Chapter 1
Plants in our Lives

Introduction

The major needs of humans are **food, clothes, shelter and fuel**. These needs come from plants. Plants use **sunlight, carbon dioxide, and water** to manufacture food through a process known as **photosynthesis** for all animals, including humans. Plants also produce **oxygen,** the essential gas for life, through the process of photosynthesis. Plants are not just the sources for food and oxygen, but also for wood, lumber, paper, rope, fabrics, beverages, medicine and cosmetics. Since plants can produce food through photosynthesis they are classified as autotrophs and they are always at the base of the food chains. They regarded as Producers while animals are consumers.

Common Types of Plants

The four common groups of organisms considered as plants include flowering plants, non-flowering plants, lower plants (algae) and fungi (may not be classified as plants).

Flowering plants or angiosperms

These are the most abundant and diverse plants in the environment. A flower of an angiosperm consists of four major parts (whorls): **sepals, petals, stamens, and carpels.** Figure 1.1.

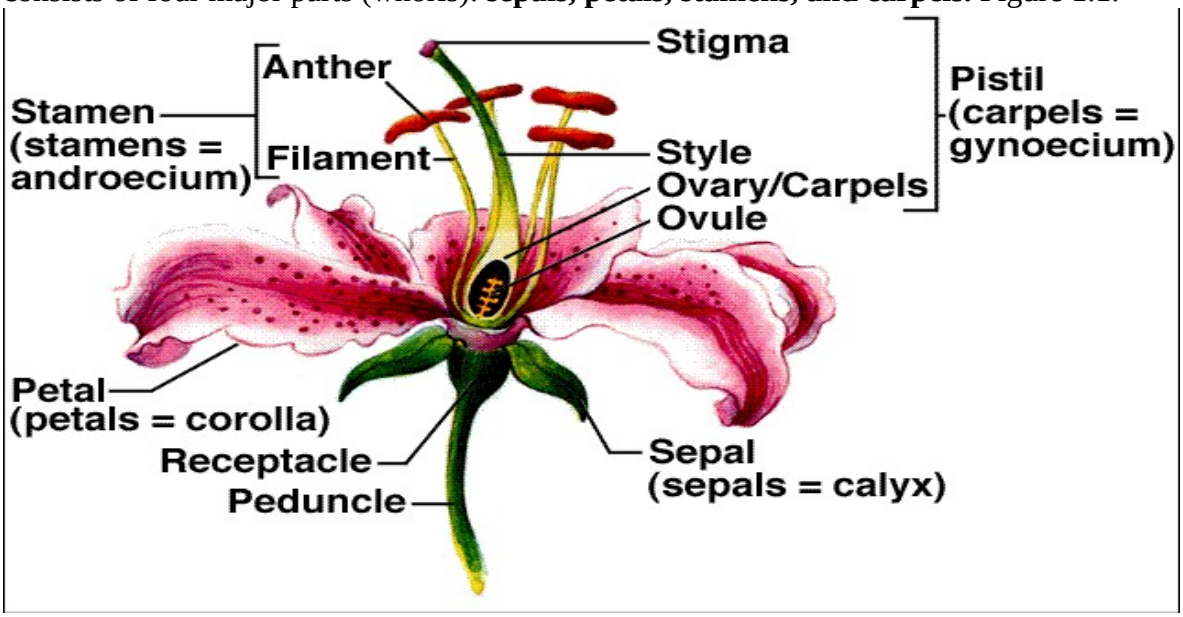


Figure 1.1. Parts of a Flowering Plant

Angiosperms

There are two groups of angiosperms: the **monocots and the dicots**. Examples of the monocots include the **grasses, lilies, orchids and palms**; examples of the dicots include **roses, oak, magnolia, geraniums, and tomatoes.**

The non-flowering plants include the **mosses, ferns** and the **gymnosperms** (cycads, ephedra, junipers etc). Among these, only the gymnosperms can bear seeds like the angiosperms.

Algae

Algae are another group of plants found in marine and fresh water habitats; they include the Sea Weeds and Kelps. Algae are also used for food, and in industries, however algae blooms (explosion of population of algae) can cause environmental damage and some algae can produce toxin to kill fishes in the sea.

