How do Earth systems affect each other? In what ways do living things, solid Earth, the atmosphere, and Earth’s water interact?

By the end of this lesson . . .

you’ll be able to describe how Earth’s systems interact.
Can You Explain It?

Our food comes from interactions among Earth’s systems. The biosphere includes the farmer and plants. Water used by the plants is part of the hydrosphere. Plants grow in soil, which is part of the geosphere. Plants absorb and give off gases that are part of the atmosphere.

1. How do you think Earth’s systems are interacting in the image?

Tip
Learn more about Earth’s systems in What Are Earth’s Major Systems?.
Cycling and Recycling

The water cycle involves all of Earth’s systems. It takes place all over Earth, and it involves a variety of different processes.

Remember that a cycle is something that repeats over and over in a pattern. In the water cycle, water moves among and between Earth’s systems. It changes forms and locations. There are many different paths that water can take through the water cycle.

2. The main processes of the water cycle are evaporation, condensation, and precipitation. Name one feature in the diagram that is most directly related to each process.

EVIDENCE NOTEBOOK  In your Evidence Notebook, identify ways that Earth’s systems interact in the water cycle. Be sure to consider all four major Earth systems in your response.
What Goes Up . . .

Water on Earth changes form and location by moving through the water cycle. As water moves through the cycle, it interacts with all of Earth’s spheres. Several of the changes it undergoes in the water cycle demonstrate how the hydrosphere and atmosphere interact. **Evaporation** is the process by which a liquid changes to a gas. **Condensation** is the process by which a gas changes to a liquid. **Precipitation** is water that falls from clouds to Earth’s surface.

a. Evaporation is a process that requires energy. In the water cycle, the sun’s energy causes water to evaporate, or change from a liquid to a gas. Here, water is evaporating from the ocean.

b. As water vapor rises into the atmosphere, it loses some energy and condenses, or changes back to a liquid. Particles of water clump together around particles of dust, forming droplets.

c. Inside clouds, water droplets combine to form raindrops that fall to Earth.

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Do the Math

**How Big Is a Drop?**

3. How do the sizes of raindrops, dust particles, and water droplets compare? One way to compare the size of these objects is by ordering fractions. When you order fractions, you place them in sequence.

A water droplet is 1/100 the size of a rain drop. A dust particle is 1/1000 the size of a water droplet. The table shows the size of droplets and dust particles in relation to the size of raindrops. Order the fractions in the table, starting with the fraction that has the smallest value at the top.

<table>
<thead>
<tr>
<th>Fractions</th>
<th>Ordered Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/100</td>
<td></td>
</tr>
<tr>
<td>1/1</td>
<td></td>
</tr>
<tr>
<td>1/1000</td>
<td></td>
</tr>
<tr>
<td>1/10</td>
<td></td>
</tr>
</tbody>
</table>
Case Study: Water and Air Pollution Affects All the Spheres

You’ve learned that water moves through all of Earth’s spheres. As it moves through the water cycle, there are many chances for it to become polluted. Look at the images to see how human actions can affect Earth’s water.

This electrical energy generating station burns fossil fuels to produce the electricity people use. Notice that pollution is being released into the atmosphere.

In the short term, acid rain discolors buildings and statues. This lion statue is beginning to show the effects from acid rain.

In the long term, acid rain wears away even the hardest brick and stone. The detail in the lion’s face is nearly gone after decades of exposure to acid rain.
Look at the images below to see how pollution can spread through water.

This rainwater has become polluted. As it moves into the storm drain, the pollution is carried along with it.

The polluted rainwater enters a body of water. Now the pollution could affect the entire body of water and all the living things in and around it.

**HANDS-ON  Apply What You Know**

**Pollution in Action**

4. Food dye can be used to model pollution. Take a teaspoon or dropper of food dye, and add it to a cup of tap water. Observe what happens. Now pour the contents of that cup into a larger container of water. What happens?

5. Trees are part of the biosphere. They need water to survive. They take in water from the soil through their roots and release water vapor into the air from their leaves. Explain how this shows an interaction of all four of Earth’s spheres.
What Happens During the Water Cycle?

Objective

Collaborate to study the influence of oceans on the water cycle.

