or gravel, then the stream will look like . . .”

Materials
- aluminum pan
- potting soil
- gravel
- sand
- water
- cup

△ Be Careful. Wash your hands with soap and water after the activity.

Test Your Hypothesis
1. Use potting soil to make a mound at one end of the aluminum pan. This will represent a mountain.

2. Use a cup to pour a small amount of water onto the top of your soil mountain. Draw and record in the chart on the next page what happens to the mountain.

3. Repeat steps 1 and 2 with gravel and sand. What differences did you see among the soil, sand, and gravel mountains?

4. Repeat the activity again, using a mixture of the three materials. Record your results in the chart.
<table>
<thead>
<tr>
<th>Draw Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5</strong> Explain What happened to the water flow when you poured the water on the soil mountain?</td>
</tr>
<tr>
<td><strong>6</strong> Explain What differences did you see among the soil, the sand, and the gravel mountains?</td>
</tr>
<tr>
<td><strong>7</strong> Infer What type of mountains or land would create the deepest streams and rivers?</td>
</tr>
</tbody>
</table>
Inquiry: Guided

What affects the speed of flowing water?

Form a Hypothesis
What can you do to change the speed at which water flows in a stream? Write your answer as a hypothesis in the form “If a streambed is made narrower, then the speed of the water will . . .”

Test Your Hypothesis
Design an experiment to investigate how changing the stream path affects the speed of flowing water. Write out the materials you will need and the steps you will follow. Record your results and observations.

Draw Conclusions
Did your experiment support your hypothesis? Why or why not? What factors contributed most to the speed of water flowing in a stream?
Inquiry: Open
What else can you learn about rivers and streams? For example, what effects do dams have on river speed and flow? Think of a question to investigate, and design an experiment to answer your question. Then carry out your experiment.

Remember to follow the steps of the scientific process.

Ask a Question


Form a Hypothesis


Test Your Hypothesis


Draw Conclusions


How do volcanic eruptions affect habitats?

Make a Prediction
If a volcano erupts, what do you think happens to the area around it? Write your answer as a prediction in the form “If a volcano erupts, then . . .”

Test Your Prediction

1. **Observe**  Study the photos of Mount St. Helens before and after the volcanic eruption of 1980.

2. What changes to the mountain and its vegetation do you see?

3. **Compare**  How did the upper and lower slopes of Mount St. Helens change?

Materials

- photo of Mount St. Helens before the eruption of 1980
- photo of Mount St. Helens after the eruption of 1980
- map showing extent of damage
Draw Conclusions

4 Do you think it would have been necessary to redraw a topographic map of this area after the volcano erupted? Why or why not?

______________________________________________________________

______________________________________________________________

______________________________________________________________

5 Analyze How would you explain what you observed? Did your observations support your prediction? How does an erupting volcano affect its surrounding area?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Explore More

Choose another natural disaster to study, such as the 1993 flooding of the Mississippi River area or the 2004 tsunami in Asia. Find photos taken before and after the disaster. Describe any changes you see in the landforms and the local vegetation. Analyze and present your results.

______________________________________________________________

______________________________________________________________
Where in the world do disasters occur?

Form a Hypothesis
Does location affect the types of natural disasters that typically occur in an area? Write your answer as a hypothesis in the form “If I find that certain types of natural disasters occur more frequently in specific parts of the United States, then . . .”

Test Your Hypothesis
1. As a class divide into five groups: the earthquake team, the volcano team, the hurricane team, the tornado team, and the fire team.

2. Obtain one copy of a map of the United States and one red pencil or marker for each team.

3. Using library or Internet resources, investigate the occurrences of the natural disaster assigned to your team. Draw red x’s on the map to indicate places where the disaster has occurred.

Materials
- research resources such as newspapers or the Internet
- map of the United States
- red pencils or markers
Draw Conclusions

Did you find a pattern to the locations where the natural disaster assigned to your group has occurred? Present your results to the class.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Inquiry: Open  Is there at least one factor in the geographic areas where you found the highest frequency of your natural disaster that might contribute to its occurrence? Write a prediction and research it.

My prediction: __________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

How I can find out: ______________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

My results: __________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Local Natural Disaster

Purpose
Your task is to investigate a natural disaster in your area and determine its effects on Earth’s surface and the people, plants, and animals in the area.

Procedure
1. Investigate a natural disaster that occurred in your area. It may be a flood, a landslide, a volcanic eruption, an earthquake, a storm, or a fire.

2. Research Use newspaper articles, interviews with local residents, topographic maps, and other sources of information to answer these questions:
   - Did the natural disaster change Earth’s surface? If yes, how?
   - Were any people harmed? Explain.
   - Were any plants and animals harmed? Explain.

<table>
<thead>
<tr>
<th>Local Natural Disaster: ____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes to Earth’s Surface</td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Draw Conclusions

3 Communicate Write a short report describing how the natural disaster affected your area. Include a map, photos, diagrams, or other appropriate visuals.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4 Going Further Can some natural disasters be beneficial to the environment? Write a prediction and research it.
My prediction: __________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
My research: __________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
My results: __________________________________________________________________________
________________________________________________________________________
What factors affect the efficiency of a solar oven?

Make a Prediction
What will happen to water in a solar oven? Write your answer as a prediction in the form “If water is placed inside a solar oven, then . . .”

Test Your Prediction

1. **Measure** Draw a 2.5-centimeter border around the top of a pizza box. **Be Careful.** Cut the three outer sides, Fold the flap up along the back edge.

2. Glue foil under the flap, shiny side out. Glue another piece of foil inside the box, shiny side up. Tape black construction paper over the foil.

3. Roll up the newspapers, and place them inside the edges of the box. Tape them in place. Tape plastic wrap under the box lid over the first piece of foil. Add plastic wrap to the top of the lid.

4. Put the bowl of water in the center of the box. Record the temperature of the water.
5. Position the oven with the flap facing the Sun. Prop the flap open with a dowel or ruler. After 10 minutes measure the temperature of the water.

Draw Conclusions

6. **Analyze** How would you explain what happened? Did your observations support your prediction?

7. **Infer** Did the temperature in the box change?

Explore More
What other factors might affect the efficiency of the oven? What would happen if you used white paper instead of black paper? Form a hypothesis and test it.
Can you catch some rays?

Make a Prediction
Light rays are one way that the Sun gives off energy. How can you capture this energy and use it to heat water? Write your answer as a prediction in the form “If I want to capture and use the Sun’s energy, then . . .”

