# Lesson 2 | Interactions of Earth Systems

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How do some Earth systems interact?

Earth’s systems constantly interact with each other. In this activity, you’ll model some common interactions.

**Procedure**

1. Read and complete a lab safety form.
2. Place a **plastic container** on a sheet of **newspaper**. In one end of the container, mold about 5 cups of **soil** into a landform of your choice.
3. Hold a **hair dryer** about 20 cm from the model landform. Using the hair dryer set on low, blow air across the model landscape for 1 min. Be careful not to blow the soil out of the container. Record your observations in the Data and Observations section below.
4. Using a **spray bottle**, spray **water** onto your landform. Record your observations.

**Data and Observations**

**Think About This**

1. How did you use the materials in this activity to model Earth’s systems?

2. How could you improve your model? What changes would you make?

3. **Key Concept** Describe how Earth systems interacted in your model.
Interactions of Earth Systems

Directions: Each of the sentences below is false. Make the sentence true by replacing the underlined word(s) with a term from the list below. Write your changes on the lines provided. NOTE: You may need to change a term to its plural form.

- climate
- condensation
- evaporation
- precipitation
- pressure
- process
- rock cycle
- transpiration
- water cycle
- weather
- uplift

1. Through the process of **uplift**, plants release water vapor from their leaves.

2. Yesterday was warm and sunny, but the **climate** changed overnight; this morning, it is cold and rainy outside.

3. **Condensation** produces the water vapor in our atmosphere.

4. Rain and snow are two main forms of **evaporation**.

5. The **rock cycle** includes many **pressures** that transport and continuously change rocks into different forms.

6. The **water cycle** produces igneous, sedimentary, and metamorphic rocks.

7. Clouds form due to the **precipitation** of water into tiny droplets.

8. Mountains may be formed by **weather**, which moves large bodies of Earth materials to higher elevations.

9. Metamorphic rocks form due to conditions of high temperatures and **transpiration**.

10. The **rock cycle** moves water through the hydrosphere, atmosphere, geosphere, and biosphere.

11. The average weather pattern for an area over a long period of time can best be described as **process**.
Interactions of Earth Systems

A. The Water Cycle

1. The continuous movement of water on, above, and below Earth’s surface is called
   the __________________ cycle.

2. The energy to move water and allow it to change __________________, from
   an __________________ to a gas or a solid ultimately comes from
   the __________________.

3. The process by which a liquid, such as water, changes into a gas is
called __________________.

4. About 90% of the water vapor in Earth’s atmosphere enters through
   __________________ from the __________________ and other bodies
   of water.
   a. About 10% of the water enters the atmosphere through
      __________________, during which plants release water vapor through
      leaves.
   b. Water vapor also enters the atmosphere through __________________,
      which takes place in many cells and produces water and carbon dioxide.

5. As water rises through the troposphere and cools, it changes from an
   __________________ to an __________________ through the
   process of condensation; when the tiny drops of water come together, they
   form __________________.

6. __________________ is moisture that falls to Earth’s surface.

B. Changes in the Atmosphere

1. Most changes that take place in the atmosphere take place in
   the __________________.

2. The state of the atmosphere at a particular time and place is called
   the __________________.
   a. The average amount of energy produced by the motion of air molecules is
      air __________________.
   b. The force exerted by air molecules in all directions is called
      air __________________.
Lesson Outline continued

c. The movement of air caused by differences in air pressure is ________________.

d. The amount of water vapor in a given volume of air is ________________; clouds and precipitation are more likely when ________________ is high.

3. The average weather pattern for a region over a long period of time is called ________________.
   a. ________________ can affect the amount of precipitation an area receives by causing the ________________ effect.
   b. ________________ blowing the ocean causes ________________ currents in the water that flow like rivers, moving the ________________ energy in water from place to place.

C. The Rock Cycle

1. The series of processes that transport and continually change rocks into different forms is called the ________________ cycle.

2. When magma or lava cools and crystallizes, it becomes ________________ rock.

3. The process that moves large bodies of Earth materials to higher elevations is called ________________.

4. The process by which glaciers, wind, water, and the activities of ________________ break down rock into sediments is called ________________; the process by which glaciers, wind, or water carry sediments to new locations is called ________________.

