

Biological Macromolecules

- Much larger than other particles found in cells
- Made up of smaller subunits
- Found in all cells
- Great diversity of functions

1

Four Classes of Biological Macromolecules

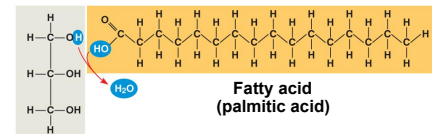
- Lipids
- Polysaccharides
- Proteins
- Nucleic Acids

2

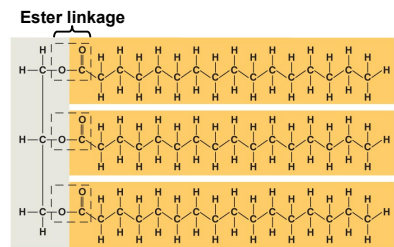
Lipids

- Hydrophobic or amphipathic
- Important for:
 - energy storage
 - membrane structure
 - signaling
 - cushioning
 - insulation
- Include:
 - fats
 - phospholipids
 - cholesterol and phytosterol
 - some hormones
 - others

3

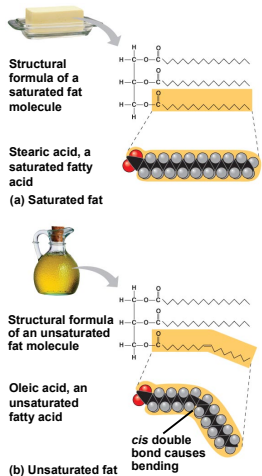


Glycerol
(a) Dehydration reaction in the synthesis of a fat



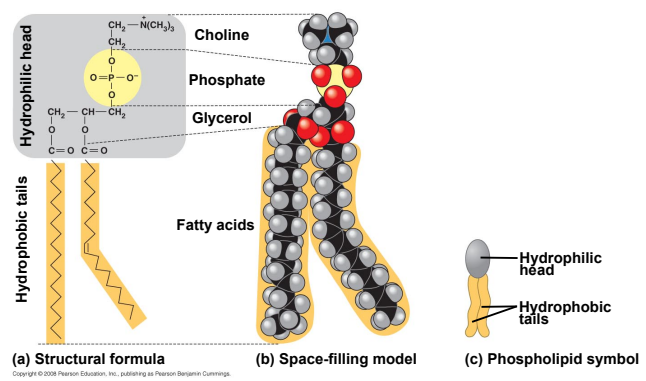
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

4



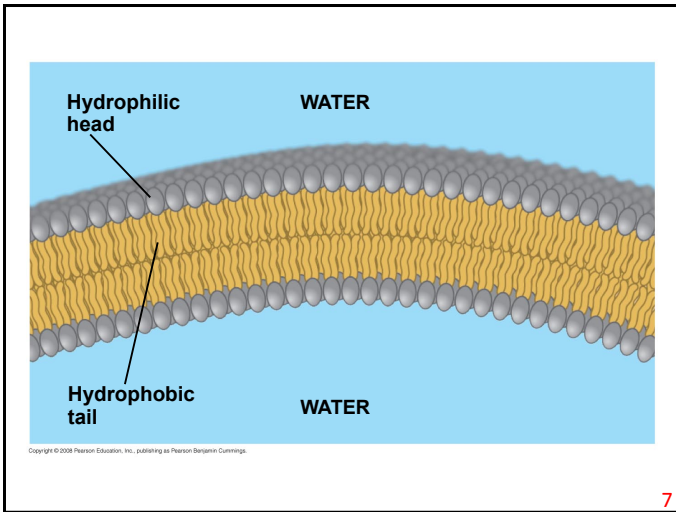
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

