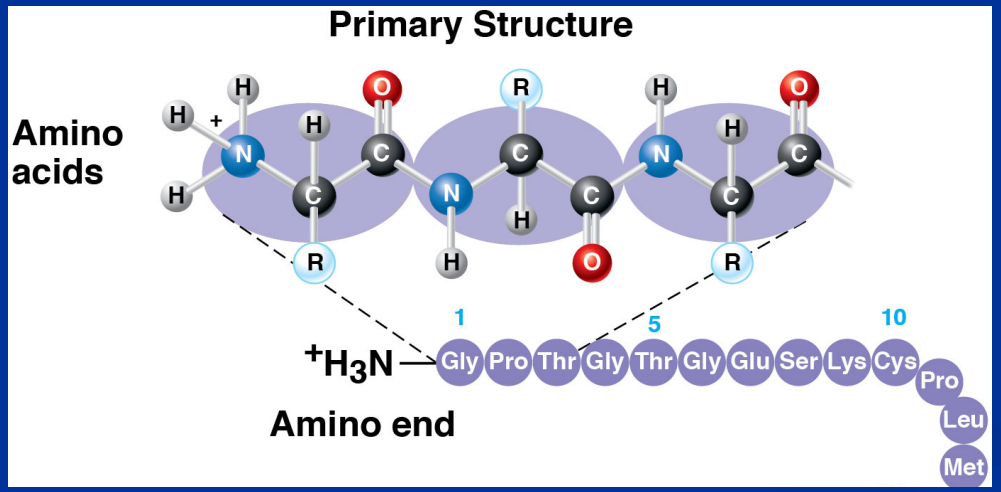
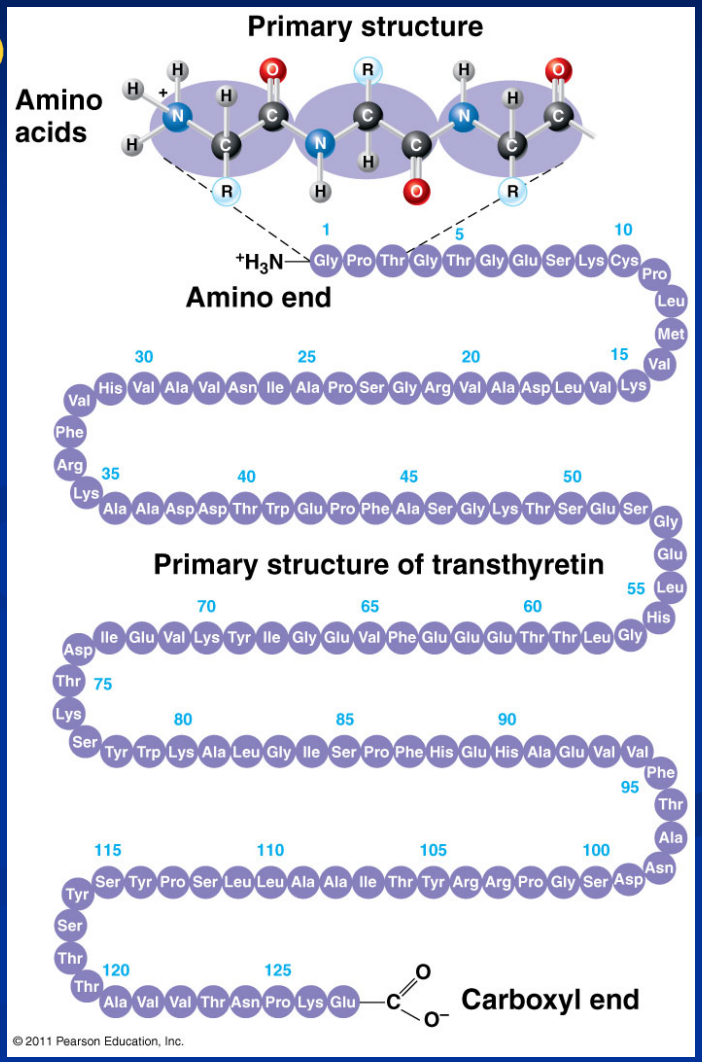
Four Levels of Protein Structure

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





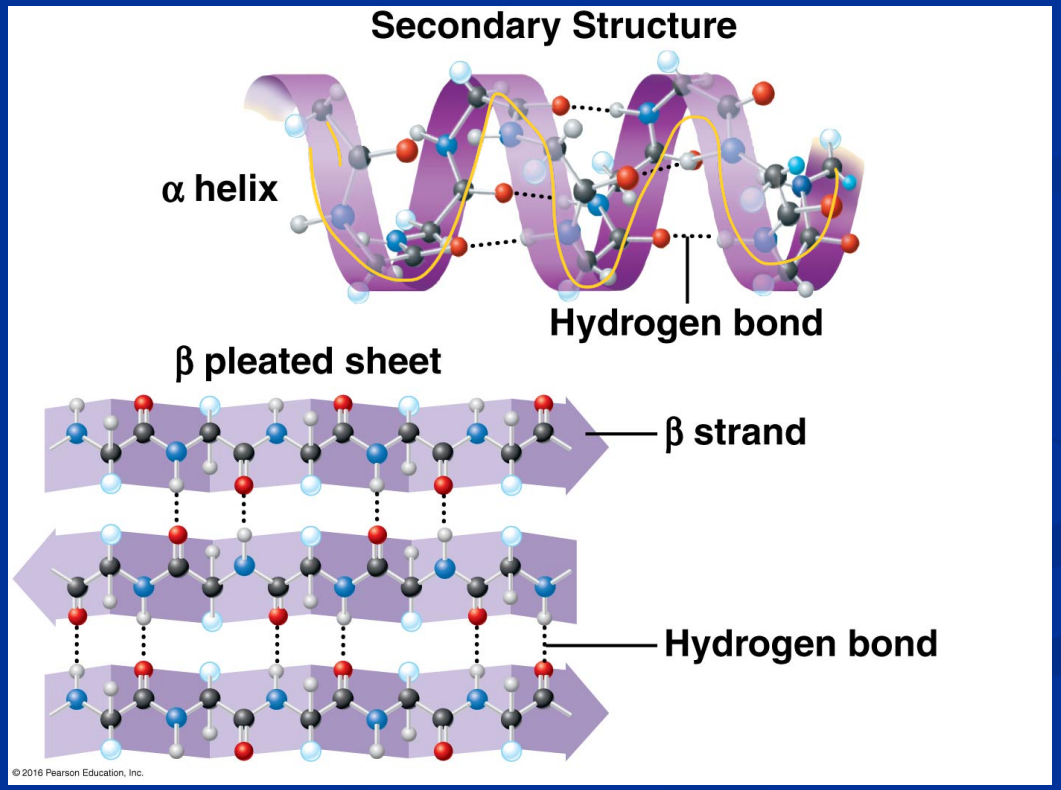
Four Levels of Protein Structure (continued)

2. Secondary

repeating patterns

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

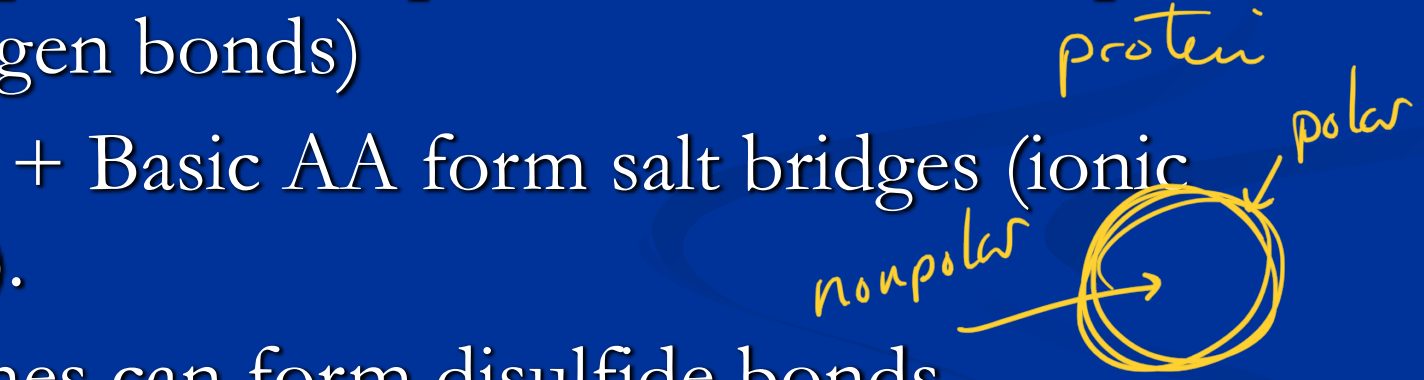
involves amino and carboxyl groups



Result of hydrogen bonding in the nonpolar interior of protein

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. Acidic + Basic AA form salt bridges (ionic bonds).
D. Cysteines can form disulfide bonds.



amino acid

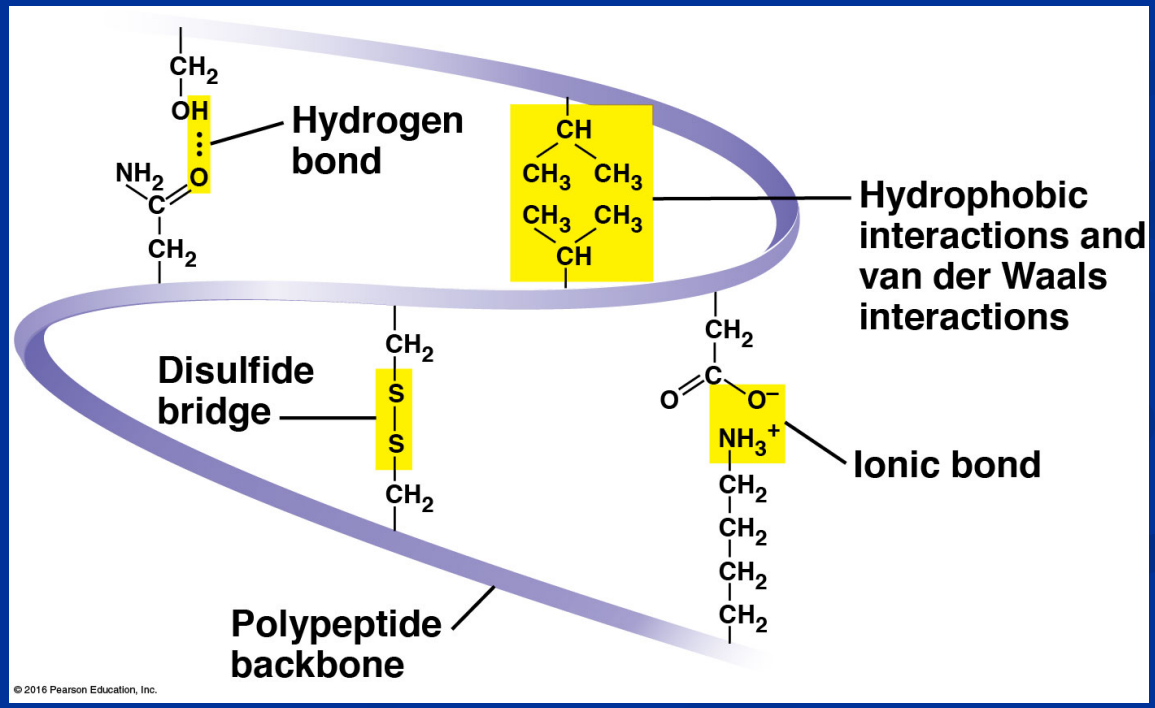
polar amino acid monomers go outward, nonpolar go inward— water leaves interior — protein collapses to functional form.