What question will you investigate to meet this objective?

Procedure

STEP 1 Label the plastic containers A and B. Make two identical clay landform models. Include a lake in each model.

Why do you think it is important that the landform models be identical?

STEP 2 Place the landform models on one end of each container. Each model should take up about ¼ of the space in its container. Stir 2 teaspoons of salt into 2 cups of water until the salt dissolves. Pour the salt water into the empty area in container A. Add 3 drops of fresh water to the lake in A and B.

How is the water in the model lakes different from the water in the model oceans?
STEP 3  Cover both containers with plastic wrap. Use a large rubber band to hold the plastic wrap in place.

Why is the plastic wrap important?

STEP 4  Place a small weight on the plastic wrap directly above the land in each model. Place both containers on a sunny windowsill. Two hours later, observe the models and record your observations.

Why is it important to place the model in a sunny area?

Analyze Your Results

STEP 5  After two hours, how did the amount of moisture on the underside of the plastic wrap compare in the two models?

STEP 6  Did you notice any change in the amount of water in the model lakes? If so, what caused the change?

Draw Conclusions

STEP 7  Make a claim about why there were differences between the two models. Cite evidence to support your claim.
The Sun’s Energy and Earth

If you step outside on a sunny day, you can feel the warmth of the sun’s light. Earth’s cycles and the processes associated with them rely on the sun’s energy. The sun’s energy moves outward in all directions. A tiny part of the sun’s total energy affects Earth’s spheres.

The sun has an essential role in the water cycle. Recall that evaporation occurs due to energy from the sun. Do the activity below to find out more about how energy from the sun reaches Earth.

**EXPLORATION 2**

**6.** Place a large sheet of black paper on a flat surface. Place two thermometers on the paper, one in the center and one near the edge. Place a desk lamp above the thermometer in the center of the paper. Measure the distance from the center thermometer to the other thermometer, and record the measurement. Turn on the lamp. Notice how the light strikes each of the thermometers. After three minutes, record the temperature on each thermometer. How did the distance from the center affect the angle at which light struck the thermometer? How does this model the way in which light strikes Earth?

**HANDS-ON  Apply What You Know**

**Let It Shine!**

**a.** At some locations, the sun’s rays do not hit Earth straight on. They strike at an angle. In these places, the energy is spread out over a bigger area. These areas are cooler.

**b.** Near the equator, the sun’s rays strike Earth at a 90° angle. The energy does not spread out. These areas are warmer because more energy is focused on a smaller area.
Not all of the sun’s energy that moves toward Earth strikes Earth’s surface.

a. About 9% of the sun’s energy is reflected by particles in the atmosphere; another 23% is reflected by clouds.

b. 2% of the sun’s energy reaches Earth’s surface but then is reflected by features such as ice and snow.

c. About 47% of the sun’s energy is absorbed by Earth’s surface. About 19% is absorbed by the atmosphere and clouds.

**7. Language SmArts** Summarize the information about the sun’s energy and Earth by stating a main idea and two supporting details about the topic.

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**8.** Choose the correct words to complete each sentence.

<table>
<thead>
<tr>
<th>warmer</th>
<th>cooler</th>
<th>all</th>
<th>about half</th>
<th>precipitation</th>
<th>evaporation</th>
</tr>
</thead>
</table>

Places where the sun’s energy strikes straight on are ____________ than places where the sun strikes at a lesser angle. About 25% of the sun’s energy that reaches Earth is reflected by clouds, the atmosphere, and Earth’s surface. ____________ of the sun’s energy is absorbed by Earth’s surface. In the water cycle, the process of ____________ is fueled by the sun’s energy.
Where the Wind Blows

When the sun’s energy heats Earth, it provides the energy that powers the water cycle. Winds also affect the water cycle. Wind over a body of water can increase evaporation and lead to precipitation.

Warm air near the equator rises in the atmosphere. Cool air from areas closer to the poles flows toward the equator to fill the void left by the rising warm air. This movement of air is wind. Wind also forms because of temperature differences over land and water. Land heats up and cools down more quickly than water. On a sunny day, air over the land warms and rises, and cooler air over the water flows inland, creating a “sea breeze.”