5

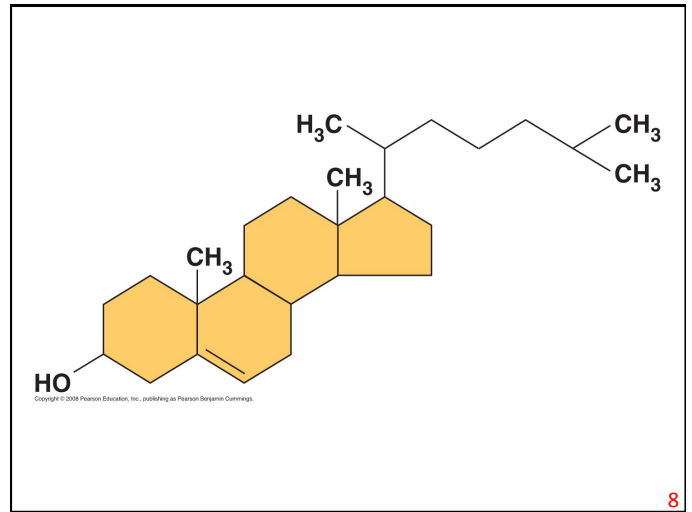


Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

6



7



8

Polysaccharides

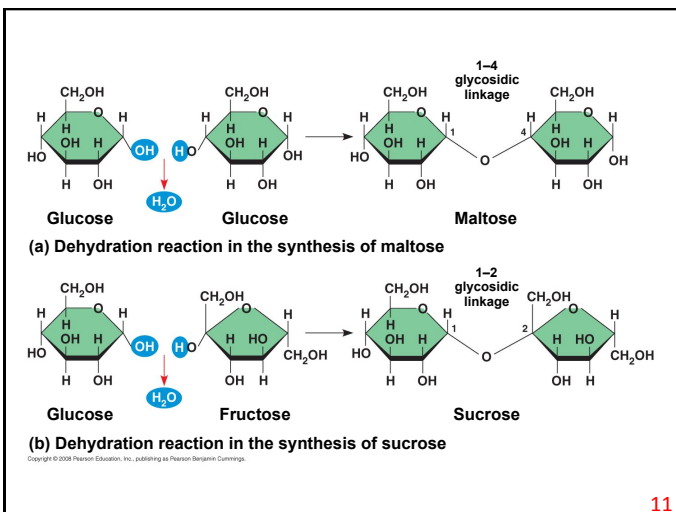
- Complex sugars
- Polymers of monosaccharides (simple sugars)
- Polysaccharides and monosaccharides are carbohydrates
- Important for:
 - structure
 - storage of energy
 - cell identity marking

9

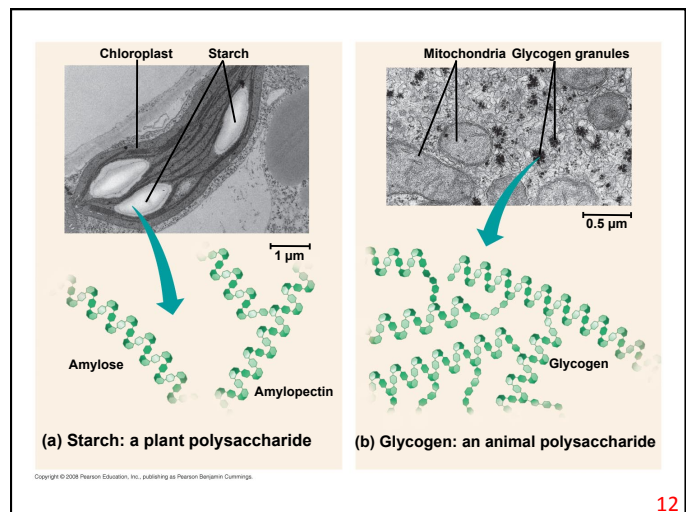
	Trioses ($\text{C}_2\text{H}_4\text{O}_2$)	Pentoses ($\text{C}_5\text{H}_{10}\text{O}_5$)	Hexoses ($\text{C}_6\text{H}_{12}\text{O}_6$)	
Alloses	$\begin{array}{c} \text{H} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Glyceraldehyde	$\begin{array}{c} \text{H} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Ribose	$\begin{array}{c} \text{H} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Glucose	$\begin{array}{c} \text{H} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Galactose
	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Dihydroxyacetone	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Ribulose	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Fructose	

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

10



11



12

(a) α and β glucose ring structures

(b) Starch: 1-4 linkage of α glucose monomers

(b) Cellulose: 1-4 linkage of β glucose monomers

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

13

Cell walls

Cellulose microfibrils in a plant cell wall

Microfibril

Cellulose molecules

β Glucose monomer

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

14

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

15

(a) The structure of the chitin monomer.

