Water on Earth

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Printed: January 23, 2015

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CHAPTER 1

Water on Earth

Lesson Objectives

- Describe how water is distributed on Earth.
- Describe what powers the water cycle and how water moves through this cycle.

Vocabulary

- condensation
- evaporation
- fresh water
- groundwater
- hydrologic (water) cycle
- precipitation
- reservoir
- residence time
- sublimation
- transpiration
- water vapor

Introduction

Water is simply two atoms of hydrogen and one atom of oxygen bonded together. Despite its simplicity, water has remarkable properties. Water expands when it freezes, has high surface tension (because of the polar nature of the molecules, they tend to stick together), and others. Without water, life might not be able to exist on Earth and it certainly would not have the tremendous complexity and diversity that we see.

Distribution of Earth's Water

Earth's oceans contain 97% of the planet's water, so just 3% is fresh water, water with low concentrations of salts (**Figure** 1.1). Most **fresh water** is trapped as ice in the vast glaciers and ice sheets of Greenland. A storage location for water such as an ocean, glacier, pond, or even the atmosphere is known as a **reservoir**. A water molecule may pass through a reservoir very quickly or may remain for much longer. The amount of time a molecule stays in a reservoir is known as its **residence time**.

How is the 3% of fresh water divided into different reservoirs? How much of that water is useful for living creatures? How much for people?

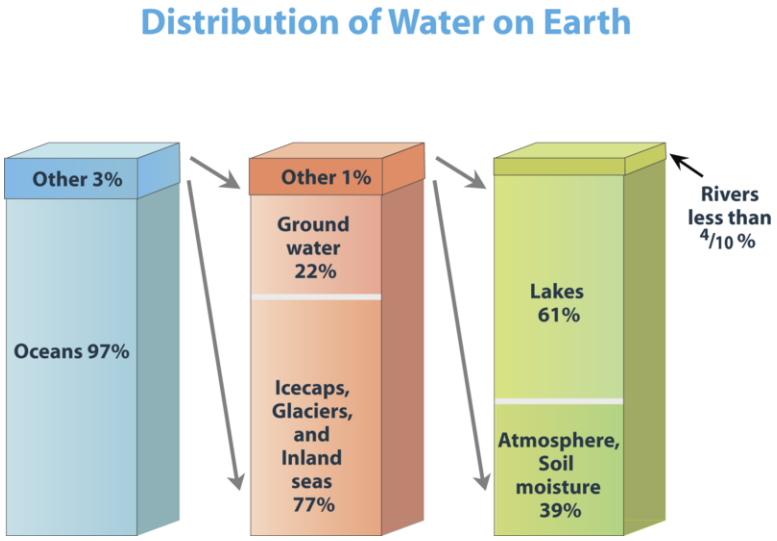


FIGURE 1.1
The distribution of Earth's water.

The Hydrologic Cycle

Because of the unique properties of water, water molecules can cycle through almost anywhere on Earth. The water molecule found in your glass of water today could have erupted from a volcano early in Earth history. In the intervening billions of years, the molecule probably spent time in a glacier or far below the ground. The molecule surely was high up in the atmosphere and maybe deep in the belly of a dinosaur. Where will that water molecule go next?

Three States of Water

Water is the only substance on Earth that is present in all three states of matter –as a solid, liquid or gas. (And Earth is the only planet where water is present in all three states.) Because of the ranges in temperature in specific locations around the planet, all three phases may be present in a single location or in a region. The three phases are solid (ice or snow), liquid (water), and gas (**water vapor**). See ice, water, and clouds (**Figure** 1.2).

FIGURE 1.2
(a) Ice floating in the sea. Can you find all three phases of water in this image? (b) Liquid water. (c) Water vapor is invisible, but clouds that form when water vapor condenses are not.

The Water Cycle

Because Earth's water is present in all three states, it can get into a variety of environments around the planet. The movement of water around Earth's surface is the **hydrologic (water) cycle** (**Figure** 1.3).

