College of pharmacy

Biochemistry I third stage

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Introduction to Biomolecules

What is Biochemistry?

- The science concerned with the chemical basis of life. The science concerned with the various molecules that occur in living cells and organisms and with their chemical reactions.

Biomolecules

- **Biomolecules are organic molecules contain mainly carbon. Other important elements are H, O, N, P and S. About 30 elements are required by biological systems, including iodine and many metals.**
- **Biomolecules contain the same types of functional groups as do organic molecules, including hydroxyl groups, amino groups, carbonyl groups, carboxyl groups, etc. However, many biomolecules are polyfunctional, containing two or more different functional groups which can influence each other's reactivity.**

Metabolism

- All the chemical reactions in an organism make up its metabolism.
- There are two types of metabolic pathways: Anabolic and Catabolic

Metabolism

- **Catabolic pathways** release energy by breaking down complex molecules into simpler compounds
- Cellular respiration, the breakdown of glucose in the presence of oxygen, is an example of a pathway of catabolism

Metabolism

- **Anabolic pathways** consume energy to build complex molecules from simpler ones
- The synthesis of protein from amino acids is an example of anabolism

Macromolecules of Cells

- **Large organic molecules**
- **Four types of macromolecules in cellular biology**
  1. **Carbohydrates**
  2. **Lipids**
  3. **Proteins**
  4. **Nucleic Acids**

1.Carbohydrates

- **Carbohydrates are the most abundant organic molecules in nature.**
- **They have a wide range of functions, including providing a significant fraction of the dietary calories for most organisms, acting as a storage form of energy in the body, and serving as cell membrane components that mediate some forms of intercellular communication. Carbohydrates also serve as a structural component of many organisms, including the cell walls of bacteria and the fibrous cellulose of plants.**

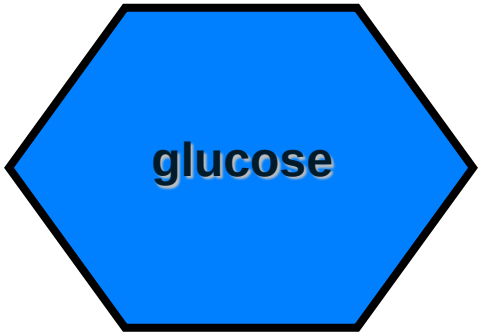
Carbohydrates include:

A. Monosaccharide

B. Disaccharide

C. Polysaccharide

Monosaccharide: one sugar unit



glucose ($C_6H_{12}O_6$) Examples:

deoxyribose

ribose

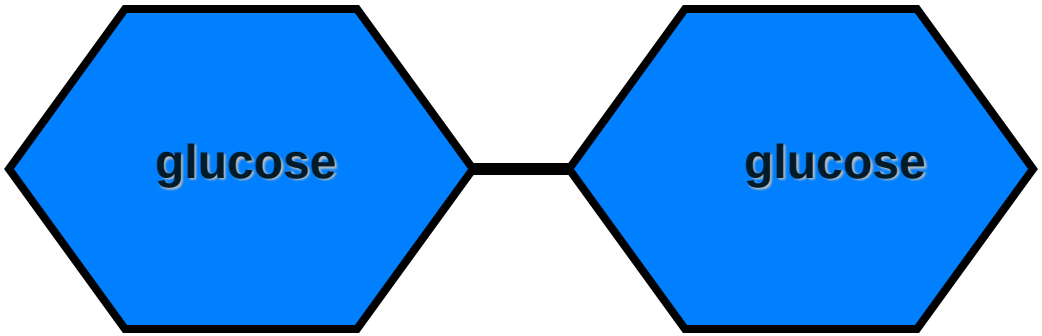
Fructose

Galactose

Disaccharide: two sugar unit

Examples:

* Sucrose (glucose+fructose)
* Lactose (glucose+galactose)
* Maltose (glucose+glucose)

