Chapter 5: Structure and Function of Macromolecules

AP Biology 2011

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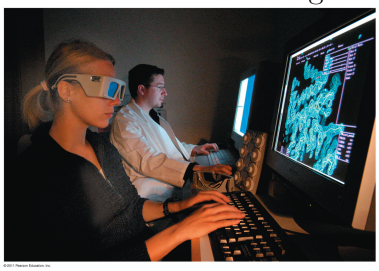
Macromolecules

Fig. 5.1



- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids
- Polymer - large molecule consisting of many similar building blocks
- Monomers - repeating units that serve as building blocks of polymers

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Synthesis of Polymers

- Often formed by condensation reactions

Fig. 5.2

3

Breakdown of Polymers

- Many polymers are broken down by the process of hydrolysis

Fig. 5.2

4

Formation of Polymers

- Each class of polymers is formed by a specific set of monomers
- All organisms share the same monomer types but are unique based on the arrangement of those monomers
    - Huge variety of polymers can be built from a small set of monomers

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Carbohydrates

- Mainly function as fuel and building material
- Includes both sugars and the polymers of sugars
- Monosaccharides
    - Multiples of CH_2O
    - simplest sugars
    - used for fuel
    - can be converted into other organic molecules
    - can be combined to form polymers

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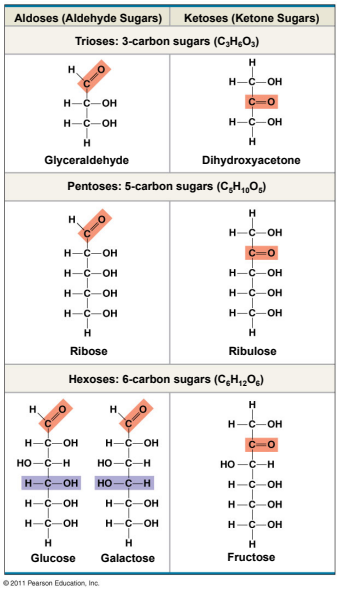
Classification of Monosaccharides

- Classified by the location of the carbonyl group (aldose or keytose) and the number of carbons in the carbon skeleton



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Forms of Monosaccharides

- Can be linear or form rings
- Rings formed readily in aqueous solutions

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Disaccharides

- Consist of two monosaccharides
- Joined by a glycosidic linkage through a dehydration reaction

Fig. 5.5

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Polysaccharides

- Polymers of sugars
- Have huge roles in organisms for storage and structure
- ex. Starch
- ex. Glycogen

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Energy Storage: Starch and Glycogen

- Both are polymers consisting entirely of glucose monomers (α-glucose)
- Starch - major storage form of glucose in plants
- Glycogen - major storage form of glucose in animals

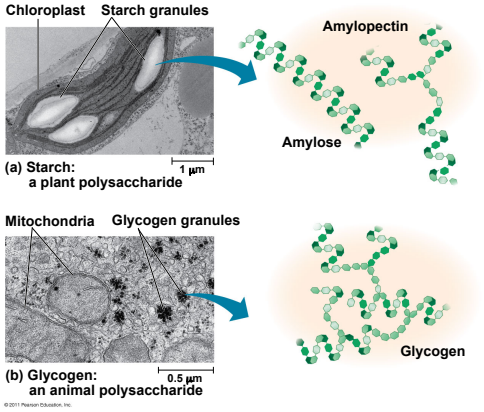

Fig. 5.6

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Structural Polymers: Cellulose

- Polymer of glucose that has different glycosidic linkages than starch because it is formed from β-glucose
- Major component of cell walls in plants
- Difficult to digest