Test Your Prediction
1. Place a sheet of white paper inside each of two shoe boxes. Place a sheet of black construction paper inside each of the other two shoe boxes.

2. Position the following side by side in direct sunlight: a sheet of white paper, a sheet of black construction paper, a shoe box lined with white paper, a shoe box lined with black construction paper, another shoe box lined with white paper, and another shoe box lined with black construction paper. Position a piece of foil-wrapped cardboard against each of the last two shoe boxes, with the cardboard propped against the side of the shoe box away from the sunlight and leaning slightly over the inside of the shoe box.

3. Put 100 milliliters of water in each of the six bowls. Record the temperature of the water in each bowl.
4 Place a bowl in the center of each of the items positioned in direct sunlight.

5 **Measure** After 10 minutes record the temperature of the water in each bowl.

---

**Draw Conclusions**

6 **Interpret Data** In general did the solar collectors using white paper or black paper heat the water to a higher temperature? Why?

---

7 **Interpret Data** Did the solar collectors with or without shoe boxes heat the water to a higher temperature? Why?

---

8 **Communicate** Which solar collector worked best at raising the temperature of the water? What features of this solar collector do you think helped it heat well? Share your answers with your classmates.
The Power of Water

Purpose
Your task is to show how a waterwheel works and to examine factors that affect how well it works.

Procedure
1. What factors do you think affect how well a waterwheel works? How can you design the blades on a waterwheel so that they turn as fast as possible?

2. Cut eight equally spaced slits from the rim to the base of a plastic cup. Fan the sections out to form eight “blades.”

3. Poke a hole through the center of the bottom of the cup, and insert a pencil as an axle.

4. Observe Hold the pencil loosely at both ends, and place it in a horizontal position. Hold the fanned-out blades under running water. What happens?

5. Will your waterwheel turn faster with more blades? With fewer blades? Experiment to find out.

Materials
- plastic cup
- scissors
- pencil
- running water
Draw Conclusions

6 Infer How can the energy from the turning blades of a waterwheel be used for work?


7 Going Further How does the speed of falling water affect the energy produced by a waterwheel?

My prediction:

My experiment:

My results:
Communicate

When you communicate you share information with others. You may do this by speaking, writing, drawing, or using sign language. First, you gather some information to share with others. Then, you share your information.

1 Learn It

Scientists look for ways to reduce energy waste. They communicate their findings to others by writing books and articles, giving interviews, and making presentations.

Heating and cooling buildings takes a lot of energy. In fact, heating and cooling are two of our biggest uses of energy. They are also sources of many air pollutants. To avoid wasting energy, people can use insulation to retain heat in winter and keep air cool in summer.
Some materials are better insulators than others. In the following activity, you will test the insulating qualities of six different materials. You will need down from an old jacket or glove, a cotton sock, a wool sock, sand, shredded newspaper, plastic air-bubble packing material, coffee cans with snap-on lids, baby food jars with screw-on lids, a graduated cylinder, warm water, and a thermometer.

Fill each jar carefully with the same amount of warm water. Measure the temperature in each jar, and write it on the chart on the next page. Put a lid on each jar, and place each jar in the center of a can. Fill the space between each jar and can with one kind of insulating material. Stuff the can to completely surround the jar. Label each can to identify the material used. Record this on your chart. Put the lids on the cans, and wait 1 hour. Open each can and then each jar to measure the temperature of the water. Record the temperatures on your chart.

Analyze the data in your chart. Which material(s) kept the water about the same temperature it was when the test started?
Communicate your actions and the results to your classmates in a written or oral report.

<table>
<thead>
<tr>
<th>Material</th>
<th>Starting Temperature</th>
<th>Temperature after 1 Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton Sock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool Sock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shredded Newspaper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic Bubble-wrap Packing Material</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Apply It

- Which insulating material do you think would best keep the air in a building cool when the weather is hot outside?

- Repeat the experiment, but this time use very cold water and one ice cube in each jar.

<table>
<thead>
<tr>
<th>Material</th>
<th>Starting Temperature</th>
<th>Temperature after 1 Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down</td>
<td></td>
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<tr>
<td>Cotton Sock</td>
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<td></td>
</tr>
<tr>
<td>Sand</td>
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<td></td>
</tr>
<tr>
<td>Shredded Newspaper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic Bubble-wrap Packing Material</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How energy efficient are different types of light bulbs?

Form a Hypothesis
Are some kinds of light bulbs more efficient than others? A light bulb gives off light and heat. This heat is wasted energy. Do some types of bulbs give off more heat than others? Develop a hypothesis in the form "If one type of light bulb is more efficient than another type, then it will give off . . ."

Be careful. Let light bulbs cool before touching them.

Test Your Hypothesis

1 Lay the towel out on a table. Place the lamp at one end of the towel. Put the thermometer at the other end of the towel where the light from the lamp will shine on it. Measure the distance between the thermometer and the bulb.

2 Experiment Unplug the lamp, and screw in the incandescent light bulb. Record the starting temperature. Angle the lamp over the thermometer, plug in the lamp, and turn it on.

Materials
- gooseneck lamp
- extension cord if needed
- 60-watt incandescent light bulb
- 13-watt compact fluorescent light bulb
- thermometer
- ruler or yardstick
- white towel
- watch or stopwatch

California Standard 6 IE 7.a., b., d.
3 **Measure** Shine the lamp on the thermometer for 5 minutes. Record the temperature. Repeat steps 2 and 3 for the fluorescent light bulb. Allow the lamp and the table to cool between the trials.

<table>
<thead>
<tr>
<th>Type of Light Bulb</th>
<th>Starting Temperature</th>
<th>Temperature After 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-watt incandescent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-watt compact fluorescent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Draw Conclusions**

4 **Infer** What conclusion can you draw about which kind of bulb produces less heat?

**Explore More**

How do you think the use of incandescent lights in a home would affect the use of air conditioning in the summer? Make a prediction and test it.
Can sunlight be used to heat water for use in homes?

Form a Hypothesis
Every home needs hot water, and hot water systems in most homes rely on electricity, fuel oil, or natural gas. If the Sun can warm oceans, lakes, and streams, can sunlight heat water for home use? Write your answer as a hypothesis in the form “If I place a cup of water in direct sunlight, then the temperature of the water . . .”

