WATER

Water has fascinated scientists down the ages: Thales of Miletus, a Greek philosopher, thought that it was an element, and only in 1774 Henry Cavendish showed that water is a compound of hydrogen with oxygen. Since then it has become one of the most investigated of all chemicals and, although its structure is very simple, its physical and chemical properties are extraordinarily complicated.

CHEMICAL STRUCTURE

In a water molecule two hydrogen atoms are bonded to an oxygen atom in a V-shaped arrangement. (the angle is about 105°). The electronic distribution shows that there are two lone pairs on the oxygen atom which are the keys of water peculiar behaviour: they attract the hydrogen nucleus of another water molecule to form what is called a hydrogen bond. Hydrogen bonds are not very strong, but they affect the properties of water significantly and allow the formation of extended three-dimensional aggregates in the condensed states. Although water molecules are largely independent of one another in the gaseous state, they interact strongly enough to form an ordered structural lattice in the solid state, where each molecule is bound to four other molecules in a tetrahedral configuration. The resulting lattice can be represented as sheets of puckered hexagonal rings: the molecules are not packed very tightly and this explains why water is one of the few substances that is less dense in solid than in liquid state. For this reason pipes burst when they freeze in winter and lakes and ponds develop a surface ice sheet in winter rather than freezing solid from bottom to top, as does a liquid that is less dense than its solid form. Far from being a "normal" fluid, with molecules moving randomly,liquid water exibits a short-range ordering: hydrogen bonds make water molecules stick to one another in aggregates that form and re-form continually. This results in anomalously high values for viscosity, surface tension, and the temperatures and heats of melting and boiling (which involve separation of molecules). At room temperature H_2O should be a gas like its sister molecule H_2S, hydrogen sulfide.

PHYSICAL PROPERTIES

Water is one of the most plentiful and essential of compounds, and the only one on Earth to occur naturally in gaseous, liquid and solid states. Water is vital to life, participating in virtually every process that occurs in plants or animals.

Water is a colourless, tasteless and odourless liquid at room temperature. One of its most important properties is its ability to dissolve many other substances. The versatility of water as a solvent is essential to living organisms. Life is believed to have originated in the world's oceans, which are complicated solutions. Living organisms use aqueous solutions (e.g. blood and digestive juices) as mediums for carrying out biological processes.

