Water CK12 Reading

Water Intro

Does dihydrogen oxide, or dihydrogen monoxide, sound dangerous?

Another name for this compound is water. Water can create some absolutely beautiful sights. Iguassu Falls is the largest series of waterfalls on the planet, located in Brazil, Argentina, and Paraguay. And water is necessary for life. Water, like carbon, has a special role in biology because of its importance to organisms. Water is essential to all known forms of life. Water, H_2O, such a simple molecule, yet it is this simplicity that gives water its unique properties and explains why water is so vital for life.

Water is a common chemical substance on Earth. The term water generally refers to its liquid state. Water is a liquid over a wide range of standard temperatures and pressures. However, water can also occur as a solid (ice) or gas (water vapor).

Where Is All the Water?

Of all the water on Earth, about two percent is stored underground in spaces between rocks. A fraction of a percent exists in the air as water vapor, clouds, or precipitation. Another fraction of a percent occurs in the bodies of plants and animals. So where is most of Earth's water? It's on the surface of the planet. In fact, water covers about 70 percent of Earth's surface. Of water on Earth's surface, 97 percent is salt water, mainly in the ocean. Only 3 percent is **fresh water**. Most of the fresh water is frozen in glaciersand polar ice caps. The remaining fresh water occurs in rivers, lakes, and other fresh water features.

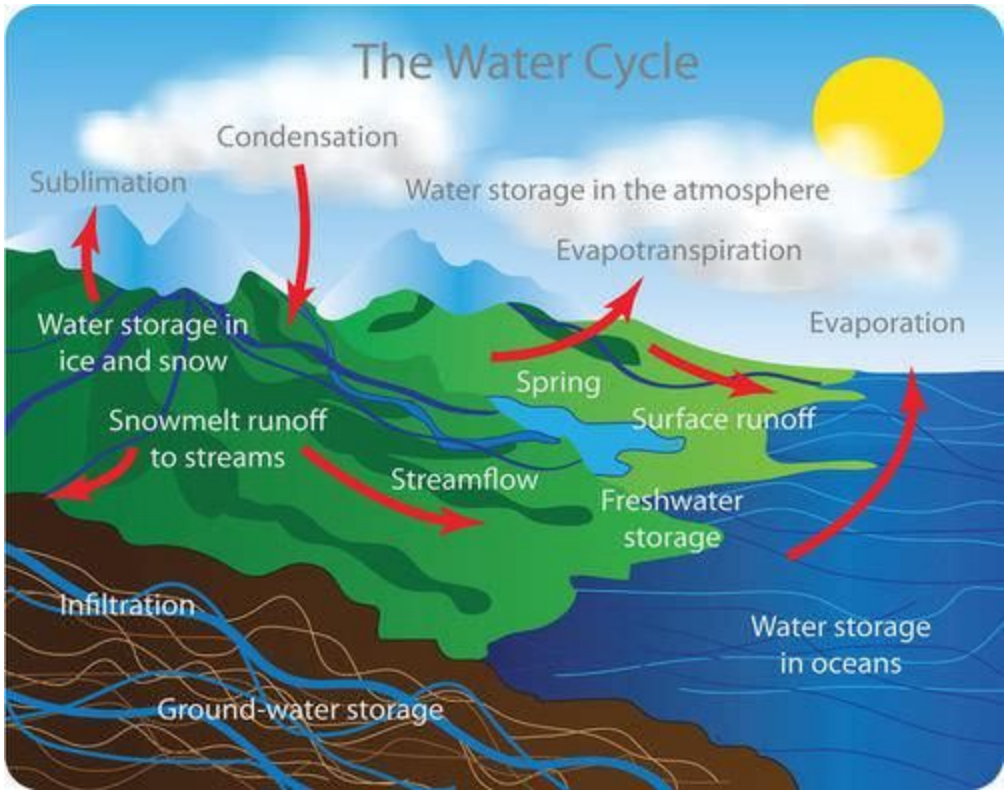
Although clean fresh water is essential to human life, in many parts of the world it is in short supply. The amount of fresh water is not the issue. There is plenty of fresh water to go around, because water constantly recycles on Earth. However, fresh water is not necessarily located where it is needed, and clean fresh water is not always available.

How Water Recycles

Like other matter on Earth, water is continuously recycled. Individual water molecules are always going through the **water cycle**, in which molecules of water cycle through both the living and non-living parts of the biosphere (discussed in the *Recycling Matter: The Water Cycle (Advanced)* concept). In fact, water molecules on Earth have been moving through the water cycle for billions of years. In this cycle, water evaporates from Earth's surface (or escapes from the surface in other ways), forms clouds, and falls back to the surface as precipitation. This cycle keeps repeating. Several processes change water from one state to another during the water cycle. They include:

- **Evaporation**—Liquid water on Earth's surface changes into water vapor in the atmosphere.
- **Sublimation**—Snow or ice on Earth's surface changes directly into water vapor in the atmosphere.

- **Transpiration**—Plants give off liquid water, most of which evaporates into the atmosphere.
- **Condensation**—Water vapor in the atmosphere changes to liquid water droplets, forming clouds or fog.
- **Precipitation**—Water droplets in clouds are pulled to Earth's surface by gravity, forming rain, snow, or other type of falling moisture.



Like other biogeochemical cycles, there is no beginning or end to the water cycle. It just keeps repeating.[Figure2]

Summary

- Most of Earth's water is salt water located on the planet's surface.
- Water is constantly recycled through the water cycle, cycling through both the living and non-living parts of the biosphere.