Test Your Hypothesis

1. Fill a cup with water. Record the temperature of the water in the table below.

2. Place the cup of water in direct sunlight.

3. Measure and record the temperature of the water every 5 minutes for 30 minutes.

<table>
<thead>
<tr>
<th>Time in Sunlight</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 minutes</td>
<td></td>
</tr>
<tr>
<td>5 minutes</td>
<td></td>
</tr>
<tr>
<td>10 minutes</td>
<td></td>
</tr>
<tr>
<td>15 minutes</td>
<td></td>
</tr>
<tr>
<td>20 minutes</td>
<td></td>
</tr>
<tr>
<td>25 minutes</td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td></td>
</tr>
</tbody>
</table>

Materials
- paper cups
- water
- thermometer
- watch or clock
What was the total increase in temperature?

__________________________

Draw Conclusions

Interpret Data Did your data support your hypothesis?

__________________________

Infer Besides raising the temperature of water, what other factors would be important in providing hot water for homes?

__________________________

Infer Besides placing water in direct sunlight, are there other ways to use sunlight to heat water for home use?

__________________________
Fuel Supply

Purpose
Your task is to determine how long the world’s supplies of oil and natural gas will last. This table shows how quickly people are using up oil and natural gas.

<table>
<thead>
<tr>
<th>Type of Energy Source</th>
<th>Proved Reserves (as of January 1, 2004)</th>
<th>Amount Used (for 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>1,265 billion barrels</td>
<td>about 80 million barrels per day</td>
</tr>
<tr>
<td>Natural gas</td>
<td>6,079 trillion cubic feet</td>
<td>about 96 trillion cubic feet per year</td>
</tr>
</tbody>
</table>

Source: U.S. Energy Information Administration

Procedure

1. **Analyze** Examine the data in the table.

2. **Communicate** Based on the data in the table, make a line graph that shows how long the world’s supplies of oil and natural gas will last. Assume that the rate of use will remain the same over time.

3. **Infer** How much time will pass until supplies of oil and natural gas run out?
Draw Conclusions

4 **Interpret Data**  What do your results suggest about the need to conserve natural resources, such as oil and natural gas?

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

5 **Going Further**  What sector is the biggest consumer of energy in the United States? How can you find out? Write a prediction, research your answer, and communicate the information in a circle graph.

My prediction: ______________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

My research: ______________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

My results: ______________________________________________________________________
____________________________________________________________________________________

[Diagram: Circle graph with 27% indicated]
Inquiry: Structured

How can you classify a renewable resource?

Purpose
Renewable resources are becoming more important as nonrenewable materials become depleted. Renewable energy sources are making an impact on the kinds of cars people drive and the ways in which people generate electricity. Wind, sunlight, and water are all renewable resources. They are sometimes used as energy sources in place of coal, oil, and natural gas in the United States. How can you determine whether a source of energy is renewable or nonrenewable? What are the advantages of each type of resource?

△ Be Careful. Be careful when handling electrical items.

Procedure
1. For the first setup, connect one wire from the solar panel to one wire on the motor. Connect the other two wires. Draw your setup in the chart on the next page, and describe what happened to the motor when you connected the wires.

2. For the second setup, connect one wire from the other motor to the positive end of the battery. Connect the other wire to the negative end of the battery. Draw this setup in the chart, and describe what happened to the motor.

3. Record the time in the chart.

4. Observe Once per hour observe both motors. Compare the speeds at which the motors are running. Continue your observations until one motor is no longer working. Then record the time in the chart along with your observations.

Materials
- solar kit with motor
- additional motor
- battery
- battery holder
- stopwatch or clock
**Draw Conclusions**

5 **Explain** What did you observe concerning the speed at which the motors were running at the beginning and at the end of the experiment?

____________________________________________________________________________________________________________________________________________________________

6 **Explain** Which type of energy, battery or solar, is renewable? Explain your answer.

____________________________________________________________________________________________________________________________________________________________

7 **Infer** If you were the owner of a company, which type of energy would you want to use to power your manufacturing plant? Why?

____________________________________________________________________________________________________________________________________________________________

**Table: Renewable and Nonrenewable Resources**

<table>
<thead>
<tr>
<th>Drawings</th>
<th>Solar Power</th>
<th>Battery Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Start: Finish:</th>
<th>Start: Finish:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Inquiry: Guided

How does insulation affect energy use?

Form a Hypothesis
How can insulation help reduce the amount of energy needed to heat and cool your home? Are some insulation materials more efficient than others? Write your answer as a hypothesis in the form “If proper insulation is used in a building, then the amount of heating and cooling needed will . . .”

Test Your Hypothesis
Design an experiment to identify the most efficient insulation material. Write out the steps you will follow. Then carry out your plan, and record your results and observations.

Draw Conclusions
Did your experiment support your hypothesis? Why or why not? Present your results to your classmates.
Inquiry: Open
What else can you learn about renewable and nonrenewable energy sources? For example, are some energy sources more efficient than others? Think of a question to investigate. Then design an experiment to answer your question, and carry out your experiment.

Remember to follow the steps of the scientific process.

Ask a Question

Form a Hypothesis

Test Your Hypothesis

Draw Conclusions
What are objects made of?

Make a Prediction
From which natural resources are most common objects made? Do such objects come from plants, animals, rocks, soil, minerals, oil, water, or metals? Make a prediction in the form “Most objects in the classroom are made from . . .”

Test Your Prediction

1. Tape the white butcher paper on the wall around the classroom. Divide the paper into four sections: Plants, Animals, Minerals, and Oil.

2. Have your teacher assign a small group to each section of the paper. One group will identify every object in the classroom made from plant materials, another will identify objects made from animals, and so on.

3. Classify Draw each object on the mural, and identify the natural resource from which it is made. Indicate whether the natural resource is renewable or nonrenewable.

Materials
- long sheet of white butcher paper
- tape
- different-colored markers or crayons
**Draw Conclusions**

4 **Analyze**  How would you explain what you observed? Were some objects made from several natural resources?

________________________________________________________________________

________________________________________________________________________

5 **Did your observations support your prediction?**

________________________________________________________________________

________________________________________________________________________

6 **Infer**  Identify the type of energy required to produce each object.

________________________________________________________________________

________________________________________________________________________

**Explore More**

What types of pollution were generated in making these items? Make a prediction, and do research. Then analyze and present your results.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
How do we handle our trash?

Form a Hypothesis
Sometimes the way we handle problems comes down to simple choices. What options do we have for making the best waste-management choices? How can we make those decisions? Write your answer as a hypothesis in the form “If we analyze what we throw away, then . . .”

Test Your Hypothesis
1 With a partner write down one item that you typically throw away on each of the index cards. You should end up with 40 items.

