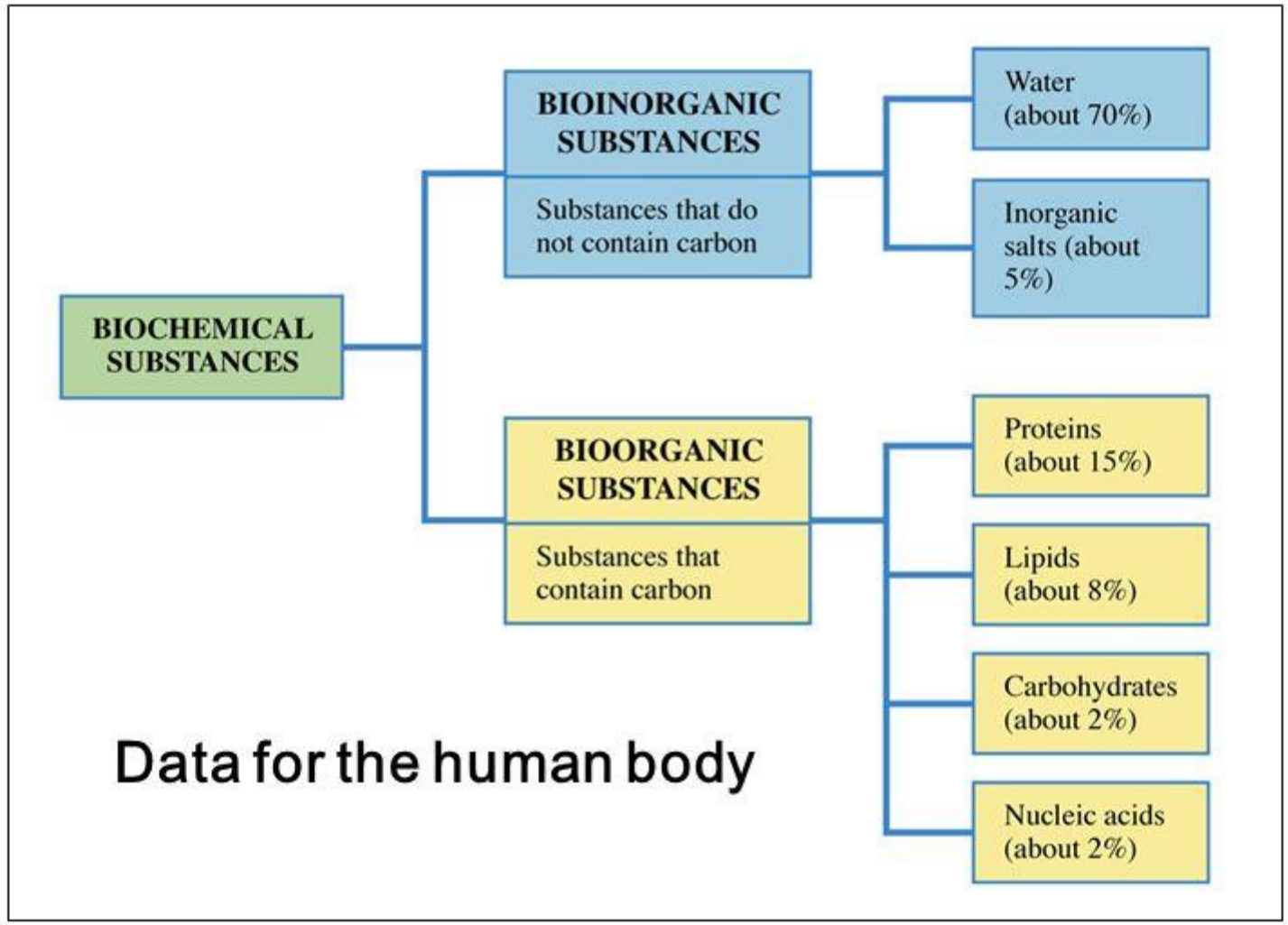
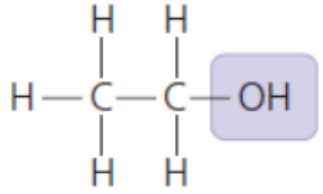
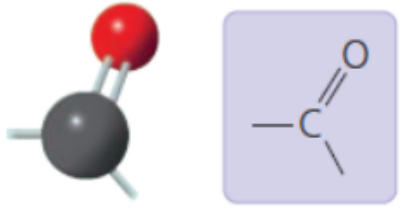
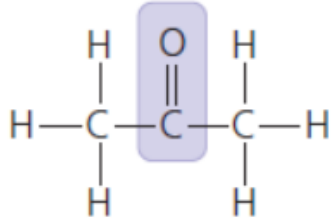
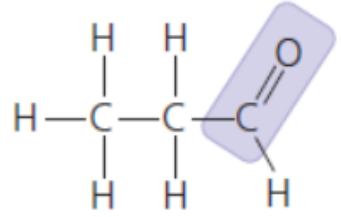
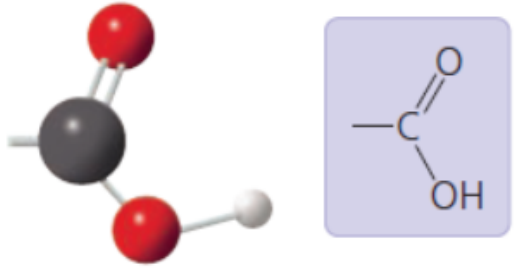
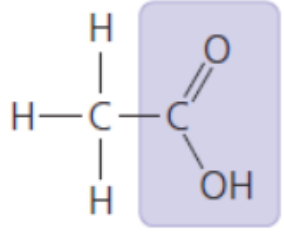
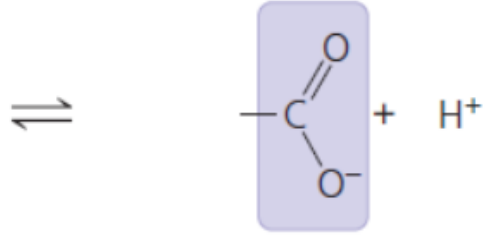
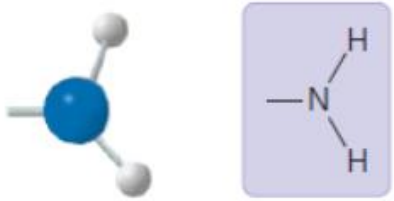
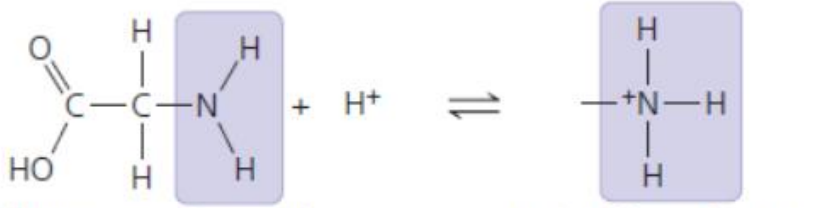
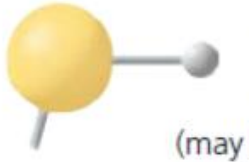
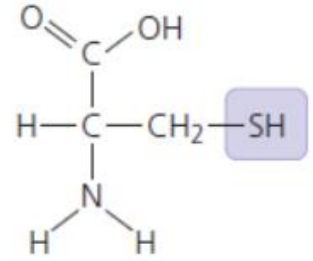
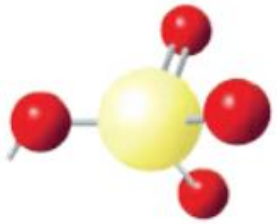
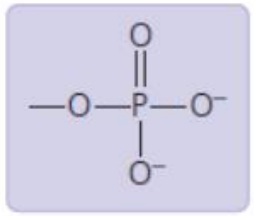
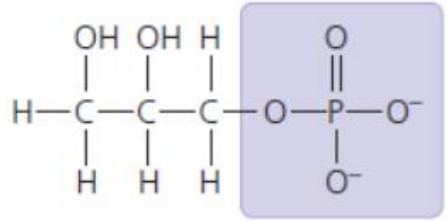
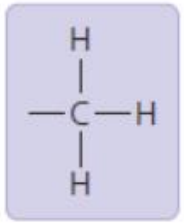
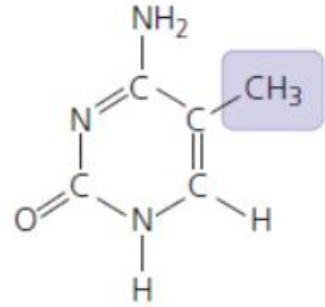
Biomolecules

Mass composition data for the human body in terms of major types of biochemical substances.



▼ **Figure 4.9** Some biologically important chemical groups.

Chemical Group	Group Properties and Compound Name	Examples
Hydroxyl group (—OH)  (may be written HO—)	Is polar due to electronegative oxygen. Forms hydrogen bonds with water, helping dissolve compounds such as sugars. Compound name: Alcohol (specific name usually ends in *-ol*)	 **Ethanol**, the alcohol present in alcoholic beverages
Carbonyl group (>C=O) 	Sugars with ketone groups are called ketoses; those with aldehydes are called aldoses. Compound name: Ketone (carbonyl group is within a carbon skeleton) or aldehyde (carbonyl group is at the end of a carbon skeleton)	 **Acetone**, the simplest ketone  **Propanal**, an aldehyde
Carboxyl group (—COOH) 	Acts as an acid (can donate H^+) because the covalent bond between oxygen and hydrogen is so polar. Compound name: Carboxylic acid, or organic acid	 **Acetic acid**, which gives vinegar its sour taste  Ionized form of —COOH (carboxylate ion), found in cells

Amino group (—NH_2)  	Acts as a base; can pick up an H^+ from the surrounding solution (water, in living organisms). Compound name: Amine	 **Glycine**, an amino acid (note its carboxyl group) Ionized form of —NH_2, found in cells
Sulfhydryl group (—SH)  —SH (may be written HS—)	Two —SH groups can react, forming a "cross-link" that helps stabilize protein structure. Hair protein cross-links maintain the straightness or curliness of hair; in hair salons, permanent treatments break cross-links, then re-form them while the hair is in the desired shape. Compound name: Thiol	 **Cysteine**, a sulfur-containing amino acid
Phosphate group (—OPO_3^{2-})  	Contributes negative charge (1– when positioned inside a chain of phosphates; 2– when at the end). When attached, confers on a molecule the ability to react with water, releasing energy. Compound name: Organic phosphate	 **Glycerol phosphate**, which takes part in many important chemical reactions in cells
Methyl group (—CH_3)  	Affects the expression of genes when on DNA or on proteins bound to DNA. Affects the shape and function of male and female sex hormones. Compound name: Methylated compound	 **5-Methyl cytosine**, a component of DNA that has been modified by addition of a methyl group

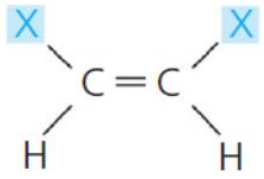
สารประกอบที่มีสูตรโมเลกุลเหมือนกันอาจมีโครงสร้างที่แตกต่างกันและมีผลทำให้สารประกอบนั้นมีสมบัติต่างกัน

สารประกอบที่เป็นไอโซเมอร์กันอาจมีสมบัติทางฟิสิกส์และเคมีไม่แตกต่างกัน แต่อาจมีชื่อเรียกแตกต่างกัน

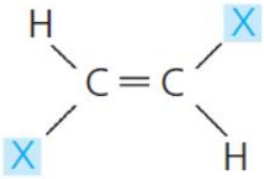
โดยทั่วไปจะมีเพียงไอโซเมอร์เดียวที่สามารถแสดงสมบัติทางชีวภาพได้

Isomers

(b) *Cis-trans* isomers



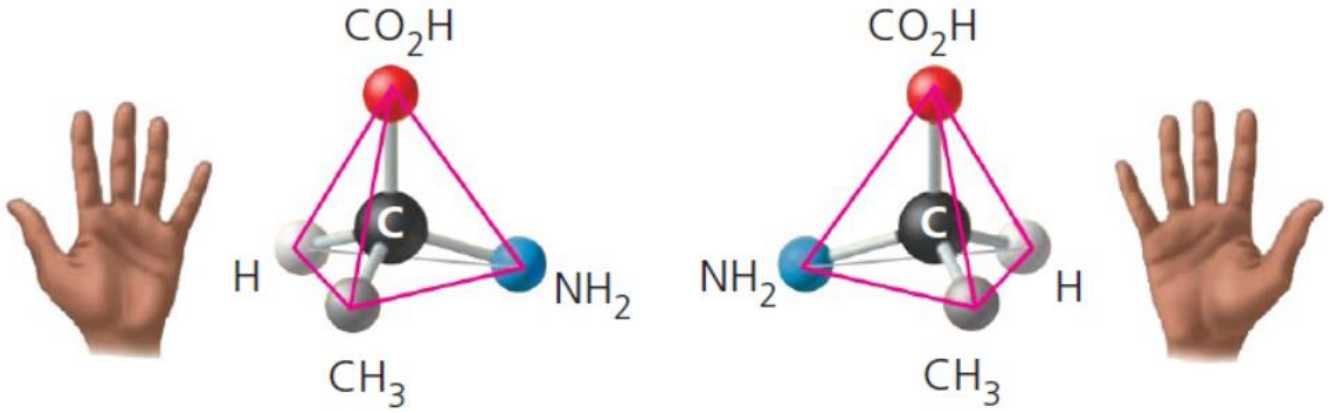
cis isomer: The two Xs are on the same side.



trans isomer: The two Xs are on opposite sides.

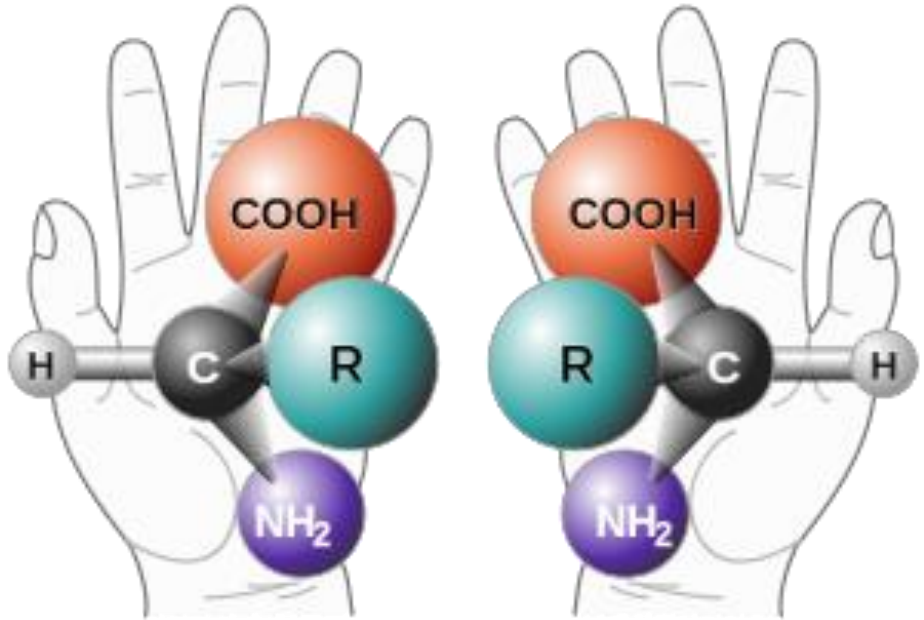
Cis-trans isomers differ in arrangement about a double bond. In these diagrams, X represents an atom or group of atoms attached to a double-bonded carbon.

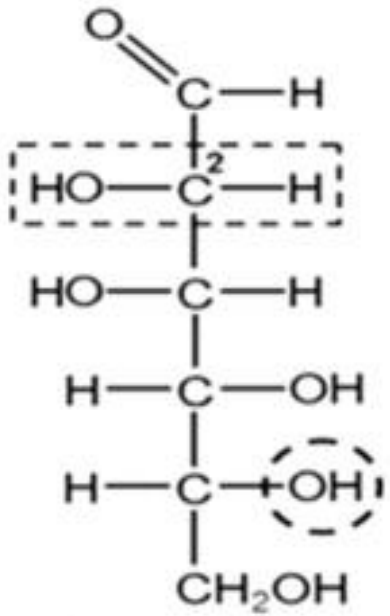
(c) Enantiomers



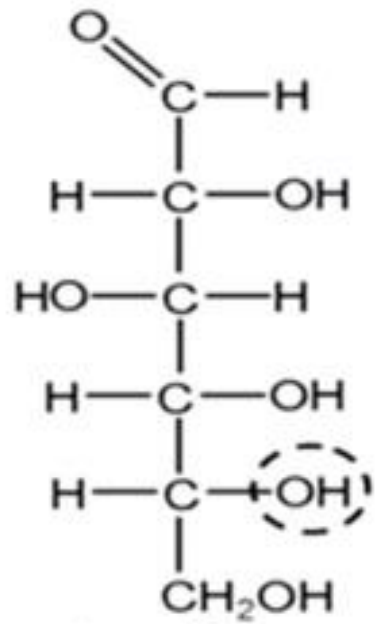
L isomer D isomer

Enantiomers differ in spatial arrangement around an asymmetric carbon, resulting in molecules that are mirror images, like left and right hands. The two isomers here are designated the L and D isomers from the Latin for "left" and "right" (*levo* and *dextro*). Enantiomers cannot be superimposed on each other.

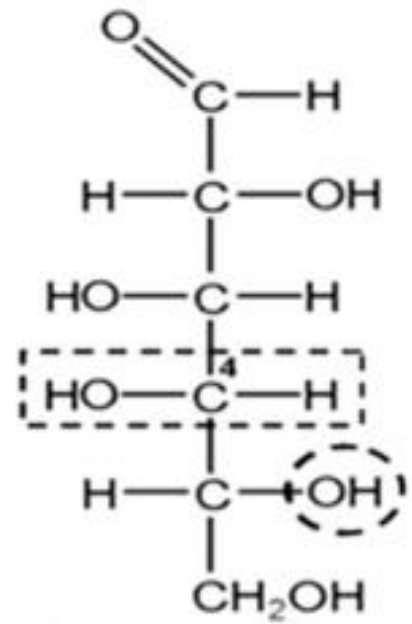




ดี-แมนโนส



ดี-กลูโคส



ดี-แกแลกโทส

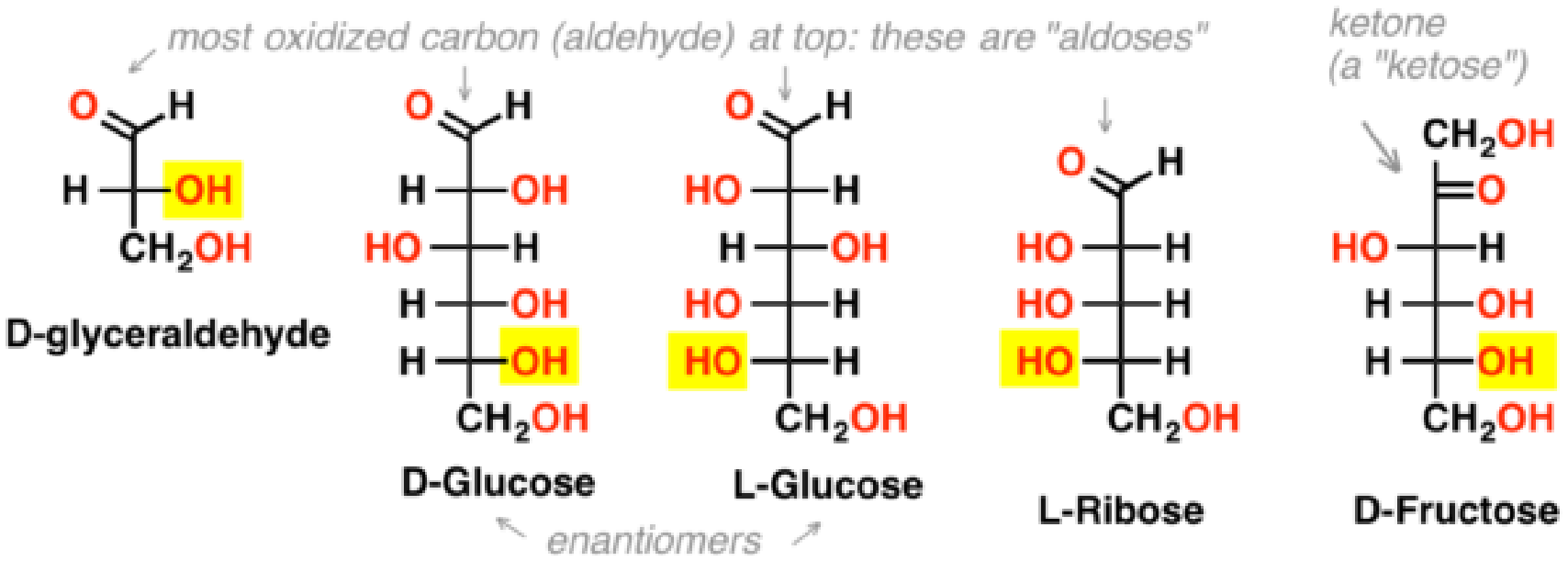
ตัวอย่างอีพิเมอร์ (epimer) ของมอโนแซ็กคาไรด์

Diastereoisomer = isomer ที่ไม่เป็นเงาในกระจกซึ่งกันและกัน เช่น อีพิเมอร์

D- and L- Sugars

For a sugar drawn in the Fischer projection with the most oxidized carbon at the top:

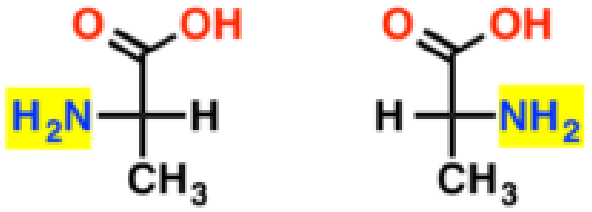
- If the OH on the bottom chiral center points to the **right**, the sugar is **D**
- If the OH on the bottom chiral center points to the **left**, the sugar is **L**



L- and D- is a means of describing the **absolute configuration** of a molecule that pre-dates *R* and *S* but is still used for some biological molecules (sugars, amino acids). It's a quick way of denoting enantiomers: e.g. L-glucose and D-glucose are enantiomers.

L- and D- have no relation to the optical rotation of a molecule.

The D- L- system can also be applied to other chiral molecules, e.g. amino acids:



- Organic molecules consisting only of **carbon** and **hydrogen** are called ***hydrocarbons.***
- Macromolecules are polymers, built from monomers
- The Synthesis and Breakdown of Polymers

Figure 5.2a

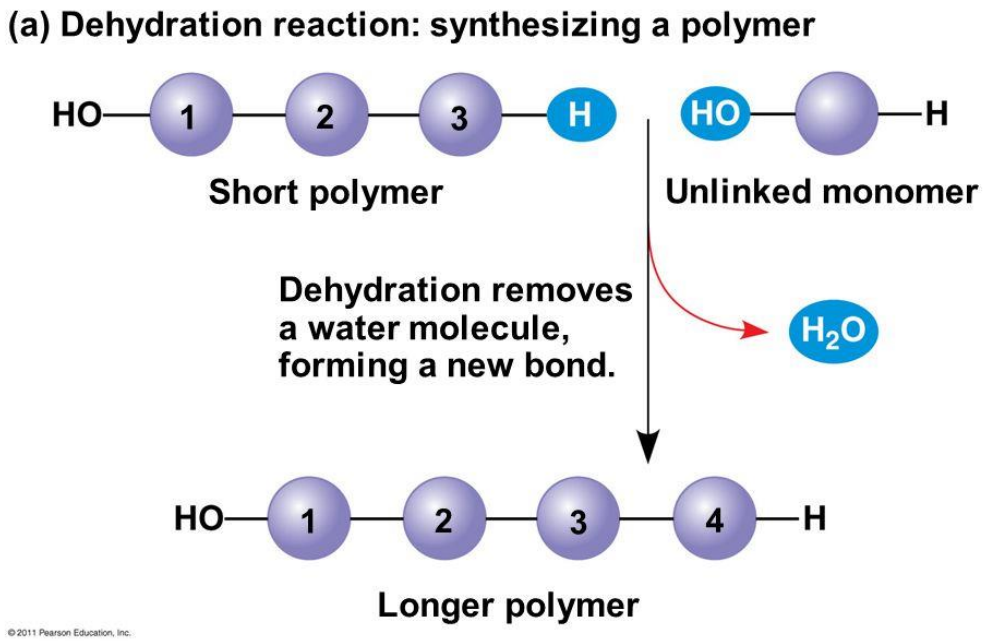
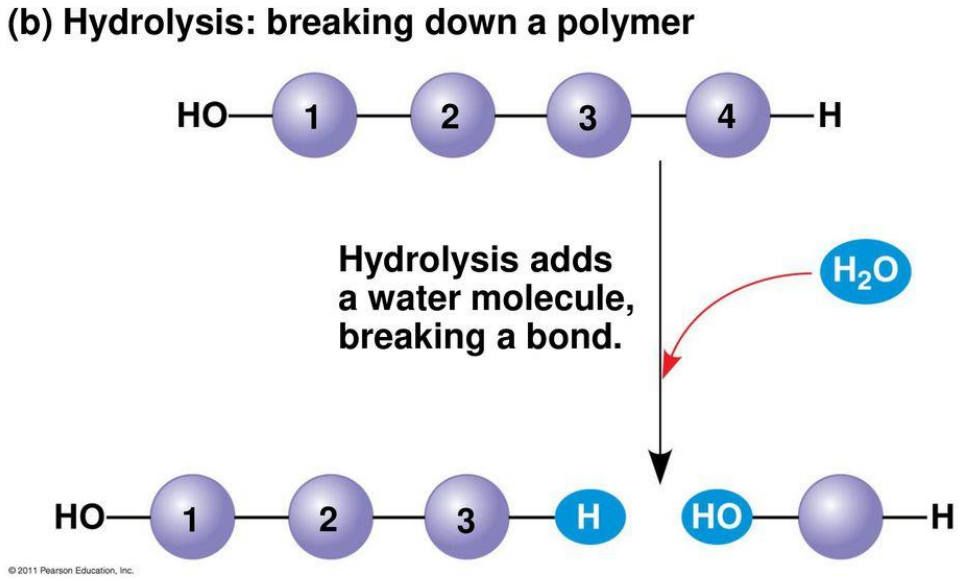


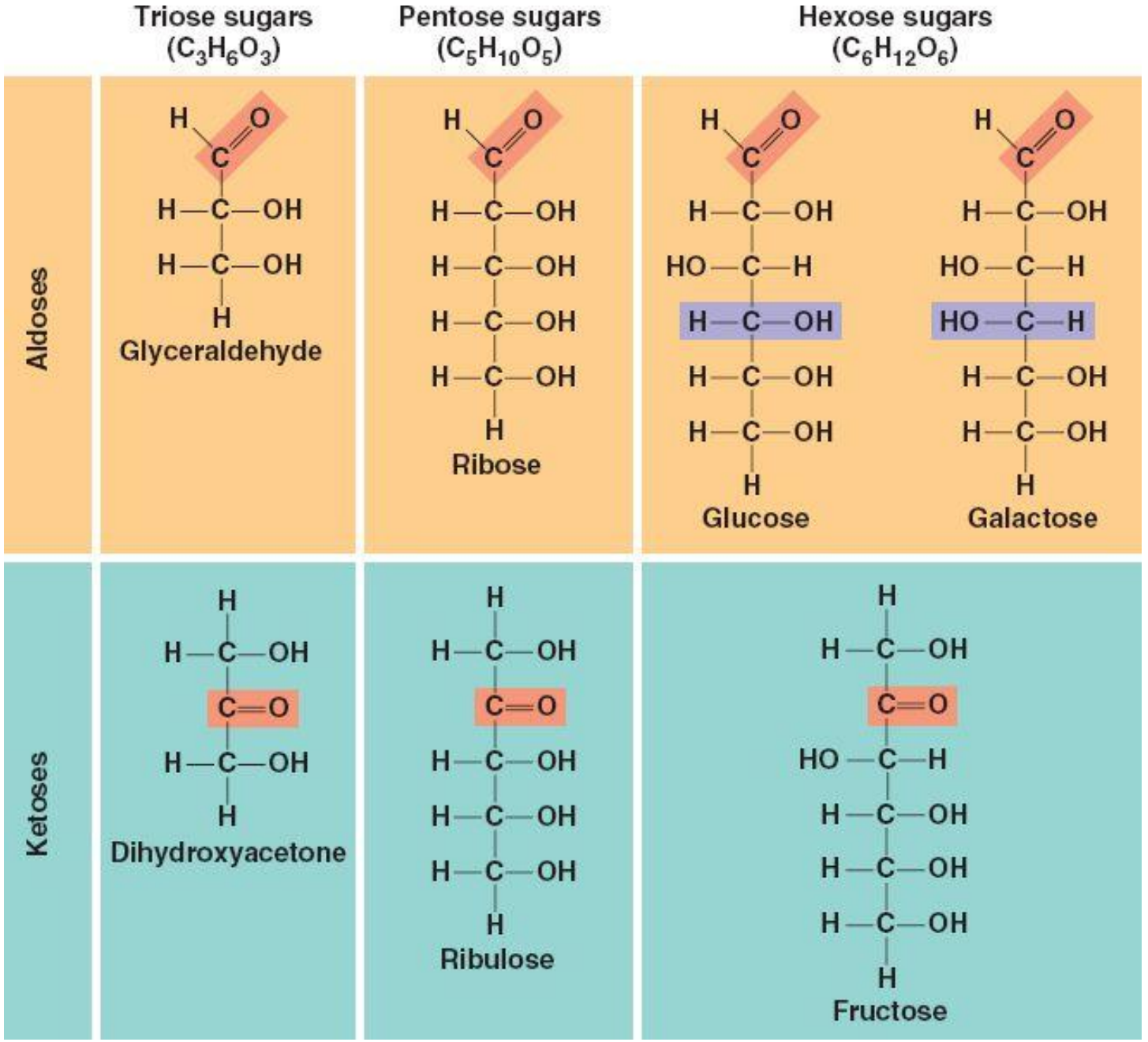
Figure 5.2b



Carbohydrates

The **carbohydrates** are a loosely defined group of molecules that contain **carbon, hydrogen, and oxygen** in the molar **ratio 1:2:1.** Their empirical formula is $(CH_2O)_n$, where n is the number of carbon atoms.

The structure and classification of some monosaccharides.



รู้ หรือไม่ ?

เพื่อบ่งบอกจำนวนคาร์บอนในมอโนแซ๊กคาไรด์ เรามักจะเรียกชื่อตาม จำนวนคาร์บอน ที่เป็นองค์ประกอบ โดยมีขั้นตอนการอ่าน ดังนี้

1.อ่านจำนวนคาร์บอนเป็นภาษากรีก

สาม อ่านว่า ไตร (tri)

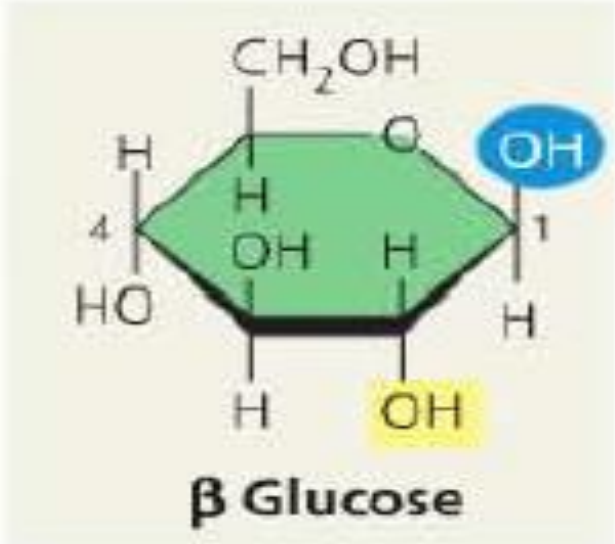
สี่ อ่านว่า เตตระ (tetra)

ห้า อ่านว่า เพนตะ (penta)

หก อ่านว่า เฮกซะ (hexa)

เจ็ด อ่านว่า เฮปตะ (hepta)

2. อ่านลงท้ายเสียง ด้วยคำว่า-โอส (-ose)



= **Hexose**

จำนวนอะตอมคาร์บอน	ชื่อมอโนแซ็กคาไรด์	สูตรโมเลกุล	ตัวอย่าง
3			
4			
5			
6			

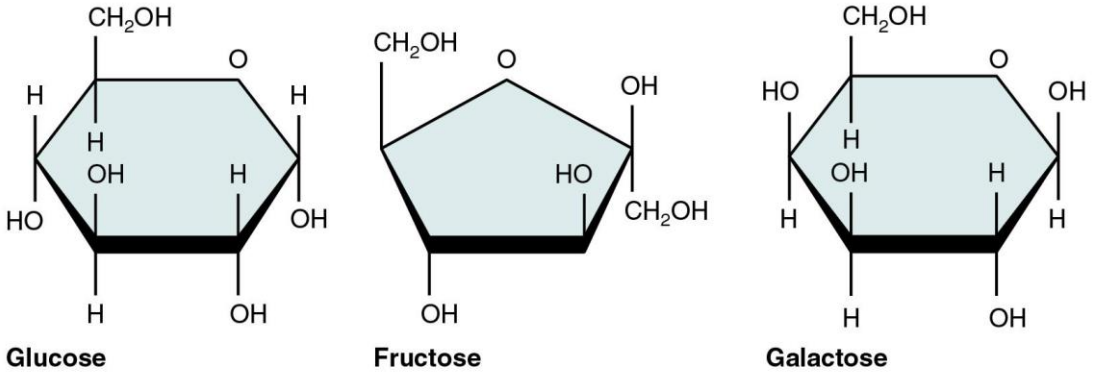
Carbohydrates

Monosaccharide

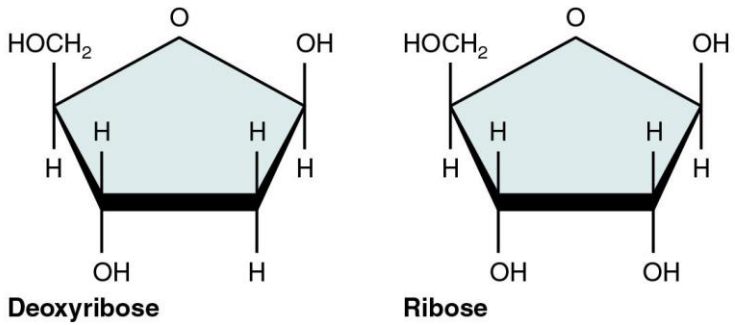
Oligosaccharide

Polysaccharide

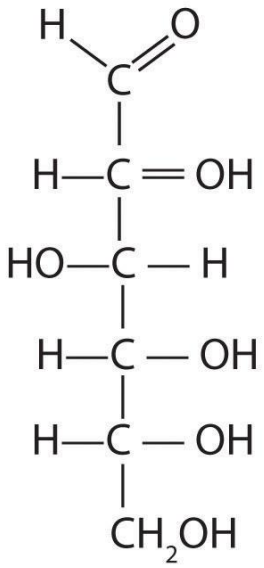
Monosaccharide



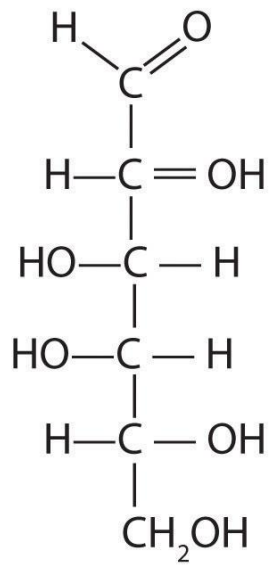
(a) Hexoses



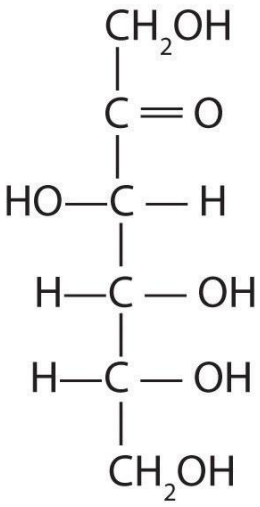
(b) Pentoses



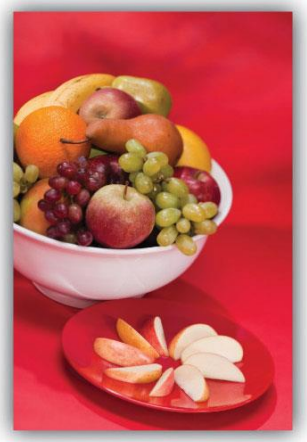
D-(+)-glucose



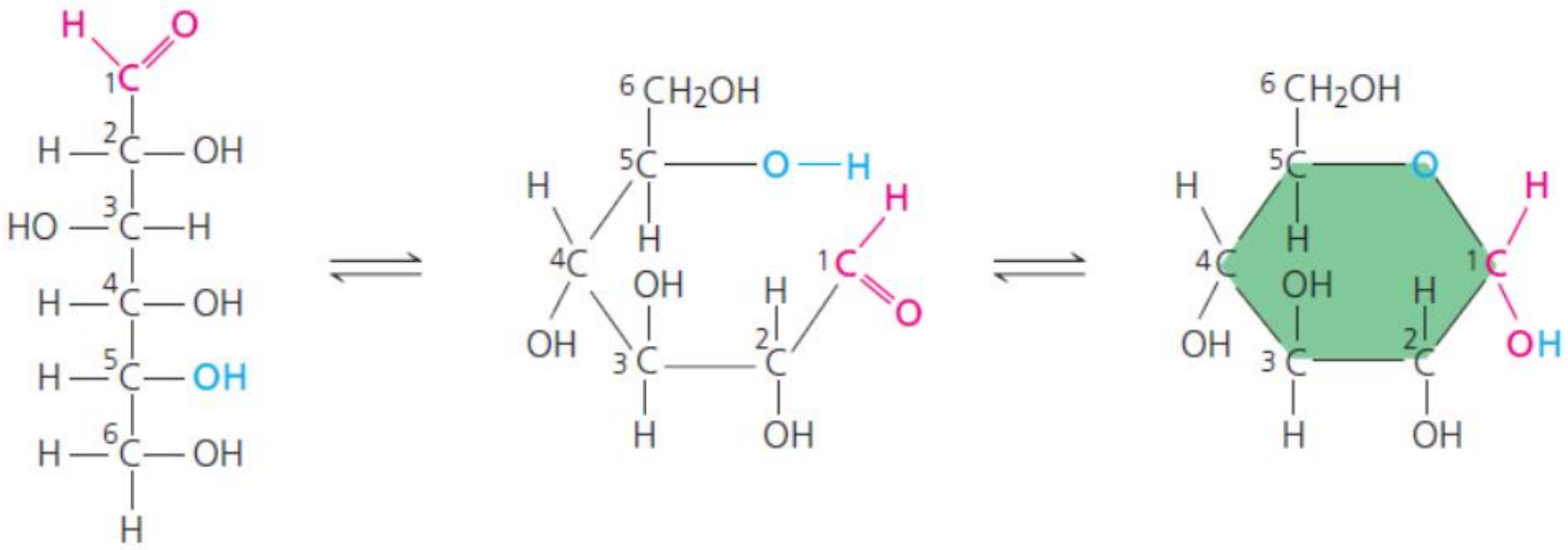
D-(+)-galactose



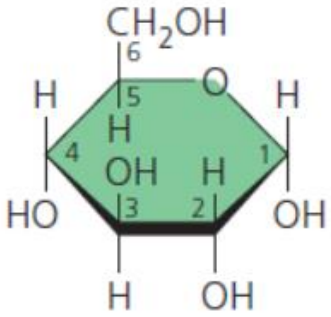
D-(–)-fructose



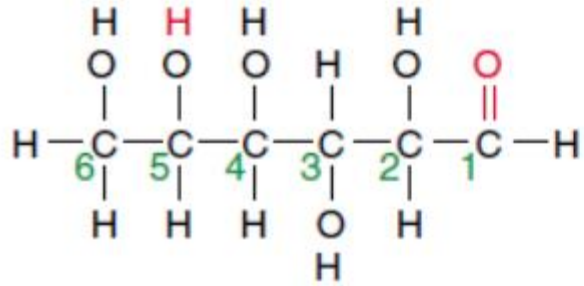
➢ เพิ่มเติม : Linear and ring forms of glucose.

