

Chapter 5: The Water Cycle

Objectives:

- Understand the distribution of water on Earth
- Identify the 5 steps of the water cycle
- Understand how water is naturally stored
- Understand the effects of pollutants

Vocabulary

Evaporation

Condensation

Precipitation

Runoff

Infiltration

Aquifer



Figure 1: Planet Earth

Intro: What is the Water Cycle?

The water cycle is the process that describes the existence, transformation, and movement of water on planet Earth. The water cycle can be broken into five steps: evaporation, condensation, precipitation, runoff, and Storage.

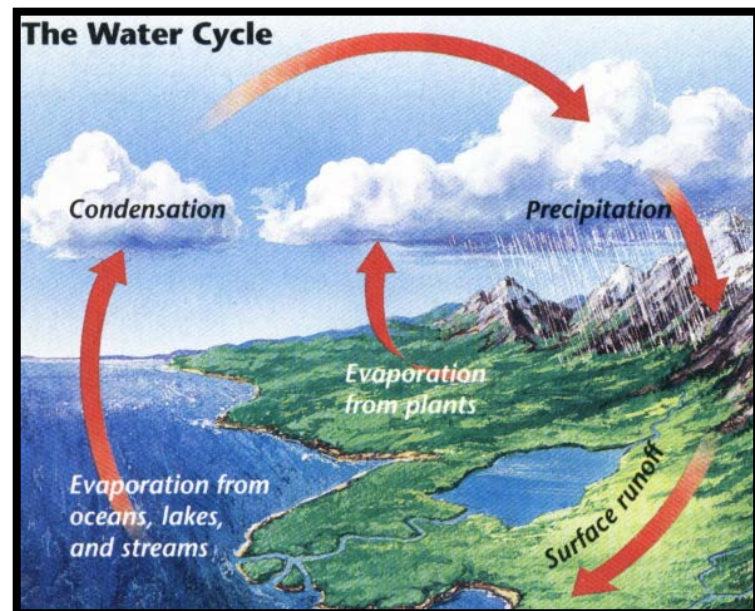


Figure 2: Basic Water Cycle

5.1 Why is the Water Cycle Important?

The water cycle is a critical process that renews the fresh water of planet Earth. Although water covers about 75% of the Earth's surface, only 3% of the water is fresh water. This 3% is split between being liquid, frozen, or contained underground. Only 1% of the total fresh water of the planet is on the surface and accessible to plants and animals, making fresh water a limited resource. The water cycle continually renews the surface water of the planet allowing life to continue to exist.