5. Due to erosion, ________________ are deposited in layers, one on top of the other.

6. The weight of upper layers of sediments pushes down on underlying sediment ________________. Water surrounding the sediments often contains dissolved ________________, which crystallize, and cement the sediments together, forming ________________ rock.

7. ________________ rock forms when any kind of rock is subject to high temperatures and ________________ deep below Earth’s surface.
How do plants contribute to the water cycle?

You have learned how water moves through Earth systems. How does the biosphere contribute to the water cycle?

Procedure

1. Read and complete a lab safety form.
2. Choose a **potted plant**.
3. Carefully slide the plant into a **self-sealing plastic bag**. Close the bag tightly.
4. Place your bag on a sunny windowsill and leave it undisturbed overnight.
5. Observe the plant and the bag. Record your observations in the Data and Observations section below.

Data and Observations

Analyze and Conclude

1. **Recognize** Where did the moisture in the bag come from?

2. **Identify** What process of the water cycle did you model?

3. **Key Concept** How does your model show interactions among Earth systems?
Interactions of Earth Systems

Directions: Complete the crossword puzzle with the correct terms from the word bank. If an answer has two words, do not leave any spaces.

climate  condensation  evaporation  precipitation  rock cycle
transpiration  uplift  water cycle  weather

Across
1. moisture that falls from clouds to Earth’s surface
3. process by which a gas changes to a liquid
5. series of processes that transport and continually change rocks into different forms
7. process by which a liquid changes into a gas
9. average weather patterns for a region over a long period of time

Down
2. process that moves large bodies of Earth materials to higher elevations
4. continuous movement of water on, above, and below Earth’s surface
6. the state of the atmosphere at a certain time and place
8. process by which plants release water vapor through their leaves
Interactions of Earth Systems

Directions: On each line, write the term that correctly completes each sentence.

1. Liquid water evaporates into a gas called ________________.

2. About 10 percent of the water that evaporates is produced by plants during ________________.

3. A(n) ________________ forms when millions of water droplets in the atmosphere come together.

4. Rain and snow are kinds of ________________.

5. Igneous rocks form when magma ________________ and ________________.

6. The process of ________________ breaks down rocks into sediments.

7. The process of ________________ carries sediments to new locations.

8. ________________ rocks form when high temperatures and pressure change rocks.
Word-Usage Activity: Adding the Suffix –tion

Many verbs can be made into nouns by adding the ending –tion.

**Verb**  
retract

**Noun**  
retraction

In many cases, the final –e of the verb is dropped. Some verbs will need another letter added before adding the ending –tion.

**Verb**  
observes

**Noun**  
observation

_directions:_ Read the following sentences. Change each verb in parentheses to a noun and write the correct form on the line.

1. Some of the water in Earth’s atmosphere is produced by plants through the process of (transpire) ________________________.
2. (Evaporate) ________________________ is the process that changes water into gas.
3. Because of the large amount of (precipitate) ________________________, our soccer game was cancelled.
4. Clouds form when millions of water droplets come together through (condense) ________________________.
5. On Earth’s surface, many (interact) ________________________ among the hydrosphere, the geosphere, and the atmosphere take place.
6. As magma cools below the surface of Earth, (crystallize) ________________________ takes place and changes the molten material into igneous rock.
7. (Cement) ________________________ occurs when minerals dissolved in surrounding water crystallize between grains of sediment.
8. The process of uplift has the ability to move a large body of Earth material to a higher (elevate) ________________________.
Language Arts Support

LESSON 2

Word-Usage Activity: Greek Prefixes

A prefix is a word part that is used before the main part, called the root, of a word. The prefix can change the meaning of the root word. For example, the words *atmosphere* and *hydrosphere* have the same root, but different prefixes. The prefixes give these words different meanings. Many prefixes have Greek origins. The meanings of eight prefixes with Greek origins are given in the table below.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Greek Origin</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>atmo–</td>
<td>atmos</td>
<td>vapor</td>
</tr>
<tr>
<td>bio–</td>
<td>bios</td>
<td>life</td>
</tr>
<tr>
<td>exo–</td>
<td>exō</td>
<td>outside</td>
</tr>
<tr>
<td>geo–</td>
<td>geō</td>
<td>Earth</td>
</tr>
<tr>
<td>hydro–</td>
<td>hudro</td>
<td>water</td>
</tr>
<tr>
<td>meso–</td>
<td>mesos</td>
<td>middle</td>
</tr>
<tr>
<td>meta–</td>
<td>meta</td>
<td>beside, after</td>
</tr>
<tr>
<td>thermo–</td>
<td>thermē</td>
<td>heat</td>
</tr>
</tbody>
</table>