(b) Chitin forms the exoskeleton of arthropods.

(c) Chitin is used to make a strong and flexible surgical thread.

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

16

Proteins

- Polymers of amino acids
- Highly complex shape
- Function is based on shape
- Huge variety of functions

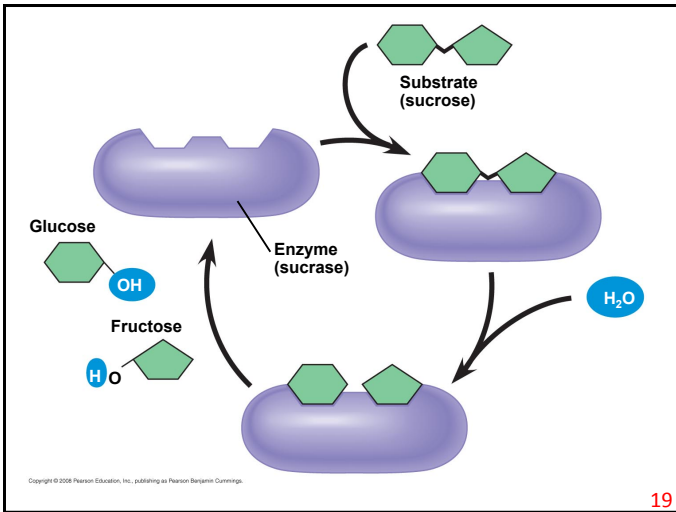
17

Table 5.1 An Overview of Protein Functions

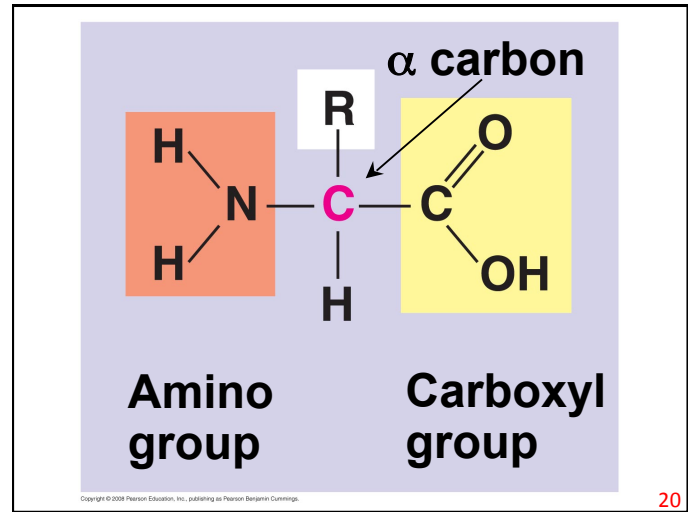
Type of Protein	Function	Examples
Enzymatic proteins	Selective acceleration of chemical reactions	Digestive enzymes
Structural proteins	Support	Silk fibers; collagen and elastin in animal connective tissues; keratin in hair, horns, feathers, and other skin appendages
Storage proteins	Storage of amino acids	Ovalbumin in egg white; casein, the protein of milk; storage proteins in plant seeds
Transport proteins	Transport of other substances	Hemoglobin, transport proteins
Hormonal proteins	Coordination of an organism's activities	Insulin, a hormone secreted by the pancreas
Receptor proteins	Response of cell to chemical stimuli	Receptors in nerve cell membranes
Contractile and motor proteins	Movement	Actin and myosin in muscles, proteins in cilia and flagella
Defensive proteins	Protection against disease	Antibodies combat bacteria and viruses.