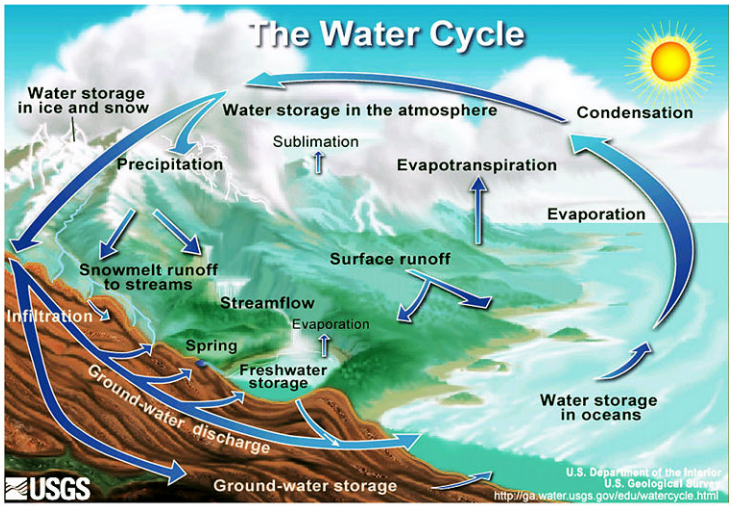


FIGURE 1.3

Because it is a cycle, the water cycle has no beginning and no end.

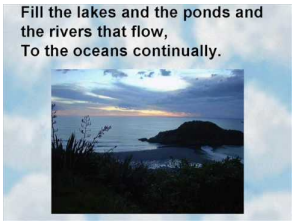
The Sun, many millions of kilometers away, provides the energy that drives the water cycle. Our nearest star directly impacts the water cycle by supplying the energy needed for evaporation.

Most of Earth's water is stored in the oceans where it can remain for hundreds or thousands of years. The oceans are discussed in detail in the chapter Earth's Oceans.

Water changes from a liquid to a gas by **evaporation** to become water vapor. The Sun's energy can evaporate water from the ocean surface or from lakes, streams, or puddles on land. Only the water molecules evaporate; the salts remain in the ocean or a fresh water reservoir.

The water vapor remains in the atmosphere until it undergoes **condensation** to become tiny droplets of liquid. The droplets gather in clouds, which are blown about the globe by wind. As the water droplets in the clouds collide and grow, they fall from the sky as precipitation. **Precipitation** can be rain, sleet, hail, or snow. Sometimes precipitation falls back into the ocean and sometimes it falls onto the land surface.

For a little fun, watch this video. This water cycle song focuses on the role of the sun in moving H_2O from one reservoir to another. The movement of all sorts of matter between reservoirs depends on Earth's internal or external sources of energy **(7c)**: http://www.youtube.com/watch?v=Zx_1g5pGFLI (2:38).



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This animation shows the annual cycle of monthly mean precipitation around the world: http://en.wikipedia.org/wiki/File:MeanMonthlyP.gif

When water falls from the sky as rain it may enter streams and rivers that flow downward to oceans and lakes. Water that falls as snow may sit on a mountain for several months. Snow may become part of the ice in a glacier, where it may remain for hundreds or thousands of years. Snow and ice may go directly back into the air by **sublimation**, the process in which a solid changes directly into a gas without first becoming a liquid. Although you probably have not seen water vapor sublimating from a glacier, you may have seen dry ice sublimate in air.

Snow and ice slowly melt over time to become liquid water, which provides a steady flow of fresh water to streams, rivers, and lakes below. A water droplet falling as rain could also become part of a stream or a lake. At the surface, the water may eventually evaporate and reenter the atmosphere.

A significant amount of water infiltrates into the ground. Soil moisture is an important reservoir for water (**Figure** 1.4). Water trapped in soil is important for plants to grow.

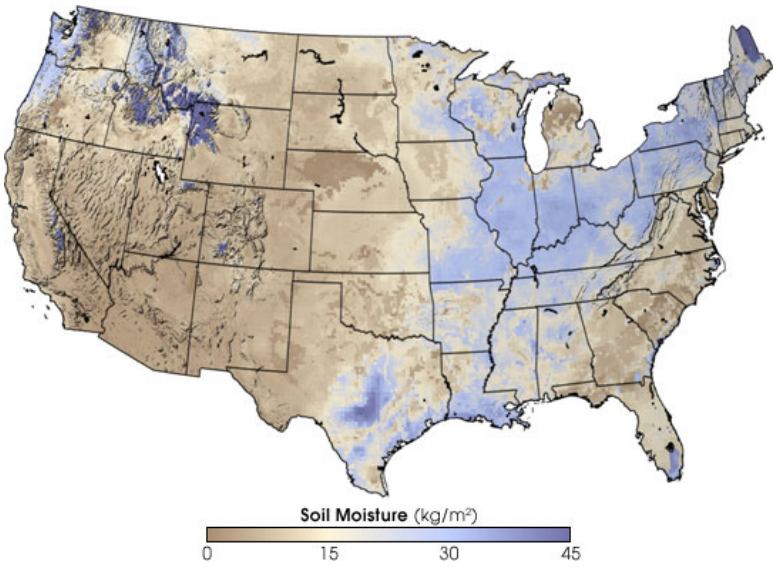

FIGURE 1.4

The moisture content of soil in the United States varies greatly.