Directions: Study the Greek prefixes above and their meanings. On the line before each phrase, write the letter of the term that matches it correctly.

_____ 1. all of Earth’s water
_____ 2. air that surrounds Earth
_____ 3. the last atmospheric layer before outer space
_____ 4. temperature increases in this atmospheric layer
_____ 5. all living things
_____ 6. existing rock changed into new rock
_____ 7. the solid part of Earth
_____ 8. between the stratosphere and the thermosphere

A. mesosphere  
B. hydrosphere
C. thermosphere
D. metamorphic
E. exosphere
F. atmosphere
G. biosphere
H. geosphere
Use a Formula

Vapor density, measured in g/m³, is the amount of water vapor in air. The maximum amount of water vapor that air can hold depends on temperature. Relative humidity (RH) compares the actual vapor density to the maximum vapor density. RH is calculated using the formula:

\[ \text{RH} = \left( \frac{\text{actual vapor density}}{\text{maximum vapor density}} \right) \times 100\% \]

At 30°C, air can contain a maximum of 30.4 g/m³ of water vapor. If the air contains 22.8 g/m³ of water vapor, what is the RH?

Step 1 Identify the values given in the problem.
- actual vapor density = 22.8 g/m³
- maximum vapor density = 30.4 g/m³

Step 2 Put the values into the formula and solve.

\[ \text{RH} = \left( \frac{22.8 \text{ g/m}^3}{30.4 \text{ g/m}^3} \right) \times 100\% \]

\[ \text{RH} = 0.75 \times 100\% \]

\[ \text{RH} = 75\% \]

Practice

1. At 30°C, air can contain a maximum of 30.4 g/m³ of water vapor. If the air contains 9.12 g/m³ of water vapor, what is the RH?

3. At 10°C, a sample of air contains 4.7 g/m³ of water vapor. If air can contain a maximum of 9.4 g/m³ of water vapor at that temperature, what is the RH?

2. At 24°C, air has a maximum vapor density of 23 g/m³. If the air contains 4.14 g/m³ of water vapor, what is the RH?

4. At 0°C, air can contain a maximum of 4.85 g/m³ of water vapor. If the air has an actual vapor density of 4.51 g/m³, what is the RH?
Interactions of Earth Systems

Directions: Use your textbook to answer each question or respond to each statement.

1. Earth’s biosphere includes all living things. Earth’s hydrosphere includes all of the water on Earth.
   Name two ways in which parts of the biosphere interact with the hydrosphere.

2. Earth’s atmosphere is the mix of gases that surrounds the planet.
   How do plants and animals interact with the atmosphere?

3. Earth’s geosphere is the solid part of the planet. The geosphere includes rocks, soil, and minerals.
   Explain how interactions among the geosphere, atmosphere, and hydrosphere affect weather and climate.

4. Earth’s geosphere also interacts with the water on Earth.
   How do interactions between the geosphere and hydrosphere produce sedimentary rocks?
**Key Concept Builder**

**LESSON 2**

**Interactions of Earth Systems**

**Key Concept**  How does the water cycle show interactions of Earth systems?

**Directions:** Complete the concept map by writing the correct term or phrase from the word bank in the space provided. Each term is used only once.

- condensation
- Plants release water vapor through their leaves.
- transpiration
- Liquid changes into gas.
- precipitation

**The Water Cycle**

- evaporation
- Gas changes to liquid.
- Moisture falls from clouds.