Four Levels of Protein Structure (continued)

3. Tertiary

3-D structure → shape

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

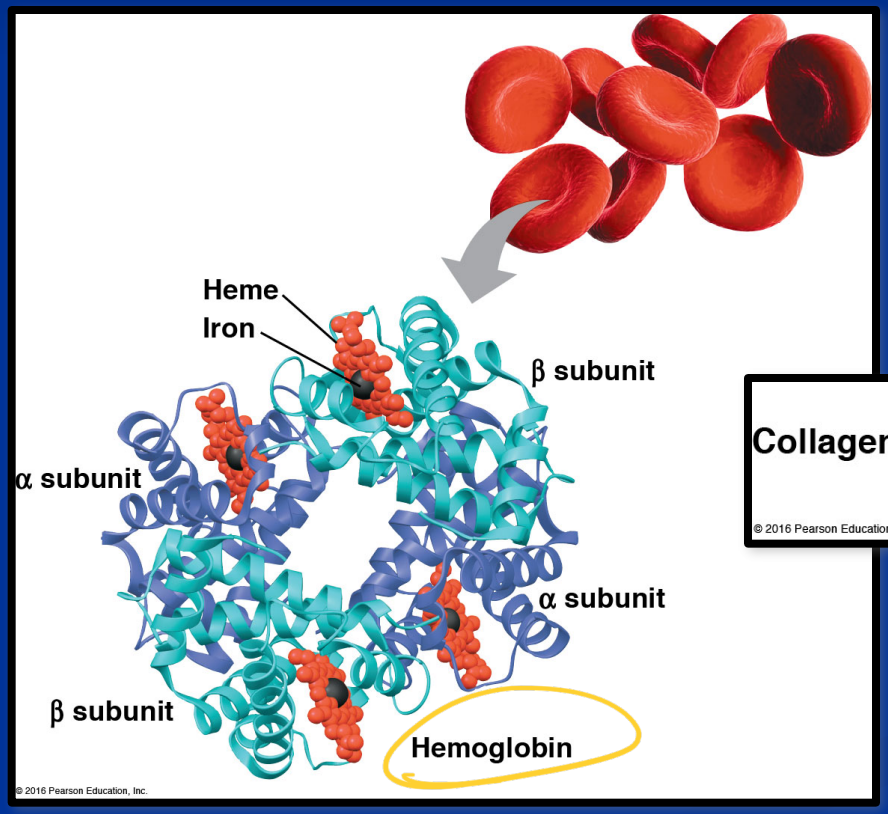


Four Levels of Protein Structure (continued)

4. Quaternary

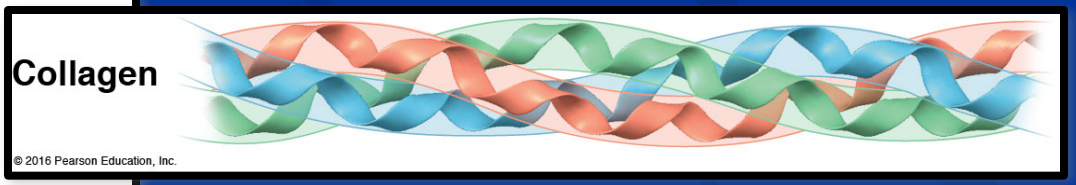
multiple polypeptide chains come together