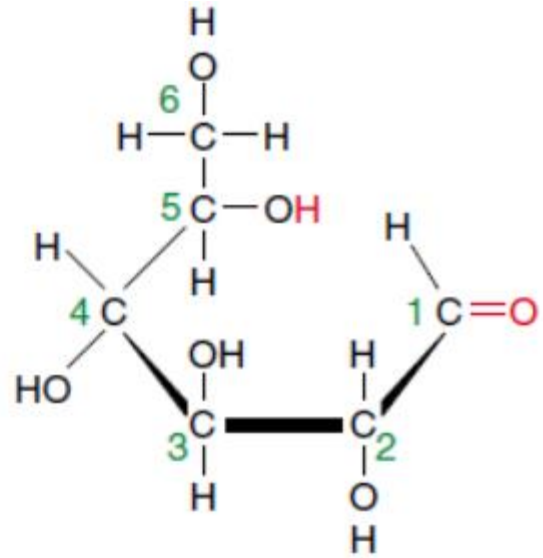


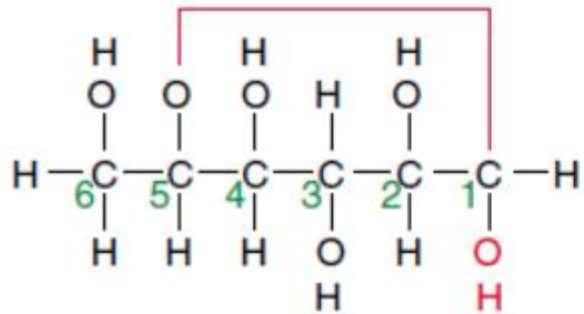
(a) Linear and ring forms. Chemical equilibrium between the linear and ring structures greatly favors the formation of rings. The carbons of the sugar are numbered 1 to 6, as shown. To form the glucose ring, carbon 1 (magenta) bonds to the oxygen (blue) attached to carbon 5.

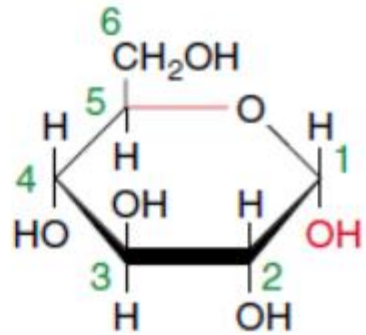


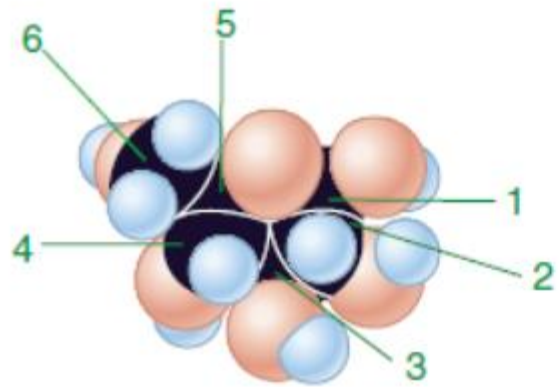
(b) Abbreviated ring structure. Each unlabeled corner represents a carbon. The ring's thicker edge indicates that you are looking at the ring edge-on; the components attached to the ring lie above or below the plane of the ring.

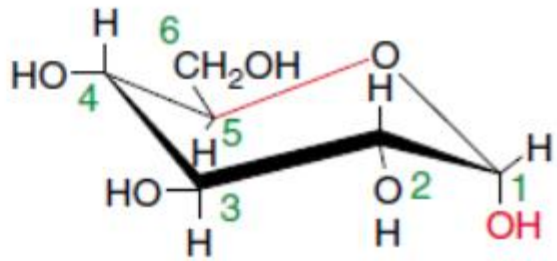


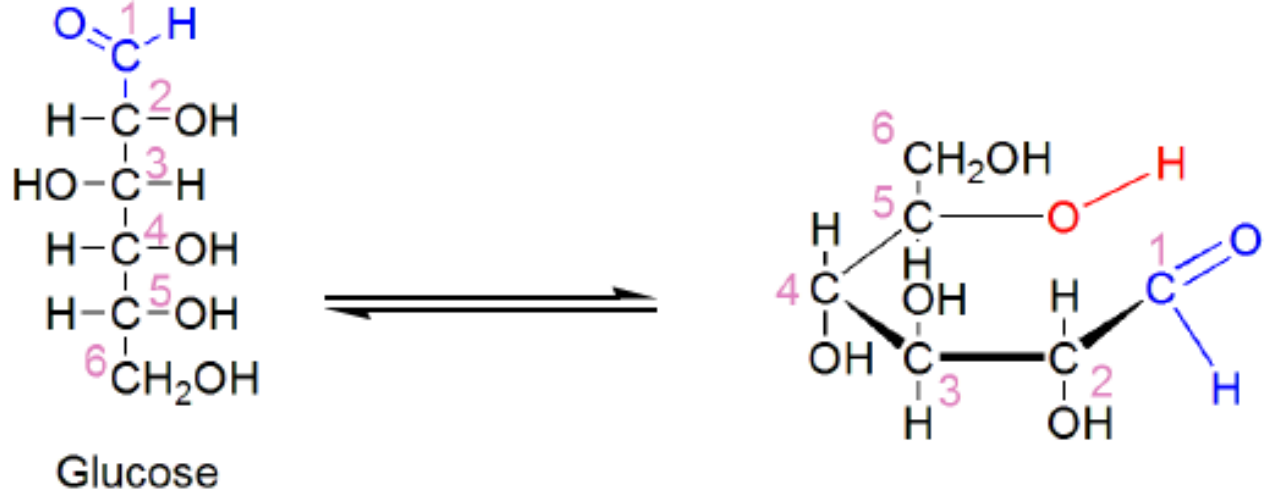




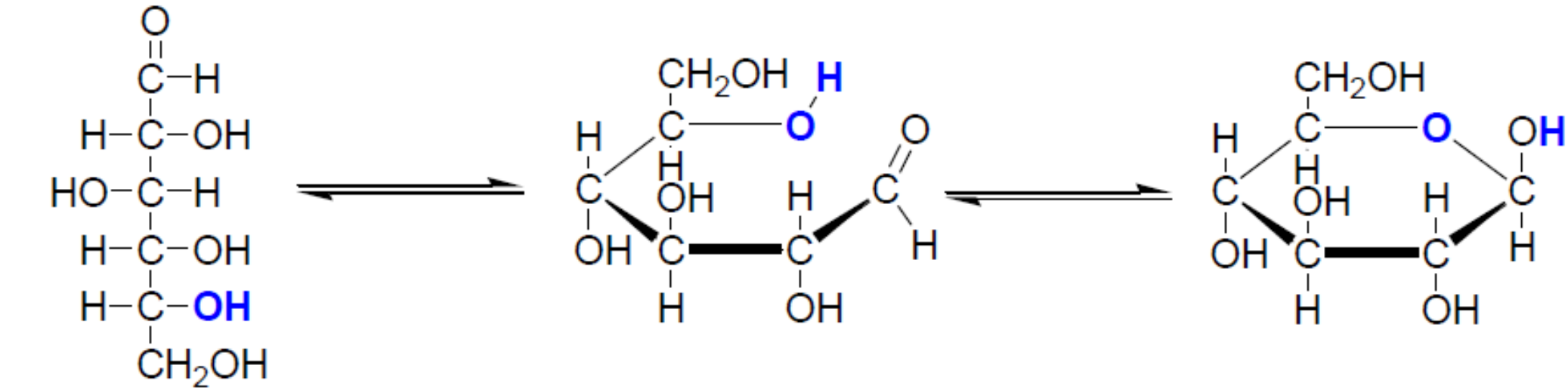






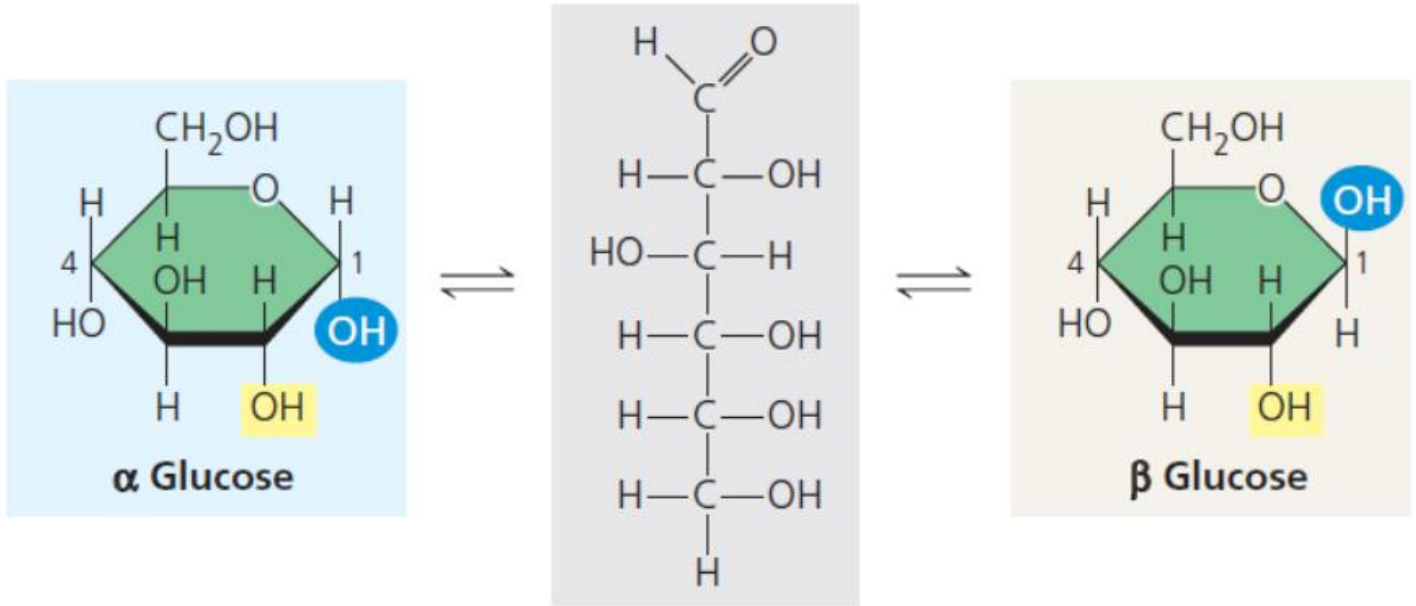


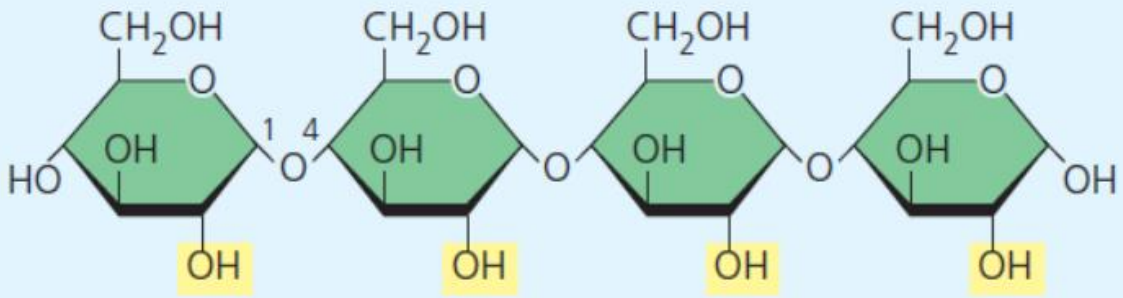
ภาพ Fischer Projection ของกลูโคสและเปิดบิดโครงสร้าง



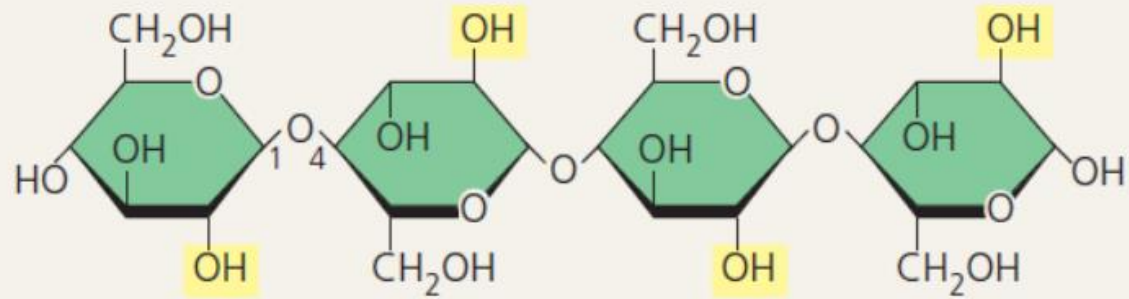
ภาพ การเกิดโครงสร้างแบบวงของกลูโคส

(a) α and β glucose ring structures. These two interconvertible forms of glucose differ in the placement of the hydroxyl group (highlighted in blue) attached to the number 1 carbon.





(b) Starch: 1–4 linkage of α glucose monomers. All monomers are in the same orientation. Compare the positions of the —OH groups highlighted in yellow with those in cellulose (c).

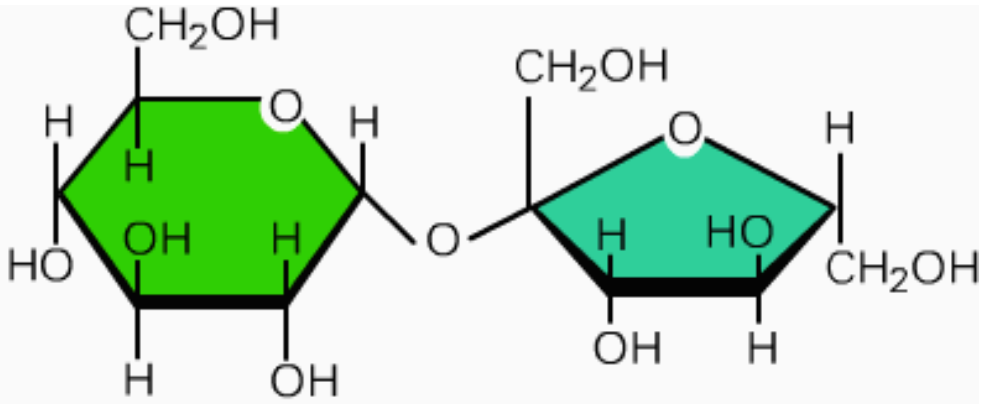


(c) Cellulose: 1–4 linkage of β glucose monomers. In cellulose, every β glucose monomer is upside down with respect to its neighbors. (See the highlighted —OH groups.)

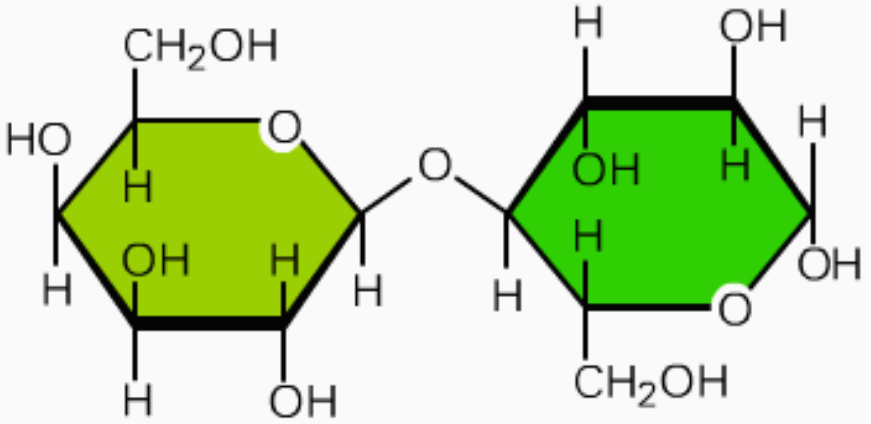
▲ Figure 5.7 Starch and cellulose structures.

Disaccharide

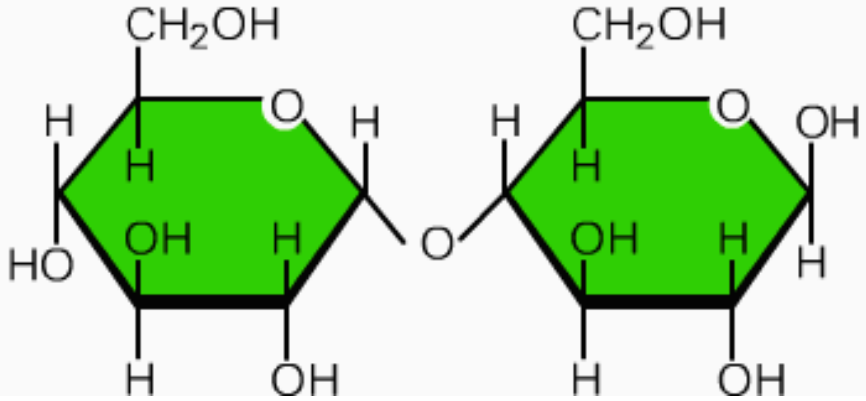
Sucrose
(glucose and fructose)



Lactose
(galactose and glucose)

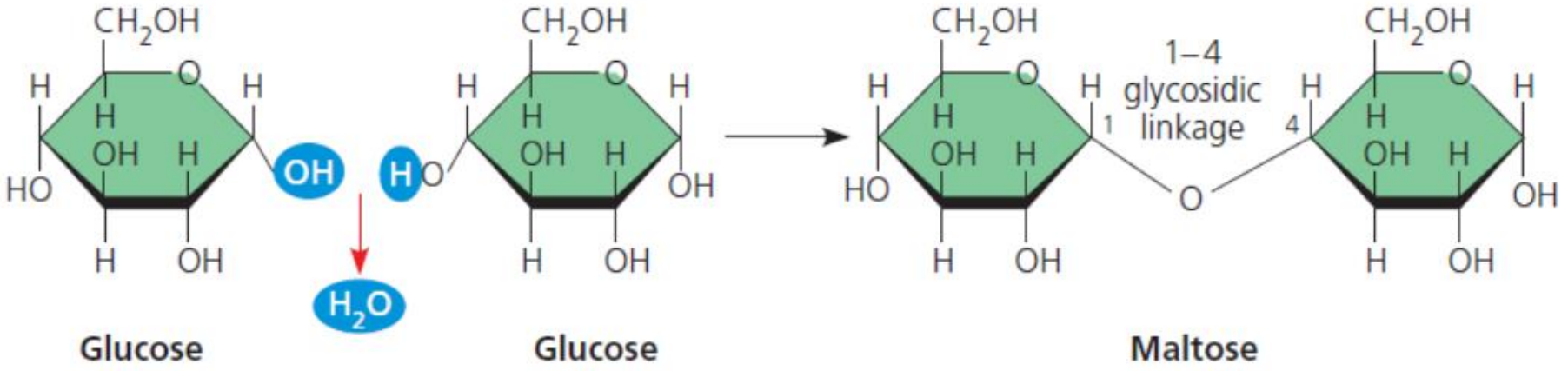


Maltose
(glucose and glucose)

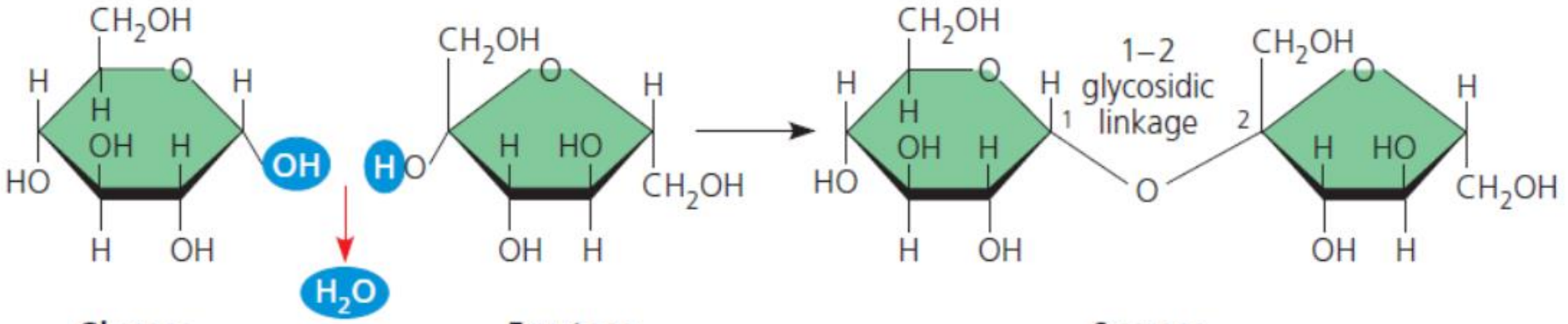


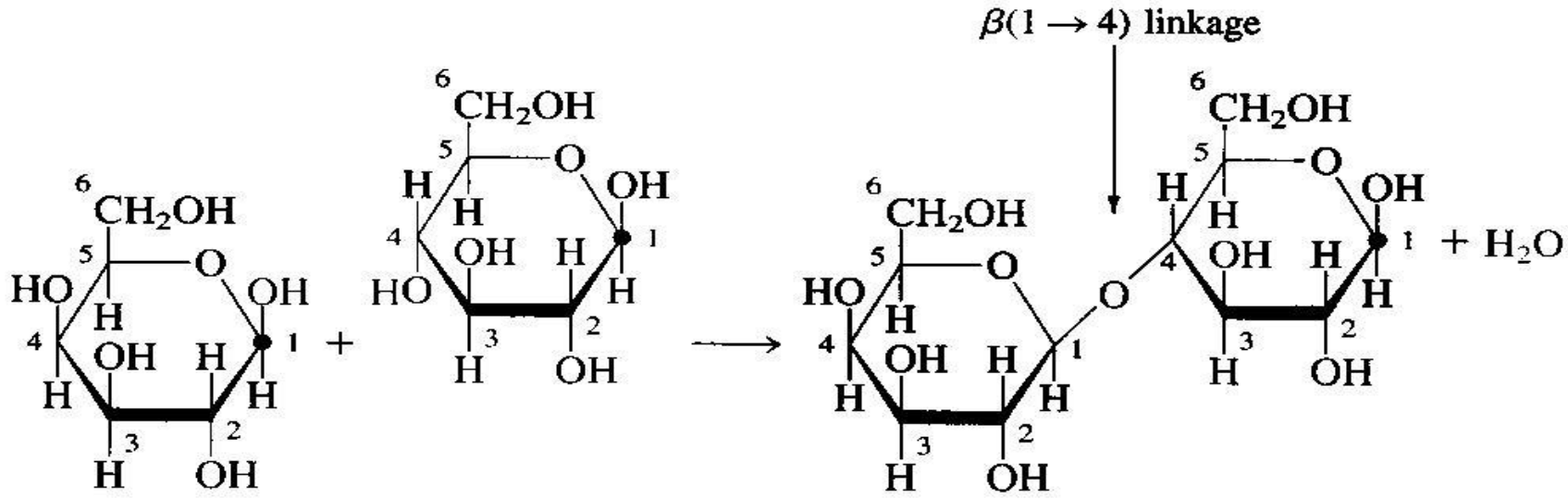
➢ Examples of disaccharide synthesis.

(a) Dehydration reaction in the synthesis of maltose. The bonding of two glucose units forms maltose. The 1–4 glycosidic linkage joins the number 1 carbon of one glucose to the number 4 carbon of the second glucose. Joining the glucose monomers in a different way would result in a different disaccharide.



(b) Dehydration reaction in the synthesis of sucrose. Sucrose is a disaccharide formed from glucose and fructose. Notice that fructose forms a five-sided ring, though it is a hexose like glucose.

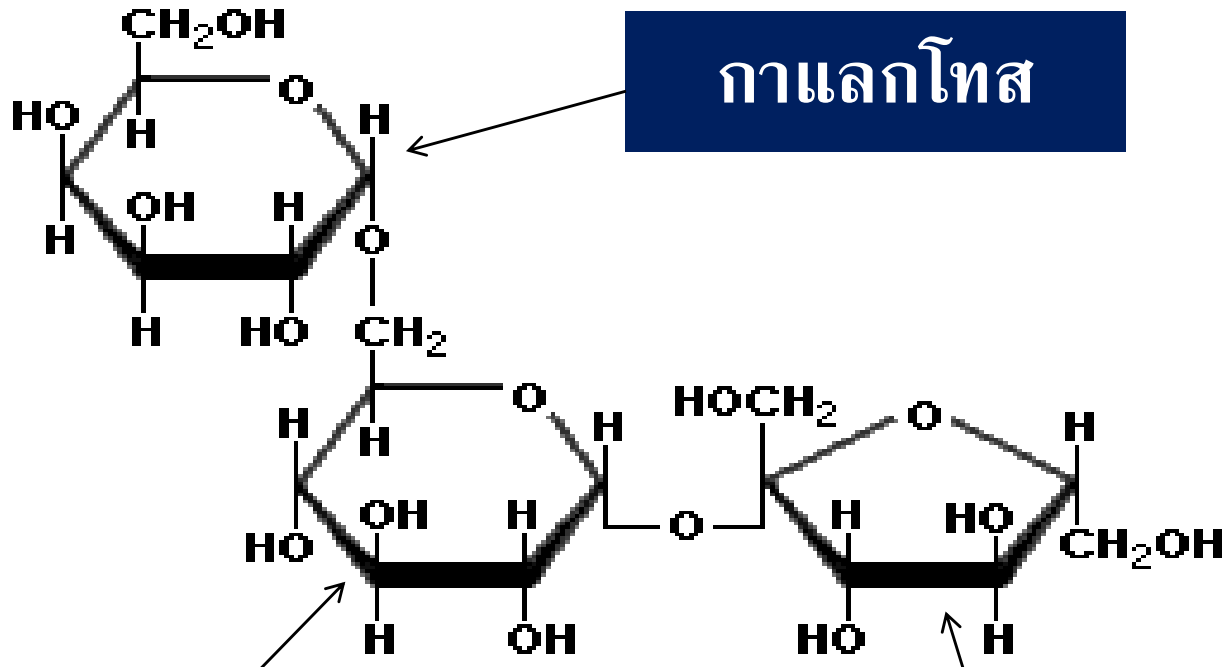




β-D-Galactose β-D-Glucose β-Lactose

trisaccharide

raffinose

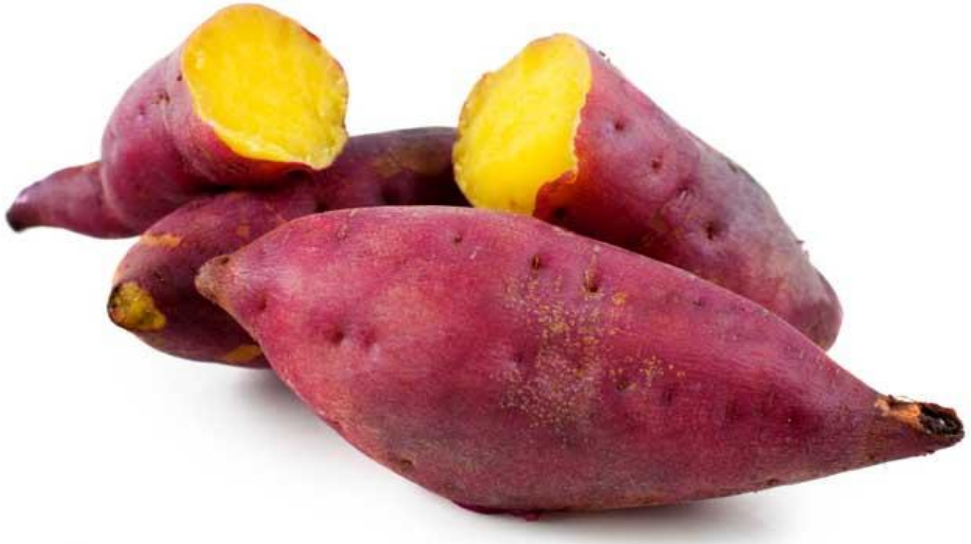


แหล่งที่พบ

หัวบีทรูท (*Beta vulgaris* L.)

Polysaccharide

Polysaccharides are macromolecules, polymers with a few hundred to a few thousand monosaccharides joined by glycosidic linkages.



Storage structures (plastids) containing starch granules in a potato tuber cell

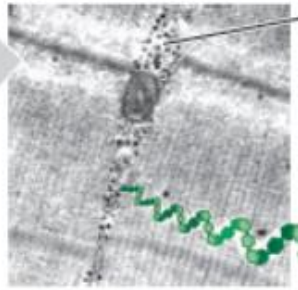
50 µm

(a) Starch

Amylose (unbranched)

Glucose monomer

Amylopectin (somewhat branched)

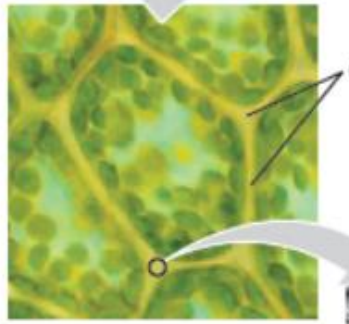


Glycogen granules in muscle tissue

1 µm

(b) Glycogen

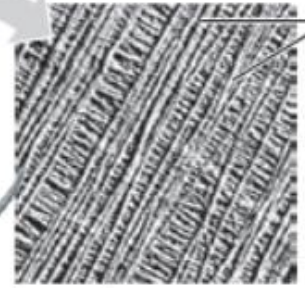
Glycogen (branched)



Cell wall

Plant cell, surrounded by cell wall

10 µm



Cellulose microfibrils in a plant cell wall

0.5 µm

Microfibril (bundle of about 80 cellulose molecules)

Cellulose molecule (unbranched)

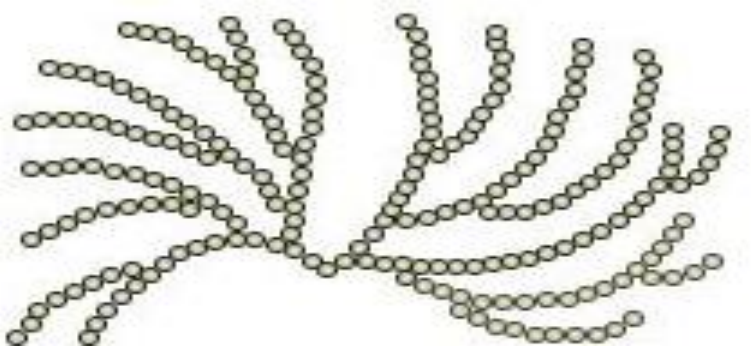
Hydrogen bonds between parallel cellulose molecules hold them together.

(c) Cellulose

เปรียบเทียบ Glycogen & Amylopectin

Amylopectin

โครงสร้าง : โมเลกุลของกลูโคสเรียงตัวต่อกัน และมีการแตกแขนง



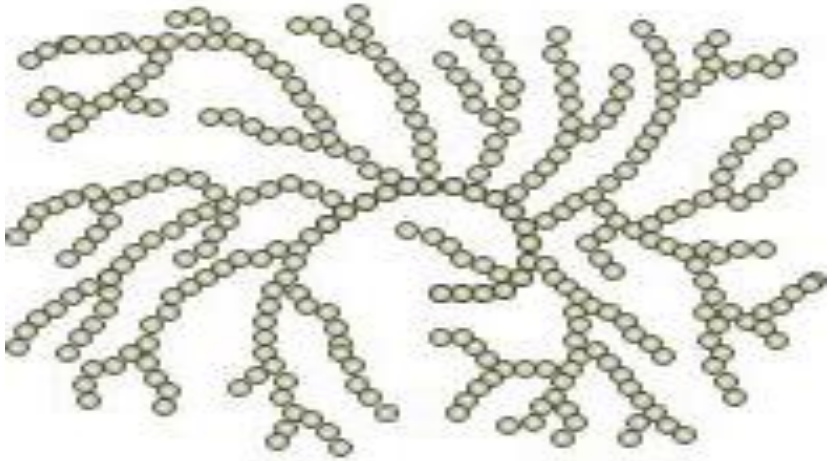
ข้อต่าง

มีขนาดเล็ก เพราะความถี่ในการแตกกิ่งน้อยกว่า (ทุก ๆ 20-24 หน่วย)

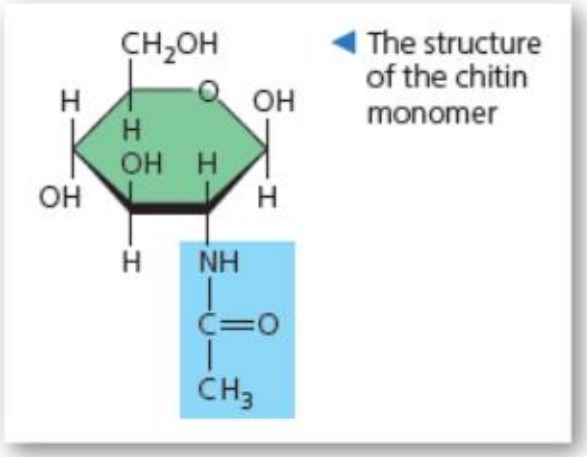
ข้อเหมือน

Glycogen

โครงสร้าง : โมเลกุลของกลูโคสเรียงตัวต่อกัน และมีการแตกแขนง



มีขนาดใหญ่ เพราะความถี่ในการแตกกิ่งมากกว่า (ทุก ๆ 8-12 หน่วย)



◀ The structure of the chitin monomer

◀ Chitin, embedded in proteins, forms the exoskeleton of arthropods. This cicada is molting—shedding its old exoskeleton and emerging in adult form.

