C1 Investigate and describe, in general terms, the role of different substances in the environment in supporting or harming humans and other living things

C1.1 identify common organic and inorganic substances that are essential to the health and growth of humans and other living things, and illustrate the roles served by these materials (e.g., identify calcium as an essential material for bones; identify minerals that are known to enhance plant growth but that limit growth if too little or too much is available)

Common Organic and Inorganic Substances

All matter is classified as either inorganic or organic in composition. Inorganic matter includes substances that have elements such as magnesium, phosphorous, potassium, and calcium in their molecular structure. These elements are essential for the proper growth of plants and animals for the following reasons:

- Magnesium is essential for carrying out photosynthesis and maintaining metabolic reaction in animals.
- Potassium stimulates protein production in plants and muscle contractions in animals.
- Calcium and phosphorous are essential for carrying or cell division in plants and for growing teeth and bones in animals.
- Nitrogen is required for building proteins. Nitrogen fixing bacteria are found in the roots of some plants that help convert nitrogen into usable form for the plants.

Organic matter includes the majority of compounds that have the element carbon in their molecular structure. Some of these compounds are essential for proper growth and development. Common organic compounds used by plants and animals are carbohydrates, lipids, and proteins.

Living organisms require inorganic and organic nutrients in varying amounts. Compounds required in large amounts such as, carbohydrates, lipids and oxygen are called macronutrients. Compounds required in much smaller amounts such as vitamin A and iodine are called micronutrients.

Plants and animals require nutrients in specific amounts; too much or too little can be harmful. For example, if soil contains a high level of potassium and a low level of magnesium, the leaves on a plant growing in the soil will develop yellow stripes.

C1.2 describe, in general terms, the forms of organic matter synthesized by plants and animals, including carbohydrates, proteins and lipids

Organic Substances Synthesized by Plants and Animals

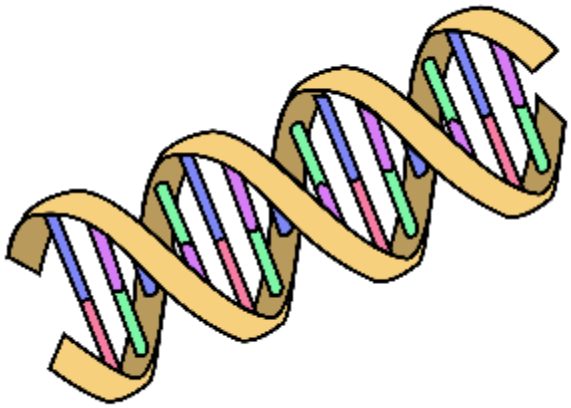
The organic substances synthesized by plants and animals are carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates are organic substances made up of carbon, hydrogen, and oxygen atoms. They can be simple molecules, such as glucose, fructose, and sucrose; or complex molecules, such as starch, cellulose, and glycogen. Green plants synthesize glucose during photosynthesis.

Lipids are also composed of carbon, hydrogen, and oxygen atoms. They are fats, oils, and waxes produced by plants and animals. Humans store energy from food in the form of fat, and human skin produces oils for protection. Plants produce oils and fats in their nuts and seeds, such as peanuts, walnuts, and canola seeds. Fat molecules are made up of fatty acids and glycerol.

Proteins are molecules composed of carbon, hydrogen, oxygen, and nitrogen atoms. Proteins are essential for the growth and repair of tissue, and they can be a source of energy. Proteins are made up of **amino acid** molecules joined together and arranged in a specific sequence.

Nucleic acids are the largest complex molecules found in living organisms. A cell contains deoxyribonucleic acid (**DNA**) and ribonucleic acid (**RNA**). A complex molecule of DNA or RNA is composed of phosphate, a simple sugar (ribose or deoxyribose), and nitrogen-containing bases. Nucleic acids are responsible for the transmission of characteristics and for controlling cell activity.



