

**Department of biology**

**Zoology**

**First stage**

**(2)**

**Elements of Life**

**By**

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**Elements of Life**

An **element** is one of the **basic building blocks of matter**; an element cannot be broken down by chemical means. Considering the variety of living and nonliving things in the world, it‘s remarkable that there are only **92** naturally occurring elements. It is even more surprising that over 90% of the human body is composed of just four elements: **carbon, nitrogen, oxygen**, and **hydrogen.**

Even so, other elements, such as **iron**, are important to our health. Iron-deficiency anemia results when the diet doesn‘t contain enough iron for the making of hemoglobin. Hemoglobin serves an important function in the body, because it transports oxygen, another element, to our cells.

**Biological Molecules and Compounds**

**Atoms** often bond with one another to form a chemical unit called a **molecule.** A molecule can contain atoms of the same type, as when an oxygen atom joins with another oxygen atom to form oxygen gas (O2).

Or the atoms can be different, as when an oxygen atom joins with two hydrogen atoms to form water. When the **atoms are different**, a **compound** is formed.

  

 **Oxygen gas Water (H2O)**

**Water**

Water is the most abundant molecule in living organisms, usually making up about **60–70%** of the total body weight. Furthermore, the physical and chemical properties of water make life as we know it possible. Water is a **polar** molecule; the oxygen end of the molecule has a slight negative charge, and the hydrogen end has a slight positive charge.

**Properties of Water**

**1. Water is a liquid at room temperature.**

The hydrogen bonding between water molecules keeps water a liquid and not a gas at room temperature.

**2. Water is the universal solvent for polar (charged) molecules and thereby facilitates chemical reactions both outside of and within our bodies.**

Ions and molecules that interact with water are called **hydrophilic.** Nonionized and nonpolar molecules that do not interact with water are called **hydrophobic.**

**3. Water molecules are cohesive or union,** so they stay together because of hydrogen bonding, and yet, water flows freely. This property allows dissolved and suspended molecules to be evenly distributed throughout a system (e.g.; blood).

**4. The temperature of liquid water rises and falls slowly, preventing sudden or severe changes,** therefore, water protects us and other organisms from rapid temperature changes and helps us maintain our normal internal temperature. Since the many **hydrogen bonds** that link water molecules cause water to absorb a great deal of heat before it boils.

The control of body temperature is an example of **homeostasis**, which is the maintenance of the internal environment within normal limits.

**The chemistry of life**

**Molecules of Life**

Four categories of organic molecules: (**1Carbohydrates**, **2Lipids**, **3Proteins**, and **4Nucleic acids**). In biology, ―organic‖ refers to a molecule that contains carbon (C) and hydrogen (H) and is usually associated with living organisms. Each type of organic molecule in cells is composed of **subunits.** When a cell forms a macromolecule, a molecule that contains many subunits, it uses a **dehydration reaction**, a type of **synthesis reaction**.

**First // Carbohydrates**

Carbohydrates are used as an **energy source** for living organisms. In some organisms, such as plants and bacteria, carbohydrates have a **structural function**. Carbohydrate molecules all have carbon, hydrogen, and oxygen atoms grouped H-C- OH, which is why they are often abbreviated as CHO. The ratio of hydrogen atoms (H) to oxygen atoms (O) is approximately 2:1.

**1- Simple Carbohydrates: Monosaccharides**

Monosaccharides (mono, one; saccharide, sugar) consist of only a single sugar molecule and are commonly called simple sugars. A monosaccharide can have a carbon backbone of three to seven carbons. For example, **pentoses** with five carbons (Ribose), and **hexoses** with six carbons. The most common monosaccharide, and the one that our bodies use as an immediate source of energy, is the hexose **glucose (**figure1):

  

**2-Disaccharides**

A disaccharide (di, ―two‖; saccharide, ―sugar‖) is made by joining only two monosaccharides together by a dehydration reaction. **Maltose** is a disaccharide formed by a dehydration reaction between two glucose molecules (Figure 2). When glucose and fructose join, the disaccharide sucrose forms, **Sucrose**, ordinarily derived from sugarcane and sugar beets, is commonly known as table sugar. **Lactose** is glucose combined with galactose. Some people are lactose intolerant because they cannot break down lactose. This leads to unpleasant gastrointestinal symptoms when they consume dairy products.



Figure 2: Disaccharide molecules (Maltose)

**3-Complex Carbohydrates: Polysaccharides**

Long polymers such as **starch, glycogen**, and **cellulose** are polysaccharides (poly=many) that contain long chains of glucose subunits. Due to their length, they are sometimes referred to as complex carbohydrates. The polysaccharides starch and glycogen are long polymers of glucose that are found in plants and animals, respectively. These chains may vary in length, but may contain several thousand glucose molecules.

Both starch and glycogen are used to store glucose to meet the energy needs of the cell. After we eat these starchy foods, the digestive system breaks down the starch into glucose, which then enters the blood stream. The release of the **hormone insulin** from the pancreas promotes the storage of glucose as glycogen in the liver (and in muscle tissue). In between eating, the hormone **glucagon** instructs the liver to release glucose; this maintains the normal blood glucose concentration at about 0.1%.



