Chemicals in the Environment

All living things are made of chemicals and depend on chemicals to survive. Without carbon dioxide and water, green plants could not produce sugar for food. Without oxygen, plants and animals could not carry out cellular respiration. Forest fires and volcanoes release large quantities of carbon dioxide (volcanoes *alone release 130 million tons of carbon dioxide each year*), sulfur dioxide and ash, which can be harmful to living things. Many chemicals that we use can cause harm.

Medicine From The Environment

Willow bark contains ***salicylic acid***. **Hippocrates** - now known as the 'Father of Medicine' - as early as 400B.C. - recommended willow bark be used to treat pain and fever. First Nations people used willow bark tea as a medicinal drink. A synthetic version of salicylic acid - ***acetylsalicylic acid*** - was developed by the Bayer Company in 1898 and **Aspirin** was born. Other medicines derived from plants found in the environment include:

- *Echinacea Purposa* - extract from the purple cornflower to help stimulate the immune system.

The Nitrogen Cycle

Nitrogen occurs naturally in the atmosphere as Nitrogen gas **(N_2).** In order for living organisms to be able to use this nitrogen, the two atoms must be separated (fixed), so they can easily combine with other elements to form usable compounds.

Nitrogen Fixation is the process by which atmospheric nitrogen gas is converted, (***fixed*** by *lightning*) so it can combine with other chemicals to form compounds that organisms can use. Certain types of bacteria (*found in root nodules of beans, clover and alfalfa*) can ***fix*** nitrogen in the soil, by separating the two nitrogen atoms, so they can combine with other elements to form compounds that can then be used by other living organisms.

After nitrogen fixation has occurred, plants can use the nitrogen-containing compounds, animals then eat the plants and make larger compounds called proteins, which decomposers can then break down into simpler compounds, to be used over again. Eventually nitrogen is released back into the atmosphere to begin the cycle all over.

The concentration of nitrogen is not the same everywhere, and if nitrogen is needed in the soil, nitrogen-fixing plants (like alfalfa) and fertilizer can help to replenish the supply.

Processes and Activities That Affect Environmental Chemicals

The chemicals in the air and food that are used by living organisms are changed by the processes of **cellular respiration** and **metabolism**. Human activities can cause **pollution** (*any change in the environment that produces a condition that is harmful to living organisms*)

- too much of a harmless substance
- toxic materials not occurring naturally

Phosphates: nutrients that enhance growth of plants (excess phosphates stimulate the growth of algae and weeds).

Dioxins: chemicals found in certain pesticides and industrial wastes can cause severe illness and possibly birth defects.

Noise Pollution: can cause hearing loss and other damage to living organisms.

Thermal Pollution: can eliminate species unable to tolerate the increase in temperature

Human Activities

Many chemicals are released into the air, water and soil every day. Activities such as agriculture, sanitation, water and waste treatment, industrial processes, manufacturing, transportation can change the concentration of different chemicals and cause an imbalance. If this becomes a problem, an *issue* is born, which can have various points of view. The issue is stated in a statement that can be supported or opposed and is science-related when science can provide relevant information on the issue.

An **issue** is a matter about which people have different opinions or viewpoints.

-cause of the problem
-seriousness of the problem
-how to solve it

People involved (with an opinion on the issue have certain viewpoints, which can often predict how they might express their opinion. Viewpoints include:

- **Ecological** - concern for protection of ecosystems
- **Economic** - concerned with money & jobs
- **Educational** - acquiring & sharing knowledge
- **Egocentric** - concern for self
- **Ethical/Moral** - right or wrong
- **Health-related** - physical and mental well-being
- **Recreational** - useable for leisure activities
- **Political** - affects a govt. party or politician
- **Scientific** - knowledge gained by observation & experimentation
- **Technological** - problem solving/application

Agricultural Activities

Farmers must have an understanding of chemistry to produce crops that will give a good yield. F**ertilizers - Pesticides - Herbicides**
All of these activities can produce issues, which can have far reaching effects.

