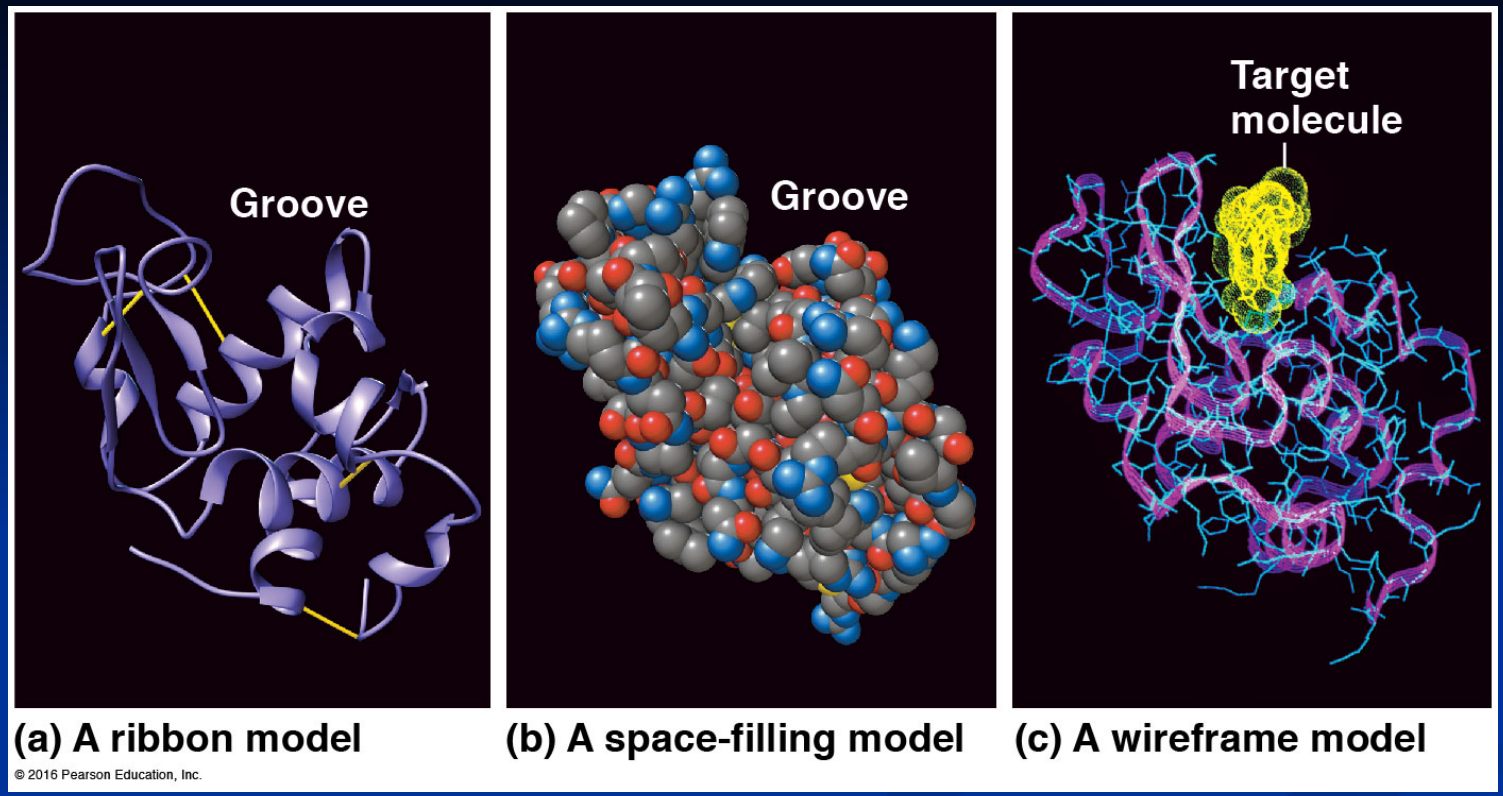
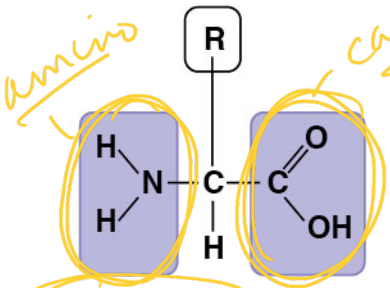
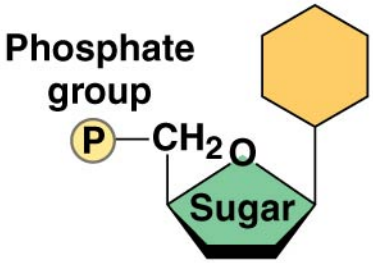


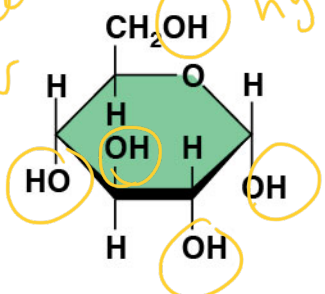
Ch. 3b: The Structure and Function of Macromolecules

Components	Examples	Functions
 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• 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

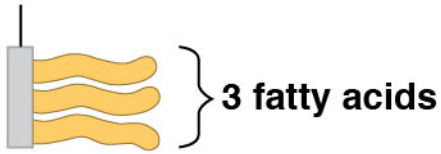
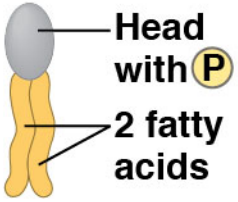
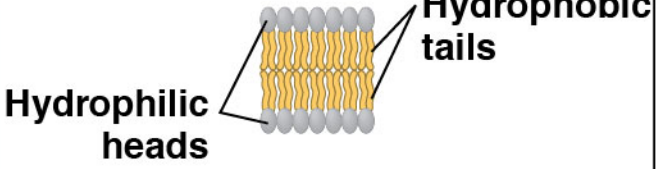
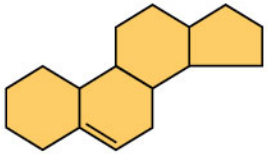
© 2016 Pearson Education, Inc.

Components	Examples	Functions
Nitrogenous base  Nucleotide monomer	DNA: • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores hereditary information
	RNA: • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Various functions in gene expression, including carrying instructions from DNA to ribosomes

© 2016 Pearson Education, Inc.

Components	Examples	Functions
 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
	Disaccharides: lactose, sucrose	
	Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls

© 2016 Pearson Education, Inc.

Components	Examples	Functions
Glycerol 	Triacylglycerols (fats or oils): glycerol + three fatty acids	Important energy source
	Phospholipids: glycerol + phosphate group + two fatty acids	Lipid bilayers of membranes 
 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signaling molecules that travel through the body (hormones)

© 2016 Pearson Education, Inc.

You Must Know

- The role of **dehydration synthesis** in the formation of organic compounds and **hydrolysis** in the digestion of organic compounds.
- How the sequence and subcomponents of the four groups of organic compounds determine their properties.
- The cellular functions of carbs, lipids, proteins, and nucleic acids.
- How changes in these organic molecules would affect their function.