- **2+ polypeptides** bond together

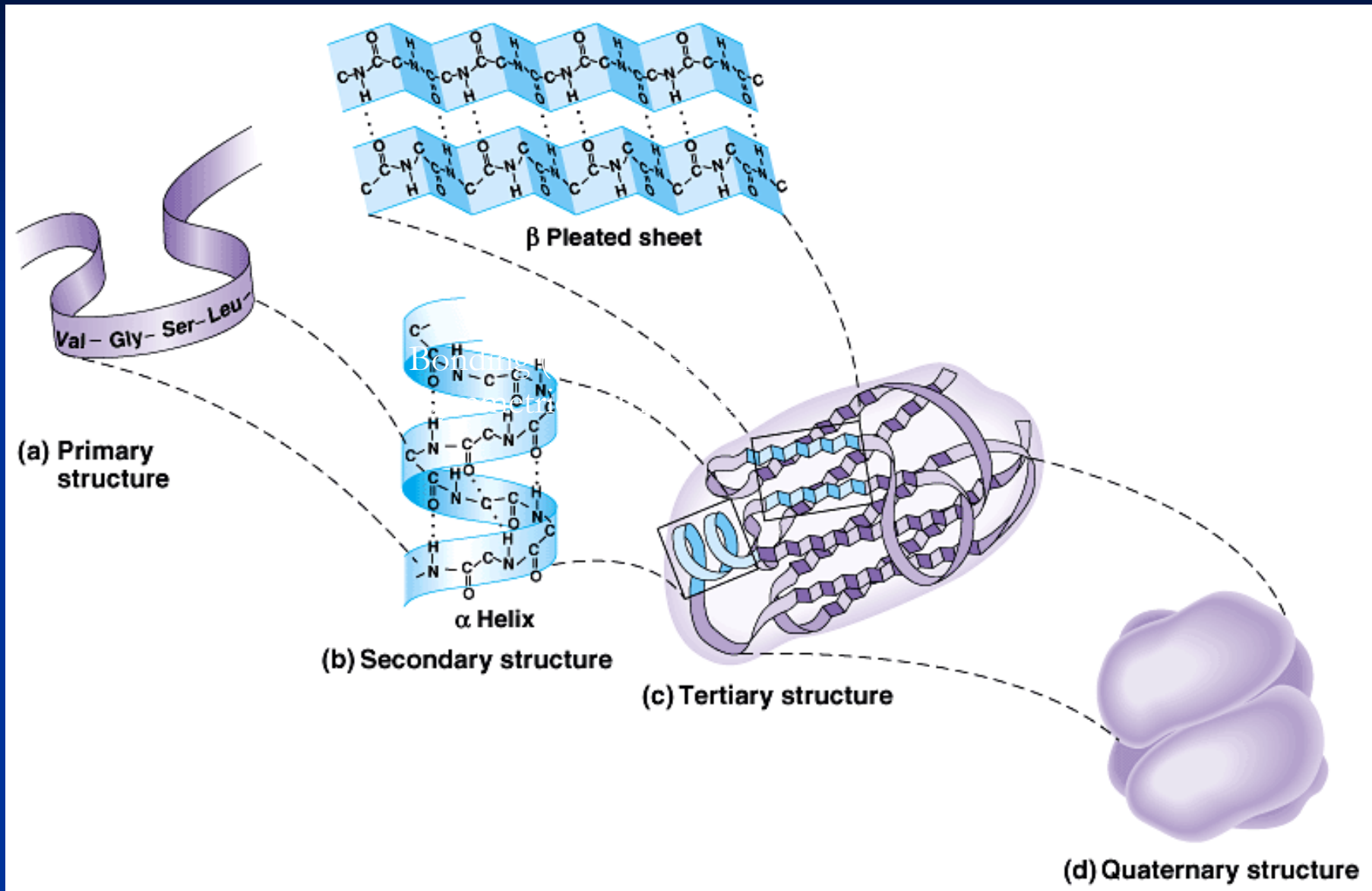


α β
β α
adult

α γ
γ α
fetal



amino acids → polypeptides → protein

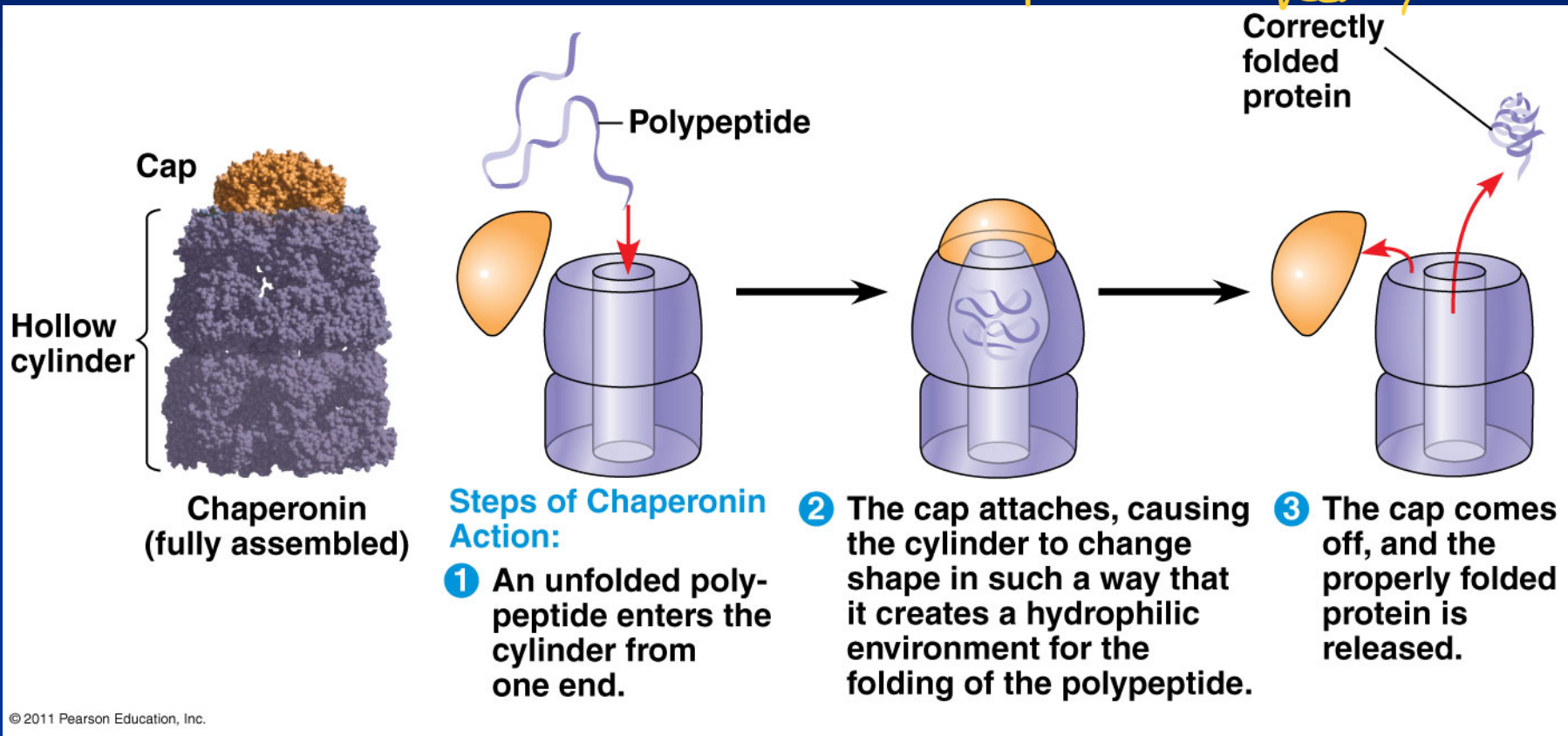


refold misfolded (denatured) protein

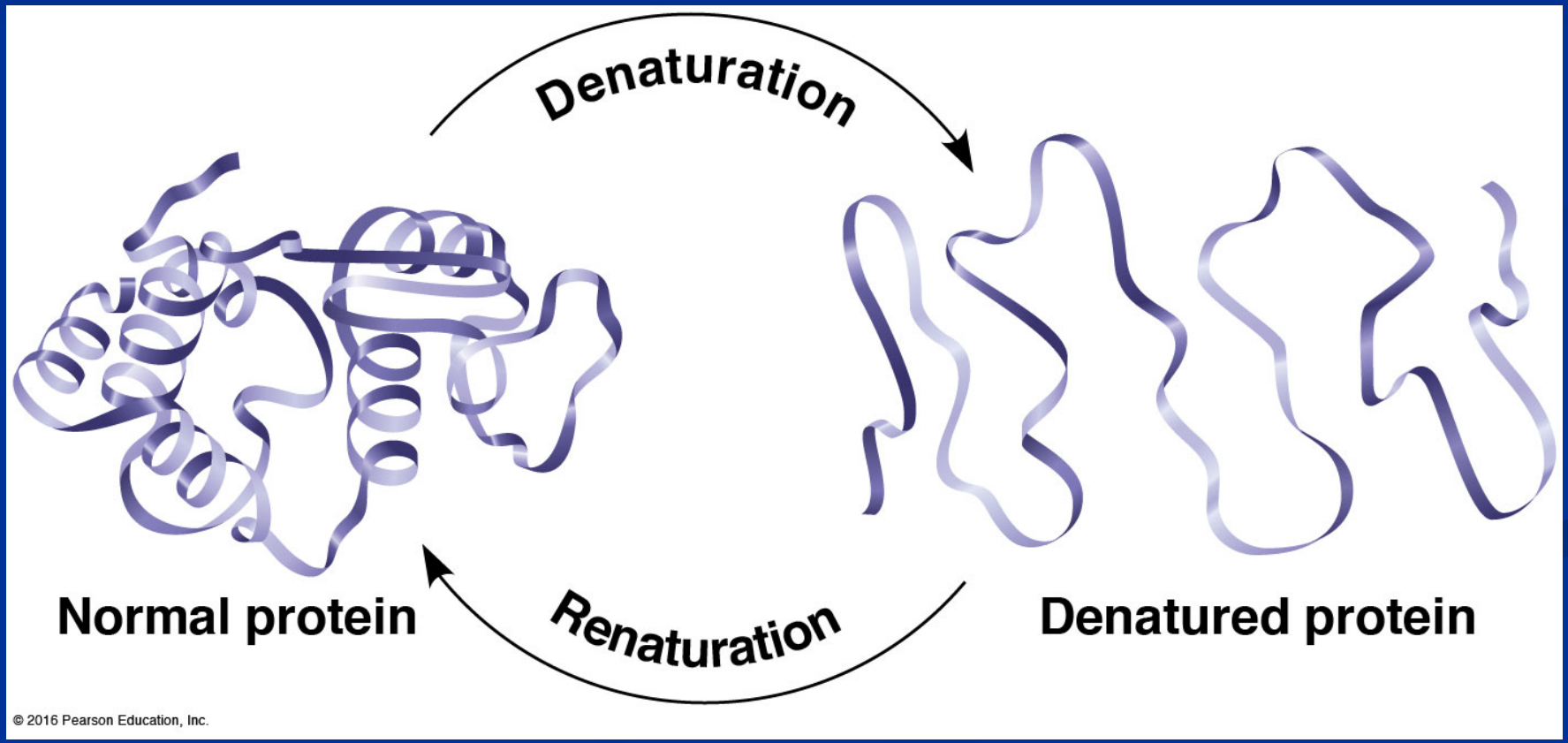
Chaperonins assist in proper folding of proteins

heat shock protein (hsp)

denatured protein → misfolded protein. occur due to heat, acid...



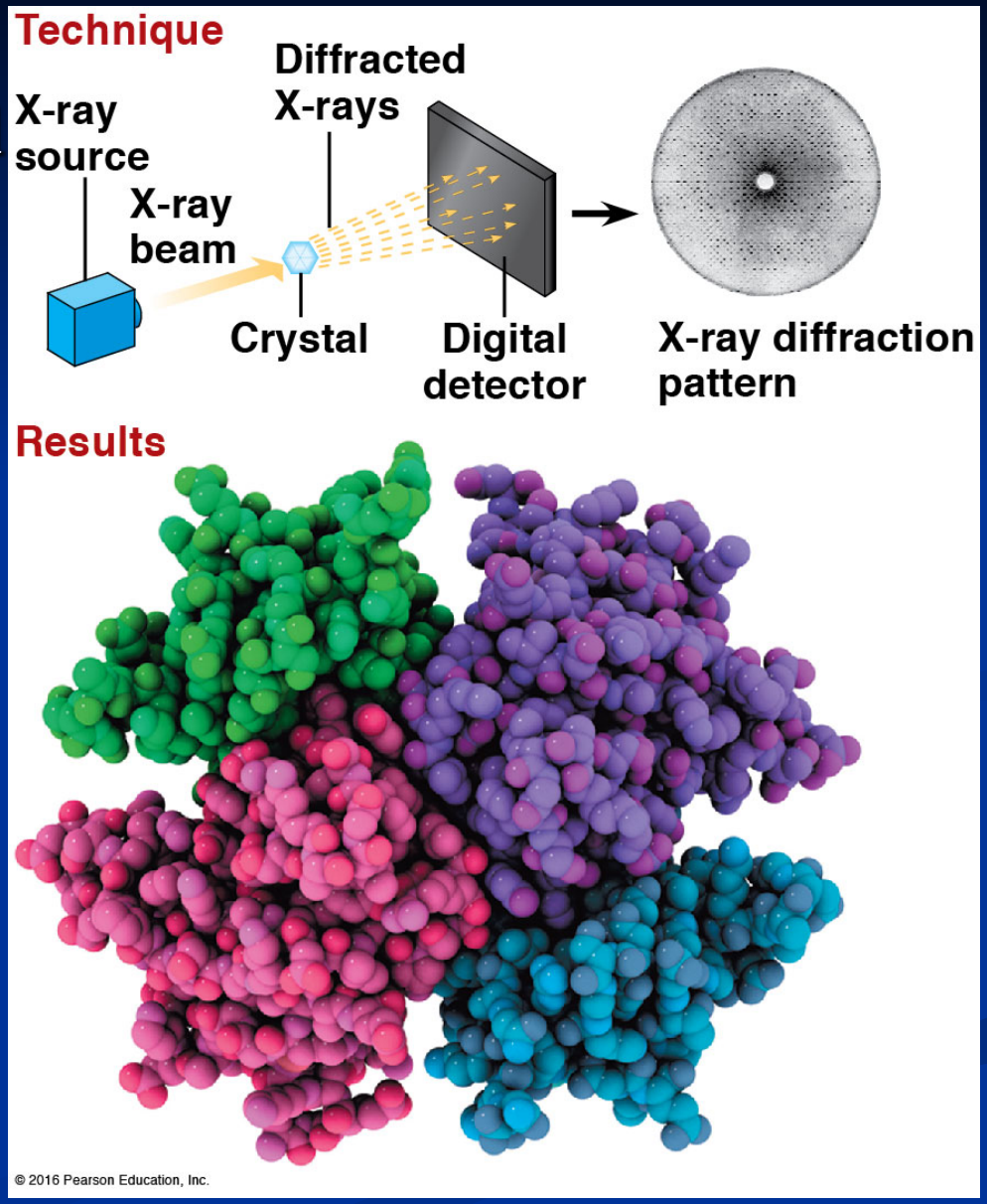
- Protein **structure and function** are sensitive to chemical and physical conditions
- Unfolds or **denatures** if **pH** and **temperature** are not optimal



change in structure = change in function

	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.