DNA Structure

C1.3 describe and illustrate processes by which chemicals are introduced to the environment or their concentrations are changed (e.g., dilution in streams, biomagnification through food chains)

Chemicals Introduced into the Environment

Both natural processes and human activities release chemicals into the environment. Carbon dioxide is released naturally into the air during cellular respiration by animals. Cellular respiration, the process by which your body uses the oxygen and chemicals in food to produce energy, releases carbon dioxide as a by-product. Carbon dioxide and other compounds are also released in the air as a result of human activities, such as diving a car or burning coal to produce electricity. The accumulation of unwanted waste matter in the environment is called **pollution**. Pollution causes changes in the environment that are harmful to living things.

The following activities pollute the environment:

- Solid waste disposal
- Waste water disposal
- Combustion
- Agricultural activities
- Industrial processes

Many of the chemicals introduced into the environment by these processes can be broken down naturally, but some of them cannot. The chemicals that cannot break down accumulate in the environment and have long-term effects on the ecosystem.

Agricultural Activities Use Chemicals

Agricultural activities are responsible for introducing many chemicals into the environment. In order to enrich the soil and improve crop yields, farmers use **fertilizer**. Fertilizers contain nitrogen, phosphorous, and potassium, and sulfur. These elements are important for plant growth. However, their overuse pollutes soil and water. Fertilizers that leach from the soil into water systems promote excessive plant growth. The decay of these plants results in oxygen depletion.

Farmers also use **pesticides** to improve their crop yields. Pesticides are chemicals designed to kill organisms that damage crops. **Herbicides** are used to kill or control weeds, **insecticides** kill or control insects, and **fungicides** kill fungi (mushrooms). All of these chemicals pose a serious threat to the ecosystem.

Solid Waste Disposal

Solid waste is garbage collected from households, industries, and construction sites. While some of this waste can be reused or recycled, a large amount is deposited in landfills. Plastic liners and clay are used in sanitary landfills to prevent chemicals from leaching into the ground.

Some wastes are too hazardous to be dumped in a landfill, and this waste is often burned in incinerators. Incinerating garbage produces air pollution.

Wastewater Disposal

The wastewater collected from bathrooms, kitchens, and laundry rooms is called **sewage**. Sewage is made up of both dissolved and undissolved substances. In rural areas, septic tanks are used to collect sewage. Bacteria in the septic tank break down the harmful substances before the substances are released into the soil. In urban areas, sewage is pumped to sewage treatment plants. Once the sewage has been broken down by bacteria or other chemical processes, the treated wastewater (called effluent) is released into nearby rivers and lakes.

Combustion

Fossil fuels such as coal, petroleum, and natural gas are often burned in order to release energy. During a combustion reaction with these fuels, large amounts of carbon dioxide and varying amounts of sulfur dioxide are produced. Many combustion particulates are heavier than air, ending up in the soil and water. Sulfur dioxide that is released combines with water in the atmosphere and causes acid rain or snow.

Combustion in vehicles is a major source of ground level ozone. High concentrations of ground level ozone cause breathing problems for people with respiratory diseases.