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

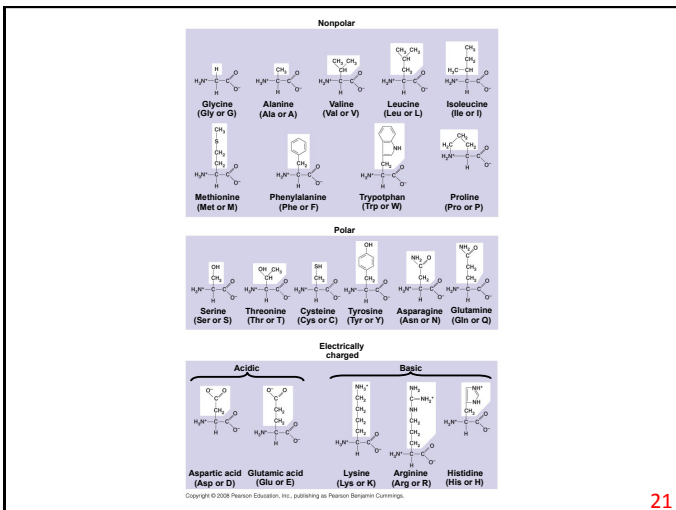
18



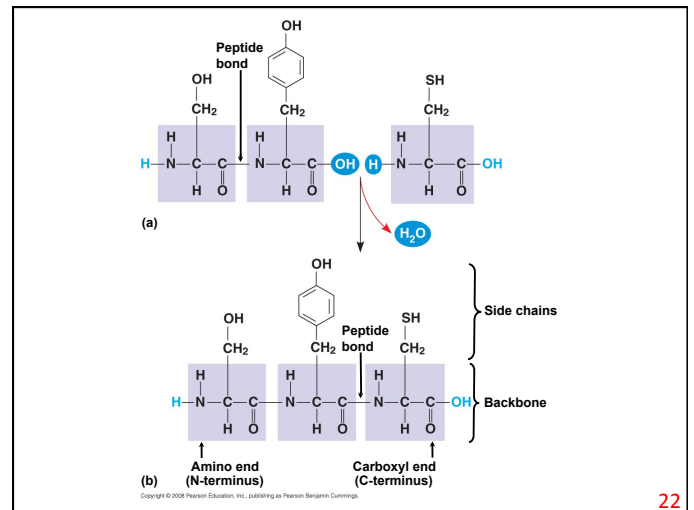
19



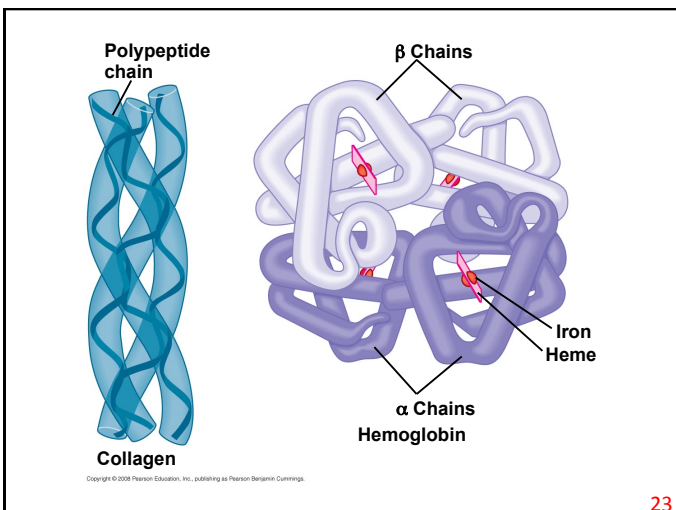
20



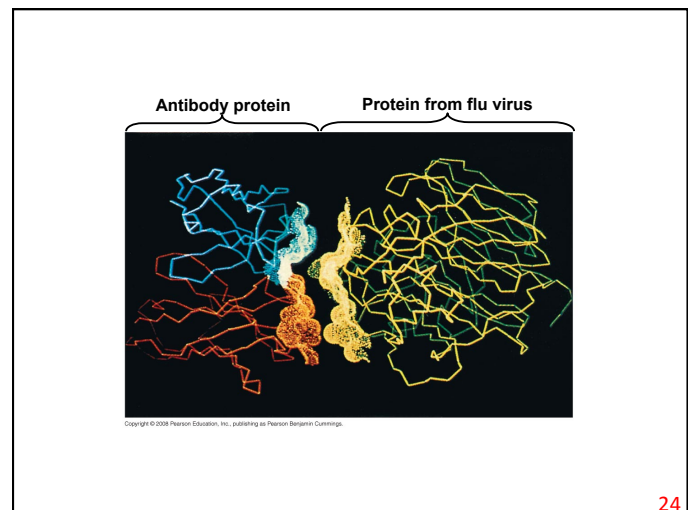
21





22



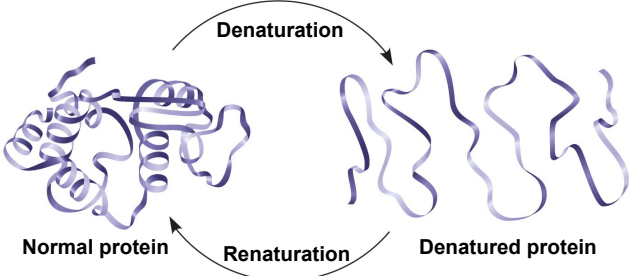
23



24

<p>Primary structure</p> <p>Normal hemoglobin 1 2 3 4 5 6 7</p>	<p>Primary structure</p> <p>Sickle-cell hemoglobin 1 2 3 4 5 6 7</p>
<p>Secondary and tertiary structures</p> <p>β subunit</p>	<p>Secondary and tertiary structures</p> <p>Exposed hydrophobic region β subunit</p>
<p>Quaternary structure</p> <p>Normal hemoglobin (top view)</p> <p>α β</p>	<p>Quaternary structure</p> <p>Sickle-cell hemoglobin</p> <p>α β</p>
<p>Function</p> <p>Molecules do not associate with one another, each carries oxygen.</p>	<p>Function</p> <p>Molecules interact with one another and crystallize into a fiber; capacity to carry oxygen is greatly reduced.</p>
