SECTION I.

SUBSTANCES THAT DISSOLVE IN WATER

TEACHER'S INFORMATION

Many substances DISSOLVE (go into SOLUTION) in water. Solids such as salts or sugar, liquids such as alcohol or acetone, and gases from the air all dissolve in water. Water is frequently called the "universal solvent" because so many different kinds of things dissolve in it. Some things do not dissolve in water. The saying that "oil and water do not mix" is based on fact.

Substances that are in solution in the water of a pond, stream, lake or ocean have a direct effect on the plants and animals that live there. Each water environment is unique, in part, because of these substances. This section discusses the most common things that are in solution in water and the ways that these substances affect plants and animals.

SALTS

SALTS are special compounds that go into solution in water easily. They consist of IONS which are atoms or molecules that have a charge. Positive ions are missing one or more electrons. An example is the sodium ion written Na+. Negative ions have one or more extra electrons. Negative chloride ions, Cl-, join with positive sodium ions, Na+, in a loose lattice in which the positive and negative charges are balanced and the ratio of sodium to chloride is 1:1. The combination is called sodium chloride or NaCl, also known as table salt. There are many different kinds of salts besides table salt. If salts are put into water, they dissolve very rapidly because the ions are not firmly bound to each other and are attracted to the water molecules.

Because salts dissolve so easily, rain water or melting snow pick them up from the soil as the water runs off to streams or percolates into the ground. Rain even dissolves chemicals in the air as it falls. Hence, air pollution leads to water pollution such as acid rain.

Eventually these weak solutions of salts and water reach the ocean or a lake such as the Great Salt Lake which has no outlet. Here the water EVAPORATES into the air, is carried aloft, CONDENSES into rain or snow and falls again on the land where it picks up more salts. Each time the salts remain behind. This water cycle constantly carries more salts to the sea. Over millions of years the oceans have become quite salty. Ocean water is called SALT WATER because of this saltiness. If 1000 g of ocean water is evaporated, 35 g of salts are left behind. This means that 35/1000ths of the weight of sea water is salts. The percent by weight that is salts is calculated by dividing 1000 into 35, which equals 0.035, and then multiplying by 100 to get the percentage. Thus sea water is 3.5% salts by weight. This is also expressed as 35 parts per thousand (ppt). The world's oceans are fairly uniformly 35 ppt salts. In lagoons where evaporation is high, it may be saltier. Salt lakes may also be saltier than the sea. Where a river runs into the sea, the saltiness is lower and is referred to as BRACKISH. The area of brackish water at the river mouth is an estuary.

Not all of the saltiness of the ocean is caused by table salt, NaCl. If you try to keep sea creatures in a solution of table salt, they will die because they require the whole range of kinds of salts in the sea. There are many kinds of things in solution in salt water. The major ions found dissolved in sea water are:

positive ions	**ppt**
sodium (Na+)	10.6
magnesium (Mg+**2**)	1.3
calcium (Ca+**2**)	0.4
potassium (K+)	0.4

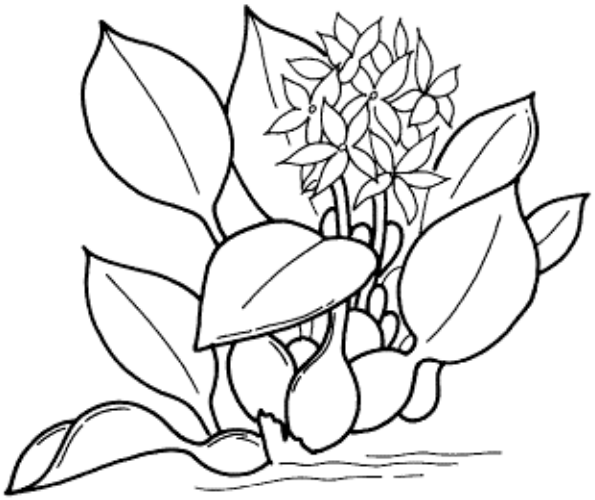
negative ions	**ppt**
chloride (Cl-)	17.3
sulfate (SO**4** -**2**)	.7
bicarbonate (HCO**3** -)	0.7

Water that has little dissolved salts is called FRESH WATER. Fresh water is not absolutely pure, however. Even rain picks up things as it falls. Different bodies of fresh water have different compositions of things in solution, depending on the characteristics of the rock and soil of the region, the plant material that enters the water and the human activities that influence the system. By definition fresh water is less than 0.5 ppt dissolved salts. This may not seem like much, but fresh water that has a good deal of calcium leaves a white residue behind in tea kettles and coffee makers and requires extra soap in the washing machine. It is often called "hard" water. By comparison "soft" water has little calcium. The differences from one freshwater system to another can directly influence the kinds of plants and animals found there.