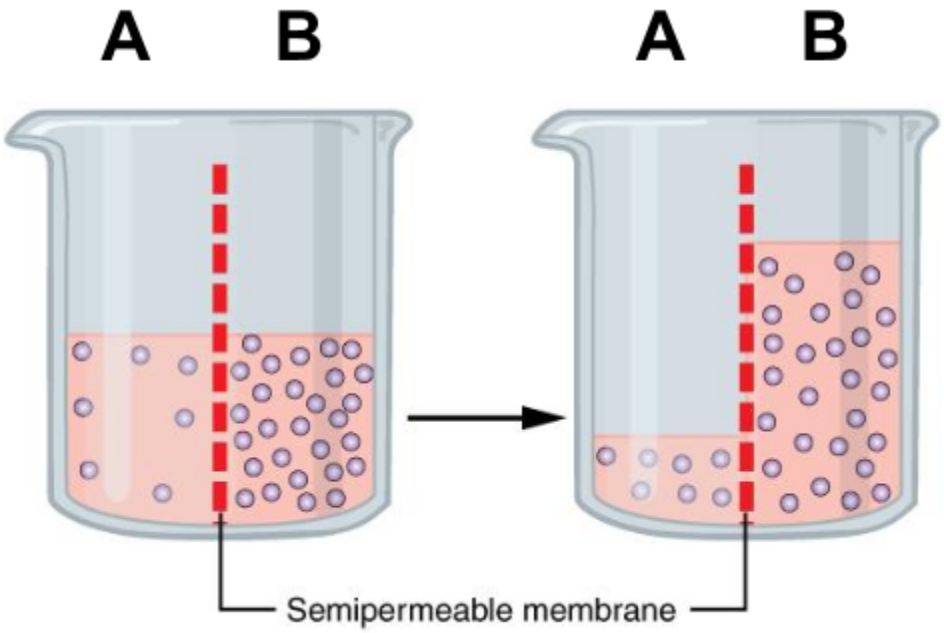
Industrial Processes

Harmful wastes are released into the environment during various industrial processes, such as the processing of crude oil. Crude oil is a mixture of many compounds including those with high toxicity. It is important to minimize the release of these compounds into the air when producing petroleum.

C1.4 describe the uptake of materials by living things through ingestion or absorption, and investigate and describe evidence that some materials are difficult for organisms to break down or eliminate (e.g., DDT, mercury)

Absorption of Nutrients in Plants

Both organic and inorganic chemical compounds are absorbed by plants. Plants absorb these substances from the air and from the soil. Water is required to transport nutrients to the cells and to carry waste products out of the cells. In plants, osmosis is one of the processes by which water in the soil moves into the root cells of a plant. The water passes through a semipermeable membrane, the cell wall, from an area of high concentration of water to an area of low concentration of water. In the diagram the water in side A will move into side B through osmosis even though there is more sugar in side B, this is because the concentration of water in side A is HIGHER than the concentration of water in side B, and they want to be EQUAL. This is the opposite of diffusion where compounds move from areas of higher concentration to areas of lower concentration.



Plants need to absorb nutrients through their roots. The concentrations of these nutrients can be higher in the roots than in the surrounding soil. This means that the nutrients needed in high concentrations will not diffuse into plant roots from the sil. The roots absorb high amounts of these nutrients through a process called active transport. Active transport is the movement of material from an area of low concentration to an area of high concentration. Unlike osmosis and diffusion, this process requires energy.

Ingestion and Absorption of Nutrients in Animals

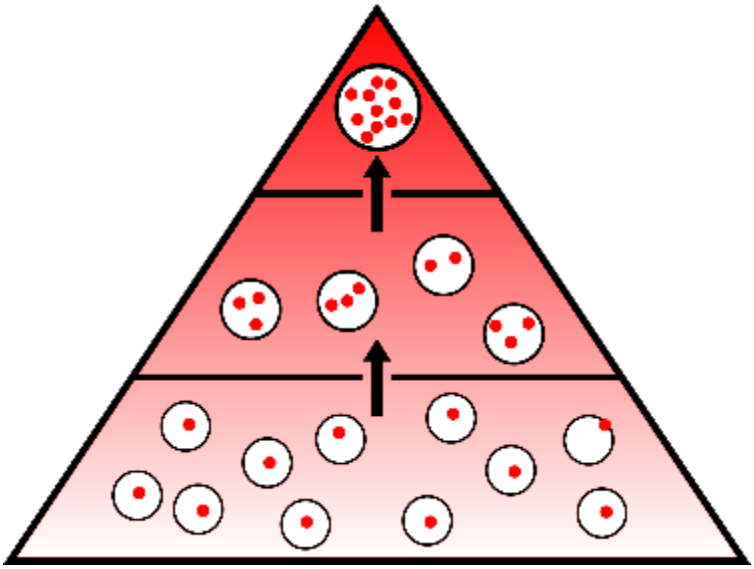
Humans and other animals get nutrients from the food they eat. The process of taking in food is called **ingestion**. The food is broken down mechanically and chemically into simpler substances that can be used by the body. **Hydrolysis** is a process in which large organic molecules, such as sugars, are broken down with water. Complex maltose sugars are hydrolyzed into simple glucose sugars. Once the maltose sugar has been broken down, the glucose nutrients are small enough to be absorbed into the bloodstream. The blood transports the nutrients to appropriate blood cells for use or storage.