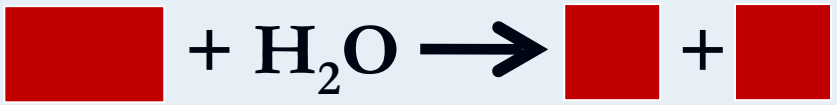
You Must Know

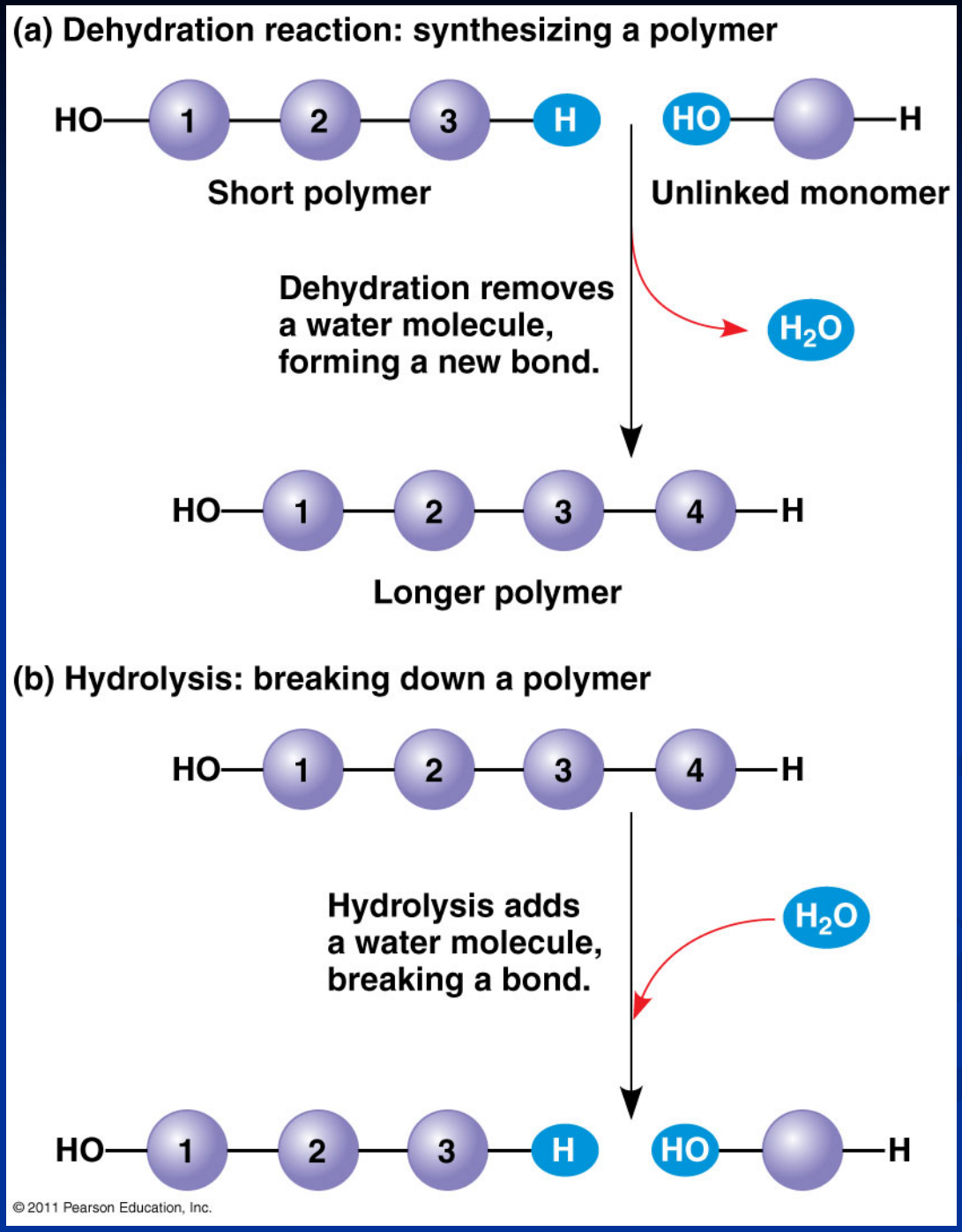
- The 4 structural levels of proteins and how changes at any levels can affect the activity of the protein.
- How proteins reach their final shape (**conformation**), the **denaturing** impact that heat and pH can have on protein structure, and how these changes may affect the organism.
- Directionality influences structure and function of polymers, such as nucleic acids (5' and 3' ends) and proteins (amino and carboxyl ends).

Monomers	Polymers	Macromolecules
•Small organic •Used for building blocks of polymers •Connects with condensation reaction (dehydration synthesis)	•Long molecules of monomers •With many identical or similar blocks linked by covalent bonds	•Giant molecules •2 or more polymers bonded together

ie. amino acid → peptide → polypeptide → protein

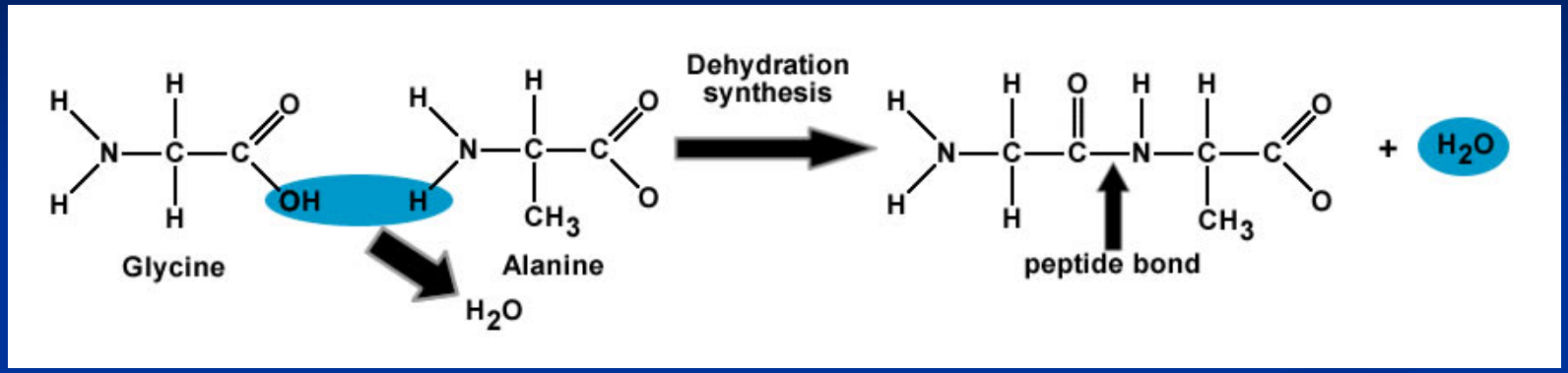
smaller ⟶ **larger**

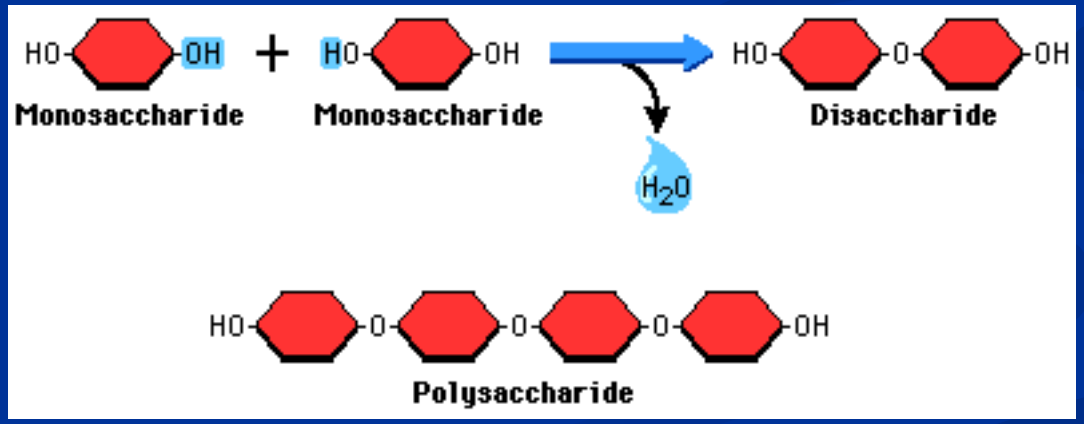
Dehydration Synthesis (Condensation Reaction)	Hydrolysis
Make polymers	Breakdown polymers
Monomers → Polymers	Polymers → Monomers
A + B → AB	AB → A + B
	



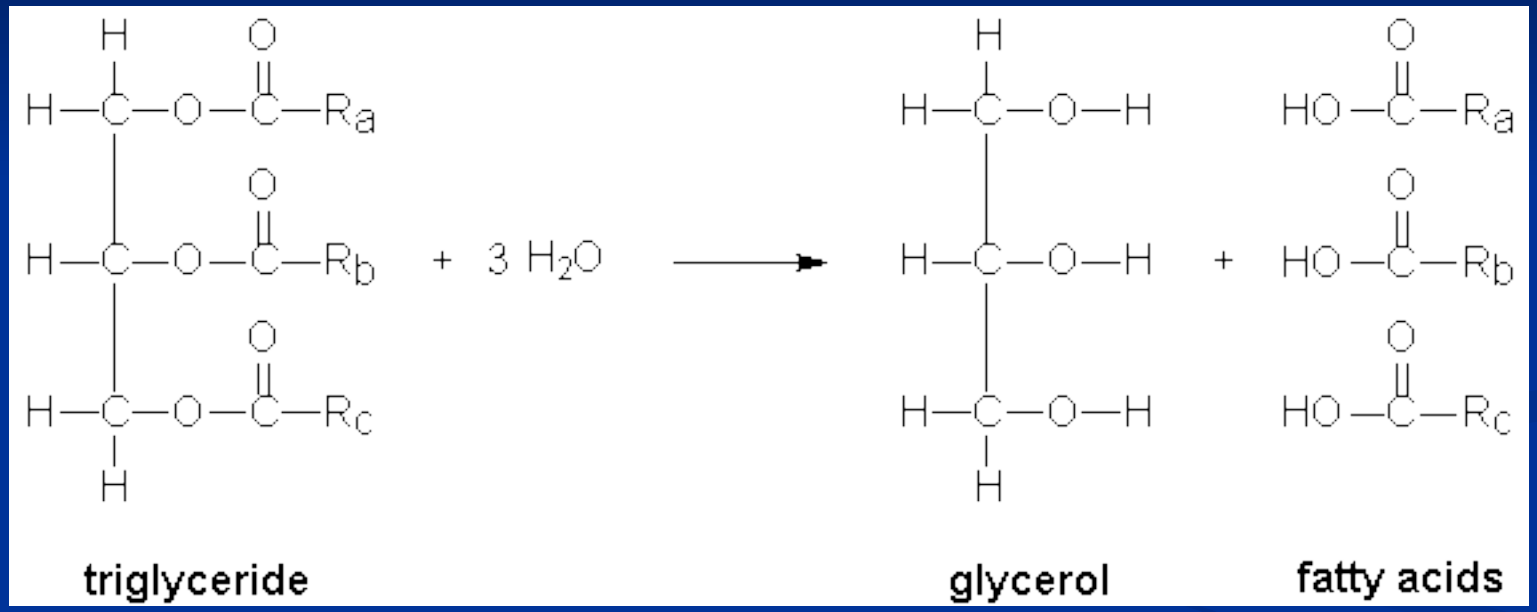
© 2011 Pearson Education, Inc.