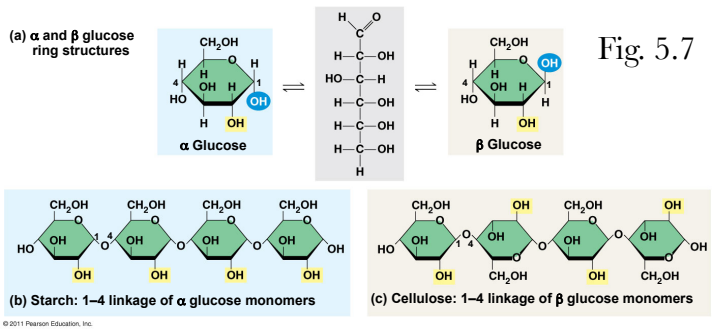

Fig. 5.7

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Chitin

- Important structural polysaccharide
- Found in exoskeleton of arthropods

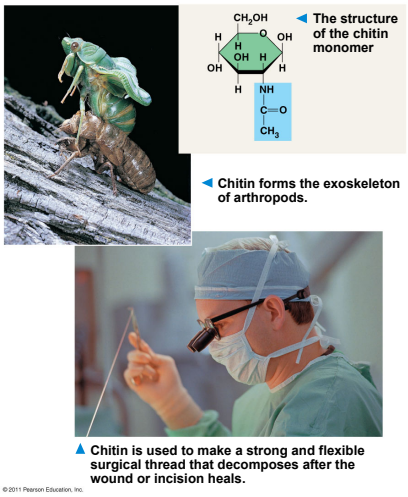

Fig. 5.9

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Lipids

- Only class of large biological molecules that do not consist of polymers
- Unifying feature is lack of an affinity for water
- Hydrophobic
- ex. Fats
- ex. Phospholipids
- ex. Steroids

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Fats

- Constructed from two types of smaller molecules, a single glycerol and three fatty acids

Fig. 5.10

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Fatty Acids

- Saturated fatty acids
  - Have the maximum number of hydrogen atoms possible
  - Have no double bonds
- Unsaturated fatty acids
  - Have one or more double bonds

- Fatty acids vary in length and number and locations of double bonds they contain

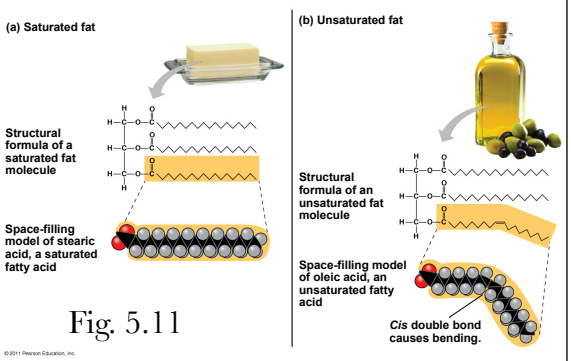

Fig. 5.11

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Phospholipids

- Have only two fatty acids
- Have a phosphate group instead of the third fatty acid
- Consist of a hydrophilic "head" and hydrophobic "tails"

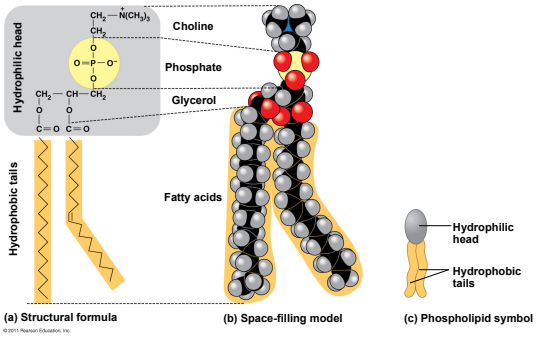

Fig. 5.12

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Cell Membranes

- Made up of phospholipids arranged as a result of their hydrophilic and hydrophobic regions
- Self-assemble in the presence of water

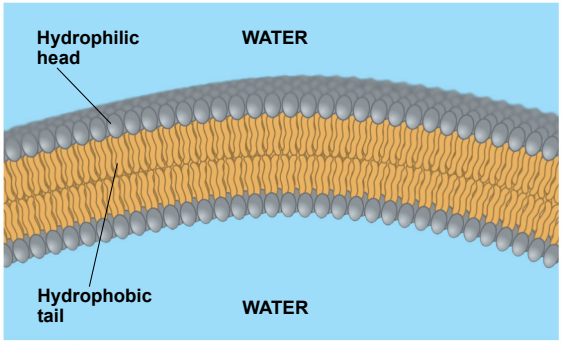

Fig. 5.13

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Steroids

- Lipids characterized by a carbon skeleton consisting of four fused rings
- Ex. cholesterol
  - found in cell membranes
  - precursor for some hormones