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



Genomics: Analysis of genes and genomes

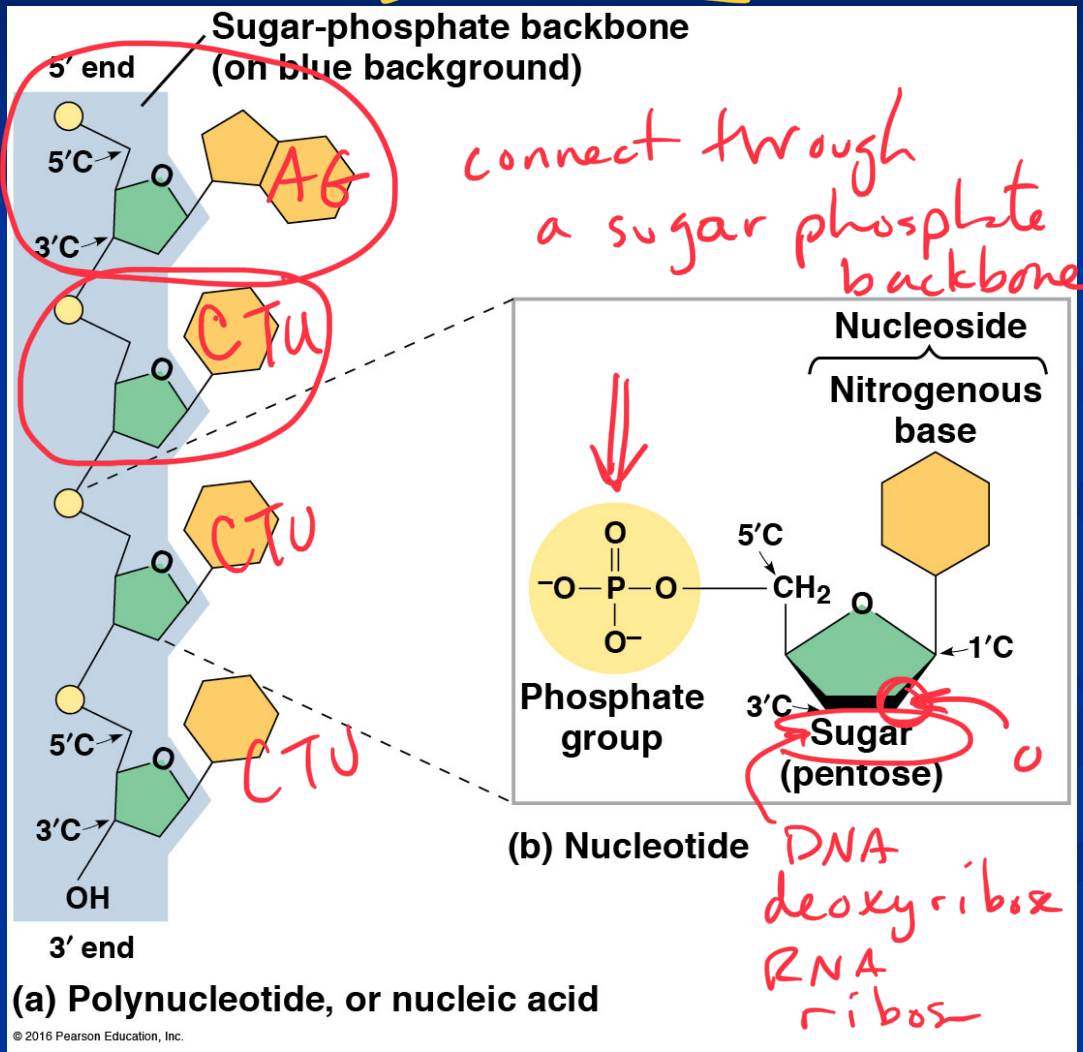
II. Nucleic Acids

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

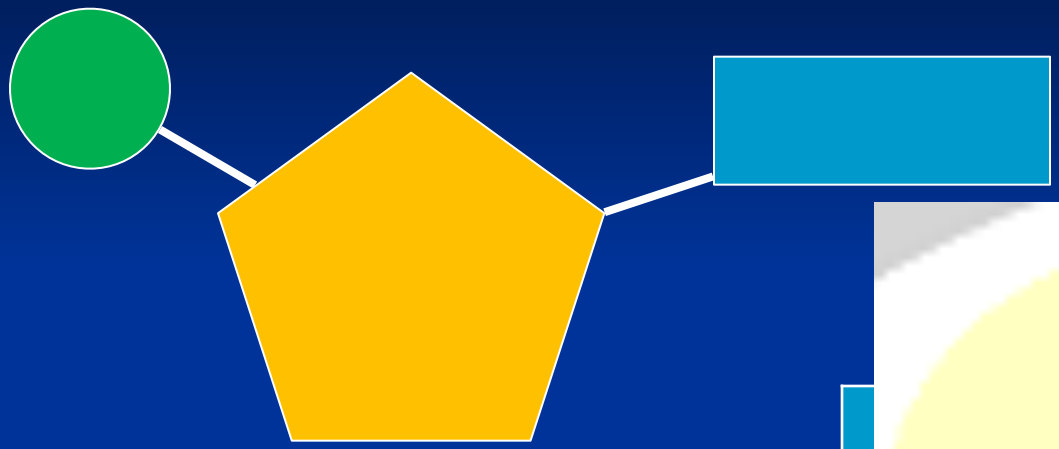
Nucleotides: monomer of DNA/RNA

Nucleotide = Sugar + Phosphate + Nitrogen Base



Nucleotide

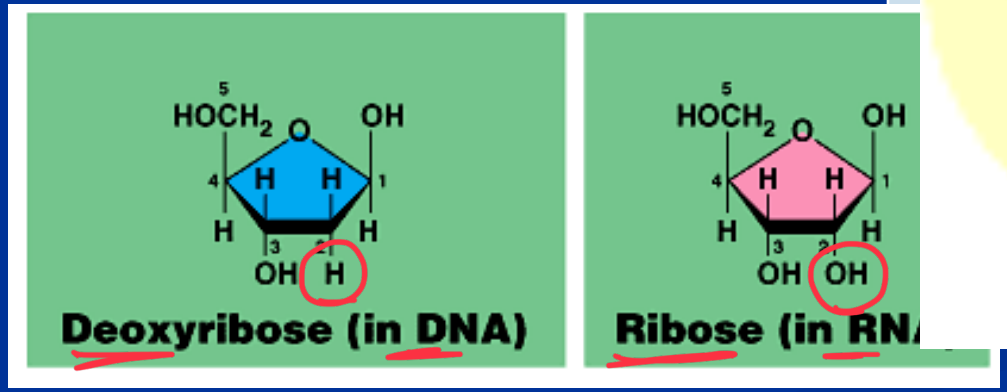
phosphate

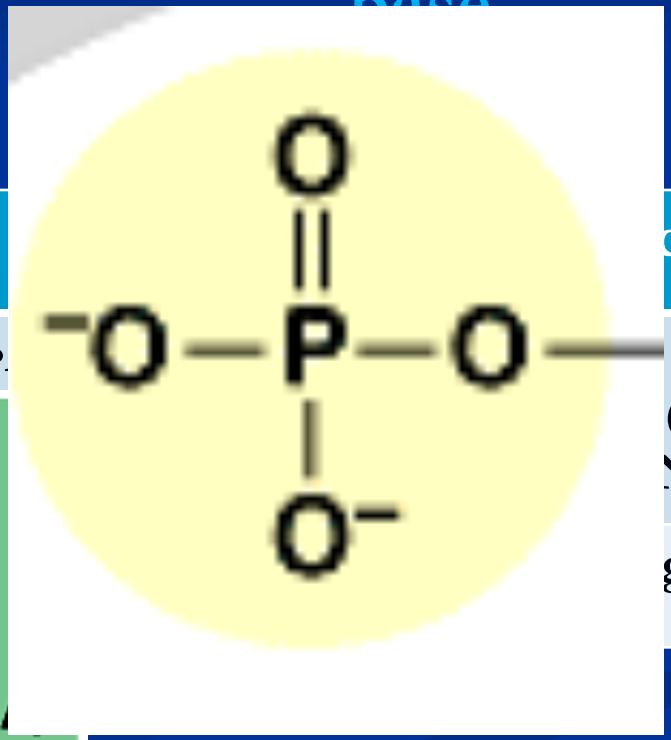


5-C sugar

Nitrogen base

A – T
G – C



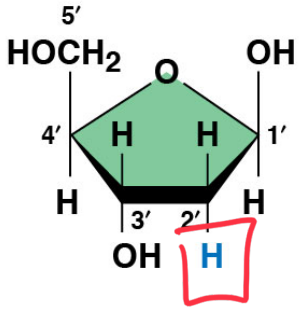


dines

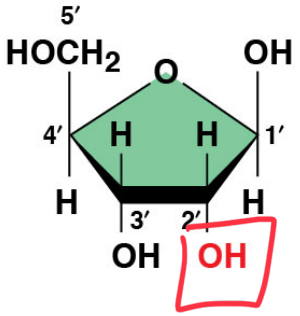
(DNA)
NA)

g

SUGARS



Deoxyribose (in DNA)

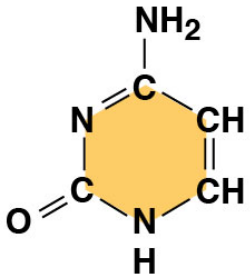


Ribose (in RNA)

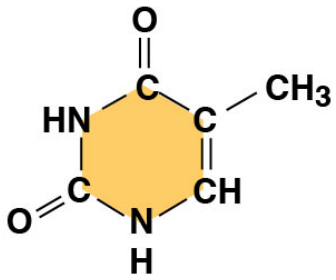
(c) Nucleoside components

NITROGENOUS BASES

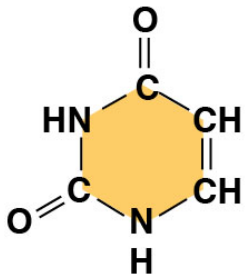
Pyrimidines



Cytosine (C)

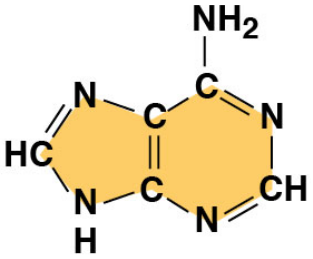


Thymine (T, in DNA)

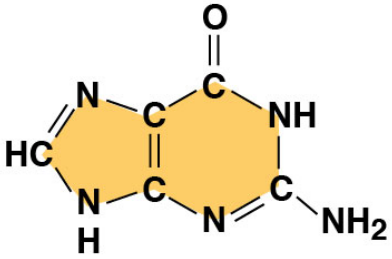


Uracil (U, in RNA)

Purines



Adenine (A)

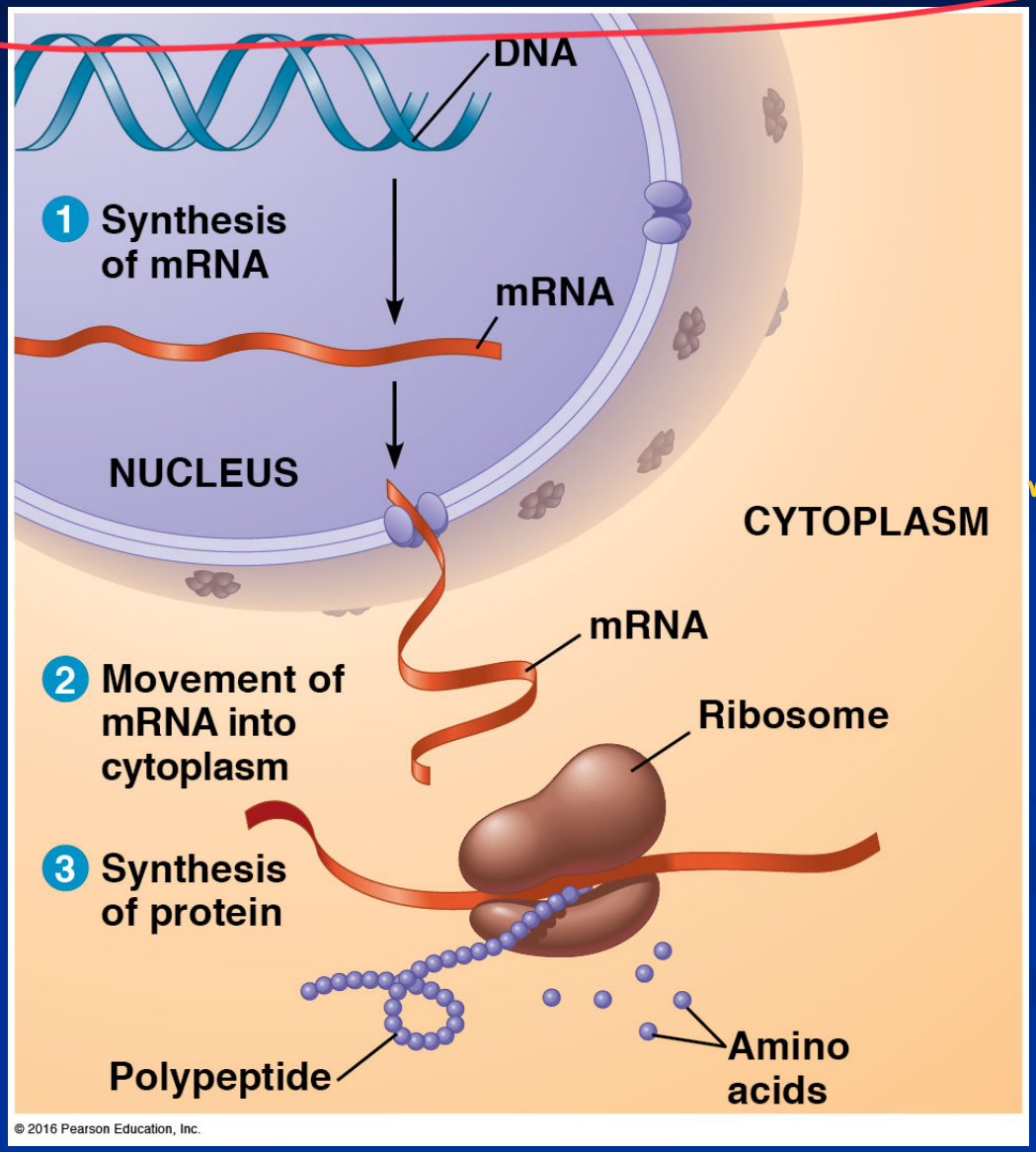


Guanine (G)

(c) Nucleoside components

Information flow in a cell: DNA → RNA → protein

"Central Dogma of Biology"