**Directions:** Respond to each statement on the lines provided.

1. Use the concepts of transpiration and respiration to show interactions between the atmosphere and the biosphere.

2. Use the concept of precipitation to show interactions between the atmosphere and the geosphere.
Key Concept Builder

LESSON 2

Interactions of Earth Systems

Key Concept  How does weather show interactions of Earth systems?

Directions: On the line before each statement, write the letter of the correct answer.

1. The state of the atmosphere at a given time and place is called
   A. climate.
   B. erosion.
   C. weather.

2. The measure of the average amount of energy produced by the motion of air molecules is
   A. wind.
   B. pressure.
   C. air temperature.

3. The force exerted by air molecules in all directions is
   A. wind.
   B. humidity.
   C. air pressure.

4. Wind is the movement of air caused by differences in
   A. humidity.
   B. air pressure.
   C. temperature.

5. The amount of water vapor in a given amount of air is
   A. wind.
   B. humidity.
   C. temperature.

6. Clouds are more likely to form when
   A. humidity is high.
   B. air pressure is high.
   C. air temperature is high.
Interactions of Earth Systems

Key Concept  How does weather show interactions of Earth systems?

Directions:  Answer each question on the lines provided.

1. What is climate?

2. What is one reason that climates differ?

3. How can mountains affect climate?

4. How can ocean currents affect climate?

Directions:  Draw a rain-shadow effect in the space provided.  Be sure to label your drawing. Use arrows to show the direction of the wind.
Interactions of Earth Systems

Key Concept How does the rock cycle show interactions of Earth systems?

Directions: On each line, write the term from the word bank that correctly completes each sentence. Each term is used only once.

- cemented
- compacted
- deposited
- erode
- igneous
- lava
- metamorphic
- rock cycle
- sedimentary
- uplift
- weather

The (1.) ____________ is the series of processes that transport and continually change rocks into different forms. Magma located inside the geosphere can flow onto Earth’s surface, where it is called (2.) ________________. When magma cools and crystallizes, it forms (3.) ________________ rock.

(4.) ________________ is the process that moves large bodies of Earth materials to higher elevations. Rocks that are deep below Earth’s surface can move up to the surface.

There, wind and water can (5.) ________________ and (6.) ________________ the rocks. These processes change the rocks into sediments.

Over time, the sediments are (7.) ________________ in new places. The weight of overlying sediments pushes down on underlying layers. The sediments are (8.) ________________ and (9.) ________________ together. These processes form (10.) ________________ rocks. Rocks can be buried deep within Earth where pressures and temperatures are extreme. The high pressure and temperatures change the rocks into (11.) ________________ rocks.
**Snowball Earth**

Recently, researchers have hypothesized that, between 800 and 550 mya, ice sheets covered all continents, and the world’s oceans froze over, encasing the globe in a 1-km-thick shell of ice. Researchers call this ice age Snowball Earth.

The main evidence for this Precambrian glaciation is based on a rock called tillite. The glacial till of the Pleistocene (our most recent ice age) is an unsorted mixture of boulders, silt, and clay that looks like loose gravel. Tillite is made of the same materials as till, but it was deposited by glaciers so long ago that it has become cemented into hard rock. Two thick layers of tillite between 750 and 580 million years old have been found on almost every continent. In some localities, the glacial deposits were found on top of limestone layers.

Researchers hypothesize that these ancient till deposits resulted from fluctuations of carbon dioxide concentrations in the atmosphere. Carbon dioxide absorbs heat in the atmosphere and warms the Earth; if carbon dioxide is removed from the atmosphere, the atmosphere and Earth cool. Two groups of researchers offer different explanations about the formation of Snowball Earth.

**Ridgwell and Team’s Explanation, 2003**

**Part A.** Carbonate ions in seawater combined with atmospheric carbon dioxide, removing the carbon dioxide from the atmosphere. As atmospheric carbon dioxide decreased, the atmosphere cooled.

**Part B.** Primitive organisms in the shallow waters of continental shelves combined carbonate ions with dissolved calcium and formed limestone deposits. Minor glaciers lowered sea level by about 100 meters, and most of the continental shelves became exposed above water. This reduced the amount of carbonate ions used to form limestone, leaving more ions to extract carbon dioxide from the atmosphere. This led to global atmospheric cooling, the growth of glaciers, and an increase in the amount of sunlight and heat reflected back into space, cooling Earth more, and resulting in the glaciers of Snowball Earth.