2 With your partner place each index card in the box that represents the best option for getting rid of the item listed.

3 Use Numbers When each team has placed all of its cards in the boxes, tally up the number of cards in each box. Record the data, and organize it into a graph.

Draw Conclusions
4 Which waste-management option contained the most cards?

5 As a class select some of the cards from each box. Discuss whether the waste-management option selected was the best choice. Were better alternatives available?
Sources of Clothes

Purpose
Your task is to identify, for a wide variety of clothing items, the materials of which they are made, the original sources used to make those materials, and the care requirements for each item.

Procedure

1. **Collect Data** Prepare an inventory of the different types of clothing, including shoes, in your classroom.

2. **Communicate** Make a chart that includes each item of clothing. Identify the type of material each item is made of, and add the type of material to the chart. Look at the labels if you need help.

<table>
<thead>
<tr>
<th>Clothing Item</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

3. Use the information you have to trace the textiles back to their original sources.

Materials
- paper and pencil
Draw Conclusions

4 Infer  Read the care instructions for each type of material used, or look on the Internet. Which are easiest to care for? Why do you think this is so?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5 Going Further  Blue jeans were first manufactured in San Francisco in 1873. A man named Levi Strauss recognized the need for durable, rugged work wear. What made these pants, originally called “waist overalls,” the perfect work wear? What did Strauss do to increase the durability of these pants? Write a prediction, and then research the answer.

My prediction: ____________________________________________

________________________________________________________________________

My research: ________________________________________________

________________________________________________________________________

________________________________________________________________________

My results: ________________________________________________
Growing Bacteria

Background
Bacteria are everywhere. They are found in the foods you eat, in the places where you study and play, and inside your body. Many bacteria are good for you, but there are also bacteria that can cause illnesses. Most food poisoning is caused by bacteria. Bacteria can also cause cavities, strep throat, and ear infections. Many of these illnesses can be cured by taking an antibiotic. Antibiotics kill the bacteria that cause many kinds of disease.

Purpose
Your task is to grow bacteria on a beet slice, one half of which has antibiotic on it.

Form a Hypothesis
How would you grow bacteria on a beet slice? What will happen to the beet? Write your answer as a hypothesis in the form “If an antibiotic is placed on half of the beet slice, then . . .”

Materials
- sterile plastic petri dish
- sliced beets
- permanent marker
- plastic forceps
- antibiotic cream
- cotton swabs
- tape
Test Your Hypothesis

1. Turn the petri dish upside down, and use a marker to divide the dish in half. Label the sides A and B.

2. Use the forceps to pick up the beet slice. Slightly lift the lid of the petri dish with your other hand and place the beet slice in the center of the dish. Replace the cover.

3. Rub a cotton swab over the fingers of one hand, slightly lift the cover of the petri dish, and gently rub the swab over the surface of the beet slice. Make sure that you touch the entire surface of the beet slice.

4. Use another cotton swab to add antibiotic cream to the half of the beet slice on side B of the dish.

5. Replace the cover, and tape the lid to the dish.

6. Place the petri dish where it will not be disturbed.

7. **Observe**  Count colonies of bacteria and check for their growth every day for 4 days. What happens to the beet slice? Do you see any pattern in the growth?

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Day 1
Number of colonies: A ________
                   B ________
Observations: _____________________________________________

Day 2
Number of colonies: A ________
                   B ________
Observations: _____________________________________________

Day 3
Number of colonies: A ________
                   B ________
Observations: _____________________________________________

Day 4
Number of colonies: A ________
                   B ________
Observations: _____________________________________________
Draw Conclusions

8 Based on your results, what is your conclusion?

______________________________
______________________________
______________________________

Critical Thinking

1 Why are refrigerators and freezers used to store food for long periods of time?

______________________________
______________________________
______________________________

2 What is antibiotic cream useful for?

______________________________
______________________________
______________________________

Did You Know?

Bacteria in the mouth feed on leftover food and can cause bad breath.
What is a carnivore?

Background
Food chains and food webs show how energy is passed from one living thing to the next. At the bottom of the food chain are plants, because they make their own energy using the Sun. Herbivores (animals that eat plants) are the next group in the food chain, or first-level consumers. Then come carnivores (meat eaters) and omnivores (meat and plant eaters), or second-, third-, and fourth-level consumers. When an animal at the top of the food chain dies, it is then eaten by decomposers. Decomposers are small organisms that break dead plants and animals down into very small pieces that are then returned to the soil and used as nutrients by plants. Every living thing gets recycled in this way.

Purpose
Your task is to conduct an experiment that will determine whether an owl is a carnivore.

Form a Hypothesis
How can you use an owl pellet (undigested material that an owl regurgitates) to determine whether an owl is a carnivore? Write your answer as a hypothesis in the form “If the pellet contains ________, then the owl is a carnivore.”
Test Your Hypothesis

1. Cover a workspace with newspaper, unwrap the owl pellet, and place it on a piece of black construction paper.

2. Using toothpicks, carefully take the owl pellet apart, and look for bones. (The bones are very fragile and need to be removed gently to avoid breaking.)

3. Once you have removed any bones, put them in the bowl of bleach solution for about 5 minutes or until the bones are thoroughly cleaned and whitened.

4. Put the screen over the top of a plastic cup, and gently pour the solution through the screen. You will now have any bones on the screen. Gently remove the bones with plastic forceps, and put them on a paper towel to dry.

5. Sort the bones, using the bone-sorting chart on the next page.

6. Glue the appropriate bones on the rodent-skeleton diagram on the next page.

Materials

- black construction paper
- sterilized owl pellet
- toothpicks
- plastic bowl with bleach solution and plastic cup
- piece of screen
- plastic forceps
- bone-sorting chart
- rodent-skeleton diagram
### Bone-Sorting Chart

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>skull</td>
<td>humerus</td>
<td>femur</td>
</tr>
<tr>
<td>vertebra</td>
<td>radius</td>
<td>tibia</td>
</tr>
<tr>
<td>rib</td>
<td>ulna</td>
<td>fibula</td>
</tr>
</tbody>
</table>

### Rodent-Skeleton Diagram

[Image of a rodent skeleton diagram]
Draw Conclusions

7. **Observe** What did you observe?

Based on your results, what is your conclusion? Is the owl a carnivore? Why? What evidence leads you to your conclusion?

Critical Thinking

1. Why is it important to protect owls and their habitats?

2. What would happen if all the owls in a large farming area died?

Did You Know?