Water may seep through dirt and rock below the soil through pores infiltrating the ground to go into Earth's groundwater system. Groundwater enters aquifers that may store fresh water for centuries. Alternatively, the water may come to the surface through springs or find its way back to the oceans.

Plants and animals depend on water to live and they also play a role in the water cycle. Plants take up water from the soil and release large amounts of water vapor into the air through their leaves (**Figure** 1.5), a process known as **transpiration**.

An online guide to the hydrologic cycle from the University of Illinois is found here: http://ww2010.atmos.uiuc.edu/%28Gh%29/guides/mtr/hyd/home.rxml

People also depend on water as a natural resource. Not content to get water directly from streams or ponds, humans create canals, aqueducts, dams, and wells to collect water and direct it to where they want it (**Figure** 1.6).

TABLE 1.1: Water Use

Use	United States	Global
Agriculture	34%	70%
Domestic (drinking, bathing)	12%	10%
Industry	5%	20%
Power plant cooling	49%	small

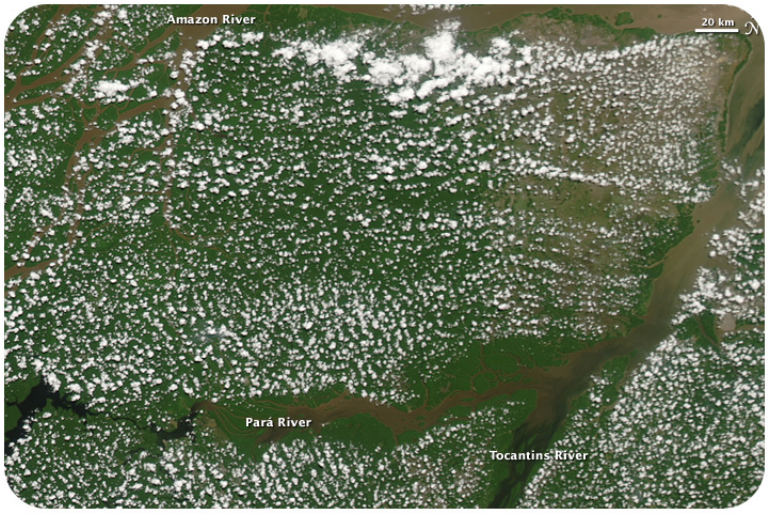

FIGURE 1.5
Clouds form above the Amazon Rainforest even in the dry season because of moisture from plant transpiration.

FIGURE 1.6
The Pont du Gard aqueduct in France was constructed during the Roman Empire.

Table 1.1displays water use in the United States and globally.

It is important to note that water molecules cycle around. If climate cools and glaciers and ice caps grow, there is less water for the oceans and sea level will fall. The reverse can also happen.

KQED: Tracking Raindrops

How the water cycle works and how rising global temperatures will affect the water cycle, especially in California, are the topics of this Quest video. Learn more at:http://www.kqed.org/quest/television/tracking-raindrops

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Lesson Summary

- Although Earth's surface is mostly water covered, only 3% is fresh water.
- Water on Earth is found in all three phases: solid, liquid, and gas.

- Water travels between phases and reservoirs as part of the hydrologic (water) cycle.
- The major processes of the water cycle include evaporation, transpiration, condensation, precipitation, and return to the oceans via runoff and groundwater supplies.

Review Questions

1. About what percent of the Earth's water is fresh water?
2. About what percent of all of Earth's water is found in groundwater, streams, lakes, and rivers?
3. In what states does water appear on Earth and on other planets?
4. What powers the water cycle? How?
5. In which of the states of matter would water be at 130^{o}C? At 45^{o}C?
6. Define the words condensation and evaporation.
7. Give a detailed summary of the water cycle.
8. What is transpiration? How is it like evaporation?
9. Why is the atmosphere so important to the water cycle?
10. If the sun grew much stronger in intensity, how would the water cycle be affected?

Further Reading / Supplemental Links

Thorough and updated information on the water cycle from NASA: http://earthobservatory.nasa.gov/Features/Water/

An introduction to life in fresh water: http://www.freshwaterlife.org/

The US Geological Survey website has lots of information about fresh water: http://www.usgs.gov/

Points to Consider

- How does precipitation affect the topography of the Earth?
- What natural disasters are caused by the water cycle?
- How might building dams disrupt the natural water cycle?
- As Earth's temperature warms, how might the water cycle be altered?

References

1. Hana Zavadska, based on data from National Climate Data Center. CK-12 Foundation . CC BY-NC 3.0
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