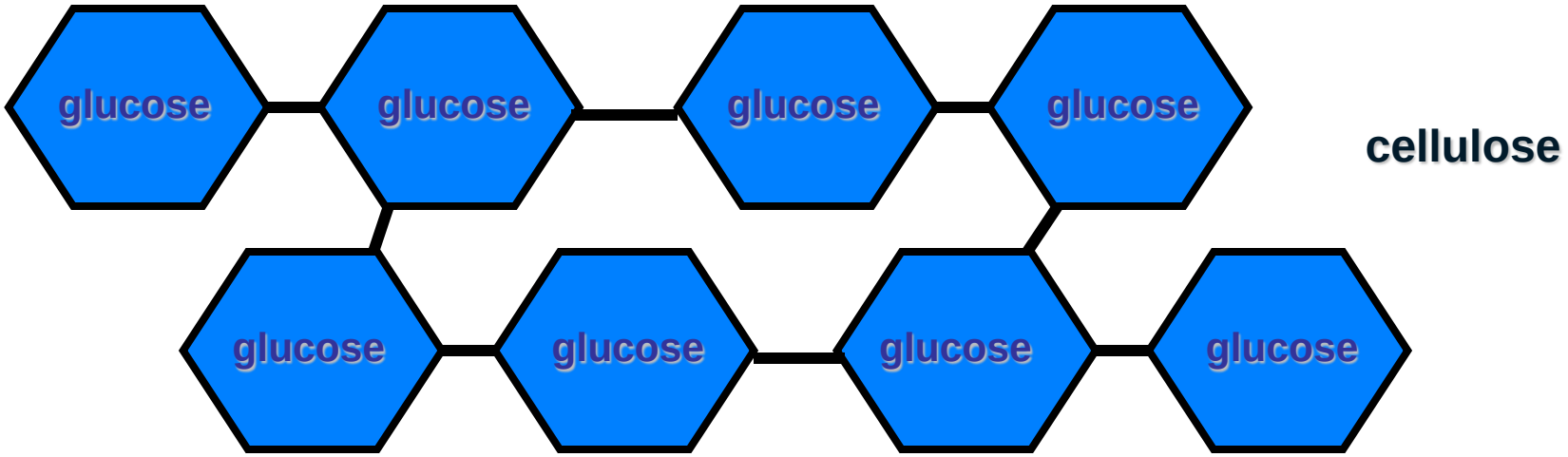


Polysaccharide: many sugar units

Examples: starch (bread, potatoes)

glycogen (beef muscle)

cellulose (corn)



2. Lipids

- **Lipids are a heterogeneous group of water insoluble (hydrophobic) organic molecules that can be extracted from tissues by non polar solvents.**
- **Because of their insolubility in aqueous solutions, body lipids are generally found compartmentalized, as in the case of membrane associated lipids or droplets of triacylglycerol in white adipocytes, or transported in plasma in association with protein, as in lipoprotein particles.**
- **Lipids include triglycerides, fatty acids, cholesterol and phospholipids.**

Functions of lipids:

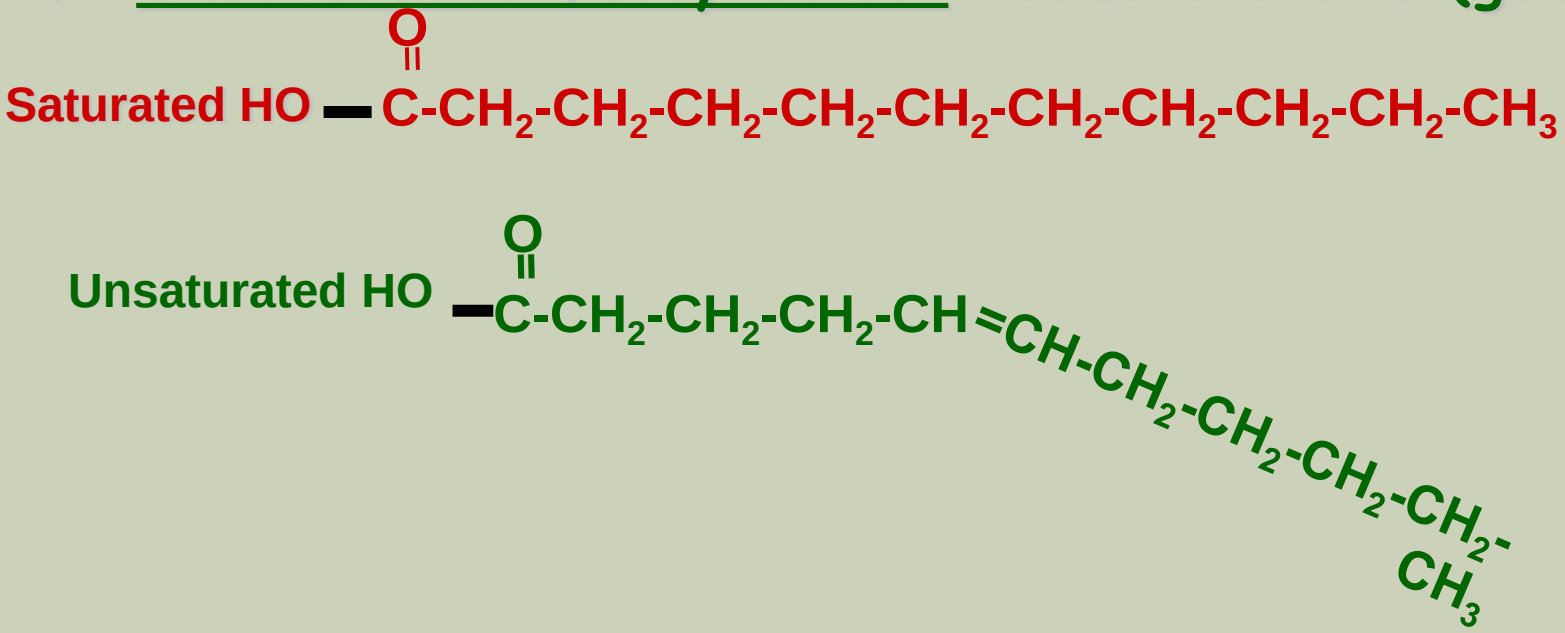
1. Long term energy storage
2. Protection against heat loss and water loss
3. Fat soluble vitamins have regulatory or coenzyme functions
4. Synthesis of several molecules such as prostaglandins and steroid hormones that play a major roles in the control of the body's homeostasis
