The Water Cycle

You read that the amount of water on Earth does not change. The water that you drink has been on Earth for a long time. Millions of years ago, a dinosaur might have swallowed the same water that you are drinking today. Or maybe that water raged down a river, flooding an ancient city. How does water move from place to place as time passes?

*The water cycle is the continuous movement of water on, above, and below Earth’s surface.* The Sun provides the energy that drives the water cycle and moves water from place to place. As this occurs, water can change state to a gas or a solid and then back again to a liquid. The change of state requires either an input or an output of thermal energy.

How does the movement of thermal energy affect evaporation and condensation? When water changes state from a gas to a liquid, thermal energy is released from the water. Thermal energy is absorbed by liquid water when it changes into water vapor.

The water cycle is continuous. That means it has no beginning or end. You will start your investigation of the water cycle in the hydrosphere’s largest reservoir, an ocean.
**Evaporation**

When the Sun shines on an ocean, water near the surface absorbs thermal energy and becomes warmer. As a molecule of water absorbs thermal energy, it begins to vibrate faster. When it has enough energy, it breaks away from the other water molecules in the ocean. It rises into the atmosphere as a molecule of gas called water vapor. **Evaporation is the process by which a liquid, such as water, changes into a gas.** Water vapor, like other gases in the atmosphere, is invisible.

**Transpiration and Respiration**

Oceans hold most of Earth’s water, so they are major sources of water vapor. But water also evaporates from rivers, lakes, puddles, and soil. These sources, along with oceans, account for 90 percent of the water that enters the atmosphere. Most of the remaining 10 percent is produced by transpiration. **Transpiration is the process by which plants release water vapor through their leaves.**

Some water vapor also comes from organisms through cellular respiration. Cellular respiration takes place in many cells. Water and carbon dioxide are produced during cellular respiration. When animals breathe, they release carbon dioxide and water vapor from their lungs into the atmosphere. The wavy arrows in the figure below show water vapor entering the atmosphere.

**Visual Check**

3. **Name** Through which processes does water vapor enter the atmosphere?

**Reading Check**

2. **Differentiate** How are transpiration and respiration similar? How are they different?

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**Water Cycle**

![Water Cycle Diagram](image)
**Condensation**

Recall that temperatures in the troposphere decrease with altitude. So as water vapor rises through the troposphere, it becomes cooler. Eventually, it loses so much thermal energy that it returns to the liquid state. *The process by which a gas changes to a liquid is condensation.* Tiny droplets of liquid water join to form larger drops. When millions of water droplets come together, a cloud forms.

**Precipitation**

Eventually, drops of water in the clouds become so large and heavy that they fall to Earth’s surface. *Moisture that falls from clouds to Earth’s surface is precipitation.* Rain and snow are forms of precipitation. More than 75 percent of precipitation falls into the ocean, and the rest falls onto land. Some of this water evaporates and goes right back into the atmosphere. Some flows into lakes or rivers, and the rest seeps into soil and rocks.

In the water cycle, water continually moves between the hydrosphere, the cryosphere, the atmosphere, the biosphere, and the geosphere. As water flows across land, it interacts with soil and rocks in the geosphere. You will learn more about these interactions when you read about the rock cycle.

**Changes in the Atmosphere**

The atmosphere is continually changing. These changes happen mainly within the troposphere, which contains most of the gases in the atmosphere. Some changes occur within hours or days. Others can take decades or even centuries.

**Weather**

*Weather is the state of the atmosphere at a certain time and place.* In most places, the weather changes a bit every day. How do scientists describe weather and its changes?

**Describing Weather** Scientists use several factors to describe weather. These factors are shown in the figure on the next page. Air temperature is a measure of the average amount of energy produced by the motion of air molecules. Air pressure is the force exerted by air molecules in all directions. Wind is the movement of air caused by differences in air pressure. Scientists measure wind speed and wind direction. Humidity is the amount of water vapor in a given volume of air. High humidity makes it more likely that clouds will form and precipitation will fall.

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**Key Concept Check**

4. Describe How do Earth systems interact in the water cycle?

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**Math Skills**

The amount of water vapor in air is called vapor density. Relative humidity (RH) compares the actual vapor density in air to the amount of water vapor the air could contain at that temperature. For example, at 15°C, air can contain a maximum of 12.8 g/m³ of water vapor. If the air contains 10.0 g/m³ of water vapor, what is the RH?

**a.** Use the formula:

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

**b.** Work out the equation.

\[ RH = \left( \frac{10.0 \text{ g}}{12.8 \text{ g}} \right) \times 100\% \]

\[ RH = 0.781 \times 100\% = 78.1\% \]

**5. Use a Formula** At 0°C, air can contain 4.85 g/m³ of water vapor. Assume the actual water vapor content is 0.970 g/m³. What is the RH?
Interactions Weather is influenced by conditions in the geosphere and the hydrosphere. For example, air masses take on the characteristics of the area over which they form. If an air mass forms over a cool ocean, that air mass will bring cool, moist air.

In addition to these interactions, the hydrosphere provides much of the water for cloud formation and precipitation. Tropical waters provide the thermal energy that produces hurricanes.

Climate What is the weather like where you live? The weather in the area where you live might change each day, but weather patterns can remain nearly the same from season to season. For example, in the summertime the weather might be different every day. One day might be a bit cool and rainy, and the next day might be hot and dry. But overall, summer is warm. These weather patterns are called climate.