9. Explain how winds are related to the water cycle.

EVIDENCE NOTEBOOK  In your Evidence Notebook, identify an effect of the uneven heating of land and air on Earth.
You’ve learned that Earth’s spheres affect one another. Look at the images and think about how these pictures show a connection between the geosphere, hydrosphere, and atmosphere.

The Sierra Nevada mountain range in the western United States is about 400 km long. This landform is a part of the geosphere that affects the atmosphere and the hydrosphere.

Death Valley is the driest part of the United States. Its average rainfall is less than 5 cm per year! Why is it so dry? And how does this affect the living things in Death Valley?

Winds carry moist air from the Pacific Ocean inland toward the Sierra Nevada. As the moist air rises up the west side of the mountains, it cools. The water vapor condenses. Rain and snow fall west of the mountains. When the air goes down the other side of the mountains, it contains very little water. The dry side is called a rain shadow because it gets very little rain. Death Valley is in a rain shadow.

Putting It Together

10. Explain how rain shadows illustrate the interactions of all four of Earth’s spheres.
Agents of Change: Wind, Water, Ice, and Organisms

Weathering and erosion are processes that cause changes to the geosphere. Recall that weathering is the breaking down of rocks on Earth’s surface into smaller pieces. Erosion is the process of moving sediment from one place to another.

What are some causes of weathering and erosion? View the images to explore how weathering and erosion demonstrate interactions between Earth’s spheres. Look for examples of interactions between the geosphere and the atmosphere, biosphere, and hydrosphere.

Paria Canyon was formed mostly by weathering and erosion caused by wind. This canyon, located near the border of Arizona and Utah, is home to many beautiful sandstone formations.

The Grand Canyon was formed by the flowing water of the Colorado River. As the water flowed over the rocks in the area, weathering occurred. The moving water broke the rock into smaller pieces and eroded, or moved, it.
A lot of the fresh water on Earth is frozen in glaciers, which are giant sheets of ice. Glaciers move slowly over Earth’s surface, causing weathering and erosion. These grooves in Earth’s surface were formed as glaciers dragged rocks along the surface.

Living things also cause weathering. This tree is one example. As the tree grows, its roots break apart, or weather, the rock. Some vines can cause weathering by climbing up rock walls and extending roots into small pores and cracks. As the roots grow, the rock can break.

11. Fill in the chart to show how weathering and erosion can affect Earth’s spheres.

<table>
<thead>
<tr>
<th>Sphere</th>
<th>Effects of weathering and erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td></td>
</tr>
<tr>
<td>Biosphere</td>
<td></td>
</tr>
<tr>
<td>Geosphere</td>
<td></td>
</tr>
<tr>
<td>Hydrosphere</td>
<td></td>
</tr>
</tbody>
</table>

**EVIDENCE NOTEBOOK** In your Evidence Notebook, describe examples of weathering and erosion in the schoolyard or around your neighborhood.
Natural Disasters Affect the Spheres

Volcanoes are a part of the geosphere. A volcanic eruption starts in the geosphere but can affect all of Earth’s spheres.

When a volcano erupts, lava flows out of it after moving through the crust as magma, or melted rock. Hot gases and ash are also ejected from the volcano. How do these products of an eruption affect the atmosphere and biosphere?

Gases and particles from the volcano mix with the atmosphere. The gases can affect the way sunlight is reflected by the atmosphere. The particles can block incoming sunlight. Volcanic eruptions can have a major impact on the weather.

Volcanic eruptions can also impact the biosphere. Plants and animals can be affected by lava and ash. Eruptions can also cause long-term changes in nearby soils. Deposits of volcanic material make rich soil that’s good for growing some types of plants.

12. Describe ways that volcanic eruptions affect the biosphere. Consider also how an impact on the atmosphere could in turn affect the biosphere.
Case Study—Soil

The geosphere includes the rocks and soil that cover Earth’s surface. Recall that soil is made of bits of weathered rock mixed with once-living materials. Air and water are also found in soil. The formation of soil is a great example of a process that involves all four spheres of Earth.

Weathered bits of rock, remains of once-living things, air, and water are all found in soil. Weathering of rocks can occur due to interactions of the geosphere with the biosphere, the atmosphere, or the hydrosphere.