**Rodents** (including mice, beavers, hamsters, gerbils, and groundhogs) are mammals that have a pair of front teeth that never stop growing; this causes them to gnaw constantly to grind their teeth down.
Potential to Kinetic Energy

Background
Potential energy is energy stored in an object. Kinetic energy is the energy of motion. Fuel such as wood, oil, and gas contains potential energy. When fuel is burned, heat is released. This heat is used to do work such as moving a car or heating a stove. Chemical reactions also involve the conversion of potential energy to kinetic energy. For example, food contains chemical bonds that contain potential energy. Digestive enzymes break down these bonds and release the potential energy. This energy is eventually converted into kinetic energy—energy used for activities such as running, jumping, and breathing.

Purpose
Your task is to devise an experiment that converts potential energy to kinetic energy, using an effervescent tablet as a test material.

Form a Hypothesis
How can you use an effervescent tablet and water to demonstrate how potential energy is converted to kinetic energy? Write your answer as a hypothesis in the form “If an effervescent tablet is added to water in a film canister and the top is put on the film canister, then the canister will . . .”
Test Your Hypothesis
This experiment must be done outdoors.

1. Put on your safety goggles.
2. Fill the film canister half full with water.
3. Put half of an effervescent tablet in the water. Immediately snap the top on the canister.
4. Hold two fingers on the top and your thumb on the bottom of the canister to prevent the cap from coming off.
5. Shake the canister briskly, and walk to a clear spot, away from people.

(Hold the canister away from your body and face.)

Materials
- safety goggles
- effervescent tablet
- a film canister with a snap-on lid (a lid that snaps inside the canister, not outside)
- water

Step 3

Step 5
6. Put the canister cap-down on a hard surface on the ground. **Move back.**

**Draw Conclusions**

7. What did you observe?

   __________________________
   __________________________
   __________________________
   __________________________

8. Based on your results, what is your conclusion?

   __________________________
   __________________________
   __________________________
Critical Thinking

1. How is the launch of a space shuttle similar to your effervescent-tablet “rocket”?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Why does the space shuttle not fly to the Moon?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Did You Know?

To maintain an orbit in space, the Shuttle must reach at least a speed of about 17,000 miles per hour.
The Light We Cannot See

Background
The electromagnetic spectrum is made up of electromagnetic radiation of different wavelengths. These include radio waves, microwaves, infrared rays, visible light, ultraviolet (UV) light, X rays, and gamma rays. Humans cannot see ultraviolet light, but some animals can. Exposing skin to ultraviolet light without using sunscreen can damage the skin.

Purpose
Your task is to design an experiment using UV beads that will determine how to protect yourself from damaging ultraviolet light. UV beads are special beads that contain a pigment that changes color when exposed to sunlight.

Form a Hypothesis
How can you determine whether UV-protective lenses block ultraviolet light from the Sun? Write your answer as a hypothesis in the form “If UV-protective lenses block ultraviolet light from the Sun, then UV beads under such sunglasses in sunlight will . . .”
Test Your Hypothesis

1. Put the UV beads in sunlight, and see if they change color.

2. Take the UV beads out of the sunlight, and see if they change color.

3. Cover the UV beads with the lenses of the sunglasses, and place them in sunlight.

Materials

- UV beads
- pair of sunglasses with UV-protective lenses
What color are the UV beads?

_____________________________________________________

_____________________________________________________

Draw Conclusions

What did you observe?

_____________________________________________________

_____________________________________________________

_____________________________________________________

Based on your results, what is your conclusion?

_____________________________________________________

_____________________________________________________

_____________________________________________________

Critical Thinking

What would happen if you covered the UV beads with sunscreen lotion and then put them in sunlight?

_____________________________________________________

_____________________________________________________

_____________________________________________________
The ozone layer around Earth acts like a large layer of sunscreen, protecting the planet from most ultraviolet light coming from the Sun. What do you think would happen to Earth if the ozone layer were damaged or weakened?

---

Did You Know?

**Ultraviolet light** is necessary for your body to produce Vitamin D.
Electricity from the Sun

Background
A solar panel is made up of photovoltaic cells. These cells work together to convert sunlight (photo-) into electricity (-voltaic). Photovoltaic cells are commonly made of silicon. When silicon is exposed to sunlight, its electrons start flowing. The flowing of electrons is called an electric current. The current from the silicon of the photovoltaic cells is directed toward the metal wires attached to the solar panel. In this way the energy of the Sun is converted into electricity. Electricity will continue to be generated by the solar panel’s cells as long as sunlight is available.

Purpose
Your task is to show that a solar panel can produce electricity.

Form a Hypothesis
How can you use a small, homemade motor to prove that a solar panel produces an electric current? Write your answer as a hypothesis in the form “If a solar panel produces an electric current and I connect it to a motor, then the motor will . . .”
Test Your Hypothesis

1 Use craft sticks to make a structure such as a windmill, a Ferris wheel, a helicopter, or a merry-go-round.

2 Attach the moving parts of your structure (such as windmill blades or helicopter blades) to the motor with the glue or tape.

3 Attach the wires from the solar panel to the leads on the motor.

Materials
- 50–100 craft sticks
- small solar panel
- small motor
- glue or double-stick tape
4 Place the solar panel in sunlight or under a very bright light.
5 Observe what happens.

**Draw Conclusions**
6 What did you observe?

________________________________________
________________________________________
________________________________________
________________________________________

7 Based on your results, what is your conclusion?

________________________________________
________________________________________
________________________________________
________________________________________

**Critical Thinking**
1 How can you stop the motor from running without moving your structure?

________________________________________
________________________________________
________________________________________
________________________________________
Do you think that solar panels could work in very cold climates?


Did You Know?

The amount of energy that Earth receives from the Sun in one hour is more energy than people throughout the world use in a year.
Rocks That Float, Rocks That Sink

Background
When a volcano erupts, hot molten lava can be thrown into the air or can flow from fissures and cracks and flow over Earth’s surface. When the lava cools and hardens, it forms igneous rocks. These rocks are called extrusive igneous rocks, because they form by cooling and hardening on Earth’s surface. Intrusive igneous rocks are formed deep within Earth. They are often exposed by an earthquake or other natural event.

Purpose
Your task is to design an experiment that will determine whether pumice, an extrusive igneous rock, will sink or float when put in water.

