

Chapter 2

Biology and Society: More Precious than Gold

- A drought is
 - a period of abnormally dry weather that changes the environment and
 - one of the most devastating disasters.
- Droughts can cause
 - severe crop damage,
 - shortages of drinking water,
 - dust storms,
 - famine,
 - habitat loss, and
 - mass migration.
- Throughout human history, droughts have helped wipe out societies and even whole civilizations.
- Droughts are catastrophic because life cannot exist without water.

SOME BASIC CHEMISTRY

- Take any biological system apart, and you eventually end up at the chemical level.
- Chemical reactions are always occurring in the human body.

Matter: Elements and Compounds

- Matter is anything that occupies space and has mass.
- Matter is found on Earth in three physical states:
 - solid,
 - liquid, and
 - gas.
- Matter is composed of chemical elements.
 - An element is a substance that cannot be broken down into other substances by chemical reactions.
 - There are 92 naturally occurring elements on Earth.
- All of the elements are listed in the periodic table.
- Twenty-five elements are essential to people.
- Four elements make up about 96% of the weight of most cells:
 - oxygen,
 - carbon,
 - hydrogen, and
 - nitrogen.
- Trace elements are
 - required in only very small amounts and
 - essential for life.
- An iodine deficiency causes goiter.
- Fluorine
 - is added to dental products and drinking water and
 - helps to maintain healthy bones and teeth.
- Elements can combine to form compounds.
 - Compounds are substances that contain two or more elements in a fixed ratio.
 - Common compounds include
 - NaCl (table salt) and

– H₂O (water).

Atoms

- Each element consists of one kind of atom.
 - An atom is the smallest unit of matter that still retains the properties of an element.

The Structure of Atoms

- Atoms are composed of subatomic particles.
 - A proton is positively charged.
 - An electron is negatively charged.
 - A neutron is electrically neutral.
- Most atoms have protons and neutrons packed tightly into the nucleus.
 - The nucleus is the atom's central core.
 - Electrons orbit the nucleus.
- Elements differ in the number of subatomic particles in their atoms.
 - The number of protons, the atomic number, determines which element it is.
 - Mass is a measure of the amount of material in an object.
 - An atom's mass number is the sum of the number of protons and neutrons in its nucleus.

Isotopes

- Isotopes are alternate mass forms of an element.
- Isotopes
 - have the same number of protons and electrons but
 - differ in their number of neutrons.
- The nucleus of a radioactive isotope decays spontaneously, giving off particles and energy.
- Radioactive isotopes have many uses in research and medicine.
 - They can be used to determine the fate of atoms in living organisms.
 - They are used in PET scans to diagnose heart disorders and some cancers.
- Uncontrolled exposure to radioactive isotopes can harm living organisms by damaging DNA.
 - The 1986 Chernobyl nuclear accident released large amounts of radioactive isotopes.
 - Naturally occurring radon gas may cause lung cancer.

Electron Arrangement and the Chemical Properties of Atoms

- Of the three subatomic particles, only electrons are directly involved in the chemical activity of an atom.
- Electrons orbit the nucleus of an atom in specific electron shells.
- The farther an electron is from the nucleus, the greater its energy.
- The number of electrons in the outermost shell determines the chemical properties of an atom.

Chemical Bonding and Molecules

- Chemical reactions enable atoms to give up or acquire electrons, completing their outer shells.
- Chemical reactions usually result in atoms
 - staying close together and
 - being held together by attractions called chemical bonds.

Ionic Bonds

- When an atom loses or gains electrons, it becomes electrically charged.
 - Charged atoms are called ions.
 - Ionic bonds are formed between oppositely charged ions.

Covalent Bonds

- A covalent bond forms when two atoms *share* one or more pairs of outer-shell electrons.
- Covalent bonds are the strongest of the various bonds.
- Covalent bonds hold atoms together in a molecule.
- The number of covalent bonds an atom can form is equal to the number of additional electrons needed to fill its outer shell.

Hydrogen Bonds

- Water is a compound in which the electrons in its covalent bonds are not shared equally.
 - This causes water to be a polar molecule, one with an uneven distribution of charge.
- The polarity of water results in weak electrical attractions between neighboring water molecules.
 - These weak attractions are called hydrogen bonds.

Chemical Reactions

- Cells constantly rearrange molecules by breaking existing chemical bonds and forming new ones.
 - Such changes in the chemical composition of matter are called chemical reactions.
 - A simple example is the reaction between oxygen gas and hydrogen gas that forms water.
- Chemical reactions include
 - reactants, the starting materials, and
 - products, the end materials.
- Chemical reactions
 - can rearrange matter
 - but cannot create or destroy matter.

WATER AND LIFE

- Life on Earth began in water and evolved there for 3 billion years.
 - Modern life remains tied to water.
 - Your cells are composed of 70–95% water.
- The abundance of water is a major reason Earth is habitable.

Water's Life-Supporting Properties

- The polarity of water molecules and the hydrogen bonding that results explain most of water's life-supporting properties.
 - Water molecules stick together.
 - Water has a strong resistance to change in temperature.
 - Frozen water floats.
 - Water is a common solvent for life.

The Cohesion of Water

- Water molecules stick together as a result of hydrogen bonding.
 - This tendency of molecules of the same kind to stick together is called cohesion.
 - Cohesion is vital for the transport of water from the roots to the leaves of plants.

- Surface tension is the measure of how difficult it is to stretch or break the surface of a liquid.
 - Hydrogen bonds give water an unusually high surface tension.

How Water Moderates Temperature

- Because of hydrogen bonding, water has a strong resistance to temperature change.
- Heat and temperature are related, but different.
 - Heat is the amount of energy associated with the movement of the atoms and molecules in a body of matter.
 - Temperature measures the intensity of heat.
- Water can absorb and store large amounts of heat while only changing a few degrees in temperature.
- Water can moderate temperatures.
 - Earth's giant water supply causes temperatures to stay within limits that permit life.
 - Evaporative cooling occurs when a substance evaporates and the surface of the liquid remaining behind cools down.

The Biological Significance of Ice Floating

- When water molecules get cold enough, they move apart, forming ice.
- A chunk of ice has fewer water molecules than an equal volume of liquid water.
- Ice floats because it is less dense than liquid water.
- If ice did not float, ponds, lakes, and even the oceans would freeze solid.
- Life in water could not survive if bodies of water froze solid.

Water as the Solvent of Life

- A solution is a liquid consisting of a homogeneous mixture of two or more substances.
 - The dissolving agent is the solvent.
 - The dissolved substance is the solute.
- When water is the solvent, the result is an aqueous solution.

Acids, Bases, and pH

- A chemical compound that releases H^+ to a solution is an acid.
- A compound that accepts H^+ and removes them from solution is a base.
- To describe the acidity of a solution, chemists use the pH scale.

- Buffers are substances that resist pH change.
- Buffers
 - accept H^+ ions when they are in excess and
 - donate H^+ ions when they are depleted.
- Increases in global CO_2 concentrations may lead to
 - the acidification of the oceans and
 - ecological disasters.