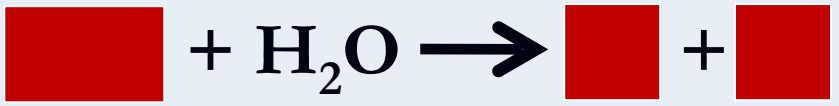
You Must Know

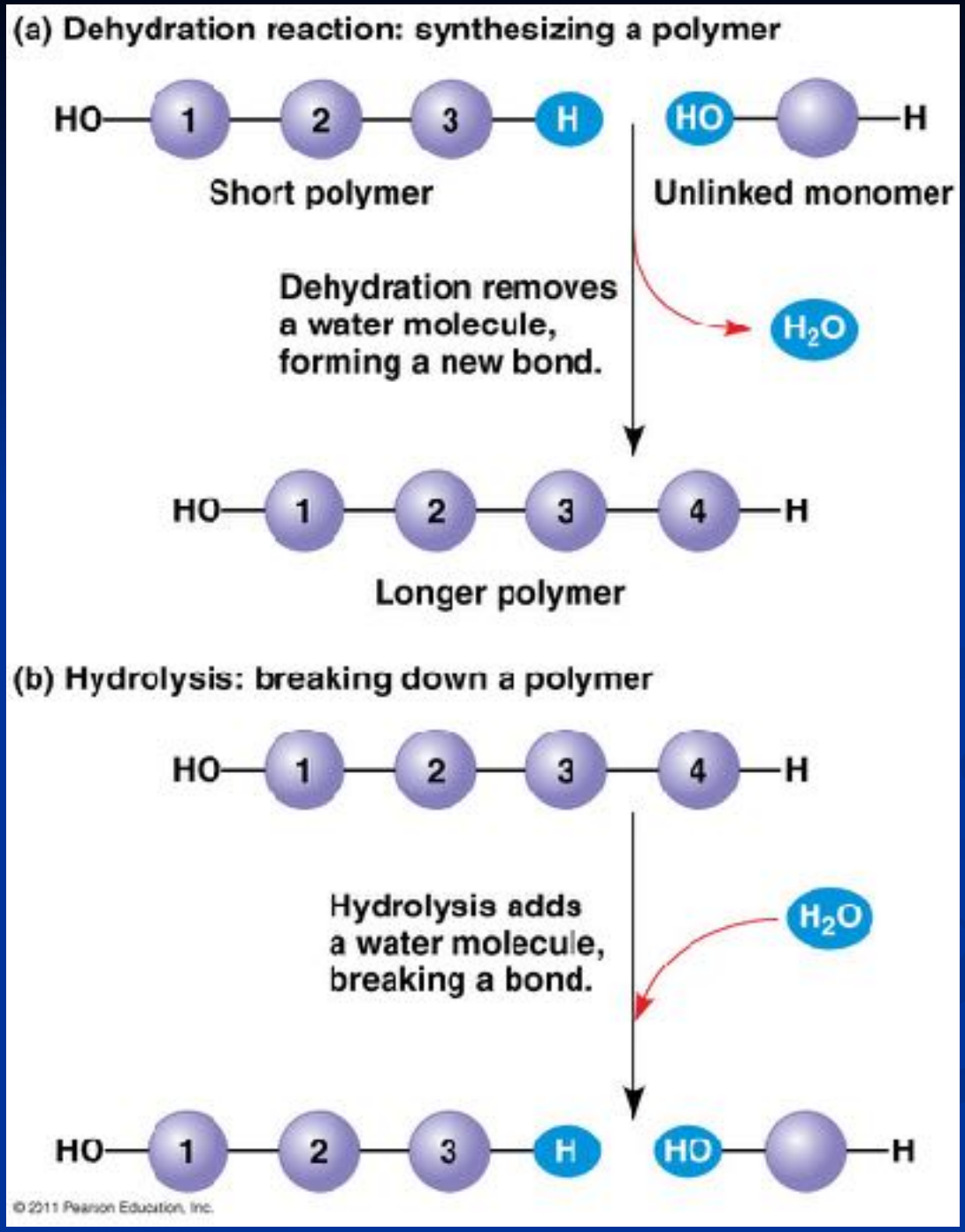
- The role of **dehydration synthesis** in the formation of organic compounds and **hydrolysis** in the digestion of organic compounds.
- How to recognize the 4 biologically important organic compounds (carbs, lipids, proteins, nucleic acids) by their structural formulas.
- The cellular functions of all four organic compounds.
- The 4 structural levels of proteins
- How proteins reach their final shape (**conformation**) and the **denaturing** impact that heat and pH can have on protein structure

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
	


(a) Dehydration reaction: synthesizing a polymer
HO
1
2
3
H
HO
H
Short polymer
Unlinked monomer
Dehydration removes a water molecule, forming a new bond.
H_2O
HO
1
2
3
4
H
Longer polymer
(b) Hydrolysis: breaking down a polymer
HO
1
2
3
4
H
Hydrolysis adds a water molecule, breaking a bond.
H_2O
HO
1
2
3
H
HO
H
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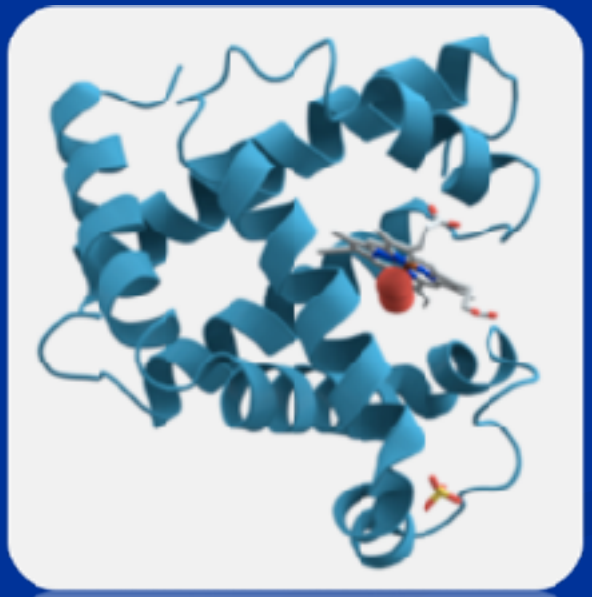
I. Proteins

- 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

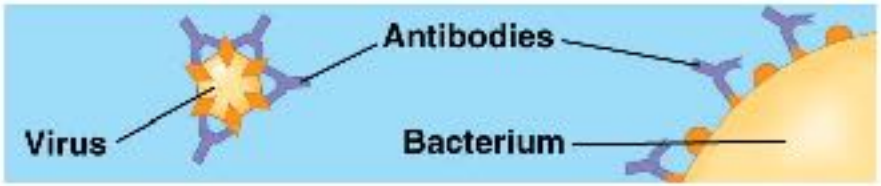
Function: Selective acceleration of chemical reactions

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

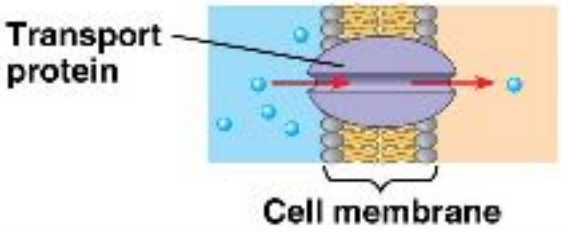
Function: Storage of amino acids

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 cell membranes.



Overview of protein functions

Hormonal proteins

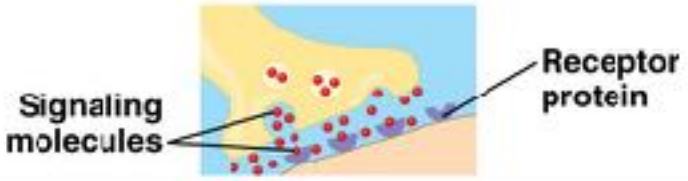
Function: Coordination of an organism's activities

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

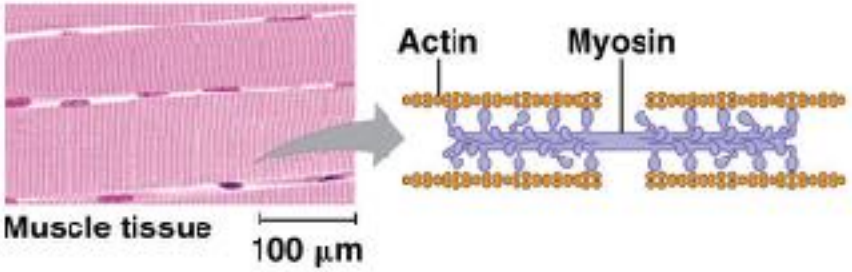
Example: Receptors built into the membrane of a nerve cell detect signaling molecules released by other nerve cells.



Contractile and motor proteins

Function: Movement

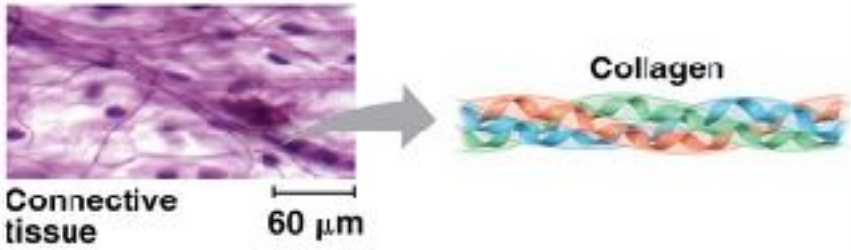
Examples: Motor proteins are responsible for the undulations of cilia and flagella. Actin and myosin proteins are responsible for the contraction of muscles.



Structural proteins

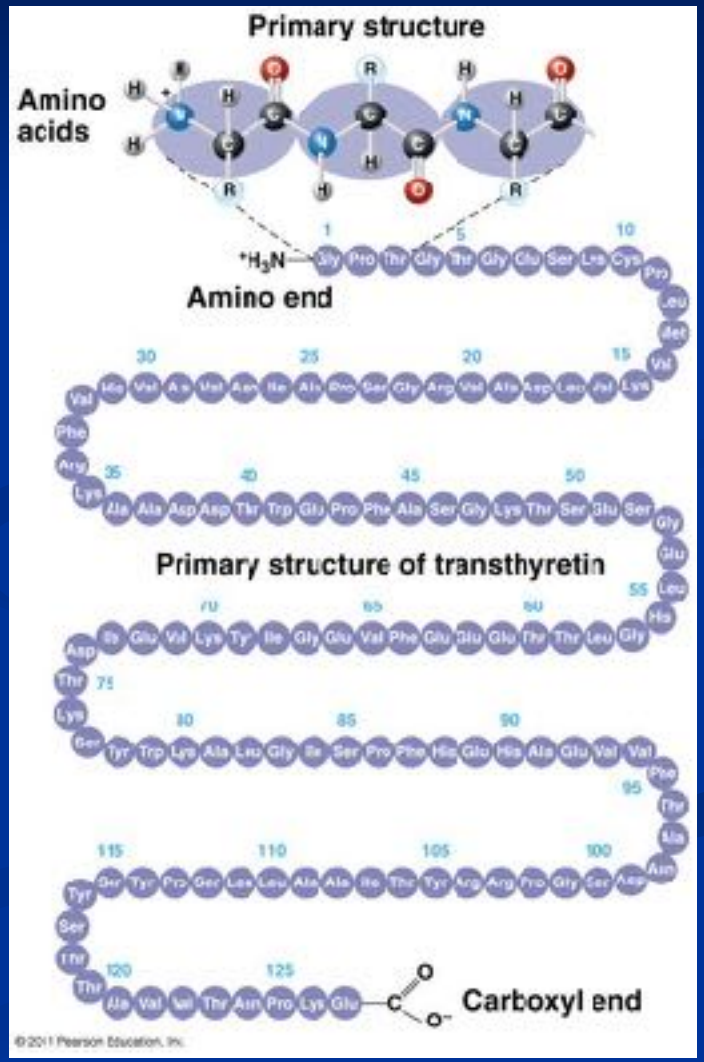
Function: Support

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.