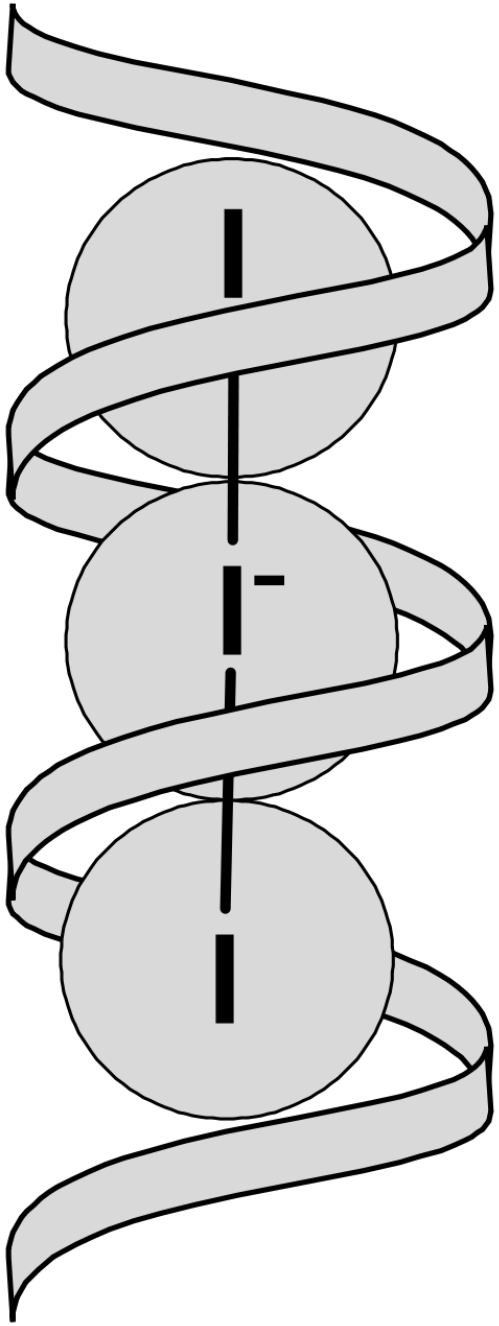
▶ Chitin is used to make a strong and flexible surgical thread that decomposes after the wound or incision heals.

▲ **Figure 5.8** **Chitin, a structural polysaccharide.**

ตารางที่ 2.12 ความหวานสัมพัทธ์ (relative sweetness) ของน้ำตาลและสารแทนน้ำตาล (sugar substitute)

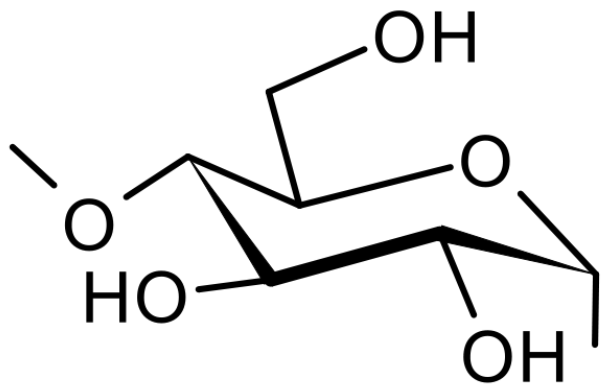
ชนิดของน้ำตาล	ความหวานสัมพัทธ์	ชนิดของสารให้ความหวานสังเคราะห์	ความหวานสัมพัทธ์
แลกโทส (น้ำตาลนม)	0.16	ไซคลาเมต (cyclamate)	30.00
มอลโทส (น้ำตาลมอลต์)	0.33	แอสพาร์แทม (aspartame)	150.00
กลูโคส (น้ำตาลในเลือด)	0.75	สเตเวียหรือหญ้าหวาน (stevia)	300.00
ซูโครส (น้ำตาลทราย)	1.00	แซ็กคาริน (saccharin)	350.00
ฟรุกโทส (น้ำตาลผลไม้)	1.75	ซูคราโลส (sucralose)	600.00

ที่มา: Enger, Ross and Bailey, 2009, หน้า 52



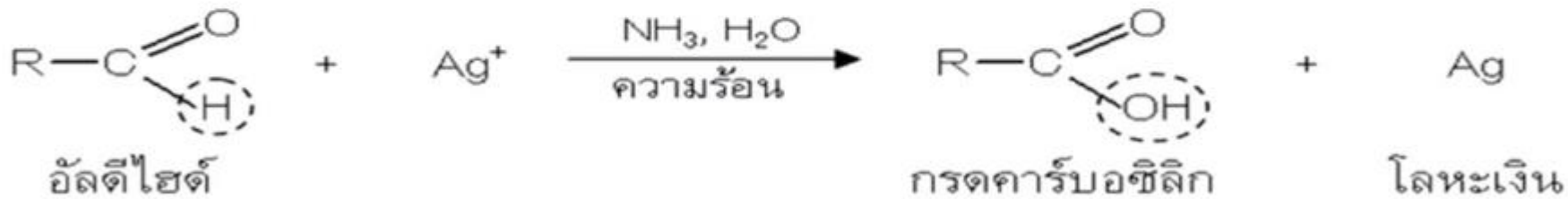
Amylosehelice with the

glucose-monomerunit:



(2) การทดสอบน้ำตาลรีดิวซ์ (reducing sugar)

การทดสอบด้วยสารละลายทอลเลนซ์ (Tollens' test)

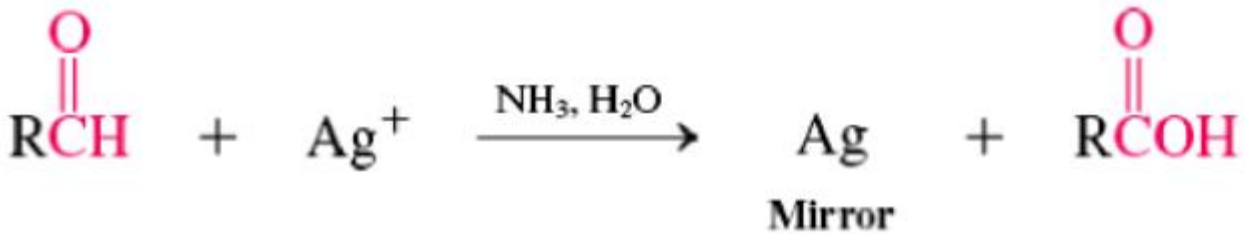


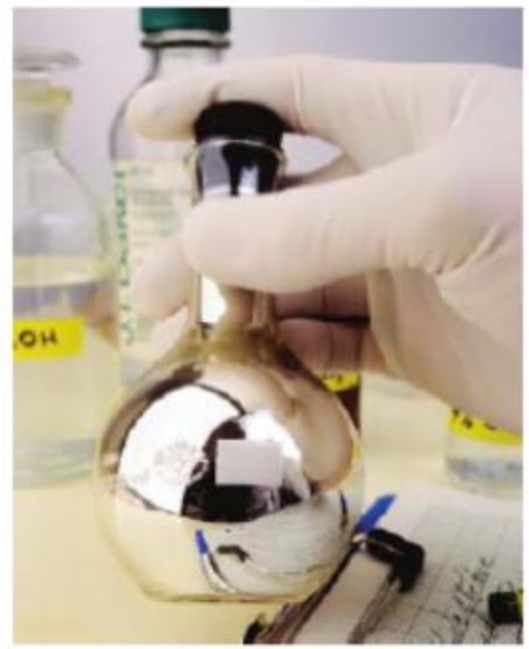
อัลดีไฮด์ กรดคาร์บอซิลิก โลหะเงิน

Tollens' reagent

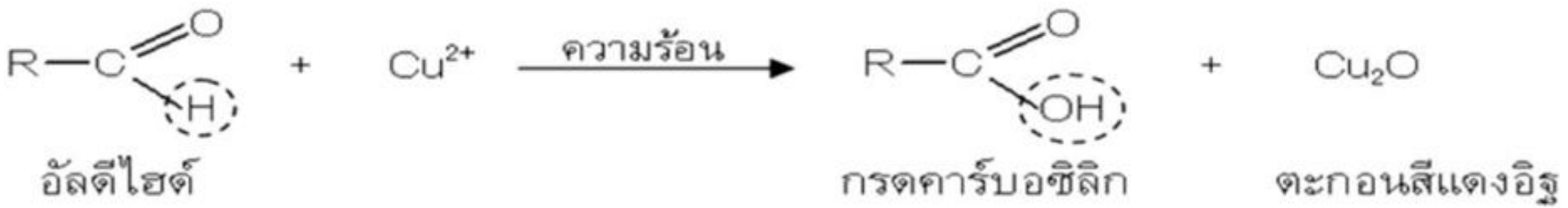
Aldehydes ถูกออกซิไดซ์ได้ด้วยตัวออกซิไดซ์อย่างอ่อน เช่น

Tollens' reagent (silver ion in ammonia solution) โดยเห็นโลหะเงินจับที่ข้างหลอดคล้ายกระจกเงา เรียกว่า silver mirror

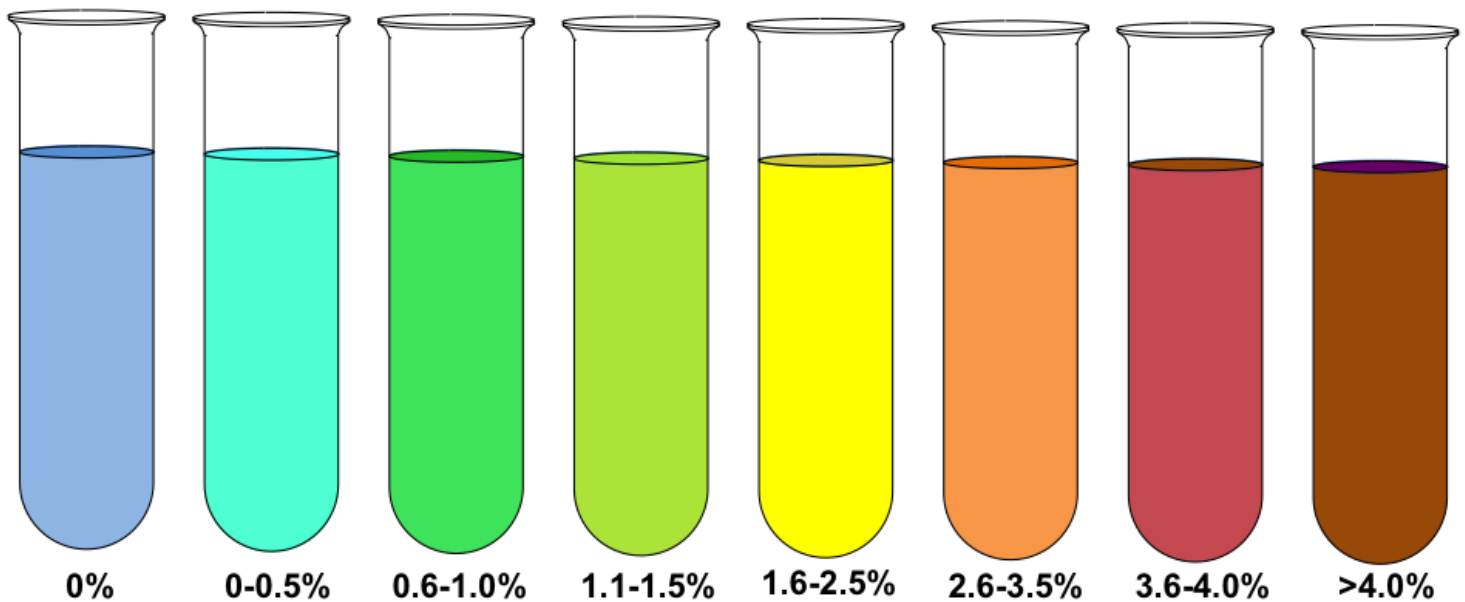




การทดสอบด้วยสารละลายเบเนดิกส์ (Benedicts' test)

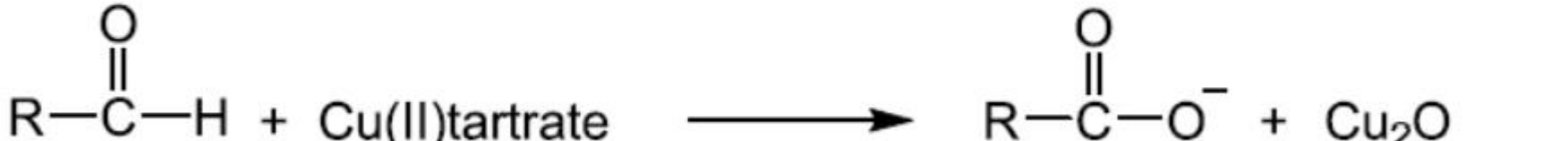


Benedict's test for sugars



Fehling's solution

$CuSO_4$ + NaOH + K-tartrate ⟶ Cu(II)tartrate complex



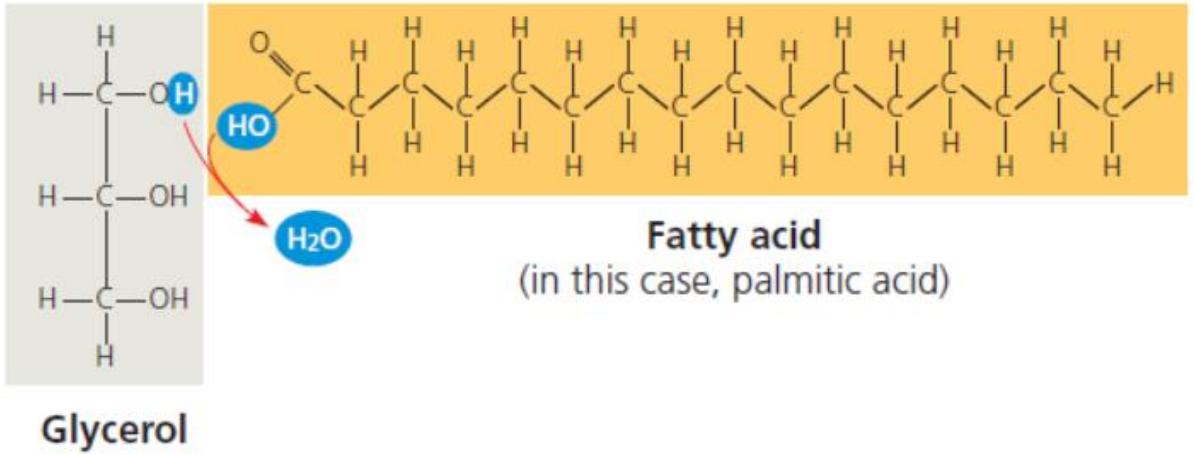
ตะกอนสีแดงอิฐ

Cu จะอยู่ในรูป Cu^{2+} เมื่อเกิดปฏิกิริยา

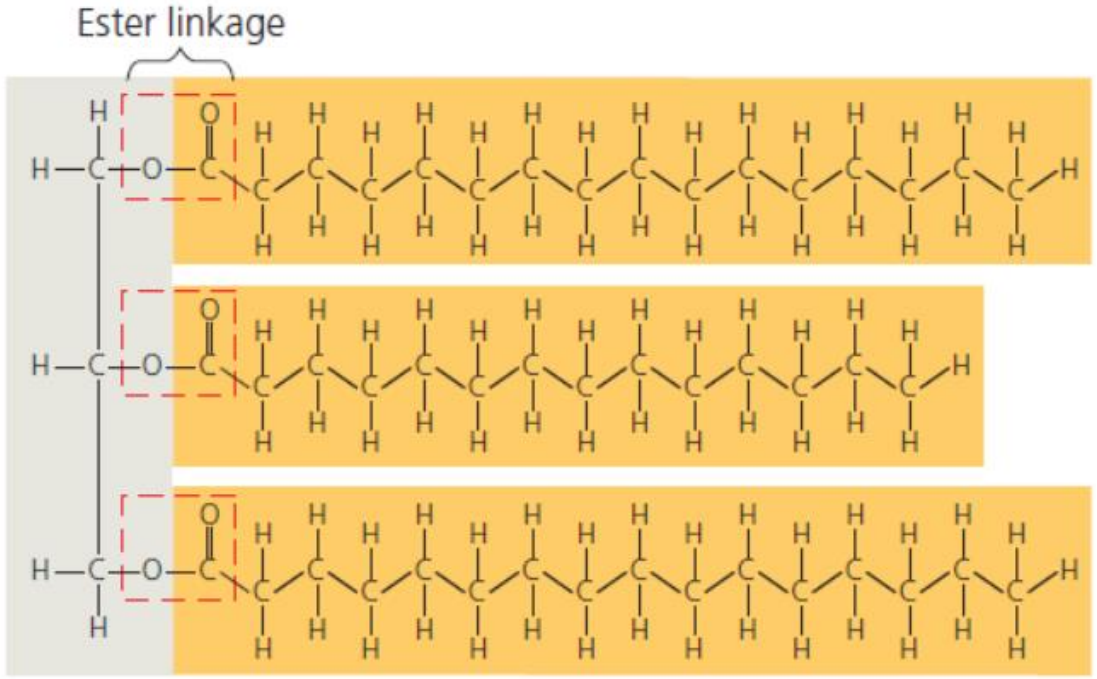
Cu^{2+} จะถูกรีดิวซ์เป็น Cu^{+}

Lipids

- Although fats are not polymers, they are large molecules assembled from smaller molecules by dehydration reactions.
- A fat is constructed from two kinds of smaller



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



(b) Fat molecule (triacylglycerol)

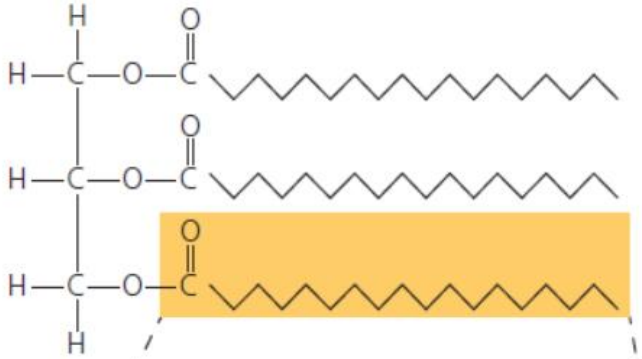
- **Glycerol is an alcohol**; each of its three carbons bears a hydroxyl group.
- **A fatty acid** has a long carbon skeleton, usually 16 or 18 carbon

The terms **saturated fats** and **unsaturated fats** are commonly used in the context of nutrition.

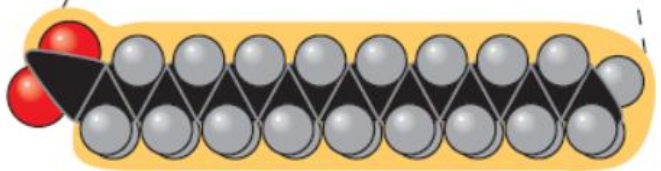
(a) Saturated fat

At room temperature, the molecules of a saturated fat, such as the fat in butter, are packed closely together, forming a solid.

Structural formula of a saturated fat molecule (Each hydrocarbon chain is represented as a zigzag line, where each bend represents a carbon atom and hydrogens are not shown.)



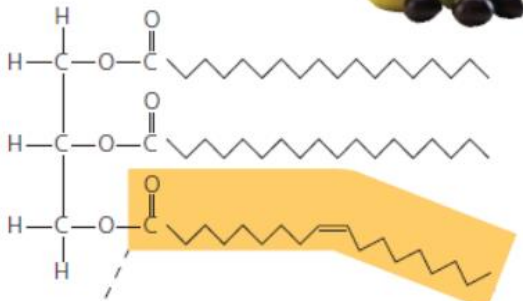
Space-filling model of stearic acid, a saturated fatty acid (red = oxygen, black = carbon, gray = hydrogen)



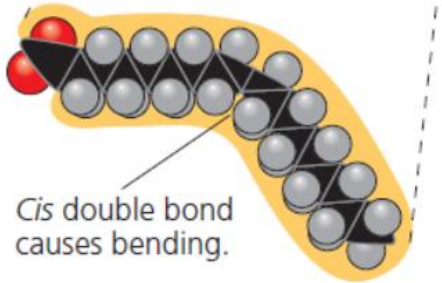
(b) Unsaturated fat

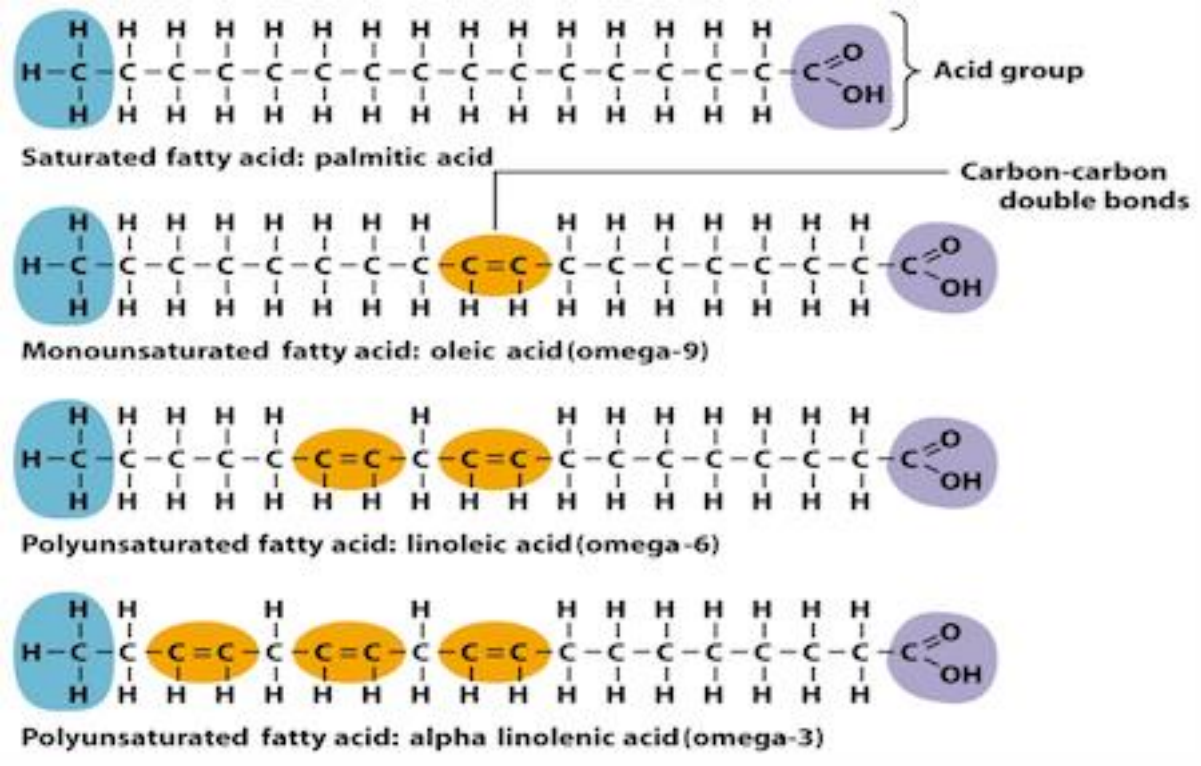
At room temperature, the molecules of an unsaturated fat such as olive oil cannot pack together closely enough to solidify because of the kinks in some of their fatty acid hydrocarbon chains.

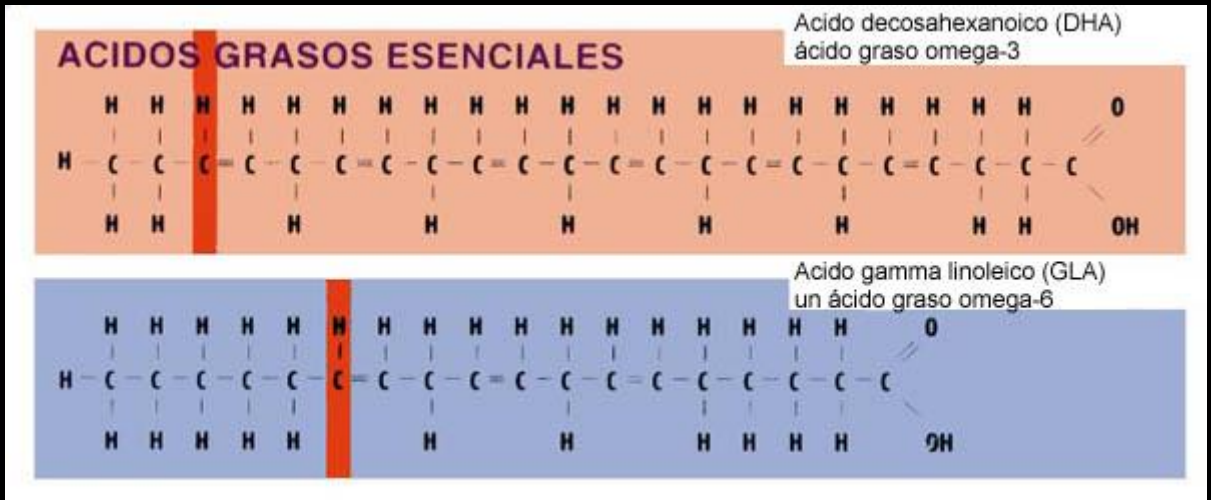
Structural formula of an unsaturated fat molecule

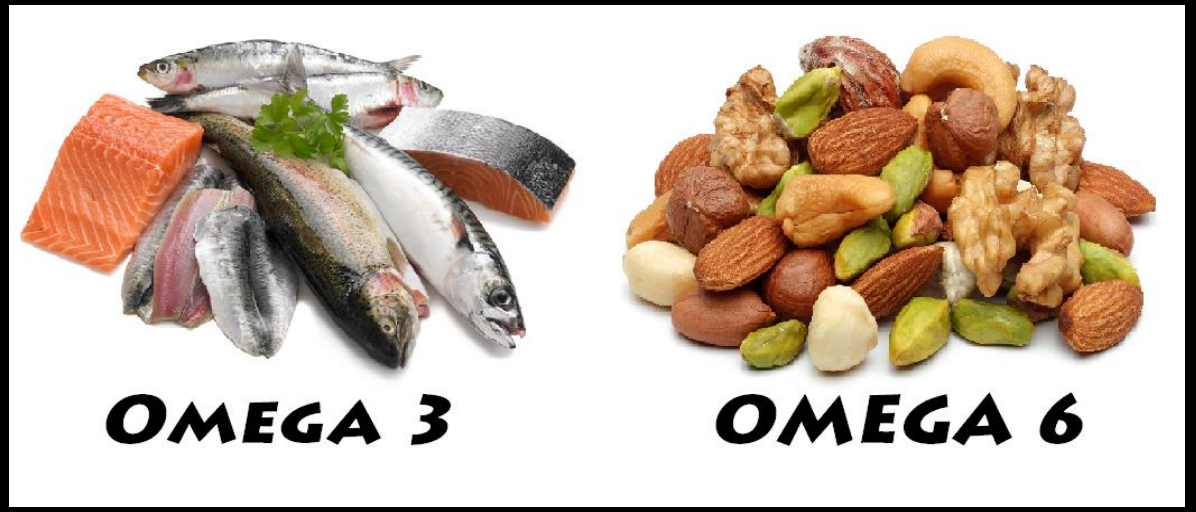


Space-filling model of oleic acid, an unsaturated fatty acid



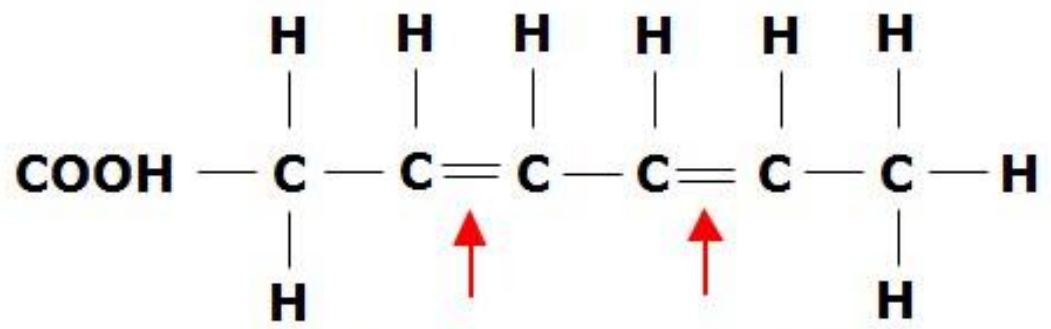

Acid group
Saturated fatty acid: palmitic acid
Carbon-carbon double bonds
Monounsaturated fatty acid: oleic acid (omega-9)
Polyunsaturated fatty acid: linoleic acid (omega-6)
Polyunsaturated fatty acid: alpha linolenic acid (omega-3)


ACIDOS GRASOS ESENCIALES
Acido decosahexanoico (DHA)
ácido graso omega-3
Acido gamma linoleico (GLA)
un ácido graso omega-6


OMEGA 3
OMEGA 6

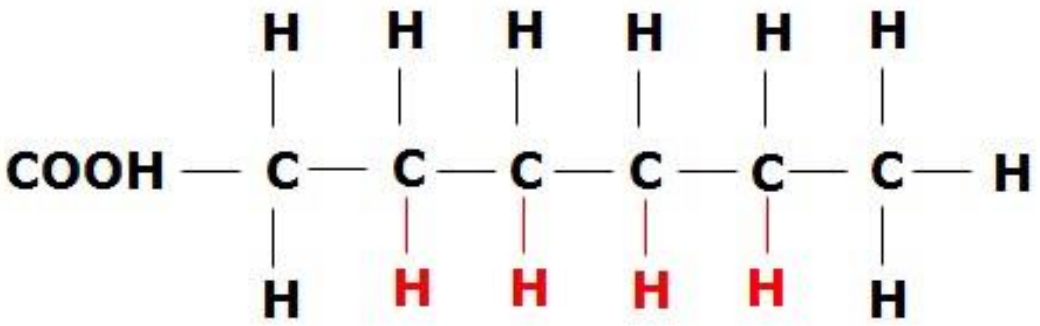
The phrase **“hydrogenated vegetable oils”** on food labels means that unsaturated fats have been synthetically converted to saturated fats by adding hydrogen.

- Peanut butter, margarine, and many other



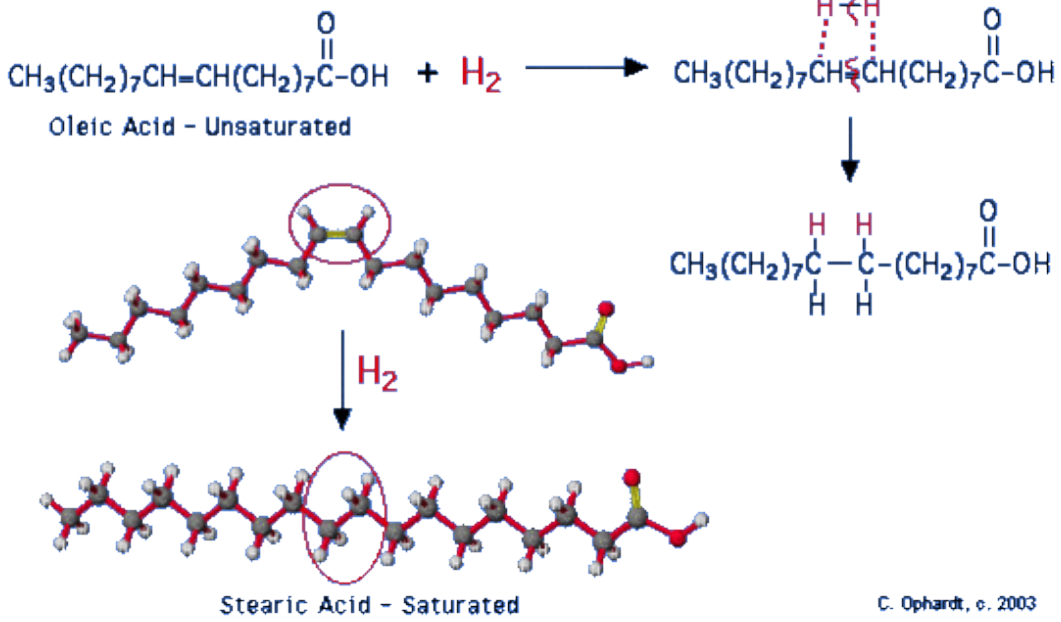
Polyunsaturated Fat

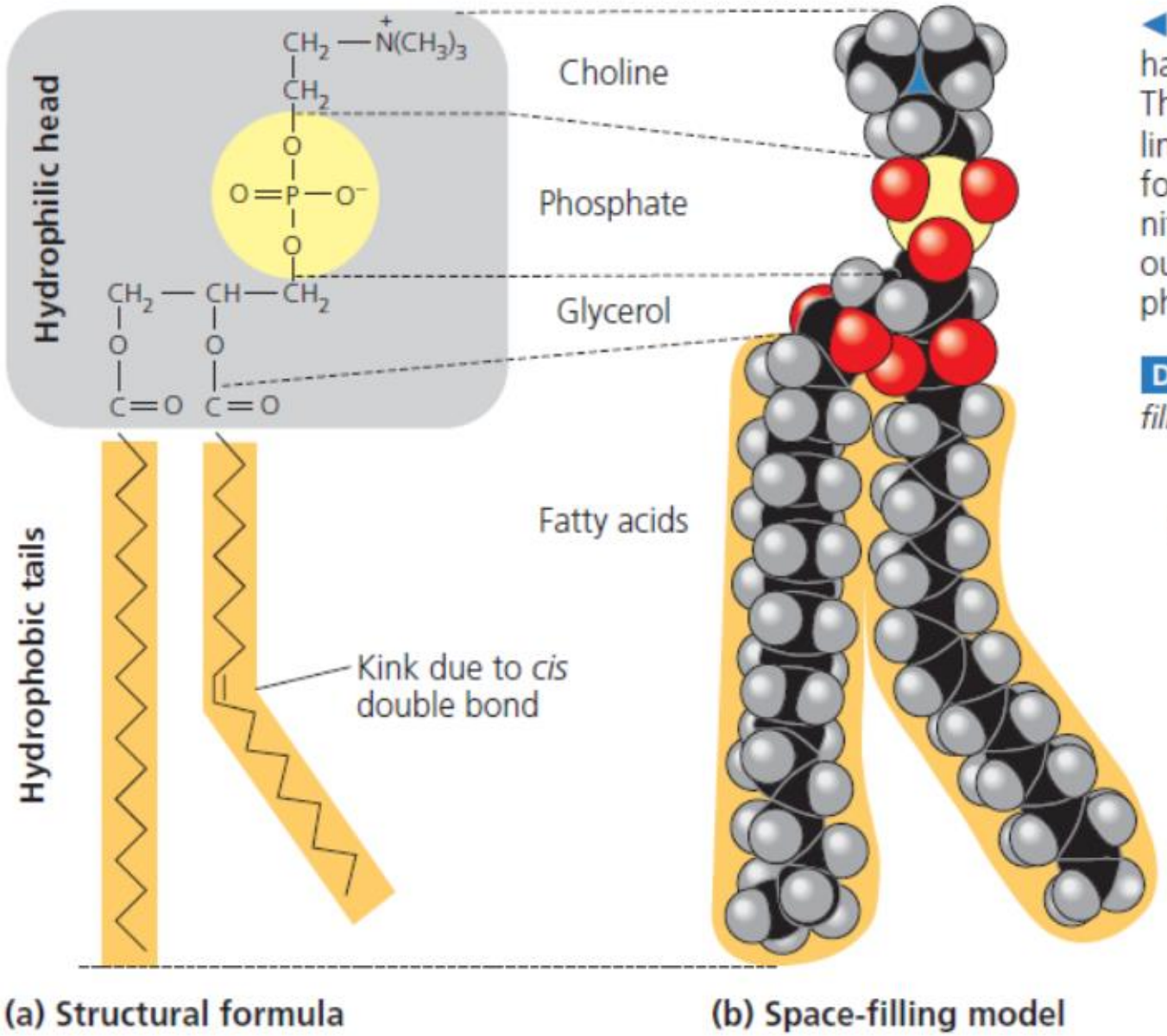
Hydrogenation



Hydrogenated Fat

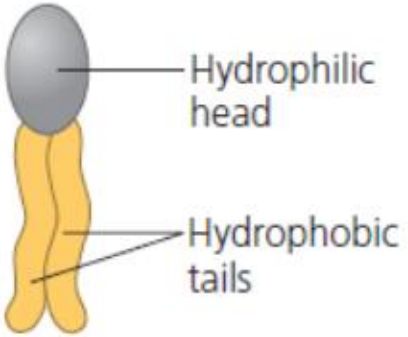
Hydrogenation of Oleic Acid

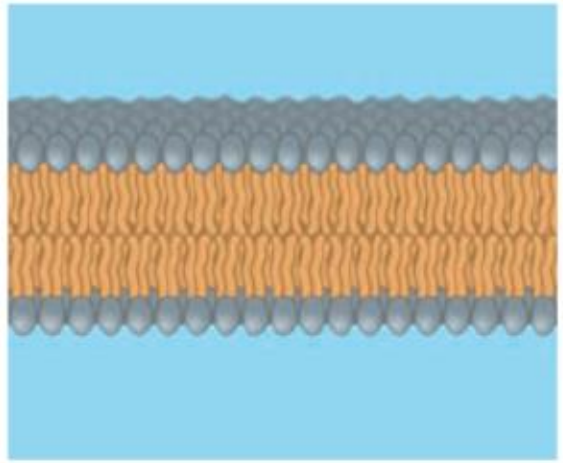


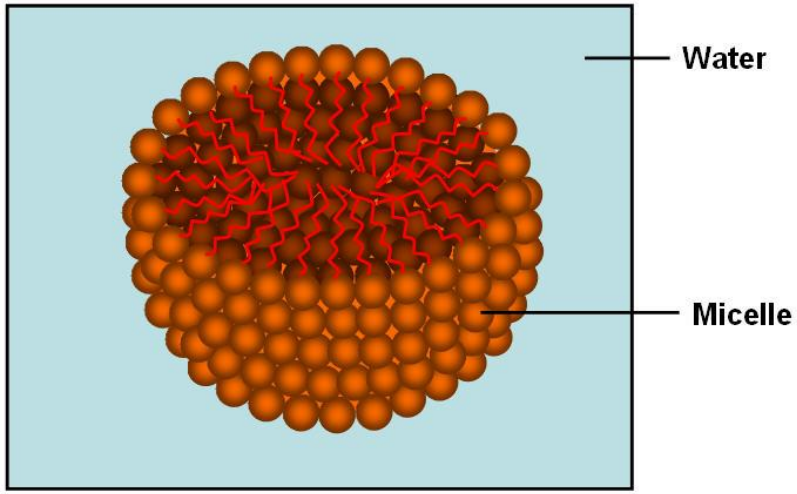


◀ Figure 5.11 The structure of a phospholipid. A phospholipid has a hydrophilic (polar) head and two hydrophobic (nonpolar) tails. This particular phospholipid, called a phosphatidylcholine, has a choline attached to a phosphate group. Shown here are **(a)** the structural formula, **(b)** the space-filling model (yellow = phosphorus, blue = nitrogen), **(c)** the symbol for a phospholipid that will appear throughout this book, and **(d)** the bilayer structure formed by self-assembly of phospholipids in an aqueous environment.