Fungi

The **fungi** are the other group of organisms that may not be considered as plants, because they do not have chlorophyll pigments, but they have significant impacts on our lives. The fungi include the **molds, mildews, yeast and mushrooms**. They are good sources for food, medicine, and even sources of diseases of other plants, animals and humans. **Fungi are non-photosynthetic organisms; some obtain food from dead organisms (saprophytes) and others from other living organisms (parasites). Fungi have a threadlike body – mycelium; they reproduce by the release of spores. They are important for decomposing materials in the environment.**

Characteristics of a Living Plant

A living plant has to be able to grow, reproduce, respond to changes in the environment, evolve and adapt to the environment, have one or more cells, and metabolize (respiration and photosynthesis).

Chemistry of Life

Chemical molecules in plants can be classified into 4: carbohydrates, proteins, lipids, and nucleic acids. Chemical elements are important for the essential growth and development of plants.
Among the chemical elements considered **macronutrients for plants include carbon, oxygen, hydrogen, nitrogen, potassium, magnesium, calcium, phosphorus, and sulfur**. In addition to these elements are others required in very minute amounts (or micronutrients), these are called trace elements.

Atom

An element is made up of atoms. Each atom has smaller particles called protons (positively charged), electrons (negatively charged), and neutrons (no charge). An atom is spherical, in the center of the atom is the nucleus, surrounding the nucleus are the electron orbitals or shells, where electrons are located to revolve around the nucleus. The nucleus contains the protons, and the neutrons.

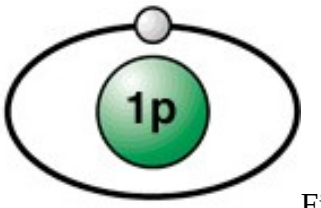


Figure 1.2. The structure of a hydrogen atom with an electron and a proton.

Molecule

When there are two or more atoms bonded together, the substance is called a molecule; an example is when an oxygen atom (O) bonds to another oxygen atom to form an oxygen molecule

that is O-O (or O_2) or a hydrogen atom bonds with another hydrogen atom to form a hydrogen molecule (H-H = H_2).

Isotope: Atoms of an element with the same number of protons number but different number of neutrons; an example is **C-12** (carbon with atomic weight 12) and **C-14** (carbon with atomic weight 14). This means that the proton # is 6 for both carbon atoms but neutron #s are 6 and 8 respectively).

Radioisotopes: Isotopes that emit radiations. Their atomic nuclei are heavy, and they are unstable, so they emit radiations. These isotopes are very useful in medical research, X-ray, fossil dating and medicine.

Atomic number of an element: This is the number of protons or electrons in an atom.

Chemical Bonds

Atoms of elements are bonded by chemical bonds to form molecules. There are three basic types of chemical bonds**: ionic bond, hydrogen bond, and covalent bond**.

Ionic bond

Electrons from one atom are donated to another atom. The atom that donates the electron loses electrons gains extra positive charges, while the atom that accepted the electrons gains extra negative charges. For example in a chemical bonding between Na and Cl:

$Na - e \rightarrow Na^+$

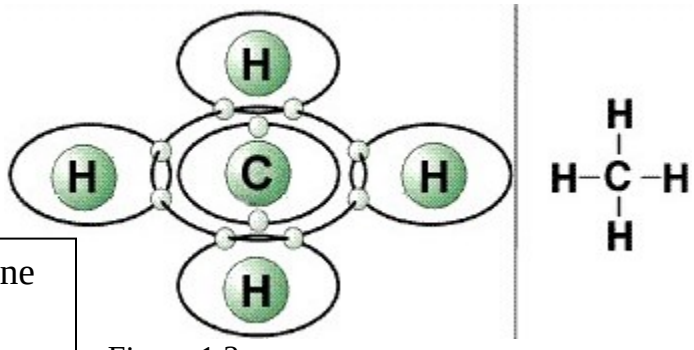
$Cl + e \rightarrow Cl^-$

$Na^+ + Cl \rightarrow NaCl$

Ionic bonds are relatively weak as compared to covalent bonds. An ionic molecule easily dissociates or ionizes (break down) in solution into the individual ions.

Covalent Bonds

In covalent bonding, electrons are shared; in some there is equal sharing of electrons, while in others, the electrons are unequally shared. Equal sharing of electrons provides very strong covalent bonds, this is considered, a **non-polar covalent bond**. Non-polar covalent molecules are typical covalent molecules. An example of a non-polar covalent molecule is methane (CH_4) (figure 1.3).



Methane
CH_4

Figure 1.3

Polar covalent bonds

Unequal sharing of electrons provides relatively less strong bonds. The molecules are known to have **polar covalent bonds**. In this chemical bonding, the molecules carry partial charges due to the unequal distribution of charges among the atoms. An example is the water (H_2O) molecule.