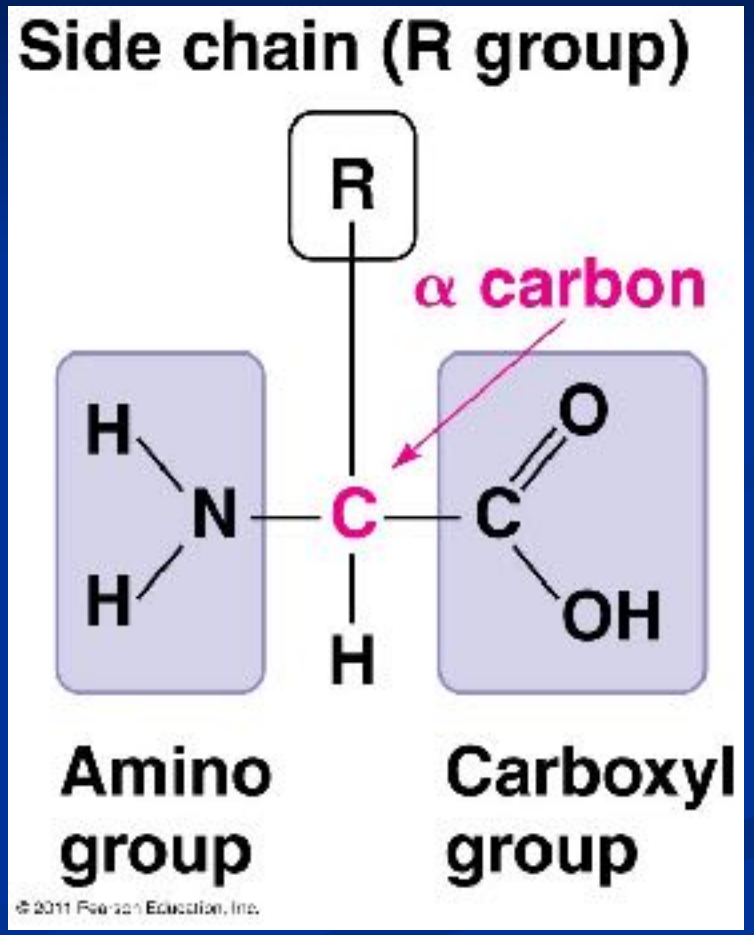
Four Levels of Protein Structure

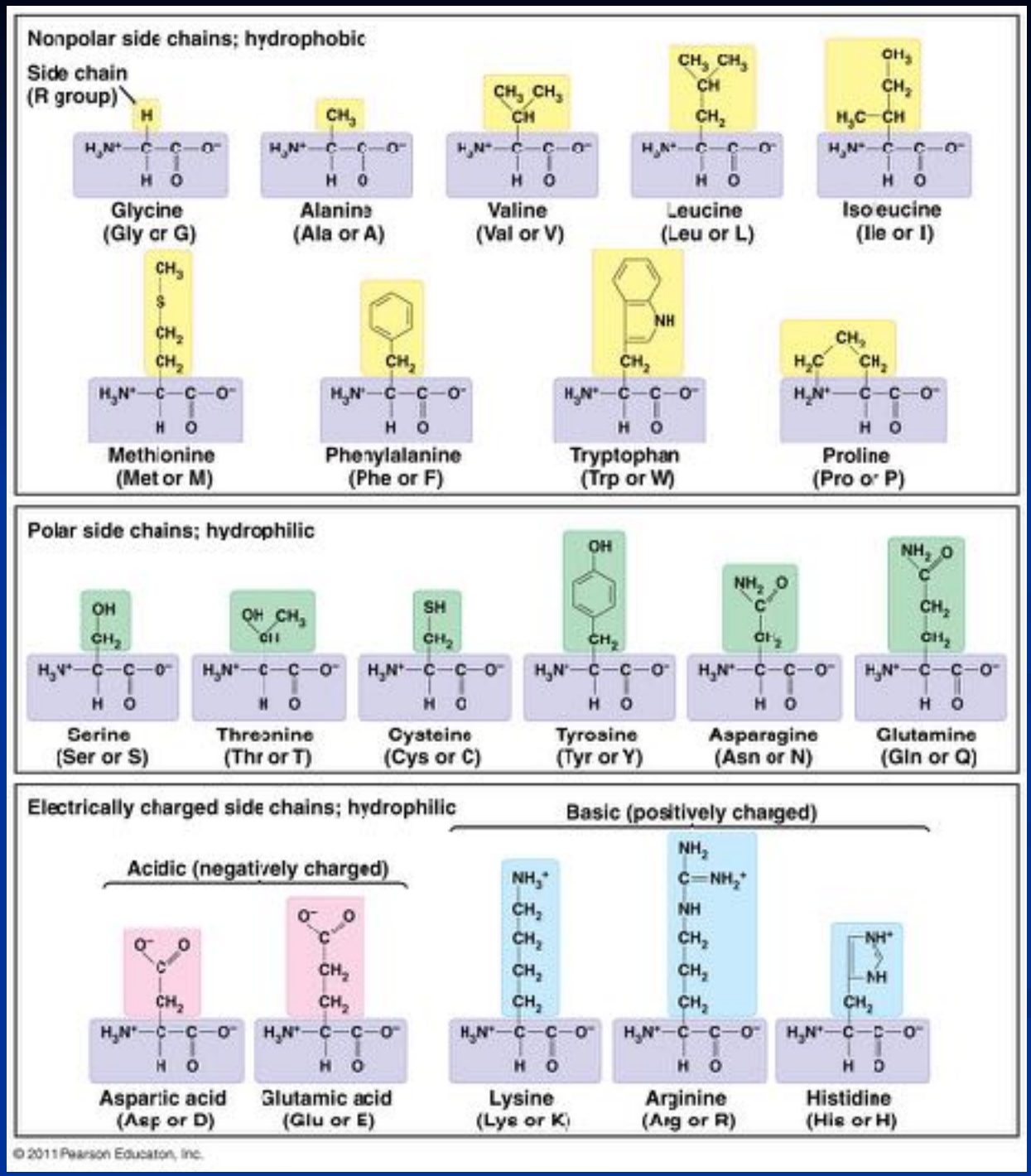
1. **Primary**
   - **Amino acid** (AA) sequence
   - 20 different AA's
   - **peptide bonds** link AA's

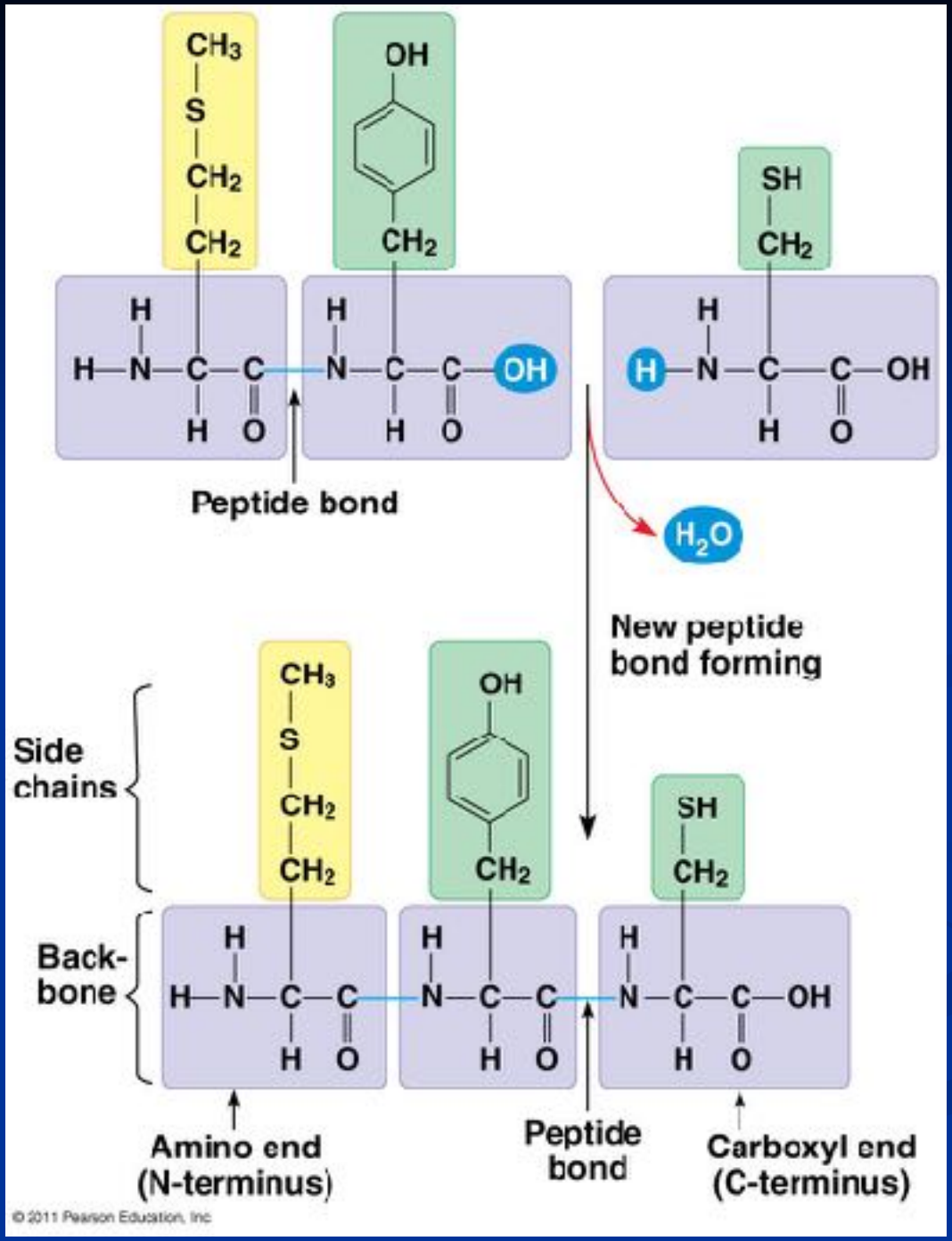


Amino Acid

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

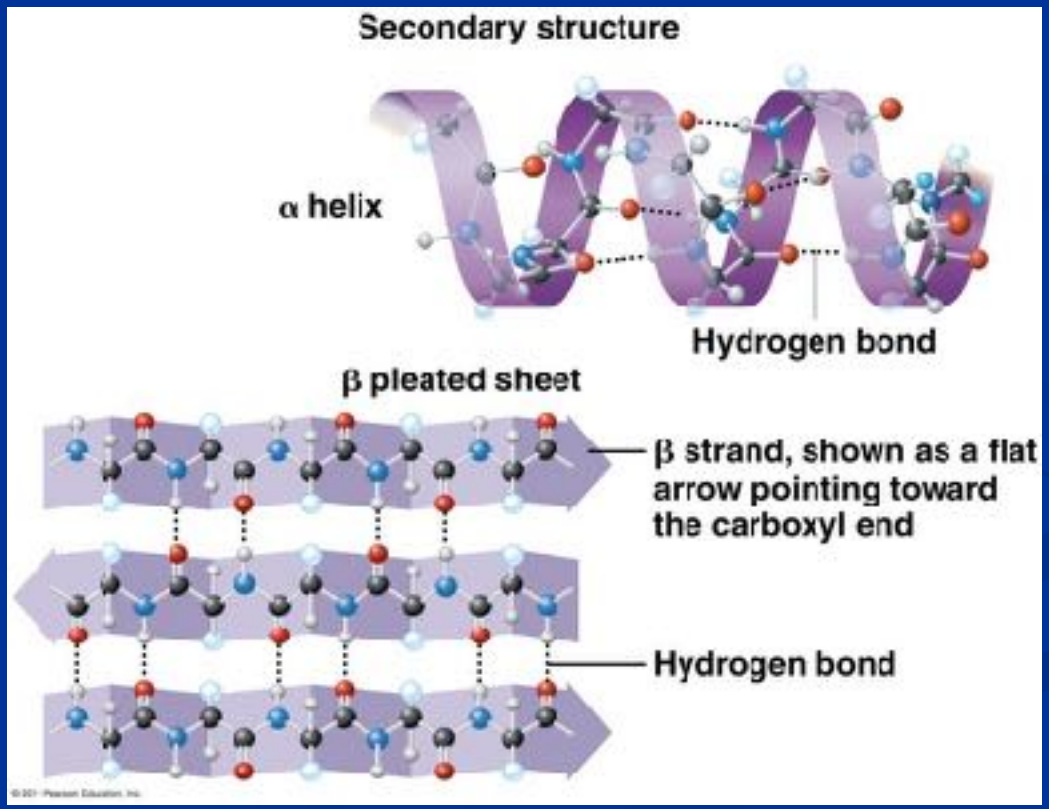





Peptide bond
H_2O
New peptide bond forming
Side chains
Back-bone
Amino end (N-terminus)
Peptide bond
Carboxyl end (C-terminus)
© 2011 Pearson Education, Inc.

Four Levels of Protein Structure (continued)

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

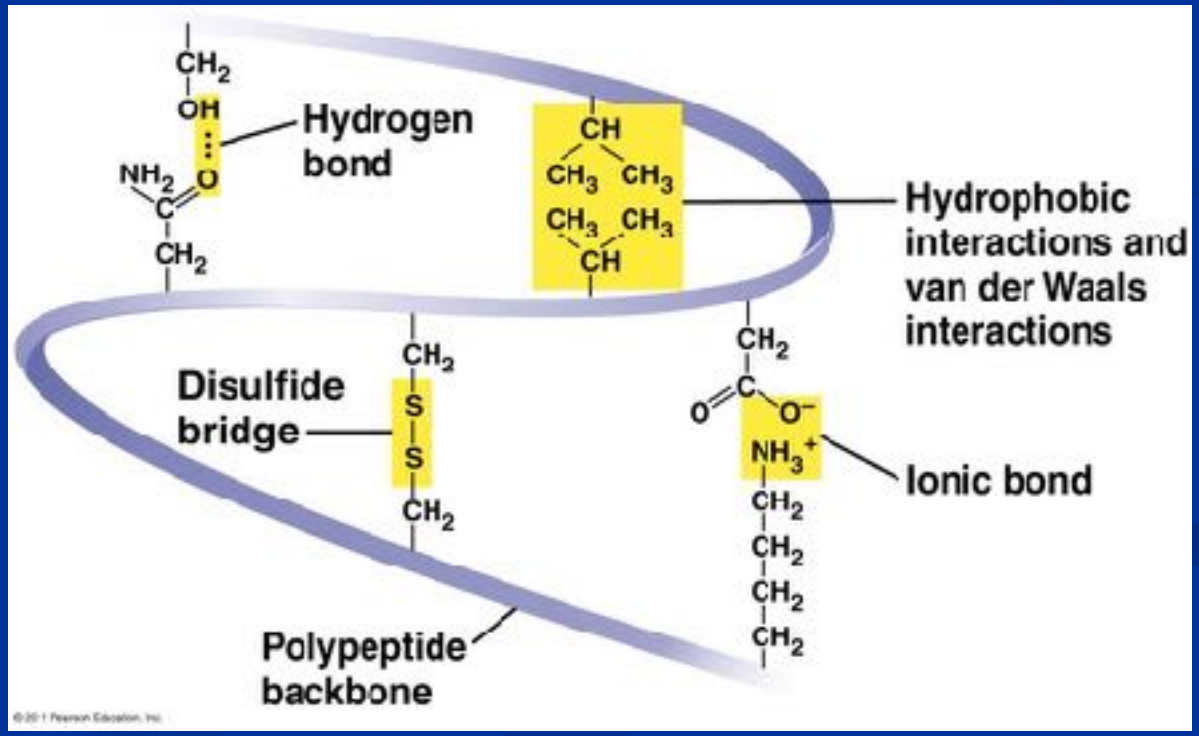


Basic Principles of Protein Folding

A. Hydrophobic AA buried in interior of protein (hydrophobic interactions)
B. Hydrophilic AA exposed on surface of protein (hydrogen bonds)
C. Cysteines can form disulfide bonds.