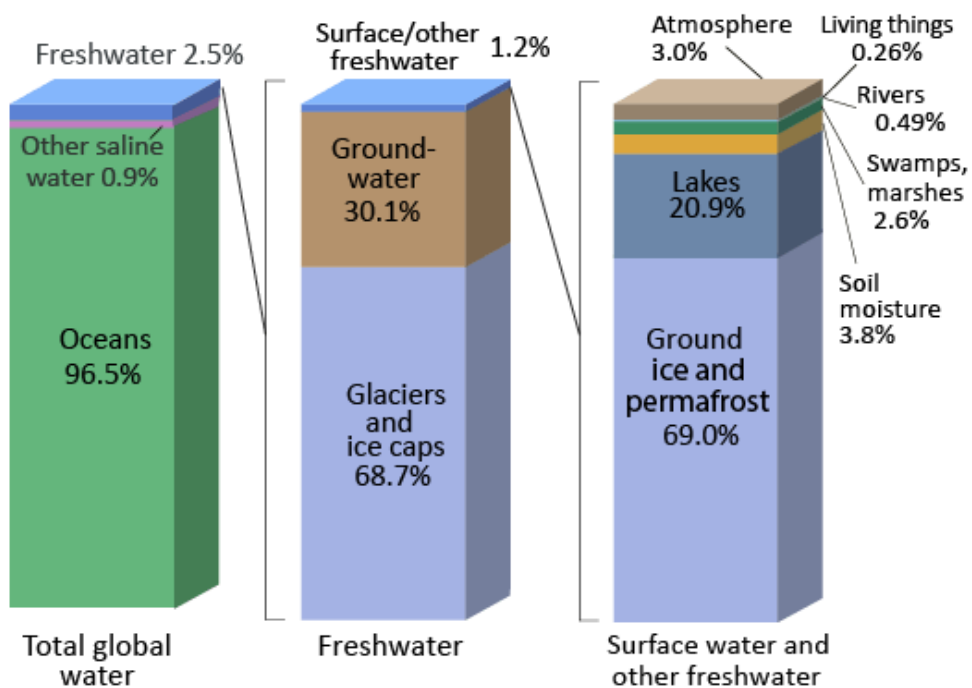


Figure 3: Distribution of Water on Planet Earth

5.2 Steps of the Water Cycle

5.2.1 Evaporation

Evaporation is a process that transforms water from its liquid state to its gaseous state known as vapor. The evaporation process begins with the solar radiation that provides energy to the surface of Earth. Next, water on Earth's surface absorb this energy, which allows the molecules to break the liquid bonds, transforming them from a liquid into a vapor. Although water boils at 212°F (100°C), evaporation is occurring at all temperatures with the rate of evaporation increasing with higher temperatures.

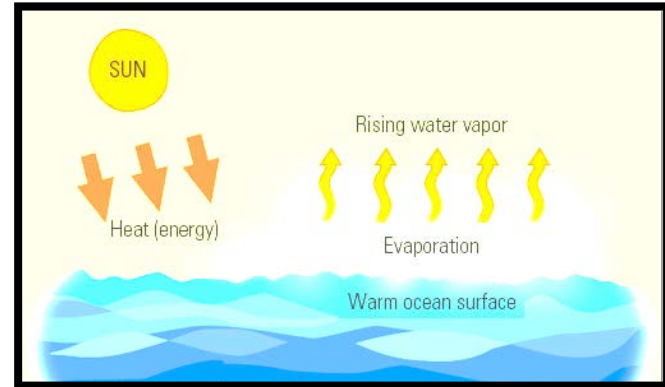
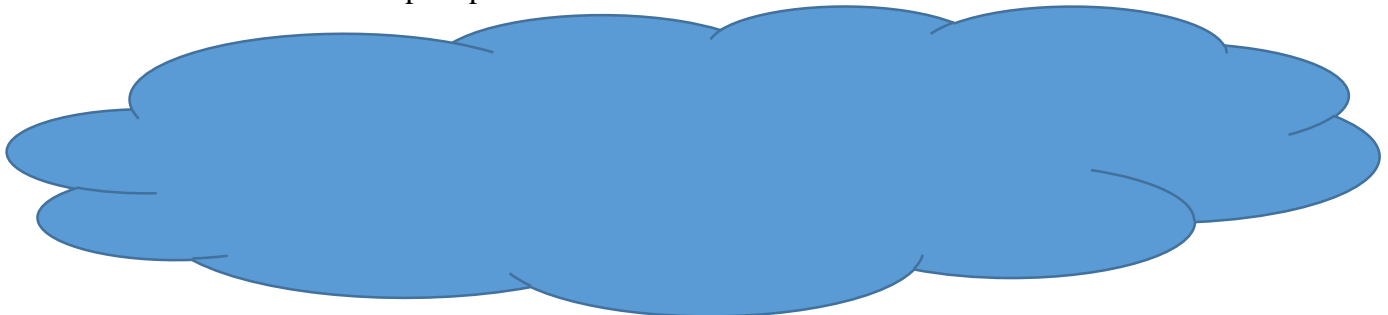


Figure 4: Evaporation

Evaporation is the purifying step in the water cycle. When evaporation occurs, pure water vapor will rise into the atmosphere, leaving salt and any other impurities behind. The result of this step is water vapor rising into the atmosphere.