DRAW IT *Draw an oval around the hydrophilic head of the space-filling model.*

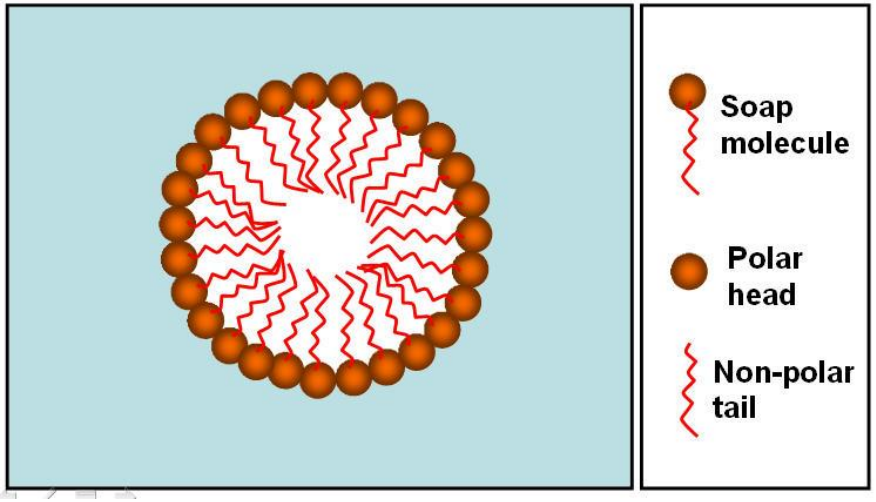


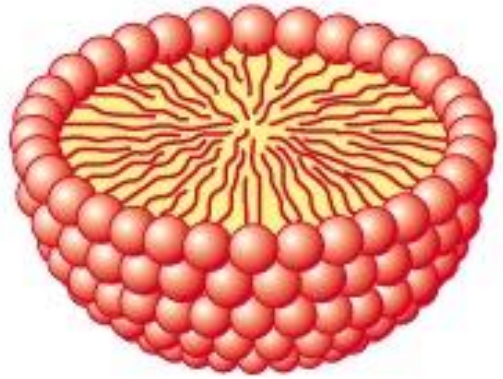




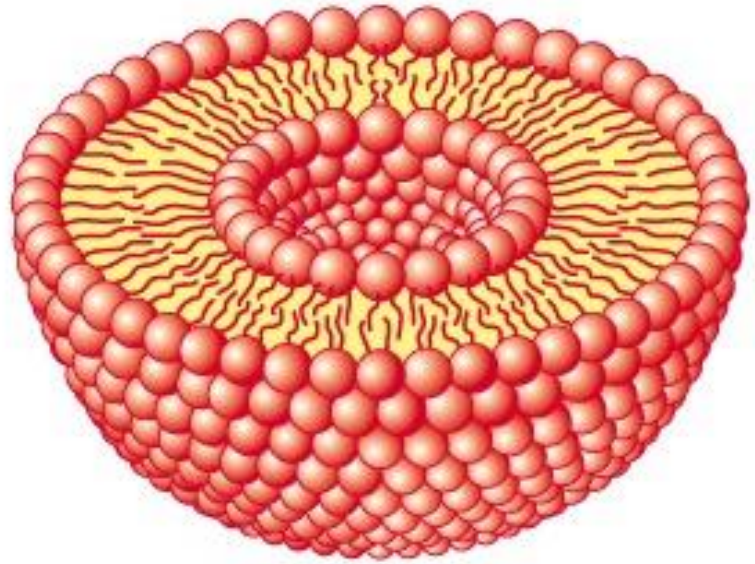
Above: a soap micelle with its top cut off – note the oil-like hydrocarbon non-polar tails aggregated in the centre and the polar heads on the outside facing the surrounding water.

Below: a slice through the same micelle.

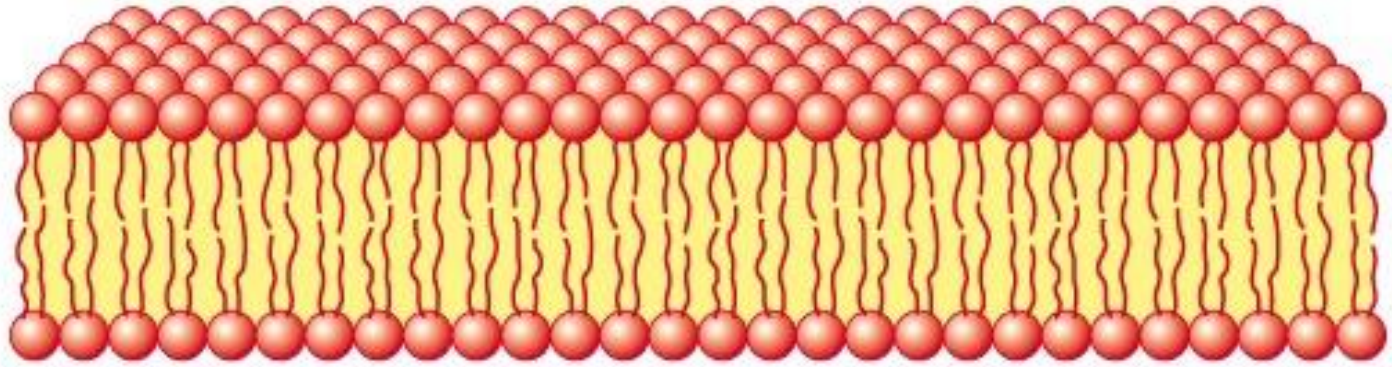




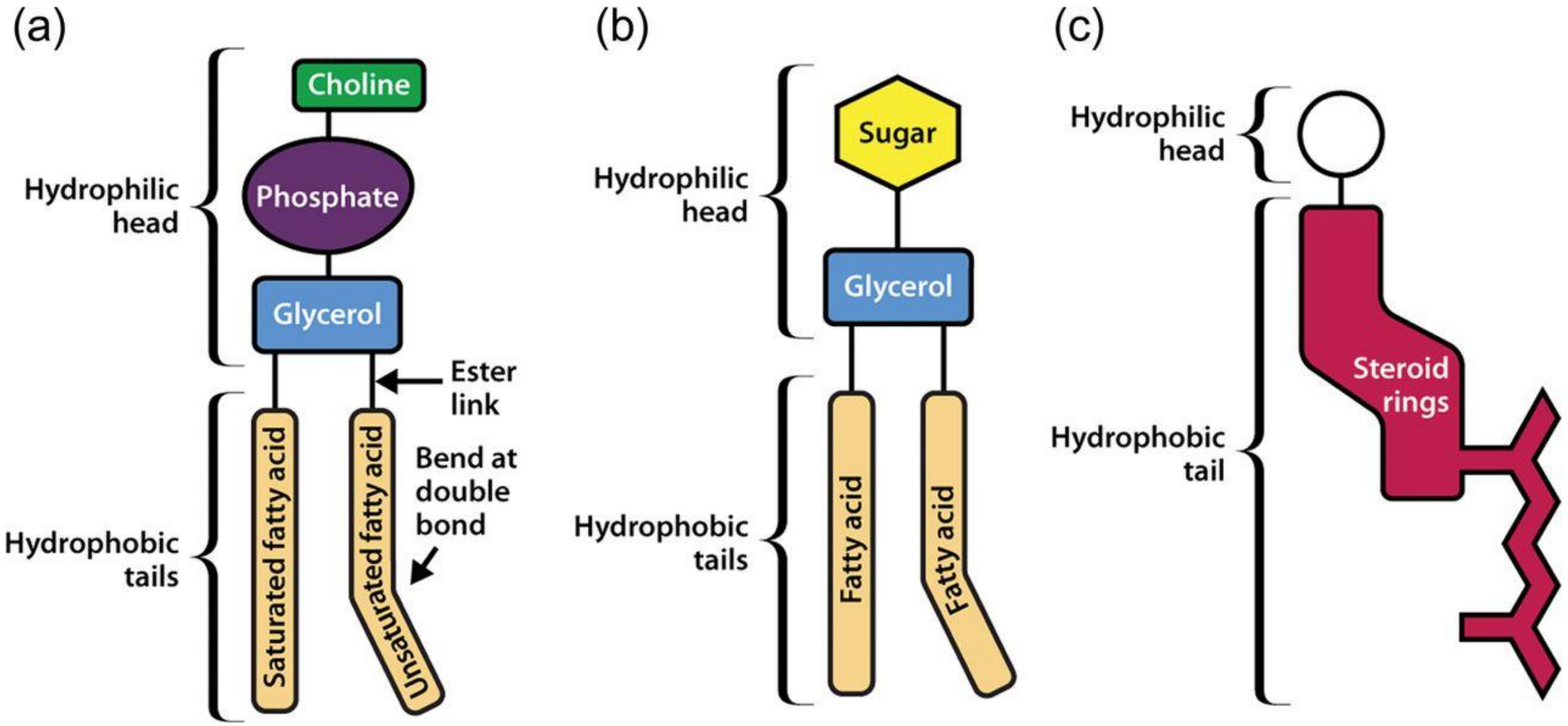
Micelle



Liposome

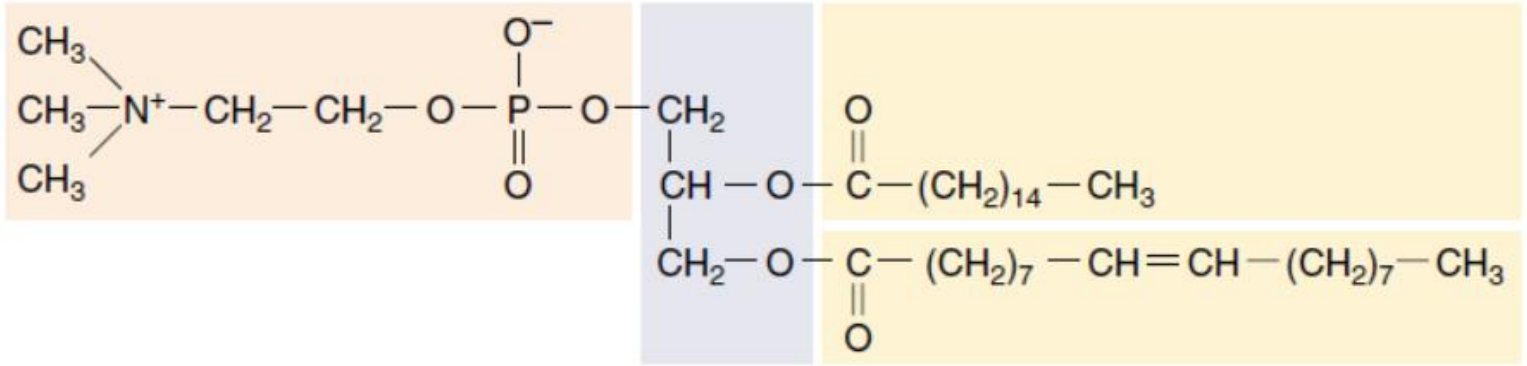


Bilayer sheet

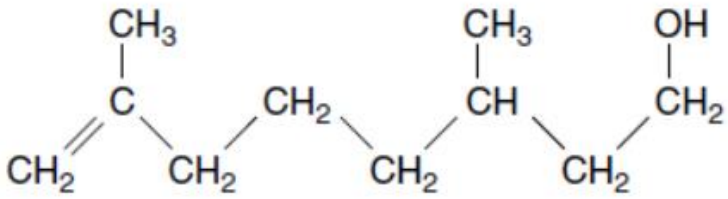


chematic representations of three types of membrane lipid.

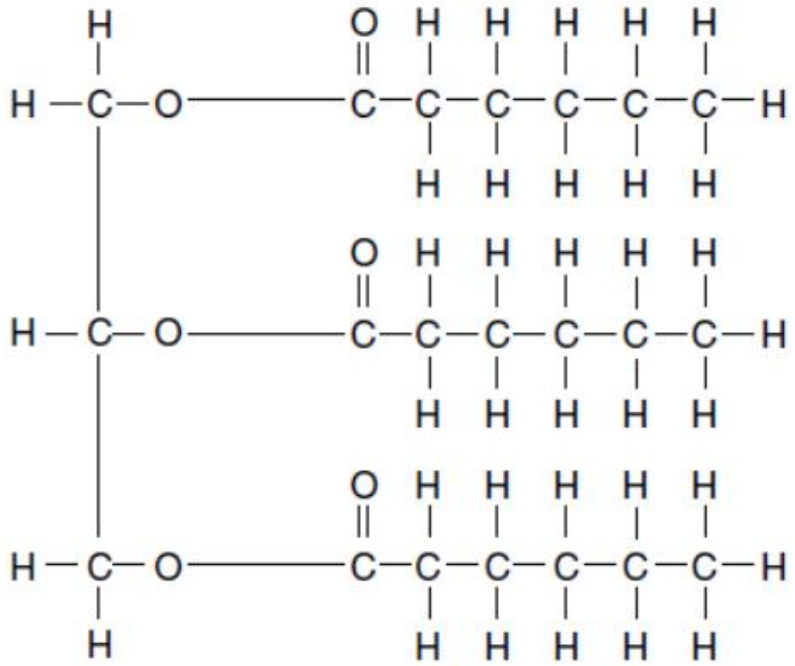
(a) Phosphatidylcholine, a glycerophospholipid. (b)



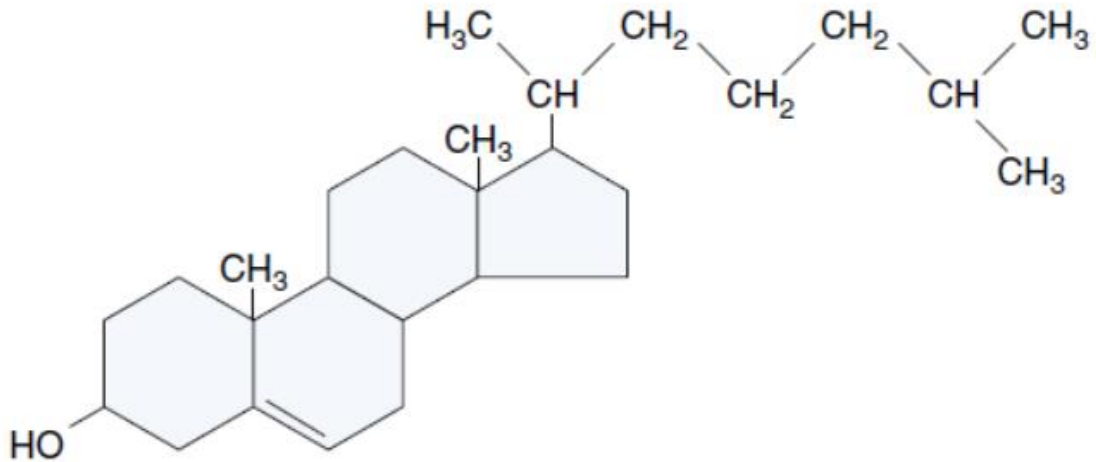
(a) Phospholipid (phosphatidyl choline)



(c) Terpene (citronellol)



(b) Triacylglycerol molecule

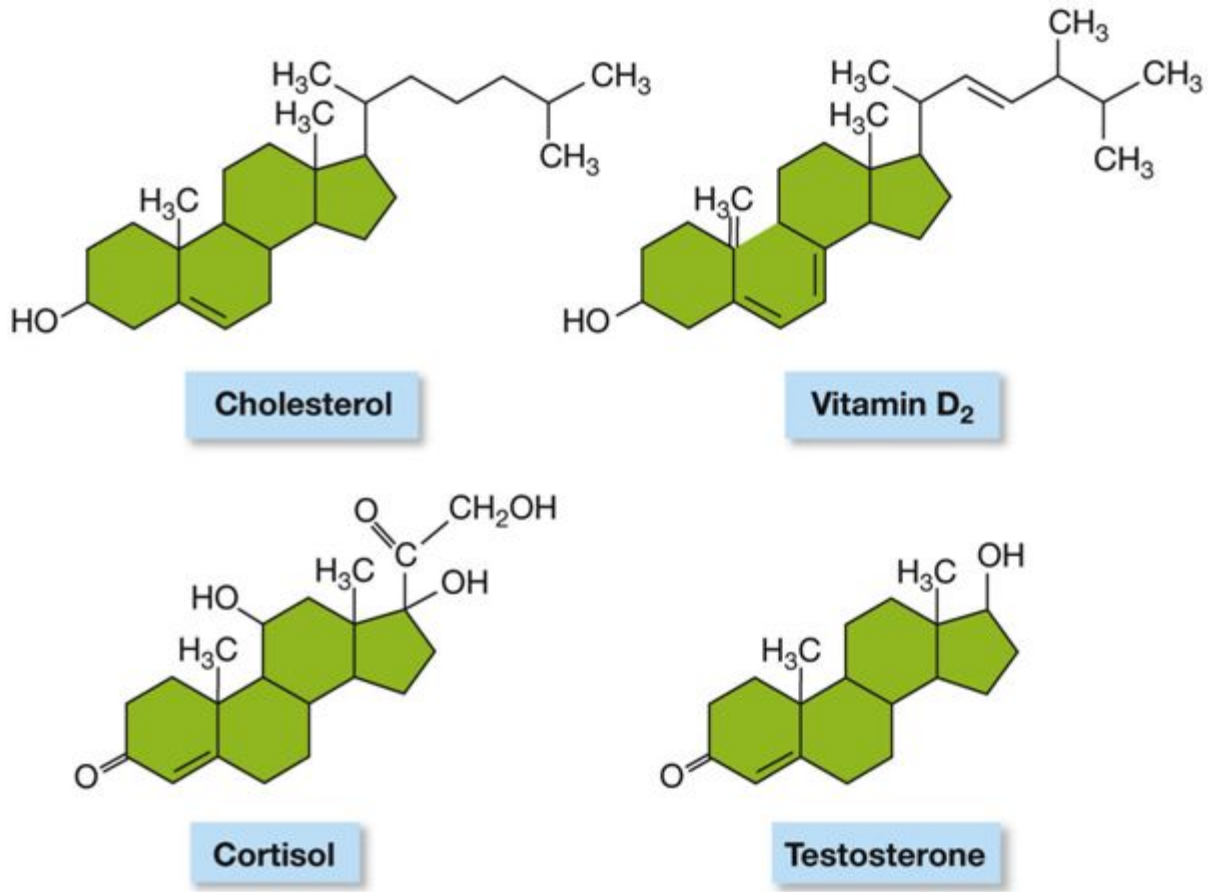


(d) Steroid (cholesterol)

FIGURE 3.19
Lipids. These structures represent four major classes of biologically important lipids: (*a*) phospholipids, (*b*) triacylglycerols (triglycerides), (*c*) terpenes, and (*d*) steroids.

Lipid (Steroids)

- Steroids
  - Are lipids characterized by a carbon skeleton consisting of four fused rings
  - Many hormones, including vertebrate sex hormones, are steroids produced from cholesterol
  - Steroids play a role in regulating cell activities



Cholesterol

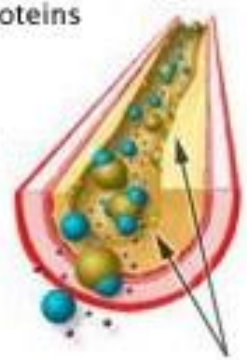
Cholesterol is a waxy fat carried through the bloodstream by lipoproteins

LDL: low density lipoproteins, or "bad cholesterol"

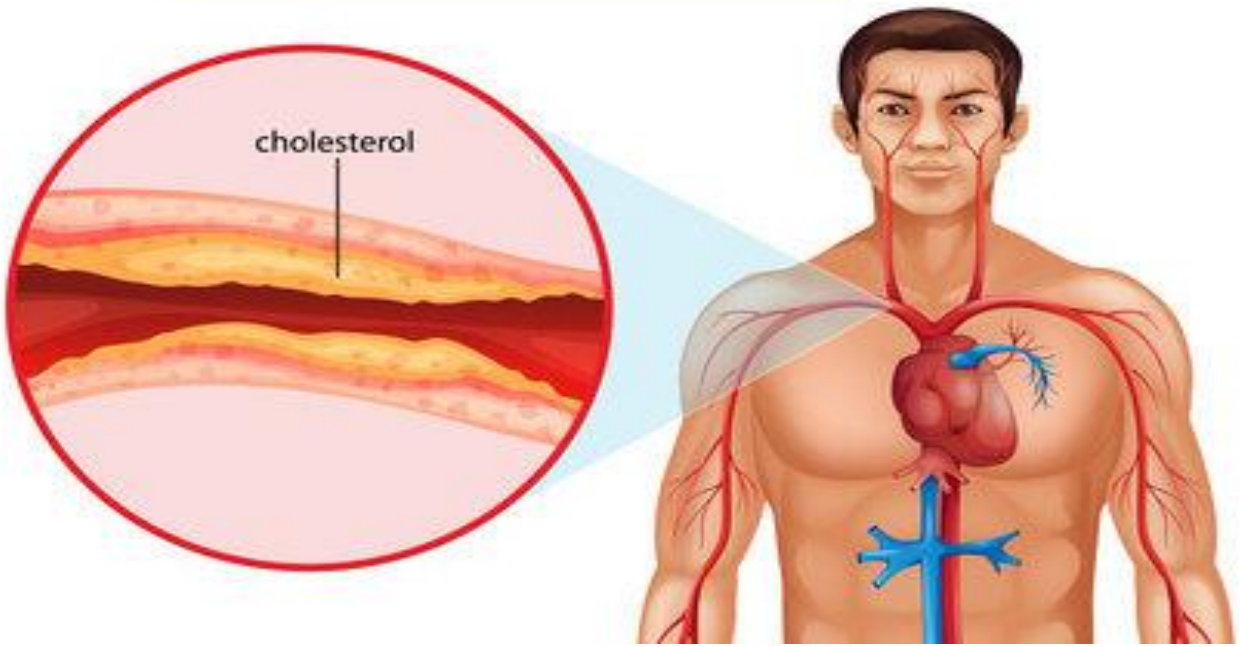
HDL: high-density lipoproteins, or "good cholesterol"

Triglycerides

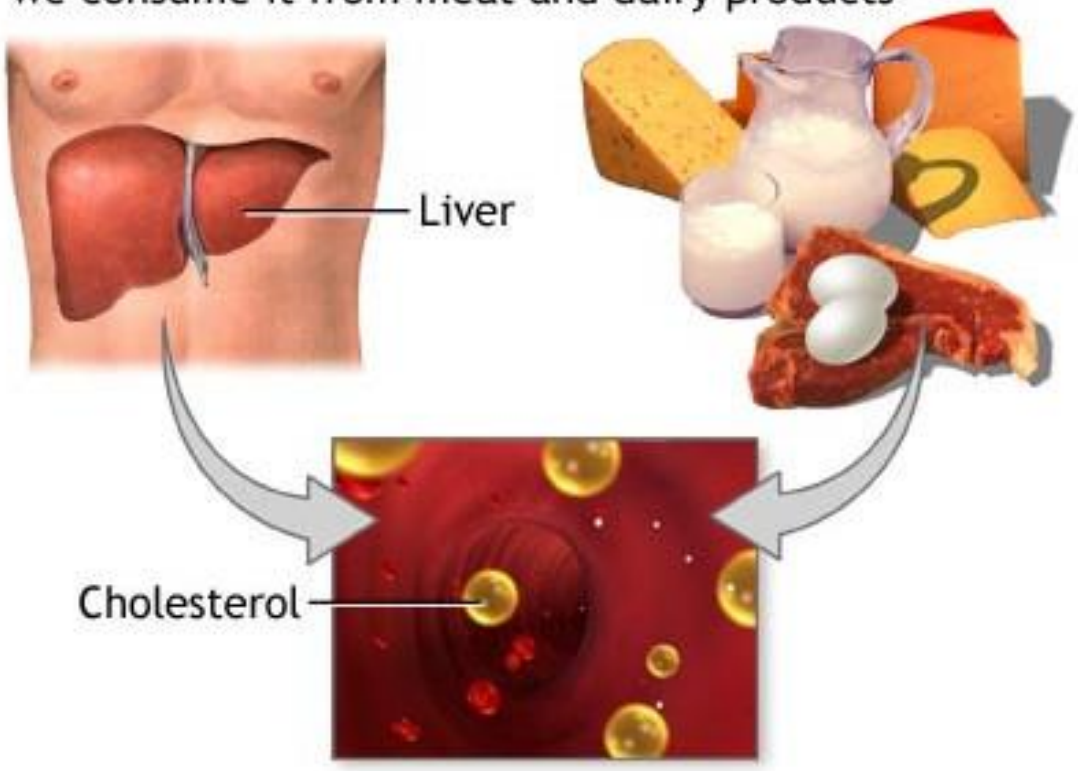
Total cholesterol



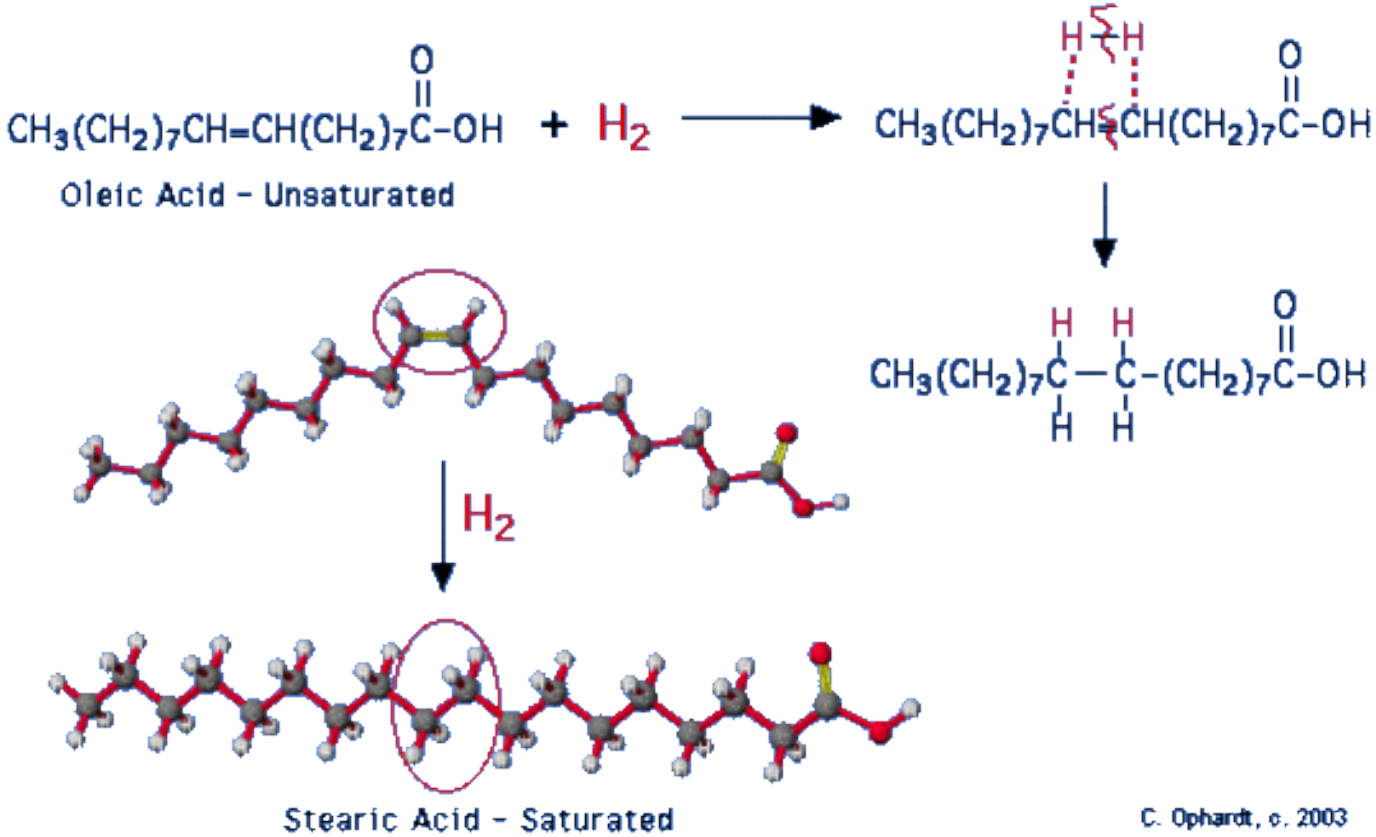
Plaque build-up

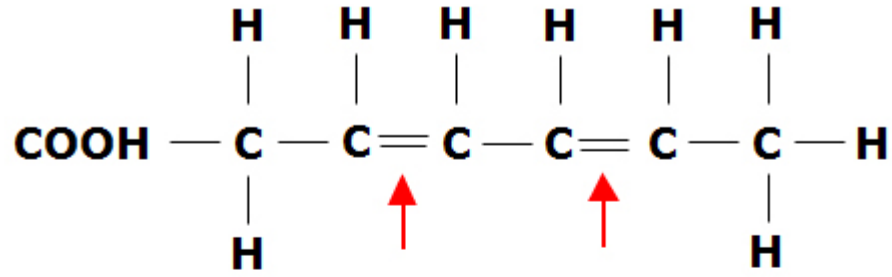


Cholesterol is produced by the liver and we consume it from meat and dairy products

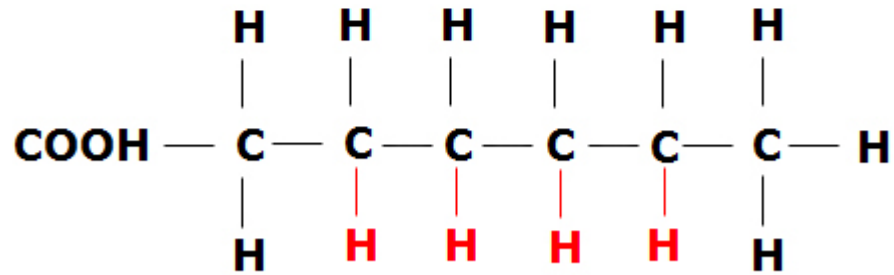


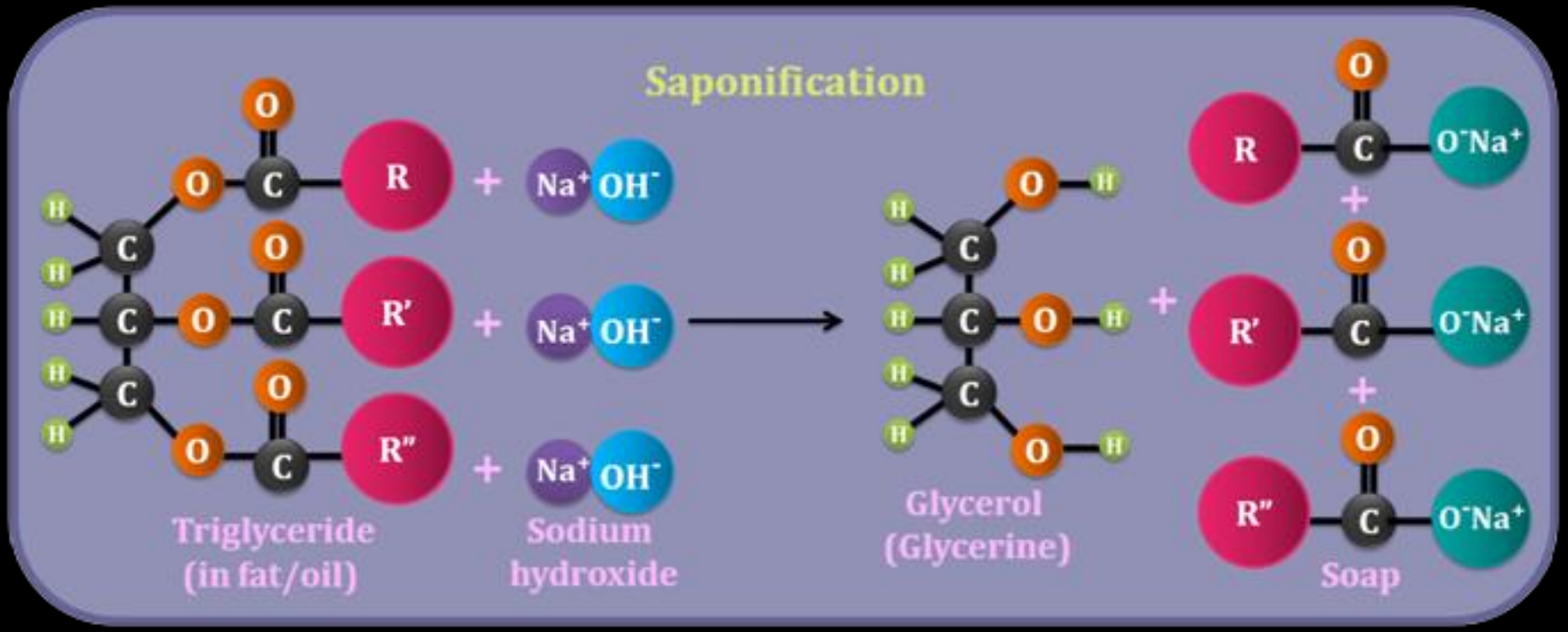
Hydrogenation of Oleic Acid

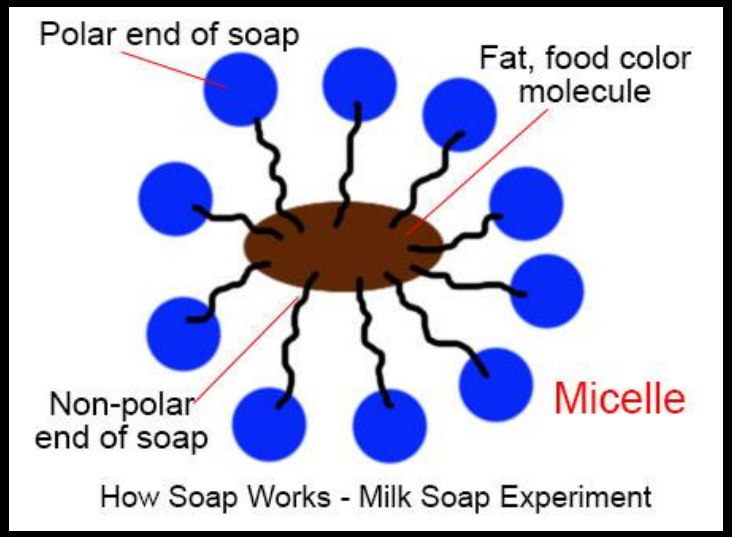


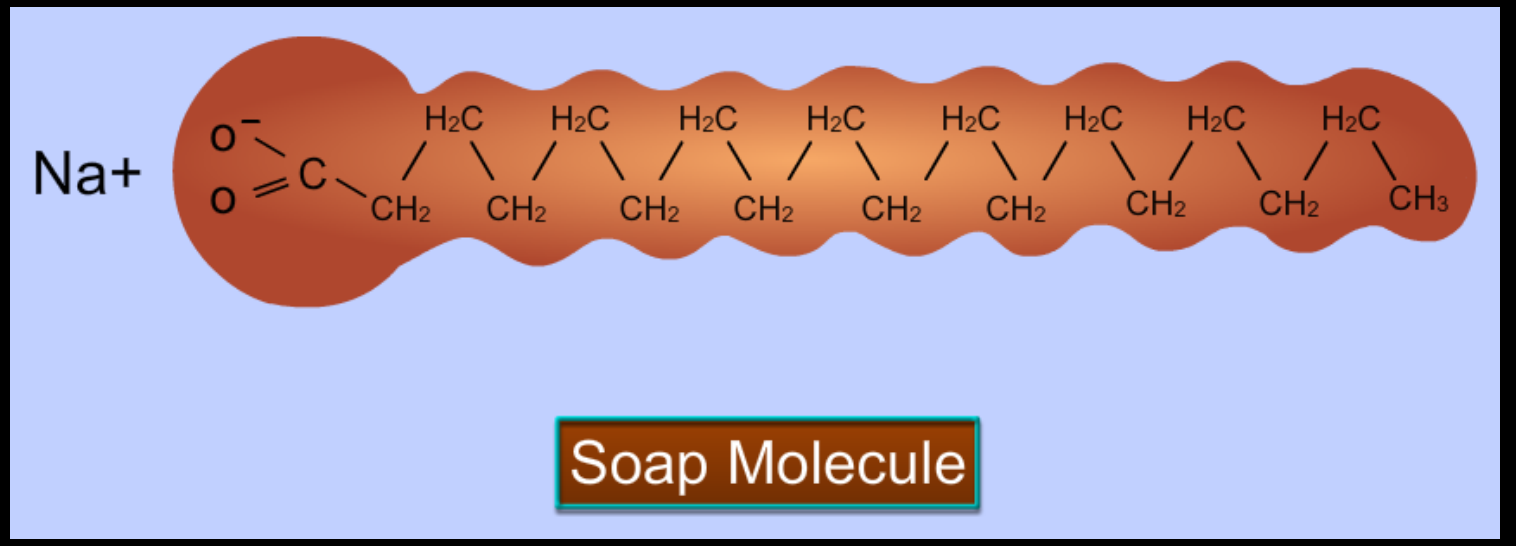


Hydrogenation




Saponification
Triglyceride
(in fat/oil)
Sodium
hydroxide
Glycerol
(Glycerine)
Soap


Polar end of soap
Fat, food color
molecule
Non-polar
end of soap
Micelle
How Soap Works - Milk Soap Experiment


Na+
Soap Molecule

Protein

▼ Figure 5.13 An overview of protein functions.