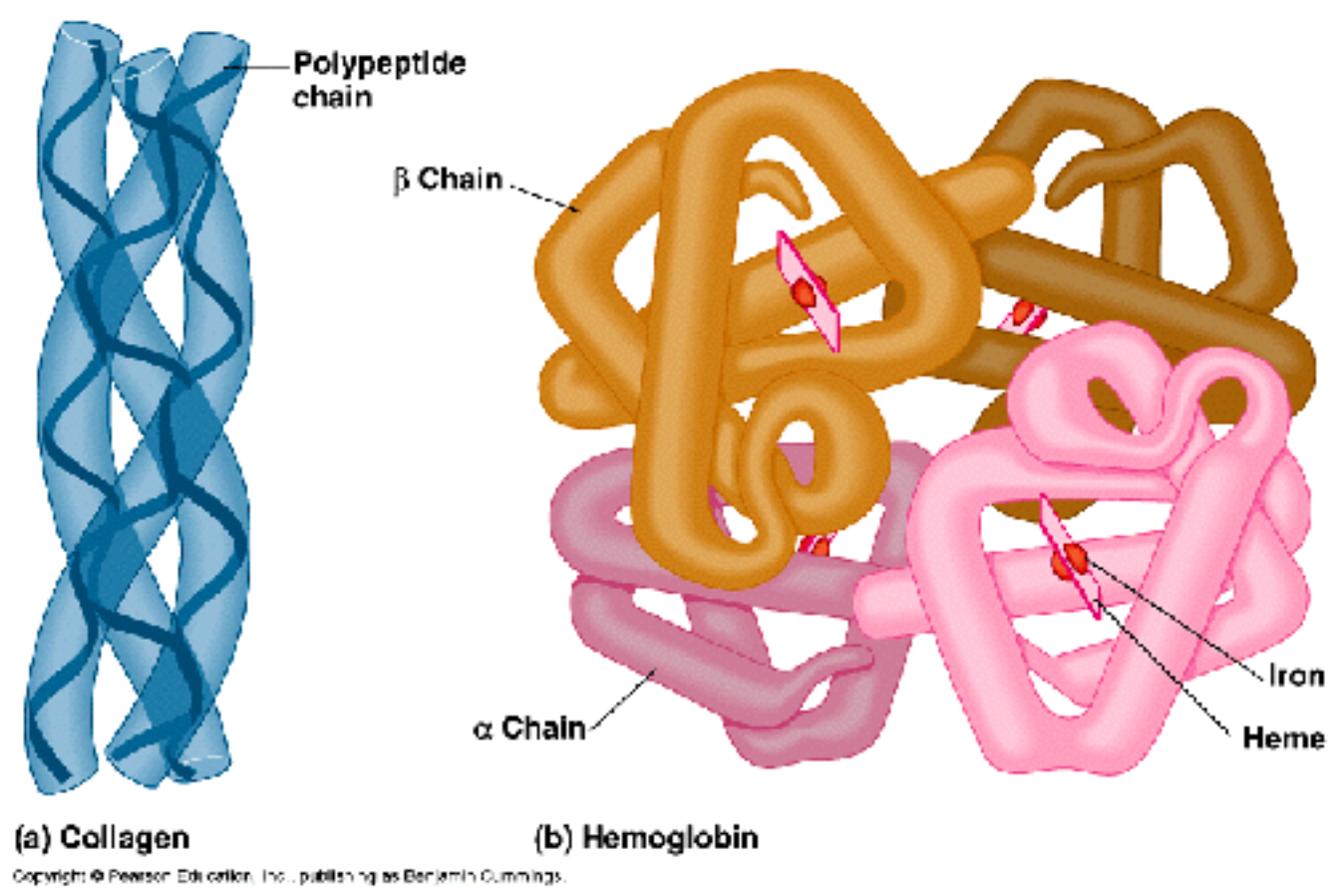
Four Levels of Protein Structure (continued)

3. **Tertiary**
   - Bonding between **side chains** (R groups) of amino acids
   - H bonds, ionic bonds, disulfide bridges, van der Waals interactions

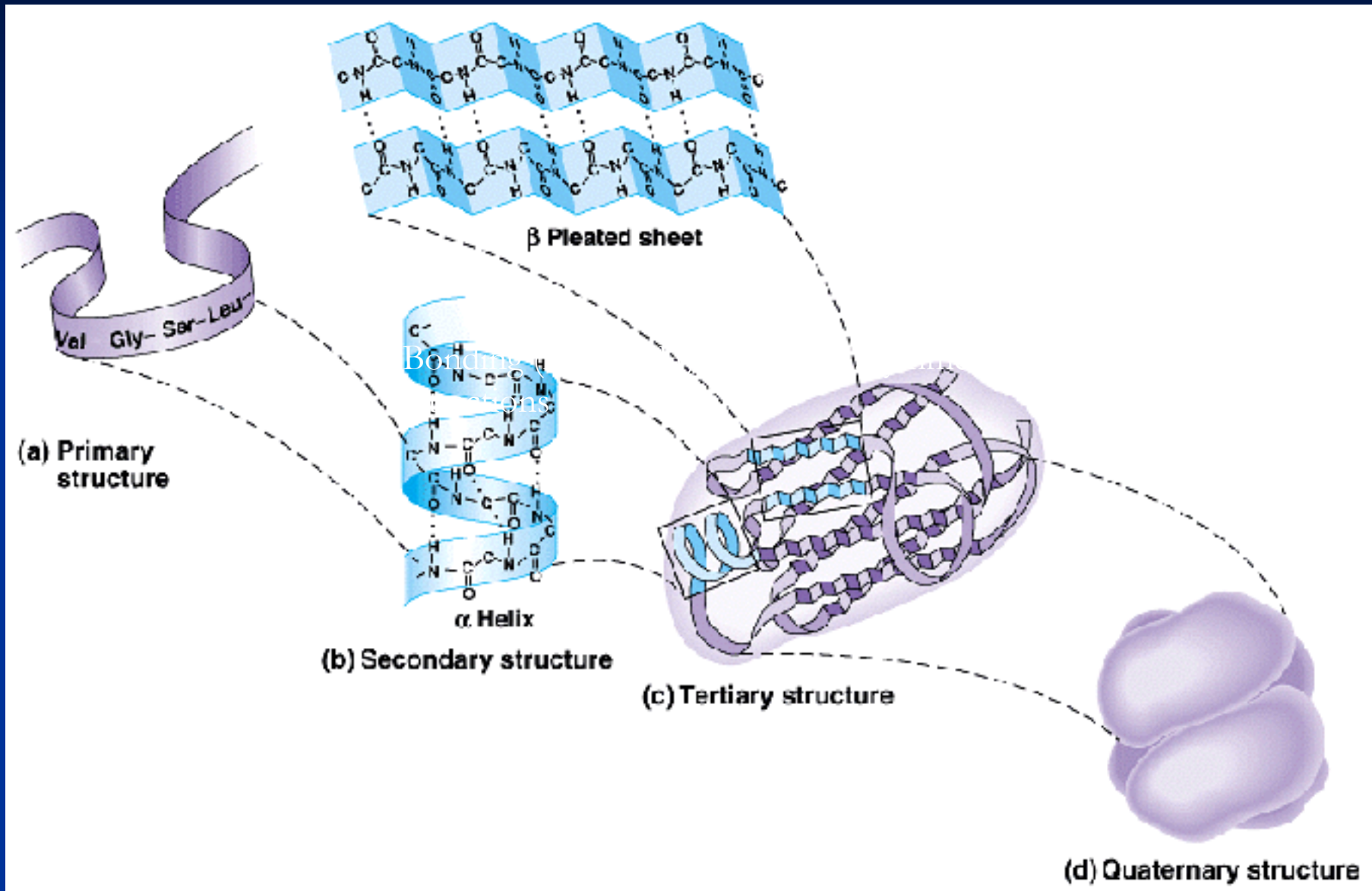


Four Levels of Protein Structure (continued)

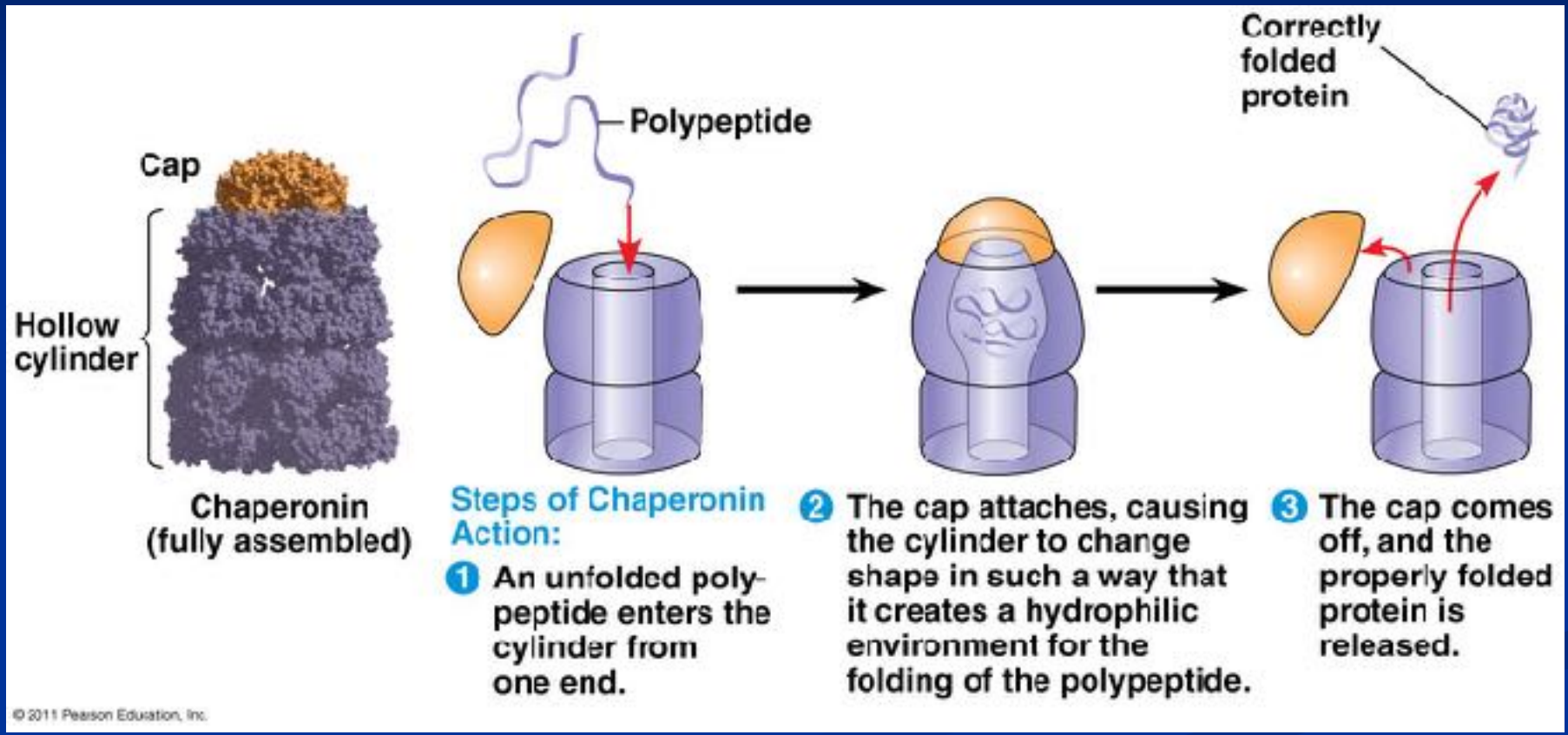
4. **Quaternary**
   - **2+ polypeptides** bond together