Dehydration Synthesis

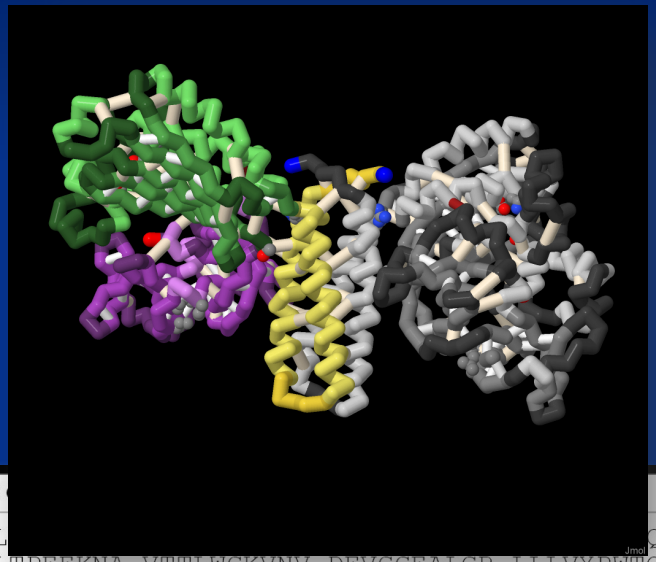




Hydrolysis



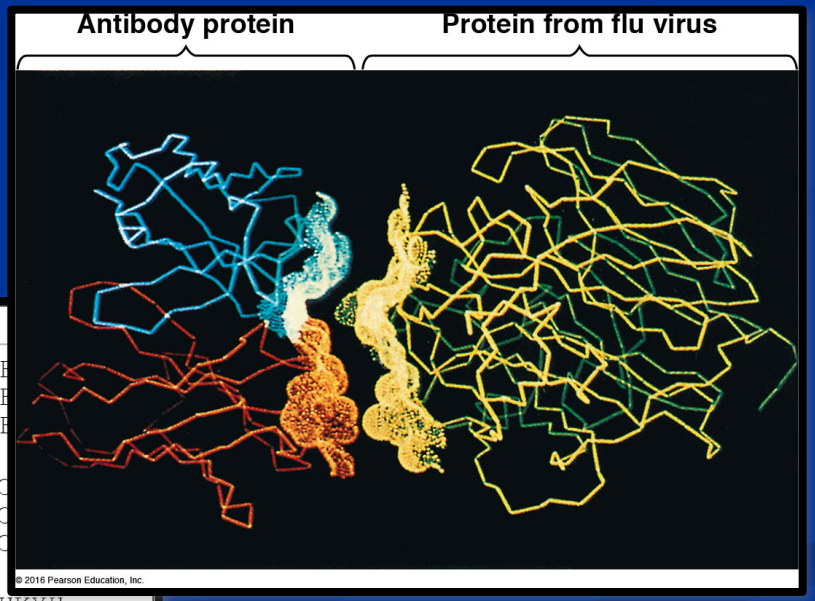
Proteomics: Analysis of proteins and sequences



Species	Alignment					
Human	1	VHL				QR FFE
Monkey	1	VHLTPEEKNA	VTTLWGKVNV	DEVGGEALGR	LLVYPWTQR	FFE
Gibbon	1	VHLTPEEKSA	VTALWGKVNV	DEVGGEALGR	LLVVYPWTQR	FFE
Human	51	PDAVMGNPKV	KAHGKKVLGA	FSDGLAHLDN	LKGTFATLSE	LHC
Monkey	51	PDAVMGNPKV	KAHGKKVLGA	FSDGLNHLDN	LKGTFAQLSE	LHC
Gibbon	51	PDAVMGNPKV	KAHGKKVLGA	FSDGLAHLDN	LKGTFAQLSE	LHC
Human	101	ENFRLLGNVL	VCVLAHHFGK	EFTPPVQAAY	QKVVAGVANA	LAHKYH
Monkey	101	ENFKLLGNVL	VCVLAHHFGK	EFTPQVQAAY	QKVVAGVANA	LAHKYH
Gibbon	101	ENFRLLGNVL	VCVLAHHFGK	EFTPQVQAAY	QKVVAGVANA	LAHKYH

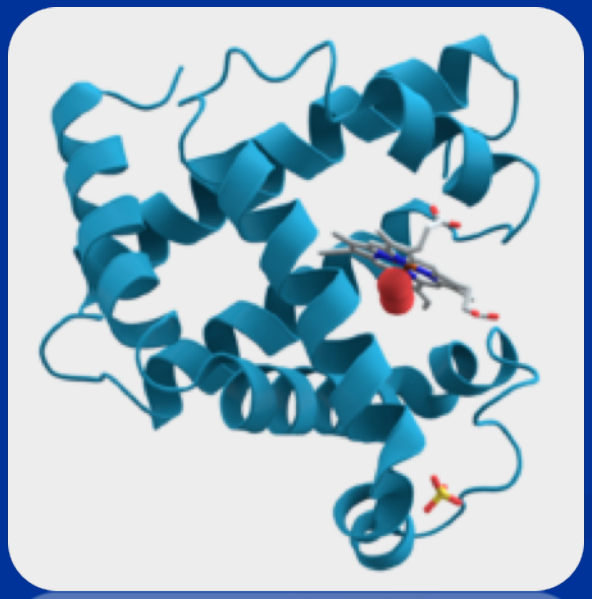
Data from Human: http://www.ncbi.nlm.nih.gov/protein/AAA21113.1; rhesus monkey: http://www.ncbi.nlm.nih.gov/ protein/122634; gibbon: http://www.ncbi.nlm.nih.gov/protein/122616

© 2016 Pearson Education, Inc.



I. Proteins

- "Proteios" = first or primary
- 50% dry weight of cells
- Contains: C, H, O, N, S



Myoglobin protein

Protein Functions (+ examples)

- Enzymes (lactase)
- Defense (antibodies)
- Storage (milk protein = casein)
- Transport (hemoglobin)
- Hormones (insulin)
- Receptors
- Movement (motor proteins)
- Structure (keratin)

Overview of protein functions

Enzymatic proteins

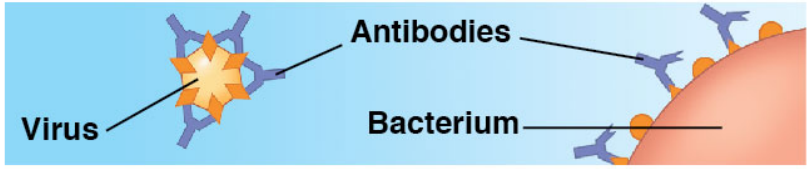
Function: Selective acceleration of chemical reactions

Example: Digestive enzymes catalyze the hydrolysis of bonds in food molecules.

Defensive proteins

Function: Protection against disease

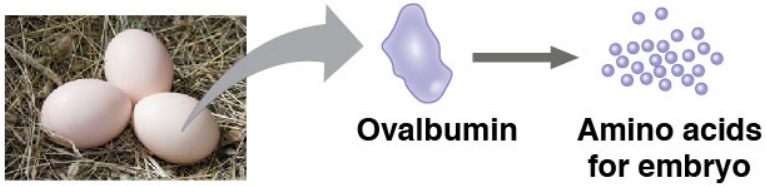
Example: Antibodies inactivate and help destroy viruses and bacteria.



Storage proteins

Function: Storage of amino acids

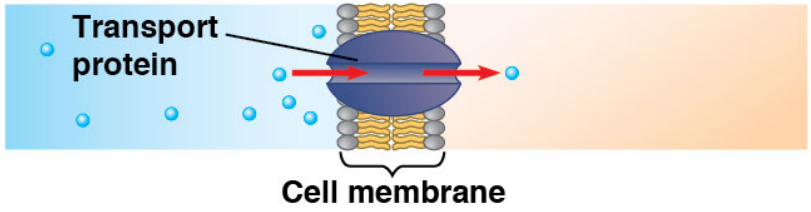
Examples: Casein, the protein of milk, is the major source of amino acids for baby mammals. Plants have storage proteins in their seeds. Ovalbumin is the protein of egg white, used as an amino acid source for the developing embryo.



Transport proteins

Function: Transport of substances

Examples: Hemoglobin, the iron-containing protein of vertebrate blood, transports oxygen from the lungs to other parts of the body. Other proteins transport molecules across membranes, as shown here.



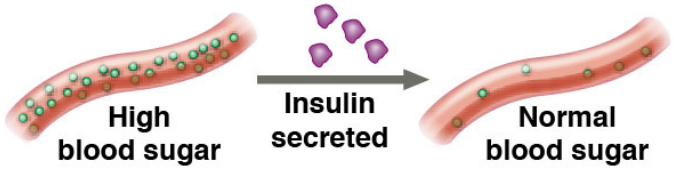
© 2016 Pearson Education, Inc.

Overview of protein functions

Hormonal proteins

Function: Coordination of an organism's activities

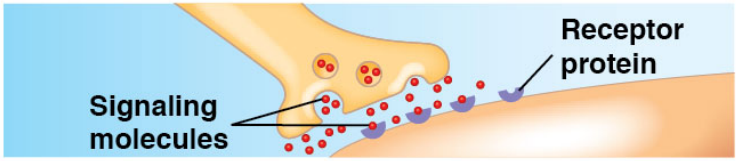
Example: Insulin, a hormone secreted by the pancreas, causes other tissues to take up glucose, thus regulating blood sugar concentration.