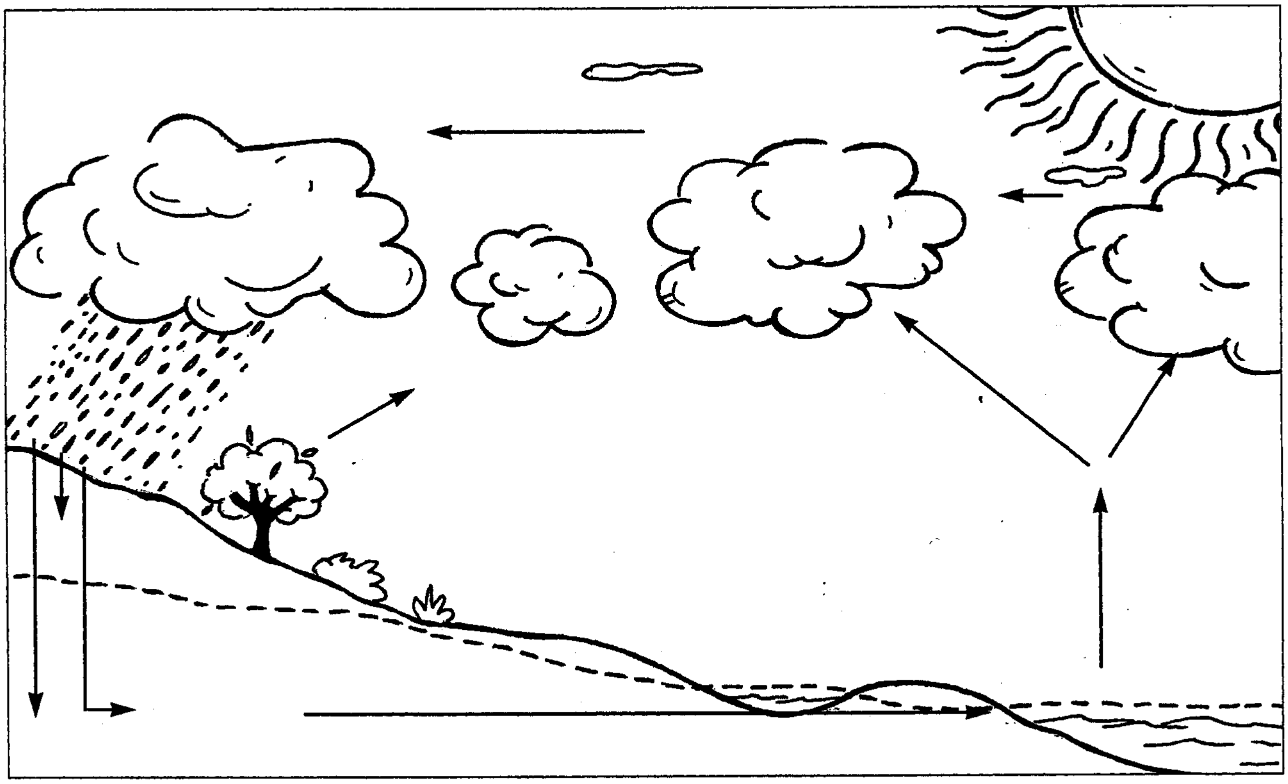
HYDROSPHERE

Approximately one billion cubic kilometres of water, in liquid and frozen form, make up the oceans, lakes, streams, glaciers and groundwater.

The hydrologic cycle consists of a group of reservoirs containing water, the processes by which water is transferred from one reservoir to another (or transformed from one state to another) and the rates of transfer associated with such processes. These transfer paths extend upward to about 15 kilometres in the atmosphere and downward to about 5 kilometres in the crust.

Over 97% of the water on Earth is ocean water, over 2% is locked up in ice caps and glaciers, and the rest is stored in rivers, lakes, groundwater, soil moisture, atmosphere and biosphere. The Earth's waters are never pure H_2O, but contain dissolved and particulate materials;

water movement plays a very important role in the trasportation of organic and inorganic substances about the planet's surface.



THE WATER CYCLE (or hydrologic cycle)

The water cycle consists of various complicated processes of precipitation, evaporation, interception, transpiration, infiltration and percolation, retention, overland flow ....

Water evaporates from the land and ocean surface before falling as precipitation. In the atmosphere water remains about 10 days and is present in gaseous form mainly. Liquid water (as tiny droplets in clouds or as rain) and solid water (as ice crystals in clouds, snowflakes or hail) occur only momentarily and locally. The presence of water in the atmosphere is very important because water plays an essential role in the greenhouse effect, keeping the Earth surface warmer than would otherwise be. Over the oceans, evaporation exceeds precipitation, and the net difference represents transport of water vapour over land, where it precipitates as rain and returns to the ocean as river runoff and groundwater discharge.

Precipitation falling toward the Earth's surface may be evaporated during its fall, or reach the ground or be held on leaves and stems if the ground is covered with dense vegetation.

This interception may result in little water reaching the ground. Rain can infiltrate the soil, or became overland flow (a form of runoff). Between rainfall periods, water held in the soil as soil-moisture is gradually lost by direct evaporation or by withdrawal by plants. Water is also returned to the atmosphere by transpiration in plants.

Water can also percolate from the soil- moisture zone through the unsaturated zone to the groundwater table. Groundwater is always in motion: can flow into rivers or lakes or collect water from surface bodies of water. Water runoff from the land surface evenctually appears in streams and rivers.

SOURCES, COLLECTION AND TREATMENT OF WATER

The water we use is often collected from aquifers (underground bodies of water). The rest comes from reservoirs or rivers.

The purity of water can be affected by:

- dirt and debris (such as leaves)
- living organisms (such as insects and algae)
- bacteria
- effluent (liquid waste - from waste water treatment works)
- chemicals applied to farms (such as pesticides and fertilisers)
- cattle slurry and silage liquor (from cattle farming)
- chemical wastes (from industry)
- contaminated land (such as old industrial sites)
- landfill sites (underground rubbish tips)

Water is collected in different ways, depending on the source. To reach the water held underground in aquifers, a borehole is drilled down to the aquifer and a pump brings the water up to a water treatment works. All water needs some form of cleaning in order to meet legal requirements and standards for quality. Water from aquifers is usually less affected by the impurities and pollution found in surface water. Water is anyway filtered to remove increasingly fine particles. Often small amounts of aluminium sulphate are added, which help to bind the particles together and ensure they are caught. Either chlorine gas, ozone or ultraviolet light may be used to sterilise the water.