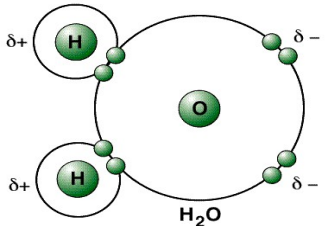


Figure 1.4. Polar Covalent bond

Hydrogen Bonds

This is a weak bond usually produced between molecules that have polar covalent bonds. Due to the partial charges carried by polar covalent molecules, the molecules attract each other when placed in close proximity. An example is the bond between the two DNA strands, or the bonds that hold water molecules in a water crystal like ice (figure 1.5).

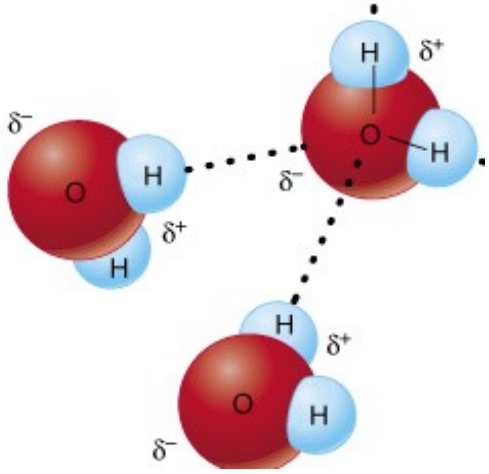


Figure 1.5. Hydrogen bond

Molecules of Life

There are four basic biological molecules that can be found in living organisms, for example in plants, these include **carbohydrates** (examples are sugars, starch, cellulose), **proteins** (made up of amino acid chains), **lipids** (fats, wax, steroids and cholesterols), and **nucleic acids** (DNA and RNA). All these molecules contain **carbon, hydrogen, and oxygen**. Only proteins and nucleic acids contain **nitrogen** in addition to carbon, oxygen, and hydrogen.

Carbohydrates

The carbohydrates are subdivided into 3 groups: **monosaccharide** (examples include glucose and fructose), **disaccharide** (examples include maltose and sucrose) and **polysaccharide** (examples include starch, and cellulose). Monosaccharide has only one unit of the sugar molecule. Disaccharides have two units of the sugar molecule, for example glucose + fructose produces sucrose (a disaccharide molecule). Polysaccharide has more than two units of sugar, an example is starch formed from: glucose + glucose + glucose + glucose--------