DNA
↓ transcription
mRNA
↓ translation
protein

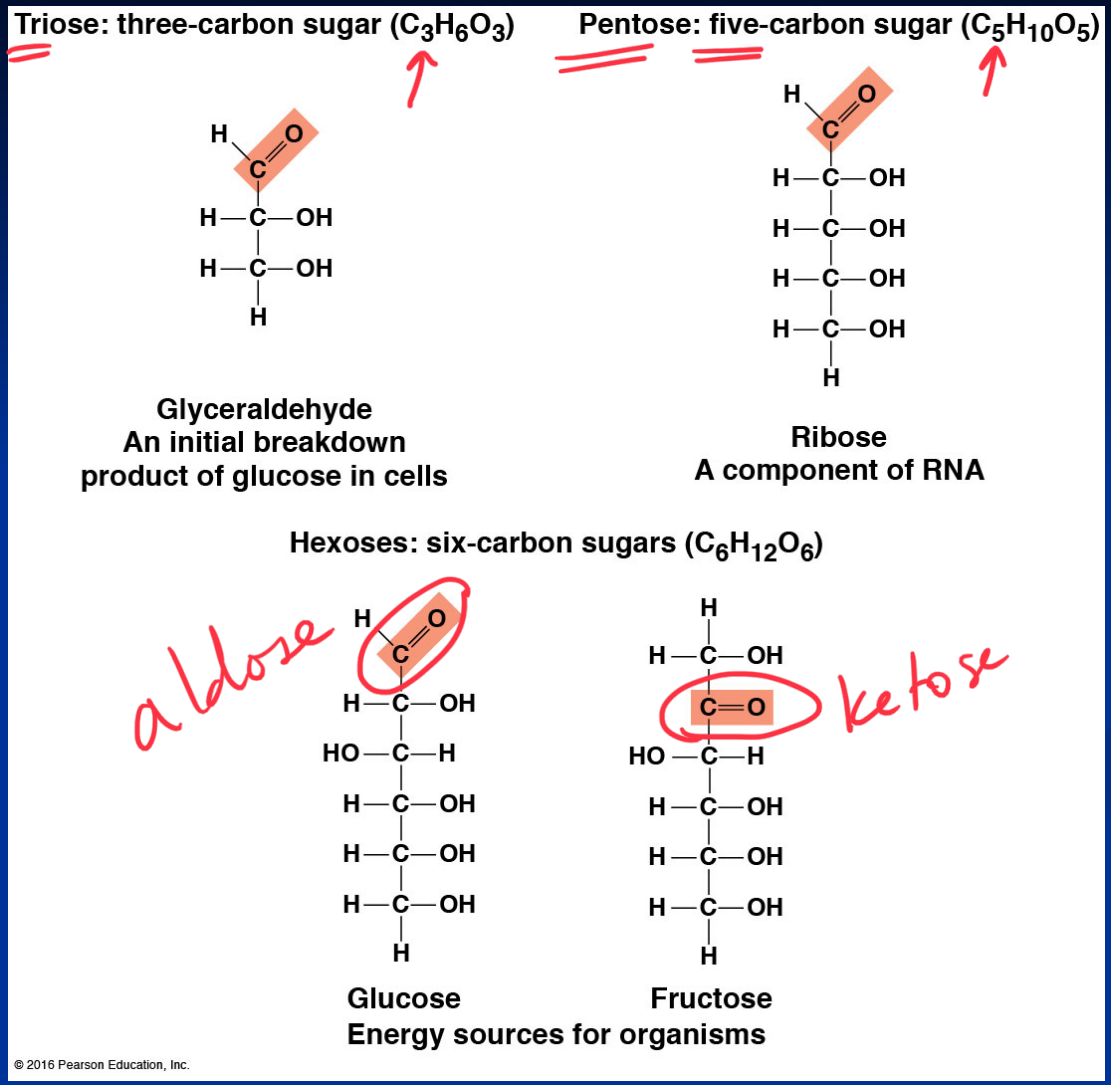
III. Carbohydrates

$C_1H_2O_1$

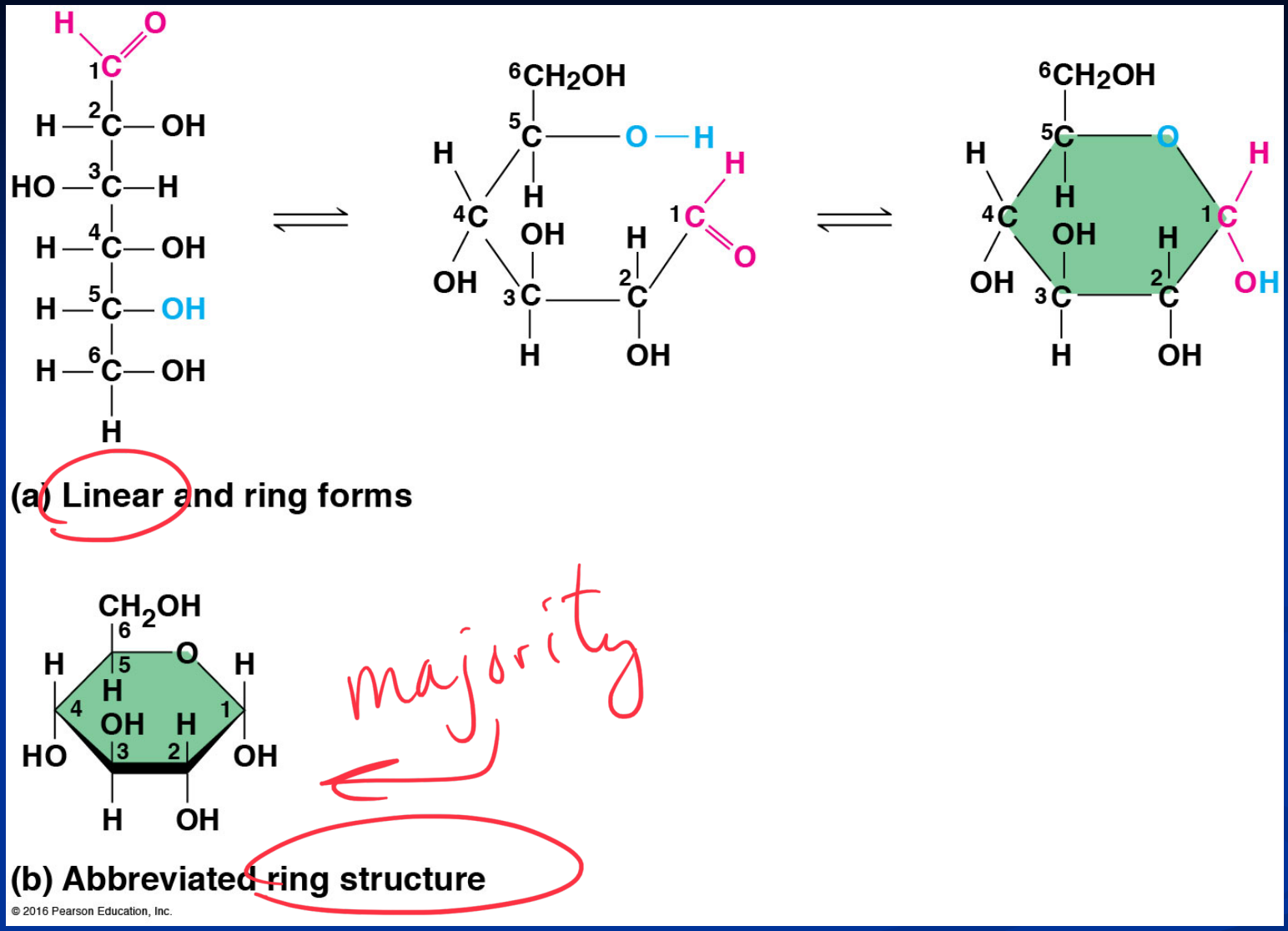
$C_1(H_2O)$

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

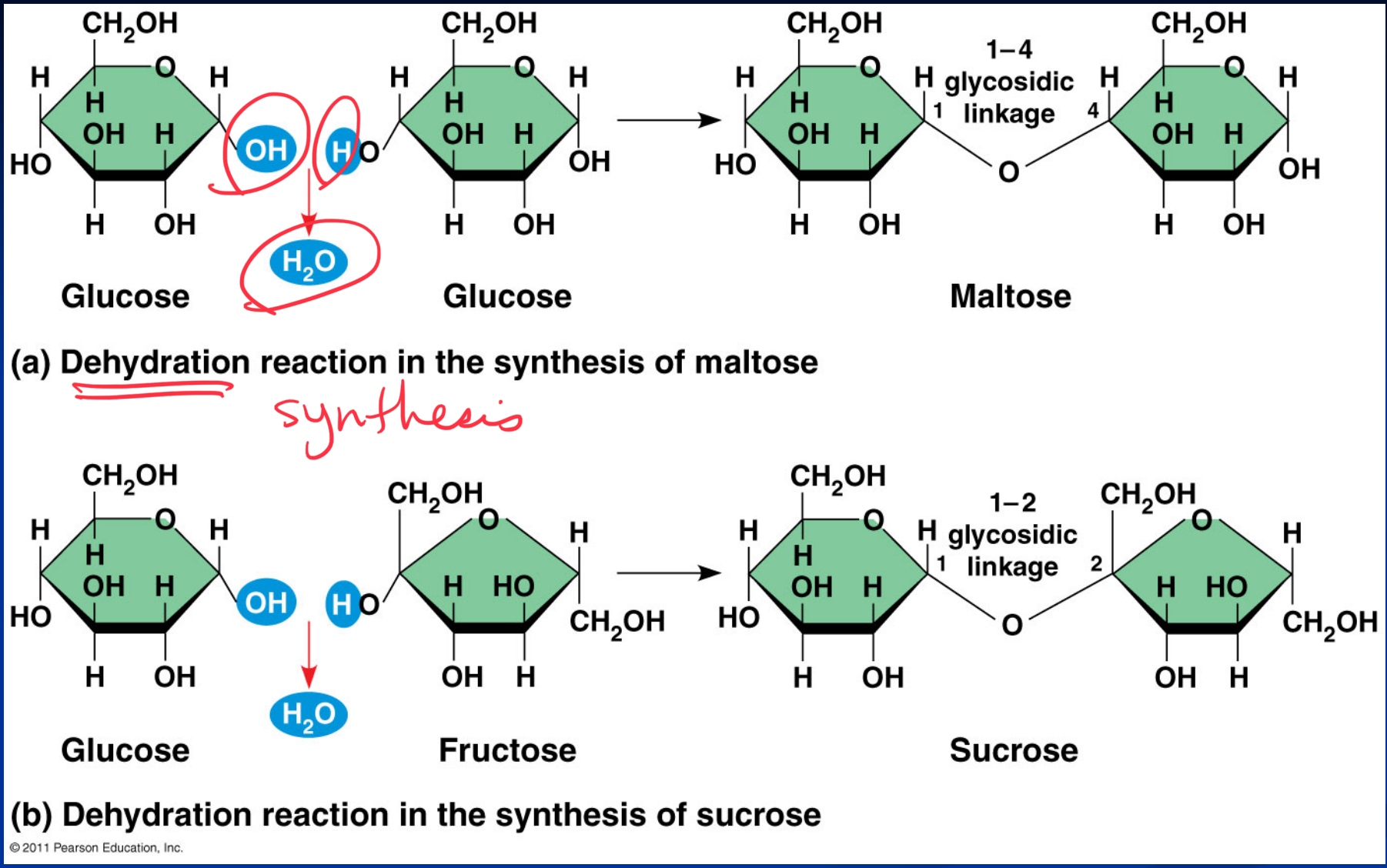
} Differ in position & orientation of glycosidic linkage



