Water in plant life

Water never leaves the Earth. It is constantly being cycled through the atmosphere, ocean, and land. This process, known as the **water cycle**, is driven by **energy** from the **sun**. The water cycle is crucial to the existence of life on our planet. **Plants** play a large role in the **hydrologic cycle**. **Transpiration**, the evaporative loss of water from leaves of natural and cultivated vegetation, returns to the atmosphere about **60 %** of the incident **precipitation** over land surfaces. Agriculture needs large quantities of water for food production. Thus **plants** are important in the **global circulation** of water; and, conversely, water plays many essential roles in plant growth and function.

The importance of the water for plants

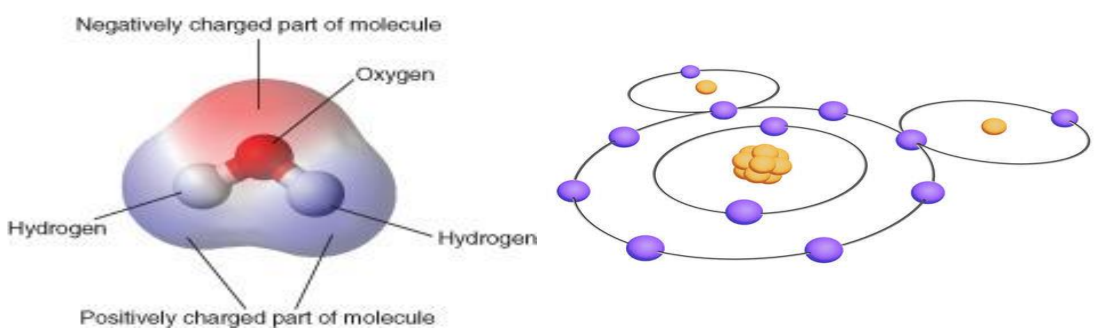
1. Water helps in the **germination** of seeds.
2. Water helps in the process of **photosynthesis** by which plants prepare their food
3. Water helps in the **transport of nutrients** and minerals from the soil to the plants.
4. Water helps in the **maintenance of the plant structure** by providing the appropriate pressure to the plant tissues
5. Water **provides habitat** in the form of ponds, rivers, lakes and sea for a large number of plants.

THE STRUCTURE AND PROPERTIES OF WATER

Properties of Water

- **Polar molecule**

Each molecule of water consists of **one atom of oxygen** and **two atoms of hydrogen**, so it has the chemical formula **H_2O**. 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.



- **Capillary Action**: Capillary action (or capillarity) describes the ability of a liquid to flow against gravity in a narrow space such as a thin tube. This spontaneous rising of a liquid is the outcome of two opposing forces:

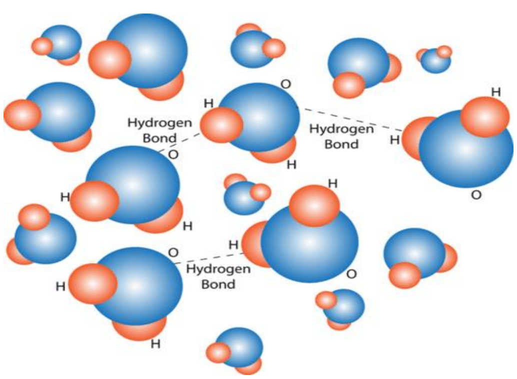
Cohesion = **water** attracted to other **water** molecules because of polar properties.

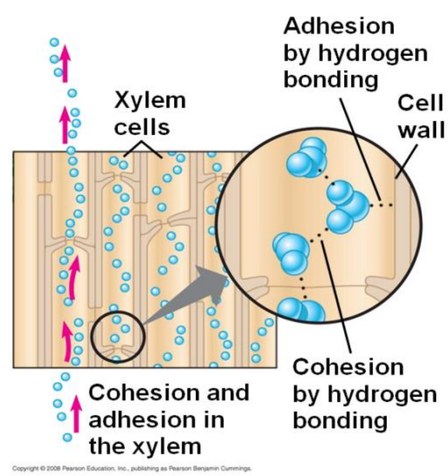
Water is characterized by high cohesion since each water molecule can form four hydrogen bonds with neighboring molecules.