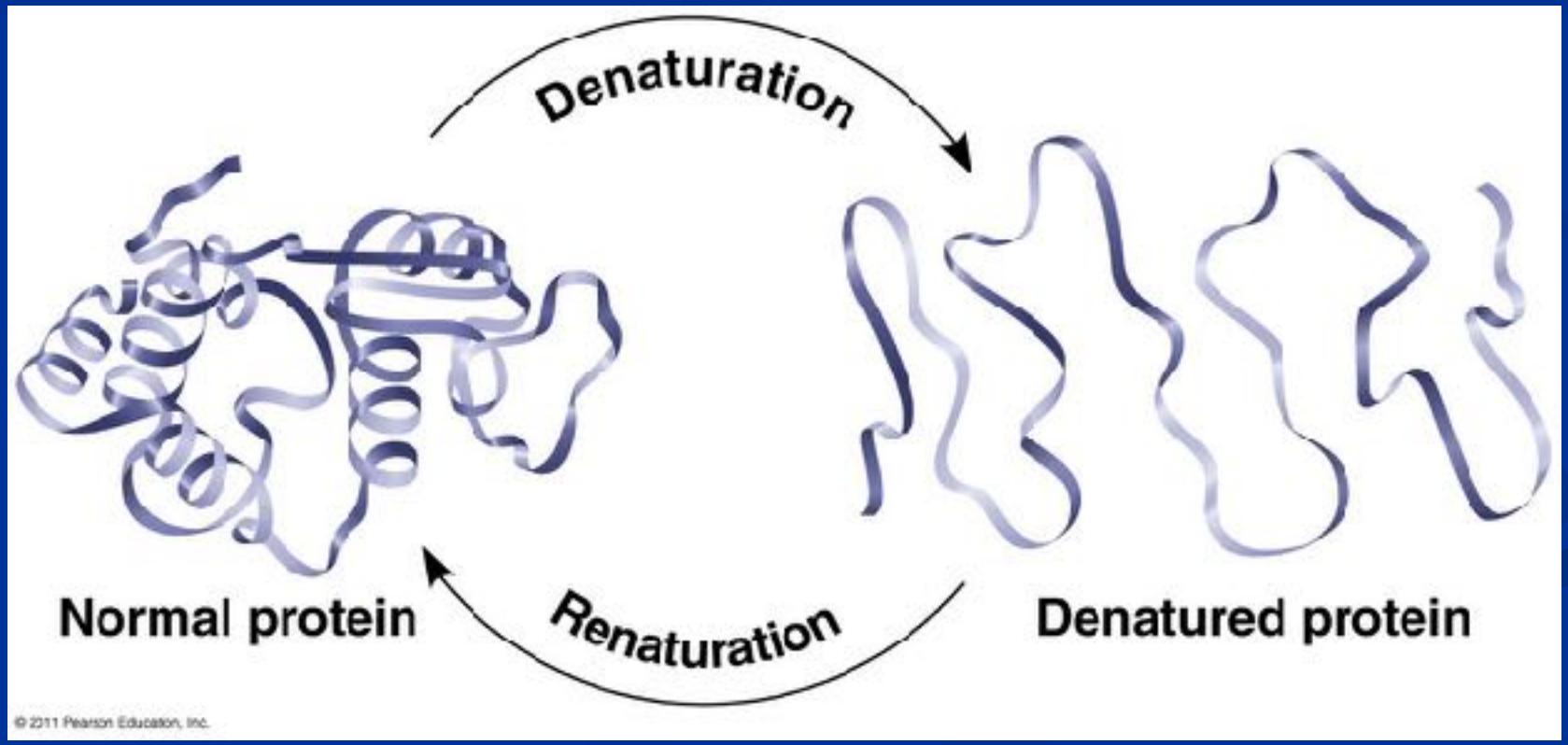
amino acids → polypeptides → protein



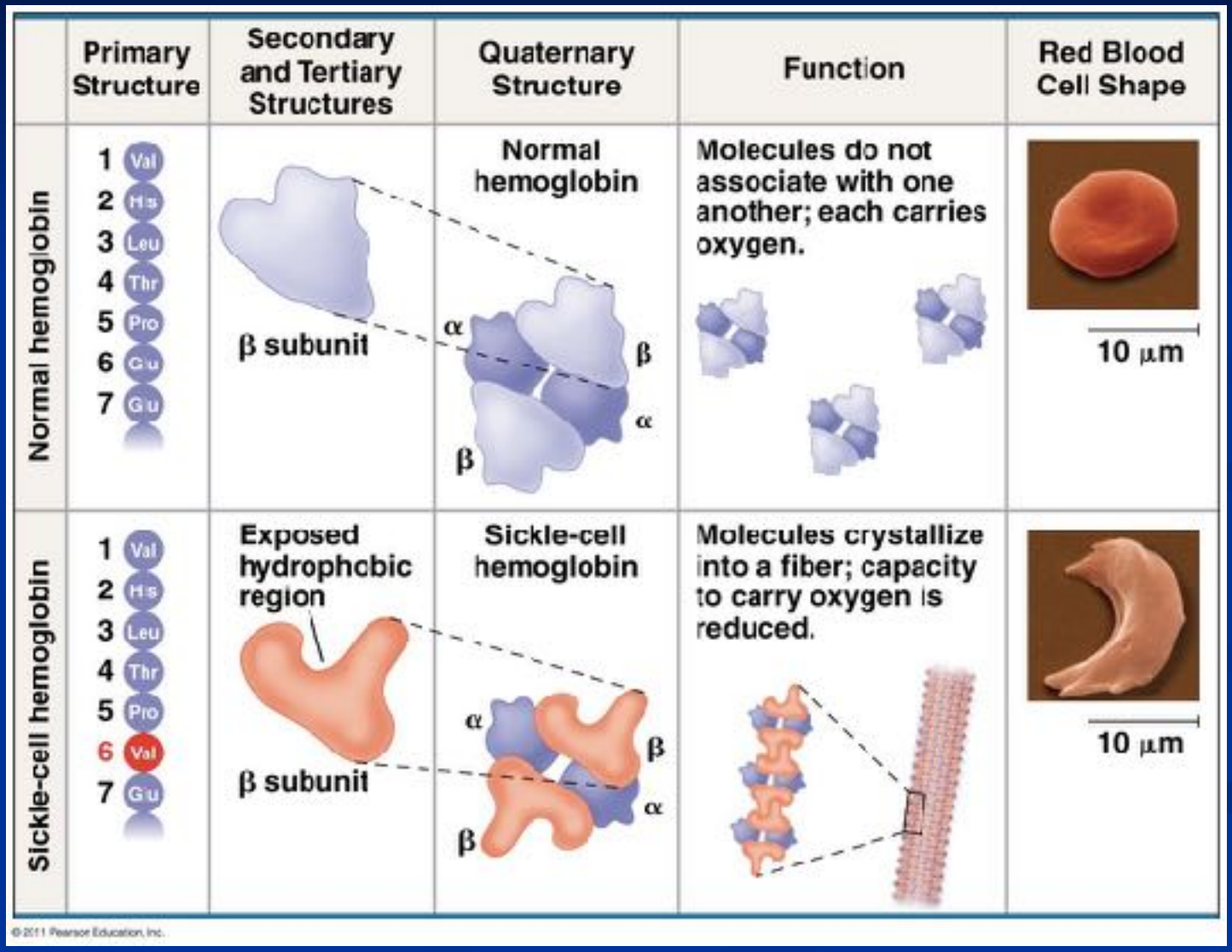
Chaperonins assist in proper folding of proteins



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



change in structure = change in function



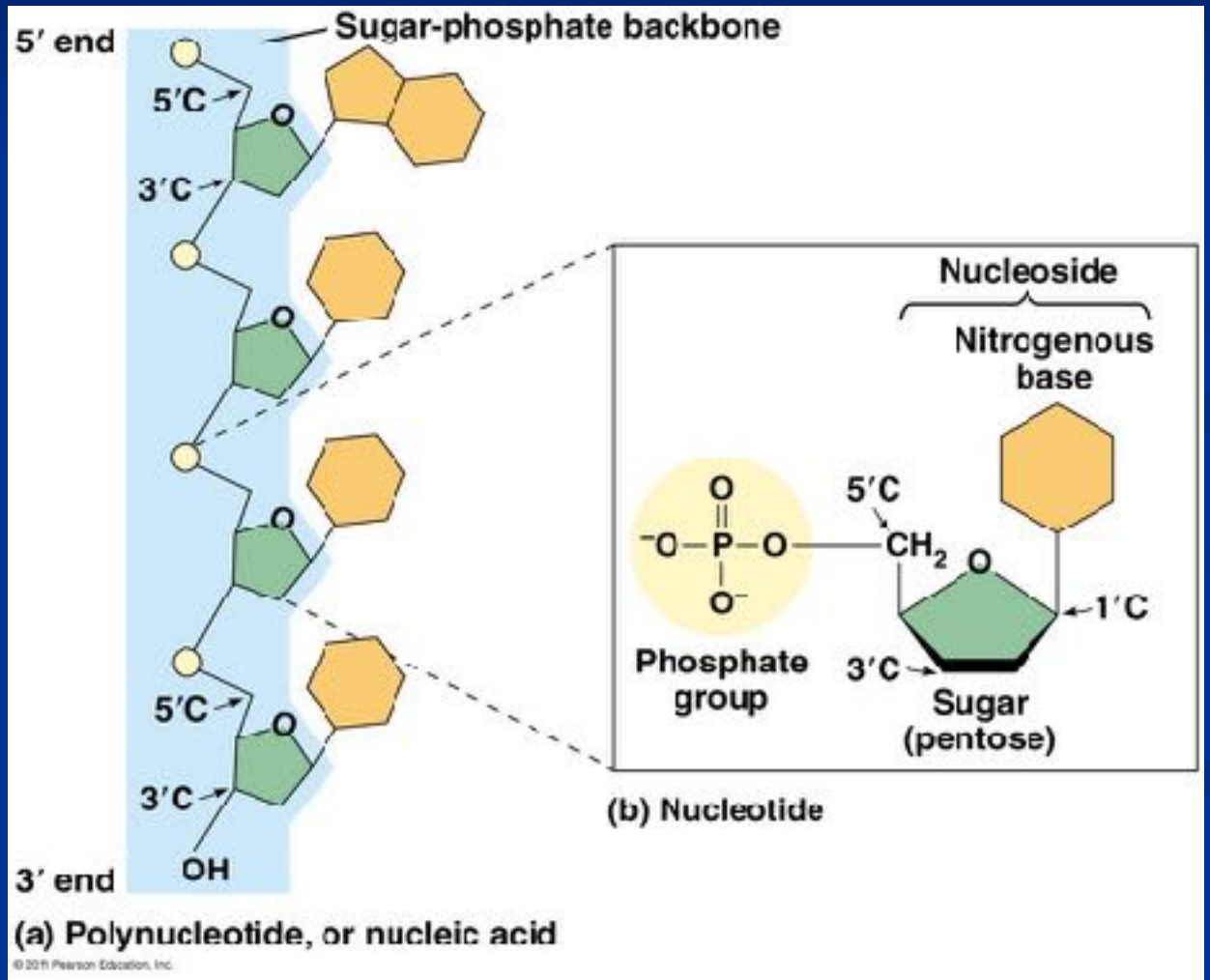
II. Nucleic Acids

Function: store hereditary info

DNA	RNA
• Double-stranded helix • N-bases: A, G, C, *Thymine* • Stores hereditary info • Longer/larger • Sugar: deoxyribose	• Single-stranded • N-bases: A, G, C, *Uracil* • Carry info from DNA to ribosomes • tRNA, rRNA, mRNA, RNAi • Sugar: ribose

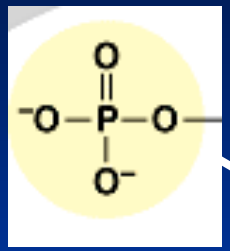
Nucleotides: monomer of DNA/RNA

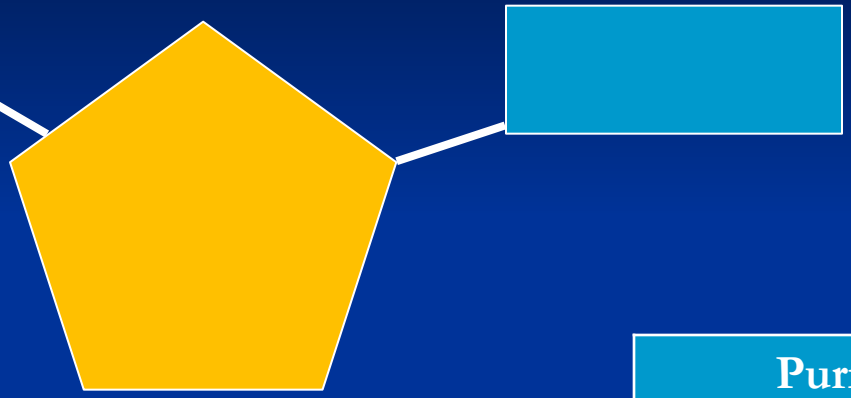
Nucleotide = Sugar + Phosphate + Nitrogen Base