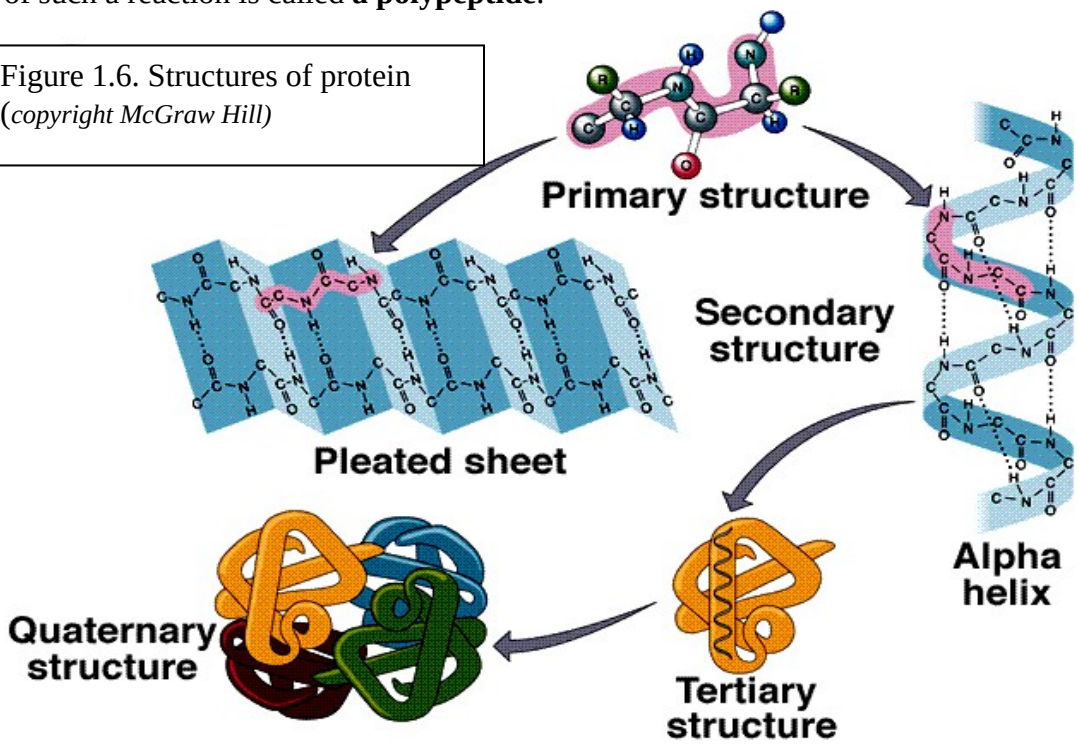
Lipids

They are classified into four groups: **triglycerides** (common fats in plants and animals), a molecule of triglyceride is made up of one **glycerol** molecule and **3 fatty acid** molecules. When triglyceride (fats) breaks down, they produce glycerol and fatty acids. Every unit of fatty acid has this functional group of "**-COOH**" attached to its molecule. The "COOH" functional group identifies every fatty acid molecule. Fatty acids could be **saturated or non-saturated** (also unsaturated). Unsaturated fatty acids have one or more double bonds, while the saturated ones have no double bonds. Polyunsaturated fatty acids or fats (fats with many double bonds) are recommended for food over the monounsaturated or saturated fats). **Phospholipids** (membrane lipids), is made up of **one phosphate/glycerol part (hydrophilic or polar) and two molecules of fatty acid chains (hydrophobic / non-polar). Steroids** are made from cholesterol; examples include **sex hormones, and lipid soluble vitamins**. **Waxes** are formed from saturated fatty acids and alcohol. They form waterproof outer coverings of plant.

Proteins

These are made up of amino acids. Each amino acid unit consists of two functional groups to identify it: "**-NH_2**" and "**-COOH**". There are 20 known amino acids, 9 are essential (not synthesized by the human body, so must be included in the diet), and 11 are non-essential (synthesized in the human body). One unit of protein is an amino acid; when two amino acid units react to form a molecule**, a dipeptide** is formed. The bond joining the two amino acids is called **a peptide bond**, this reaction is called a **dehydrating synthesis**, in all such reactions, water is released. When many molecules of amino acids are joined by peptide bonds, the product of such a reaction is called **a polypeptide**.

Figure 1.6. Structures of protein (*copyright McGraw Hill)*



Characteristics of Proteins

Proteins are polypeptides. Proteins can breakdown to release amino acids, a process called hydrolysis or digestion, water is always added in such reactions. Proteins have high molecular

weight. Enzymes are special types of proteins. **Enzymes are biological catalysts**; they speed up chemical reactions in the cell by lowering the activation energy of the reactions. Proteins are easily denatured (alteration in the structure of proteins) by heat. **Proteins have 4 levels of structural organization: primary, secondary, tertiary, and quaternary (figure 1.6)**. **A primary structure of protein is a straight chain of amino acids. In the secondary structure of proteins, the chain folds into a spiral shape or pleated sheet shape molecule. In the tertiary structure, the chain folds into a tight globular or spherical shape. In the quaternary structure** many globular proteins are linked by hydrogen bonds / disulfide bonds to form one protein unit.

Nucleic Acids

The nucleic acids are made up of **nucleotides**. Each nucleotide consists of **a sugar, a phosphate, and a nitrogenous base.** There are altogether 5 known nitrogenous bases in the cell**: adenine (A), guanine (G), thymine (T), uracil (U), cytosine (C). In DNA, A, T, G and C are present, while in RNA, A, G, C, and U are present.** Note that uracil replaces thymine in RNA.

DNA has deoxyribose sugar, while RNA has ribose sugar. DNA in higher organisms like the plant cell or the animal cell is double a stranded structure, while the RNA is a single stranded structure. The DNA structure in plant cells is described as a double alpha helical (or double spiral) structure (figure 1.7). The RNA structure varies because there are 3 kinds of RNAs with 3 different shapes: **mRNA** (messenger RNA), a straight chain of nucleotides, **tRNA** (transfer RNA) is globular but looks like a "t" in shape, and the rRNA (ribosomal RNA) that has a globular shape like two spherical proteins joined together.

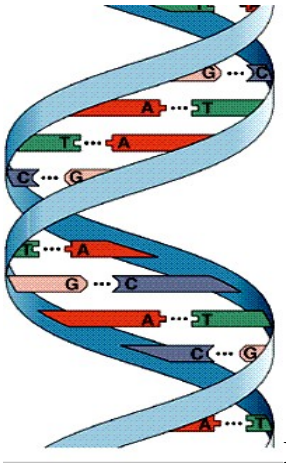


Figure 1.7. DNA structure

Replication

DNA is formed from another DNA template, a process known as replication; RNA is formed from DNA, a process known as **transcription**, while protein is formed from RNA, a process known as **translation**.