5.2.2 Condensation

After evaporation occurs the water vapor will rise to the atmosphere it is here that condensation will take place. *Condensation* is defined as the transformation in matter from the gas phase to the liquid phase. This step in the water cycle occurs in the upper atmosphere where temperatures and pressures are lower than on the surface. Condensation is visible as clouds, which are comprised of both water vapor and water droplets; however, in most clouds, the water droplets are too small to fall as precipitation. The water is temporarily stored in the atmosphere as clouds until conditions meet for precipitation to form.



5.2.3 Precipitation

Precipitation is the process of water particles falling from the atmosphere back to the surface of Earth. Precipitation is a direct result of evaporation and condensation.

So, why are all clouds not causing precipitation?

The water stored in clouds is in the form of droplets. These droplets are often so small and have so little mass that updraft pressure can hold them in the upper atmosphere. However, as clouds condense larger amounts of water vapor, the droplets increase in size until their weight overcomes the updraft forces. When this occurs the cloud will lose the droplets and precipitation will fall. The form of precipitation (rain, sleet, or snow) will depend on the temperature of the cloud and the surface below (See Figure 5).

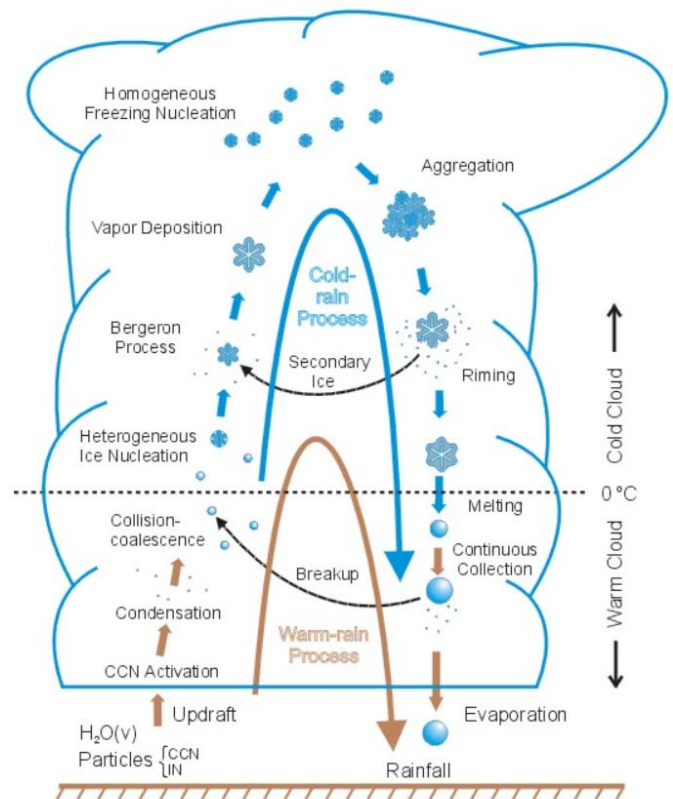


Figure 5: Precipitation Mechanisms inside a Cloud

5.2.4 Runoff

Once precipitation falls on landmass it will be pulled by gravity from high elevations to lower elevations. The process of the water flow is called *Runoff*. Runoff plays a major role in the erosion process that will be seen in Chapter 7.

5.2.5 Water Storage

Surface Storage

Water is most commonly stored in oceans, seas, lakes, and rivers. There is also a substantial amount of water frozen in glaciers, snow, and permafrost.

Infiltration and Aquifer Storage

Infiltration is the physical process of water movement through soil and rock. During infiltration, the ground water can move through porous soil and continue to flow in underground streams and springs. From here it will either return to the surface or seep deeper into rocks and fill *Aquifers* which are underground deposits of water.