Climate is the average weather pattern for a region over a long period of time. Earth has many climates. One reason climates are different in different regions of Earth is because of interactions between the atmosphere and other Earth systems.

Mountains Recall that air temperature decreases with altitude. So the climate near the top of a mountain often is cooler than the climate near the mountain's base. Mountains also can affect the amount of precipitation an area receives—a phenomenon known as the rain-shadow effect.
The Rain-Shadow Effect As shown in the figure below, warm, wet air rises and cools as it moves up the windward side of a mountain. Clouds form and precipitation falls, giving this side of the mountain a wet climate. The air, now dry, continues to move over and down the leeward side of the mountain. This side of the mountain often has a dry climate.

Ocean Currents As wind blows over an ocean, it creates surface currents. Surface currents are like rivers in an ocean—the water flows in a predictable pattern. These currents move the thermal energy in water from place to place. For example, the Gulf Stream carries warm waters from tropical regions to northern Europe, making the climate of northern Europe warmer than it would be without these warm waters.

The Rock Cycle

In the water cycle, water moves throughout the hydrosphere, the cryosphere, the atmosphere, the biosphere, and the geosphere. Another natural cycle is the rock cycle. The rock cycle is the series of processes that transport and continually change rocks into different forms. The rock cycle takes place in the geosphere, but it is affected by interactions with the other Earth systems.

As rocks move through the rock cycle, they might become igneous rocks, sedimentary rocks, or metamorphic rocks. At times they might not be rocks at all. Instead, they might take the form of sediments or hot, flowing magma.

Like the water cycle, the rock cycle has no beginning or end. Some processes in this cycle take place on Earth’s surface, and others take place deep within the geosphere.
Cooling and Crystallization

Magma is located inside the geosphere. When magma flows onto Earth’s surface, it is called lava. Mineral crystals form as magma cools below the surface or as lava cools on the surface. This crystallization changes the molten material into igneous rock.

Uplift

Even rocks formed deep within Earth can eventually be exposed at the surface. Uplift is the process that moves large bodies of Earth materials to higher elevations.

Uplift is often associated with mountain building. After millions of years of uplift, rocks that formed deep below Earth’s surface could have moved upward to the surface.

Weathering and Erosion

Rocks on Earth’s surface are exposed to the atmosphere, the hydrosphere, the cryosphere, and the biosphere. Glaciers, wind, and rain, along with the activities of some organisms, break down rocks into sediment. This process is called weathering.

Weathering can occur in the mountains, where uplift has exposed rocks. Weathering of rocks into sediments is often accompanied by erosion. Erosion occurs when the sediments are carried by agents of erosion—water, wind, or glaciers—to new locations.

Deposition

Eventually, agents of erosion lose their energy and slow down or stop. When this happens, eroded sediments are deposited, or laid down, in new places. This process is called deposition.

Deposition forms layers of sediment. Over time, more and more layers are deposited.

Compaction and Cementation

As more layers of sediment are deposited, their weight pushes down on the layers below. The deeper layers are compacted. This means they are packed down and pressed together. This process is called compaction.

Minerals dissolved in surrounding water crystallize between grains of sediment and cement the sediments together. This process is called cementation. Compaction and cementation produce sedimentary rocks.
Metamorphic rocks form when rocks are subjected to high temperatures and pressure. This usually occurs far beneath Earth’s surface.

Igneous, sedimentary, and even metamorphic rocks can become new metamorphic rocks. Then, uplift can bring the rocks to the surface. There, the rocks are broken down and continue moving through the rock cycle. This process along with other processes in the rock cycle is shown in the figure above and on the next page. Remember that as rocks move slowly through the rock cycle, they change from one form to another.

Endless Interactions Most interactions among the geosphere, the hydrosphere, the cryosphere, and the atmosphere occur on Earth’s surface. For example, energy from the Sun—the atmosphere—reaches Earth, where it heats land and water—the hydrosphere and cryosphere. The energy is reflected by Earth’s surface—the geosphere—which in turn heats the atmosphere. This affects climate. These are just a few simple examples of different interactions among Earth’s systems.
A Unified System  You have read about different interacting subsystems of Earth in this chapter:

- The atmosphere is the layer of gases surrounding Earth.
- The hydrosphere is the liquid water found on Earth.
- The cryosphere is the frozen water on Earth.
- The geosphere is Earth’s entire solid body.
- The biosphere consists of all living organisms on Earth.

But even though these systems are different, they function together as one unified system—planet Earth.

15. Consider  Are you a part of the biosphere? Explain your answer.

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Mini Glossary

climate: the average weather pattern for a region over a long period of time
condensation: the process by which a gas changes to a liquid
evaporation: the process by which a liquid, such as water, changes into a gas
precipitation: moisture that falls from clouds to Earth's surface
rock cycle: the series of processes that transport and continually change rocks into different forms

transpiration: the process by which plants release water vapor through their leaves
uplift: the process that moves large bodies of Earth materials to higher elevations
water cycle: the continuous movement of water on, above, and below Earth's surface
weather: the state of the atmosphere at a certain time and place

1. Review the terms and their definitions in the Mini Glossary. Write a sentence contrasting evaporation and condensation.

2. In the graphic organizer below, identify the five factors scientists use to describe weather.

3. How do metamorphic rocks form? Where do they form?

What do you think NOW?
Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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END OF LESSON