<p>Red blood cell shape</p> <p>Normal red blood cells are full of individual hemoglobin molecules, each carrying oxygen.</p> <p>10 μm</p> 	<p>Red blood cell shape</p> <p>Fibers of abnormal hemoglobin deform red blood cells into sickle shape.</p> <p>10 μm</p> 

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings. 25



Denaturation

Normal protein

Renaturation

Denatured protein

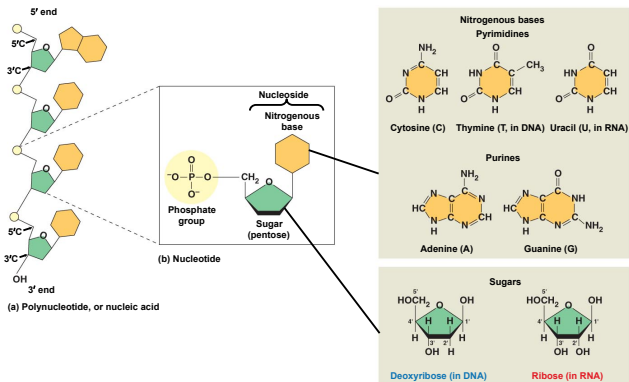
Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings. 26

Nucleic Acids

- Polymers of nucleotides
 - also called polynucleotides
- Store and convey information
- Instruction manual of the cell

- Include:
 - DNA (deoxyribonucleic acid)
 - RNA (ribonucleic acid)
- Important for:
 - reproduction of cells
 - production of proteins