**Second // Lipids**

Lipids are diverse in structure and function, but they have a common characteristic: They do not dissolve in water. Their low solubility in water is due to an absence of hydrophilic polar groups. They contain little oxygen and consist mostly of carbon and hydrogen atoms. Lipids contain more energy per gram than other biological molecules. Therefore, fats in animals and oils in plants function well as energy storage molecules. Others (phospholipids) form a membrane so that the cell is separated from its environment and has inner compartments as well. Steroids are a large class of lipids that includes, among other molecules, the sex hormones.

**Phospholipids** have a phosphate group and are the primary components of the plasma membranes in cells.

**Third // Proteins**

Proteins are macromolecules with **amino acid** subunits. The central carbon atom in an amino acid bonds to a hydrogen atom and to three other groups of atoms. The name amino acid is appropriate because one of these groups is an -NH2 (amino group) and another is a -COOH (carboxyl group, an acid). The third group is the R group for an amino acid (Figure 1).



**Figure 1: The structure of the amino acid**

The covalent bond between two amino acids is called a **peptide bond**. When three or more amino acids are linked by peptide bonds, the chain that results is called a **polypeptide**.

Proteins are of primary importance in the structure and function of cells. Some of their many functions in humans include:

**1-Support:** Some proteins are structural proteins. Keratin, for example, makes up hair and nails. Collagen lends support to ligaments, tendons, and skin.

**2-Enzymes:** Enzymes bring reactants together and thereby speed chemical reactions in cells and only function at body temperature.

**3-Transport:** Channel and **carrier proteins** in the plasma membrane allow substances to enter and exit cells. Some other proteins transport molecules in the blood of animals; hemoglobin in red blood cells transports oxygen.

**4-Defense:** Antibodies are proteins combine with foreign substances, called antigens preventing from destroying cells and upsetting homeostasis.

**5-Hormones:** Hormones are regulatory proteins. They serve as intercellular messengers that influence the metabolism of cells.

**6-Motion:** The contractile proteins actin and myosin allow parts of cells to move and cause muscles to contract facilitating the movement of animals.

**Fourth // Nucleic Acids**

**Nucleic acids,** which are polymers of **nucleotides,** store information, include instructions for life, and conduct chemical reactions. The general structure of a nucleotide is shown in Figure (2).

**Figure 2: The general structure of a nucleotide**

Two types of nucleic acids (**DNA & RNA**) are important in the storage and processing of the **genetic information**. **DNA** (deoxyribonucleic acid) is the type of nucleic acid that not only stores information about how to copy, or replicate, itself but also specifies the order in which **amino acids** are to be joined to make a protein.

**Nucleotide Structure**

Each **nucleotide** is a molecular complex of three types of subunit molecules phosphate (phosphoric acid), a pentose (5-carbon) sugar, and a nitrogen-containing base. The nucleotides in DNA contain the sugar deoxyribose, and the nucleotides in RNA contain the sugar ribose; this difference accounts for their respective names, also, there are four different types of bases in DNA:

**Adenine (A), Thymine (T), Guanine (G),** and **Cytosine (C)**

(Table 1).

The base can have two rings (adenine or guanine) or one ring (thymine or cytosine). In RNA, the base **uracil (U)** replaces the base thymine. These structures are called bases because their presence raises the pH of a solution.

The nucleotides link to make a polynucleotide called a **strand**, which has a backbone made up of phosphate-sugar-phosphate-sugar. The bases project to one side of the backbone.

**DNA (deoxyribonucleic acid)**

DNA is **double-stranded**, with the two strands twisted about each other in the form of a **double helix** (Figure 3). In DNA the two strands are held together by hydrogen bonds between the bases.



**Figure 3 : DNA structure**

Thymine (T) always pairs with adenine (A), and guanine (G) always pairs with cytosine (C). **Complementary** bases have shapes that fit together. Complementary base pairing allows DNA to replicate in a way that ensures that the sequence of bases will remain the same. This is important because it is the sequence of bases that determines the sequence of amino acids in a protein.

**RNA (Ribonucleic acid)**

RNA is **single-stranded**. When RNA forms, complementary base pairing with one DNA strand passes the correct sequence of bases to RNA. RNA is the nucleic acid directly involved in **protein synthesis**.

RNA (ribonucleic acid) is a diverse type of nucleic acid that has multiple uses, RNA main types contains:

1-**Messenger RNA (mRNA)** is a temporary copy of a gene in the DNA that specifies what the amino acid sequence will be during protein synthesis.

2-**Transfer RNA (tRNA)** is necessary in synthesizing proteins and helps **translate** the sequence of nucleic acids in a gene into the correct sequence of amino acid during protein synthesis.

3-**Ribosomal RNA (rRNA)** is the RNA component of the ribosome, it works as an enzyme to form the peptide bonds between amino acids in a polypeptide.

**ATP (adenosine triphosphate)** is a nucleotide stores large amounts of energy needed for synthetic reactions and for various other energy-requiring processes in cells.

**Differences in the Structures of DNA and RNA**

Though both DNA and RNA are polymers of nucleotides, there are some small differences in the types of subunits each contains and in their final structure. These differences give DNA and RNA their **unique functions** in the body.

**Table 1: Comparison between DNA and RNA Structure**

|  |  |  |
| --- | --- | --- |
|  | **DNA** | **RNA** |
| **Sugar** | Deoxyribose Ribose | Ribose |
| **Bases** | Adenine, guanine, thymine, cytosine | Adenine, guanine, uracil, cytosine |
| **Strands** | Double-stranded with base pairing | Single-stranded |
| **Helix** | Yes | No |