**Donnadieu’s Explanation, 2004**

**Part A.** Weathering of continental silicate removed carbon dioxide from the atmosphere and formed limestone in the ocean. The decrease in atmospheric carbon dioxide resulted in global cooling.

**Part B.** Between 800 and 700 mya, the supercontinent Rodinia broke apart, exposing more coastline to the ocean. Coastal rainfall and runoff increased weathering, which decreased atmospheric carbon dioxide, cooling Earth. Glaciers expanded, the ice and snow reflected more sunlight back into space, and the glaciers grew larger until they covered all continents, and the sea froze over, resulting in Snowball Earth.

**Applying Critical-Thinking Skills**

**Directions:** Respond to each statement.

1. **Define** Snowball Earth.

2. **Compare** the mechanisms provided by the two explanations for the formation of Snowball Earth.
Earth System Interactions: Then and Now

All of Earth might have been a harsh environment 800 to 600 million years ago. According to the Snowball Earth hypothesis, the entire planet might have been covered with ice during the late Proterozoic eon. Ice is thought to have formed at Earth’s poles and spread all the way to its equator. The Snowball Earth hypothesis suggests that changes in the atmosphere caused the surface of Earth to completely freeze over. The Snowball Earth hypothesis involves interactions between all four of Earth’s systems: the geosphere, hydrosphere, atmosphere, and biosphere.

Draw and Compare Graphic Organizers

1. Draw a flow chart that shows the carbon interactions between Earth’s four systems during the development and formation of Snowball Earth.

2. Draw a parallel flow chart that shows the carbon interactions between Earth's four systems as they are happening today.

3. Identify three major differences between the chart describing interactions in the time of Snowball Earth and the chart describing the interactions occurring on Earth today.
How do Earth’s systems interact?

You’ve learned about the rock cycle and the water cycle. These are just two examples of how Earth systems work together. Each system interacts with the others to help maintain an ecological balance on Earth. What happens if one system is disrupted?

Ask a Question
How does a change in one system affect other systems? How can you model interactions among Earth systems?

Materials
beaker      water      lamp      terrarium      small fan      sand

Safety

Make Observations

☐ 1. Read and complete a lab safety form.

☐ 2. Think about Earth’s four systems and how they interact with each other.
   ☐ Describe a real-world scenario that shows these interactions. The photos in your textbook show examples of real-world scenarios.

☐ 3. Use the materials listed, or make a list of your own materials. Then, design a model of your scenario.
   ☐ Think about the following as you plan your model:
   • How can you represent each of Earth’s systems?
   • How will you show the systems interacting?
   • Will your model be self-contained or open to the air?
Lab A continued

Form a Hypothesis

4. After your teacher approves your design, build your model according to your design plans.

5. After building your model, formulate a hypothesis on how a change in one system might affect the other systems.

Test Your Hypothesis

6. Add or take away something in your model to cause one system to change.
   - Is the change realistic? Could this happen in real life?

7. Observe and record the results immediately after the change occurs.
   - Examine your model again on the following day. Be sure to record the results.

<table>
<thead>
<tr>
<th>Time of Change to System</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Change</td>
<td></td>
</tr>
<tr>
<td>Day After Change</td>
<td></td>
</tr>
</tbody>
</table>
Lab A continued

Analyze and Conclude

8. Identify Which parts of your model represent each system?

9. Summarize how the change you made to one system affected the others.

10. Interpret Was the change you modeled helpful or harmful?

Was it caused by human activities or natural events? Explain.

11. The Big Idea Earth is sometimes described as a rocky planet. Based on what you observed in this lab, does that statement accurately describe Earth?

Why or why not?

Communicate Your Results
Take your classmates on a “tour” of your model. Point out each Earth system, explain your hypothesis, recreate the change you introduced, and describe your results. Invite your classmates to ask questions and offer suggestions about improving your model.

Remember to use scientific methods.

Make Observations

Ask a Question

Form a Hypothesis

Test your Hypothesis

Analyze and Conclude

Communicate Results
How do Earth’s systems interact?

