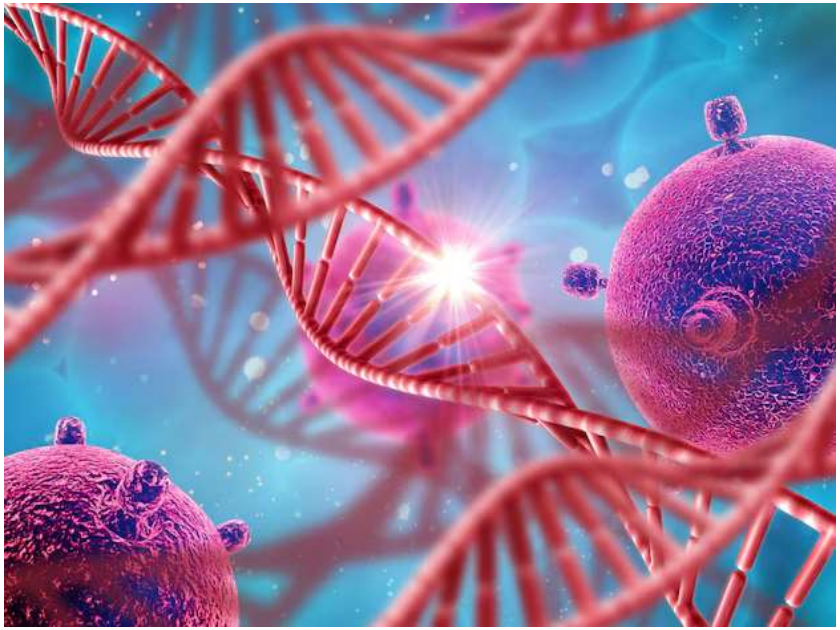
Lecture 6

General Biology & Cytology Course 2301130



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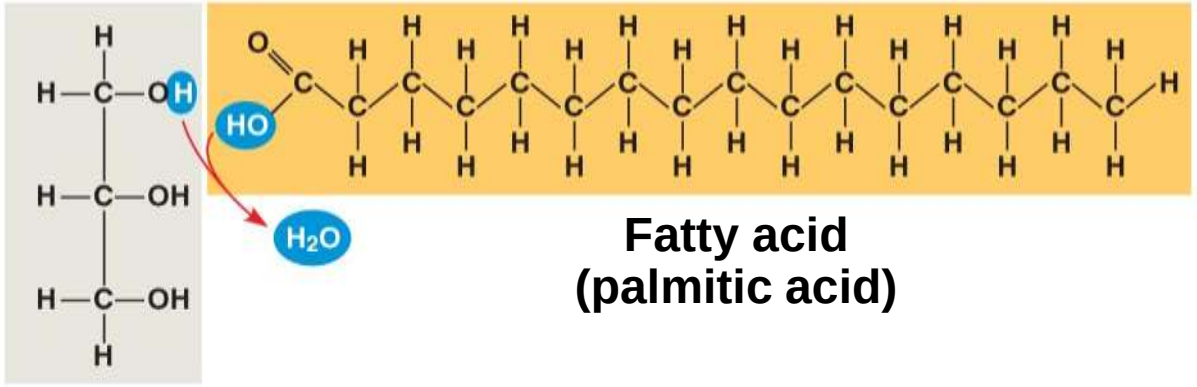
Lipids are a diverse group of hydrophobic molecules

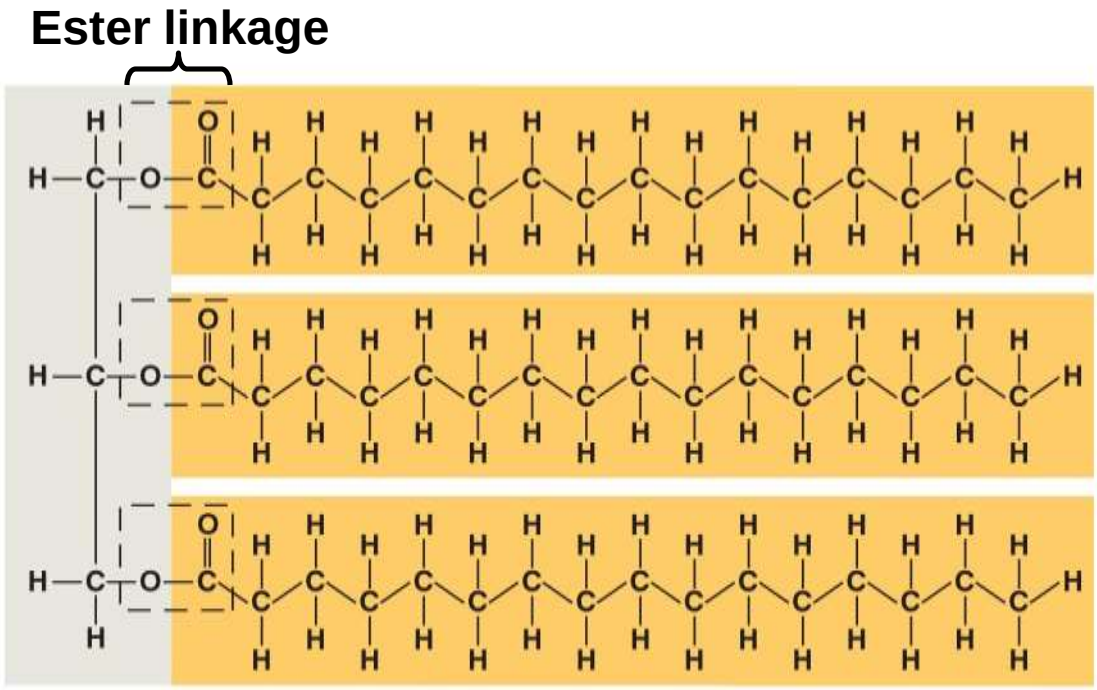
- **Lipids** are the one class of large biological molecules that do not form polymers
- The unifying feature of lipids is having little or no affinity for water
- Lipids are hydrophobic because they consist mostly of hydrocarbons, which form nonpolar covalent bonds
- The most biologically important lipids are fats, phospholipids, and steroids

Fats

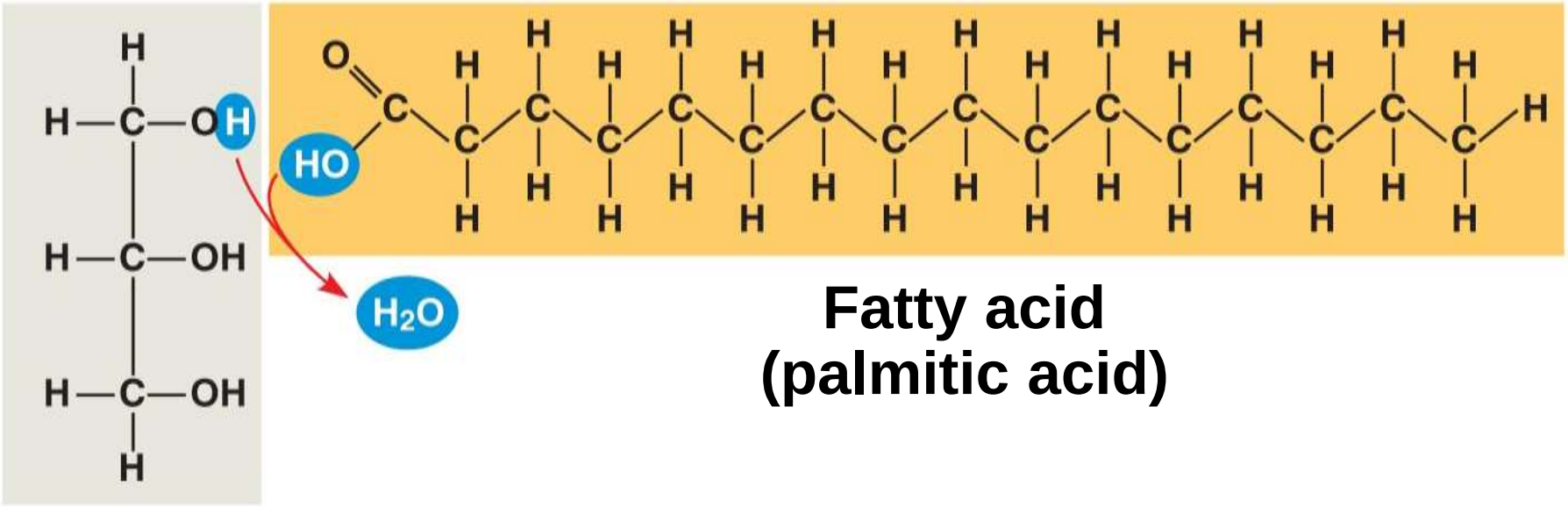
- **Fats** are constructed from two types of smaller molecules: glycerol and fatty acids
- Glycerol is a three-carbon alcohol with a hydroxyl group attached to each carbon
- A **fatty acid** consists of a carboxyl group attached to a long carbon skeleton