Receptor proteins

Function: Response of cell to chemical stimuli

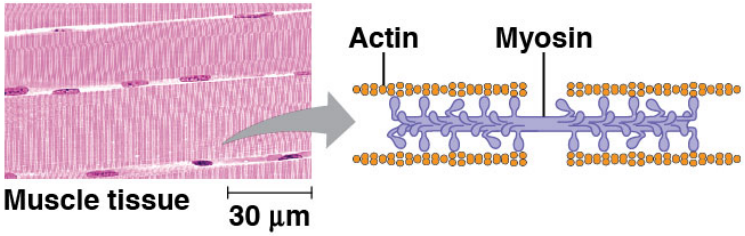
Example: Receptors built into the membrane of a nerve cell detect signaling molecules released by other nerve cells.



Contractile and motor proteins

Function: Movement

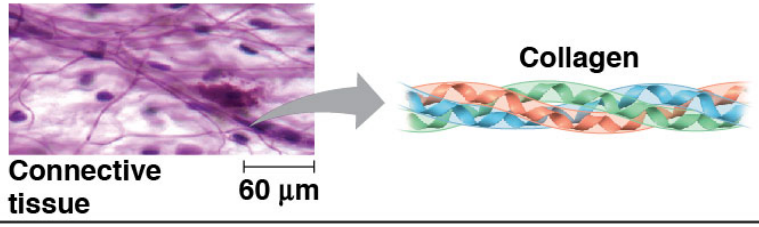
Examples: Motor proteins are responsible for the undulations of cilia and flagella. Actin and myosin proteins are responsible for the contraction of muscles.



Structural proteins

Function: Support

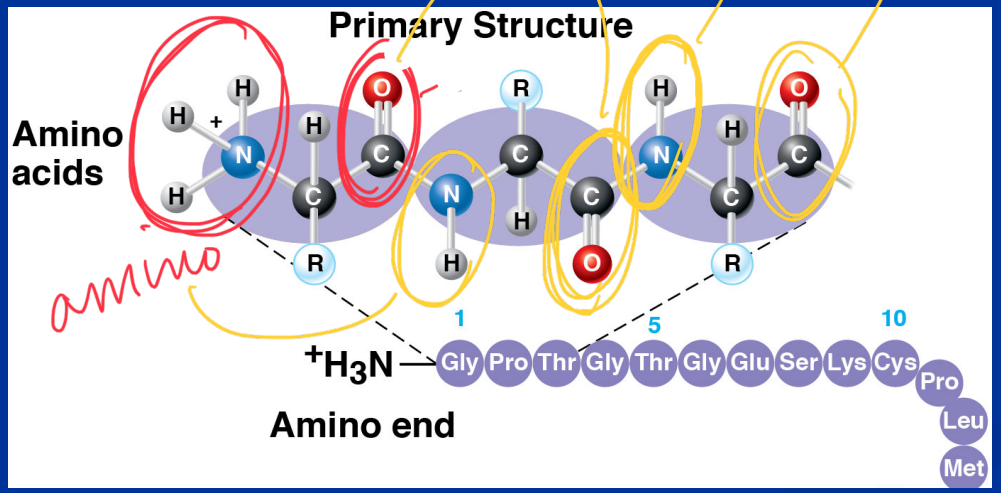
Examples: Keratin is the protein of hair, horns, feathers, and other skin appendages. Insects and spiders use silk fibers to make their cocoons and webs, respectively. Collagen and elastin proteins provide a fibrous framework in animal connective tissues.

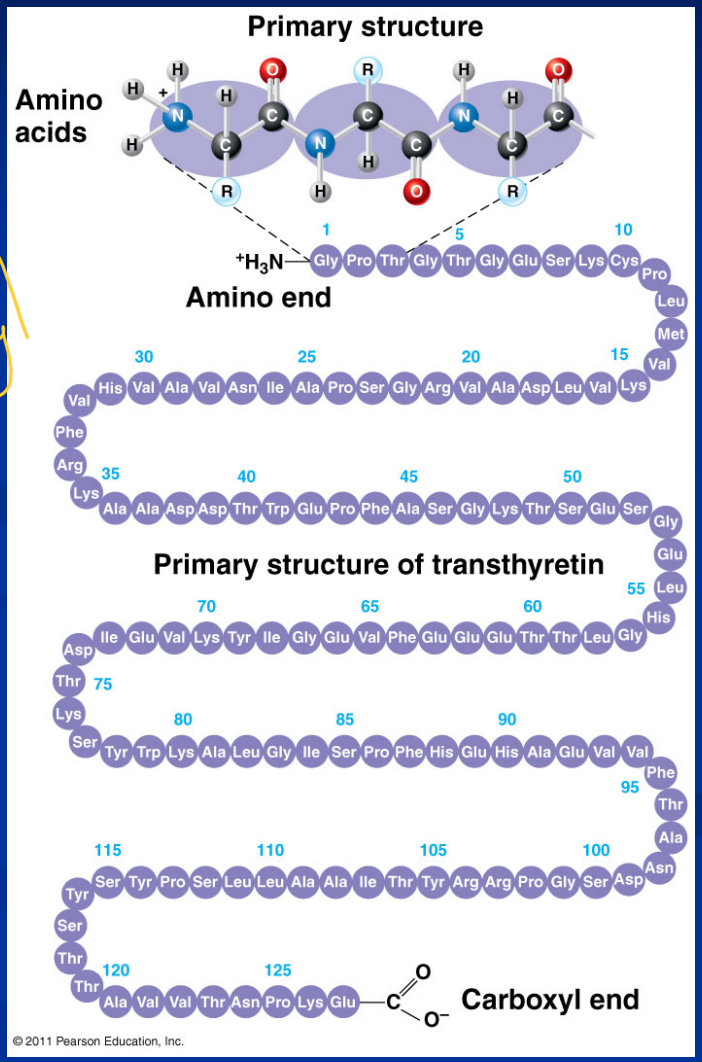


© 2016 Pearson Education, Inc.

Four Levels of Protein Structure

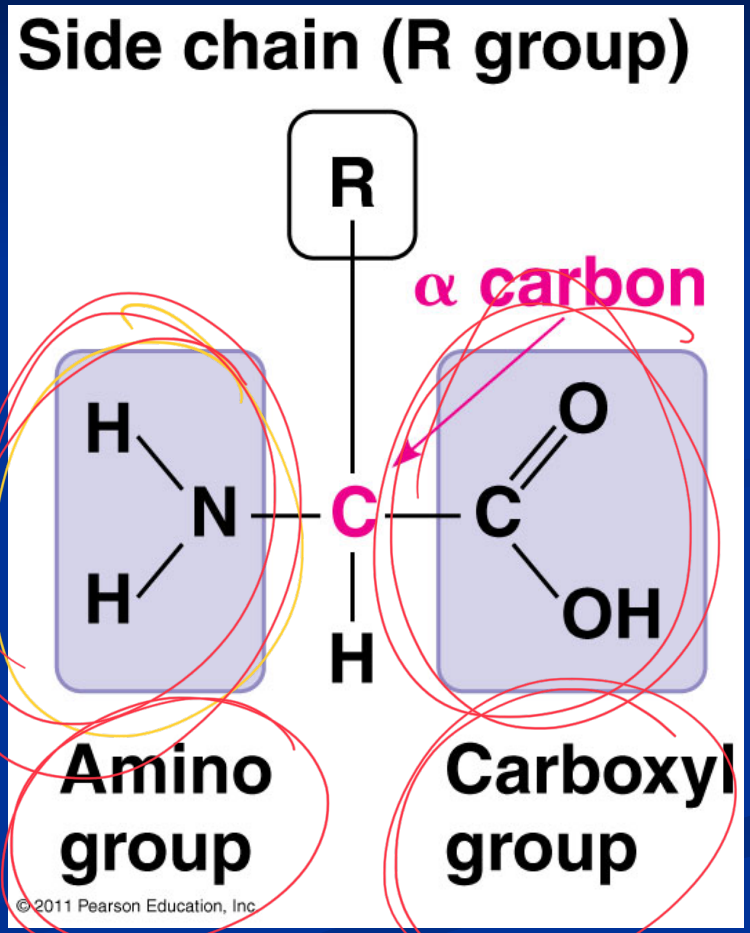
1. **Primary**
   - **Amino acid** (AA) sequence
   - 20 different AA's
   - **peptide bonds** link AA's