For example, plant roots can break apart rocks. Wind blowing over the surface of rocks can weather and erode rocks. Water that gets into cracks in rocks can freeze and thaw, breaking apart rocks.

The weathered bits of rock mix with the remains of once-living things, air, and water to form soil. When plants grow in the soil, they too die, and parts of them mix with the soil.

13. Describe a cause-and-effect relationship among at least two of Earth’s spheres that leads to soil formation. Make sure to use language that clearly connects a specific cause and effect.
How the Biosphere, Geosphere, and Atmosphere Interact

**Carbon and Nitrogen Cycles**

Matter cycles through Earth’s spheres. It moves among the spheres and is combined and recombined in different ways. Recall that water moves among Earth’s spheres through the water cycle. The sun provides energy to the water cycle. Energy is vital to the cycles of matter.

The carbon cycle shown is important to the biosphere. But a larger version of the carbon cycle also impacts gases in the atmosphere, the weathering of rocks of the geosphere by those gases, and the particles that end up in oceans of the hydrosphere.

**EXPLORATION 4**

**a.** During photosynthesis, producers use energy from sunlight to change carbon dioxide and water into food. Consumers get energy when they eat the producers or other consumers.

**b.** Living things release carbon dioxide during respiration, when they break down food molecules to release the matter and energy in them. Carbon dioxide is a waste product of respiration.

**c.** Carbon is found in living things. When organisms die, their bodies may not decompose completely. Instead, they are changed over time into fossils or fossil fuels.

**d.** When fossil fuels are burned, the carbon and energy in the fossil fuels are released. Carbon that is released during the burning of fossil fuels enters the atmosphere.
Nitrogen fixing bacteria can change nitrogen in the atmosphere to a form that can be used by living things. Plants use nitrogen. When animals eat plants, they absorb some of that nitrogen, and it becomes a part of the animals’ bodies. Humans can affect the nitrogen cycle by producing and using nitrogen-containing fertilizers needed by plants for growth. Decomposers release nitrogen back into the soil, providing the nutrition for plants.

14. Choose the correct words to complete each sentence.

<table>
<thead>
<tr>
<th>taken in</th>
<th>released by</th>
<th>fossil fuels</th>
<th>food molecules</th>
</tr>
</thead>
<tbody>
<tr>
<td>producers</td>
<td>decomposers</td>
<td>make</td>
<td>fix</td>
</tr>
</tbody>
</table>

Respiration is a process that results in carbon being ____________ by organisms. Carbon in the atmosphere taken in by plants can be used in the formation of ____________ during the process of photosynthesis. Carbon and nitrogen in the remains of once-living things is released by the action of ____________. Bacteria play a key role in the nitrogen cycle when they ____________ nitrogen.
Case Study—Glen Canyon Dam

Humans are a part of the biosphere. Human actions can impact all of Earth’s spheres. The Glen Canyon Dam is an example of the ways in which human activities influence Earth’s spheres and systems. There are advantages and disadvantages to all human activities.

The Glen Canyon Dam in Arizona produces hydroelectric energy for many people. It helps prevent flooding of the Colorado River by controlling how much water flows downstream. Construction of the dam decreased the number of fish in the river and permanently changed the movement of sediment in the Colorado River.

Lake Powell was formed by the construction of Glen Canyon Dam. It stores water that is released in a controlled way during droughts. Recent droughts have resulted in extremely low water levels in Lake Powell. Many species that lost their habitat when the dam was built. Lake Powell also affects long term weather patterns in Utah.

15. What are some advantages of the Glen Canyon Dam and Lake Powell? What are some disadvantages?

Putting It Together

16. Provide evidence to support the argument that organisms in the biosphere affect all of Earth’s spheres.
Measuring Weather Across the Spheres

When you think of weather, you might think of the conditions right outside your door. But weather happens all around Earth. Weather is the result of the interactions of Earth’s spheres.

To prepare weather forecasts and to warn people of possible hazardous weather, scientists need to gather data about the weather all around Earth. Not just on land but in locations over the oceans as well. They also need to know about conditions high up in the atmosphere. The data are analyzed and combined to help scientists understand how Earth’s spheres interact and predict upcoming weather.