Enzymatic proteins

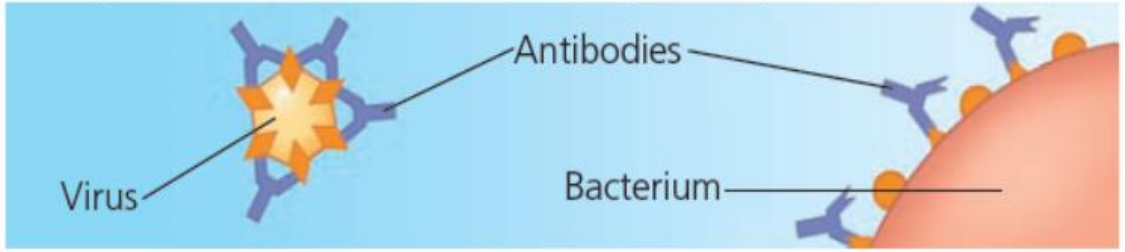
Function: Selective acceleration of chemical reactions

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

Defensive proteins

Function: Protection against disease

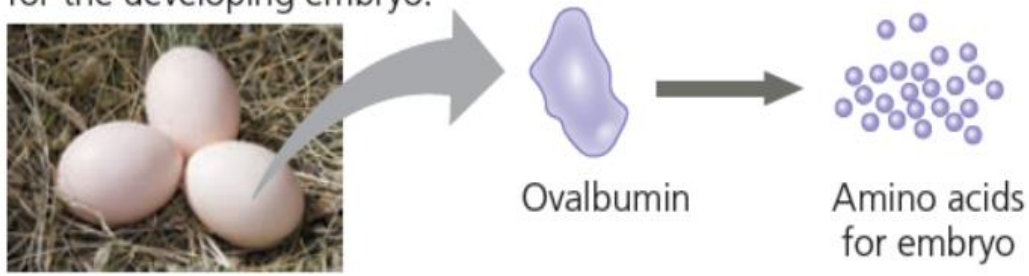
Example: Antibodies inactivate and help destroy viruses and bacteria.



Storage proteins

Function: Storage of amino acids

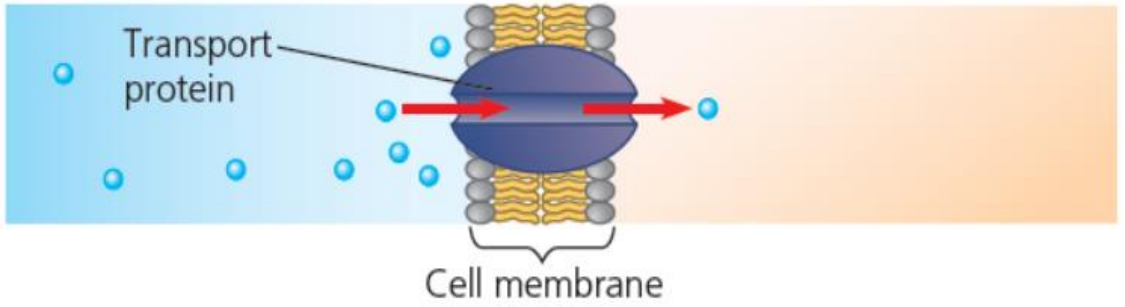
Examples: Casein, the protein of milk, is the major source of amino acids for baby mammals. Plants have storage proteins in their seeds. Ovalbumin is the protein of egg white, used as an amino acid source for the developing embryo.



Transport proteins

Function: Transport of substances

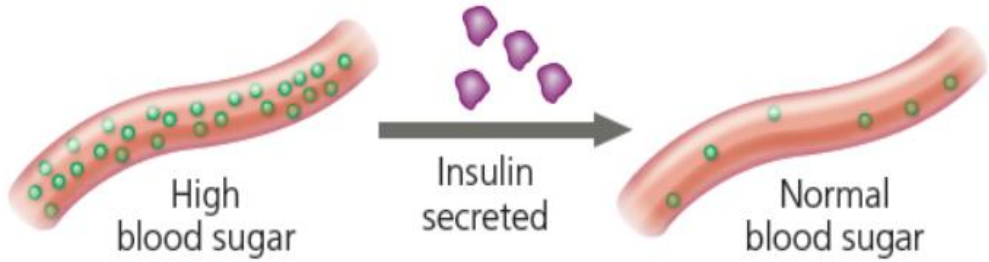
Examples: Hemoglobin, the iron-containing protein of vertebrate blood, transports oxygen from the lungs to other parts of the body. Other proteins transport molecules across membranes, as shown here.



Hormonal proteins

Function: Coordination of an organism's activities

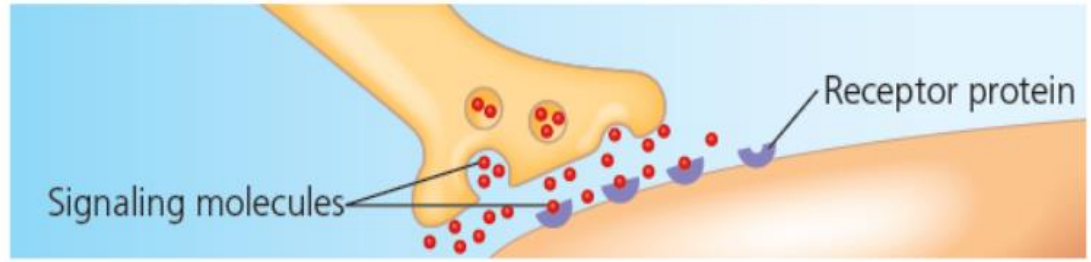
Example: Insulin, a hormone secreted by the pancreas, causes other tissues to take up glucose, thus regulating blood sugar concentration.



Receptor proteins

Function: Response of cell to chemical stimuli

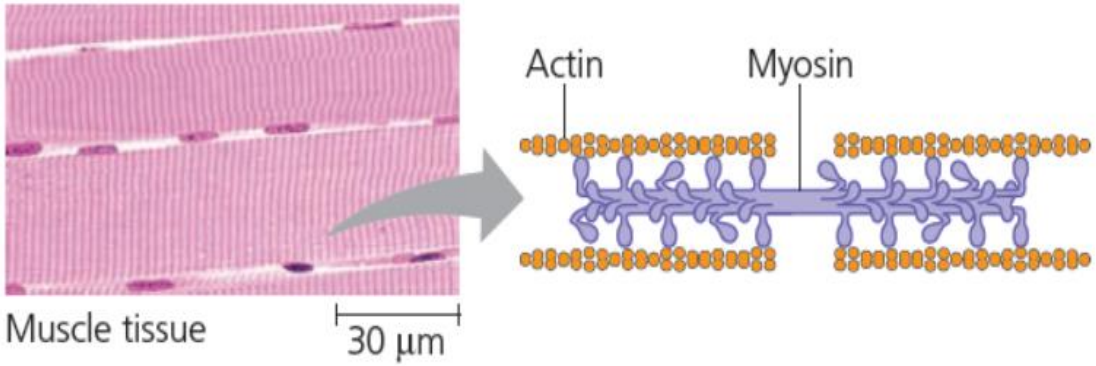
Example: Receptors built into the membrane of a nerve cell detect signaling molecules released by other nerve cells.



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.

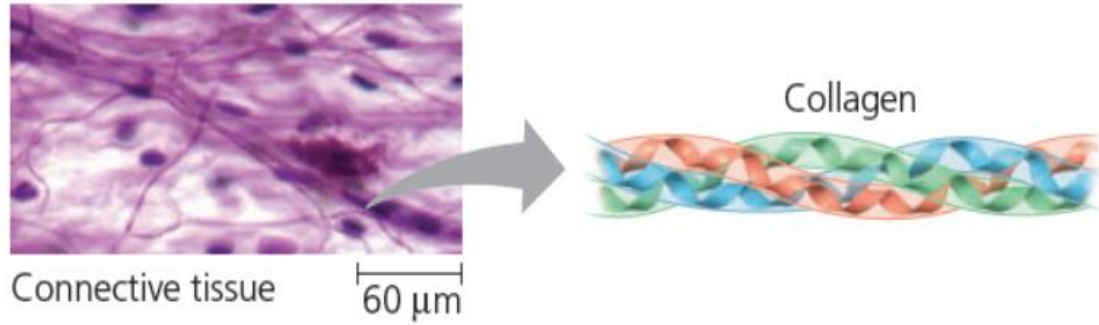
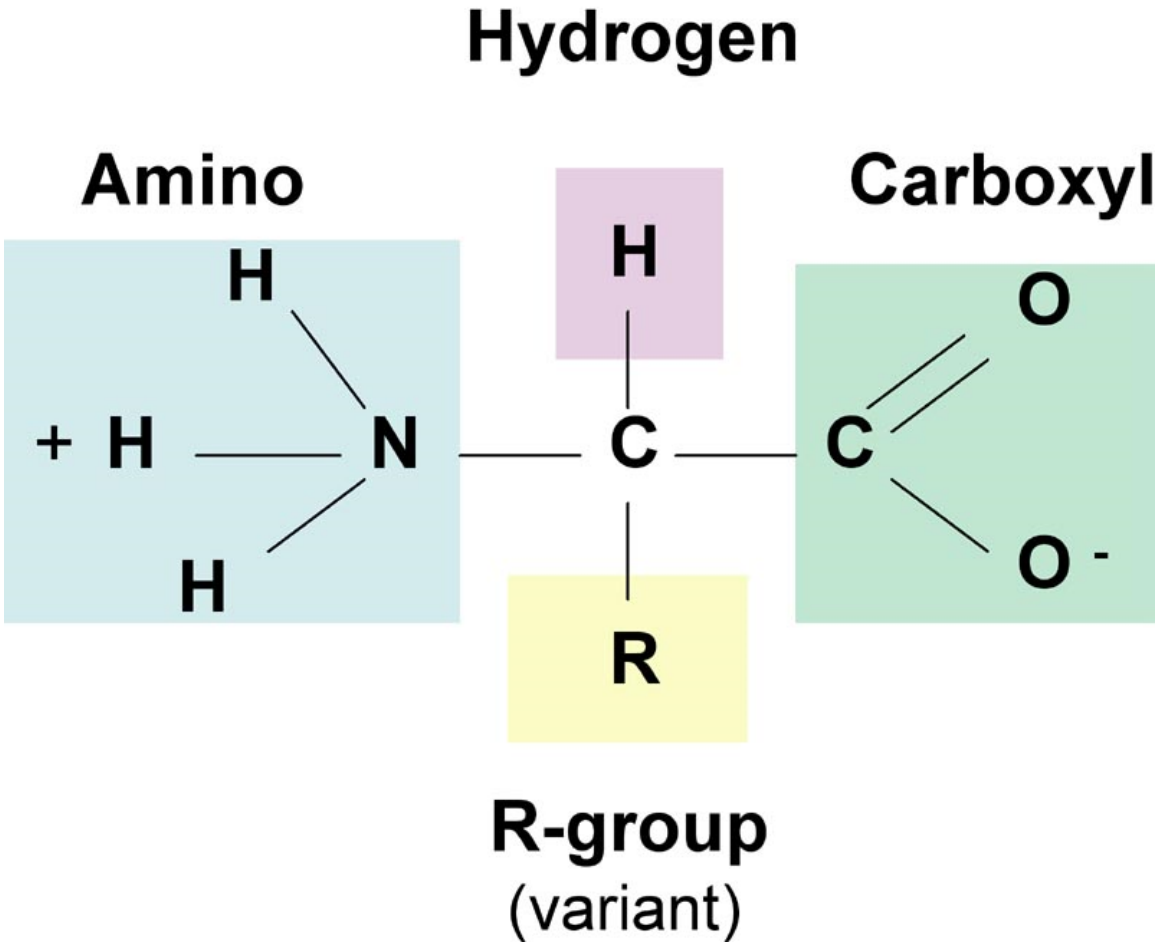


Table 3.2 The Many Functions of Proteins

Function	Class of Protein	Examples	Use
Metabolism (Catalysis)	Enzymes	Hydrolytic enzymes	Cleave polysaccharides
		Proteases	Break down proteins
		Polymerases	Produce nucleic acids
		Kinases	Phosphorylate sugars and proteins
Defense	Immunoglobulins	Antibodies	Mark foreign proteins for elimination
Cell recognition	Toxins	Snake venom	Block nerve function
Transport throughout body	Cell surface antigens	MHC proteins	"Self" recognition
	Globins	Hemoglobin	Carries O_2 and CO_2 in blood
		Myoglobin	Carries O_2 and CO_2 in muscle
		Cytochromes	Electron transport
Membrane transport	Transporters	Sodium-potassium pump	Excitable membranes
		Proton pump	Chemiosmosis
		Anion channels	Transport Cl^- ions
Structure/Support	Fibers	Collagen	Cartilage
		Keratin	Hair, nails
		Fibrin	Blood clot
Motion	Muscle	Actin	Contraction of muscle fibers
		Myosin	Contraction of muscle fibers
Osmotic regulation	Albumin	Serum albumin	Maintains osmotic concentration of blood
Regulation of gene action	Repressors	lac repressor	Regulates transcription
Regulation of body functions	Hormones	Insulin	Controls blood glucose levels
		Vasopressin	Increases water retention by kidneys
		Oxytocin	Regulates uterine contractions and milk production
Storage	Ion binding	Ferritin	Stores iron, especially in spleen
		Casein	Stores ions in milk
		Calmodulin	Binds calcium ions

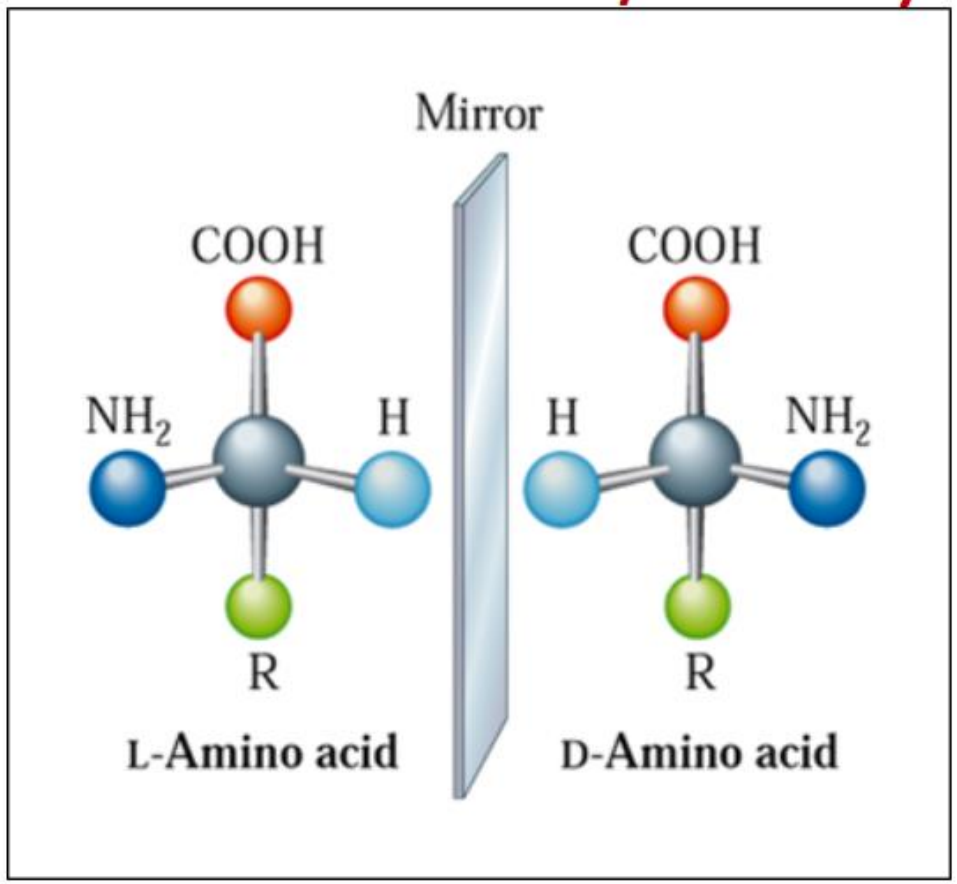
Amino Acid Structure

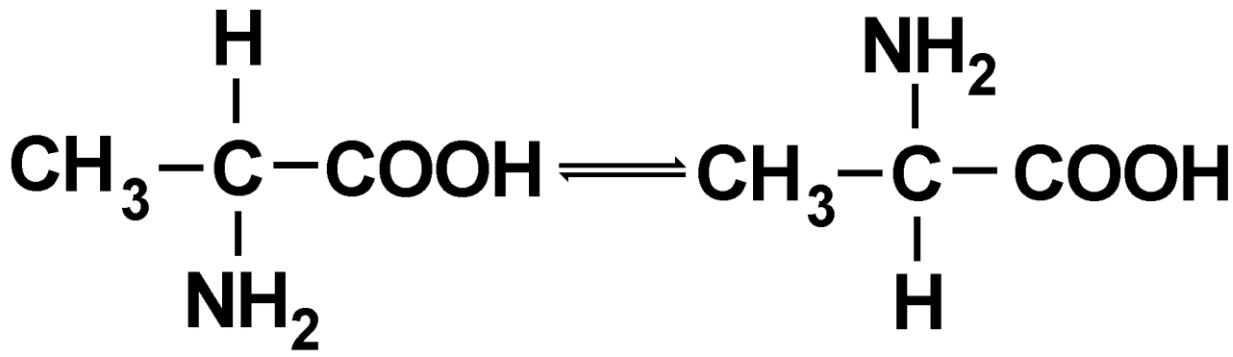


At the center of the amino acid is an asymmetric carbon atom called the alpha
(α) carbon.

- Its four different partners are an **amino group, a carboxyl group, a hydrogen atom, and a variable group**

Handedness/Chirality of Amino Acids

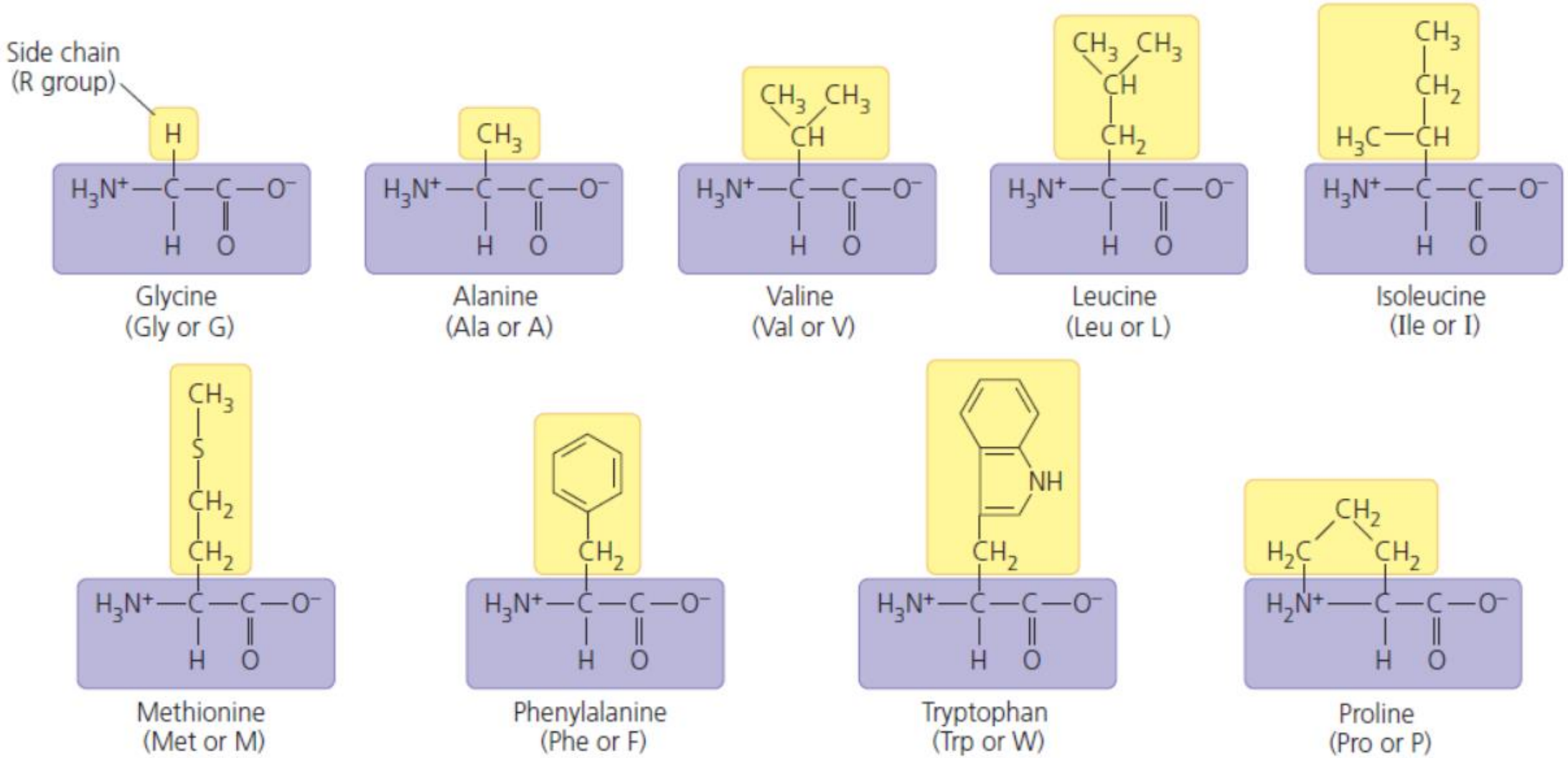




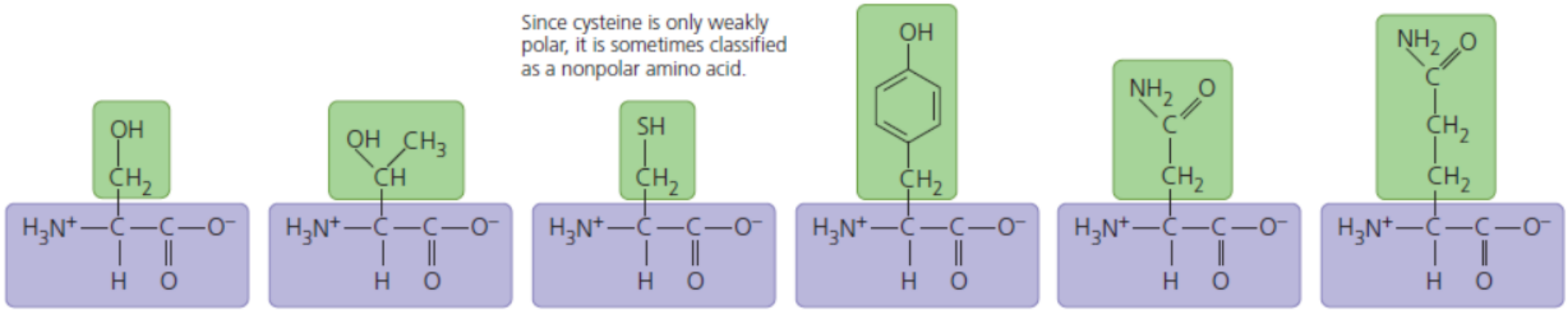
L-Alanine D-Alanine

▼ Figure 5.14 The 20 amino acids of proteins. The amino acids are grouped here according to the properties of their side chains (R groups) and shown in their prevailing ionic forms at pH 7.2, the pH within a cell. The three-letter and one-letter abbreviations for the amino acids are in parentheses. All of the amino acids used in proteins are L enantiomers (see Figure 4.7c).

Nonpolar side chains; hydrophobic



Polar side chains; hydrophilic



Electrically charged side chains; hydrophilic

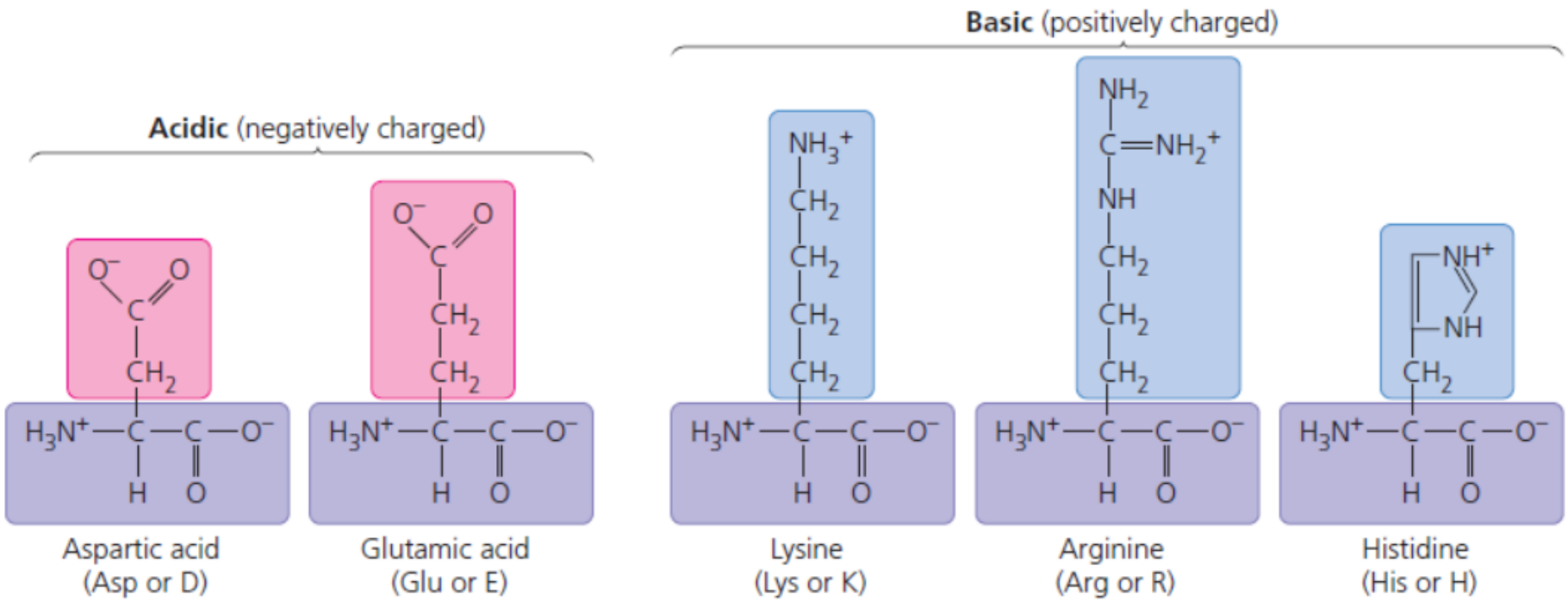


TABLE 18–1 Nonessential and Essential Amino Acids for Humans and the Albino Rat

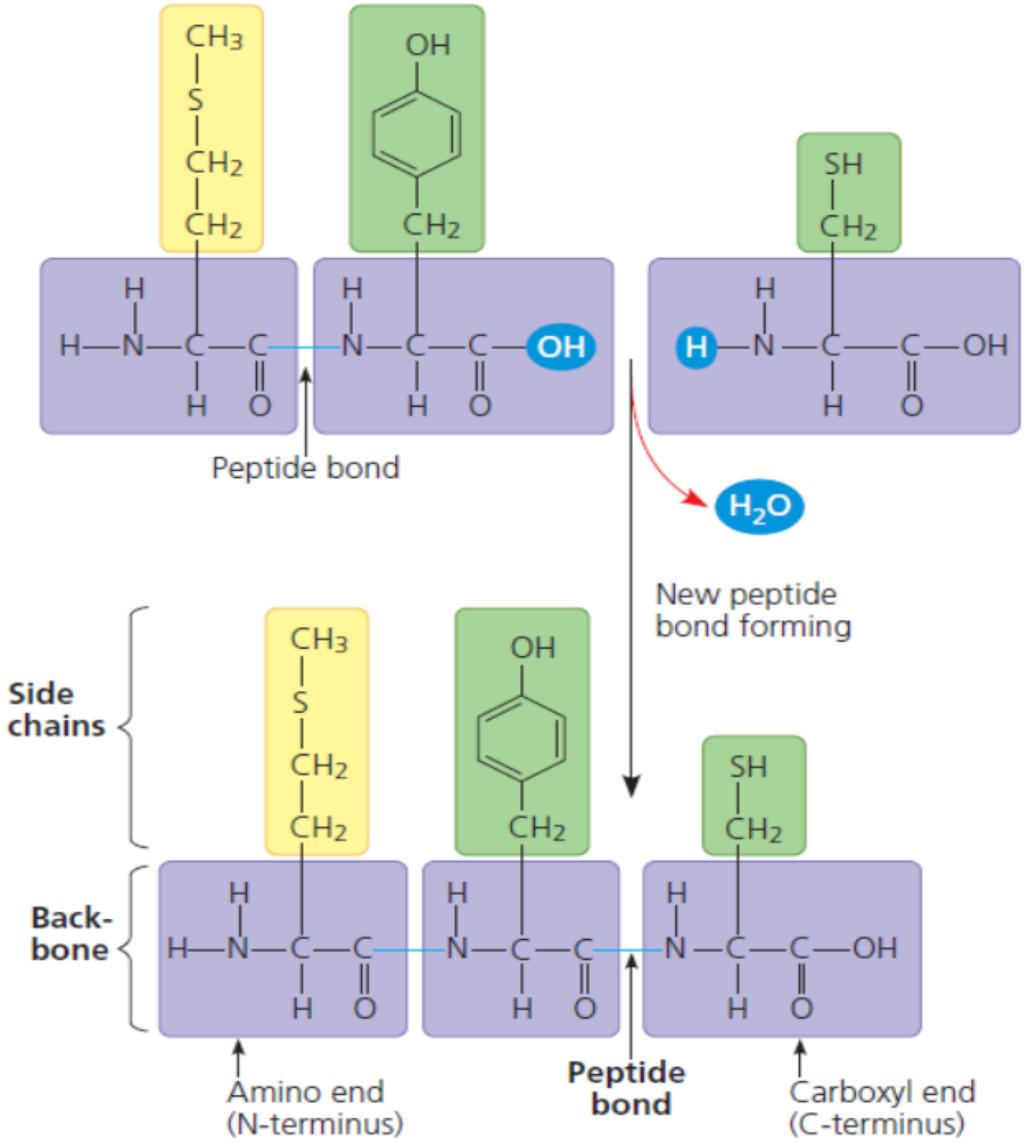
Nonessential	Conditionally essential*	Essential
Alanine	Arginine	Histidine
Asparagine	Cysteine	Isoleucine
Aspartate	Glutamine	Leucine
Glutamate	Glycine	Lysine
Serine	Proline	Methionine
	Tyrosine	Phenylalanine
		Threonine
		Tryptophan
		Valine

*Required to some degree in young, growing animals, and/or sometimes during illness.

Table 18-1
Lehninger Principles of Biochemistry, Fifth Edition

Polypeptides (Amino Acid Polymers)

Making a Polypeptide Chain



Note: dehydration synthesis.

Note: carboxyl group of one end attaches to amino group of another.

Note: peptide bond is formed.

Note: repeating this process builds a polypeptide.

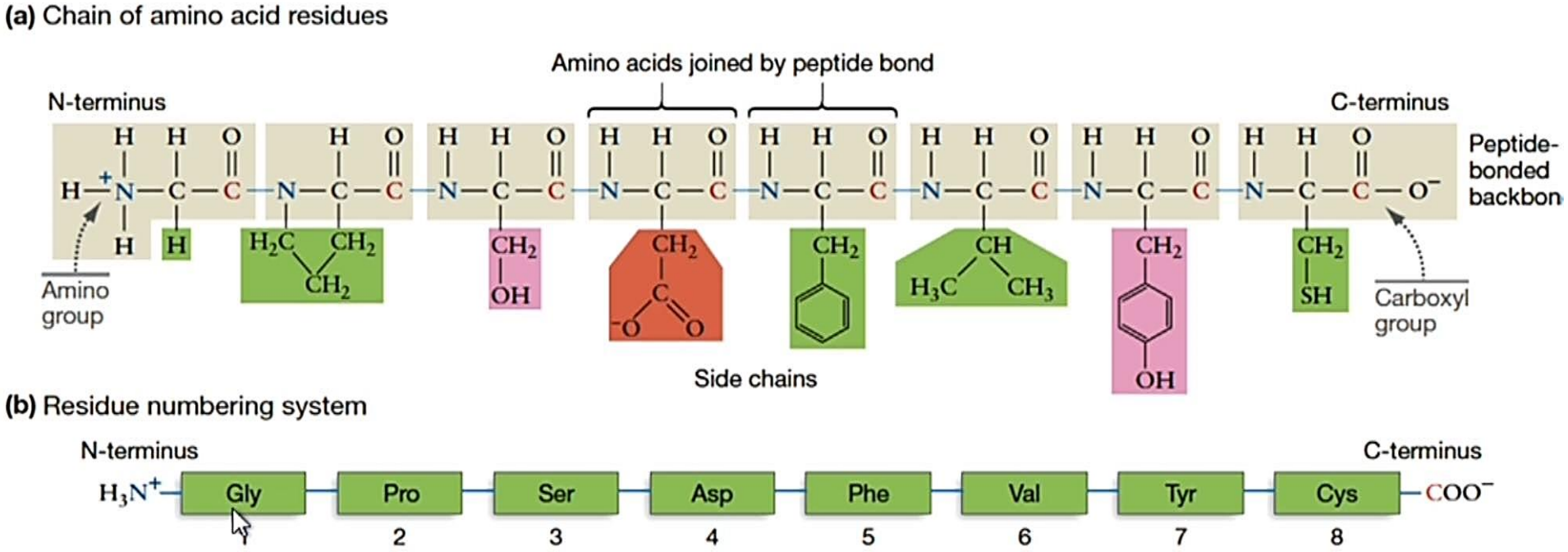


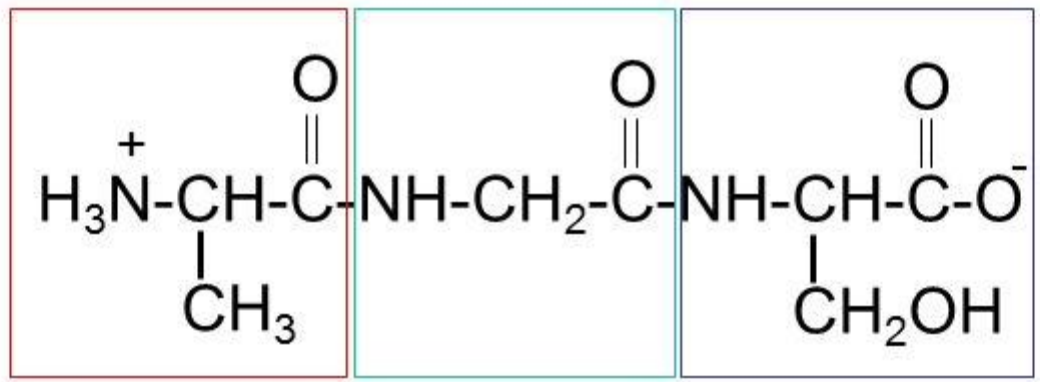
Figure 3.6 Amino Acids Polymerize to Form Chains.