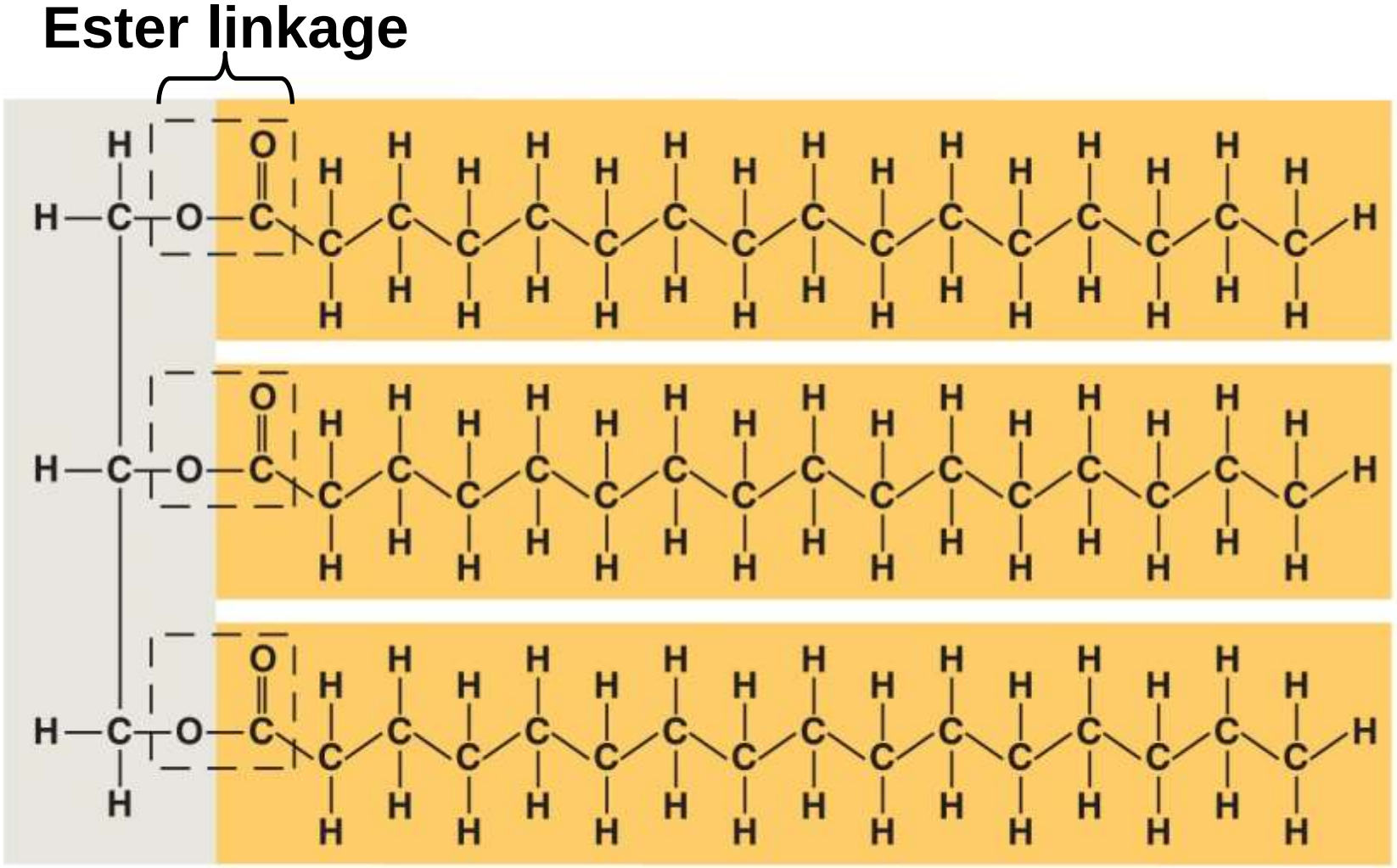
(a) Dehydration reaction in the synthesis of a fat



(b) Fat molecule (triacylglycerol)



(a) Dehydration reaction in the synthesis of a fat

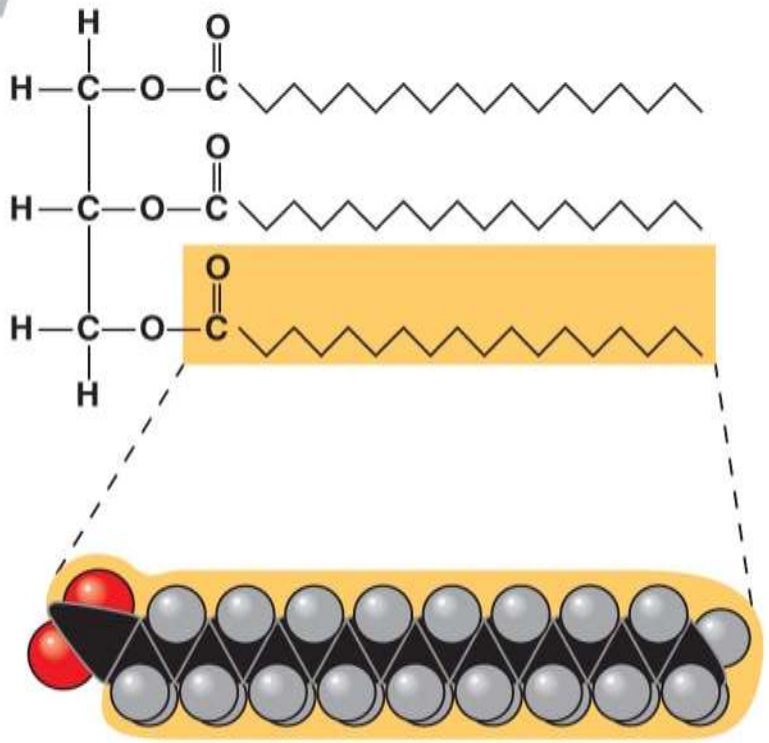


(b) Fat molecule (triacylglycerol)

- Fats separate from water because water molecules form hydrogen bonds with each other and exclude the fats
- In a fat, three fatty acids are joined to glycerol by an ester linkage, creating a **triacylglycerol**, or triglyceride

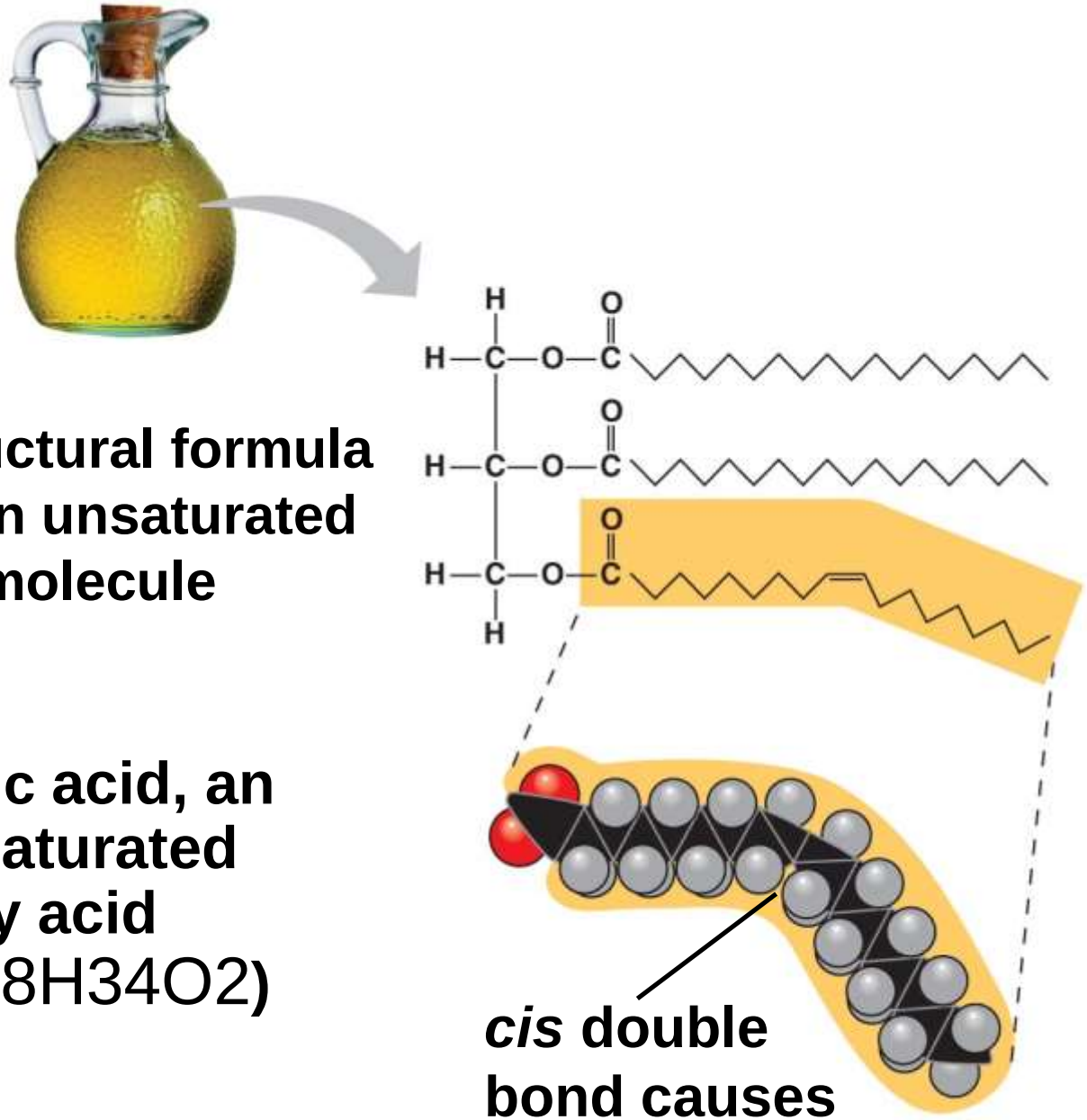
- Fatty acids vary in length (number of carbons) and in the number and locations of double bonds.
- **Saturated fatty acids** have the maximum number of hydrogen atoms possible and no double bonds
- **Unsaturated fatty acids** have one or more double bonds

Structural formula of a saturated fat molecule



Stearic acid, a saturated fatty Acid ($C_{18}H_{36}O_2$).