Form a Hypothesis
Examine the pumice, and make a sketch of it in the space on the next page. What do you think will happen if you put a piece of pumice in a bowl of water? Will it sink or float? What would happen if you did this with other rocks? State your hypothesis in the form “If I place a piece of pumice in water, then the pumice will . . .”
Appearance of pumice:


Texture of pumice:


Test Your Hypothesis

1 Fill your bowl with water.

2 Place a piece of pumice in the water, and make a sketch of what you see in the space on the next page.
Sketch of Pumice in Water

Draw Conclusions

3 What did you observe?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4 Based on your results, what is your conclusion?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Critical Thinking

1. Why do you think the surface of pumice is full of holes or pores? How does this affect its buoyancy?

2. Feel the surface of the pumice. Why do you think pumice is added to some soaps?

Did You Know?

Pumice is really a form of glass. It cools before crystals can form.
The Pressure Is On

Background
Though we are not aware of it, air pressure is pushing on us from every direction all the time. Usually we are only aware of sudden changes in air pressure—for example, when our ears pop in an airplane or when traveling to high altitudes in a car or bus. Air pressure and changes in air pressure have far-reaching effects on our environment. Changes in air pressure even affect the weather, as when air moving from a high-pressure area to a low-pressure area creates wind.

Purpose
Your task is to design an experiment that will prove or disprove Bernoulli’s principle: If the movement of a fluid increases in speed, the pressure, or force, of that fluid pushing against an object will decrease. (Fluids include both liquids and gases.)

Form a Hypothesis
How can you use a simple strip of paper to prove Bernoulli’s principle? Write your answer as a hypothesis in the form “If I take a strip of paper and blow hard over the top of it, then . . .”
Test Your Hypothesis

1. Hold one end of the strip of paper just below your lower lip.

2. Blow hard over the top of the paper.

Draw Conclusions

3. What did you observe?

   __________________________________________
   __________________________________________
   __________________________________________

4. Based on your results, what is your conclusion?

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

Materials

- strip of paper 15 cm long and 1 cm wide
Further Inquiry
You can also test this principle using a piece of string and 2 balloons.

1. Measure a 30-centimeter piece of string, and tie a balloon on each end.

2. Lightly support the undersides of the balloons, holding them about 6 centimeters apart, and blow very hard between the balloons.

3. What did you observe?

________________________________________________________________________
________________________________________________________________________

4. Explain your observations.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Critical Thinking

1. How does Bernoulli’s principle apply to an airplane taking off?

2. Why does low air pressure mean bad weather?

Did You Know?

The first part of the word barometer comes from the Greek word baros, which is related to the Greek word for “heavy.” A barometer measures the heaviness, or weight, or pressure, of the air.
Sponges from Oil

Background
Polymers are formed when many molecules are linked together. Some polymers, such as plastic, are created from petroleum. Petroleum, or crude oil, is a black liquid pumped out of the ground. Superabsorbent polymers can be made from a by-product of petroleum refining. These polymers attract water and are linked in such a way that there are many “pockets” within the linkages that hold water molecules.

Purpose
Your task is to design an experiment that will show how superabsorbent polymers work.

Form a Hypothesis
How can you use water and disposable baby diapers to demonstrate how superabsorbent polymers work? Write your answer as a hypothesis in the form “If disposable diapers work because they contain superabsorbent polymers, then these polymers will . . .”

Materials
- ultrathin diapers
- plastic cups
- small garbage bag with twist tie
- scissors
Test Your Hypothesis

1. Cut open a diaper, and put the cottonlike filling into the garbage bag.

2. Feel inside the bag, and note that the filling feels gritty.

3. Close the bag with the twist tie.

4. By manipulating the closed bag, tear the filling into small pieces.

5. Rub the filling between your fingers (still holding the bag closed).

6. Shake the bag.

7. Open the bag, and see whether there is powder at the bottom of the bag. If the filling still feels gritty and there is not enough powder, repeat steps 3–6.

8. Once enough powder has been collected, remove the filling from the bag and pour the powder into a plastic cup.
9 Fill a second cup with water.
10 Add the water from the second cup to the cup with the powder.
11 Pour the mixture from one cup into the other several times.

**Draw Conclusions**
12 What did you observe?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

13 Based on your results, what is your conclusion?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Critical Thinking

1. What is the advantage of putting superabsorbent polymers in diapers?

2. Why do you think farmers use superabsorbent polymers in the soil?
How can you build a living ecosystem in a container?

Inquiry: Structured

Create a Producer Habitat

Ask Questions
Can you build a plant habitat in a small container? What will you need to put in it? Where do plants get the food and energy they need to grow? How will your plant habitat grow?

Make a Prediction
Write your answer as a prediction in the form “If I build a plant habitat in a small container, the habitat will . . .”

Test Your Prediction

1. Place the soil in the container to a depth of 5 centimeters, and use the mister to add water. The soil should be damp but not soaking wet. Place the leaves, twigs, and stones on top of the soil. Plant the plants and seeds in the soil, and cover the container.

2. Place your plant habitat where it will get plenty of light but will not get too hot. Make a detailed drawing of the habitat in the space on the next page. Predict what you think it will look like in 2 to 3 weeks. Write your prediction below your drawing.
3 **Observe** The next day check your plant habitat, and add water as needed to keep the soil moist. Compare your habitat to the drawing you made on the first day.

4 **Record Data** What changes are occurring on top of the soil? What changes are occurring beneath the soil?

<table>
<thead>
<tr>
<th>Habitat Data Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
</tr>
<tr>
<td>Watered Soil</td>
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<tr>
<td>M</td>
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<td>T</td>
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<td>S</td>
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<tr>
<td>SUN</td>
</tr>
</tbody>
</table>
Conclusions/observable changes after 3 weeks:

Repeat steps 3 and 4 for 2 to 3 weeks. Do the changes support your prediction?

Communicate Your Results
Have a class discussion, and share your drawings and data. What did you learn? What caused the changes over time in the plant habitat? Use your data to answer these questions:

▲ How were the needs of the plants in your habitat met? How did the plants get light, water, air, and food?

▲ How did the habitat grow and change? What abiotic factor might limit the growth of the plants?

▲ What could you do to turn your producer habitat into an ecosystem?
Inquiry: Guided

Building an Ecosystem

Ask Questions
How will the plant habitat change if you introduce worms and other small animals? How will the worms interact with the soil? Will interaction between the producers and the consumers benefit all of the organisms? What constitutes an ecosystem?

Make a Prediction
Write your answer as a prediction in the form “If I introduce worms, insects and other small animals into the plant habitat, then . . .”

Test Your Prediction

1. Tape the cardboard in place around three sides of the habitat.
2. Gently and carefully add the worms and other small animals to the container. Replace the cover.
3. **Observe** Note where each animal goes once it is inside the container.