Figure 1.8. DNA replication).

During Replication, with the help of DNA polymerase enzyme / helicase enzyme, DNA unwinds, and complementary nucleotides of DNA are brought to match the ones on each unwound strand. The nucleotide matching process occurs antiparallel to each other until two new double-stranded DNA are formed. Each newly synthesized DNA consists of one old and one new strand. This method of replication is known as **Semi-conservative replication** (figure 1.8)

Transcription

When RNA is to be formed, a process known as transcription, a segment of DNA unwinds, one strand is ignored (mis-sense strand) while the other strand is regarded as the sense strand. This sense strand is copied by the RNA polymerase enzyme by matching complementary nucleotides to the ones on the template DNA strand (or sense strand).

Key Points

Plant in our lives

1. Plants have many uses: food, wood, furniture, building materials, medicine, clothes, and cosmetics.
2. Things generally referred to as plants include flowering plants, non- flowering plants, algae, and even fungi.
3. The characteristics of a living plant includes growth, reproduction, response to stimuli, respiration and metabolism.

Chemistry of Life

4. Plants require certain chemical elements for growth. Examples are carbon, hydrogen, nitrogen, potassium, magnesium, calcium, phosphorus sodium, and sulfur.
5. An element like carbon is made up of carbon atoms. An atom has a central nucleus (containing a neutrons and protons) surrounded by clouds of electrons arranged in orbitals (or shells).
6. A chemical molecule is formed from 2 or more atoms, H_2O
7. Some elements have atoms with the same number of electrons but different neutron number, these elements are regarded as isotopes.
8. Some isotopes can emit radiations, because their nuclei are heavy and unstable, these are called radioisotopes.

Chemical Bonds

9. There are 4 basic types of chemical bonds that bind atoms of elements to form molecules in the cell; these are ionic bonds, polar covalent bonds, non – polar covalent bonds, and hydrogen bonds. The strongest of them is the non–polar covalent bond. The weakest is the hydrogen bond. An Ionic bond is also weak; it bonds elements like sodium and chlorine together in the formation of sodium chloride. The molecule can easily dissociate back into individual ions.

Basic Molecules of Life

10. The molecules in plants and other living things are classified into its major groups: carbohydrates, lipids, proteins and nucleic acid. Carbohydrates are starch, and sugars; lipids are fats, wax, and steroids; proteins are made up of amino acids; and nucleic acids are DNA (deoxyribnucleic acids) and RNA (ribonucleic acids); they are made up of nucleotides.

11. Carbohydrates exist as monosaccharides (glucose; fructose and galactose); disaccharides (maltose, lactose, and sucrose); and polysaccharides (starch, glycogen, and cellulose).
12. Enzymes are proteins. Enzymes are biological catalysts; they speed up the rates of chemical reactions (metabolism) in the cells.

Study Questions

1. List 10 uses of plants
2. Name 3 major groups of plants
3. State why a fungus may not be classified as a plant
4. List at least 5 chemical elements required for plant growth
5. What is an atom? State the particles that make up an atom
6. What is the difference between an atom and a molecule?
7. What is the difference between a radioisotope and a non – radioisotope?
8. Define an isotope of a chemical element.
9. The # of protons or electrons in an atom is called _____.
10. The 3 chemical bonds in a molecules are ionic, covalent (polar and non – polar) and hydrogen bonds. Describe how each is formed, and state the differences among them.
11. List 5 characteristics of a living thing (plant).
12. Give an example of a monosaccharide, a disaccharide, and a polysaccharide. State the difference among each group.
13. Triglycerides are the common fats; state the two basic molecules of triglycerides.
14. These major molecules make up phospholipids.
15. Phospholipids are found mainly in ------- of the cell.
16. State any steroid molecule that can be found in a plant cell.
17. Apart from triglycerides, phospholipids and steroids, which other lipids are common in plants
18. State the functional group that identifies fatty acid from other molecules.
19. List the two functional groups in an amino acid.
20. What is a peptide bond?
21. What is a polypeptide?

22. Describe the primary, secondary, tertiary, and quaternary structures of a protein.
23. A nucleic acid is made of small units called _____?
24. What is a nucleotide made up of _____?
25. There are 5 nitrogenous bases, list which ones are in DNA
and which ones are in RNA.
26. How do the nitrogenous bases pair in a DNA double stranded structure?