Nucleotide

phosphate

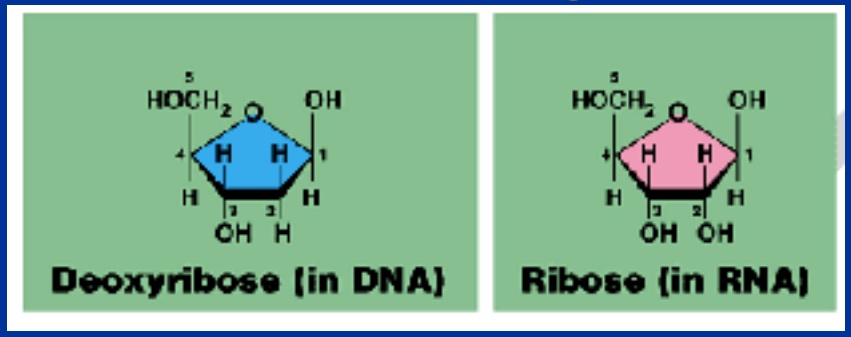




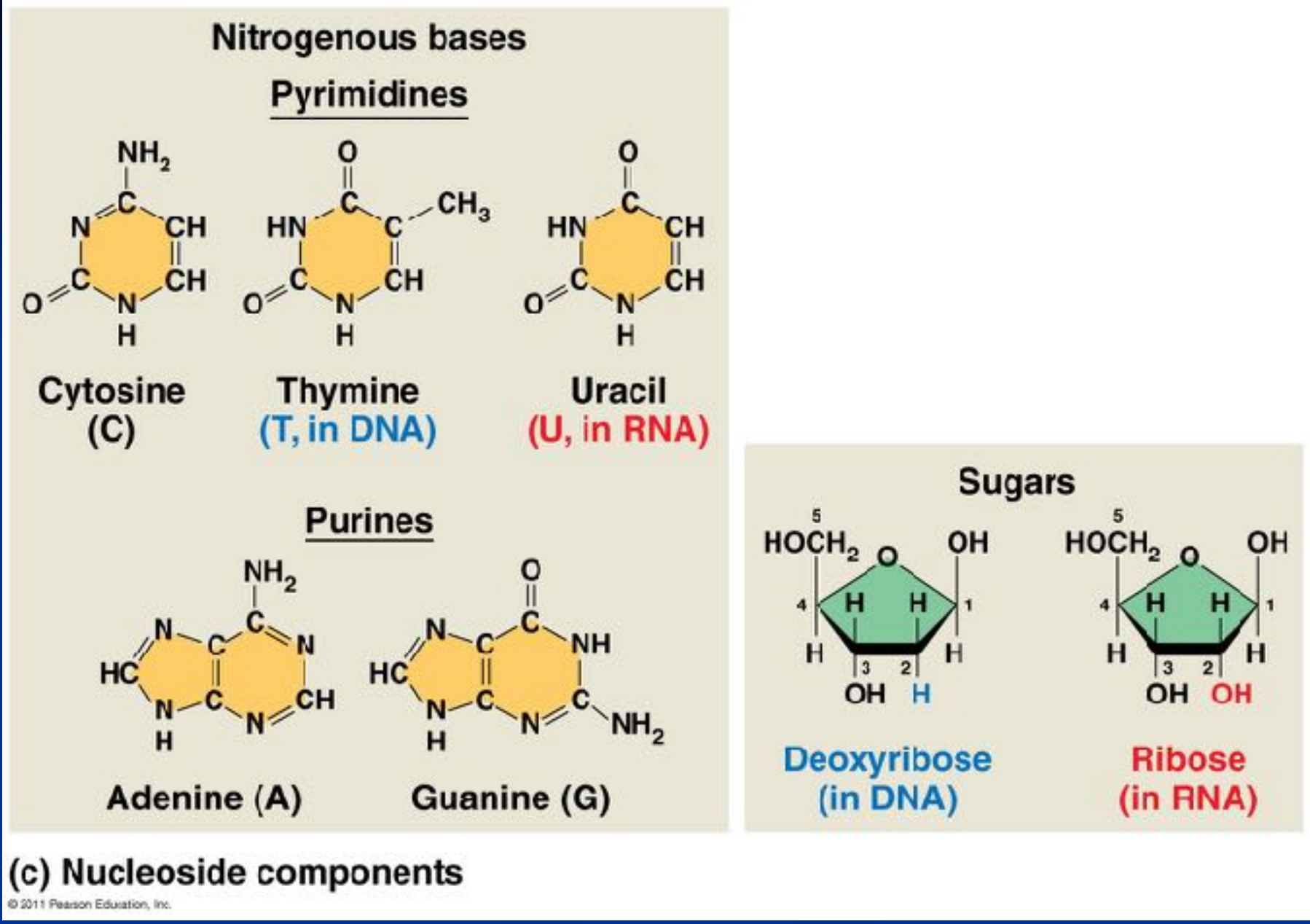
Nitrogen base

A – T
G – C

5-C sugar

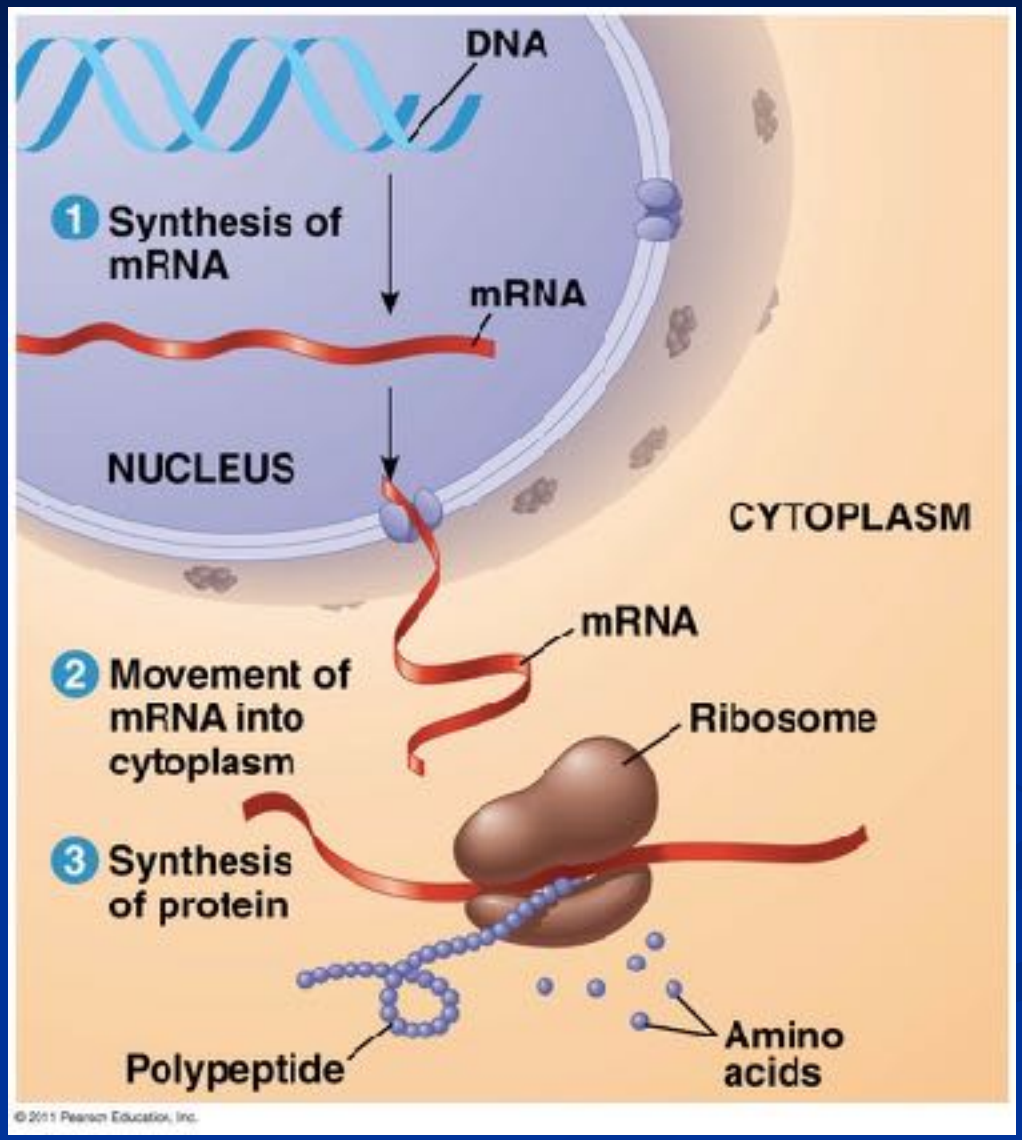


Purines	Pyrimidines
•Adenine •Guanine	•Cytosine •Thymine (DNA) •Uracil (RNA)
•Double ring	•Single ring



(c) Nucleoside components

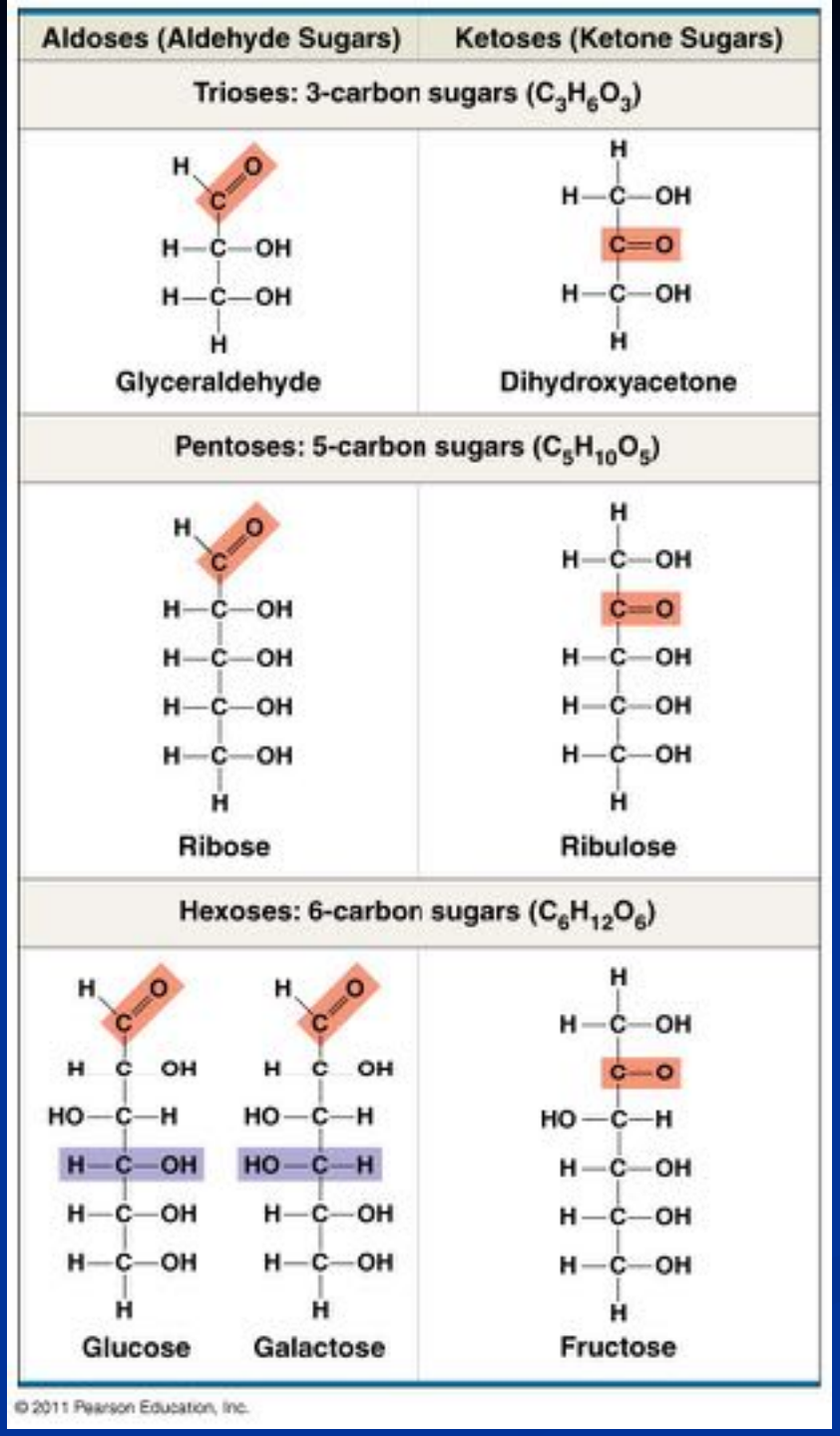
Information flow in a cell: DNA → RNA → protein