The structure and classification of some monosaccharides



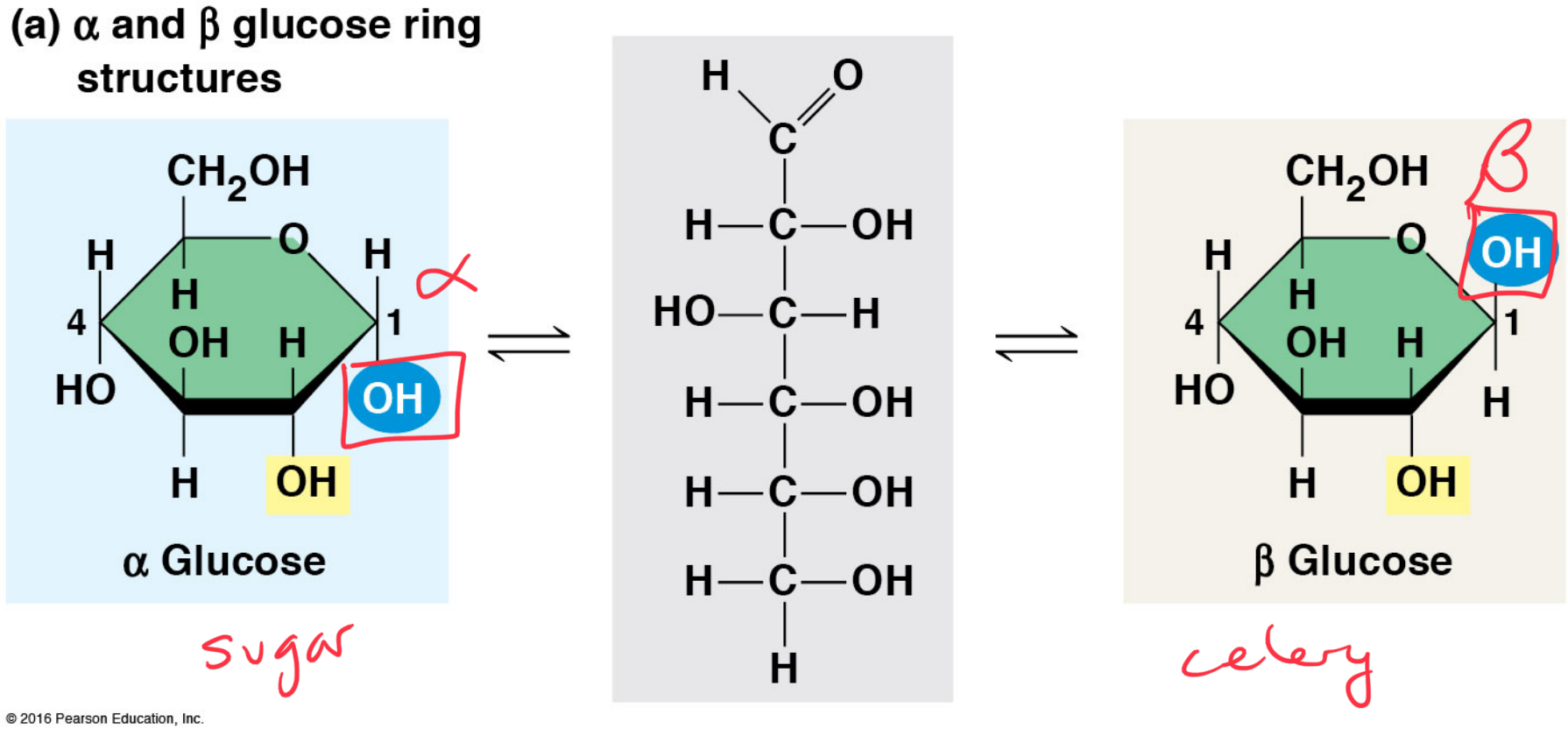
Linear and ring forms of glucose



Carbohydrate synthesis

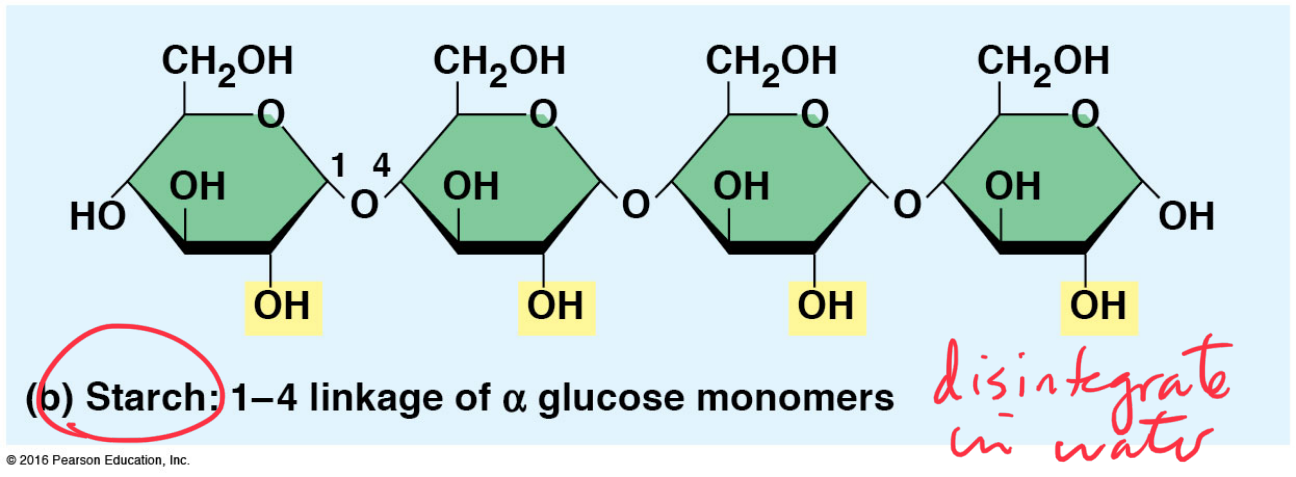
Cellulose vs. Starch

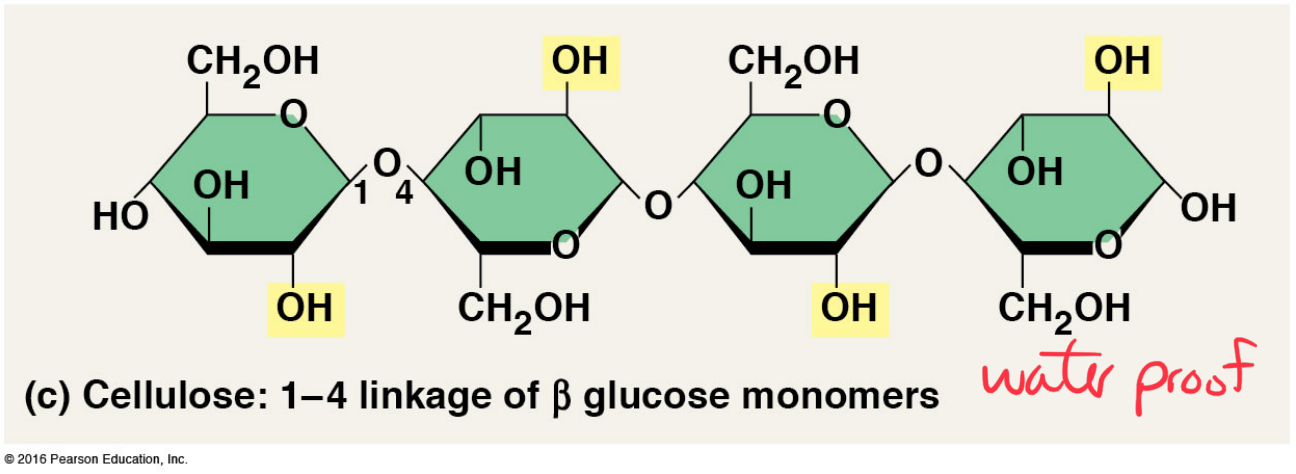
Two Forms of Glucose: α glucose & β glucose



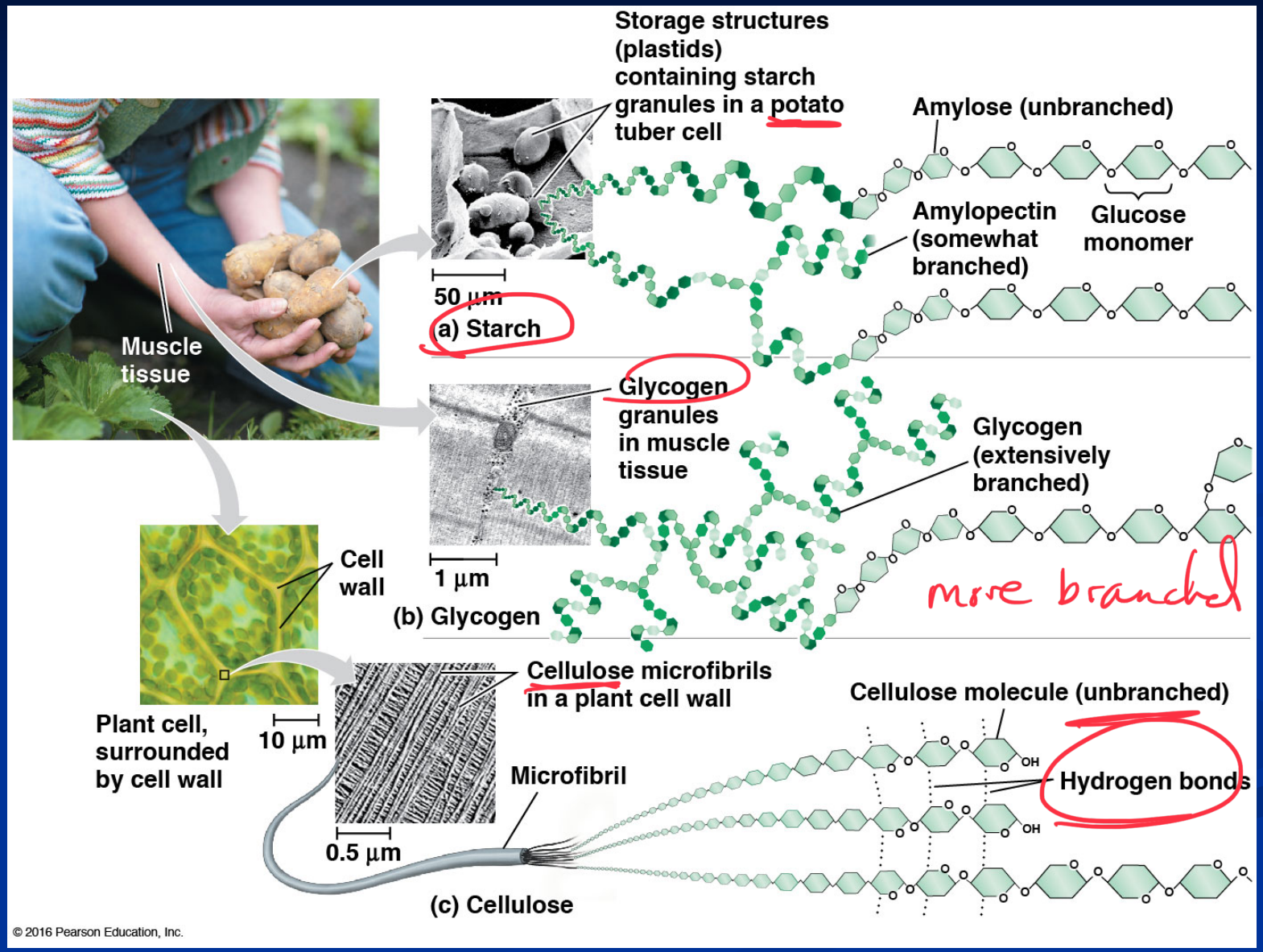
Cellulose vs. Starch

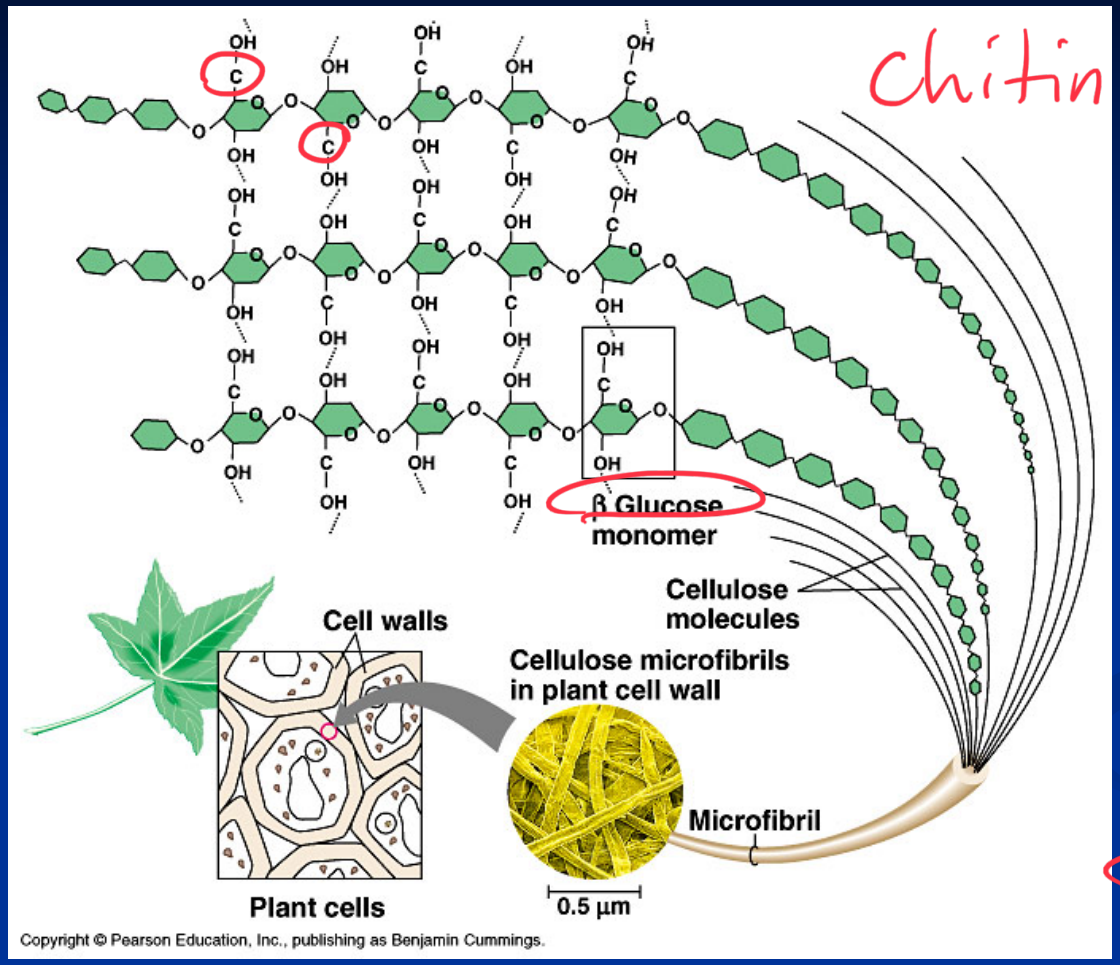
- Starch = α glucose monomers
- Cellulose = β glucose monomers