Naming of peptides

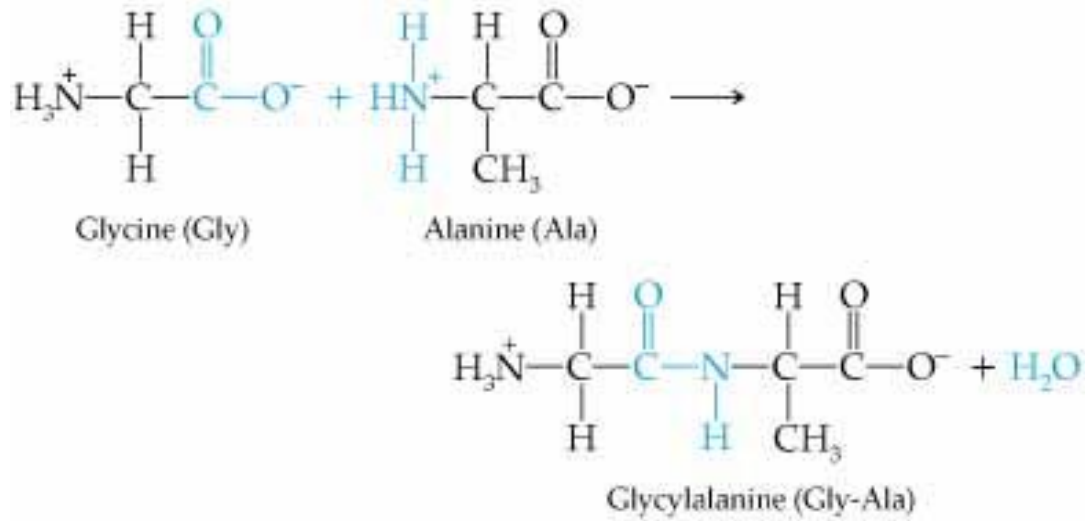
- Begin from the N terminal.

- Drop “-ine” and it is replaced by “-yl”.

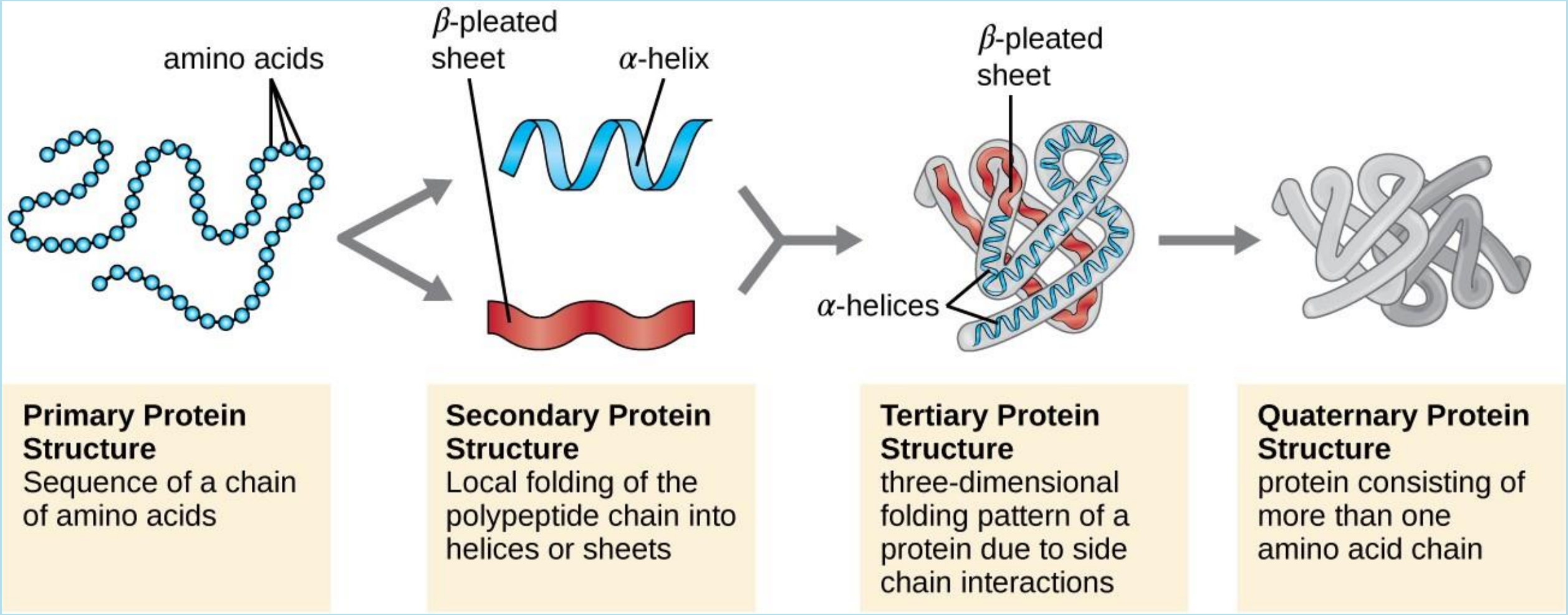
- Give the full name of amino acid at the C terminal.



Alanylglycylserine
(Ala-Gly-Ser)



Levels of Protein Structur

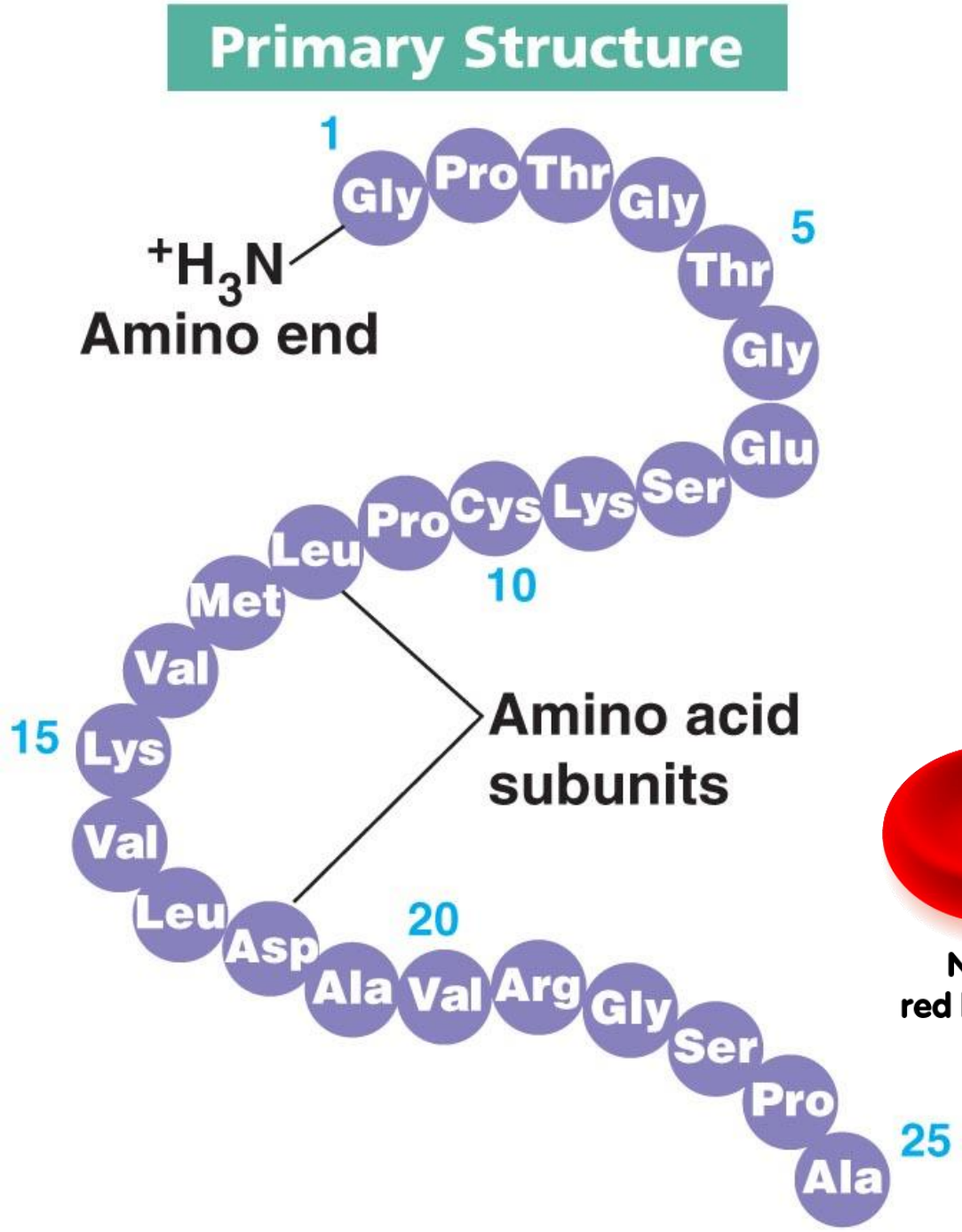


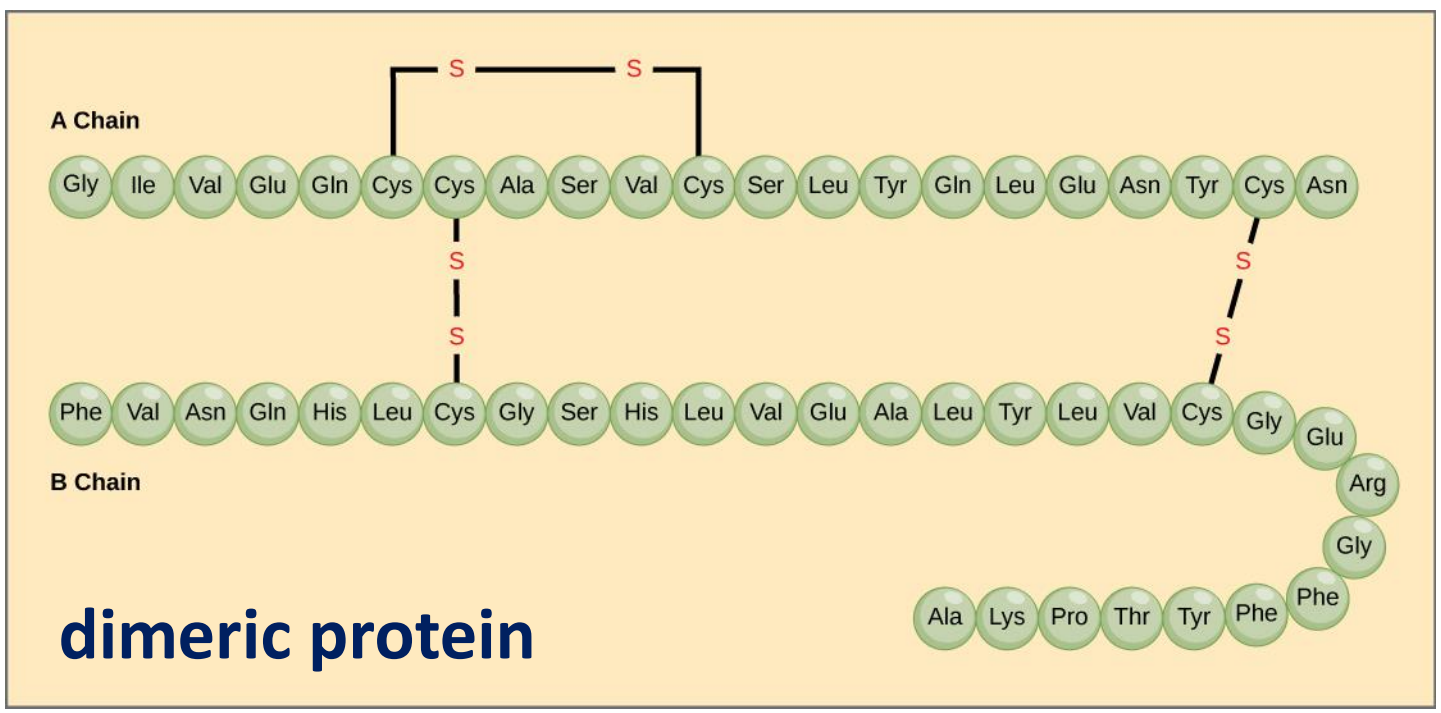
Primary Protein Structure
Sequence of a chain of amino acids

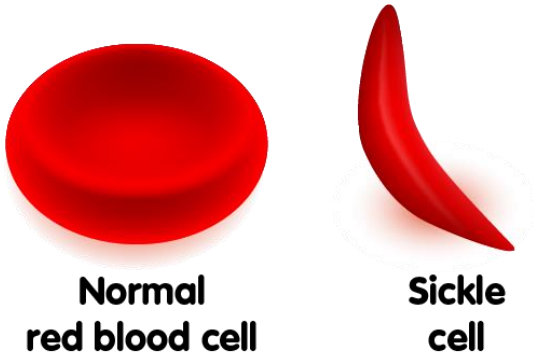
Secondary Protein Structure
Local folding of the polypeptide chain into helices or sheets

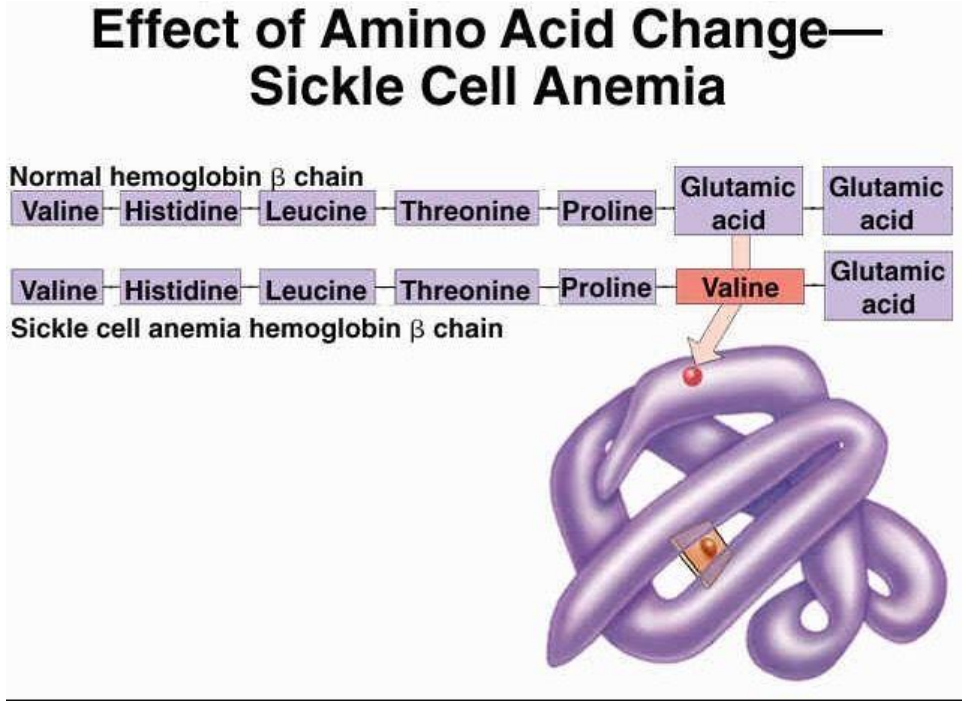
Tertiary Protein Structure
three-dimensional folding pattern of a protein due to side chain interactions

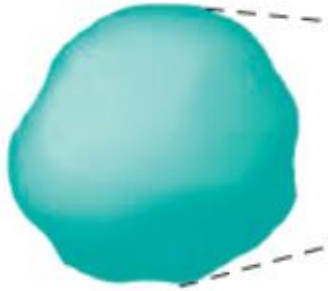
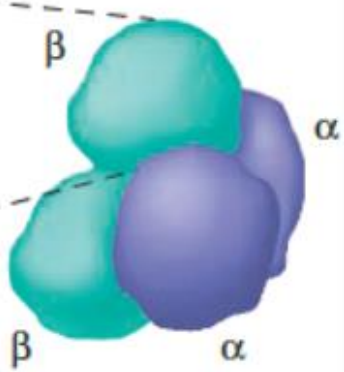
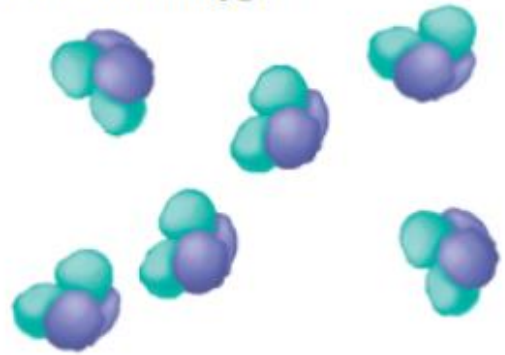
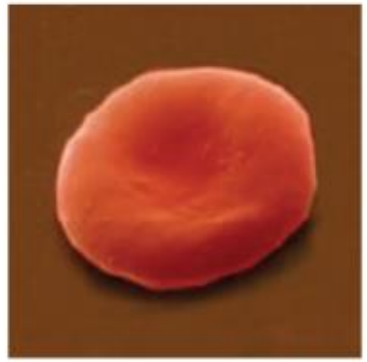
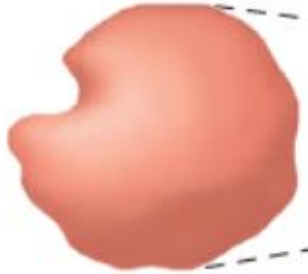
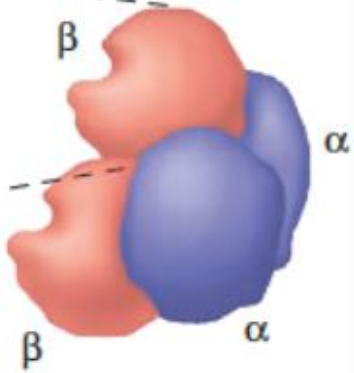
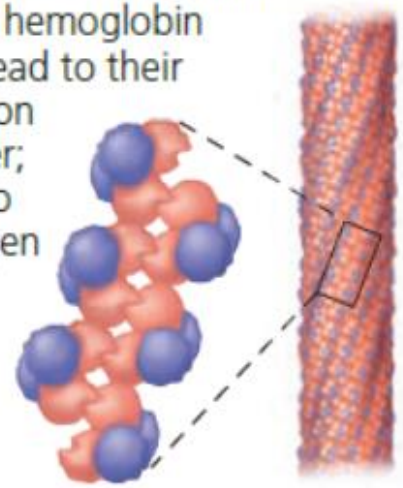
Quaternary Protein Structure
protein consisting of more than one amino acid chain







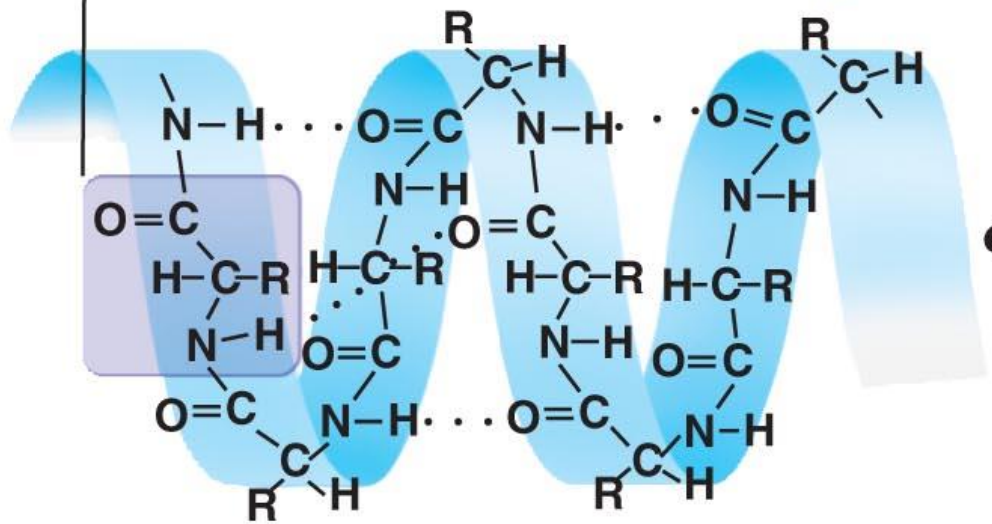


	Primary Structure	Secondary and Tertiary Structures	Quaternary Structure	Function	Red Blood Cell Shape
Normal hemoglobin	1 Val 2 His 3 Leu 4 Thr 5 Pro 6 Glu 7 Glu	Normal β subunit 	Normal hemoglobin 	Normal hemoglobin proteins do not associate with one another; each carries oxygen. 	Normal red blood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

Secondary Structure

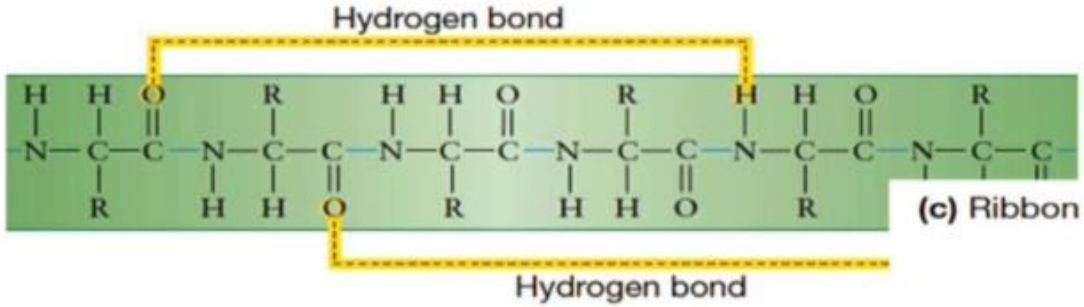
β pleated sheet

Examples of amino acid subunits

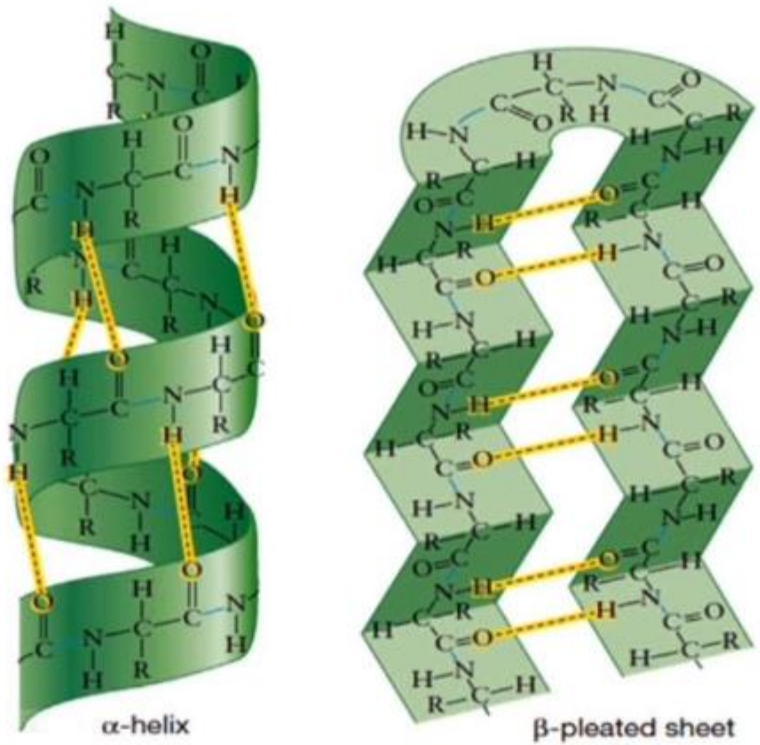


α helix

(a) Hydrogen bonds can form between nearby amino and carbonyl groups on the same polypeptide chain.



(b) Secondary structures of proteins result.



(c) Ribbon diagrams of secondary structure

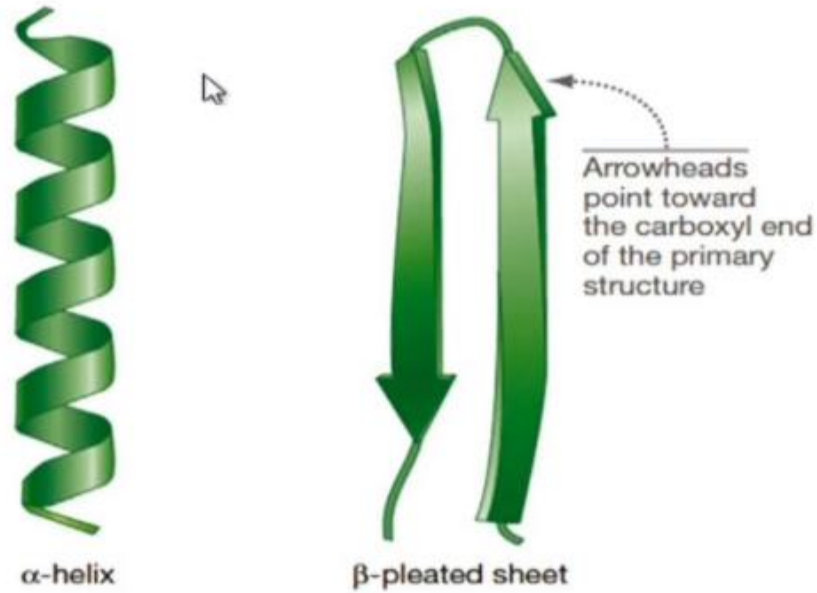


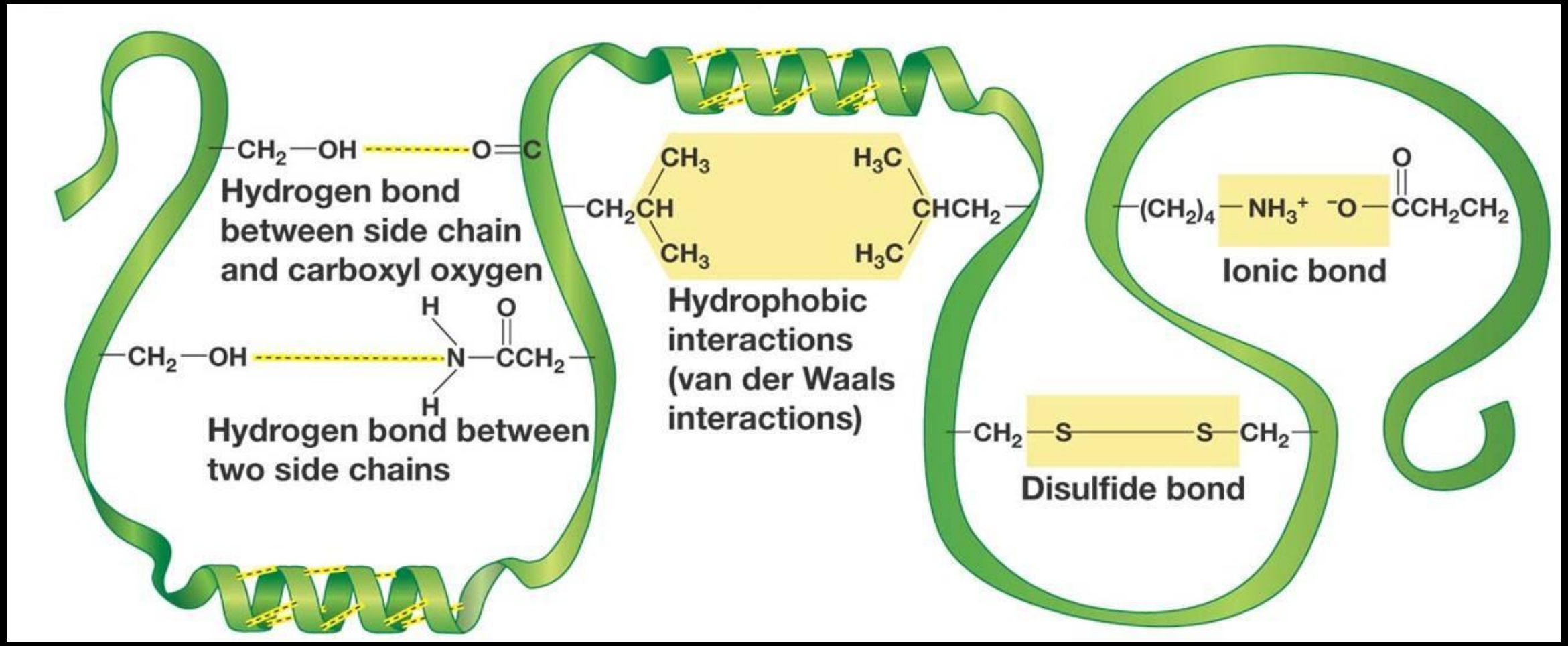
Figure 3.10 Secondary Structures of Proteins. **(a)** Neighboring regions in a polypeptide chain can form hydrogen bonds between N–H and C=O groups in the peptide-bonded backbone. **(b)** These interactions can result in helical coils or folds that form pleated-sheet structures in the polypeptide. **(c)** Ribbon diagrams represent secondary structures using coils for helices and parallel arrows for pleated sheets.

a.

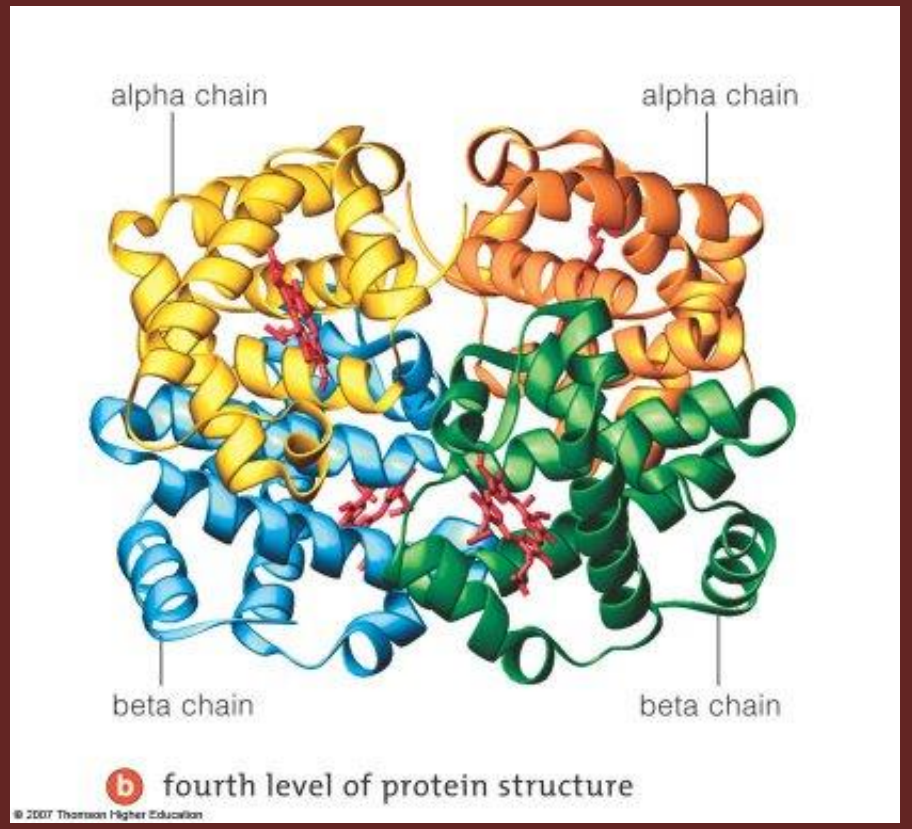
b.

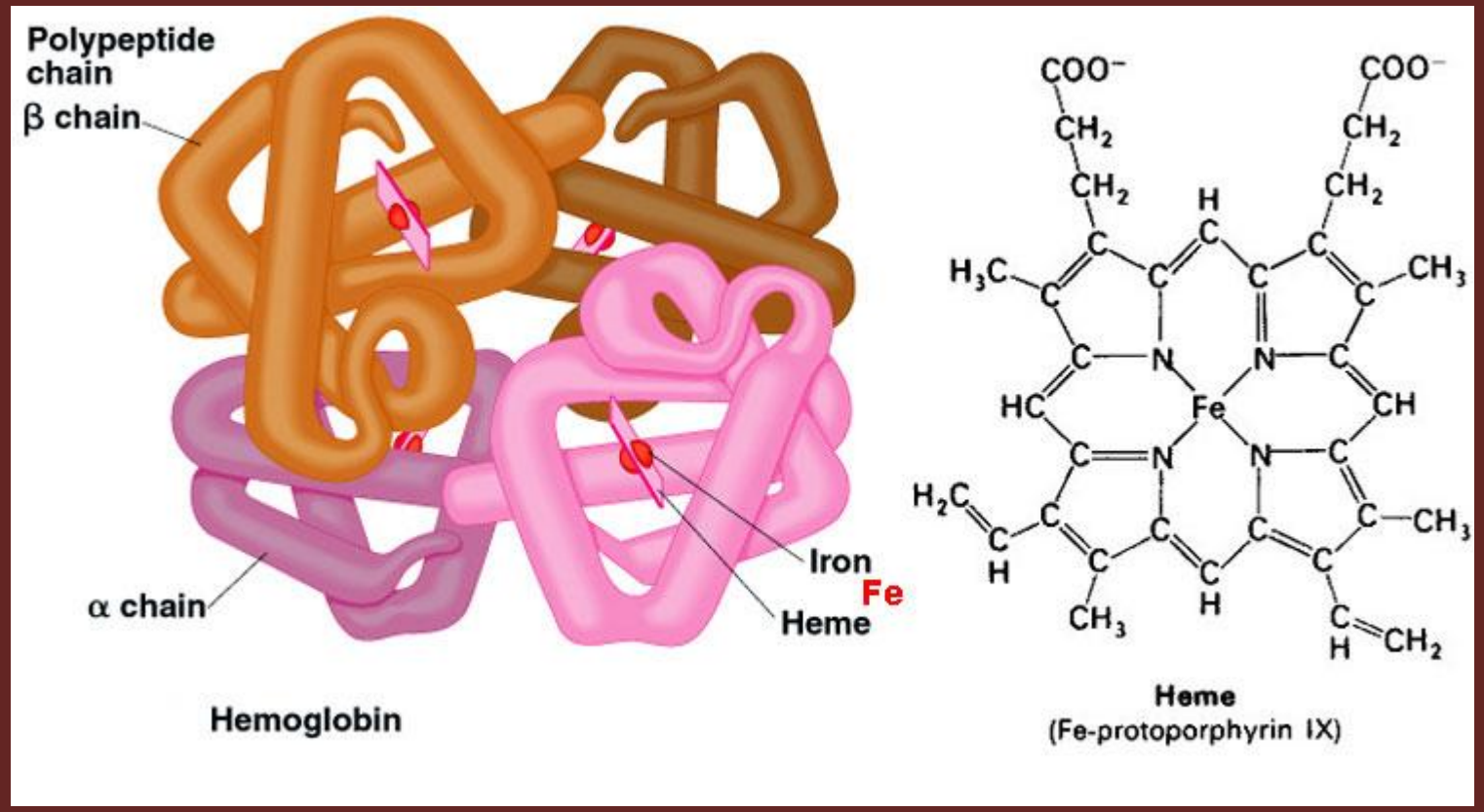
FIGURE 3.18 Fibrous proteins.