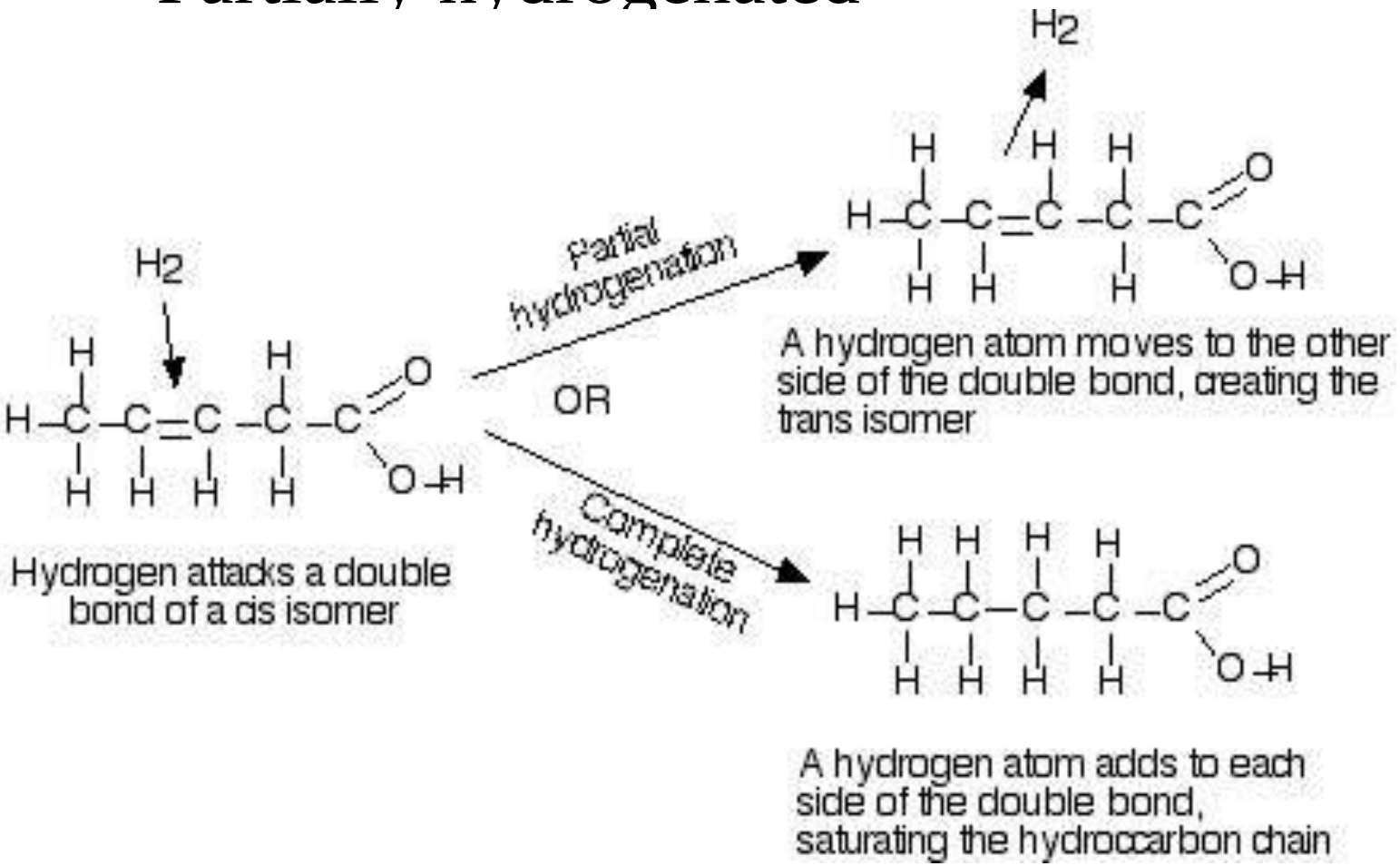
(a) Saturated fat



- Fats made from saturated fatty acids are called saturated fats, and are solid at room temperature
- Most animal fats are saturated
- Fats made from unsaturated fatty acids are called unsaturated fats or oils, and are liquid at room temperature
- Plant fats and fish fats are usually unsaturated

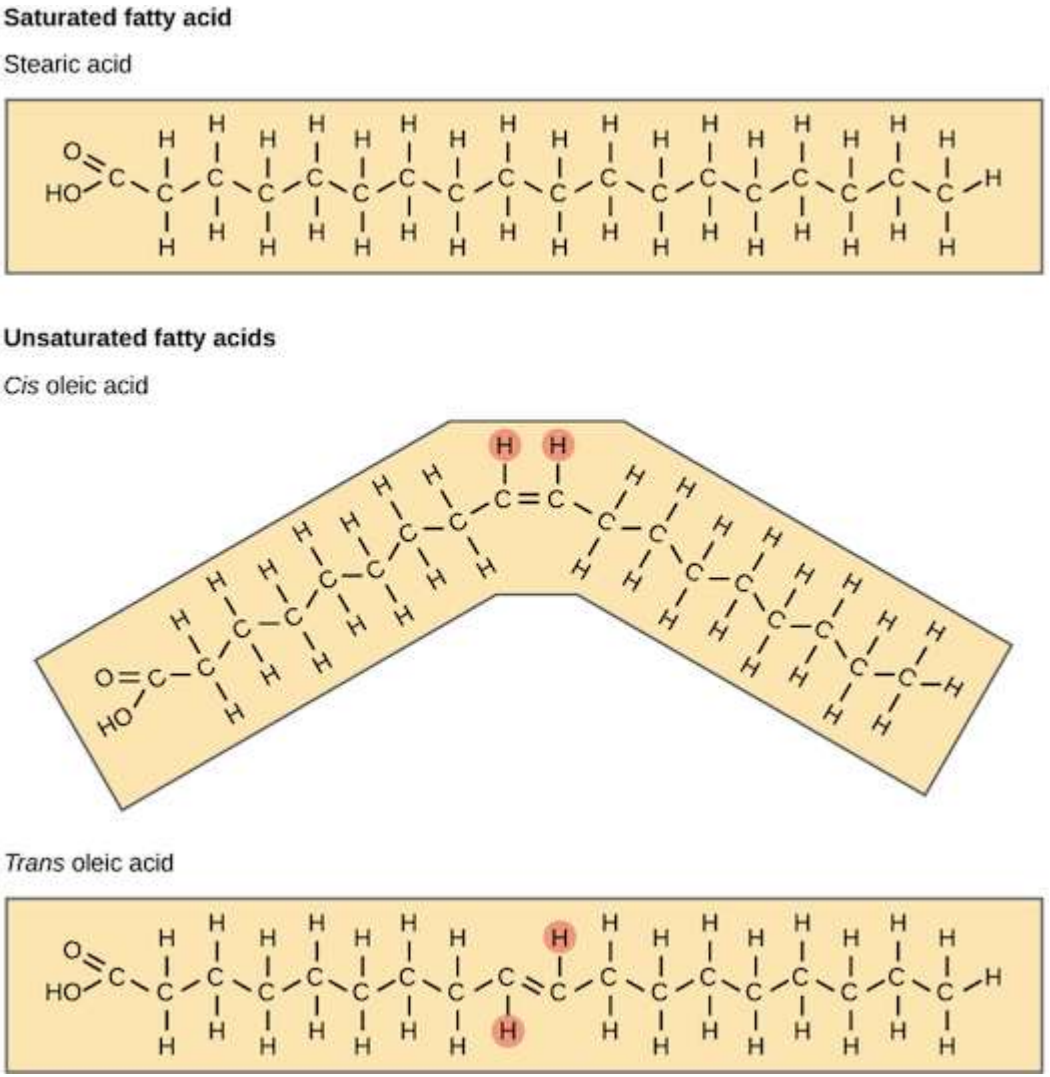
- A diet rich in saturated fats may contribute to cardiovascular disease through plaque deposits
- Hydrogenation is the process of converting unsaturated fats to saturated fats by adding hydrogen
- Hydrogenating vegetable oils also creates unsaturated fats with *trans* double bonds
- These *trans* fats may contribute more than saturated fats to cardiovascular disease