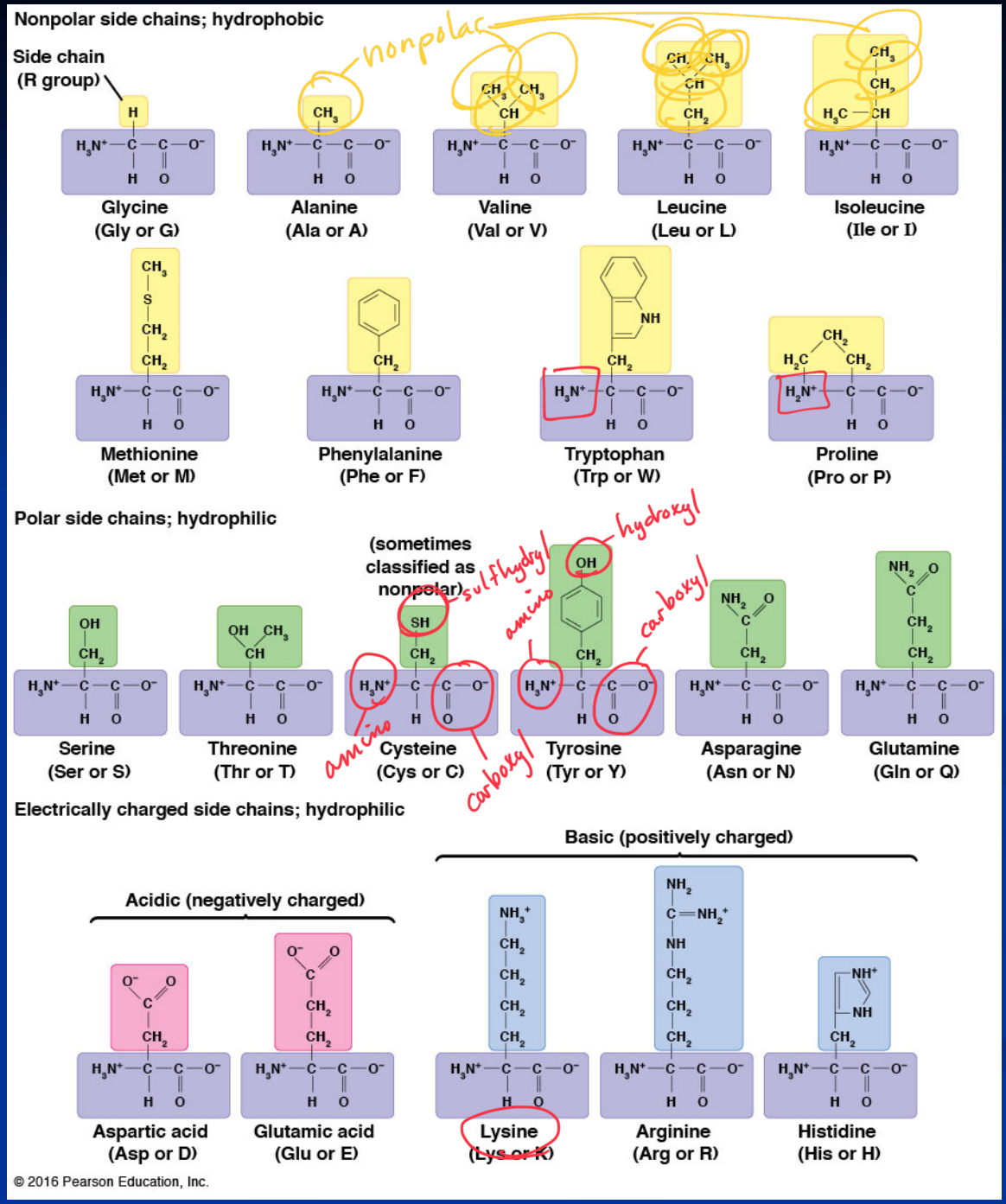




Amino Acid

- **R group** = side chains
- Properties:
  - hydrophobic
  - hydrophilic
  - ionic (acids & bases)
- "amino" : $-NH_2$
- "acid" : -COOH





© 2016 Pearson Education, Inc.