You’ve learned about the rock cycle and the water cycle. These are just two examples of how Earth systems work together. Each system interacts with the others to help maintain an ecological balance on Earth. What happens if one system is disrupted?

Ask a Question
How does a change in one system affect other systems? How can you model interactions among Earth systems?

Materials
beaker    water    lamp    terrarium    small fan    sand

Safety

Make Observations
1. Read and complete a lab safety form.
2. Think about Earth’s four systems and how they interact with each other. Describe a real-world scenario that shows these interactions. The photos in your textbook show examples of real-world scenarios.

3. Use the materials listed, or make a list of your own materials. Then, design a model of your scenario. Think about the following as you plan your model:
   • How can you represent each of Earth’s systems?
   • How will you show the systems interacting?
   • Will your model be self-contained or open to the air?
Lab B continued

4. After your teacher approves your design, build your model according to your design plans.

Form a Hypothesis

5. After building your model, formulate a hypothesis on how a change in one system might affect the other systems.

Test Your Hypothesis

6. Add or take away something in your model to cause one system to change. Is the change realistic? Could this happen in real life?

7. Observe and record the results immediately after the change occurs. Examine your model again on the following day. Be sure to record the results.

Analyze and Conclude

8. Identify Which parts of your model represent each system?
9. **Summarize** how the change you made to one system affected the others.

____________________________________________________________________________

____________________________________________________________________________

10. **Interpret** Was the change you modeled helpful or harmful? Was it caused by human activities or natural events? Explain.

____________________________________________________________________________

____________________________________________________________________________

11. **The Big Idea** Earth is sometimes described as a rocky planet. Based on what you observed in this lab, does that statement accurately describe Earth? Why or why not?

____________________________________________________________________________

____________________________________________________________________________

**Communicate Your Results**

Take your classmates on a “tour” of your model. Point out each Earth system, explain your hypothesis, recreate the change you introduced, and describe your results. Invite your classmates to ask questions and offer suggestions about improving your model.

**Remember** to use scientific methods.

- Make Observations
- Ask a Question
- Form a Hypothesis
- Test your Hypothesis
- Analyze and Conclude
- Communicate Results

**Extension**

Conduct research to locate a place where the change you observed in your model has occurred. Find out what impact it had on the living things in the area. Determine if the change is still impacting life in the area.
How do seasonal changes affect Earth’s systems?

Directions: Use the information and data from the Lab How do Earth’s systems interact? to perform this lab.

You have learned that Earth’s four systems interact and that a change to one system can affect all of the systems. In Lab B you investigated this interaction by making a model of Earth’s systems and then making a change to your model. Now consider how the changes that occur during Earth’s four seasons might affect your system, each one in turn. Depending upon your model, you might want to consider seasonal severe weather as well as the typical temperatures and precipitation of the different seasons.

Please note that you must complete Lab B before beginning Lab C. Also, have your teacher approve your design and safety procedures before beginning your experiment.
Our Planet—Earth

End-of-Chapter Practice

Directions: Work with your class to create a display showing interactions among Earth systems in your area.

- Your class should divide into four groups. Each group should select a different Earth system to investigate. Answer the following questions about the system:

<table>
<thead>
<tr>
<th>Earth System:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is the composition of the system?</td>
</tr>
<tr>
<td>• What is the structure of the system?</td>
</tr>
<tr>
<td>• What are some unique properties of the system in our area?</td>
</tr>
</tbody>
</table>

- As a class, decide which interactions among Earth systems you would like to display. Select interactions that are relevant to your area. Try to choose interactions that include input from all groups. Discuss the following questions as you make your decision.

<table>
<thead>
<tr>
<th>How many interactions should we display?</th>
<th>Which interactions should we display?</th>
<th>What format should we use to display the interactions?</th>
<th>What materials will we need?</th>
<th>Who will accomplish each task?</th>
</tr>
</thead>
</table>

- Create your display. Obtain permission from the school administration to display your work in a hallway. Arrange for members of your class to be available to answer questions from other students on the first day that your work is displayed.

Display Requirements:
- scientifically accurate
- visually pleasing
- includes labels and captions explaining Earth system interactions
- includes contributions from all class members