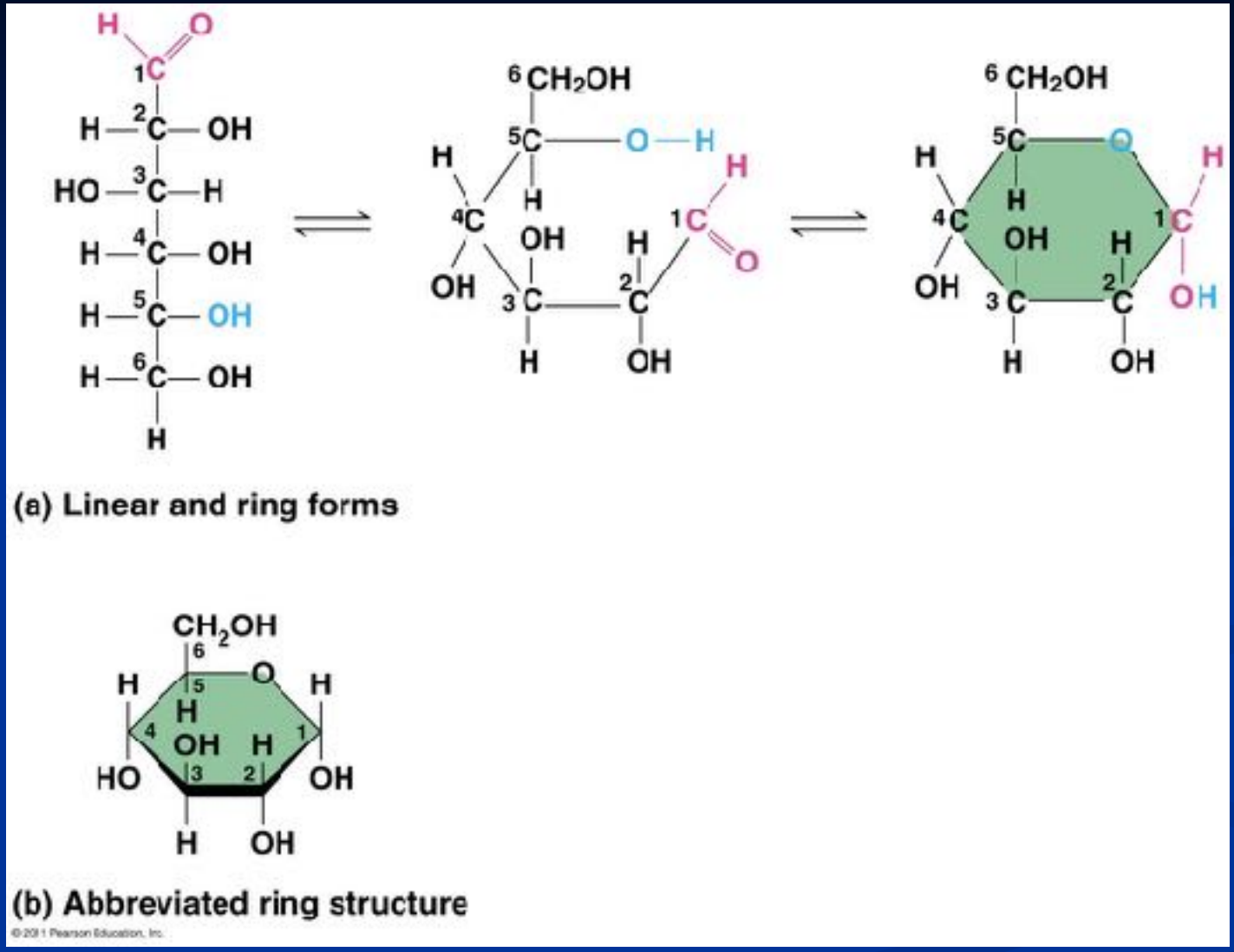
III. Carbohydrates

- **Fuel** and **building material**
- Include simple sugars (fructose) and polymers (starch)
- Ratio of 1 carbon: 2 hydrogen: 1 oxygen or CH_2O
- monosaccharide → disaccharide → polysaccharide
- Monosaccharides = monomers (eg. glucose, ribose)
- Polysaccharides:
  - Storage (plants-starch, animals-glycogen)
  - Structure (plant-cellulose, arthropod-chitin)

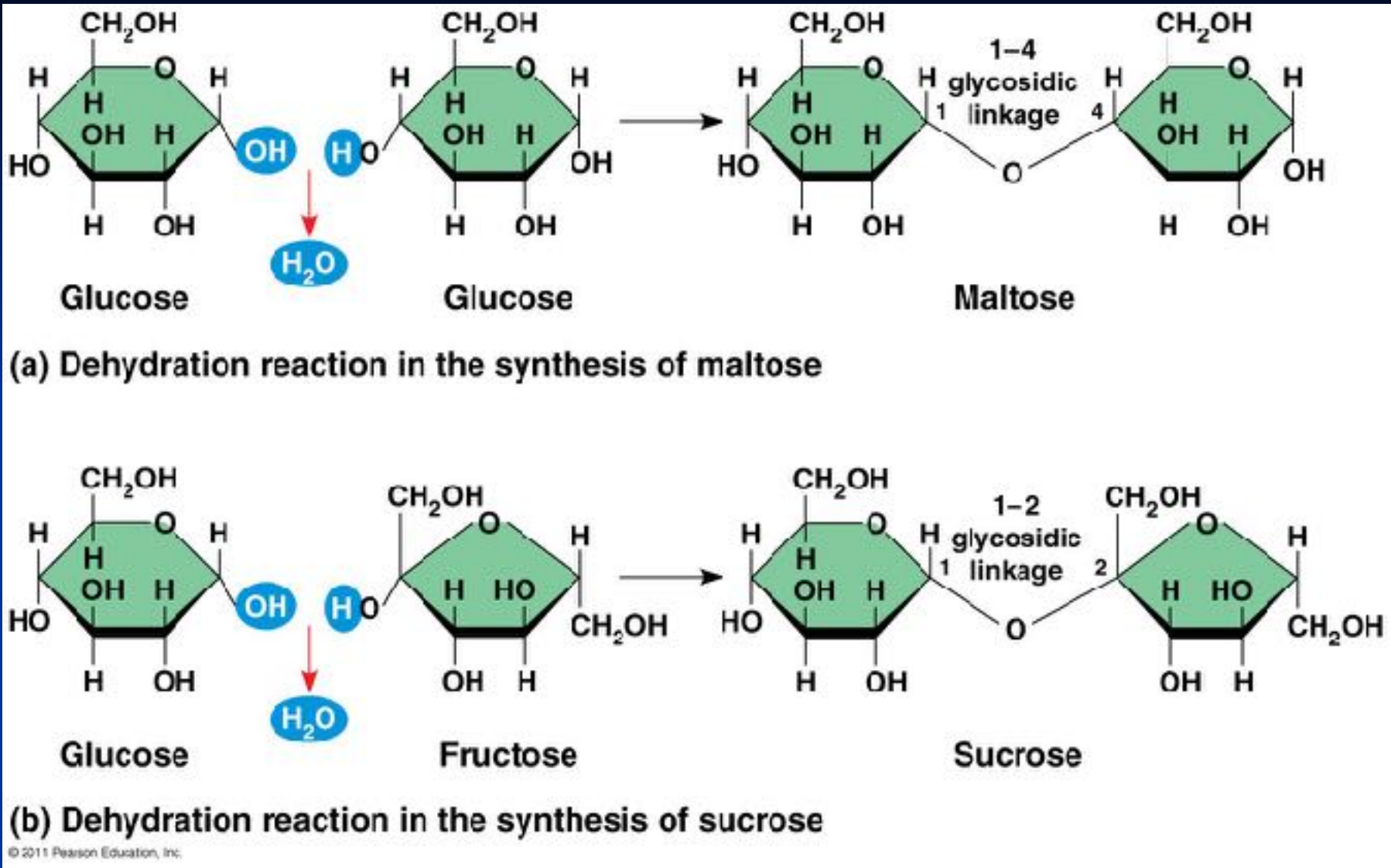
} Differ in position & orientation of glycosidic linkage



The structure and classification of some monosaccharides



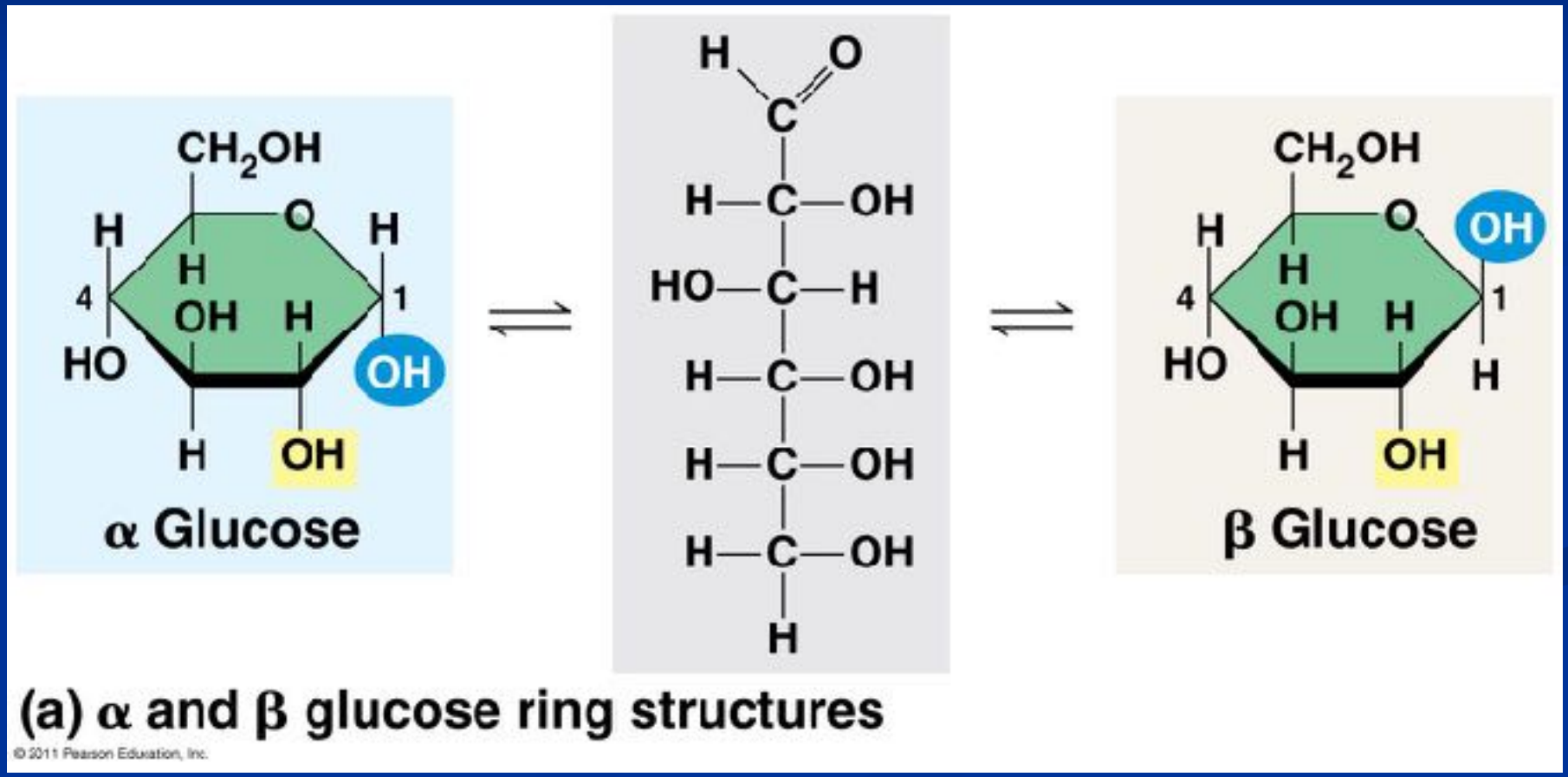
Linear and ring forms of glucose



Carbohydrate synthesis

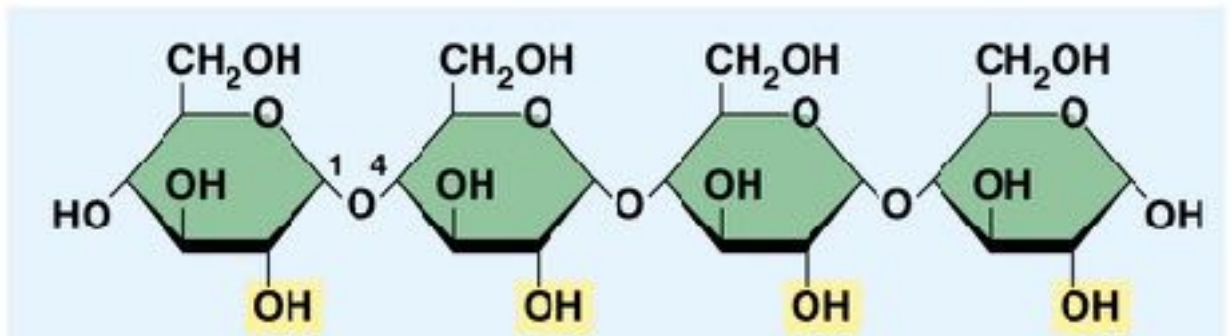
Cellulose vs. Starch

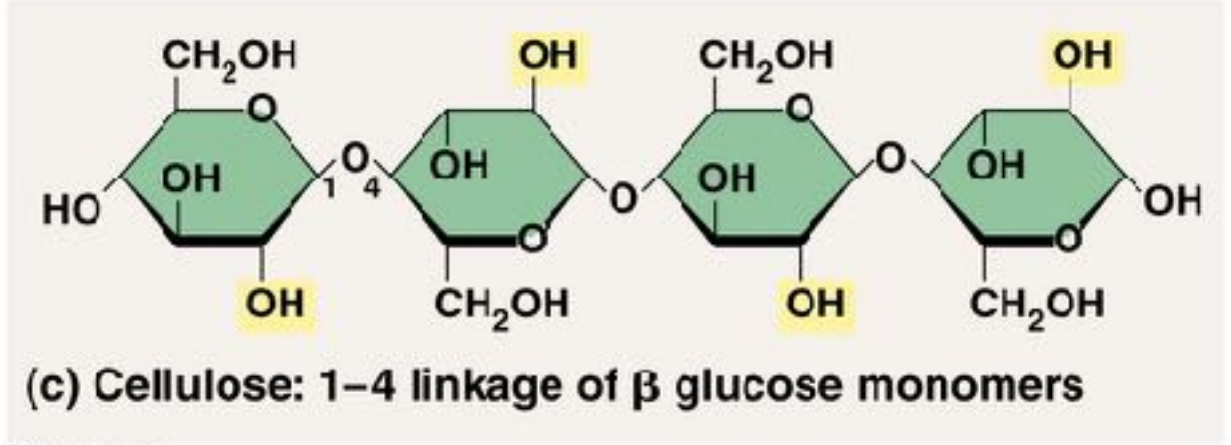
Two Forms of Glucose: α glucose & β glucose