   ____________________________________________________________

   ____________________________________________________________

   ____________________________________________________________

4. **Observe** The next day check the container, and add water as needed to keep the soil moist.
5 **Record Data** Write down the location and activities of each animal. Describe any plant and animal interactions you observe. What changes are occurring on top of the soil? Beneath the soil? Record your data in the chart below.

<table>
<thead>
<tr>
<th>Watered Soil</th>
<th>Observations</th>
<th>Watered Soil</th>
<th>Observations</th>
<th>Watered Soil</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
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<td>SUN</td>
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</tr>
</tbody>
</table>

6 Repeat steps 4 and 5 for 2 to 3 weeks. Did the changes you recorded support your prediction?

---

**Communicate Your Results**

Have a class discussion, and share your results with the other students. What did you find out? Use your data to answer these questions.

- What changes did the animals cause in the plant habitat over time?

---
Were the worms, the soil, the plants, and other animals beneficial to each other? Explain.

Did you build an ecosystem? Why or why not?

If you built an ecosystem, identify the producers, consumers, and decomposers. What abiotic factors are important in your ecosystem?

Inquiry: Open

Design Your Own Ecosystem

Invent and test other ways to build an ecosystem. Make a prediction, and design an experiment to test your prediction. Record your data, and communicate your findings.

Make a poster that illustrates what you found out. Here are some ideas to get you started.

- Use a different kind of soil. How well does a plant habitat work with soil that is sandy or high in clay content? What types of plants will grow in these soils?
- Use different plants and animals. How do these organisms interact? Do these plants need more water? Less light?
- Use fish and plants to make a water ecosystem in an aquarium. What types of fish can share this ecosystem? What types of plants provide food for the fish? Can you add decomposers to your ecosystem?
Name __________________________ Date __________

My question: __________________________________________

My prediction: __________________________________________

My experiment: __________________________________________

My results: ____________________________________________
How can you find out what happens to thermal energy?

Inquiry: Structured

Mixing Warm and Cold Water

△ Be Careful. Wear safety goggles.

Ask Questions

How does the temperature of cold and warm water change when they are mixed together? Can you predict the result?

Make a Prediction

What will happen to the temperature of water that was mixed from warm and cold water? Write your answer as a prediction in the form “If warm and cold water are mixed together, then the temperature of the mixed water will . . .”

Materials

- measuring cup or beaker calibrated in milliliters (capacity of 100 milliliters or more)
- two clear 20-ounce plastic cups or two 500-milliliter beakers
- plastic spoon
- 2 thermometers
- warm tap water and cold (refrigerated) tap water
- safety goggles

Test Your Prediction

1 Measure and pour water into the plastic cups or beakers as indicated in the investigation guide, and measure and record the temperatures on the chart on the next page.

2 Pour the water from one cup or beaker into the other, and stir for a few seconds with the spoon.

3 Measure and record the temperature of the mixed water on the investigation guide. (It may take a minute for the thermometer to show the correct temperature.)
Mixing Warm and Cold Water Investigation Guide

<table>
<thead>
<tr>
<th>Test A</th>
<th>Beaker #1:</th>
<th>Beaker #2:</th>
<th>Beaker #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 mL COLD water</td>
<td>100 mL WARM water</td>
<td>200 mL MIXED water</td>
</tr>
<tr>
<td></td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test B</th>
<th>Beaker #1:</th>
<th>Beaker #2:</th>
<th>Beaker #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 mL COLD water</td>
<td>200 mL WARM water</td>
<td>300 mL MIXED water</td>
</tr>
<tr>
<td></td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test C</th>
<th>Beaker #1:</th>
<th>Beaker #2:</th>
<th>Beaker #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 mL COLD water</td>
<td>300 mL WARM water</td>
<td>400 mL MIXED water</td>
</tr>
<tr>
<td></td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test D (invent your own test)</th>
<th>Beaker #1:</th>
<th>Beaker #2:</th>
<th>Beaker #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>_____ mL COLD water</td>
<td>_____ mL WARM water</td>
<td>_____ mL MIXED water</td>
</tr>
<tr>
<td></td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
<td>Temperature: _______</td>
</tr>
</tbody>
</table>

4 Record Data Repeat steps 2 and 3 for Tests B, C, and D, writing down your data in the chart. Do you see any patterns?

Communicate Your Results
Have a class discussion, and share your results. What did you find out? Use your data to answer these questions:

- What do your results tell you about temperature changes when warm and cold water are mixed together?

- Based on the test results, can you state a general rule about what happens when liquids of different temperatures are mixed? Share your rule with the class.
Inquiry: Guided

Warming Up or Cooling Down

Ask Questions
How does wrapping a cup of warm or cold water in different materials affect how quickly the water in the cup cools down or warms up?

Make a Prediction
Write your answer as a prediction in the form “If a glass is wrapped in aluminum foil (or another material of your choice), then the temperature of the water it contains will heat (or cool) ________ than water at the same temperature in an unwrapped glass.”

Test Your Prediction
1 Refer to Cooling or Warming Water, Test #1, on the next page.
2 Decide whether you want to use warm or cold water. Circle Cooling on the table if you decide to start with warm water; circle Warming if you decide to start with cold water.
3 Fill two cups with the same amount of water. Measure and record the starting temperatures on the chart on the next page, making sure the temperatures are the same.
4 Choose a material, and wrap one cup in it. (The unwrapped cup is the control.)
5 Record Write down your choice of covering material on the chart.
6 Place the cups side by side in a safe place. Measure and record their temperatures on the chart every 3 minutes for 30 minutes.
7 **Use Numbers** Use your data to create a line graph. Put the temperature on the vertical axis and the time on the horizontal axis. Plot the changes in both cups of water on the same graph, using 2 colors or 2 types of lines (for example, solid and dotted) to distinguish between the covered cup and the (uncovered) control.

8 Repeat steps 2 through 7 for Test #2. You might start with cold water instead of warm water or vice versa, or you might use a different material to wrap one cup.