OXYGEN

The gases found in air are also in solution in water. The most important to things that live in water is oxygen. In surface waters oxygen is present in the same proportions as in air. Under certain circumstances the amount of oxygen varies in different parts of a body of water. Biological activity, incomplete circulation and the slow DIFFUSION or movement of gases through water contribute to this unequal distribution of oxygen. In a shallow pond rich with plants and animals, the oxygen level may be higher than expected during the day when the plants are producing oxygen during PHOTOSYNTHESIS in excess of the use of oxygen by both plants and animals in RESPIRATION. At night the oxygen falls rapidly as the plants and animals use it during respiration. In the oceans and lakes there are areas where oxygen is low, and mixing and diffusion do not replace it as fast as it is used.

MINERALS
Many other ions and elements are also found dissolved in sea water, including the two MINERALS that are the most essential nutrients for plant growth: PHOSPHORUS as phosphate (PO_4^{-3}) and NITROGEN as ammonium (NH_4^{+}) or nitrate (NO_3^{-2}).



POLLUTANTS
All sorts of other things end up in solution in water. Many of them are natural products, although human actions may cause levels of these that are higher than would occur naturally. Mercury or nitrates are examples. Others are products which we have manufactured that are entirely new such as pesticides and herbicides and other organic chemicals. Run off may carry farm chemicals into streams and rivers. Factories and cities dump their sewage into SURFACE WATERS (rivers, bays and oceans). Water that percolates down into the soil to the GROUND WATER can carry chemicals from farms or waste disposal sites. Pollution of ground water is a major problem because over half the people in the United States get their drinking water from wells.

Water pollution constitutes a direct health hazard. It also may destroy the plants and animals that live in water environments or may disrupt the relationships between them in such a way that the community structure is changed.

One way of classifying pollution is to separate materials which come from an identifiable source (POINT SOURCE POLLUTION) from those that enter water all along its course (NON-POINT SOURCE POLLUTION). In the past most attention was focused on point source pollution because it was easier to see and identify. Regulators were able to write laws that specified how much pollution came out of a factory or sewage treatment plant. As point source pollution is beginning to come under some degree of control, attention is turning to non-point source pollution. It is important, but hard to define and regulate.

This table shows the basic kinds of water pollution, the sources and form of discharge or entry to the water. Some of these are under reasonably good control. Others are just beginning to be studied.

kinds of pollution	point source pollution	non-point source pollution
disease organisms	human wastes from sewage treatment plants	some problems where people camp or backpack
man-made and naturally occuring organic compounds	chemical manufacturing plants and disposal; oil spills	agricultural run-off from pesticides, herbicides, and fertilizer
inorganic or mineral compounds; plant nutrients	mining and manufacturing electric power generation; sewage	agricultural run off of fertilizer
radioactive material	mining, manufacturing, accidental, discharge and disposal	airborne following testing or an accident
biological wastes that use oxygen in decomposition	human sewage, animal wastes, agricultural wastes, paper and food processing	some run-off manure
sediment	storm water from drains carrying eroded soil	erosion from fields and developments
heated water	primarily from electrical generating plants; also some from manufacturing	

A problem common in many bodies of water is pollution that results in oxygen use or low DISSOLVED OXYGEN (DO). Oxygen is used faster than it diffuses into the water. It is used by DECOMPOSING organisms which are acting upon such pollutants as sewage or animal wastes. The decomposing organisms may also be feeding on the remains of plants that grew in over-abundance due to excessive fertilization of the water with plant nutrients from human sewage or farm fertilizer. Environments that are very low in oxygen are said to be ANOXIC and are difficult places for most animals to survive. Bodies of water with very low dissolved oxygen may experience major fish kills, especially in summer. Warm water holds less oxygen and at the same time fosters faster decomposition.

As you can see, all sorts of human activities lead to problems of water quality. Different areas have different problems. Depending on where you live, you may want to discuss in some detail certain of these problems. For example, if you are in the northeastern U.S., acid rain may be the biggest current threat to water quality for wildlife. If you are living along the Chesapeake Bay, sediment, human waste and agricultural run-off may be of the greatest concern. In the arid

western U.S. agricultural run-off carries inorganic salts that make the run-off salty and may even be toxic to wildlife. If you lived in Russia near the Chernobyl power plant, radioactive waste in the water would be of concern. For many of us downstream from Three Mile Island, it was also a very real concern as the entire Chesapeake could have been contaminated with radioactive materials. Along Lake Superior, asbestos particles from mining waste were a problem. Love Canal was ground water contamination in an extreme form. As we learn more, we find new issues to address and new problems to solve.

If you find all this discouraging, do not! We have made progress in some areas. Fish are swimming in some rivers that used to be empty. Lake Erie, once a death trap for fish, seems to be recovering from its abuse. Progress can be made. Public education is a very important part of that progress, because we learn to treat our environment more carefully when we understand the consequences of our actions.