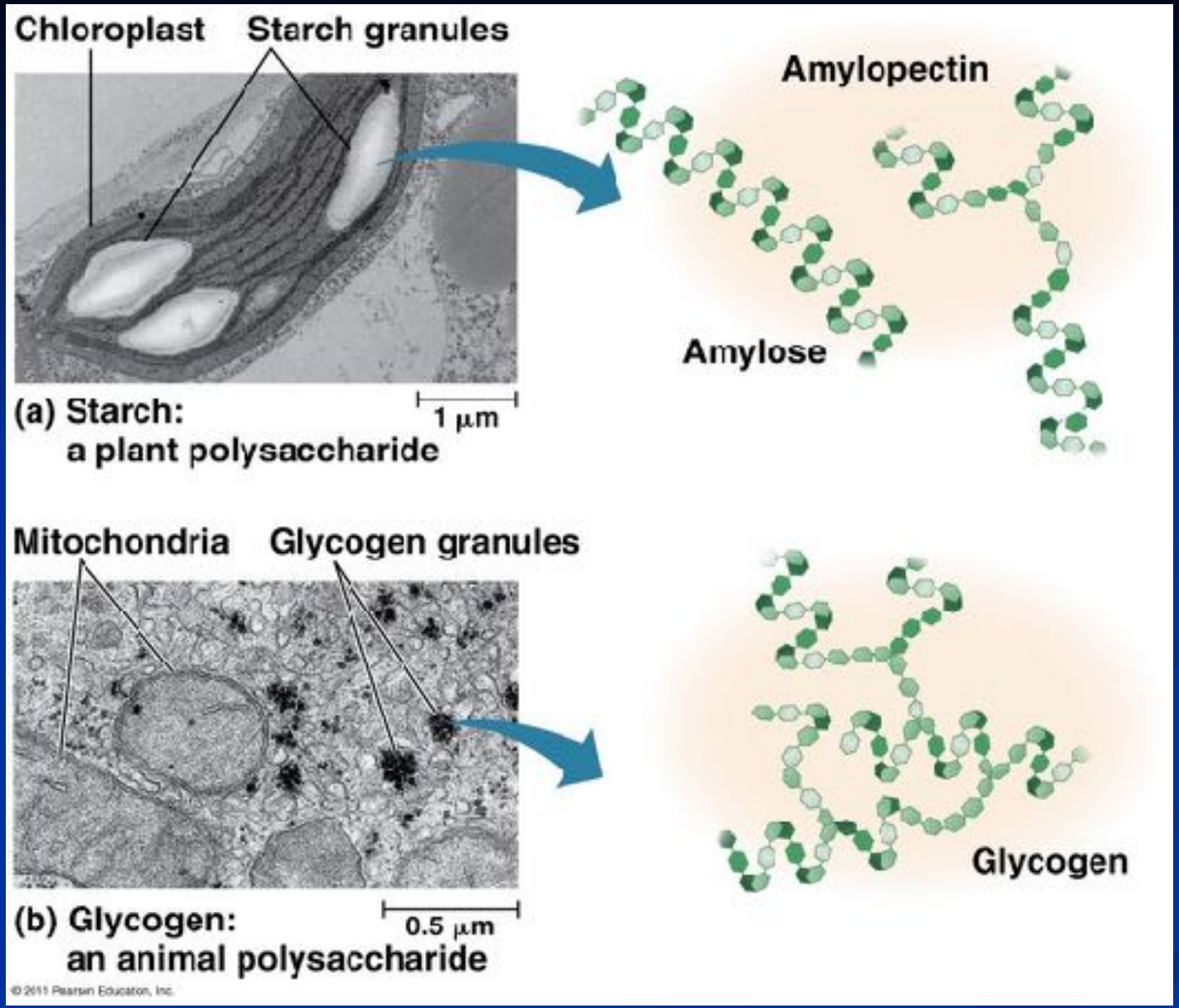


Cellulose vs. Starch

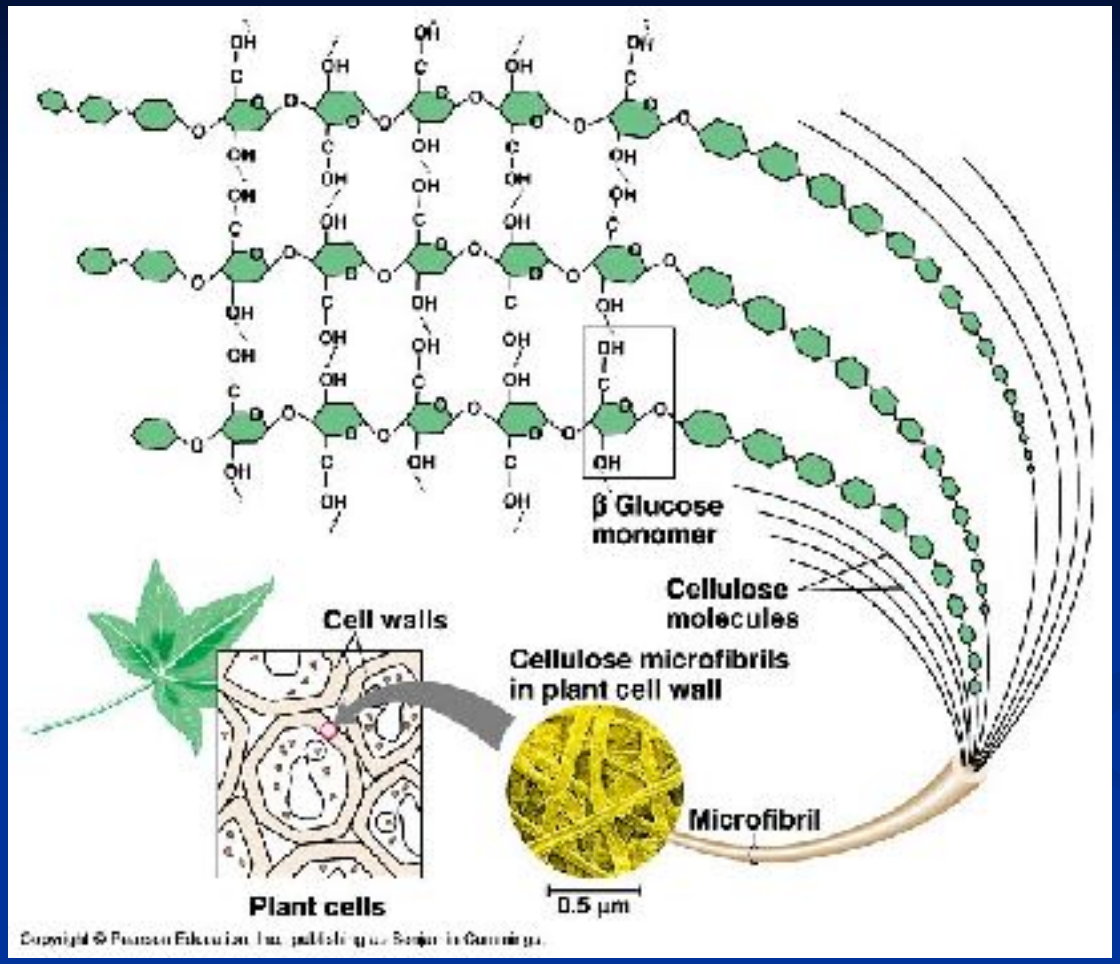
- Starch = α glucose monomers
- Cellulose = β glucose monomers







Storage polysaccharides of plants (starch) and animals (glycogen)



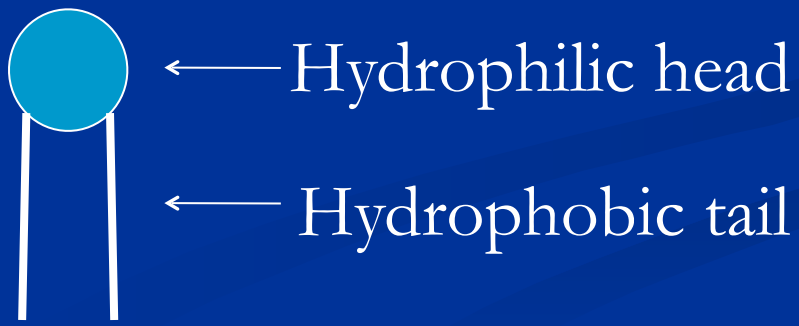
Structural polysaccharides: cellulose & chitin (exoskeleton)

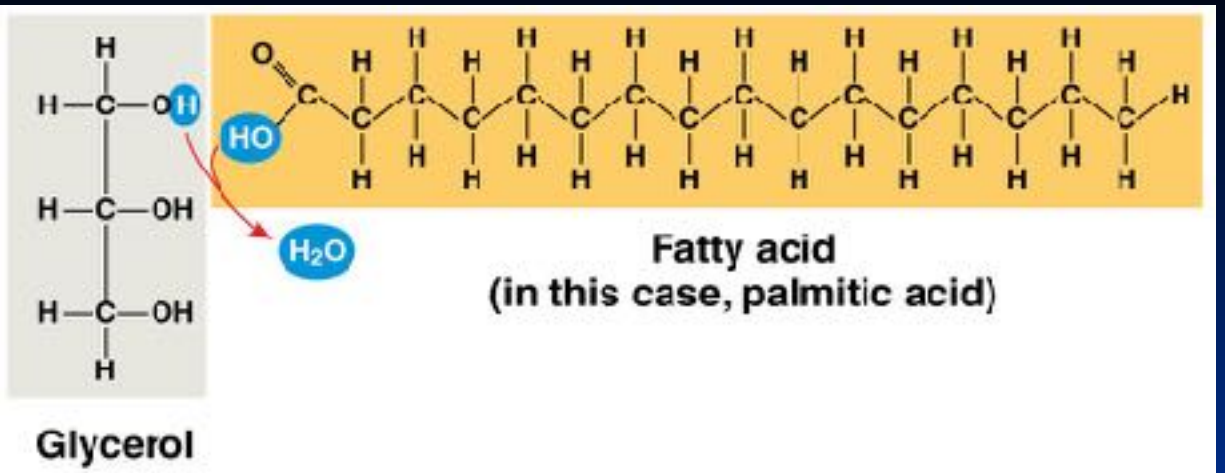
II. Lipids

A. **Fats (triglyceride):** store energy
   - Glycerol + 3 Fatty Acids
   - saturated, unsaturated, polyunsaturated

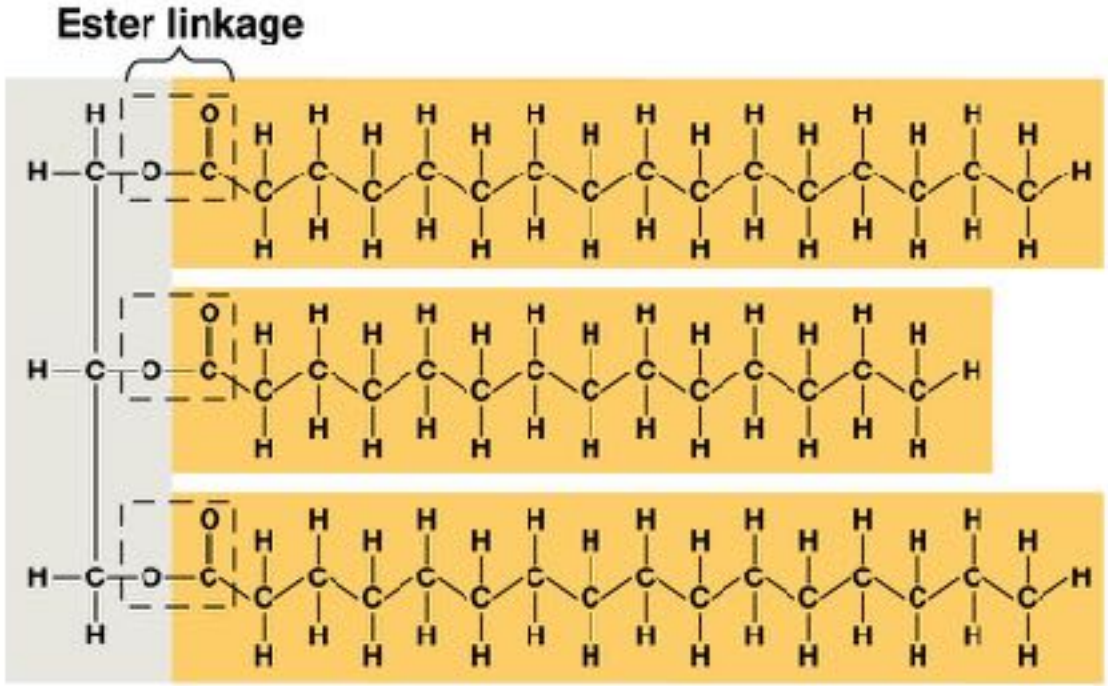
B. **Steroids**: cholesterol and hormones