Solid Waste

Solid waste includes the garbage collected from households, industries, commercial retailers, institutions and construction or demolition sites. Some of this waste can be recycled or reused, but most of it is placed in landfill sites. A small amount is incinerated (burned). Some of the hazards that can occur when solid waste, containing chemicals which are harmful to the environment are not properly disposed of include:

- air pollution (controlled emissions - scrubbers)
- leaching (prevented by plastic liners and compacted clay foundation at the landfill site)

Waste management is everyone's responsibility. The 4 R's of Waste Management

Reduce: - to decrease the amount of waste produced (less packaging, buying in bulk)

Reuse: - to use things either for the same purpose a second time, or for a different purpose (reusing returnable bottles and cans)

Recycle: - to collect waste of a certain type (break it down and rebuild it into other products (recycling depots)

Recover/Reclaim: - to reclaim either waste material or energy in order to put it to another use (incineration provides thermal energy which can be converted into electrical energy)

Wastewater

Sewage includes: dissolved and undissolved materials from your kitchen, bathroom and laundry.

Septic tank (rural areas) - A septic tank is a large underground container that traps grease and large solids. The remaining liquid waste is distributed through pipes with holes; the pipes lead into a drainage area containing gravel. Bacteria and other micro-organisms in the grave! and soil break down the organic waste and use it as a source of food energy. This system mimics the way in which decomposers normally recycle biodegradable wastes. (tank is periodically pumped out to prevent overflow)

Sewage Treatment Plant (urban areas) - A facility treating sewage in three levels or steps.

- **Primary** - *physical* - filtering. sieving and settling waste water can be further treated with chlorine and returned to the environment as **effluent**. Waste material, called **sludge**, can be recycled as fertilizer or landfill.
- **Secondary** - *biological* - bacteria and micro-organisms decompose most of the remaining biodegradable waste.
- **Tertiary** - *chemical* - removes dissolved nitrates, phosphates and undissolved solids from the effluent

Fuel Combustion

The burning of **hydrocarbons** (fossil fuels - including coal, oil and natural gas - from dead plants and animals) produces large amounts of carbon dioxide and water vapor. Sulfur dioxides and nitrogen oxides, traces of mercury and lead are also produced.

Industrial Processes

The generation of electrical energy , mineral processing and fertilizer production can release harmful chemicals (sulfur dioxides and nitrogen oxides) into the air. Natural gas contains compounds such as methane, ethane, propane, and butane. If natural gas contains hydrogen sulfide it is called '*sour gas*'. If it doesn't it is called '*sweet*'. When hydrogen sulfide is removed, sulfur dioxide is produced. Laws have been made to reduce these emissions, and the recovery of most of the pure sulfur has enabled the natural gas processing plants to manufacture sulfuric acid, which is used in making fertilizers, steel, synthetic fibers and paint.

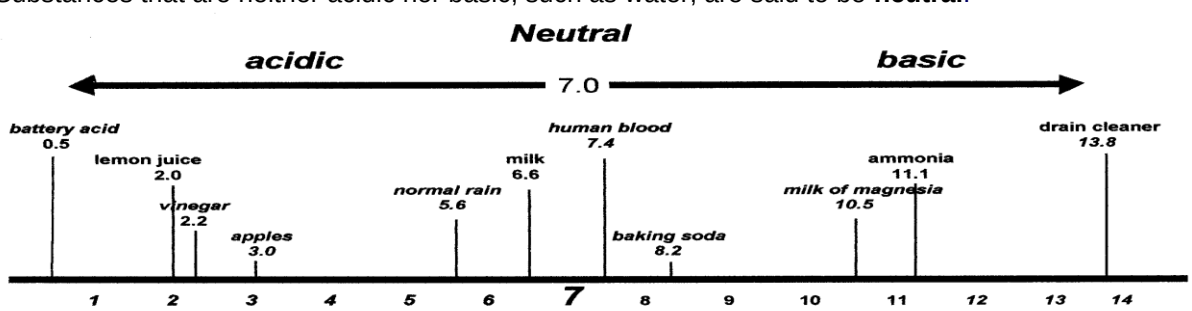
Acids and Bases

pH is a measure of the **concentration of hydrogen ions** in a solution**.**

Acids taste sour, are soluble in water, undergo similar chemical reactions and have a pH of less than 7

Bases taste bitter, are soluble in water, feel slippery, react with acids and have a pH of more than 7

Substances that are neither acidic nor basic, such as water, are said to be **neutral**.