Bioaccumulation and Biomagnification

When harmful chemicals are introduced into an environment, they can be absorbed by living organisms. Some toxic chemical compounds that are absorbed into an organism's body do not easily break down and do not get removed from the organism's body. Even if there are very low levels of the toxic compound in an organism's environment, the compound can accumulate in the organism's body over time, making the organism sick or even killing it. The process of low levels of chemicals building up in the bodies of living organisms is called **bioaccumulation**.

Each level of the food chain is called a trophic level. Producers make up the first trophic level, primary consumers (herbivores) make up the second trophic level, and secondary consumers (carnivores) make up the tertiary (third) and higher trophic levels.

Because toxic substances that bioaccumulate become part of the tissues of an organism's body, they will be passed on when that organism is eaten. As these compounds are passed up through each trophic level, they accumulate in greater concentrations in organisms of higher trophic levels. This process is called **biomagnification**.



The given diagram shows a food pyramid with trophic levels and relative concentrations of harmful substances at each level.

The effect of a "red tide" is an example of how bioaccumulation effects consumers at different trophic levels. A harmful algal bloom or "red tide" occurs in the ocean when there is the rapid reproduction of single-celled algae, or phytoplankton, which produces a natural toxin. When toxin-producing phytoplankton begin to reproduce rapidly, the organisms that feed on them accumulate the toxic in their bodies. Shellfish are filter-feeders that store the toxins from "red tides" in their bodies for several weeks. Shellfish are at the second trophic level and are not usually severely harmed by the toxin but these harmful algal blooms can make organisms at higher trophic levels that eat the shellfish such as fish, whales, sea lions, and people very ill.

C1.5 identify questions that may need to be addressed in deciding what substances - in what amounts - can be safely released into the environment (e.g., identify questions and considerations that may be important in determining how much phosphate can be released into river water without significant harm to living things)

Safe Release of Substances into the Environment

Motor vehicles are a primary source of air pollution. Combustion in the engine of a motor vehicle releases nitrogen oxide, carbon monoxide, and carbon dioxide pollutants into the air. What level of pollution emissions by vehicles is considered to be acceptable? How can vehicle emissions by reduced to safe levels? These are some of the questions that need to be addressed.

In an attempt to reduce the pollution emissions from motor vehicles, car manufacturers have designed more energy efficient engines that burn less fuel. Car makers have also designed a catalytic converter for the muffler system that removes pollutants from the vehicle's exhaust. Human actions like driving small vehicles, carpooling, and taking public transit help to reduce emissions in the atmosphere.

Landfills are specially designed areas where solid wastes are disposed of. Selecting a landfill site is not an easy task. The location must be one that is economical to get to, environmentally safe, and large enough to store the increasing amount of household waste. Landfills are constructed with a think clay liner which prevents the garbage leachate from seeping into the nearby water system. Methane gas produced by the rotting garbage in a landfill must be safely contained. Sometimes the gas is collected and piped to a power plant where it is used as a fuel to produce electricity.

Finding a suitable landfill site is becoming more difficult. That is why it is important to reduce the waste matter that ends up in a landfill. Personal actions such as reusing and recycling can reduce the amount of solid waste taken to landfills.

It is important to consider the effects that natural and human activities have on the environment and to take steps to reduce the impact of these processes.