amino acids are bound together using peptide bonds

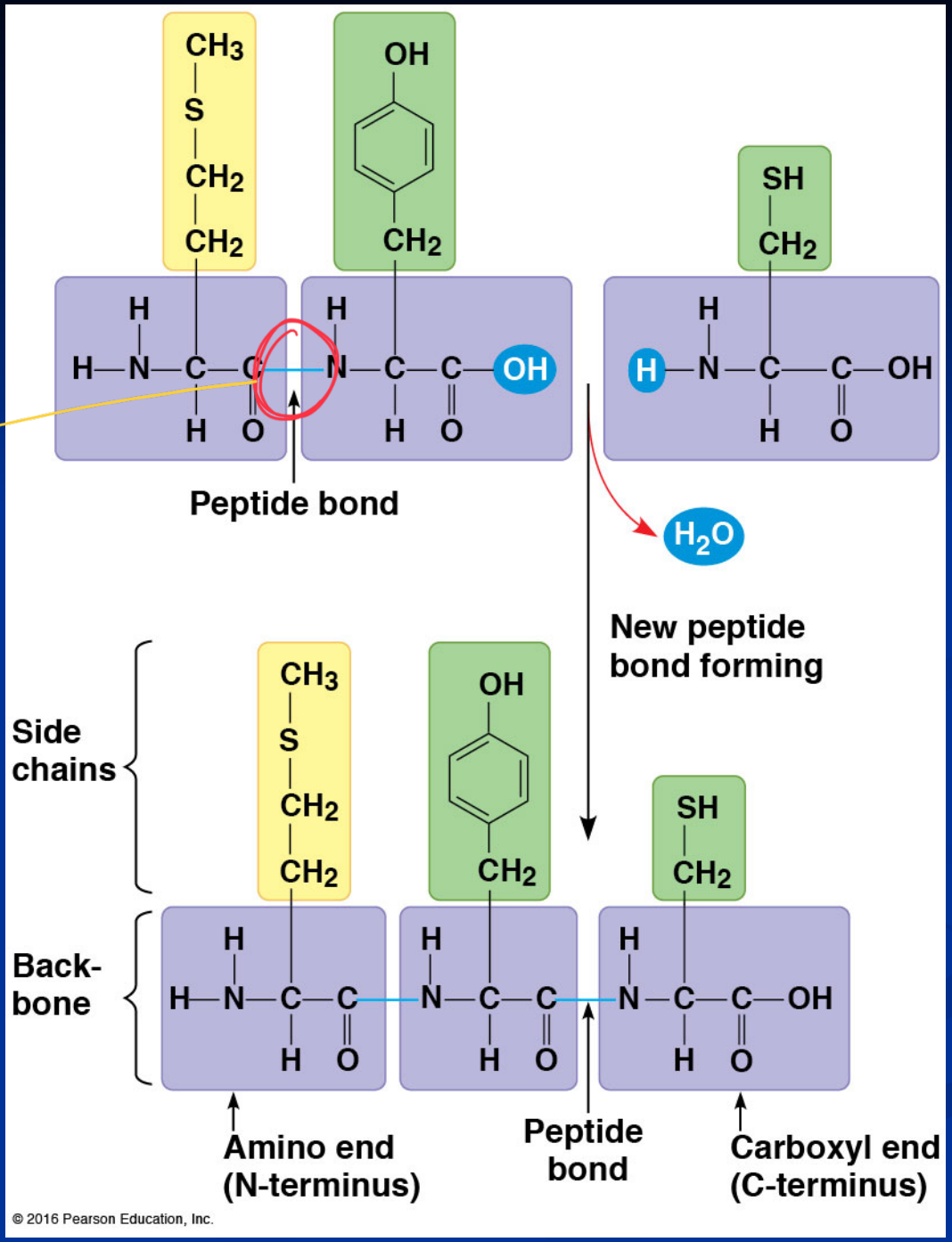
monomer

amino acid

polymer

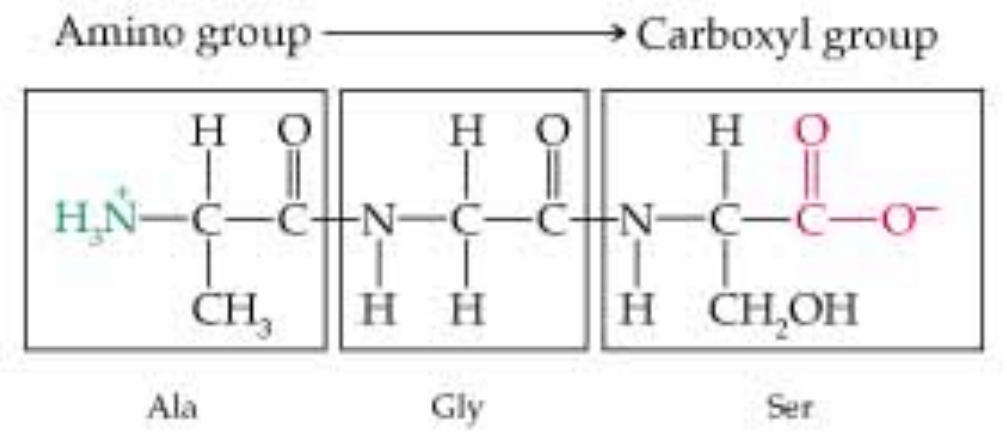
polypeptide

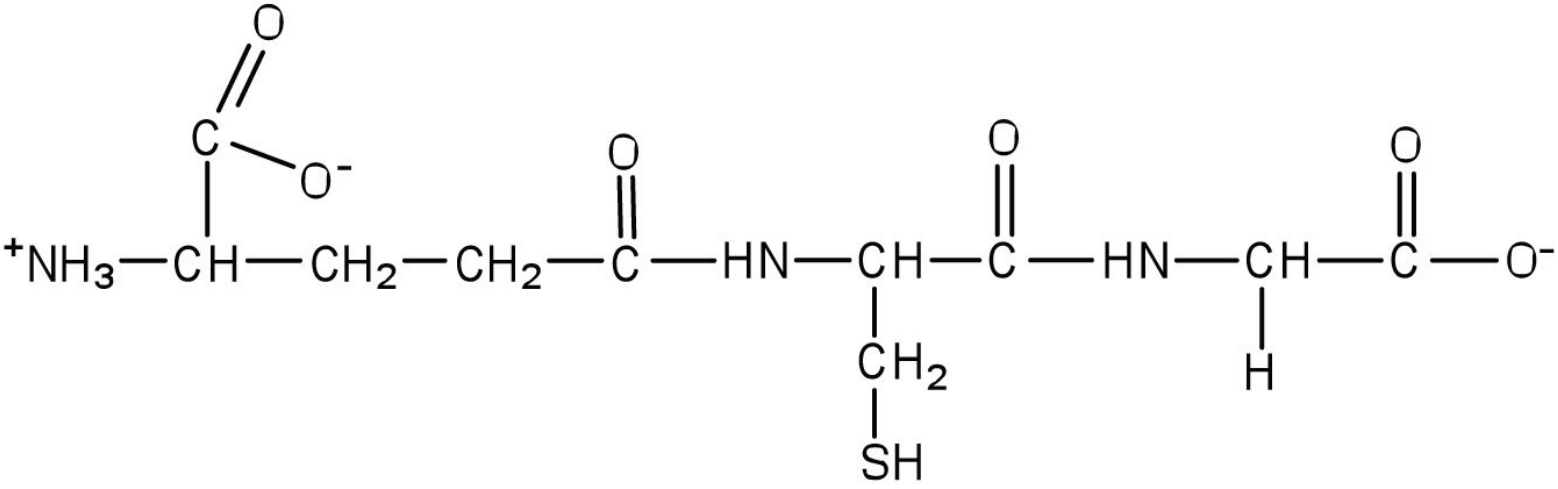
many peptide bonds



© 2016 Pearson Education, Inc.

Peptide Bonds



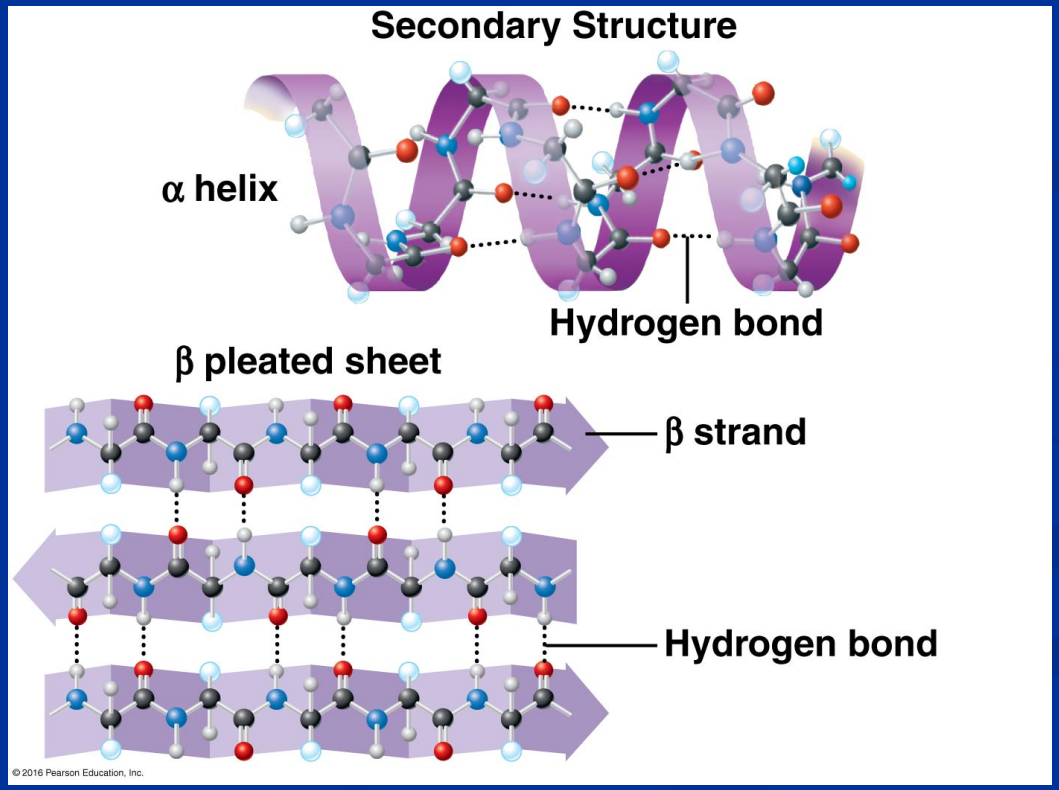


Four Levels of Protein Structure (continued)

2. Secondary → patterns that form in the interior proteins

- Gains 3-D shape (folds, coils) by **H-bonding**
- **Alpha (α) helix**, **Beta (β) pleated sheet**

alpha



Basic Principles of Protein Folding

NONPOLAR aa = amino acid

A. Hydrophobic AA buried in interior of protein (hydrophobic interactions) Nonpolar aa orient inward to get away from the polar water.

POLAR

B. Hydrophilic AA exposed on surface of protein (hydrogen bonds) polar aa orient themselves outward → toward water

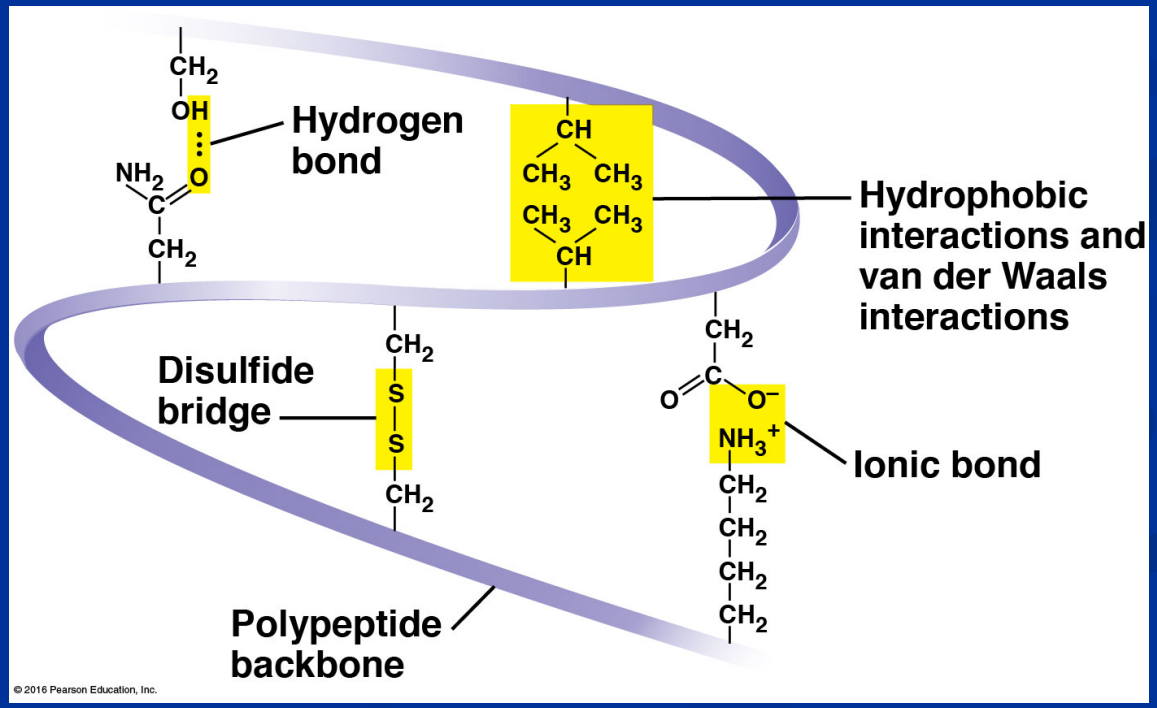
C. Acidic + Basic AA form salt bridges (ionic bonds).