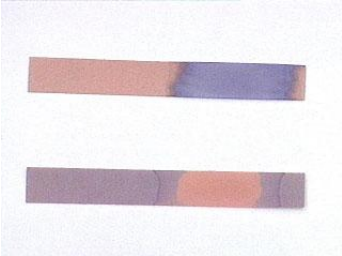


Acidity is measured on the pH scale, which is a scale of numbers from 0 to 14. 7.0 is neutral. All substances below 7.0 are acidic, while all substances above 7.0, are basic

Measuring pH

To identify a substance as an acid, a base, or neutral, an indicator is used. It changes color according to the type of substance it is put into. Indicators can be solids, such as litmus paper, or universal indicator (which change color over a wide pH range can identify many different substances and is more precise), or they can be liquids. such as phenol red. Common indicators include: litmus paper / universal indicator paper / phenolphthalein / BTB (Bromothymol Blue) grape Juice / red cabbage Juice / tea

A **universal indicator** is used to measure pH.



Red litmus paper will turn **blue** in the presence of a **base**.

Blue litmus paper will **turn red** in the presence of an **acid**,

Neutralization

Acids and bases react together when they are mixed. This type of reaction is called **neutralization**. Both the acid and the base are used up in this type of reaction. A **salt** and **water** are produced.

Acid in your stomach has a normal pH of 2. This acid helps in the digestion of food and kills off bacteria. If you eat too quickly, or are under stress, your stomach produces an excess amount of gastric acid (giving you heartburn). To neutralize the excess acid, an antacid tablet is swallowed. This antacid is a mild base. (eg. Tums, Rolaids, Milk of Magnesia, Pepto Bismal)

Hydrochloric Acid + Sodium Hydroxide ------ » Sodium Chloride + Water

$$HCl + NaOH \text{ ------ } \rightarrow NaCl + H_2O$$

Neutralizing The Effects Of Acid Rain

Rainwater is naturally slightly acidic. When this water combines with chemicals in the atmosphere such as sulfur dioxide or nitrogen dioxide, the effect results in **Acid Rain** (with a pH as low as 3 - in some parts of Canada). This can have devastating effects on living organisms. To neutralize this acid rain, lime (calcium hydroxide - which is a base) is added to lakes.

Calcium Hydroxide + Sulfuric Acid ------ » Calcium Sulfate + Water

$$Ca(OH)_2 + H_2SO_4 \text{ ------ } \rightarrow CaSO_4 + H_2O$$

This is not necessary in places which contain rich deposits of limestone, making the water naturally basic. When the acid rain falls, it is neutralized almost immediately.

Common Substances Essential to Living Things

Our body needs about 25 different chemicals for normal growth. The complex organization of these chemicals produces **organic compounds** which contain Carbon, as well as mostly Oxygen and Hydrogen. Substances that do not contain Carbon are called **inorganic compounds.**

Macronutrients

Nutrients, which are made up of elements and compounds, help living organisms survive. Plants obtain carbon, oxygen and hydrogen from the air, and nitrogen, phosphorus, potassium, magnesium, calcium and sulfur from the soil. These nine elements are called **macronutrients** (because they are in needed in large quantities) are essential for plants to grow. There are other elements that are also needed, but not in large quantities. These elements are called **micronutrients**. The most important elements, which are *macronutrients* are:

Nutrient	Importance in Plants	Importance in Humans
Nitrogen (N)	- proteins & chlorophyll - leaf and stem growth	- composition of proteins & nucleic acids - growth and repair of tissue
Phosphorus (P)	- root and flower growth - cellular respiration & photosynthesis	- composition of bones, teeth & DNA - metabolic reactions
Potassium (K)	- stimulates early growth - starch and protein production - disease resistance - chlorophyll production & tuber formation	- muscle contraction & nerve impulses
Magnesium)Mg)	- chlorophyll structure - photosynthesis	- composition of bones & teeth - absorption of calcium & potassium
Calcium (Ca)	- cell wall structure - cell division	- composition of bones & teeth - blood clotting - muscle & nerve function
Sulfur (S)	- production of fruits and grains	- protein synthesis - enzyme activation - detoxification

Maintaining the Right Level of Nutrients

By knowing how plants use each element, agriculturalists can diagnose deficiencies and excesses, and act accordingly, to alleviate the problem.

> *Problem:* yellow striping on lower leaves & soil test indicates high levels of potassium and low levels of magnesium
> *Analysis:* potassium is interfering with the plants ability to absorb the magnesium
> *Solution:* stop applying fertilizer containing potassium and apply more fertilizer with magnesium

Optimum Amounts

A micronutrient may be present in larger amounts than normal. If this occurs it can have harmful effects. Too little can also have harmful effects. The **optimum amount** of a substance, such as the micronutrient - *selenium*, is the amount that provides an organism with the best health.

Types of Organic Molecules

Organic Compounds	Description	Examples
Carbohydrates	- are organic molecules made up of atoms of carbon, hydrogen, and oxygen	sugar, starch, cellulose, glucose
Lipids	- are compounds composed of many carbon, hydrogen, and oxygen atoms	fats, oils and waxes
Proteins & Amino Acids	- protiens are organic compounds made up of amino acids (each protein has its own unique number, combination and arrangement of amino acids) - functions include growth and repair, as well as a source of energy	enzymes
Nucleic Acids	- large complicated molecules that play a major role in heredity and in controlling the cell's activities	DNA (deoxyribonucleic acid) RNA (ribonucleic acid)

How Organisms Take In Substances

Plants take in **inorganic compounds** to make **organic compounds**. Consumers use the organic compounds made by plants for their energy, growth and repair. When organisms take in these compounds, other substances are also taken. These substances may be harmless or harmful.

Uptake Of Substances By Plants

Nutrients enter the roots by **diffusion** - the movement of molecules from an area of high concentration to an area of low concentration. This action continues until the areas are equal concentrations. (No energy is required for this to occur).

Osmosis

Water moves through plants by a special type of diffusion, called **osmosis**. In this process, water moves through the walls of the plant's roots from an area where there are more water molecules to an area where there are fewer water molecules. As the plant uses the water it draws more up from its roots.

Active Transport

Plants need high concentrations of some nutrients in their roots. These nutrients may have higher concentrations in the roots than in the surrounding soil. To maintain these high concentrations, plants move more nutrients into their roots from areas of lower concentration (in the soil) by a process called **active transfer**. This process requires energy.

Ingestion and Absorption of Materials by Animals

25 different elements are used by humans for growth and function. The process of taking in the nutrients (elements and compounds) we need is called ingestion. These compounds are broken down chemically in the digestive system by a process called **hydrolysis**.

A substance that has been broken down by **hydrolysis** has been **hydrolyzed**.

(example) **Maltose + Water ------ » Glucose**

$$C_{12}H_{22}O_{11} + H_2O \text{ ------ » } 2C_6H_{12}O_6$$

Nutrients such as glucose and amino acids are then absorbed through cell membranes and into the bloodstream, which carries them to where they will be used or stored.

Taking In Nutrients In Different Environments

Where organisms live affects how and when they can obtain the nutrients they need. Some organisms get the nutrients they need often by restricting other organisms from getting the same nutrients (reducing the competition).

Substrates

A **substrate** is a material on which an organism moves or lives. Some organisms attach themselves to the substrate, others obtain their nutrients from their substrate.

Red single-celled algae survive on a substrate that is near freezing, low in nutrients and often acidic.

Tubeworms can survive on the floor of the ocean where lava is rising to the surface - "hot smokers' - and many harmful chemicals (like hydrogen sulfide) are being dissolved in the water nearby.