Tertiary structure



quaternary structure





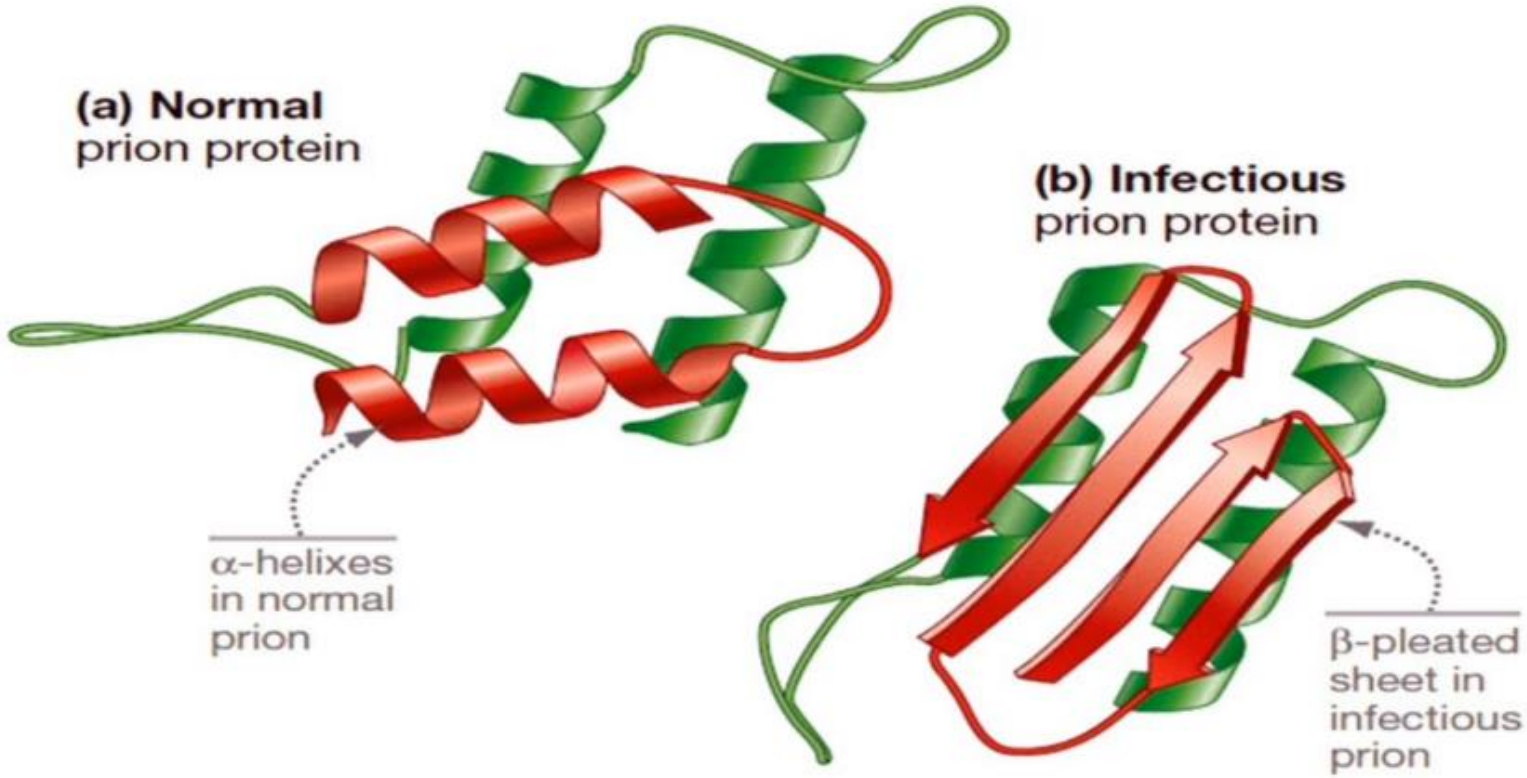


Figure 3.14 Prion Infectivity Is Linked to Structure. Ribbon diagram of **(a)** a normal, noninfectious prion protein with α-helices; and **(b)** the infectious form with β-pleated sheets that causes mad cow disease in cattle.

Figure 20.9 A telephone cord has three levels of structure. These structural levels are a good analogy for the first three levels of protein structure.

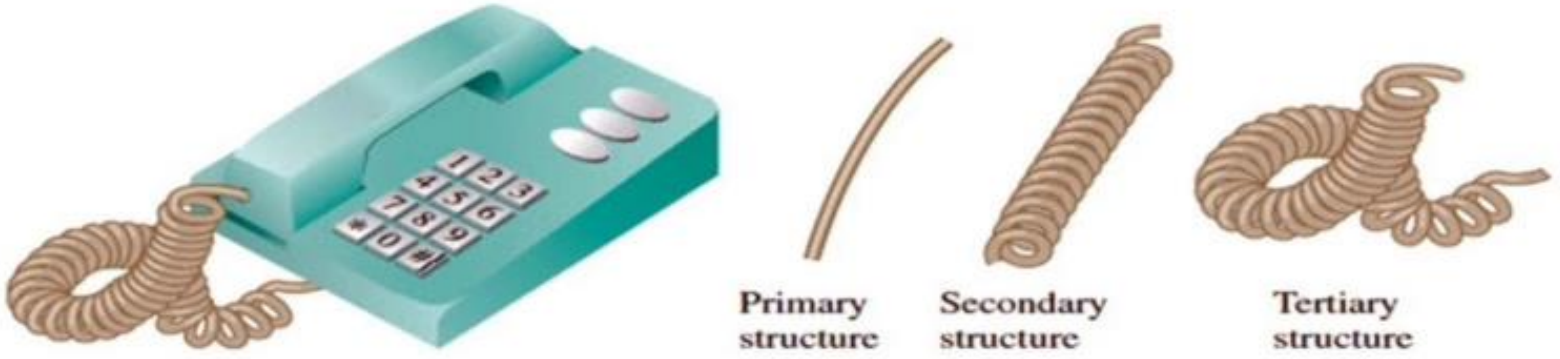
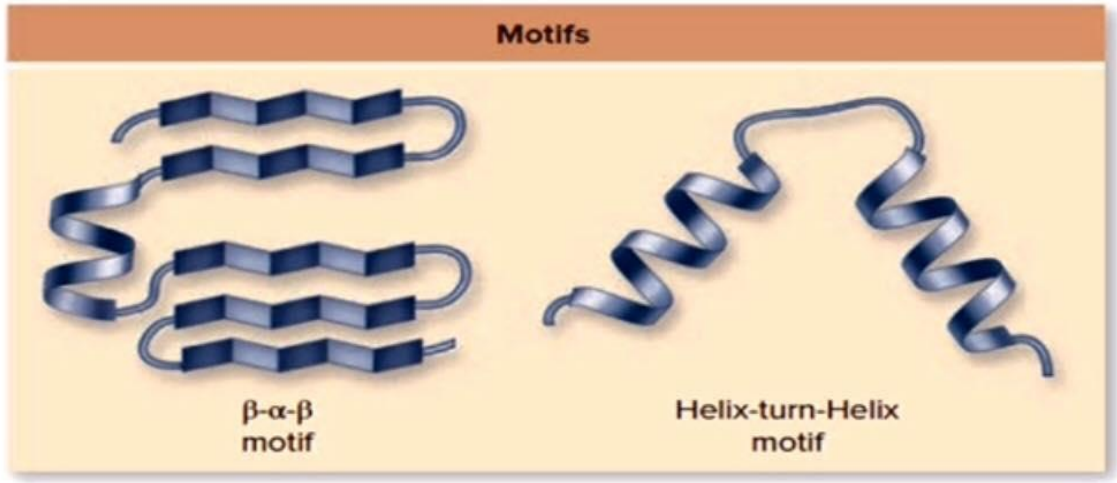


TABLE 16.6 Summary of Structural Levels in Proteins

Structural Level	Characteristics
Primary	Peptide bonds join amino acids in a specific sequence in a polypeptide.
Secondary	The coiled α helix, β-pleated sheet, or a triple helix forms by hydrogen bonding between peptide bonds along the chain.
Tertiary	A polypeptide folds into a compact, three-dimensional shape stabilized by interactions between R groups of amino acids to form a biologically active protein.
Quaternary	Two or more protein subunits combine to form a biologically active protein.



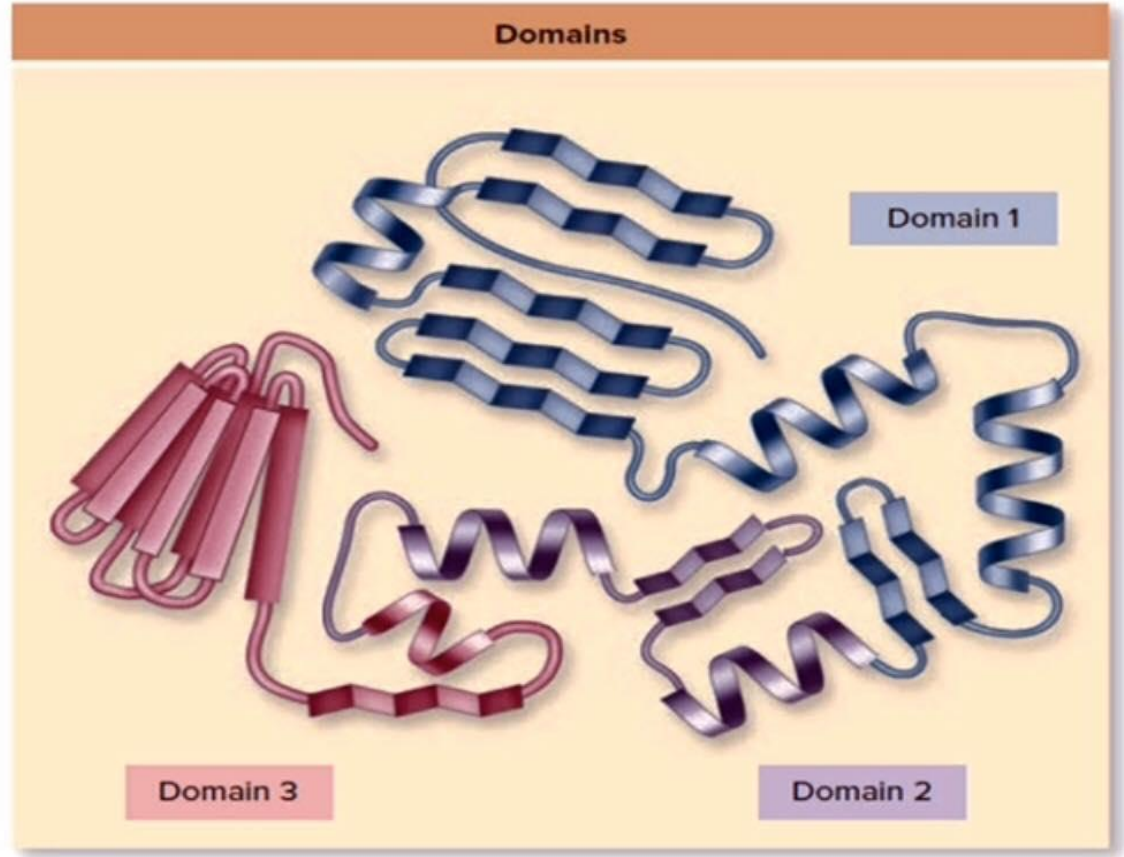


Figure 3.16 Motifs and domains. The elements of secondary structure can combine, fold, or crease to form motifs. These motifs are found in different proteins and can be used to predict function. Proteins also are made of larger domains, which are functionally distinct parts of a protein. The arrangement of these domains in space is the tertiary structure of a protein.

agents: pH, temp, ionic strength, solubility

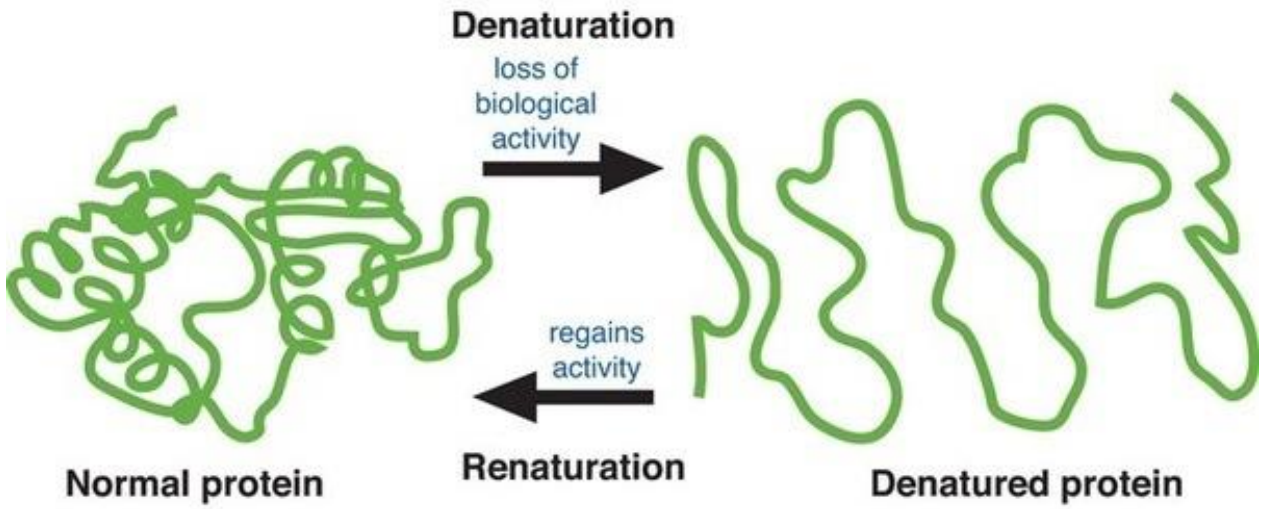
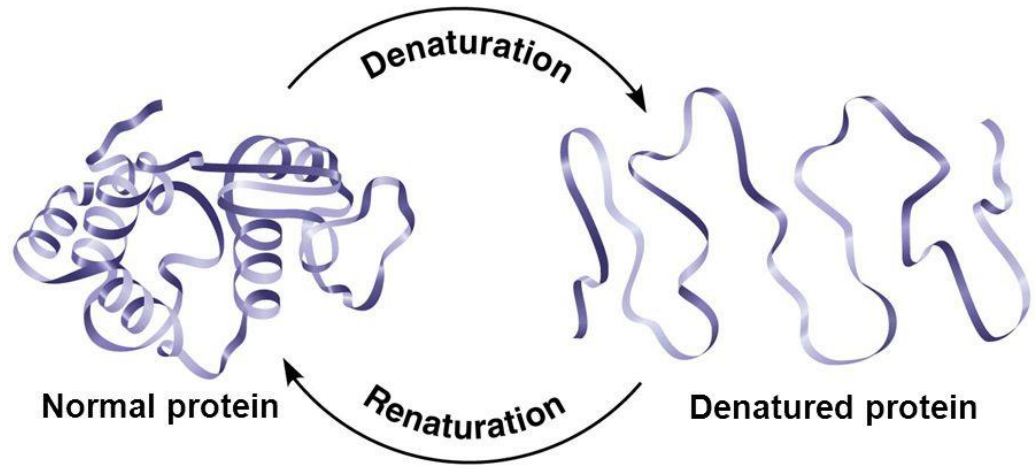
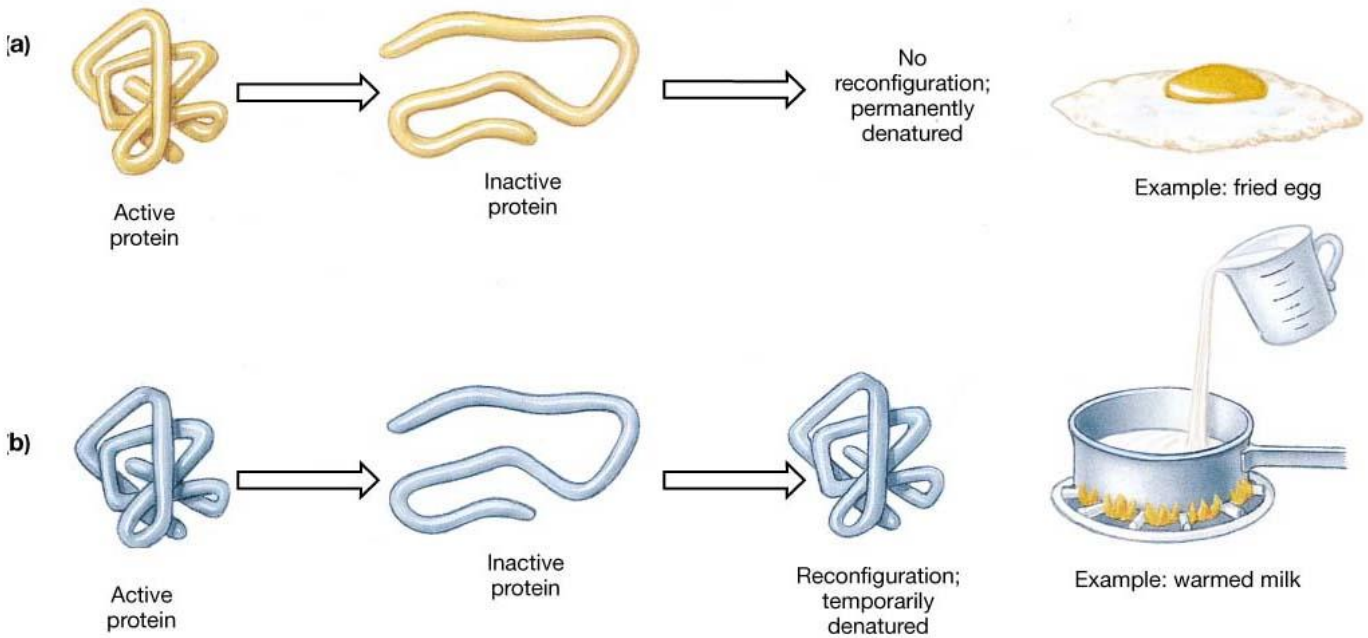


Figure 3.23-3





ตารางที่ 3.11 กลไกการเสียสภาพของโปรตีนจำแนกตามสิ่งที่ทำให้เสียสภาพ

สิ่งทำให้เสียสภาพ (denaturing agent)	กลไกการเสียสภาพ (mode of action)
ความร้อน	ทำให้พันธะไฮโดรเจนระหว่างโมเลกุลสั่นสะเทือนอย่างรุนแรง จนทำให้เกิดการตกตะกอน เช่น การทอดไข่ดาว
รังสีไมโครเวฟ	ทำให้เกิดการสะเทือนของโมเลกุลอย่างรุนแรงจนทำให้พันธะไฮโดรเจนแตกออก
รังสีอัลทราไวโอเลต	ทำให้พันธะไฮโดรเจนระหว่างโมเลกุลสั่นสะเทือนอย่างรุนแรง เช่น ผิวไหม้จากแสงแดด
การเขย่าอย่างรุนแรง (violent shaking)	ทำให้โมเลกุลโปรตีนทรงกลมยืดยาวออกจนพันกันยุ่ง เช่น การตีไข่ขาวให้เป็นครีมในการทำขนมเบื้องหรือเมอร์แรงก์ (merringe)
สารซักฟอก (detergent)	มีผลต่อพันธะของโซ่ข้าง (หมู่ R)
ตัวทำละลายอินทรีย์ (เช่น เอทานอล แอซีโตน)	มีผลต่อพันธะของโซ่ข้าง (หมู่ R) เนื่องจากตัวทำละลายอินทรีย์ทำลายพันธะไฮโดรเจน และทำให้โปรตีนเสียสภาพอย่างรวดเร็ว เช่น การทำลายแบคทีเรียด้วยเอทานอลร้อยละ 70
กรดแก่ และเบสแก่	ทำลายพันธะไฮโดรเจน และสะพานเกลือ (salt bridge) จนทำให้เกิดปฏิกิริยาสลายพันธะเพปไทด์ของโปรตีน
เกลือของโลหะหนัก (เช่น เกลือของ Hg^{2+}, Ag^{+}, Pb^{2+})	โลหะหนักจับกับหมู่ซัลฟ์ไฮดริลและเกิดเป็นเกลือที่เป็นพิษ (poisonous salt)
สารรีดิวซ์	รีดิวซ์พันธะไดซัลไฟด์ของโปรตีนเกิดเป็นกรดอะมิโนที่มีหมู่ซัลฟ์ไฮดริล

ตารางที่ 3.12 จุดประจุไฟฟ้าสมดุล (pI) ของโปรตีนบางชนิด

โปรตีน	pI	โปรตีน	pI	โปรตีน	pI
เพปซิน	< 1.0	บีตา-แลกโทโกลบูลิน	5.2	ไคโมทริปซิโนเจน	9.5
อัลบูมินในไข่ขาว	4.6	อินซูลิน	5.4	ไซโทโครม ซี	10.7
อัลบูมินในซีรัม	4.9	ฮีโมโกลบิน	6.8	ฮีสโทน	10.8
ยูรีเอส	5.0	ไมโอโกลบิน	7.0	ไลโซไซม	11.0

pI > pH ของสารละลาย — **net charge (–)**

pI < pH ของสารละลาย — **net charge (+)**

} **โปรตีนผลักกัน ไม่ตกตะกอน**

pI = pH ของสารละลาย — **net charge (0)**

โปรตีนรวมกัน ตกตะกอน

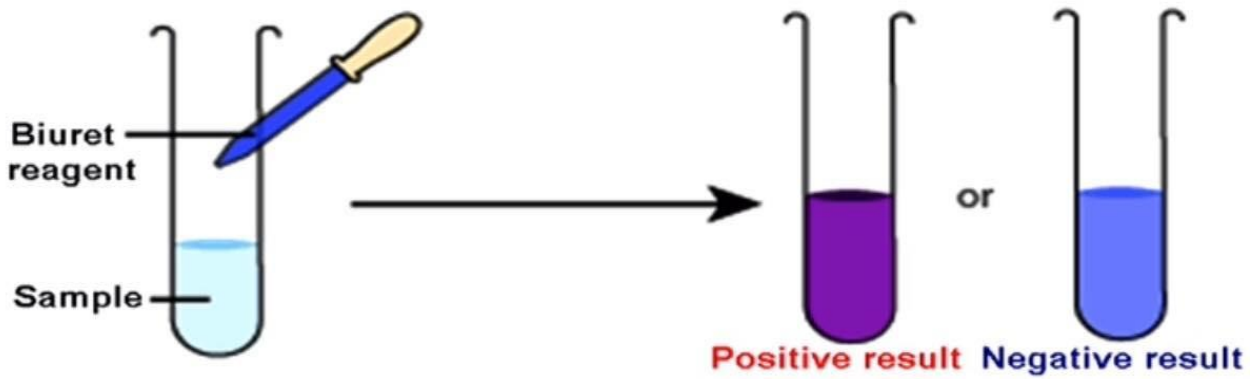
กรดอะมิโนแต่ละชนิดมีค่าความเป็นกรด-เบสที่ทำให้ประจุมีค่าสมดุลหรือมีจำนวนประจุบวกและประจุลบเท่ากัน เรียกค่าความเป็นกรด-เบสนี้ว่า **จุดไอโซอิเล็กทริกหรือจุดประจุไฟฟ้าสมดุล (isoelectric point, pI)**

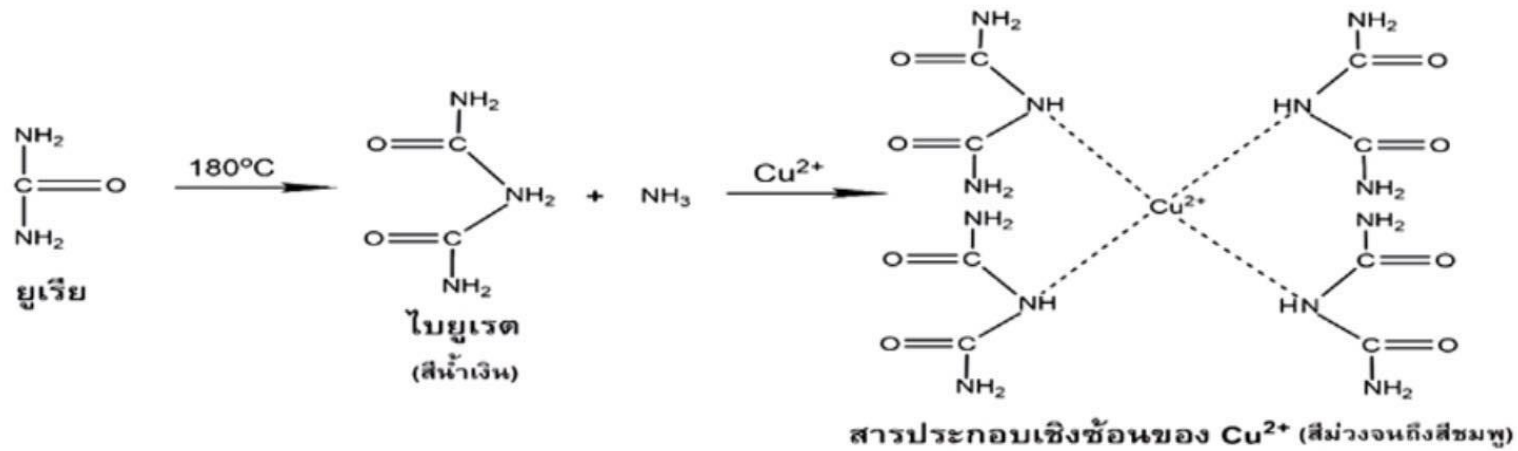
กรดอะมิโน	pI	กรดอะมิโน	pI	กรดอะมิโน	pI
ไกลซีน	5.97	เฟนิลอะลานีน	5.48	ไทโรซีน	5.66
อะลานีน	6.01	ทริปโตเฟน	5.88	กรดแอสพาร์ทิก	2.77
เวลีน	5.97	เซรีน	5.68	กรดกลูทามิก	3.22
ลิวซีน	5.98	ทรีโอนีน	5.87	ไลซีน	9.74
ไอโซลิวซีน	6.02	ซิสเทอีน	5.07	อาร์จินีน	10.76
โพรลีน	6.48	แอสพาราจีน	5.41	อีสทิดีน	7.59
เมไทโอนีน	5.74	กลูทามีน	5.65		

การทดสอบโปรตีน

Biuret test

ทดสอบสารที่มีพันธะเพปไทด์ (– CO–NH –) ตั้งแต่ 2 ตำแหน่งขึ้นไป ได้แก่ ไตรเพปไทด์ โอลิโกเพปไทด์ และโปรตีนที่มีโครงสร้างซับซ้อน





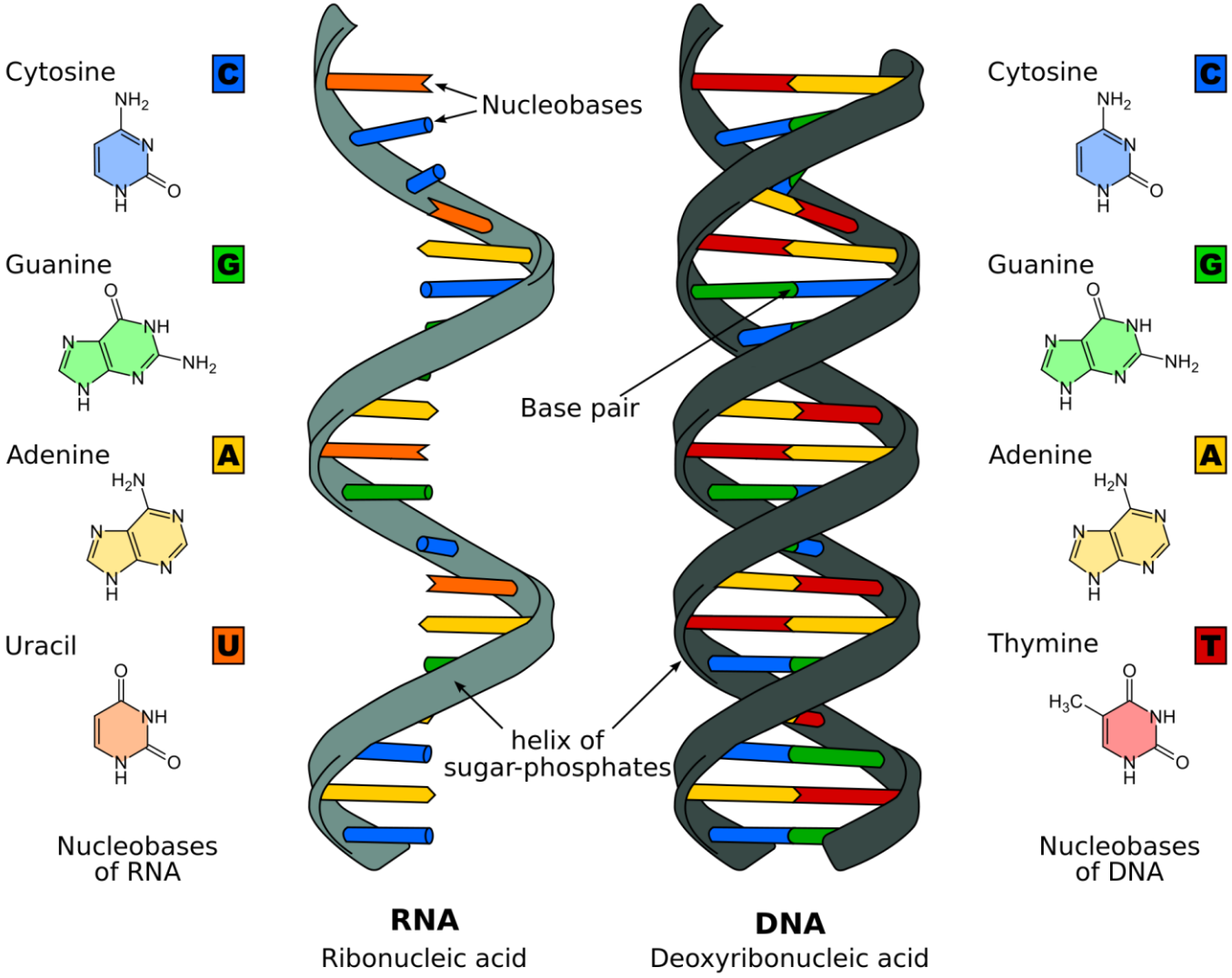
Sulfur test ทดสอบกรดอะมิโนที่มีกำมะถันเป็นองค์ประกอบ ได้แก่ ซีสเทอีน และซิสทีน ยกเว้นเมไทโอนีน

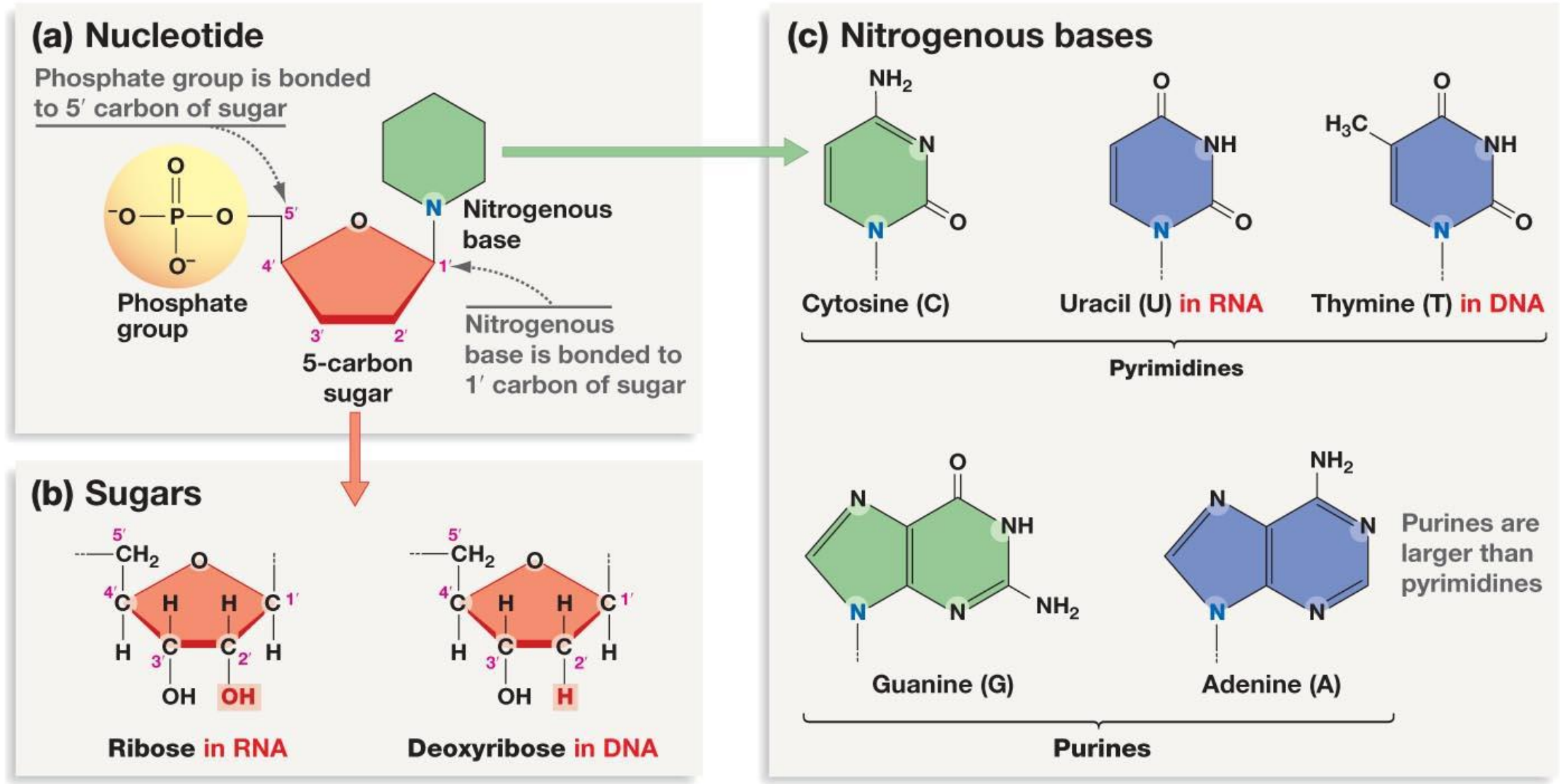
$$Na_2S + (CH_3COO)_2Pb \longrightarrow PbS + 2CH_3COONa$$

ตะกอนดำ

Sakaguchi reaction ใช้ทดสอบกรดอะมิโนอาร์จีนีนที่มีโซ่ข้าง เป็นกวานิดีน (guanidine)

Nucleic acids





DNA double helix is made of two strands.

Each strand is a chain of of antiparallel nucleotides.