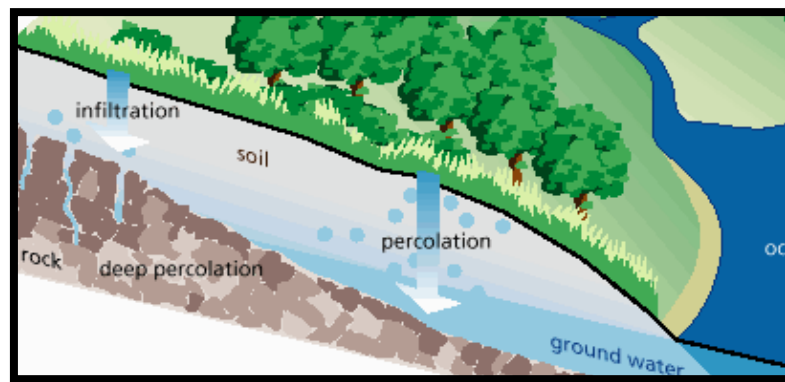


Figure 6: Infiltration Diagram

5.3 Pollutions Effect

Air pollution can mix with the condensing water vapor in the atmosphere causing acid rain. First, note that rain water is naturally acidic with a PH of 5.6, this is caused by carbon dioxide in the air that converts some of the water vapor into carbonic acid (H_2CO_3). This form of acidic rain is not harmful unlike the acids caused by pollution. Today, the main form of pollution is greenhouse gases produced from burning fossil fuels (coal, oil, and natural gas). When these gases mix with clouds of water vapor, the pure H_2O is transformed into Sulfuric Acids (H_2SO_4) and Nitric Oxides (NO_x). The water acid mixture will then fall as acid rain causing damage to plants, animals, and contamination the surface water. Air pollution has destroyed the purifying purpose of the water cycle.

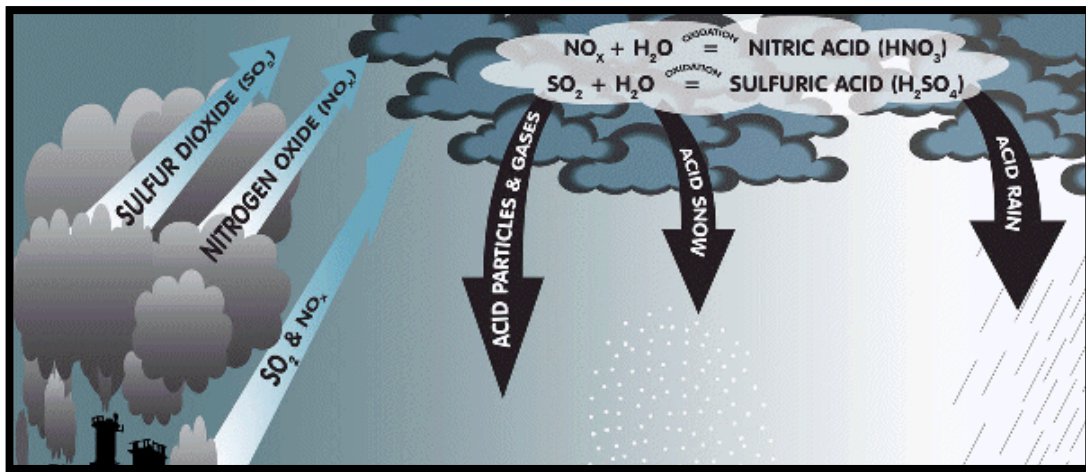


Figure 7: Acid Rain Diagram

5.4 Water Cycle Summary

The sun will radiate energy into the surface water of planet Earth. Surface water will absorb the energy, and water vapor will be formed as the liquid bonds are broken. Evaporation will cause the water vapor to rise into the upper atmosphere. As the water rises, both temperature and pressure will lower, and condensation will occur. Clouds will form as vapor condenses into water droplets. Once the conditions are right, the droplets will become too heavy and begin to precipitate as rain, sleet, or snow. This precipitation will fall back to the surface and flow downhill as runoff. The runoff will then either flow into rivers, lakes, and oceans or infiltrate into aquifers. The water on the surface will evaporate and the cycle will be repeated (See Figure 8 below).