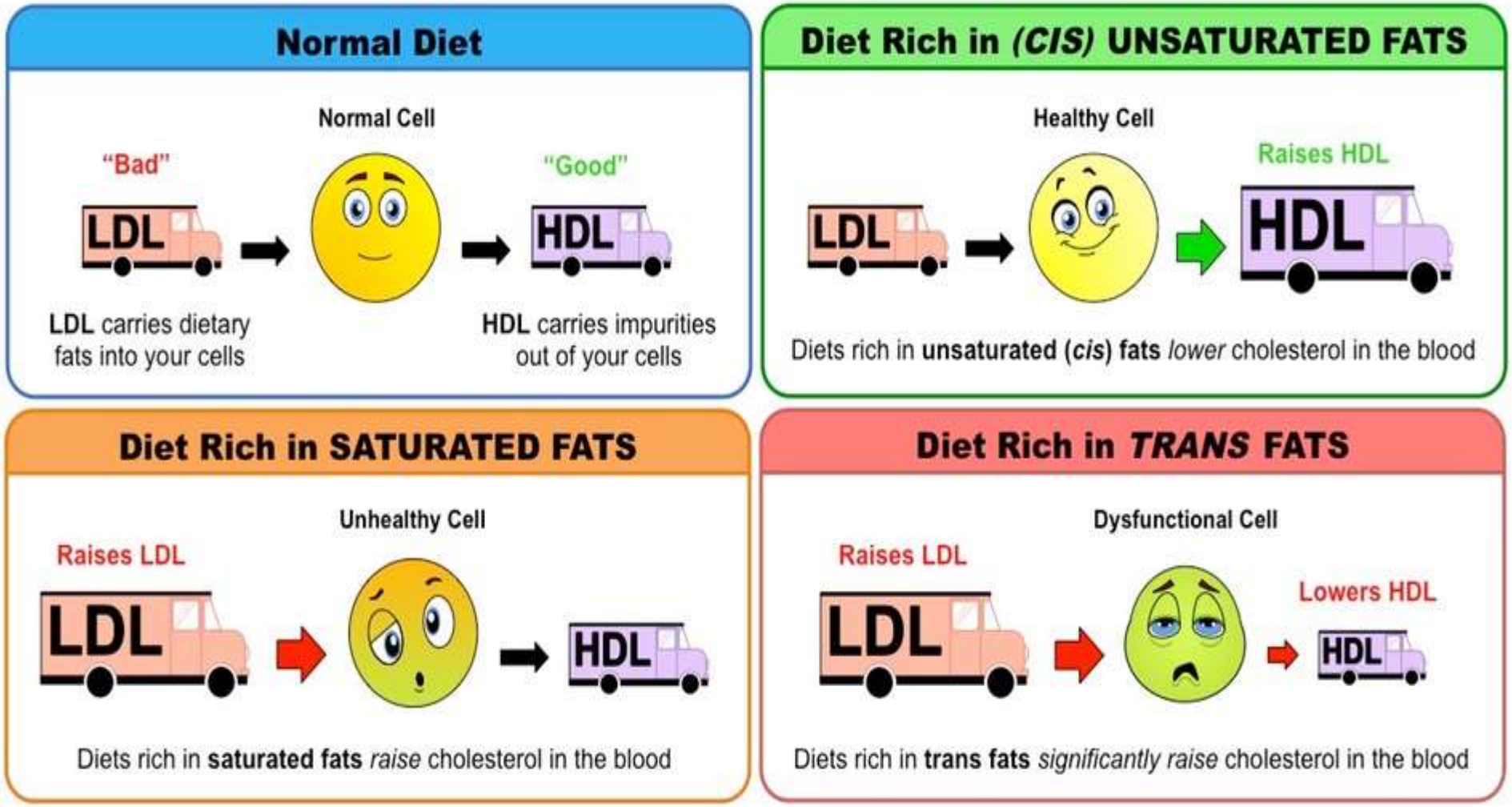
- **There are two types of hydrogenated oil:**
  - Fully hydrogenated.
  - Partially hydrogenated



- Most trans fatty acids are not found naturally in foods, but are a result of a process called hydrogenation.

- Fats and cholesterol cannot dissolve in blood and are consequently packaged with proteins (to form **lipoproteins**) for transport.
- Low density lipoproteins (**LDL**) carry cholesterol from the liver to the rest of the body.
- High density lipoproteins (**HDL**) scavenge excess cholesterol and carry it back to the liver for disposal.
- Hence LDLs raise blood cholesterol levels (‘bad’) while HDLs lower blood cholesterol levels (‘good’)



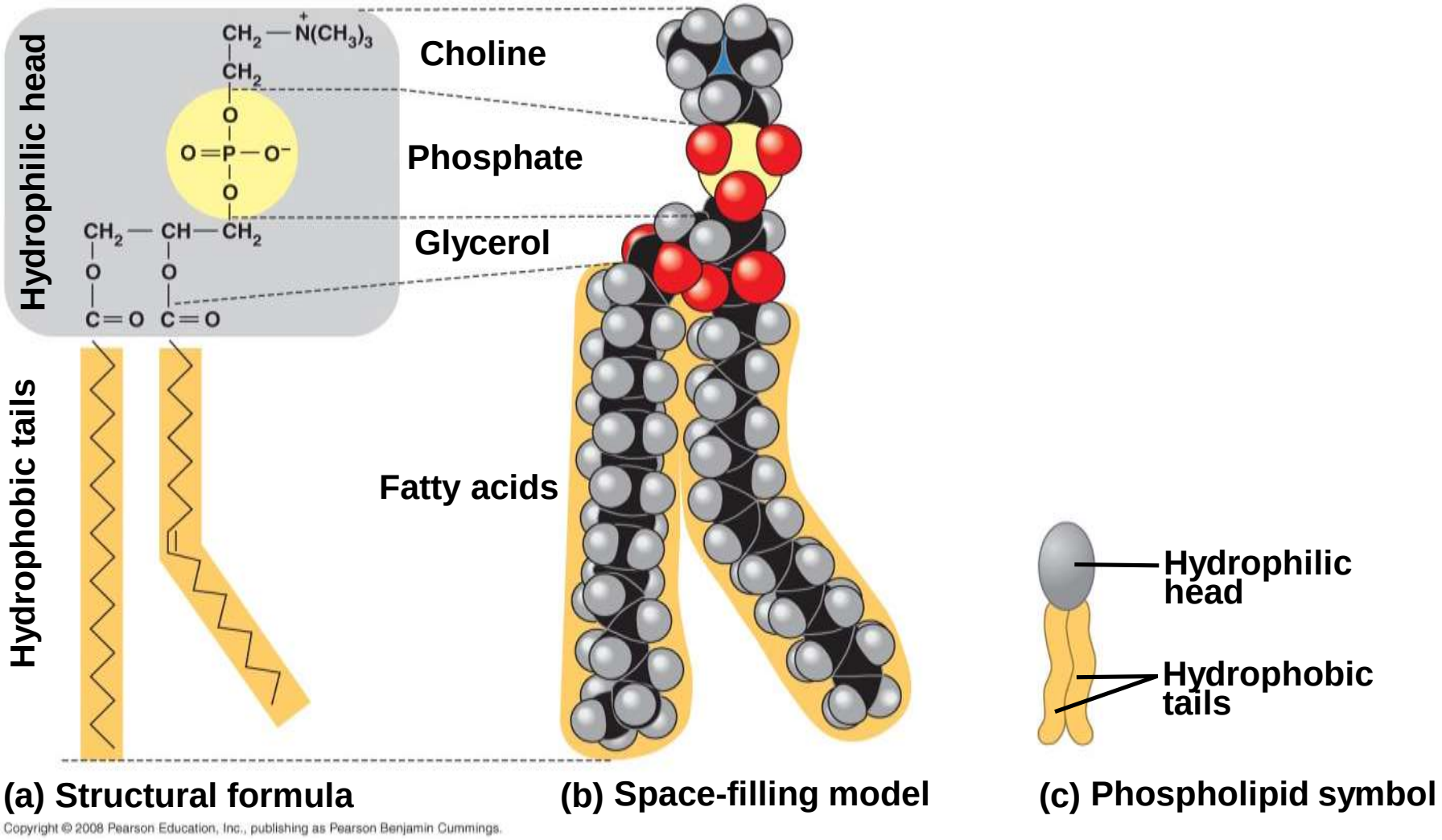


- High cholesterol levels in the bloodstream lead to (*atherosclerosis*)

