

BIOLOGY STUDY GUIDE
CHAPTER 4—THE CHEMICAL BASIS OF LIFE

- **Matter** = anything that takes up space and has mass (major types of matter = solid, liquid, and gas)
- Any type of matter is made of one or more elements.
 - o **Element** = a substance that cannot be broken down into other substances by regular chemical processes. (examples: gold, silver, mercury, etc.)
 - **There are approximately 25 elements necessary for life.**
 - Examples: oxygen, carbon, hydrogen, nitrogen, calcium, phosphorous, etc.
 - **Trace elements** = those elements that make up less than 0.01 percent of your body mass (examples: iodine, iron, copper, etc.)
- **Compounds** = a substance containing two or more elements; these elements are always present in this compound in the same ratio
 - o For instance, water is a compound where hydrogen and oxygen are combined. The ratio of hydrogen to oxygen in water is always 2:1. (Remember that the chemical formula of water is H₂O.)
 - o Compounds have different characteristics than the elements that make them up. (Water is liquid at room temperature, but when hydrogen and oxygen are by themselves, they are gases at room temperature.)
- **Atoms** = smallest possible piece of an element
 - o **A better definition of an atom may be: the most basic unit of matter that cannot be broken down into smaller pieces by ordinary chemical methods.**
 - o This can be confusing, because when you read the above definition or when you start looking at the periodic table in class, is oxygen an atom or an element?
 - o An element is essentially the same as an atom.
 - Why do we bother with two different words?
 - An element is the most common version of an atom. The element you see on the periodic table for oxygen is the most common version of the oxygen atom that exists in nature. There are several different kinds of oxygen atoms (with different numbers of neutrons than the one found on the table), but they are not as commonly found in nature.
- **All atoms are made of even smaller pieces called subatomic particles.**
 - o **PROTON** = subatomic particle with a positive (+) charge.
 - o **ELECTRON** = subatomic particle with a negative (-) charge.
 - o **NEUTRON** = subatomic with no charge (neutral).
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- **Basic structure of the atom:**
 - Protons and neutrons sit in the center of an atom, forming a central core called the **nucleus**.
 - Electrons circle quickly around the outside of the nucleus.
 - All atoms of an element have the same number of protons. The number of protons is known as the **atomic number**.
 - The most common version of an atom (the element found on the periodic table) is electrically neutral, meaning the number of protons = the number of electrons.
 - Other versions of an atom NOT found on the periodic table are called isotopes and may have differences in their number of neutrons.
 - A different version/form of an atom (one that is less common and NOT found on the periodic table) is called an **isotope**.
 - An oxygen isotope has the same number of protons as the most common form of oxygen (the form found on the periodic table), but the isotope has a different number of neutrons.
 - **Radioactive isotope** = an atom with an unstable nucleus that breaks down over time; as the nucleus breaks down, radioactive energy is given off. Radioactive isotopes are often used in research and medicine.

- **More on electrons:**
 - Electrons circle around the nucleus.
 - Think of the area outside the nucleus like a track (as in track and field); there are several lanes on this track.
 - The innermost lane (nearest the nucleus) can hold a maximum of two electrons.
 - The next lane can hold up to eight electrons.

- **Chemical bonds join atoms to one another.**
- **Types of chemical bonds:**
 - **Ionic** = occurs between two atoms that are charged.
 - In other words, an ionic bond occurs between two ions.
 - An **ion** is an atom with a charge. (The atom is charged because it is missing one of its electrons and so is positively charged OR it has gained an electron and so has a negative charge.)
 - Be sure to look at picture on p. 78
 - **Covalent** = occurs when two atoms SHARE electrons.
 - See p. 79 for picture.
 - **Molecule** = formed when two or more atoms are held together by covalent bonds.
 - A **chemical formula** tells you the number and types of atoms in a molecule (example: H₂O)

- A **structural formula** shows how atoms in a molecule are linked by bonds
 - Example of structural formula for water: H—O—H
 - A **space filling model** uses spheres to represent atoms and shows a 3D model of the molecule.
- **Chemical Reactions** = changes that result in the formation of one or more new substances
- Example of a chemical reaction: hydrogen and oxygen combine to form water.
 - **Reactants** = the starting materials for a reaction
 - **Products** = the ending materials produced by the reaction.
- **WATER:**
- **Structure of water:**
 - Water is **POLAR**, meaning its opposite ends have opposite electrical charges (see page 81, figure 4-12).
 - Water molecules will bond with other molecules using a special type of chemical bond called a **hydrogen bond** (between the hydrogen of one water molecule and the oxygen of a different water molecule).
 - **Characteristics of water:**
 - **Cohesion** = water molecules will stick to one another
 - **Adhesion** = water molecules will stick to different molecules (water will stick to a table surface, for instance).
 - **Temperature Moderation** = it takes a long time to significantly heat up or cool down water.
 - **Thermal energy** = the energy that allows atoms and molecules to move about randomly in a piece of matter
 - **Temperature** = a measure of the average energy of random motion of particles in a substance
 - **Evaporation** = liquid water can escape from a surface and be released as gas
 - The solid form of water (ice) is able to float in liquid water because the molecules are less densely packed than those found in liquid water.
 - Water can dissolve other substances:
 - **Solution** = a uniform mixture of two or more substances
 - **Solvent** = the substance that does the dissolving
 - **Solute** = the substance being dissolved
 - **Aqueous solution** = any solution in which water is the solvent.
 - Example: take salt water – SALT is the solute and WATER is the solvent.

- **Acids, bases, and pH:**
 - **Acid** = any aqueous solution with a more H⁺ ions than OH⁻ ions.
 - **Base** = any aqueous solution with a more OH⁻ ions than H⁺ ions
 - **pH scale** = used to describe how acidic or basic a substance is.
 - Score of 0 = most acidic (H⁺ ions > OH⁻ ions)
 - Score of 7 = neutral (this substance has equal concentrations of H⁺ and OH⁻ ions).
 - Score of 14 = most basic (OH⁻ ions > H⁺ ions)

 - The pH of the solution inside most living cells is close to 7.
 - See page 85 for picture of pH scale.
 - **Buffers** = substances that allow a solution to resist changes in pH *even when* a strong acid or base is added to that solution.