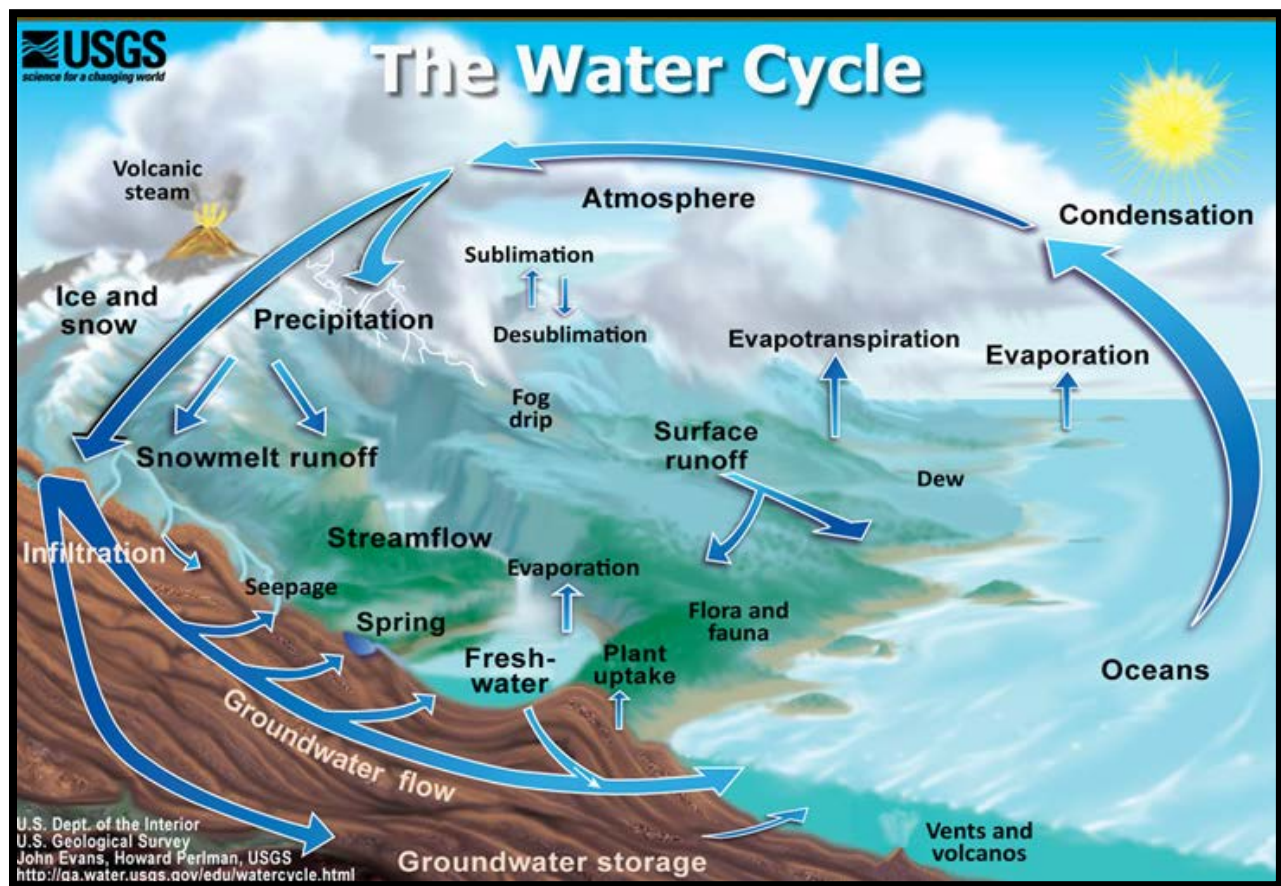


Figure 8: Advanced Water Cycle

Resources and References

"The Water Cycle." *The Water Cycle*, U.S. Geological Survey (USGS) Water Science School. U.S. Department of the Interior and U.S. Geological Survey, 07 Aug. 2015. Web. 20 Oct. 2015. <http://water.usgs.gov/edu/watercycle.html>

"Description of Hydrologic Cycle." *Description of Hydrologic Cycle*. Northwest River Forecast Center, n.d. Web. 20 Oct. 2015. http://www.nwrfc.noaa.gov/info/water_cycle/hydrology.cgi

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