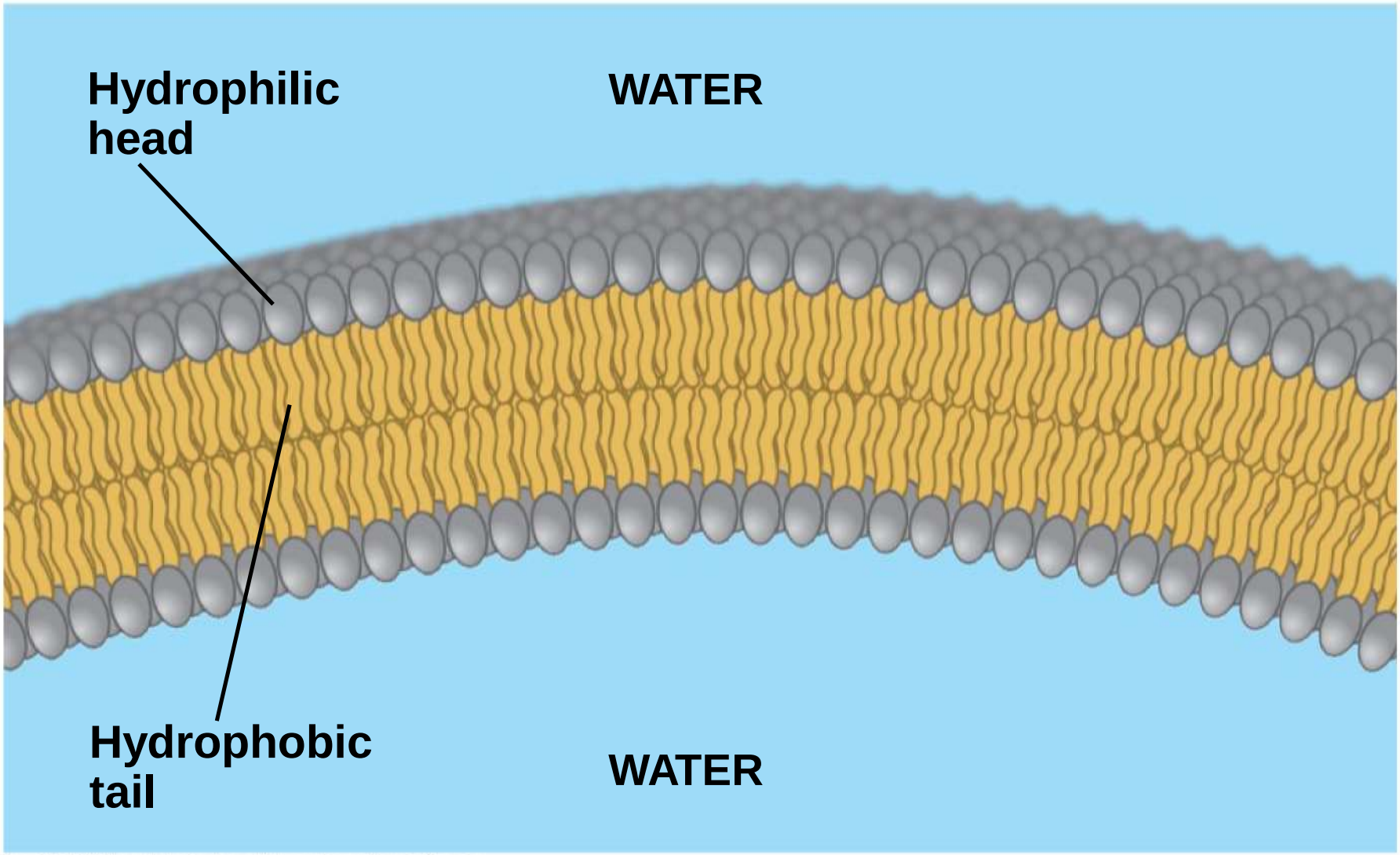
- The major function of fats is energy storage
- Humans and other mammals store their fat in adipose cells
- Adipose tissue also cushions vital organs and insulates the body

Phospholipids

- In a **phospholipid**, two fatty acids and a phosphate group are attached to glycerol
- The two fatty acid tails are hydrophobic, but the phosphate group and its attachments form a hydrophilic head



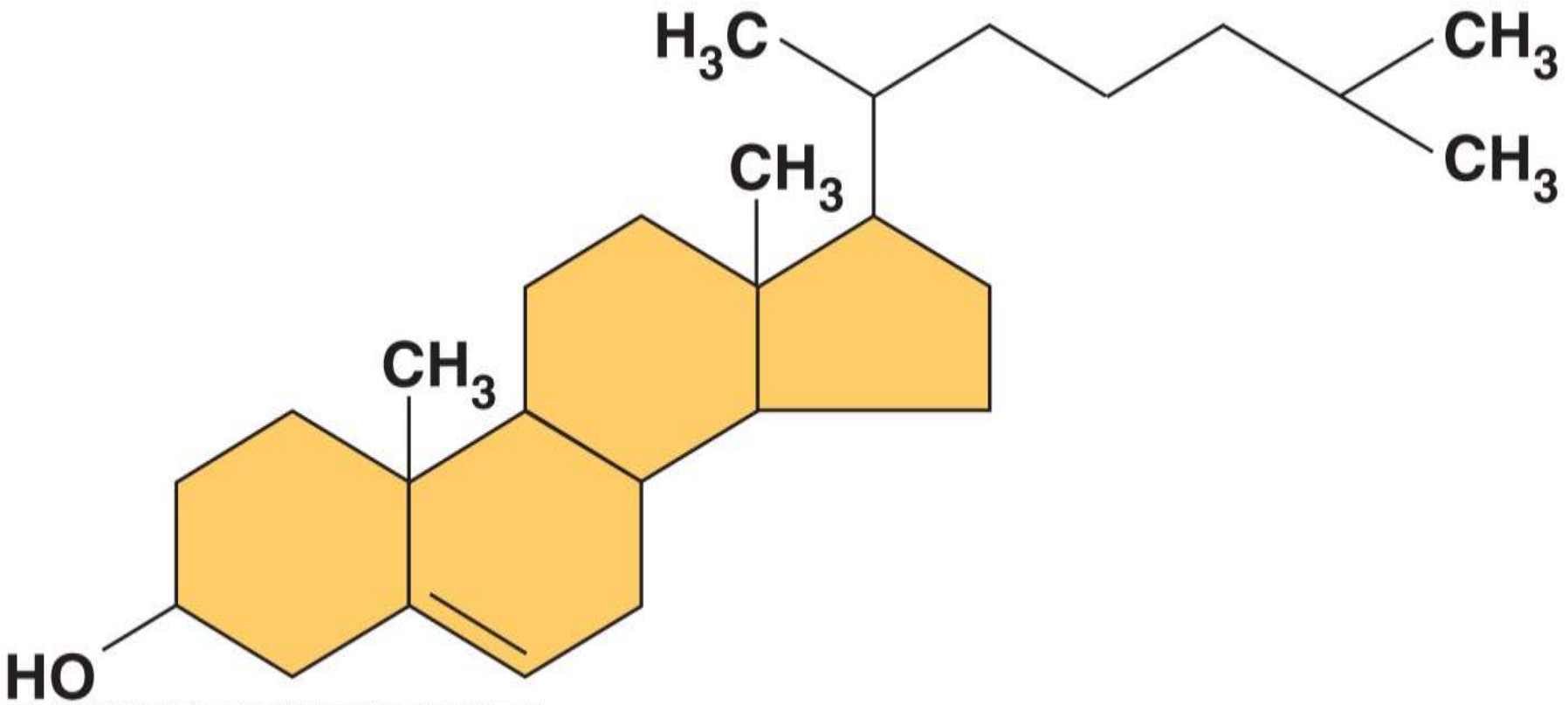
- When phospholipids are added to water, they self-assemble into a bilayer, with the hydrophobic tails pointing toward the interior
- The structure of phospholipids results in a bilayer arrangement found in cell membranes
- Phospholipids are the major component of all cell membranes



Steroids

- **Steroids** are lipids characterized by a carbon skeleton consisting of four fused rings
- **Cholesterol**, an important steroid, is a component in animal cell membranes
- Although cholesterol is essential in animals, high levels in the blood may contribute to cardiovascular disease

Cholesterol is a type of steroid the body produces to perform many vital functions. It is the precursor to many steroid hormones, including sex hormones and hormones necessary for glucose metabolism and ion balances in the body



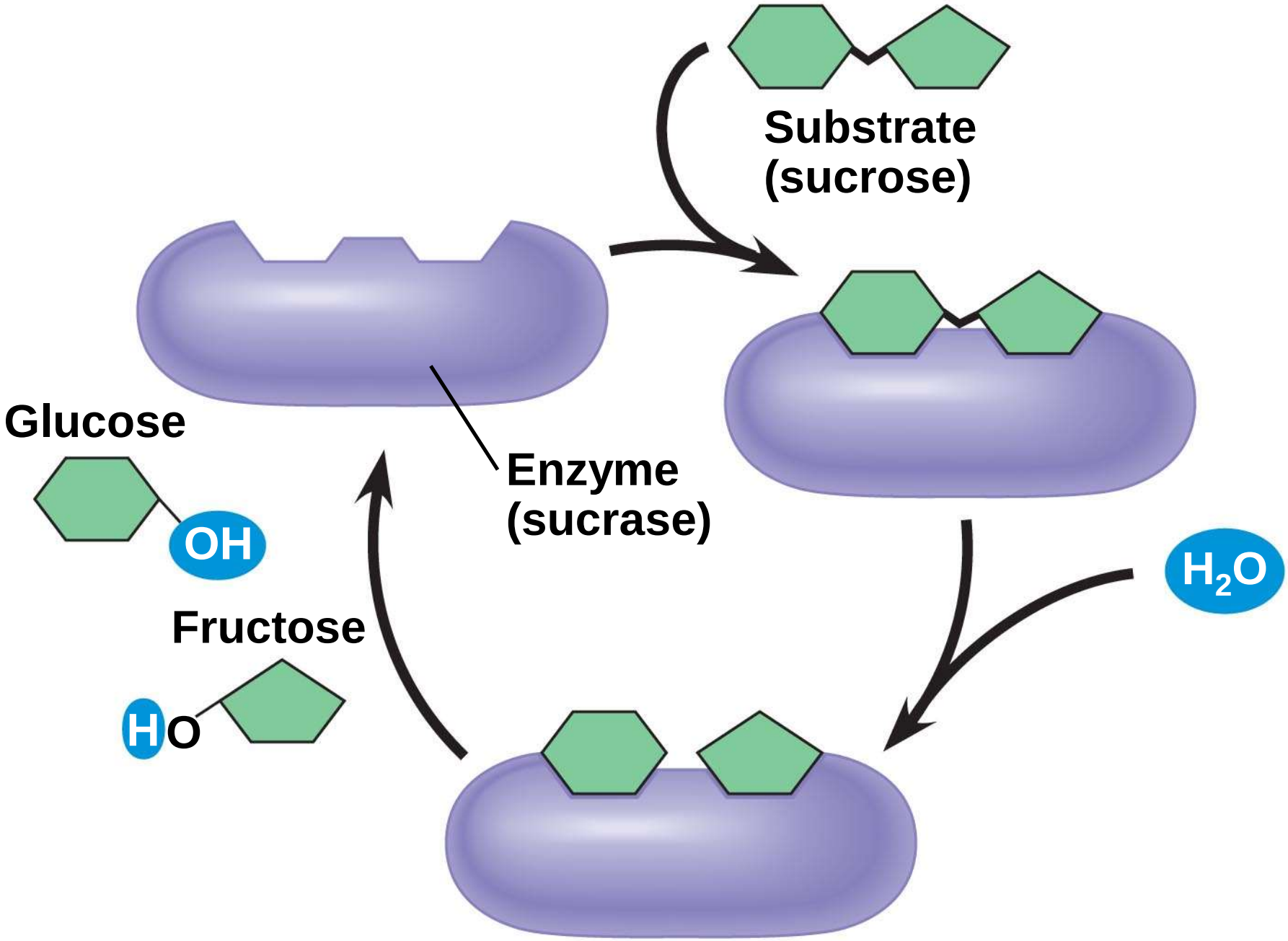
Proteins have many structures, resulting in a wide range of functions