After treatment, clean water is stored in large water tanks or underground water reservoirs. From here it is pumped into the water mains pipes.

WASTE WATER TREATMENT

The waste water from homes, offices and factories flows through bigger and bigger pipes until it arrives at a waste water treatment works. Here water is usually lifted a few meters so that the waste water can flow by gravity through a number of treatment stages.

The waste water first flows through metal screens. Large objects are caught on the metal bars and taken away for disposal. Bits of grit and stone are then allowed to settle out of the waste water and sink to the bottom. This is done by slowing the flow of water in channels called grit channels.

The next step is to separate out the lighter solids, such as human wastes and bits of food (organic matter) in the primary settlements tanks, where the water remains up to six hours. Sludge forms at the bottom of the settlement tanks and is pumped away.

The water that flows from the top of settlement tanks is called effluent and can be piped out into rivers or sea, or can undergo an activated sludge treatment for further purification.

PROPERTIES OF THE HYDROSPHERE

Rainwater - Rainwater is not pure but contains dissolved gases and salts, fine-ground particulate material, organic substances and even bacteria. The sources of the materials in rainwater are the oceans, soils, fertilizers, air pollution and fossil-fuel combustion.

The discovery of the high salt content of rain near coastlines was somewhat surprising because sea salts are not volatile, and it might be expected that the process of evaporation of water from the sea surface would "filter" out the salts. It has been demonstrated, however, that a large percentage of the salts in rain is derived from the bursting of small bubbles at the sea surface due to impact of rain droplets or the breaking of waves, which results in the injection of sea aerosol in the atmosphere. This sea aerosol evaporates, with resultant precipitation of the salts as tiny particles that are subsequently carried high into the atmosphere by turbulent winds. These particles may then be transported over continents to fall in rain or as dry deposition.

Ocean and river water - River discharge constitutes the main source for the oceans. Seawater contains, by weight, about 3.5 % dissolved salts (35 grams per liter). Of the average 35 parts per thousand salts, sodium and chlorine make up almost 30 parts, magnesium and sulfate contribute another four parts, the rest being calcium, potassium and carbonate mainly. Only 8 elements make up 99 per cent of seawater, though most of the 92 naturally occurring elements have been detected therein. Salinity in seawater can range from 4.6 grams per liter (Baltic Sea) to 240 grams per liter (Dead Sea).

In contrast to ocean water, the average salinity of the world's rivers is very low (0.12 grams per liter). The composition of river and lakes water is controlled by water-rock interactions: the minerals in continental rocks can be dissolved by water containing carbon dioxide or other chemicals (from rain or soil); the disintegration of rocks explains also the presence of suspended particles in the water.

IMPACT OF UMAN ACTIVITIES ON THE HYDROSPHERE

The activities of modern society are having a severe impact on the hydrologic cycle: the quality of water is affected by the discharge of toxic chemicals, radioactive substances and industrial wastes; by seepage of fertilisers, herbicides, pesticides; by inadvertent and deliberate discharge of petroleum; by improper sewage disposal and by thermal pollution.

Eutrophication - The processof eutrophication is defined as high biological productivity resulting from increased input of nutrients or organic matter into aquatic systems. Eutrophic waters have large concentrations of plankton and are usually murky, and lakes and coastal marine systemsmay be oxygen-depleted at depth.

Acid rain - The emission of sulfur dioxide and nitrogen oxides to the atmosphere by human activities (fossil-fuel burning) has led to the acidificaion of rain and freshwater aquatic systems. Acid rain, which is defined as precipitation with a pH of less than 5.7, leads to increase mobilization of aluminum, and this accounts for damage to forests and fish populations.

Buildup of greenhouse gasses - Greenhouse gasses have the property of trapping the heat of the atmosphere. It has been shown that the concentration of carbon dioxide (350 ppmv) is 25 % higher than in the eighteenth century. Much of the increase is due to the burning of coal, oil, gas and wood. The effect of the potential rise in surface temperatures would be to speed up the hydrologic cicle: the water balance would be altered, with some places becoming drier and others wetter. Global warming could further affect the water cycle by the melting of the ice in the Greenland and Antartic ice caps and in mountain glaciers, resulting in transfer of water to the oceans and a rise in sea level of nearly one meter over the next century. (The melting of all glacial ice would raise the sea level of about 56 meters).