Adhesion = **water** attracted to other **materials**.

The capillarity of the liquid is said to be high when adhesion is greater. Hence, knowledge of the liquid is not sufficient to determine when capillary action will occur, since we must also know the chemical composition of the tube. These two, together with the contact area (the tube's diameter), comprise the key variables. For example, water in a thin glass tube has strong adhesive forces due to the hydrogen bonds that form between the water molecules and the oxygen atoms in the tube wall (glass = silica = SiO2). In contrast, mercury is characterized by stronger cohesion, and hence its capillarity is much lower.

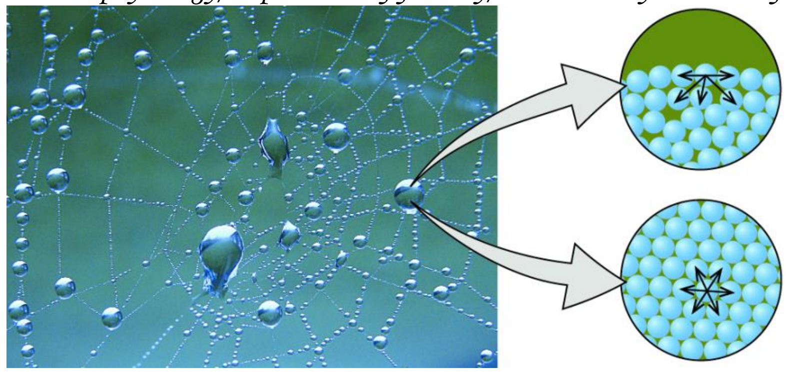
Because water has both adhesive and cohesive properties, capillary action is present.





- **Surface Tension**

At liquid-air interfaces, surface tension results from the greater attraction of liquid molecules to each other (cohesion) than to the molecules in the air (adhesion). Because of the relatively high attraction of water molecules for each other, water has higher surface tension as compared to the surface tension of many other liquids because hydrogen bonds among surface water molecules resist stretching or breaking the surface.



- **High specific heat**

The specific heat is "the **amount of heat** per unit mass required to **raise the temperature** by **one degree Celsius**."

Water has a **high** heat capacity, because in order to raise the temperature of water, it takes much more energy to raise the temperature of water compared to other solvents because **hydrogen bonds** hold the water molecules together.

- **Universal solvent of life**

Water is an excellent solvent. It dissolves greater amounts of a wider variety of substances than do other related solvents. This versatility as a solvent is due in part to:

1. The **small size** of the water molecule.
2. Its **polar nature**: makes water a particularly good solvent for ionic substances and for molecules such as sugars and proteins that contain polar —OH or —NH2 groups.

The Kinetic Theory of Matter

The **kinetic theory of matter** helps us to explain why matter exists in different ***phases*** (i.e. solid, liquid and gas), and how matter can change from one phase to the next. The kinetic theory of matter also helps us to understand other properties of matter. It is important to realize that what we will go on to describe is only a *theory*. It cannot be proved beyond doubt, but the fact that it helps us to explain our observations of changes in phase, and other properties of matter, suggests that it probably is more than just a theory.

Broadly, the Kinetic Theory of Matter says that:

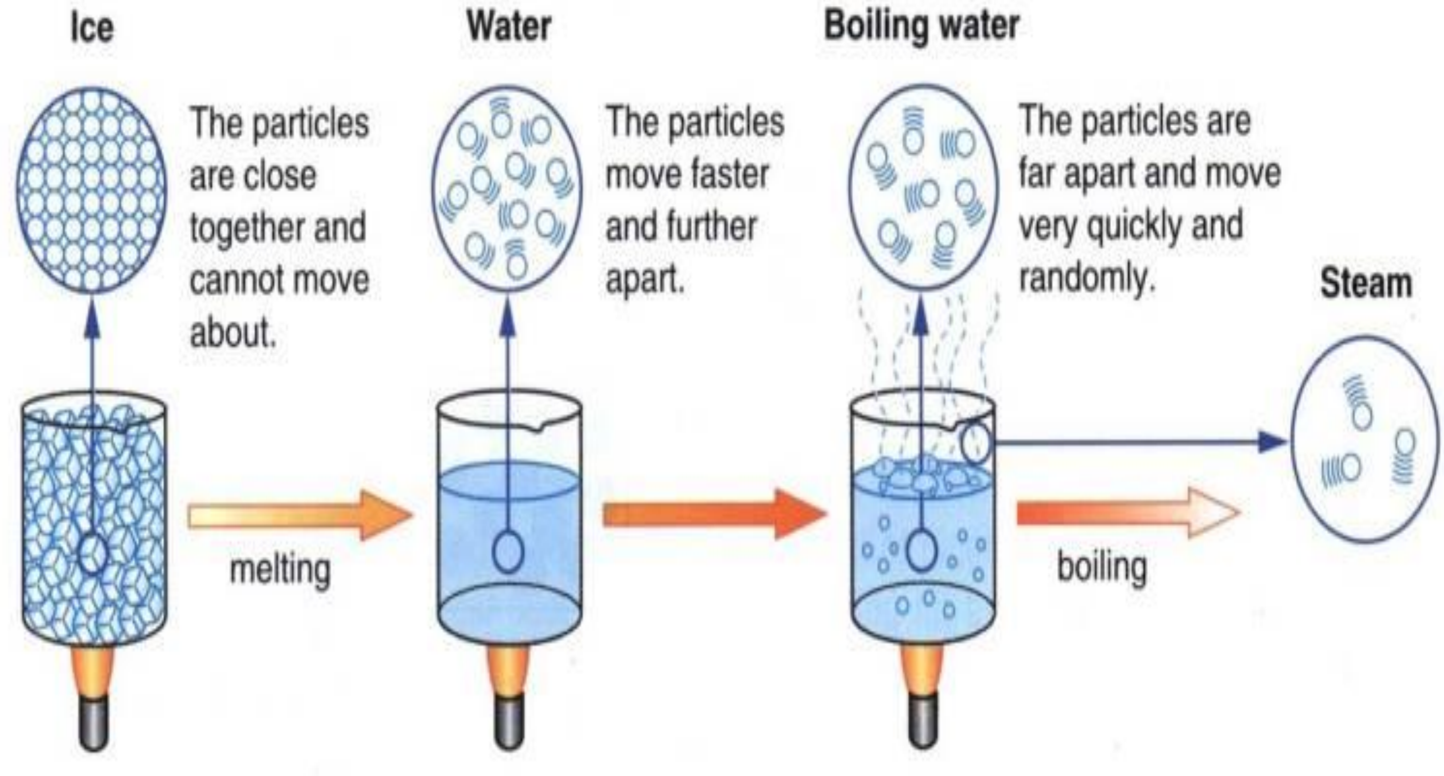
1. Matter is made up of **particles** that are constantly moving.
2. All particles have **energy**, but the energy varies depending on whether the substance is a solid, liquid or gas. Solid particles have the least amount of energy and gas particles have the greatest amount of energy.
3. The **temperature** of a substance is a measure of the *average kinetic energy* of the particles.
4. A change in **phase** may occur when the energy of the particles is changed.
5. There are **spaces** between the particles of matter.

6. There are **attractive forces** between particles and these become stronger as the particles move closer together. These attractive forces will either be intra molecular forces (if the particles are atoms) or intermolecular forces (if the particles are molecules).

Let's look at an example that involves the three phases of water: ice (solid), water (liquid) and water vapor (gas).

Taking water as an example we find that in:

1. The solid phase the water molecules have **very little energy** and can't move away from each other. The molecules are held closely together in a regular pattern called a ***lattice***.
2. If the ice is heated, the **energy** of the molecules **increases**. This means that some of the water molecules **are able to overcome the intermolecular** forces that are holding them together, and the molecules **move further apart to form *liquid water***. This is why liquid water is able to **flow**, because the molecules are **freer to move** than they were in the solid lattice.
3. If the molecules are **heated** further, the liquid water will become **water vapor**, which is a **gas**. Gas particles have **lots of energy** and are **far away from each other**. That is why it is **difficult to keep a gas in a specific area**! The attractive forces between the particles are **very weak** and they are only loosely held together. The figure below shows the changes in phase that may occur in matter, and the names that describe these processes.



▲ Changes of state in matter.