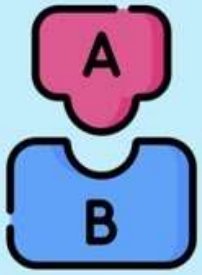
- Proteins account for more than 50% of the dry mass of most cells
- Protein functions include structural support, storage, transport, cellular communications, movement, and defense against foreign substances

Table 5.1 An Overview of Protein Functions

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

- **Enzymes** are a type of protein that acts as a catalyst to speed up chemical reactions without being consumed or changed in the process.
- An example can be found in digestive enzymes; in their absence, it would take us up to two to three weeks to digest one single meal. With enzymes, it just takes four hours.





6 Classes

ENZYMES

1. Oxidoreductases → oxidase, dehydrogenase
2. Transferases → transferase, kinase
3. Hydrolases → nuclease, protease
4. Lyases → decarboxylase, aldolase
5. Isomerases → isomerase
6. Ligases → DNA ligase

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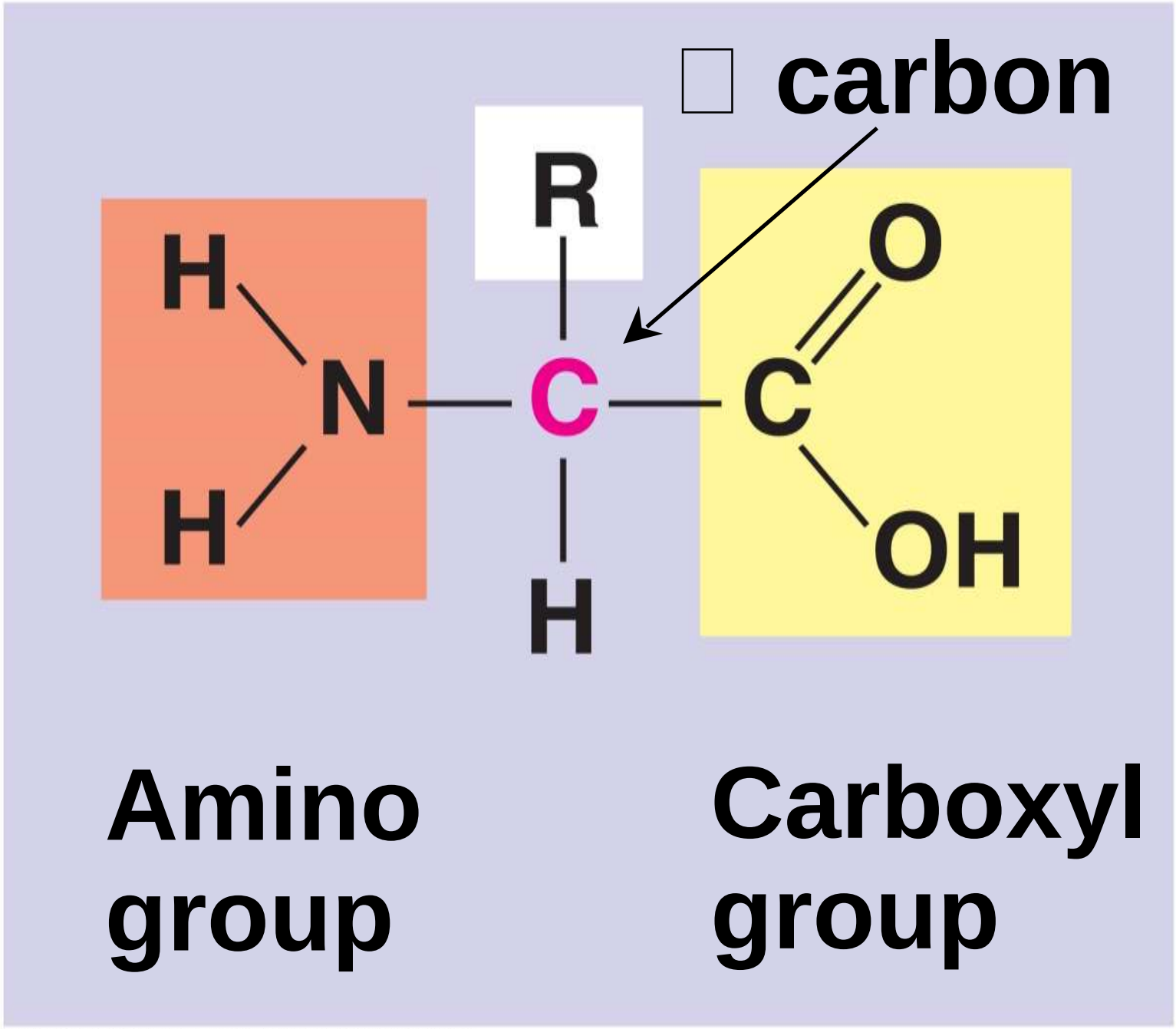
Polypeptides

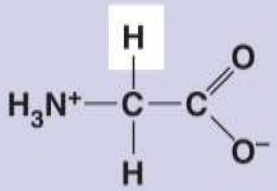
- **Polypeptides** are polymers built from the same set of 20 amino acids
- A **protein** consists of one or more polypeptides

Amino Acid Monomers

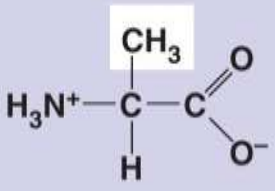
- **Amino acids** are organic molecules with carboxyl and amino groups
- Amino acids differ in their properties due to differing side chains, called R groups



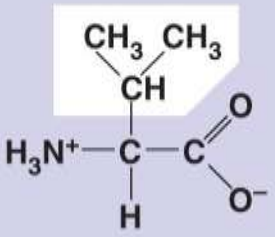
Nonpolar (hydrophobic nature)



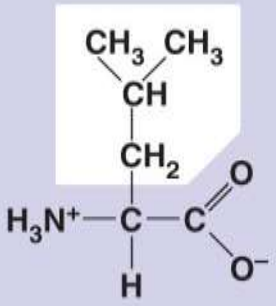
Glycine (Gly or G)



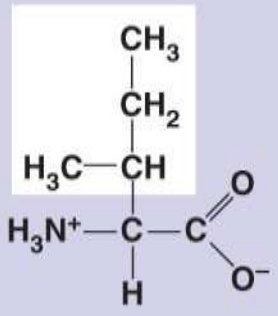
Alanine (Ala or A)



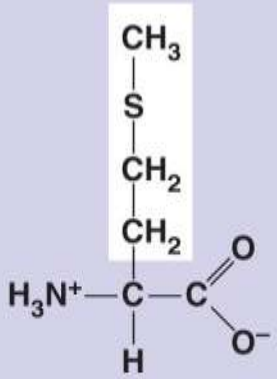
Valine (Val or V)



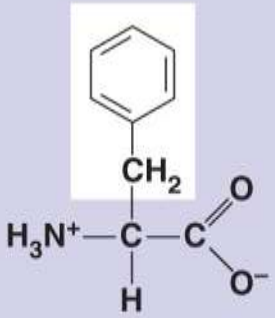
Leucine (Leu or L)



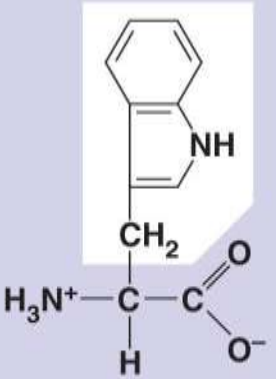
Isoleucine (Ile or I)