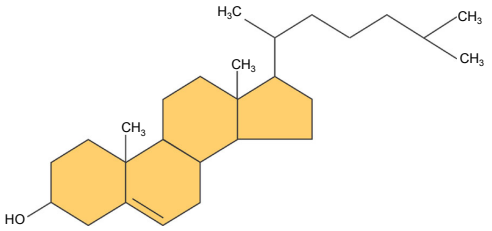

Figure 5.15

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Proteins

- Account for more than 50% of the dry mass of most cells
- Have many structures and functions inside of the cell
  - structure, storage, transport, cellular communications, movement, and defense against foreign substances

Fig. 5.15

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Enzymes

- Type of protein that acts as a catalyst speeding up chemical reactions

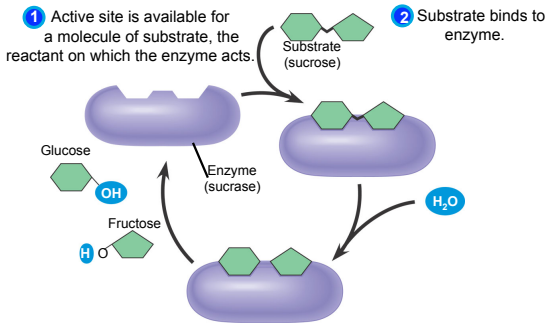

Figure 5.16

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Polypeptides

- Amino Acids - monomers of a protein with carboxyl and amino groups
  - Differ in properties based on different side chains (called R groups)
- Polypeptides - polymers of amino acids linked by peptide bonds
- Protein - consists of one or more polypeptides

Amino Acid Types

- Nonpolar
- Polar
- Electrically charged (acidic and basic)

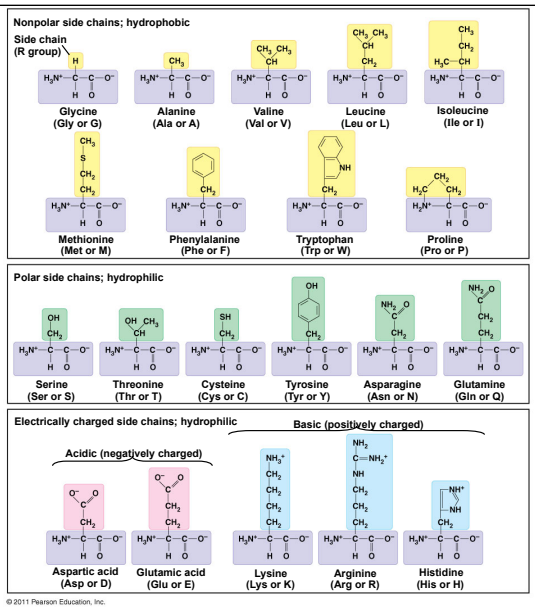


Fig. 5.16

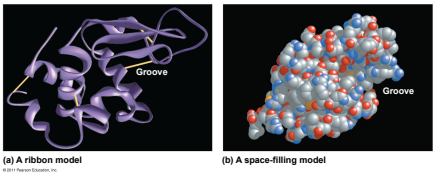
Amino Acid Linkages

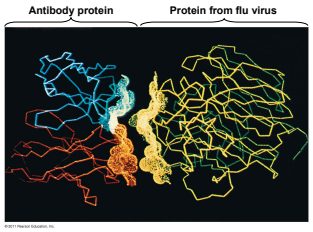
- Linked by peptide bonds

Fig. 5.17

Protein Structure and Function

- Functional protein has one or more polypeptides precisely twisted, folded, and coiled into a unique shape
- The sequence of amino acids determines the protein's three-dimensional structure and the structure determines the function





Figs. 5.18 - 5.19

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Protein Structure

- Levels
  - Primary - unique sequence of amino acids (determined by genetic info)
  - Secondary - coils and folds of the polypeptide chain