5. Chemical messengers (hormones)
6. Major component of membranes (phospholipids)

Fatty Acids

There are two kinds of **fatty acids** you may see these on food labels:

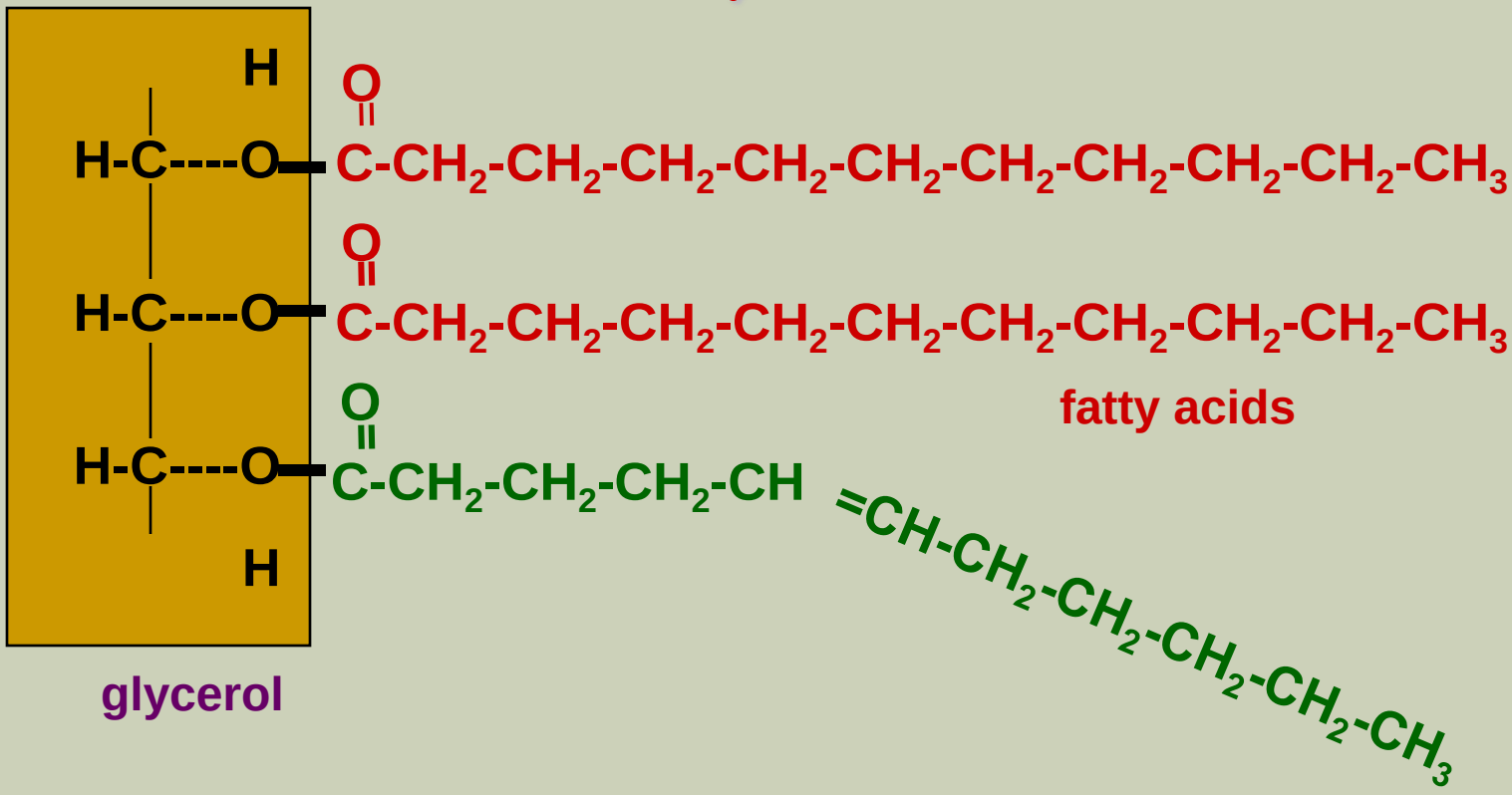
1. **Saturated fatty acids:** no double bonds (bad)