### Cooling or Warming Water

<table>
<thead>
<tr>
<th>Test #1:</th>
<th>What I Wrapped My Cup In:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time After Start</td>
<td>Control-Cup Temperature</td>
</tr>
<tr>
<td>0 minutes</td>
<td></td>
</tr>
<tr>
<td>3 minutes</td>
<td></td>
</tr>
<tr>
<td>6 minutes</td>
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<td>9 minutes</td>
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<td>12 minutes</td>
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<td>24 minutes</td>
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<td>27 minutes</td>
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</tr>
<tr>
<td>30 minutes</td>
<td></td>
</tr>
</tbody>
</table>

### Cooling or Warming Water

<table>
<thead>
<tr>
<th>Test #2:</th>
<th>What I Wrapped My Cup In:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time After Start</td>
<td>Control-Cup Temperature</td>
</tr>
<tr>
<td>0 minutes</td>
<td></td>
</tr>
<tr>
<td>3 minutes</td>
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<td>27 minutes</td>
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<td>30 minutes</td>
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</tr>
</tbody>
</table>
Communicate Your Results
Work in groups of four to eight, and discuss what you found out about the cooling or warming of the water.

> What did you observe? How did the temperatures change? Did different students have different results?

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

> Compare your data to your predictions. How do you explain what happened? Was there a difference between keeping the water cold and keeping the water warm? What is the difference?

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

Inquiry: Open
More Cool (and Hot) Experiments
Invent other ways to explore cooling off and heating up. Ask a question, make a prediction, design and perform an experiment to test your prediction, record your data, and communicate your findings. Make a poster to show what you did and what you found out. What did you observe? Here are some ideas to get you started.

> Where do ice cubes melt the fastest? Find out by having each student in your class place some ice cubes in a different container or on a different surface. For example, place ice in a cup of room-temperature tap water, in a cup of salt water, on a paper plate, on a metal pie plate, or in a glass with no water.

> Do different materials feel warmer, colder, or the same if subjected to the same temperature? Place a cotton towel and a metal spoon in a refrigerator for 2 hours. Take them out of the refrigerator. Which one of them feels coldest? Is the one that feels coldest really colder? Explain.
Would a cup of warm water cool faster if you put two metal spoons in the water? What if you put two plastic spoons in the water? Does it make a difference, and if so, why?

My question: ________________________________________________________________

My prediction: ______________________________________________________________

My experiment: ______________________________________________________________

My results: _________________________________________________________________
How can you model the energy of moving fluids?

Inquiry: Structured

Tracking the Movement of Wind

Ask Questions
Can a helium balloon be used as a tool for tracking moving air?

Make a Prediction
Write your answer as a prediction in the form “If the air in a classroom is moving, then a helium balloon will . . .”

Test Your Prediction

1. Tie one end of the string to the helium balloon. Punch a hole near the corner of each 3-inch by 5-inch index card, and tie the cards to the other end of the string, one at a time, until the balloon just begins to sink. Tear small pieces off the index cards until the balloon neither rises nor sinks.

2. Bring the balloon into a large room where it can float sideways or up and down. Choose a location, and let the balloon hang freely in the air.

3. Observe Keep your eye on the balloon. As the air in the room moves, the balloon will move with the air.

4. Record Data In the space on the next page, draw a picture of the room, and show the path the balloon has taken around the room.
Room and Balloon Paths

The air may be moving in different directions at different speeds in various locations in the room. Choose three more locations in the room, let the balloon hang freely in the air, and repeat steps 3 and 4, showing the path of each balloon in a different color or a different style of line.

Communicate Your Results
Have a class discussion, and share your drawings. With other students create a map that shows air movement in your classroom. Use your data to answer these questions:

▲ Is the air in the room moving? How did you reach your conclusion?

__________________________________________________________________________

▲ If the air in the room is moving, what causes the air to move?

__________________________________________________________________________
Does a balloon move at different speeds and in different directions at different locations in the room? How can you explain your observations?

Did your observations confirm your prediction?

Inquiry: Guided

Warm and Cold Water

Ask Questions
How can you use warm and cold water in a container to explain how mixing hot and cold fluids can make the fluids move?

Make aPrediction
Write your answer as a prediction in the form “If I mix warm and cold water, the warm water will ______ and the cold water will ______.”

Test Your Prediction

1. Use the paper punch to make two holes side by side in each film canister lid.

2. Fill the clear soda bottle with room-temperature water to within 5 centimeters of the top. Use the thermometer to determine the temperature of the water, and write it down on the chart on the next page.

Materials

- 2 empty, 35-millimeter film containers with smooth lids
- paper punch
- clear, 2-liter soda bottle with top 10 centimeters cut off
- room-temperature water
- thermometer
- hot tap water and cold (refrigerated) tap water
- red and blue food coloring
- 2 large beakers or cups
3 Fill one beaker with warm tap water, and add a few drops of red food coloring. Use the thermometer to determine the temperature of the water, and write it down on the chart.

4 Pour the red-colored water into the film container, and secure the lid.

5 Gently push the sealed film canister into the room-temperature water in the clear soda bottle to about halfway between the surface and the bottom, then turn the canister sideways.

6 Observe What happened to the colored water? Where did it go? Record your observations on the chart.

7 Repeat steps 2 through 6, substituting refrigerated water for the warm tap water and blue food coloring for red food coloring.

<table>
<thead>
<tr>
<th>Starting Temperature of Room-Temperature Water: ________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red-Colored Water</td>
</tr>
<tr>
<td>Starting temperature: ________</td>
</tr>
<tr>
<td>Observations:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Blue-Colored Water</td>
</tr>
<tr>
<td>Starting temperature: ________</td>
</tr>
<tr>
<td>Observations:</td>
</tr>
</tbody>
</table>

Communicate Your Results

Work in groups of four to eight, and discuss your findings.

- How did the warm, red-colored water move once it was in the room-temperature, clear water? Draw a picture that shows the path of the red-colored water within the soda bottle in the space at the right.
How did the blue-colored water move once it was in the room-temperature, clear water? Draw a picture that shows the path of the blue-colored water within the soda bottle in the space at the right.

Path of blue-colored water:

Develop a hypothesis that explains how hot and cold water or air causes ocean currents or wind to form.

How can this model help explain the way energy from the Sun gets distributed on Earth?
Inquiry: Open

Keep It Moving
Invent and test other ways to explore the movement of fluids. Design and perform an experiment. Ask a question, make a prediction, do an experiment to test your prediction, record your data, and communicate your findings. Make a poster to show what you did and what you found out. Here are some ideas to get you started:

- If you filled a balloon with warm water, would it float or sink in cold water? Would a balloon filled with cold water float or sink in warm water?
- Would a helium balloon that neither floats nor sinks move differently in a moving stream of warm air and one of cold air? Could you find out using a handheld hair dryer?
- What other experiments can you do with balloons to explore air currents?

My question: ____________________________________________________________

My prediction: __________________________________________________________

My experiment: __________________________________________________________

My results: ______________________________________________________________