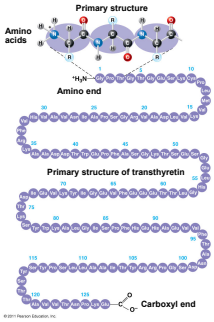
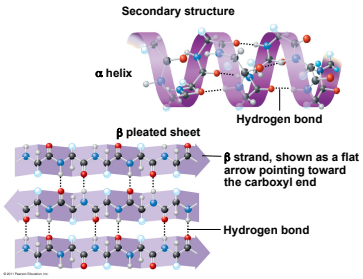


Fig. 5.20



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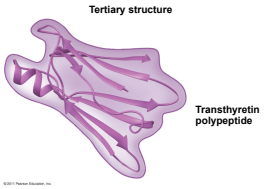
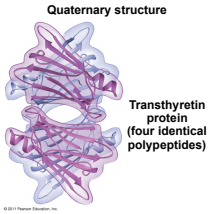
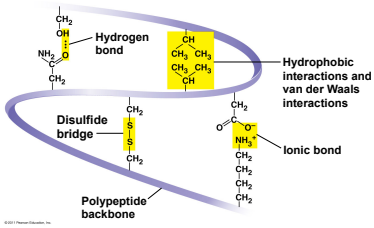
Primary Structure

- Tertiary - determined by interactions of side chains (R groups)
- Quaternary - many polypeptide chains

Fig. 5.20







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Case Study: Sickle Cell Disease

- Results from a single amino acid substitution in the protein hemoglobin
  - substitution of valine for glutamic acid
  - the abnormal hemoglobin molecule crystalizes deforming the cell into a sickle shape
    - causes blood flow to be impeded

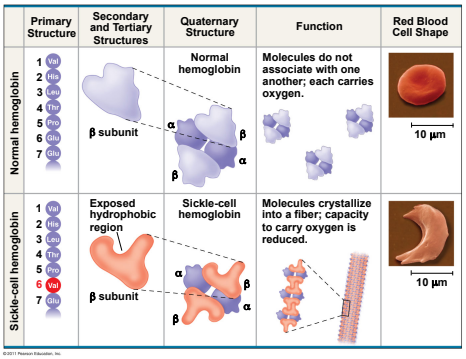

Fig. 5.21

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Protein Conformation

- Depends on the physical and chemical conditions of the protein's environment
- If pH, salt concentration, temperature, or other aspects are altered the protein may denature
- Denaturation - the protein unravels and loses its native conformation

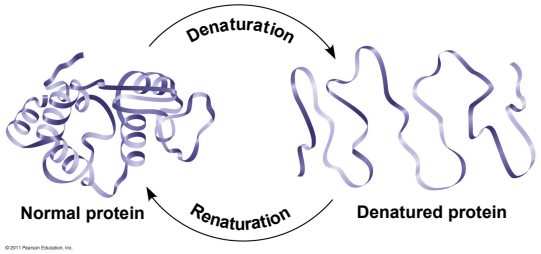

Fig. 5.22

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Protein Folding

- Proteins must go through several intermediate states on their way to a stable conformation
- Chaperonins - protein molecules that assist in the proper folding of other proteins

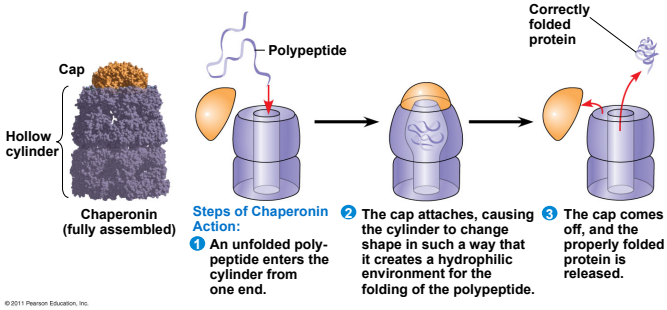

Fig. 5.23

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Structure Determination

- Difficult to determine the 3D structure of a protein
- X-ray crystallography
- NMR spectroscopy