C. **Phospholipids:** lipid bilayer of cell membrane
   - **<u>hydrophilic head</u>**, **<u>hydrophobic tails</u>**

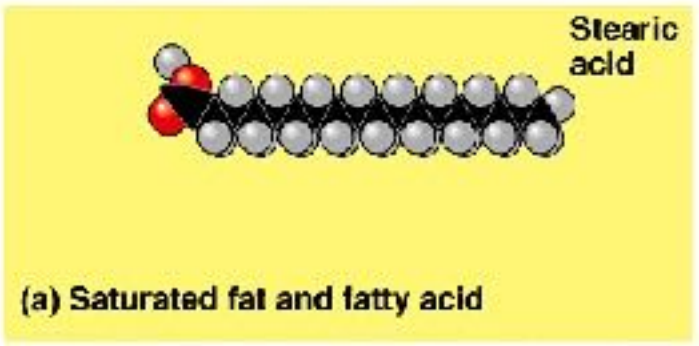


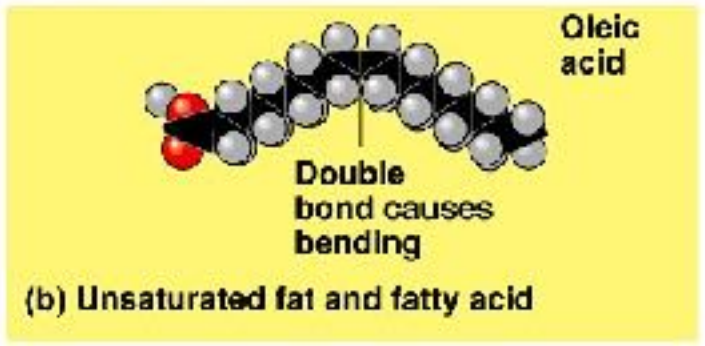


(a) One of three dehydration reactions in the synthesis of a fat

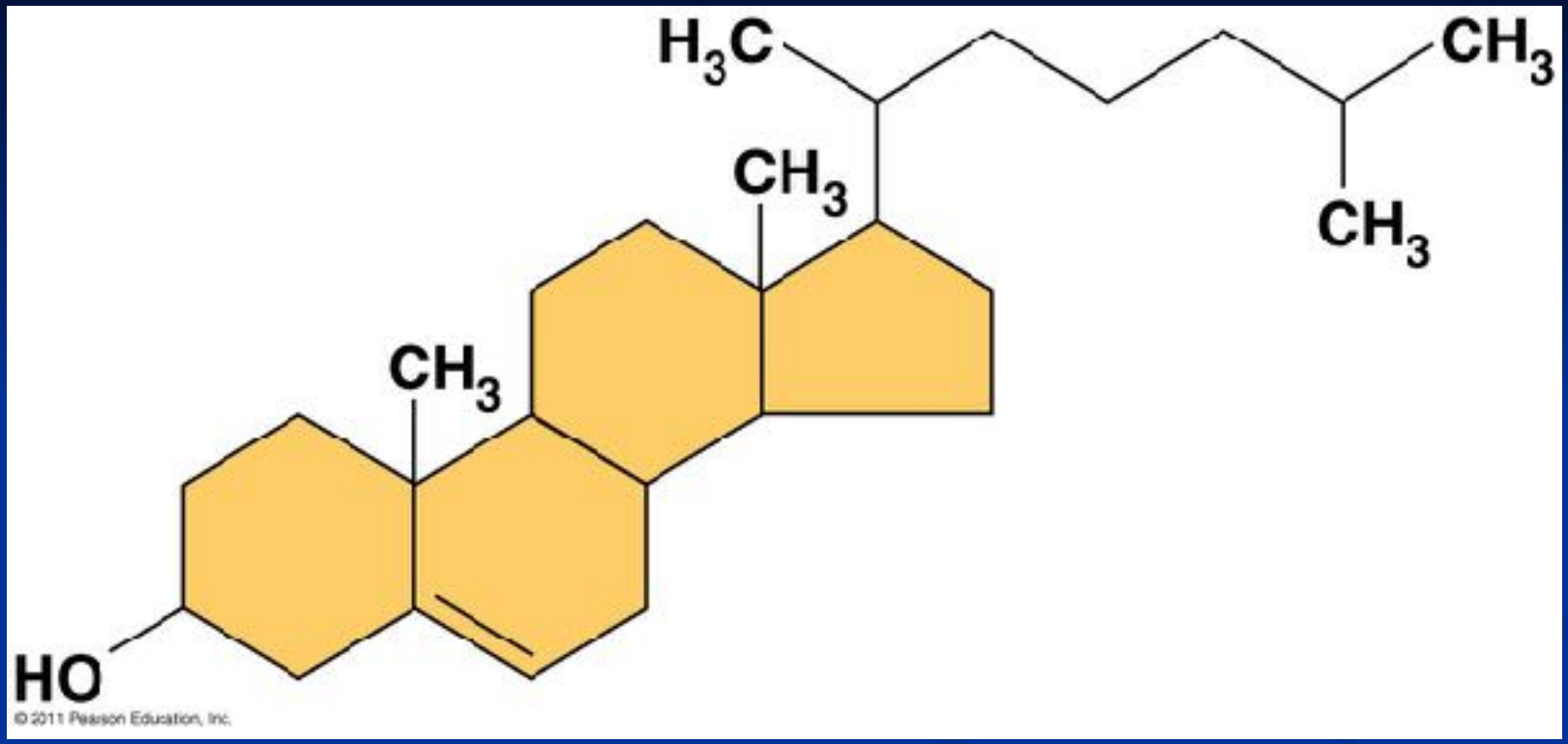


(b) Fat molecule (triacylglycerol)

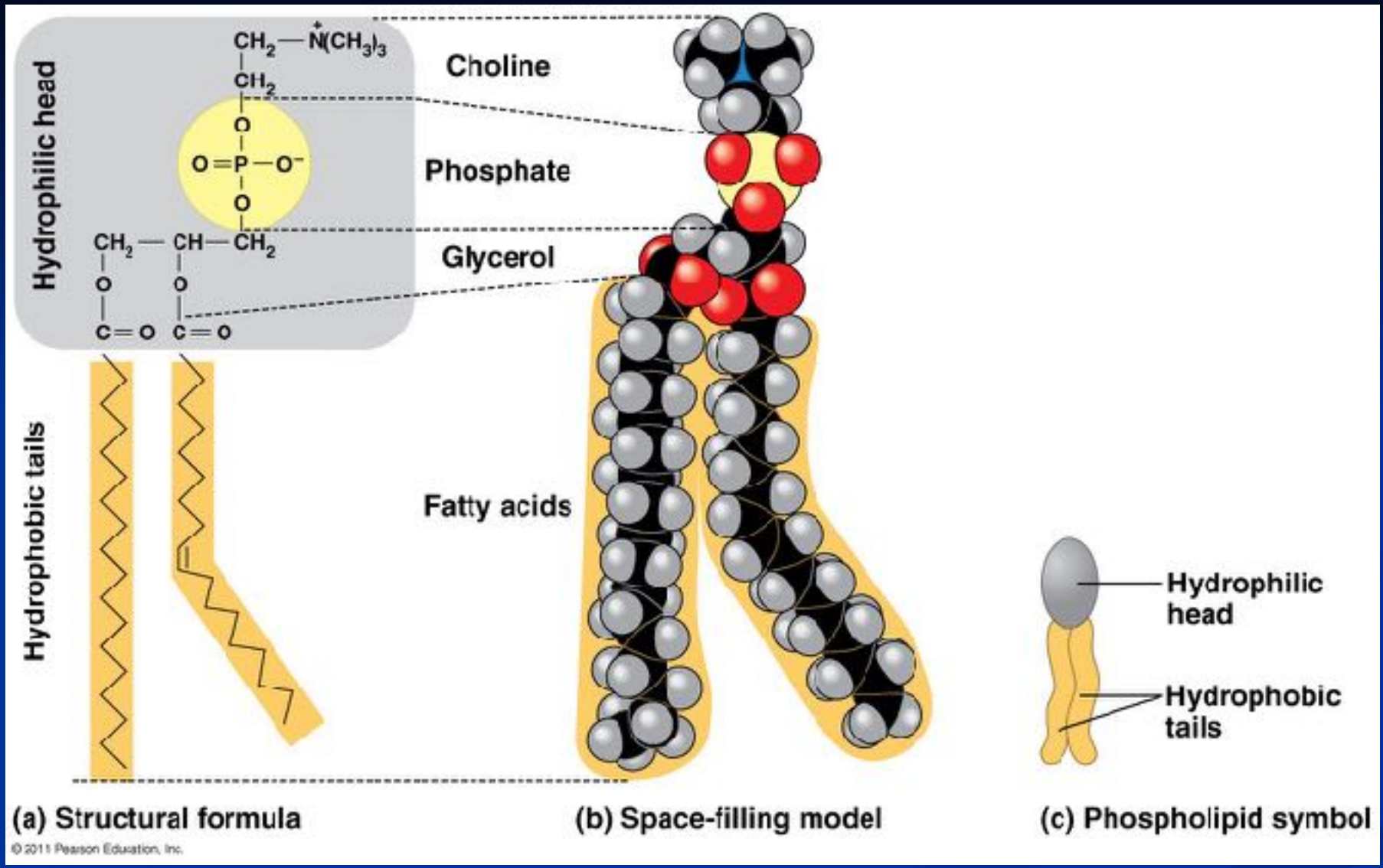




Saturated	Unsaturated	Polyunsaturated
"saturated" with H	Have some C=C, result in kinks	
In animals	In plants	
Solid at room temp.	Liquid at room temp.	
Eg. butter, lard	Eg. corn oil, olive oil	

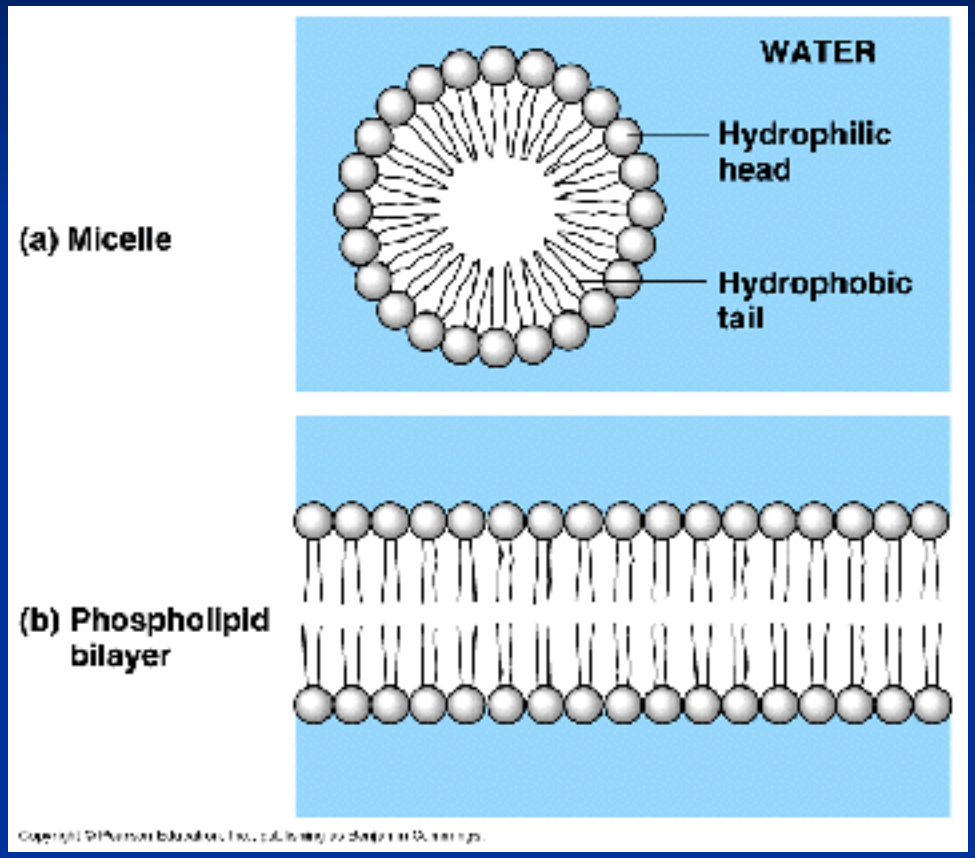


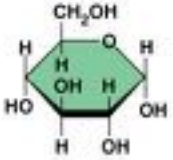
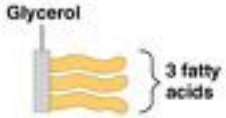
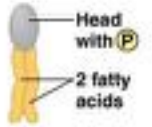
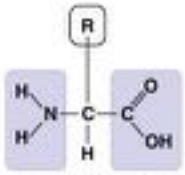
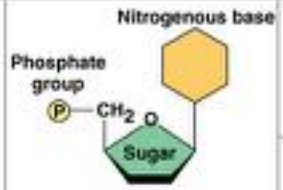
Cholesterol, a steroid



The structure of a phospholipid

Hydrophobic/hydrophilic interactions make a **phospholipid bilayer**



Large Biological Molecules	Components	Examples	Functions
CONCEPT 5.2 Carbohydrates serve as fuel and building material	 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
CONCEPT 5.3 Lipids are a diverse group of hydrophobic molecules		**Triacylglycerols** (fats or oils): glycerol + 3 fatty acids	Important energy source 
		**Phospholipids:** phosphate group + 2 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)
CONCEPT 5.4 Proteins include a diversity of structures, resulting in a wide range of 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
CONCEPT 5.5 Nucleic acids store, transmit, and help express hereditary information	 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 during gene expression, including carrying instructions from DNA to ribosomes