Review

1. Where is most of Earth's water? What percent of that is salt water?
2. Where is most of the fresh water on Earth?
3. What are the two concerns of fresh water?
4. What is the water cycle?
5. Draw a circle diagram to represent basic components of the water cycle. Identify the states of water and the processes in which water changes state throughout the cycle.

Water Shortages

What may be the most important molecule for life?

Some may argue DNA. Some may argue certain proteins. But many would argue water. And what makes water so important? Its properties. The nature of the three atoms and how they interact with each other. This allows water to be a polar molecule, which allows it to interact with many other molecules necessary for life. Most of the substances in a cell are floating around in a water-based cytoplasmic environment.

Chemical Structure and Properties of Water

You are probably already familiar with many of water's properties. For example, you no doubt know that water is tasteless, odorless, and transparent. In small quantities, it is also colorless. However, when a large amount of water is observed, as in a lake or the ocean, it is actually light blue in color. The blue hue of water is an intrinsic property and is caused by selective absorption and scattering of white light. These and other properties of water depend on its chemical structure.

The transparency of water is important for organisms that live in water. Because water is transparent, sunlight can pass through it. Sunlight is needed by water plants and other water organisms for photosynthesis.

Chemical Structure of Water

Each molecule of water consists of one atom of oxygen and two atoms of hydrogen, so it has the chemical formula H_2O. The arrangement of atoms in a water molecule, shown in **Figure** below, explains many of water's chemical properties. In each water molecule, the nucleus of the oxygen atom (with 8 positively charged protons) attracts electrons much more strongly than do the hydrogen nuclei (with only one positively charged proton). This results in a negative electrical charge near the oxygen atom (due to the "pull" of the negatively charged electrons toward the oxygen nucleus) and a positive electrical charge near the hydrogen atoms. A difference in electrical charge between different parts of a molecule is called **polarity**. A **polar molecule** is a molecule in which part of the molecule is positively charged and part of the molecule is negatively charged.

Water has some unusual properties due to its hydrogen bonds. One property is **cohesion**, the tendency for water molecules to stick together. The cohesive forces between water molecules are responsible for the phenomenon known as **surface tension**. The molecules at the surface do not have other like molecules on all sides of them and consequently they cohere more strongly to those directly associated with them on the surface. For example, if you drop a tiny amount of water onto a very smooth surface, the water molecules will stick together and form a droplet, rather than spread out over the surface. The same thing happens when water slowly drips from a leaky faucet. The water doesn't fall from the faucet as individual water molecules but as

droplets of water. The tendency of water to stick together in droplets is also illustrated by the dew drops in **Figure** below.

Droplets of dew cling to a spider web, demonstrating cohesion, the tendency of water molecules to stick together because of hydrogen bonds.[Figure6]

Another important physical property of water, is **adhesion**. In terms of water, adhesion is the bonding of a water molecule to another substance, such as the sides of a leaf's veins. This process happens because hydrogen bonds are special in that they break and reform with great frequency. This constant rearranging of hydrogen bonds allows a percentage of all the molecules in a given sample to bond to another substance. This grip-like characteristic that water molecules form causes **capillary action**, the ability of a liquid to flow against gravity in a narrow space. An example of capillary action is when you place a straw into a glass of water. The water seems to climb up the straw before you even place your mouth on the straw. The water has created hydrogen bonds with the surface of the straw, causing the water to adhere to the sides of the straw. As the hydrogen bonds keep interchanging with the straw's surface, the water molecules interchange positions and some begin to ascend the straw.

Adhesion and capillary action are necessary to the survival of most organisms. It is the mechanism that is responsible for water transport in plants through roots and stems, and in animals through small blood vessels.

Hydrogen bonds also explain why water's **boiling point** (100°C) is higher than the boiling points of similar substances without hydrogen bonds. Because of water's relatively high boiling point, most water exists in a liquid state on Earth. Liquid water is needed by all living organisms. Therefore, the availability of liquid water enables life to survive over much of the planet.

Furthermore, water has a high **specific heat** because it takes a lot of energy to raise or lower the temperature of water. As a result, water plays a very important role in temperature regulation. Since cells are made up of water, this property helps to maintain **homeostasis**.

Density of Ice and Water

The **melting point** of water is 0°C. Below this temperature, water is a solid (ice). Unlike most chemical substances, water in a solid state has a lower density than water in a liquid state. This is because water expands when it freezes. Again, hydrogen bonding is the reason. Hydrogen bonds cause water molecules to line up less efficiently in ice than in liquid water. As a result, water molecules are spaced farther apart in ice, giving ice a lower density than liquid water. A substance with lower density floats on a substance with higher density. This explains why ice floats on liquid water, whereas many other solids sink to the bottom of liquid water.

In a large body of water, such as a lake or the ocean, the water with the greatest density always sinks to the bottom. Water is most dense at about 4°C. As a result, the water at the bottom of a lake or the ocean usually has temperature of about 4°C. In climates with cold winters, this layer of 4°C water insulates the bottom of a lake from freezing temperatures. Lake organisms such as fish can survive the winter by staying in this cold, but unfrozen, water at the bottom of the lake.

Summary

- Water molecules are polar, so they form hydrogen bonds. This gives water unique properties, such as a relatively high boiling point, high specific heat, cohesion, adhesion and density.

Review

1. Describe the structure of a water molecule.
2. What is polarity, and why is water polar?
3. What is capillary action? Give an example.
4. What property of water helps to maintain homeostasis and how?