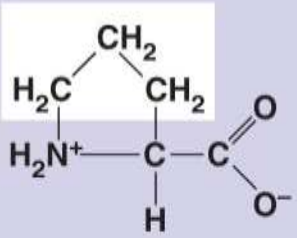
Methionine (Met or M)



Phenylalanine (Phe or F)

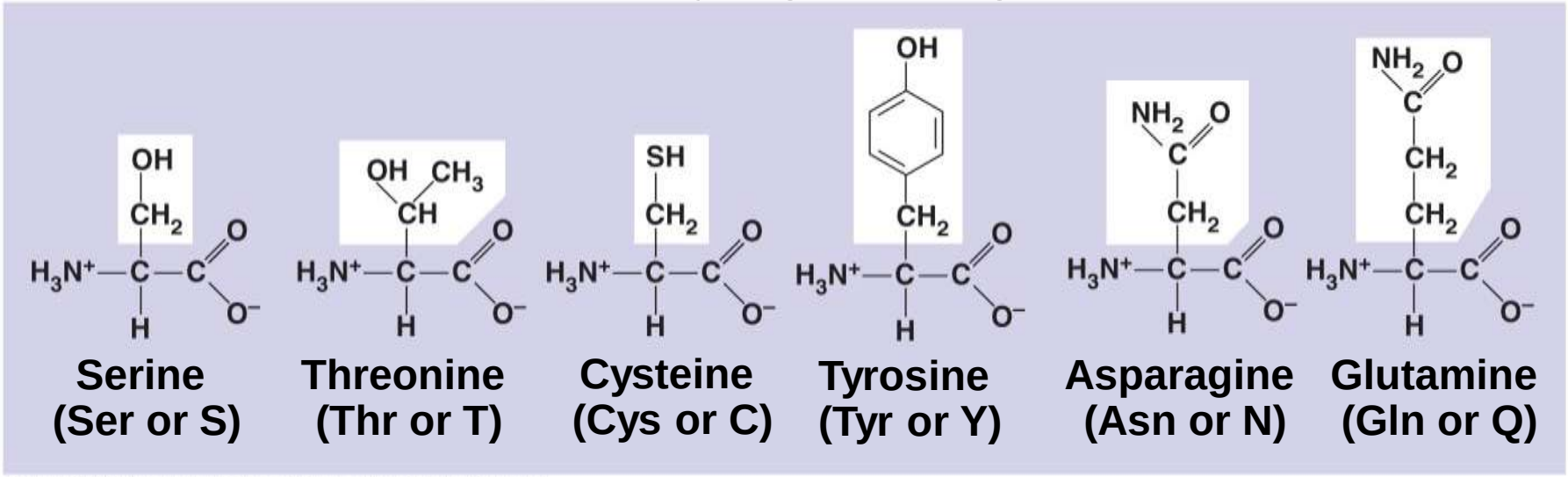


Tryptophan (Trp or W)



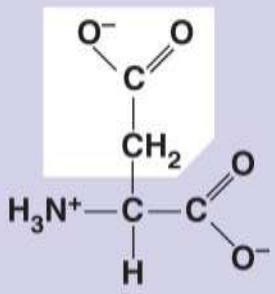
Proline (Pro or P)

Polar which can participate in hydrogen bonding with water molecules

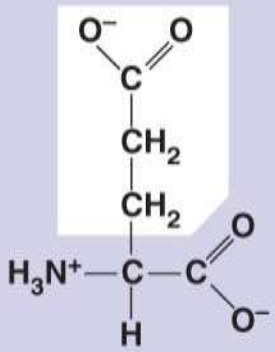


Electrically charged

Acidic

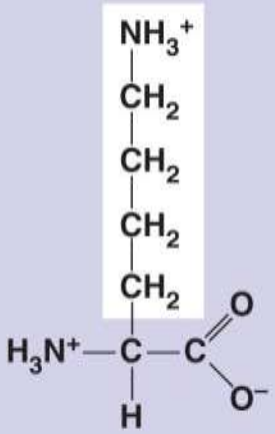


Aspartic acid (Asp or D)

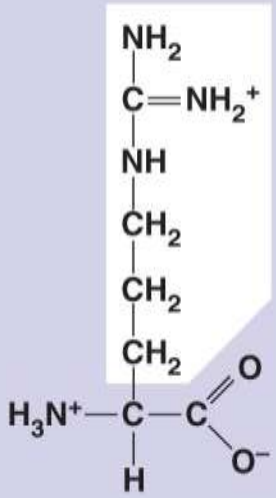


Glutamic acid (Glu or E)

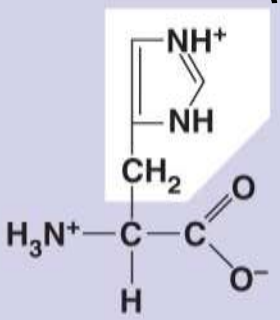
Basic



Lysine (Lys or K)



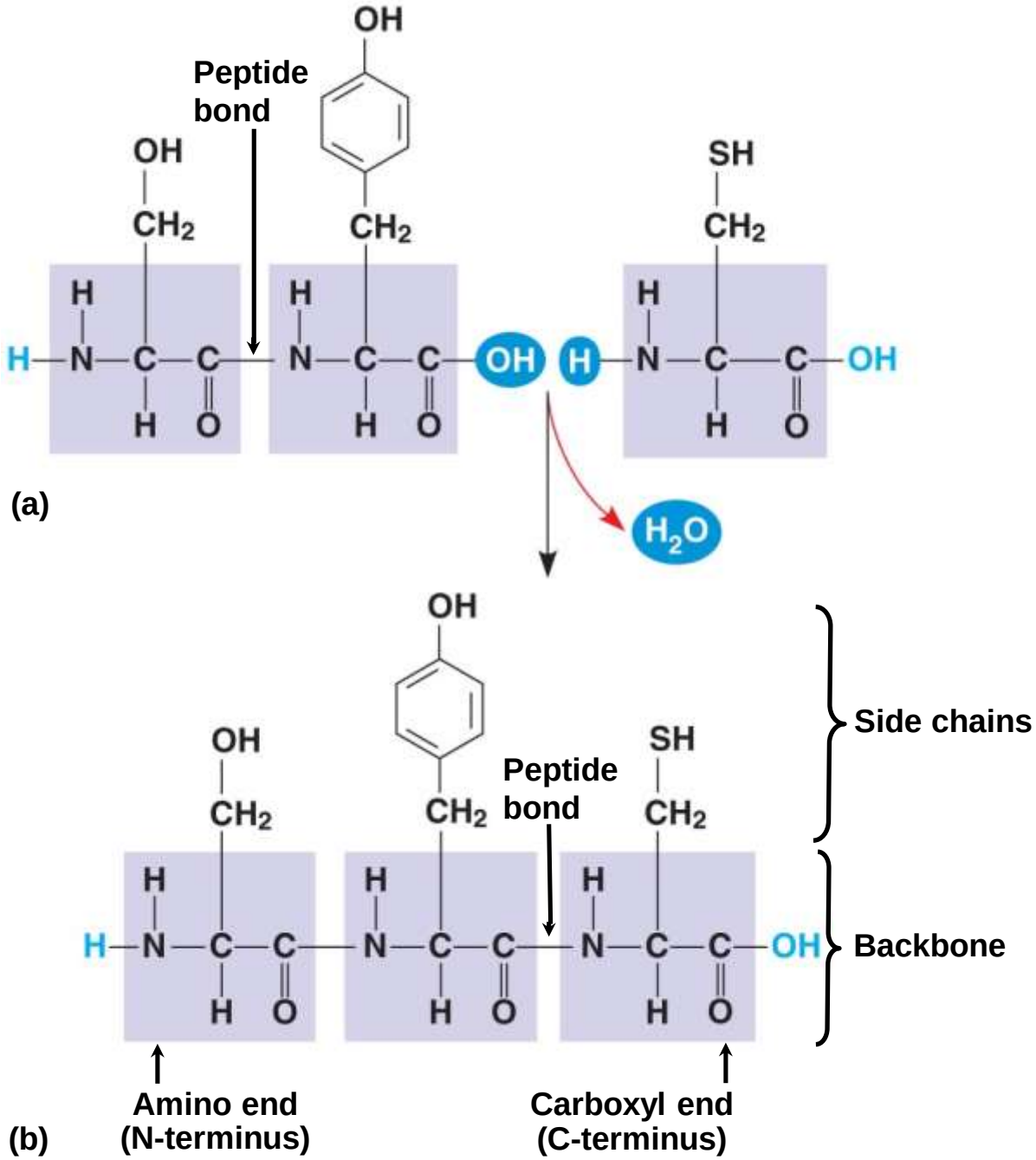
Arginine (Arg or R)



Histidine (His or H)