A weather station buoy is a technology used to gather data on the ocean. Weather station buoys collect and record data about air temperature, wind speed, wave heights, and air pressure.
Satellites orbit Earth. Some are equipped to gather data about weather conditions, such as cloud cover. They are also used to gather data about the paths of large storms. These bits of information are transmitted back to Earth, where they can be analyzed.

Weather balloons are used to carry technology called radiosondes. A radiosonde measures weather factors such as air temperature, air pressure, and the amount of water in the air, or humidity.

Technology is also used to gather weather data on land. Weather stations gather information about conditions such as air temperature and pressure, and they measure and record precipitation. Some use radar to gather data.

17. Think about what you’ve learned about Earth’s systems and how they interact. Use one or more specific things you’ve learned as evidence to support an argument that many different technologies in many different locations are required to develop a good understanding of weather conditions on Earth.
LESSON 2

Lesson Check

Can You Explain It?

1. Now that you’ve learned more about Earth’s spheres, explain what you see in the image as an interaction of all four spheres. Be sure to do the following:
   • Identify the four spheres of Earth.
   • Describe how each of the spheres is involved with growing crops.
   • Identify and describe one specific interaction of spheres.

   EVIDENCE NOTEBOOK Use the information you’ve collected in your Evidence Notebook to help you answer these questions.

Checkpoints

2. Which best describes a rain shadow? Circle the correct answer.
   a. a location that receives very little rain due to mountains or hills blocking winds
   b. an area where the sun’s rays strike Earth directly, leading to lots of evaporation
   c. a location where rain causes a great amount of erosion, resulting in moisture in the atmosphere
3. Which of these processes are directly involved in the water cycle? Circle all that apply.
   a. evaporation  
   b. erosion  
   c. condensation  
   d. weathering  
   e. precipitation

4. Which best describes the interaction shown in this image? Circle the correct answer.
   a. the atmosphere affecting the hydrosphere  
   b. the biosphere affecting the geosphere  
   c. the hydrosphere affecting the biosphere  
   d. the geosphere affecting the atmosphere

5. Which of these explain(s) what happens when fossil fuels are burned? Circle all that apply.
   a. The amount of carbon in the atmosphere increases.  
   b. Nitrogen is changed to a more usable form.  
   c. The amount of carbon stored in the ground decreases  
   d. Nitrogen is stored in the ocean.

6. Draw lines to match the processes with the cycles of matter they are part of.

   **Nitrogen cycle**
   - Bacteria carry out fixation.

   **Carbon cycle**
   - Photosynthesis takes place.
   - Decomposers break down dead organisms.
   - Crops are fertilized.
   - Respiration takes place.

   **Both cycles**
LESSON 2

Lesson Roundup

A. Draw a line to match each term to its definition.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporation</td>
<td>Water that falls from clouds to Earth’s surface</td>
</tr>
<tr>
<td>Condensation</td>
<td>The process by which a liquid changes into a gas</td>
</tr>
<tr>
<td>Precipitation</td>
<td>The process by which a gas changes into a liquid</td>
</tr>
</tbody>
</table>

B. Draw a line to match each sphere to how it is affected by a volcanic eruption.

<table>
<thead>
<tr>
<th>Sphere</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>New rock is produced and soil is enriched.</td>
</tr>
<tr>
<td>Geosphere</td>
<td>Plants and wildlife can be harmed by flowing lava.</td>
</tr>
<tr>
<td>Biosphere</td>
<td>Hot gases and ash are released into the air.</td>
</tr>
</tbody>
</table>

C. Choose the word that correctly completes each sentence.

Near the equator, the sun’s rays strike Earth __________. These areas are warmer. Wind is one effect of the __________ heating of Earth’s surface. __________ air near the equator rises in the atmosphere. __________ air flows from the poles toward the equator.

D. Choose the word that correctly completes each sentence.

The carbon cycle is an example of how Earth’s spheres interact. For example, carbon from the atmosphere is taken in by living things and used for __________. __________ release carbon into the soil when they break down dead organisms. The process of __________ releases carbon into the environment, including the atmosphere and hydrosphere.