Biomolecules

I. Introduction.

- biochemistry: study of chemical reactions occurring in living systems.
- organic compounds: molecules unique to living systems—carbohydrates, lipids, proteins, and nucleic acids (all contain carbon).

II. Carbohydrates.

- contain C, H, O; H:O ratio = 2:1.
- classified according to size/solubility as monosaccharides, disaccharides, or polysaccharides.

A. Monosaccharides: simple sugars.

- single chain or ring structures containing 3-7 C.
- C:H:O ratio = 1:2:1.
- examples are glucose ($C_6H_{12}O_6$), and ribose ($C_5H_{10}O_5$).
- named according to the number of C they contain; most important in body are hexoses and pentoses.

1. Hexoses (6C).

a. glucose: most important CH_2O in body; all ingested CH_2Os are broken down into glucose.

b. & c. fructose and galactose: isomers of glucose, same number of C, arranged differently.

2. Pentoses: (5C).

a. deoxyribose - DNA component.

b. ribose - RNA component.

B. Disaccharides: double sugars.

- formed when 2 monosaccharides are joined by dehydration synthesis (loss H_20).

1. sucrose.

2. maltose.

3. lactose.

*Note-disaccharides are too large to pass through cell membranes, must be digested to monosaccharides subunits prior to absorption.

C. Polysaccharides: long chains of simple sugars linked together by dehydration synthesis.

- due to size, they are water insoluble.
- great storage products; also have structural roles.
- polysaccharides of importance to body: starch & glycogen, both glucose polymers.

1. starch: storage CH_2O formed by plants.

2. glycogen: storage carbohydrate in animal tissue, found primarily in skeletal muscle & liver cells.

III. Lipids.

- organic compounds insoluble in water but readily soluble in other lipids and organic solvents such as alcohol and ether.
- contain C, H, and O; however oxygen proportions in lipids are much lower than in CH_2O.
- phosphorous found in some more complex lipids.
- lipids are diverse: triglycerides (neutral fats), phospholipids, and steroids.

A. Triglycerides (TGs): neutral fats.

1. Structure.

a. glycerol: modified simple sugar.

b. three fatty acids: long chains of C and H with organic acid groups at one end.

2. Synthesis

- fatty acids attached to glycerol backbone by dehydration synthesis; glycerol backbone is identical in all TGs, fatty acid chains vary in length and saturation.
- concept of saturation: fatty acid chains with only single covalent bond between carbons are saturated hydrocarbon chains; fatty acid chains with one or more double covalent bonds between carbons are unsaturated hydrocarbon chains.
- saturation and length of fatty acid hydrocarbon chains determines how solid a TG is at a given temperature; TGs with short and/or unsaturated fatty acid are liquid at the right temperature (plant lipids such as vegetable oils); TG with longer and/or saturated fatty acids are solid at room temperature (animal lipids such as lard, butter).

3. Functions:
   - major source of stored energy in body; insulation and protection (in fat deposits).

B. Phospholipids.

1. Structure.
   - modified TGs with phosphorous containing group and two fatty acid chains; phosphate group gives phospholipids characteristic properties
      - polar head; TGs form two non polar tails.

2. Functions:
   - chief component of biological membranes.

C. Steroids:
   - flat molecules formed by 4 interlocking hydrocarbon rings.
   - in body, most important steroid is cholesterol - structure is the basis for all other body steroids - bile salts, vitamin D, sex hormones, and adrenal cortical hormones.

IV. Proteins
   - basic structural material of body.
   - also play vital roles in cell function; include enzymes, hemoglobin, contractile proteins, some hormones, etc.
   - most varied function of any molecule in the body.
   - may contain C, O, H, N, S, P.

A. Amino acids and peptide bonds.
   - building block of proteins are amino acids (aa); structure with >10 aa. is a polypeptide; molecule with >50 aa. is a protein.

B. Levels of protein structure.

1. Primary structure: linear sequence of aa, the polypeptide chain; determines all other levels of structure.

2. Secondary structure: conformation of the polypeptide chain.
   a. alpha helix: "slinky-like"; formed by coiling of polypeptide chain, stabilized by hydrogen bonds.
   b. beta pleated sheet: polypeptide chains do not coil, linked side-by-side by hydrogen bonds to form accordion-like structure

Note: a polypeptide chain can have both alpha helix regions and areas of beta sheet.

3. Tertiary structure: alpha-helical or beta-pleated regions of the polypeptide chain fold onto one another to form compact ball-like molecule; the 3-D shape assumed by various areas of secondary structure.

4. Quaternary structure: tertiary structures of two or more polypeptide chains aggregate to form a complex protein (hemoglobin).

C. Types of proteins.

1. Fibrous protein: extended, strand-like appearance; usually displays only one form of secondary structure.
- linear, insoluble in water, very stable, provide tensile strength; usually are structural proteins.

2. Globular proteins: display multiple forms of secondary structure contributing to a specific tertiary structure; some also display quaternary structure.
- usually water soluble, mobile, chemically active; crucial in all biological processes, most are functional proteins.

D. Enzymes and enzyme activity.

1. General comments:
- enzymes are globular proteins, act as biological catalysts; they cannot force a reaction to occur, only accelerate rate at which it proceeds.
- some enzymes are just globular proteins, others consist of proteins and cofactors.
- enzymes are highly specific, usually involved in control of one chemical reaction.
- enzymes are either produced in an active form or in an inactive form.

2. Mechanisms of enzyme activity:
- chemical reactions cannot occur unless participating molecules reach certain energy states.
- every reaction requires an input of energy to prime the system, the activation energy.
- enzymes lower the amount of activation energy required for a reaction to occur.
- the induced fit model.

E. Protein denaturation.

- really a loss of tertiary structure.
- destruction of tertiary structure-stabilizing bonds will alter structure and change function.

V. Nucleic acids.

A. General comments.

- composed of C, O, H, N, P.
- largest molecules in the body.
- store genetic information.
- template for production of all body proteins.
- structural units are nucleotides; nucleotides have three components joined together by dehydration synthesis: a phosphate group, pentose sugar, and a nitrogen-containing base.
- in DNA sugar is deoxyribose; in RNA, ribose.
- 5 nitrogenous bases involved: adenine and guanine (purines), cytosine, thymine, and uracil (pyramidines).

B. DNA

- large double stranded polymer—"spiral ladder", two interwoven chains of nucleotides.
- the backbone or sides of ladder are formed by alternating sugar and phosphate molecules, the rungs are formed by bases.
- the two nucleotide chains are held together by hydrogen bonds between adjacent bases.
- concept of complementarity
- complimentarity is the basis for DNA replication and translation of DNA to RNA.

C. RNA

- single strand of nucleotides.
- phosphate/ribose/nitrogenous base.
- produced from a DNA template.
- three types are mRNA, rRNA, tRNA.

VI. Adenosine triphosphate (ATP).

A. General comments.

- while glucose is most important cellular fuel, none of the chemical energy contained in its bonds is used directly to fuel cell reactions.
- ATP provides a form of chemical energy usable by all body cells.

B. Structure.

- an adenine containing nucleotide.
- two extra phosphate groups attached to AMP (adenine monophosphate) backbone by high energy bonds; breaking of these high energy bonds by hydrolysis liberates energy used to drive cellular processes.