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





Structural polysaccharides: cellulose & chitin (exoskeleton)

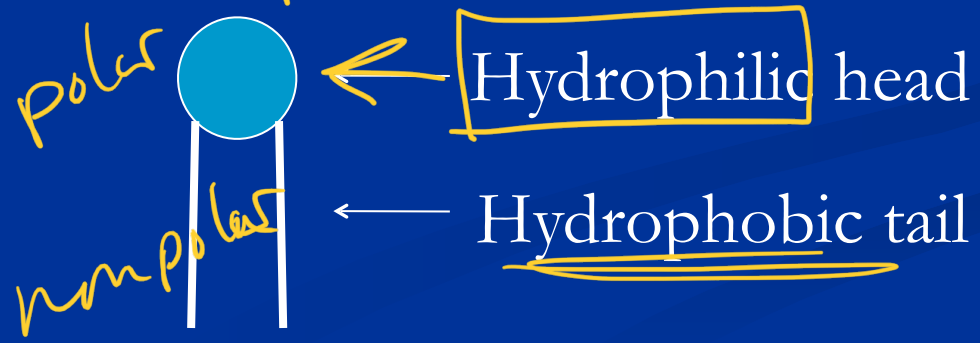
IV. Lipids

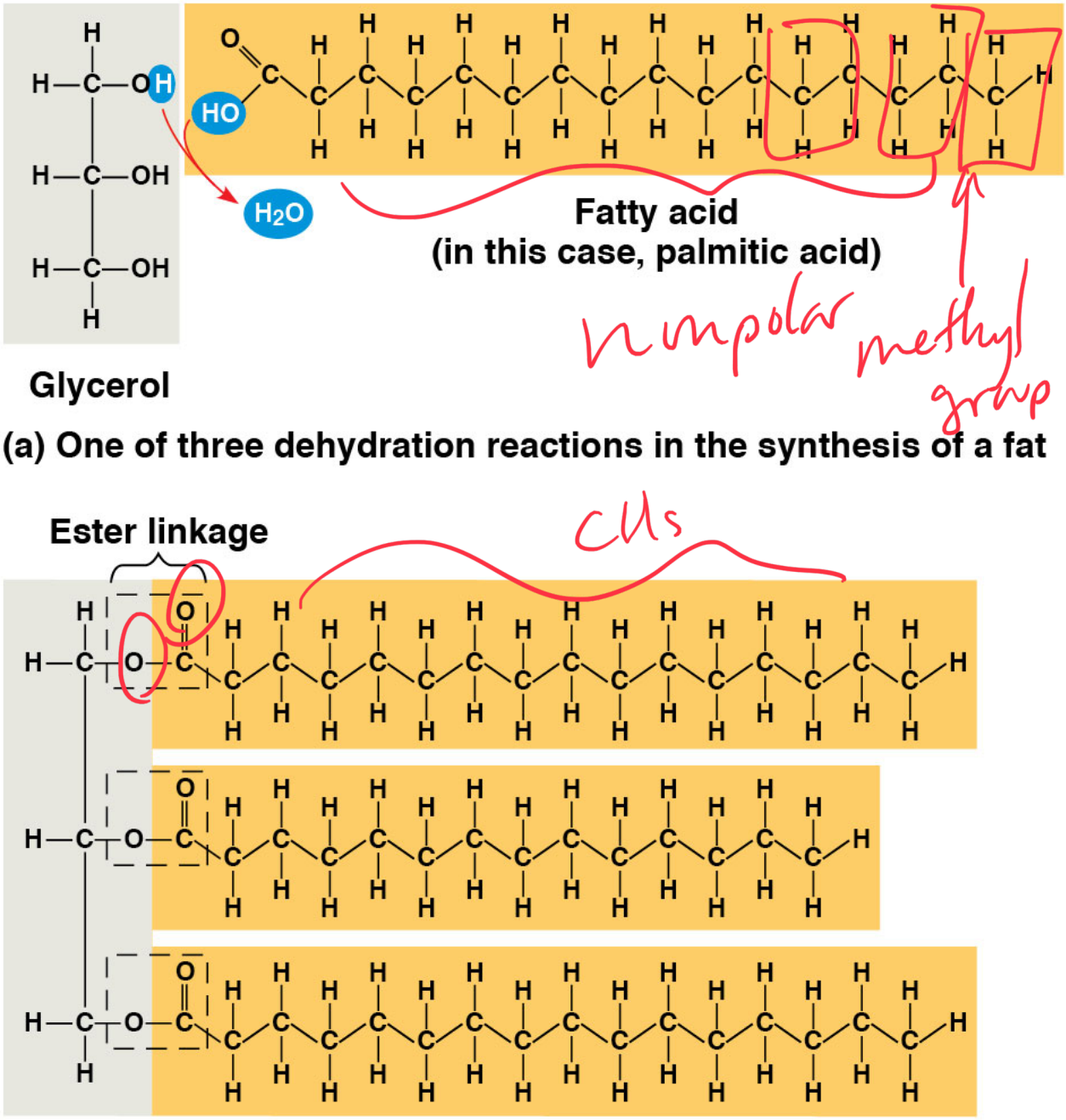
A. **Fats (triglyceride):** store energy
   - Glycerol + 3 Fatty Acids
   - saturated, unsaturated, polyunsaturated

B. **Steroids:** cholesterol and hormones

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

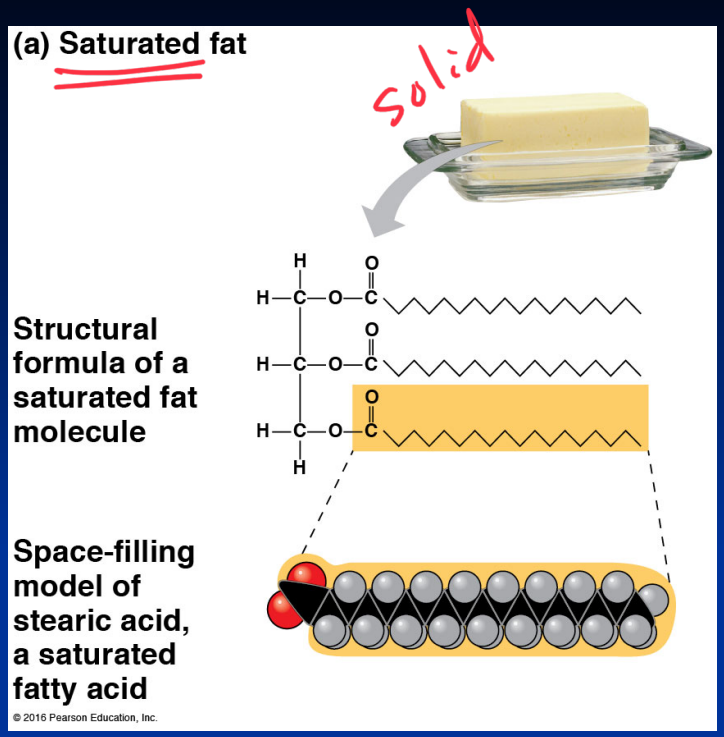
amphipathic both polar and nonpolar ends

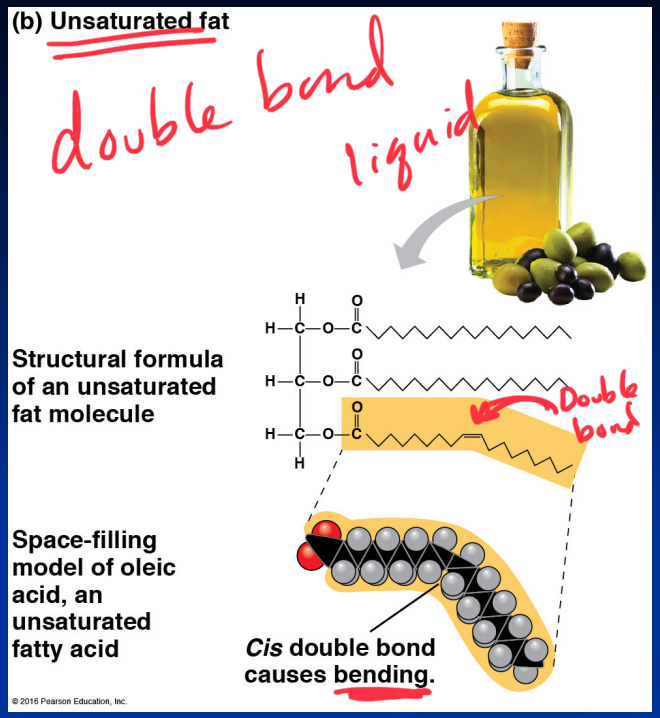




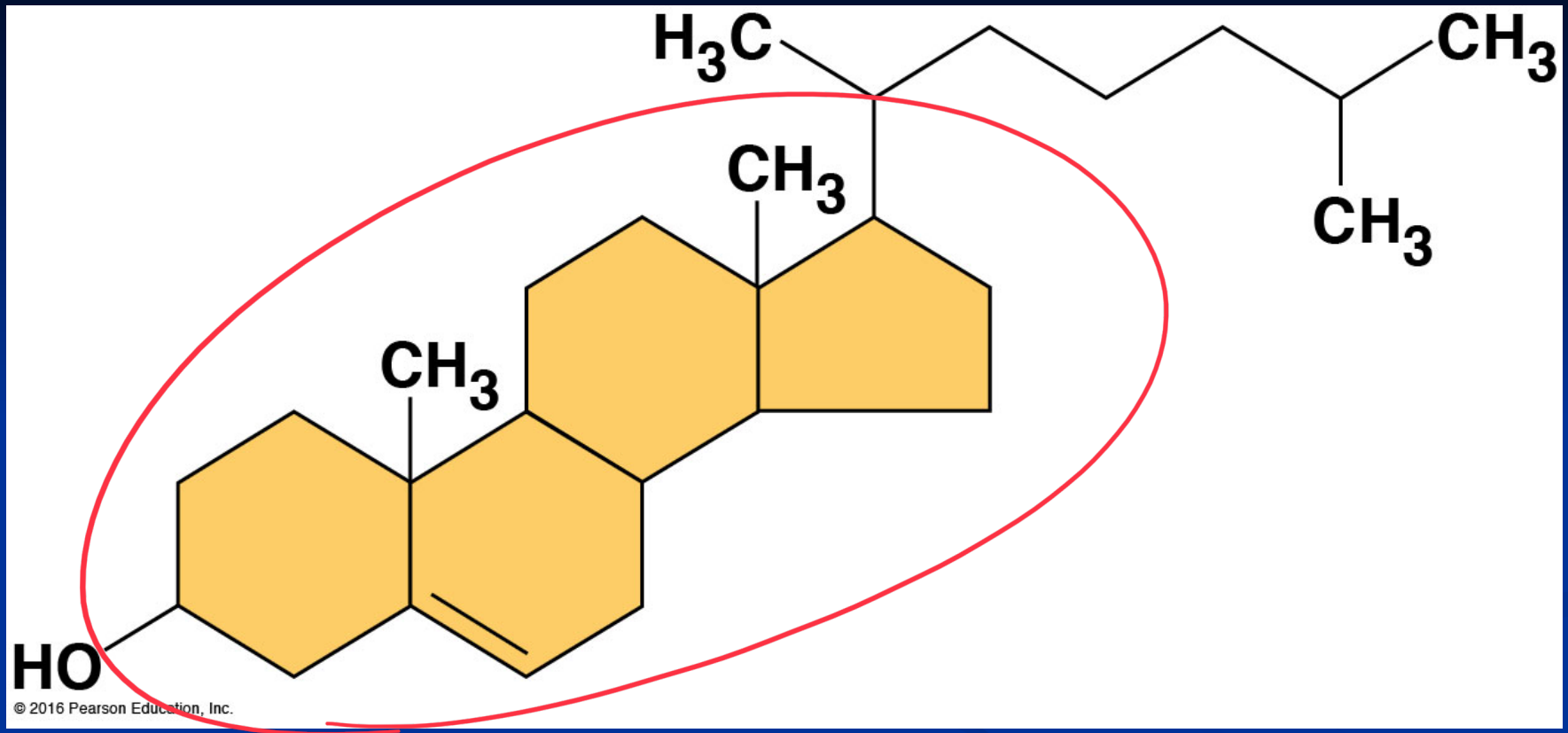
(a) One of three dehydration reactions in the synthesis of a fat