PROTEIN COLLAPSES ↓ functional form

D. Cysteines can form <u>disulfide bonds</u>.

Four Levels of Protein Structure (continued)

3. **Tertiary** → shape of the protein. Shape gives protein its structure
   - Bonding between **side chains** (R groups) of amino acids
   - H bonds, ionic bonds, disulfide bridges, hydrophobic interactions, van der Waals interactions



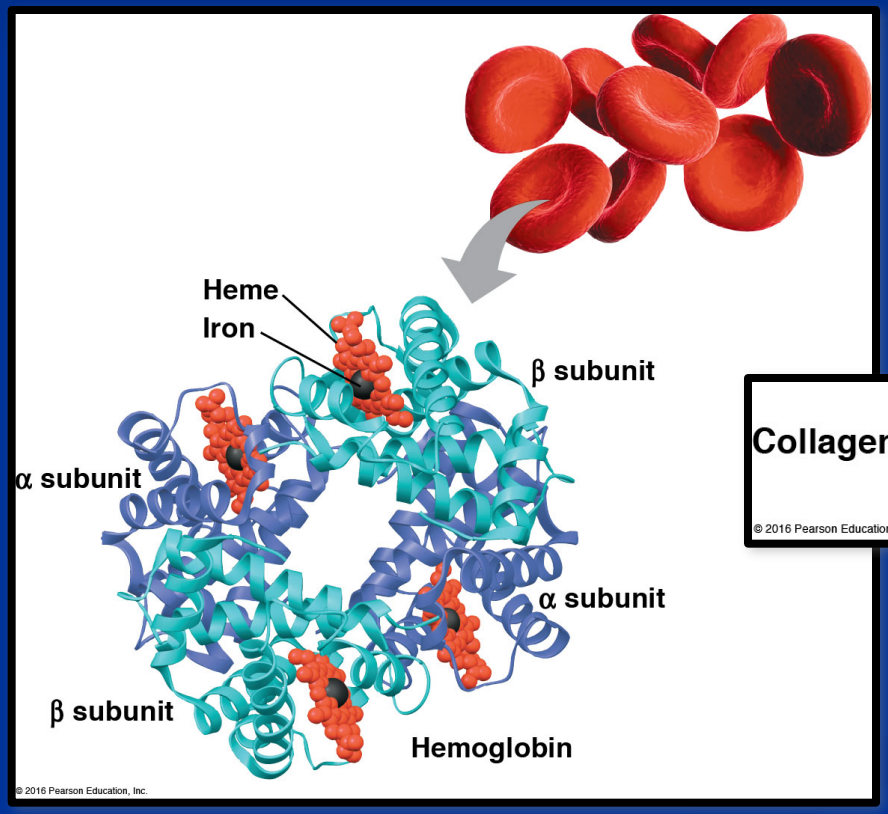
Four Levels of Protein Structure (continued)