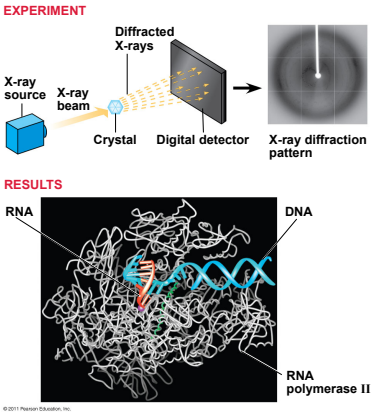

Fig. 5.24

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Nucleic Acids

- Store and transmit hereditary information
- Genes
  - unit of inheritance
  - determine the amino acid sequence of polypeptides
- Two types:
  - Deoxyribonucleic acid (DNA) - double stranded
  - Ribonucleic acid (RNA) - single stranded

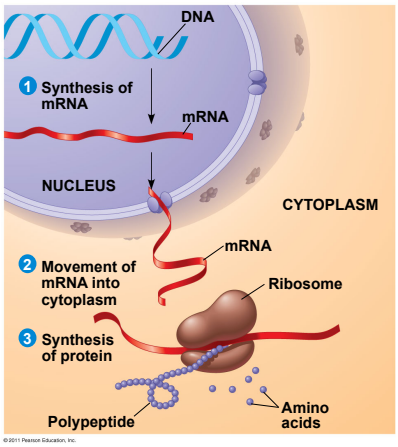

Fig. 5.25

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Nucleic Acids

- Monomer - nucleotide
- Polymer - polynucleotide

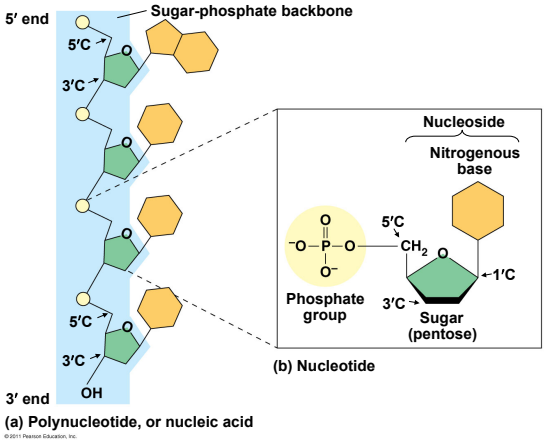

Fig. 5.26

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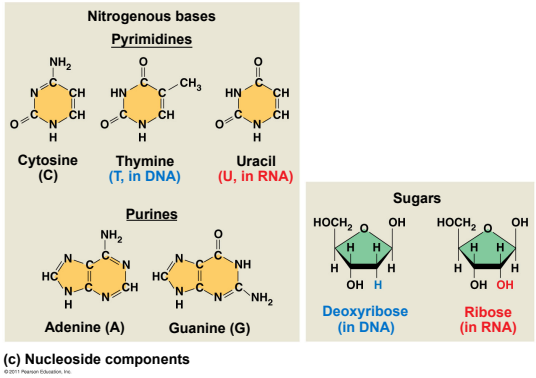
Nucleotide Monomers

- Made up of nucleosides (nitrogenous base and sugar) and phosphate groups
- Nucleotide - nucleoside and phosphate group



(c) Nucleoside components

Fig. 5.26

Nucleotide Polymers

- Made up of nucleotides linked by the -OH group on the 3' carbon of one nucleotide and the phosphate on the 5' carbon on the next
- DNA organized in a double helix of two antiparallel nucleotide strands
  - forms hydrogen bonds with the complementary strand (A pairs with T and C with G)

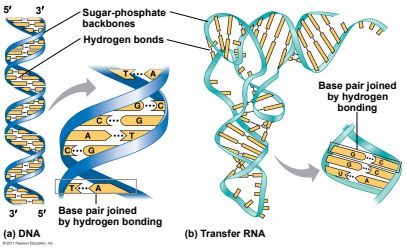


Fig. 5.27