27

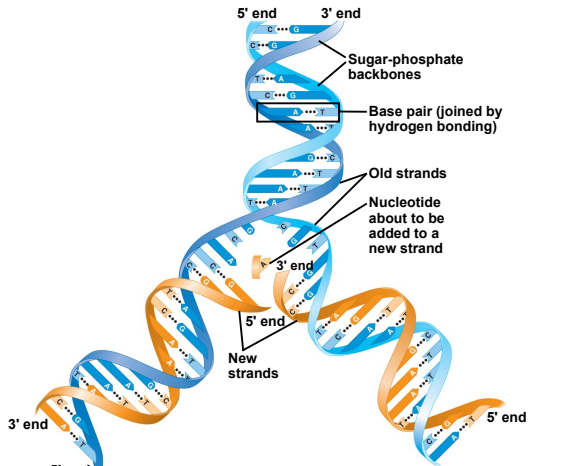


(a) Polynucleotide, or nucleic acid

(b) Nucleotide

(c) Nucleoside components: sugars

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings. 28



5' end 3' end

Sugar-phosphate backbones

Base pair (joined by hydrogen bonding)

Old strands

Nucleotide about to be added to a new strand

3' end

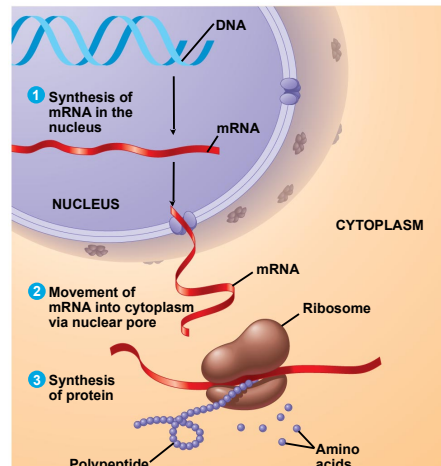
5' end

New strands

3' end 5' end

3' end 5' end

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings. 29



1 Synthesis of mRNA in the nucleus

2 Movement of mRNA into cytoplasm via nuclear pore

3 Synthesis of protein

DNA

mRNA

NUCLEUS

CYTOPLASM







mRNA

Ribosome

Polypeptide

Amino acids

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings. 30

Large Biological Molecules	Components	Examples	Functions
Concept 5.2 Carbohydrates serve as fuel and building material	 <p>Monosaccharide monomer</p>	Monosaccharides: glucose, fructose Disaccharides: lactose, sucrose Polysaccharides: <ul style="list-style-type: none"> Cellulose (plants) Starch (plants) Glycogen (animals) Chitin (animals and fungi) 	Fuel: carbon sources that can be converted to other molecules or combined into polymers <ul style="list-style-type: none"> Strengthens plant cell walls Stores glucose for energy Stores glucose for energy Strengthens exoskeletons and fungal cell walls
Concept 5.3 Lipids are a diverse group of hydrophobic molecules and are not macromolecules	 <p>Glycerol + 3 fatty acids</p>  <p>Phospholipids: phosphate group + 2 fatty acids</p>  <p>Steroid backbone</p>	Triglycerides (fats or oils): glycerol + 3 fatty acids Phospholipids: phosphate group + 2 fatty acids Steroids: four fused rings with attached chemical groups	Important energy source Lipid bilayers of membranes Component of cell membranes (cholesterol) Signals that travel through the body (hormones)
Concept 5.4 Proteins have many structures, resulting in a wide range of functions	 <p>Amino acid monomer (20 types)</p>	<ul style="list-style-type: none"> Enzymes Structural proteins Storage proteins Transport proteins Hormones Receptor proteins Motor proteins Defensive proteins 	<ul style="list-style-type: none"> Catalyze chemical reactions Provide structural support Store amino acids Transport substances Coordinate organismal responses Receive signals from outside cell Function in cell movement Protect against disease
Concept 5.5 Nucleic acids store and transmit hereditary information	 <p>Nucleotide monomer</p>	DNA: <ul style="list-style-type: none"> Sugar = deoxyribose Nitrogenous bases = C, G, A, T Usually double-stranded RNA: <ul style="list-style-type: none"> Sugar = ribose Nitrogenous bases = C, G, A, U Usually single-stranded 	Stores all hereditary information Carries protein-coding instructions from DNA to protein-synthesizing machinery

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Benjamin Cummings.