(b) Fat molecule (triacylglycerol)

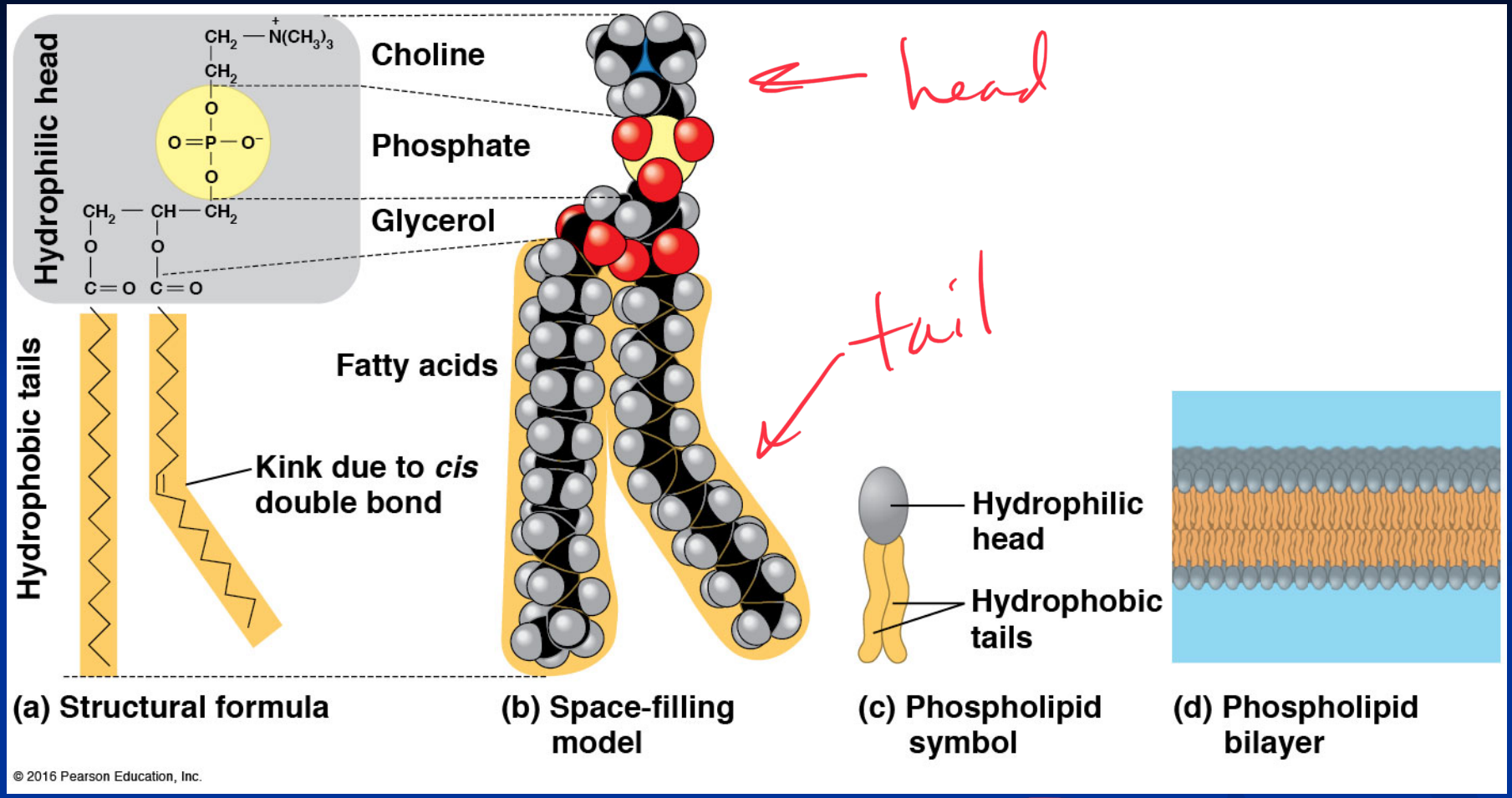




Saturated	Unsaturated	Polyunsaturated
"saturated" with H	Have some C=C, result in kinks	
In animals	In plants	
Solid at room temp.	Liquid at room temp.	
Eg. butter, lard	Eg. corn oil, olive oil	

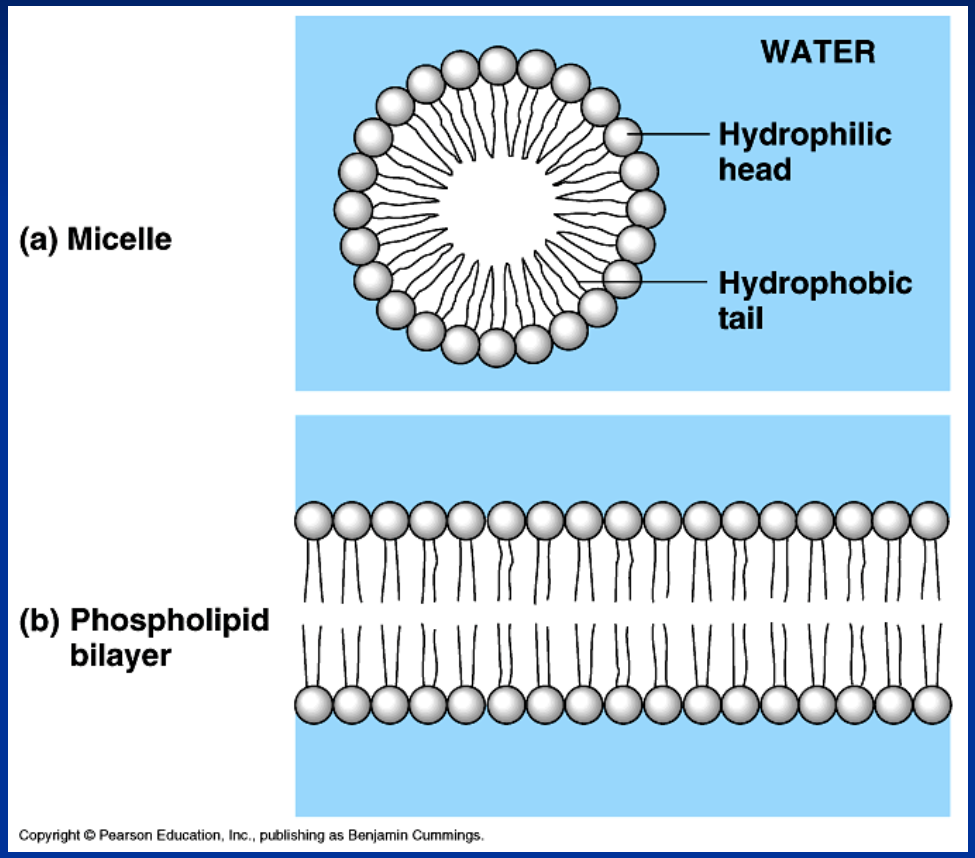


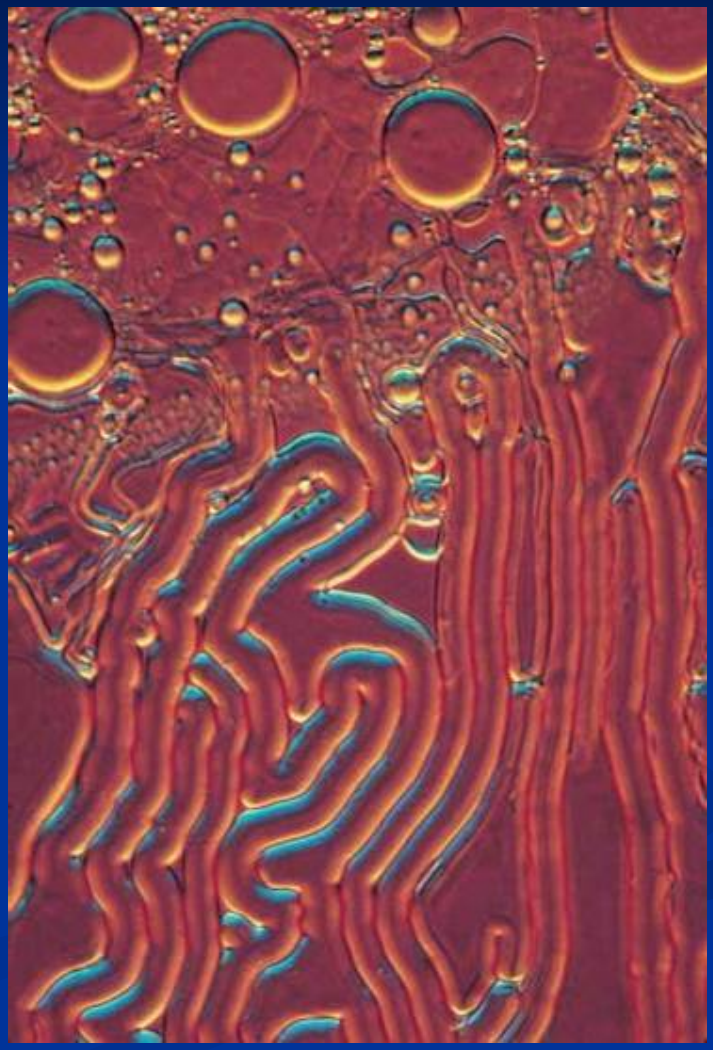
Cholesterol, a steroid

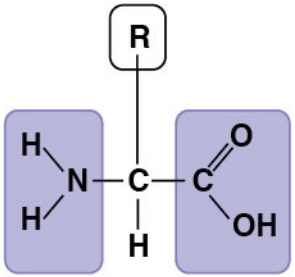


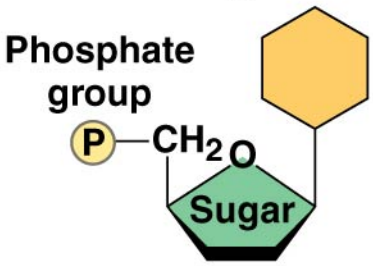
The structure of a phospholipid

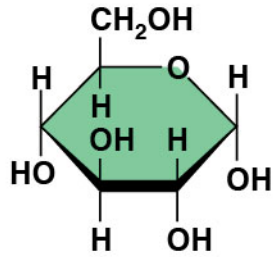
Hydrophobic/hydrophilic interactions make a **phospholipid bilayer**

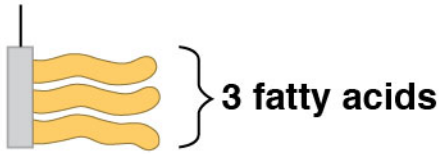
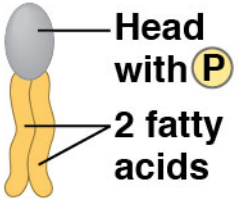
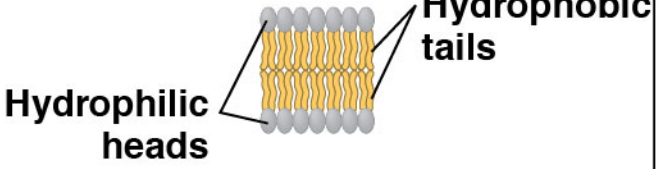
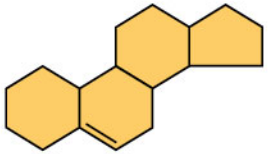




Components	Examples	Functions
 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease

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

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

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)