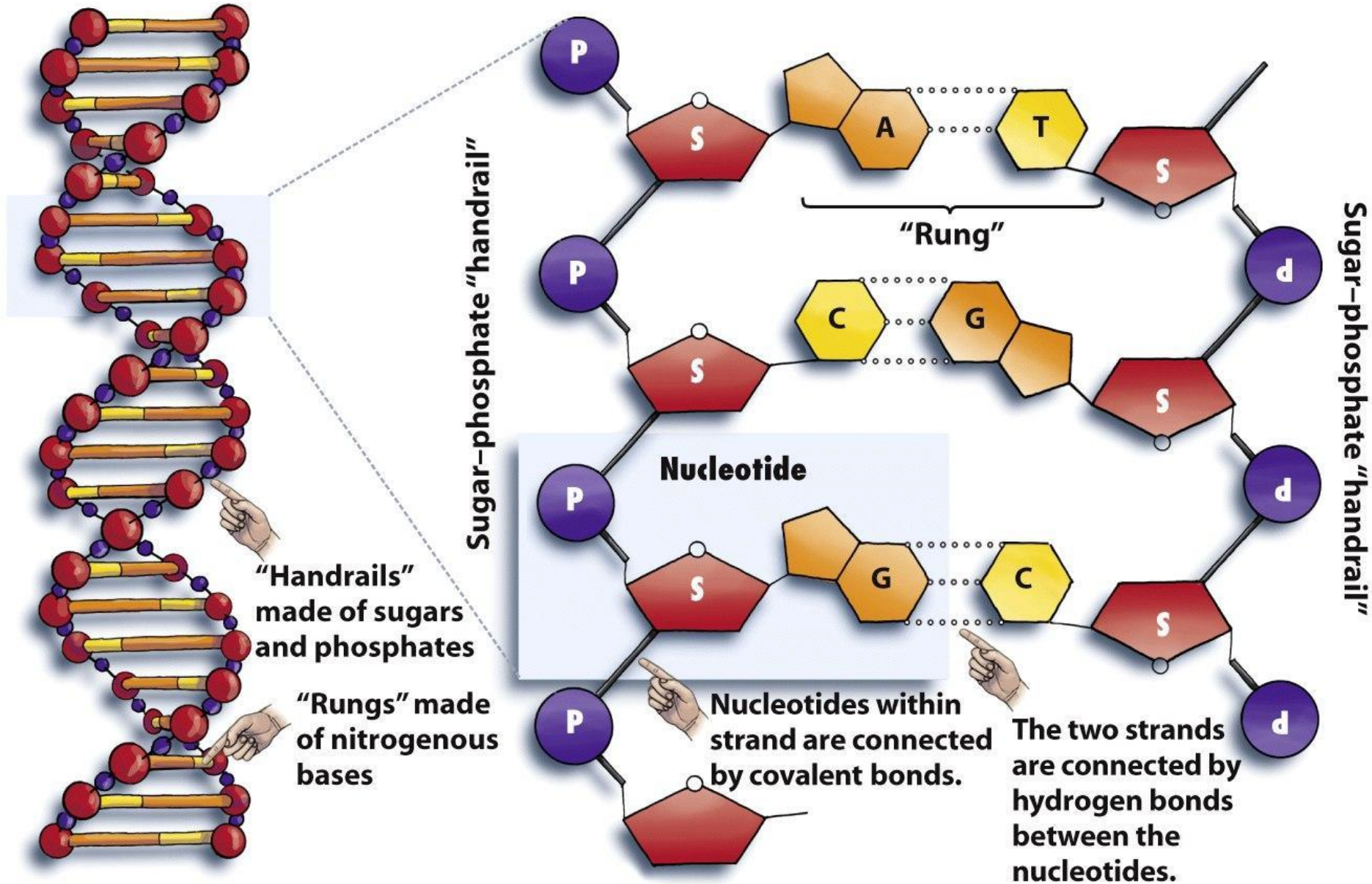
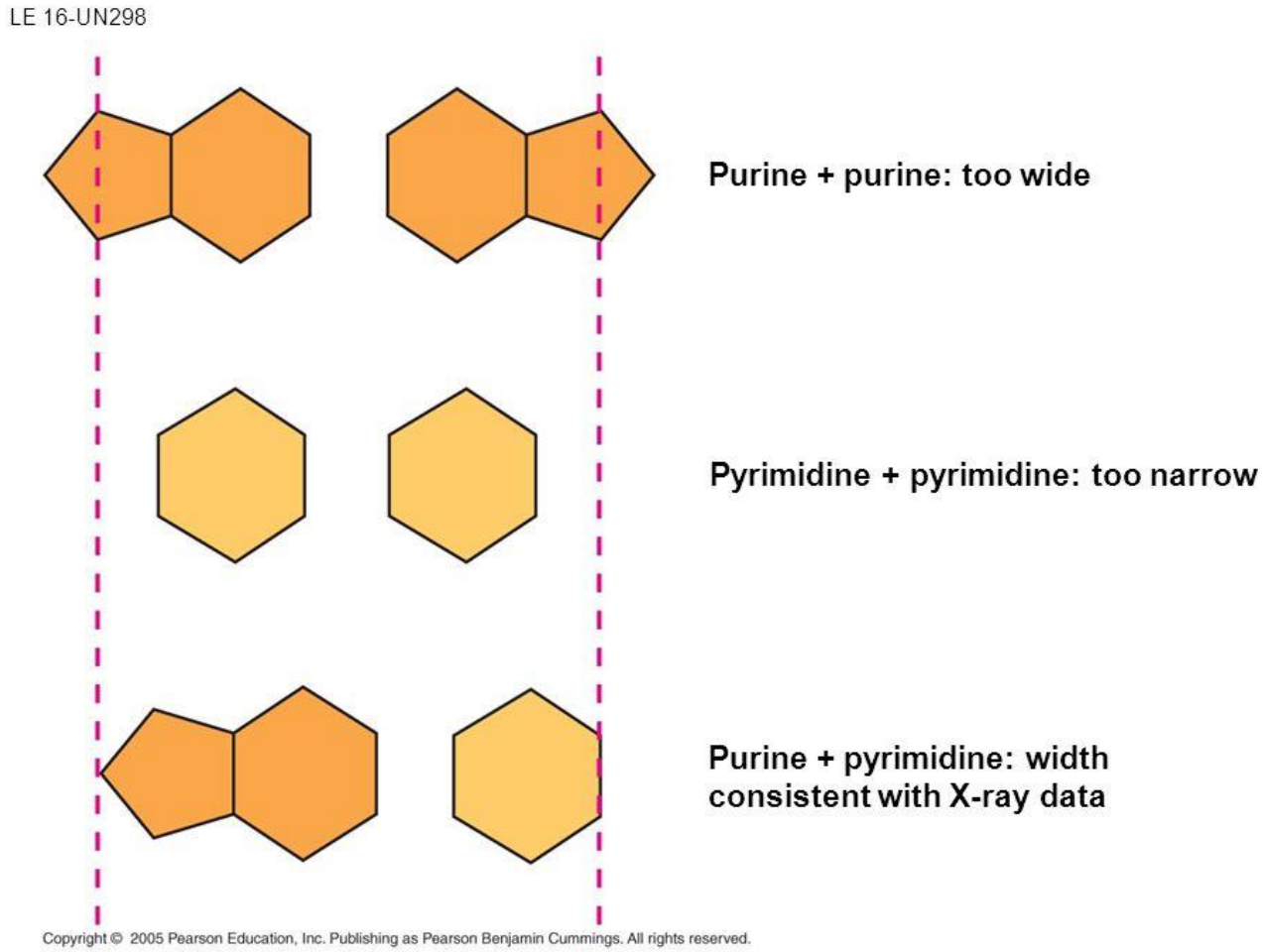


Figure 2-13ab Biology: Science for Life, 2/e

A purine-purine pair is too wide and a pyrimidine-pyrimidine pair too narrow to account for the 2-nm diameter of the double helix.



Chargaff's Rule: Rule of Base Pairing

Table 8.1 Base composition of DNA from different sources and ratios of bases

Source of DNA	A	T	G	C	Ratio A/T	Ratio G/C	Ratio (A + G)/(T + C)
E. coli	26.0	23.9	24.9	25.2	1.09	0.99	1.04
Yeast	31.3	32.9	18.7	17.1	0.95	1.09	1.00
Sea urchin	32.8	32.1	17.7	18.4	1.02	0.96	1.00
Rat	28.6	28.4	21.4	21.5	1.01	1.00	1.00
Human	30.3	30.3	19.5	19.9	1.00	0.98	0.99

Table 8.1
Genetics Essentials: Concepts and Connections, First Edition

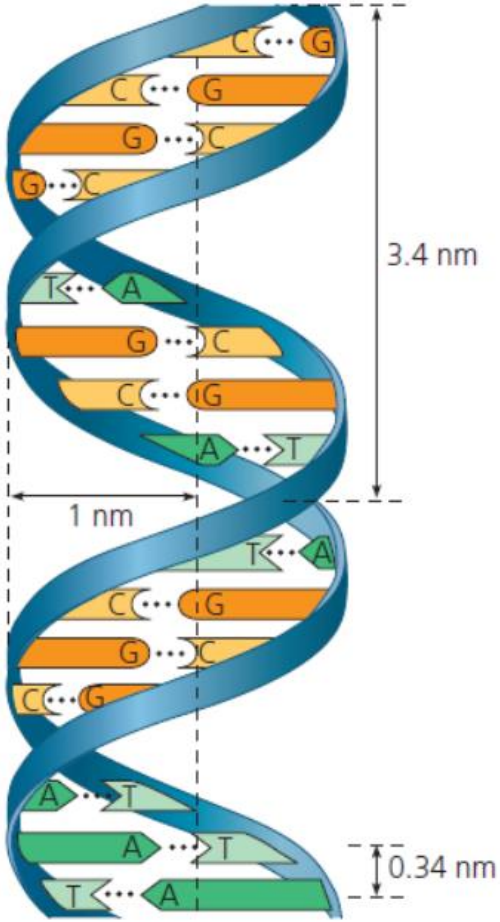
All DNA, A=T & G=C,

that is, A+G/T+C = 1

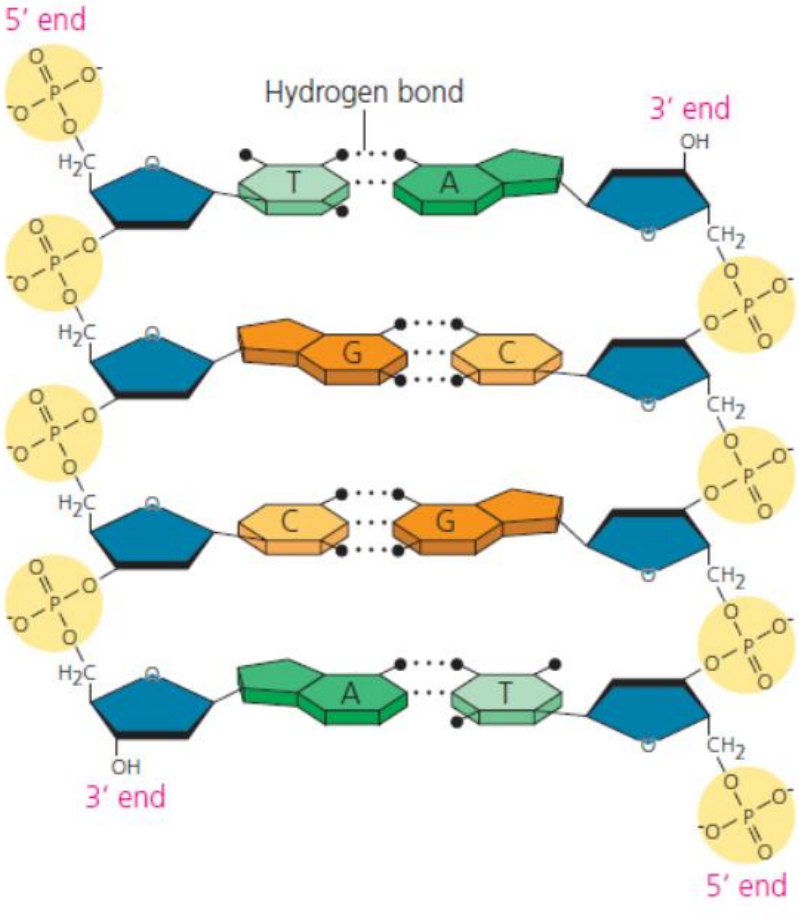
เพิ่มเติม

Names of Nucleosides and Nucleotides

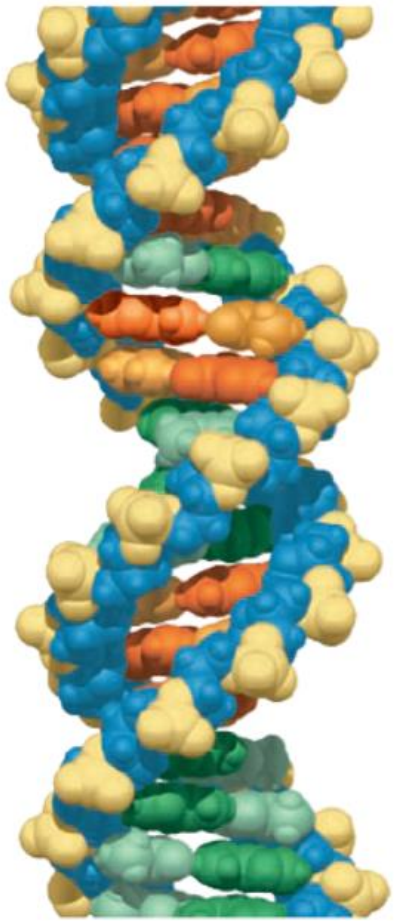
Base	Nucleosides	Nucleotides
RNA		
Adenine (A)	Adenosine (A)	Adenosine 5'-monophosphate (AMP)
Guanine (G)	Guanosine (G)	Guanosine 5'-monophosphate (GMP)
Cytosine (C)	Cytidine (C)	Cytidine 5'-monophosphate (CMP)
Uracil (U)	Uridine (U)	Uridine 5'-monophosphate (UMP)
DNA		
Adenine (A)	Deoxyadenosine (A)	Deoxyadenosine 5'-monophosphate (dAMP)
Guanine (G)	Deoxyguanosine (G)	Deoxyguanosine 5'-monophosphate (dGMP)
Cytosine (C)	Deoxycytidine (C)	Deoxycytidine 5'-monophosphate (dCMP)
Thymine (T)	Deoxythymidine (T)	Deoxythymidine 5'-monophosphate (dTMP)



(a) Key features of DNA structure. The "ribbons" in this diagram represent the sugar-phosphate backbones of the two DNA strands. The helix is "right-handed," curving up to the right. The two strands are held together by hydrogen bonds (dotted lines) between the nitrogenous bases, which are paired in the interior of the double helix.

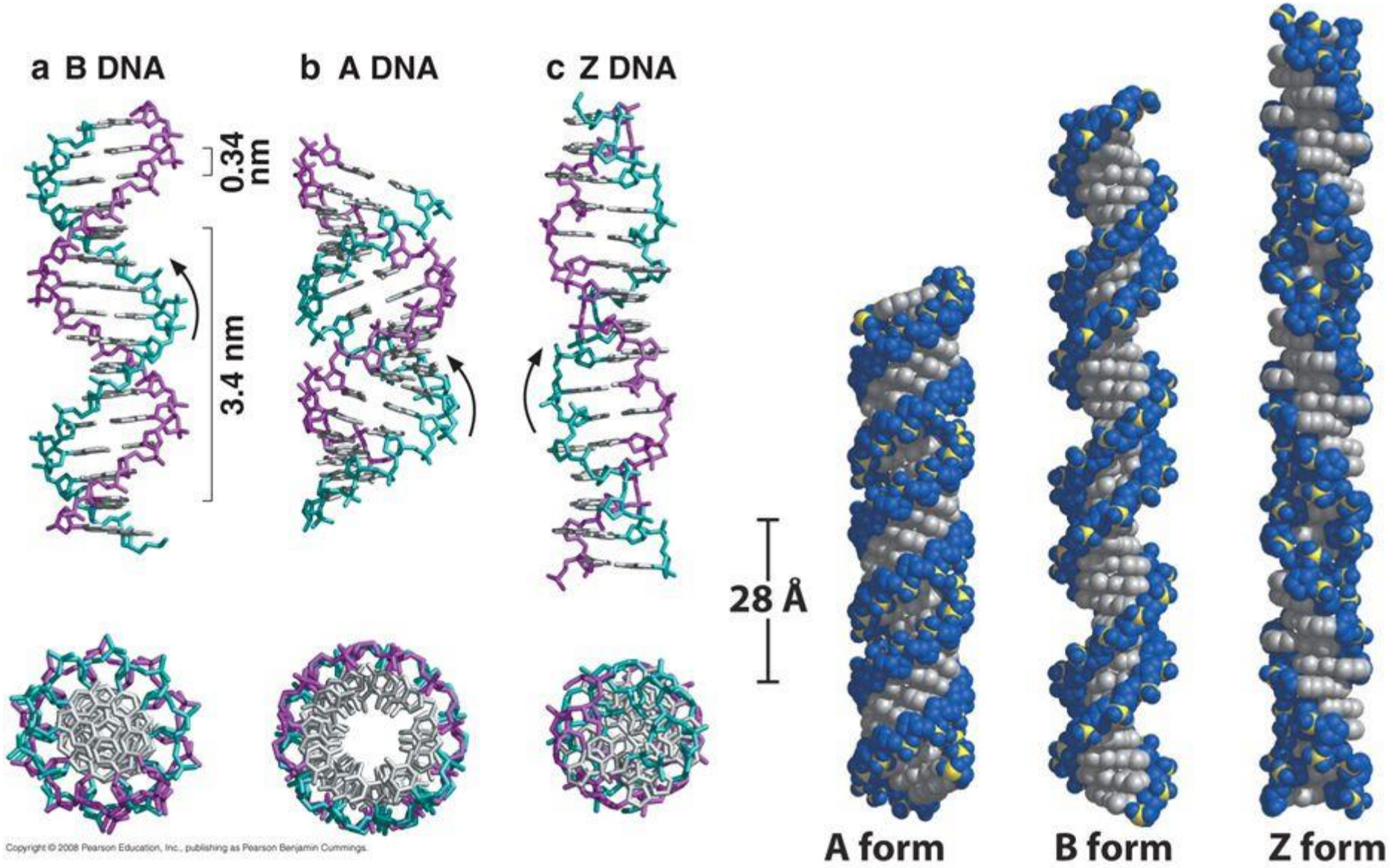


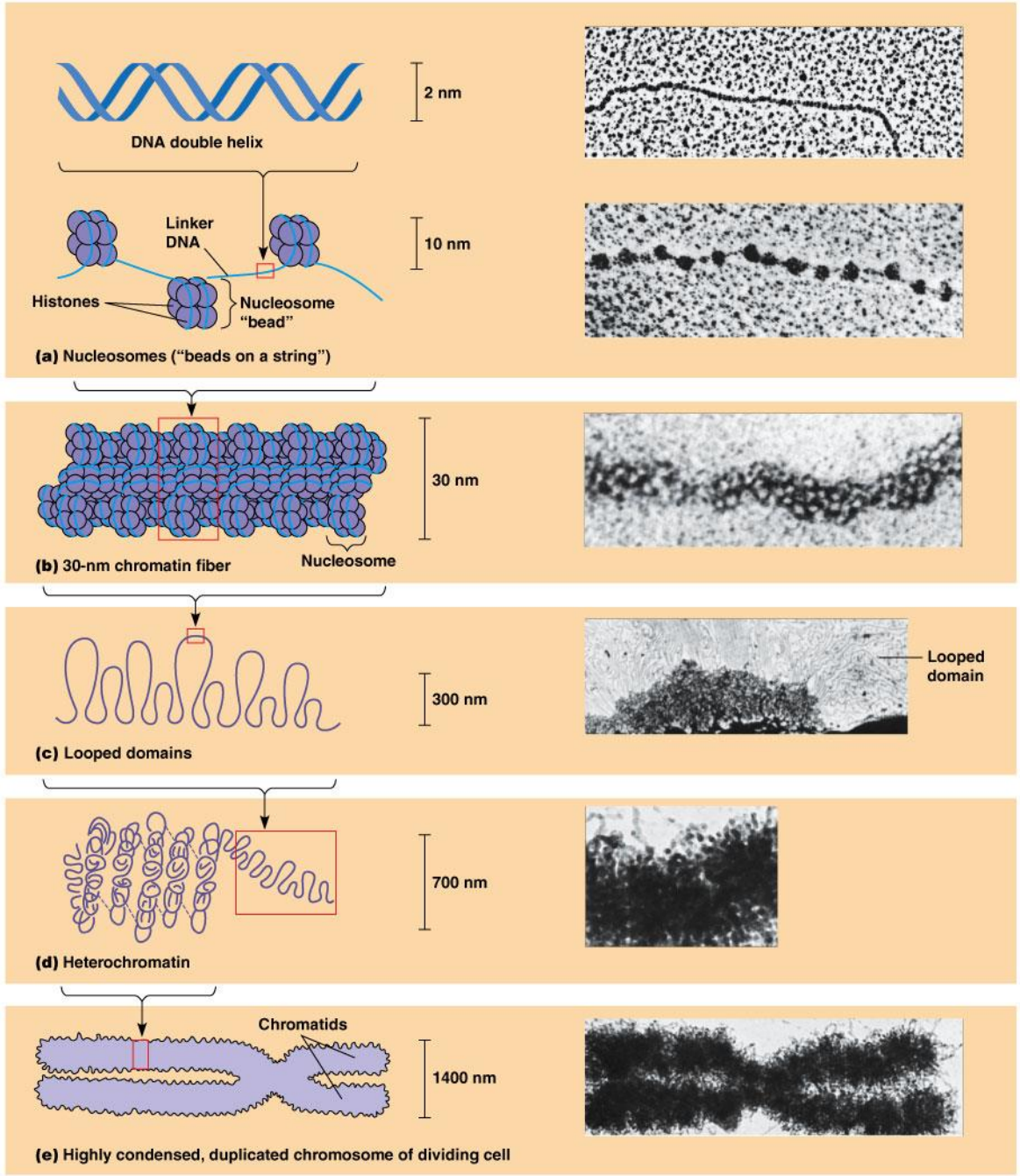
(b) Partial chemical structure. For clarity, the two DNA strands are shown untwisted in this partial chemical structure. Strong covalent bonds link the units of each strand, while weaker hydrogen bonds between the bases hold one strand to the other. Notice that the strands are antiparallel, meaning that they are oriented in opposite directions, like the lanes of a divided highway.



(c) Space-filling model. The tight stacking of the base pairs is clear in this computer-generated, space-filling model. Van der Waals interactions between the stacked pairs play a major role in holding the molecule together.

The double helix exists in multiple conformations





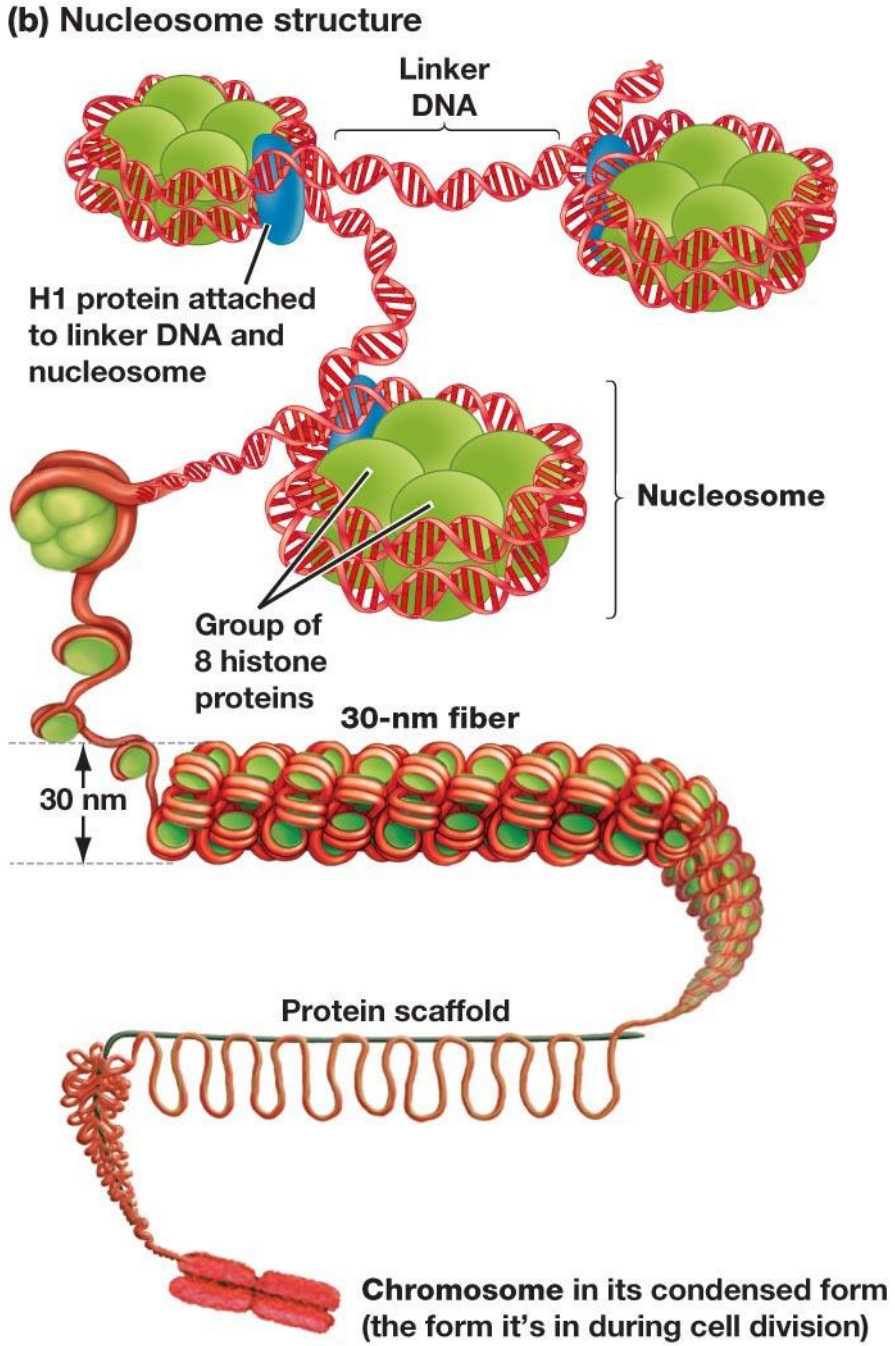
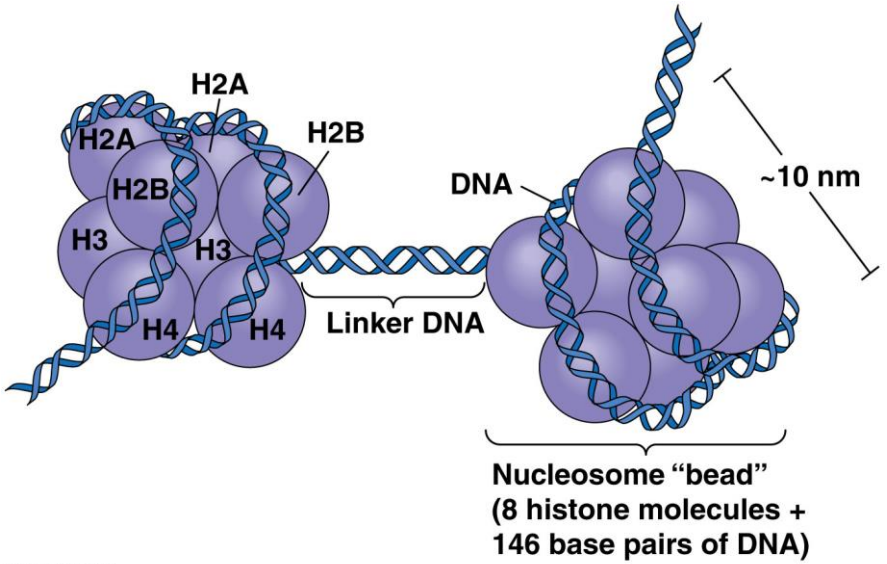
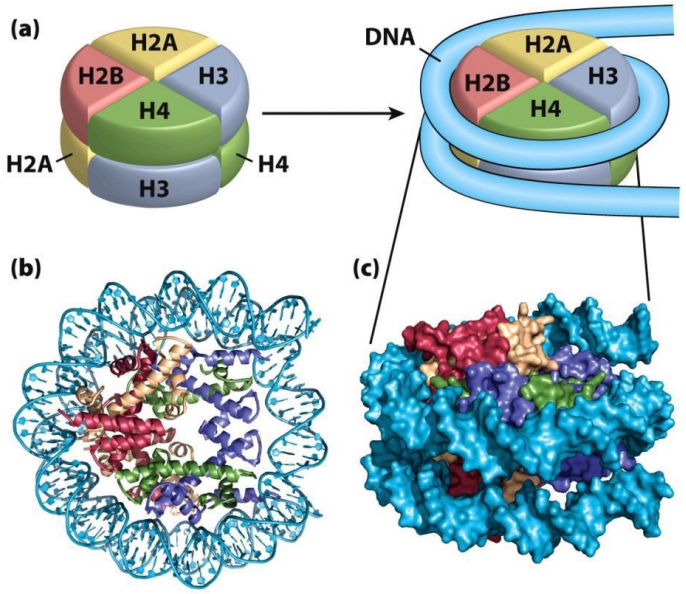


TABLE 5.4 The Major Histone Proteins

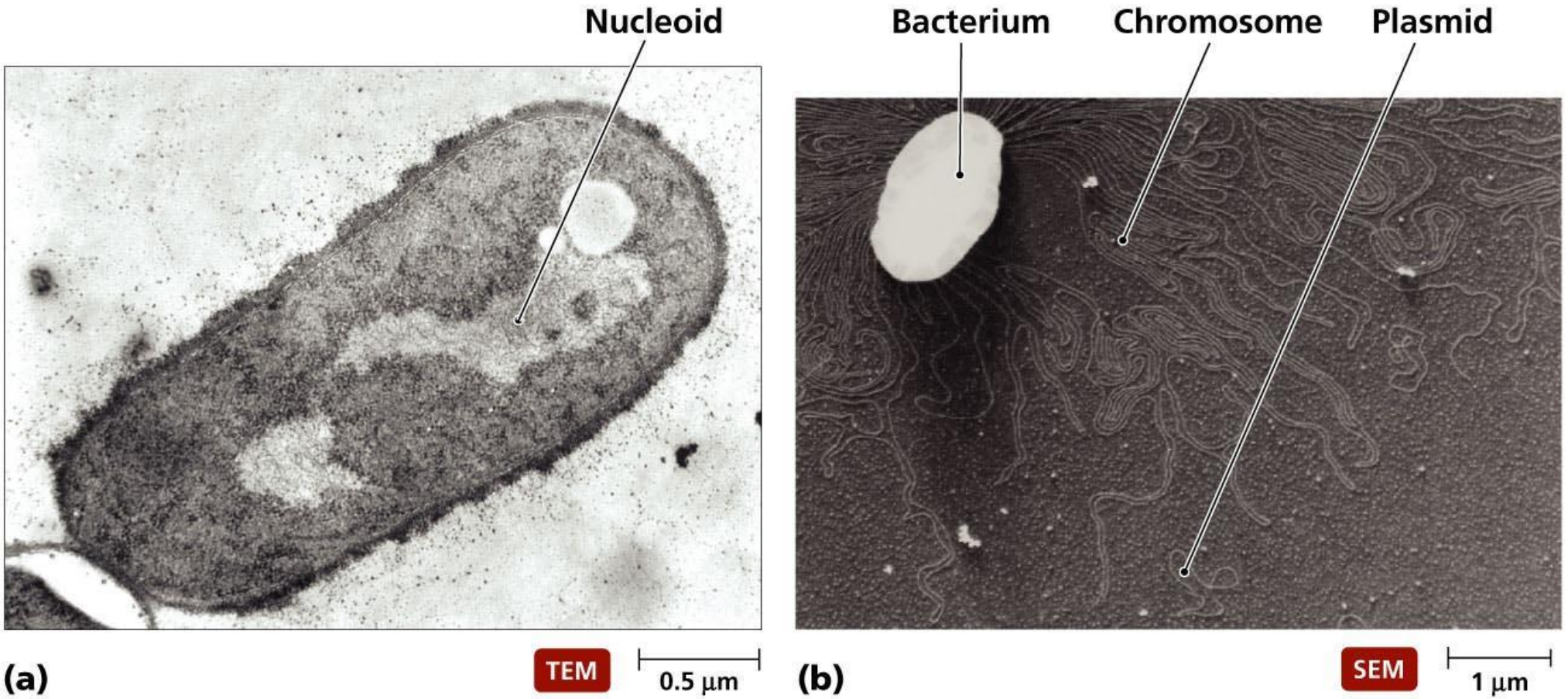
Histone[a]	Molecular weight	Number of amino acids	Percentage lysine + arginine
H1	22,500	244	30.8
H2A	13,960	129	20.2
H2B	13,774	125	22.4
H3	15,273	135	22.9
H4	11,236	102	24.5

[a] Data are for rabbit (H1) and bovine histones.

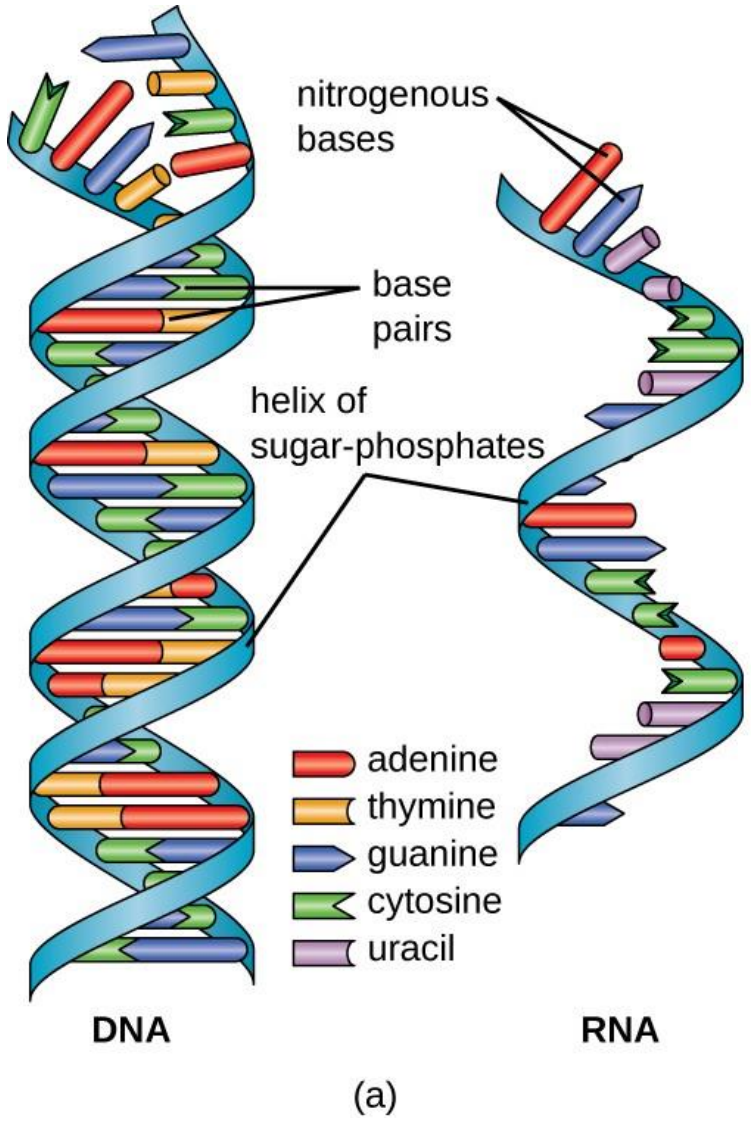


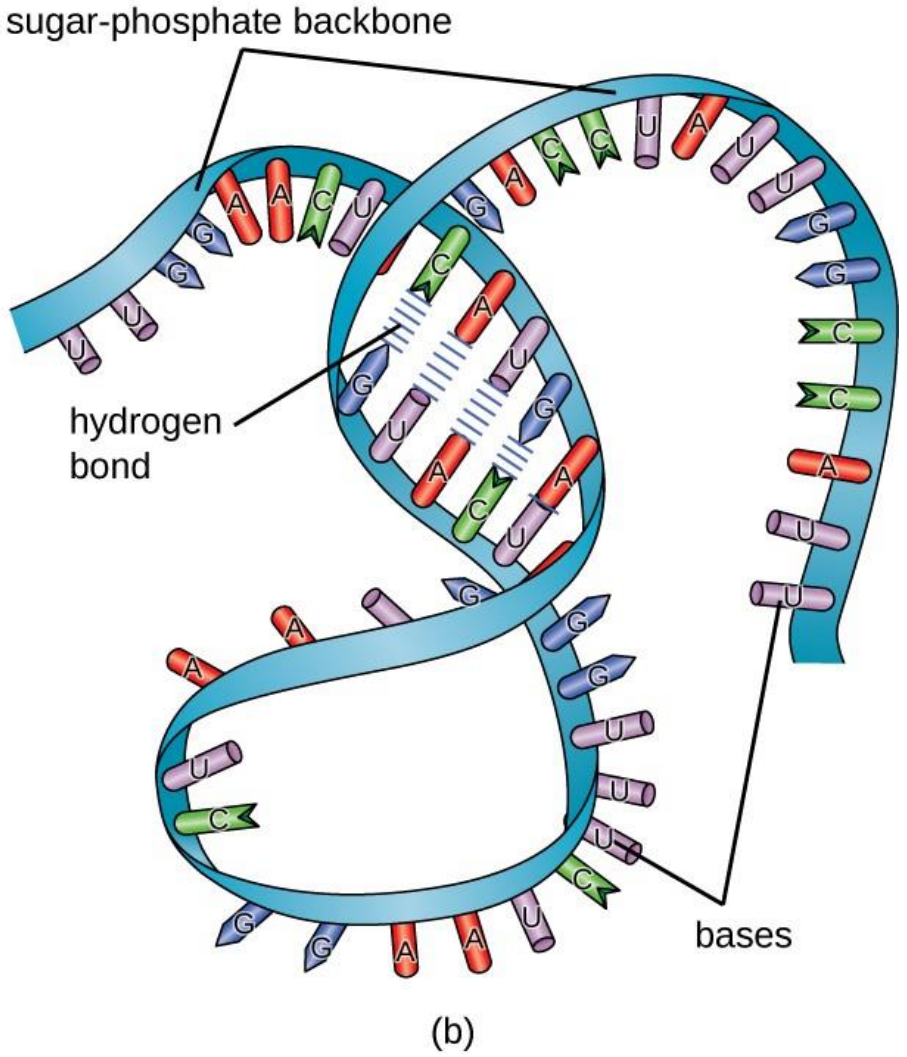


Bacterial chromosome



RNA


nitrogenous bases
base pairs
helix of sugar-phosphates
adenine
thymine
guanine
cytosine
uracil
DNA
RNA
(a)


sugar-phosphate backbone
hydrogen bond
bases
(b)

Types of RNA

The three main types of RNA are:

Messenger RNA

Ribosomal RNA

Transfer RNA