2. **Unsaturated fatty acids:** double bonds (good)



Triglycerides:

composed of 1 glycerol and 3 fatty acids.



3. Proteins

- **The building blocks of proteins are amino acids. There are only 20 types of Amino Acids.**
- **There are millions of different proteins, and they are all built from different combinations of the 20 amino acids.**
- **Amino acids join together to form peptides, polypeptides, and polypeptide chains.**

Amino acids

Peptide

Protein

Functions of proteins

Support	**Structural proteins (e.g., keratin, collagen)**
Enzymes	**Speed up chemical reactions**
Transport	**Cell membranes channels, transporters in blood (e.g., Hemoglobin)**
Defense	**Antibodies of the immune system**
Hormones	**Cell signaling (e.g., insulin)**
Motion	**Contractile proteins (e.g., actin, myosin)**

4. Nucleic acids

- **Nucleic acids are composed of long chains of nucleotides linked by covalent bond.**

- **Nucleotides composed from phosphate group, pentose sugar (5-carbon) (deoxyribose in DNA and ribose in RNA) and nitrogenous bases. Nitrogenous bases: adenine (A), cytosine (C), guanine (G) [both DNA and RNA], thymine (T) [DNA only], and uracil (U) [RNA only].**

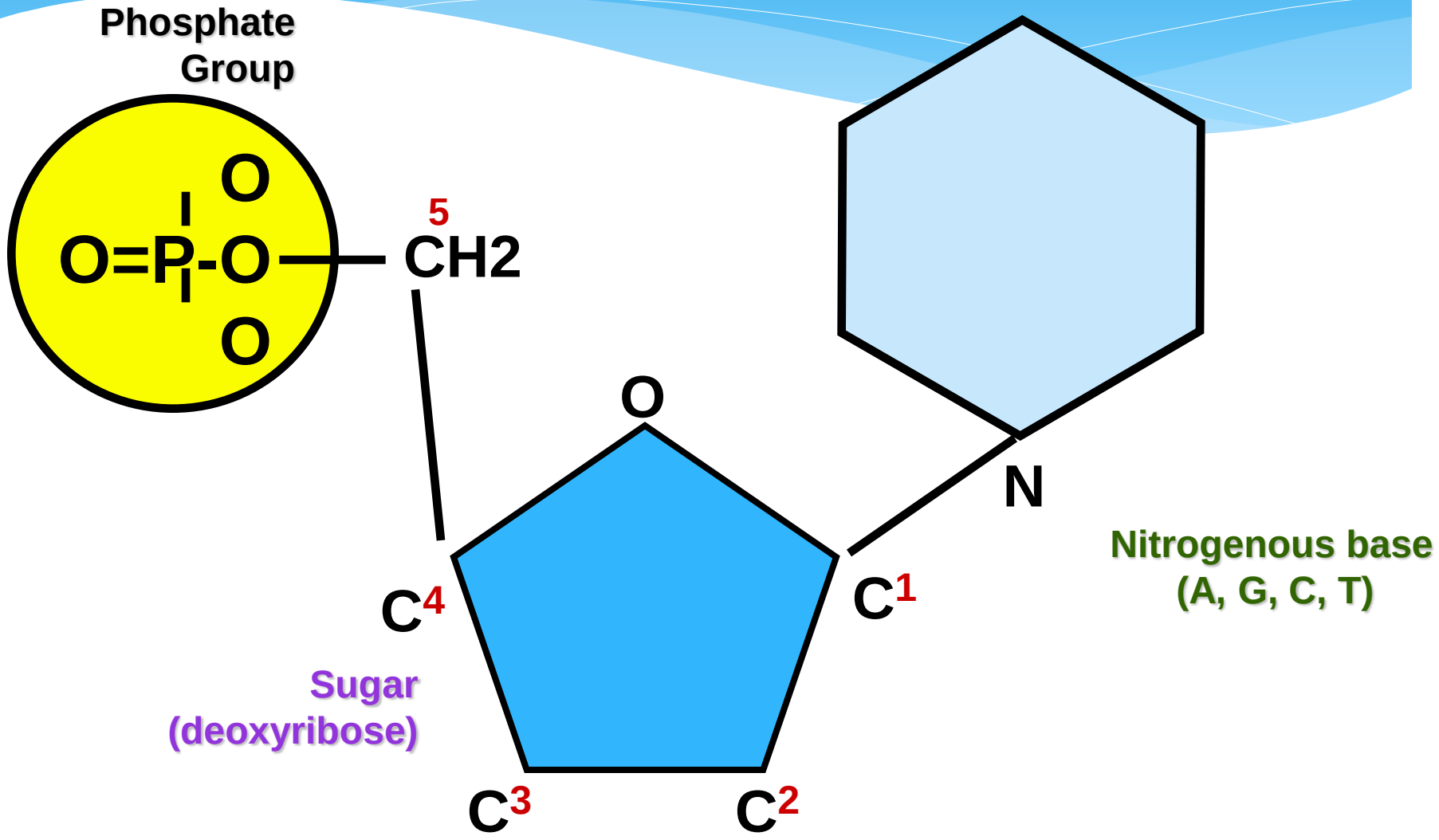
- **DNA: Deoxyribonucleic acid**

- **RNA: Ribonucleic acid**

Functions of nucleotides

- **Nucleotides are essential for all cells. Without them, neither RNA nor DNA can be produced and, therefore, proteins cannot be synthesized or cells proliferate.**
- **Nucleotides also serve as structural components of several essential coenzymes, such as coenzyme A, FAD, NAD^+, and $NADP^+$.**
- **Nucleotides, such as cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP), serve as second messengers in signal transduction pathways.**
- **Nucleotides play an important role as "energy currency" in the cell (ATP).**

Nucleotide


Phosphate Group
O
O=P-O
O
5
CH2
O
N
C4
C1
C3
C2
Sugar (deoxyribose)
Nitrogenous base (A, G, C, T)

Other biomolecules

- **Small organic molecules:** These molecules can be precursors of biomolecules that help enzymes function (often related to vitamins).
- **Inorganic ions:** Many inorganic ions are required by cells, often in trace amounts. These include calcium, sodium, iron, magnesium, potassium, chlorine, etc. Inorganic ions perform a variety of functions such as structural elements (calcium in bone), regulation of osmotic pressure and transport (sodium), and components of proteins and enzymes (iron).
- Combinations of biomolecules: Sometimes one biomolecule can contain components from two of the major classes, such as a lipoprotein (lipid plus protein) or a glycoprotein (carbohydrate plus protein).