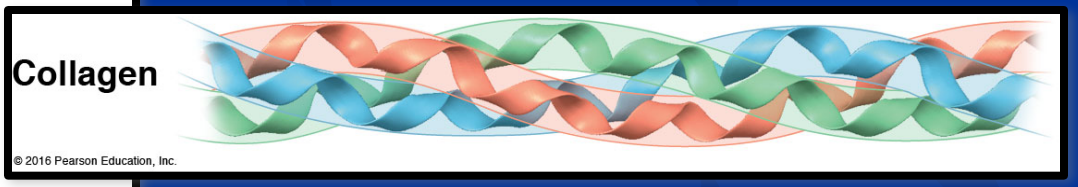
4. Quaternary

musical band → multiple instruments

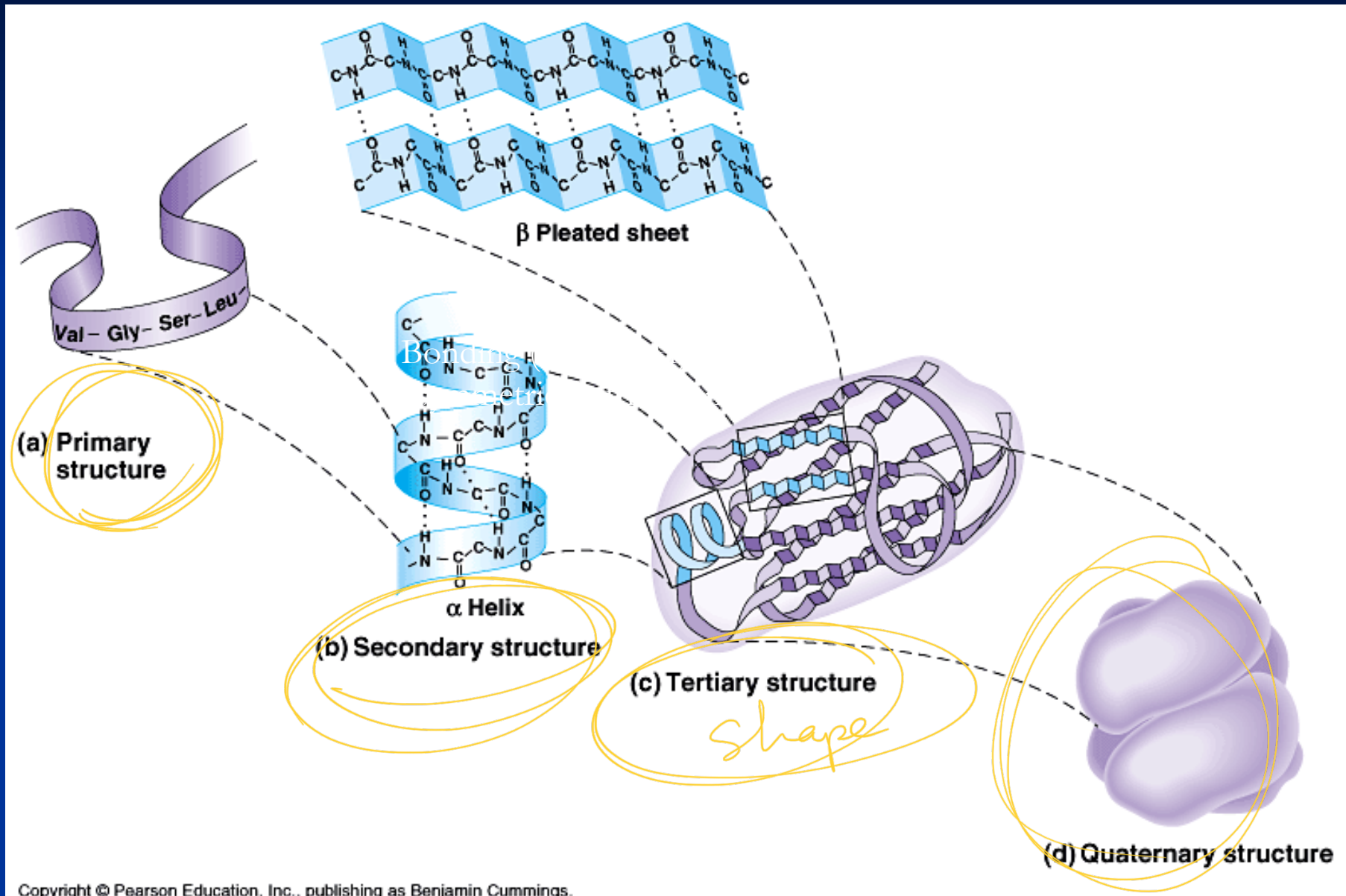
- 2+ **polypeptides** bond together

2 separate strands of amino acids that come together to form one protein





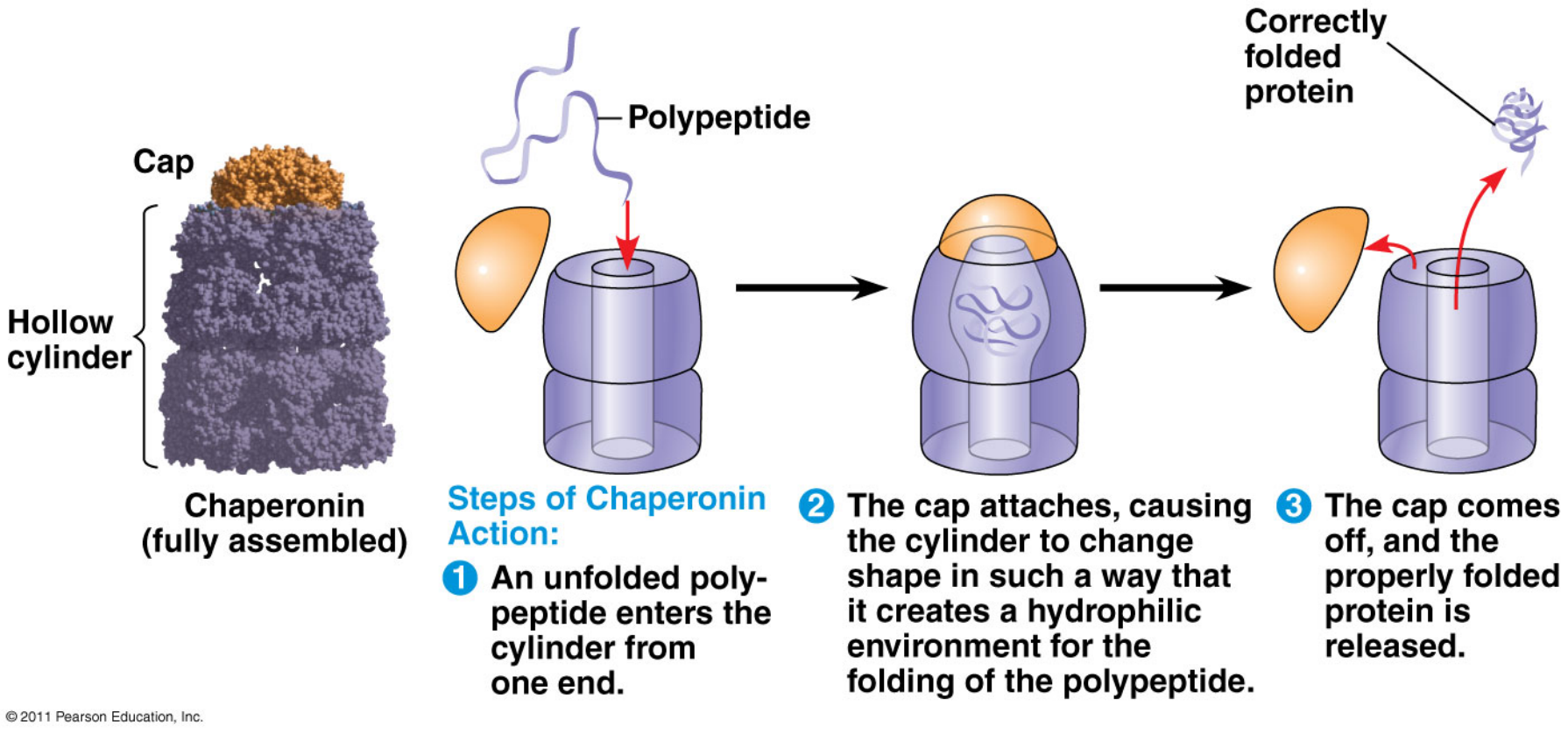
amino acids → polypeptides → protein



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

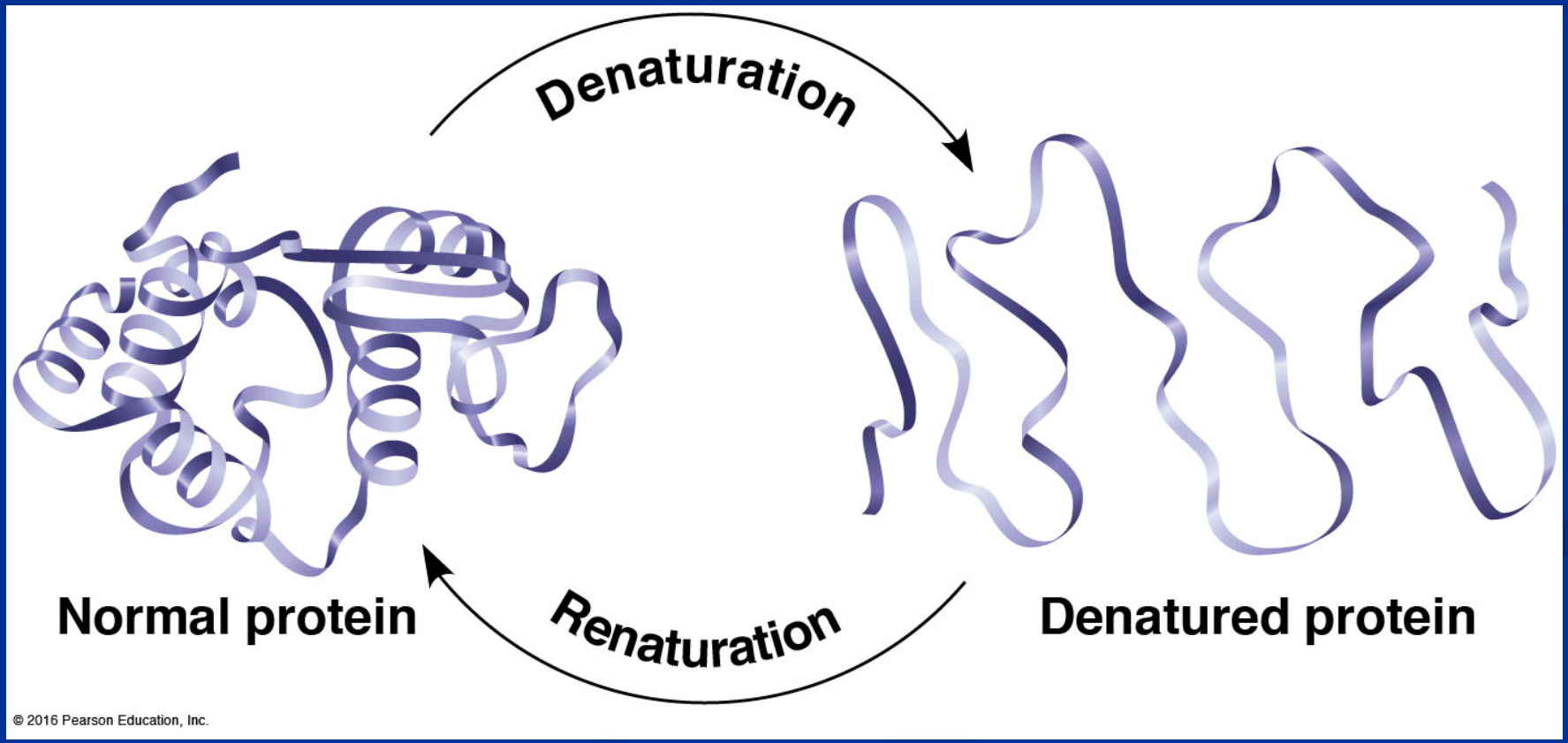
Chaperonins assist in proper folding of proteins

"heat shock proteins"



© 2011 Pearson Education, Inc.

- Protein **structure and function** are sensitive to chemical and physical conditions
- Unfolds or **denatures** if **pH** and **temperature** are not optimal

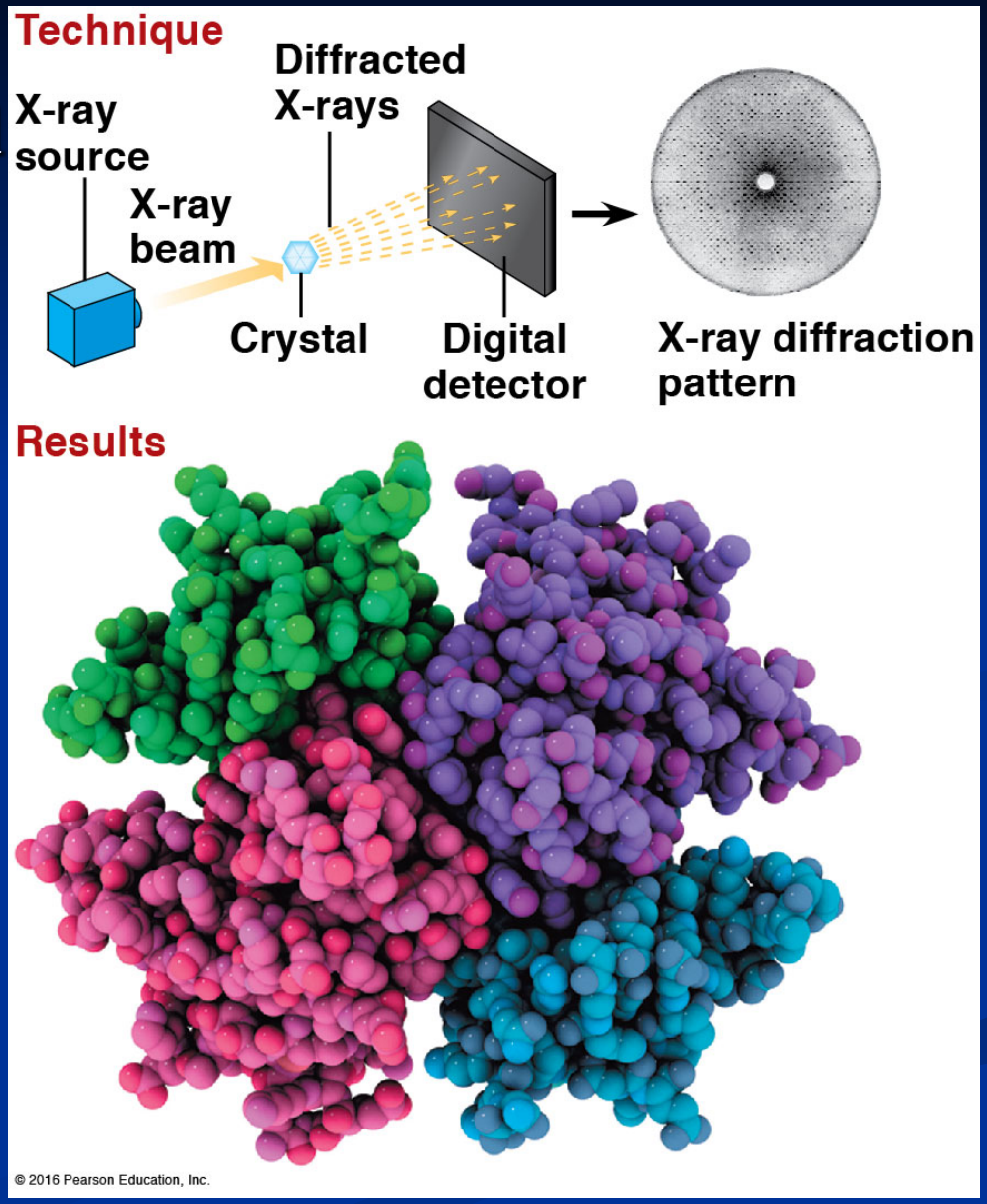


change in primary structure structure = change in function

	Primary Structure	Secondary and Tertiary Structures	Quaternary Structure	Function	Red Blood Cell Shape
Normal	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Glu 7 Glu	Normal β subunit	Normal hemoglobin	Proteins do not associate; each carries oxygen.	Normal red blood cells are full of individual hemoglobin proteins.
Sickle-cell	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Val 7 Glu	Sickle-cell β subunit	Sickle-cell hemoglobin	Hydrophobic interactions between proteins lead to aggregation; oxygen carrying capacity reduced.	Fibers of abnormal hemoglobin deform red blood cell into sickle shape.

© 2016 Pearson Education, Inc.

X-ray crystallography used to determine the 3-D structure of proteins



Genomics: Analysis of genes and genomes