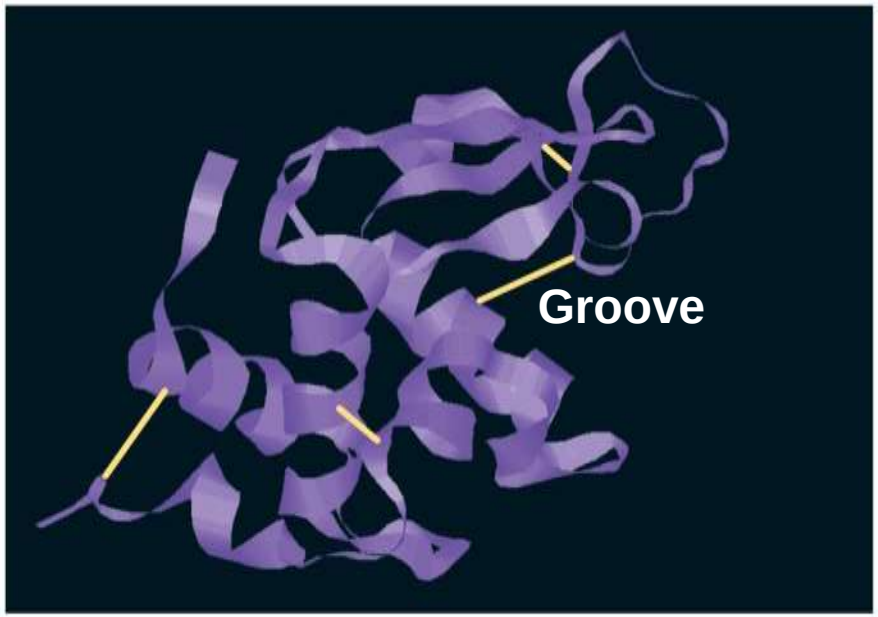
Amino Acid Polymers

- Amino acids are linked by **peptide bonds**
- A polypeptide is a polymer of amino acids
- Polypeptides range in length from a few to more than a thousand monomers
- Each polypeptide has a unique linear sequence of amino acids

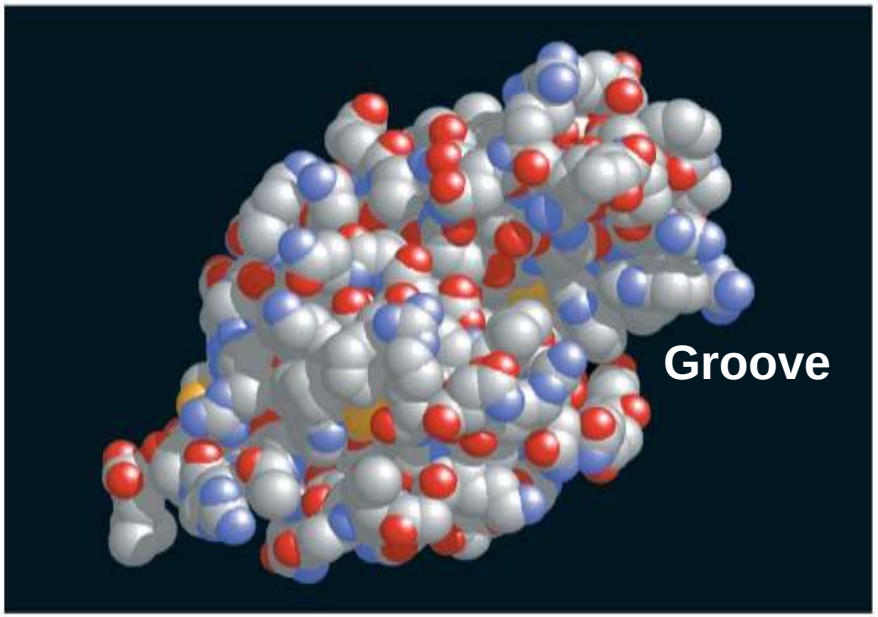


Protein Structure and Function

- A functional protein consists of one or more polypeptides twisted, folded, and coiled into a unique shape
- The sequence of amino acids determines a protein's three-dimensional structure
- A protein's structure determines its function



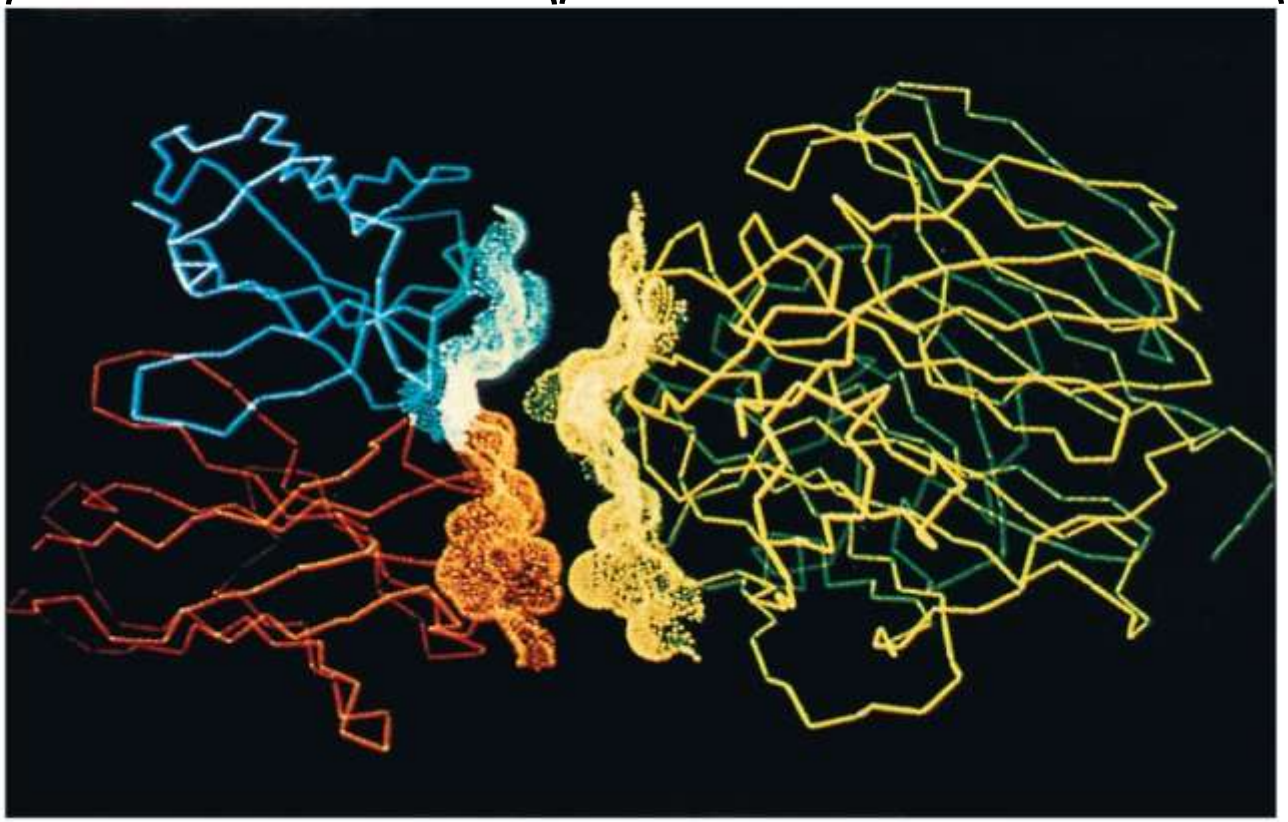
(a) A ribbon model of lysozyme



(b) A space-filling model of lysozyme

Antibody protein

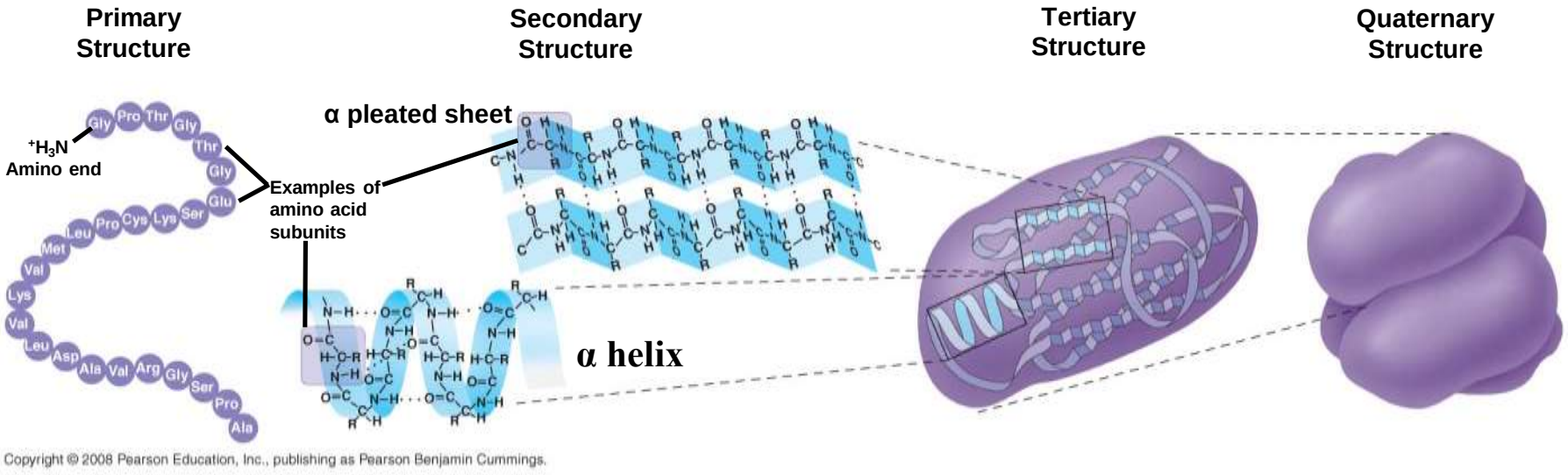
Protein from flu virus



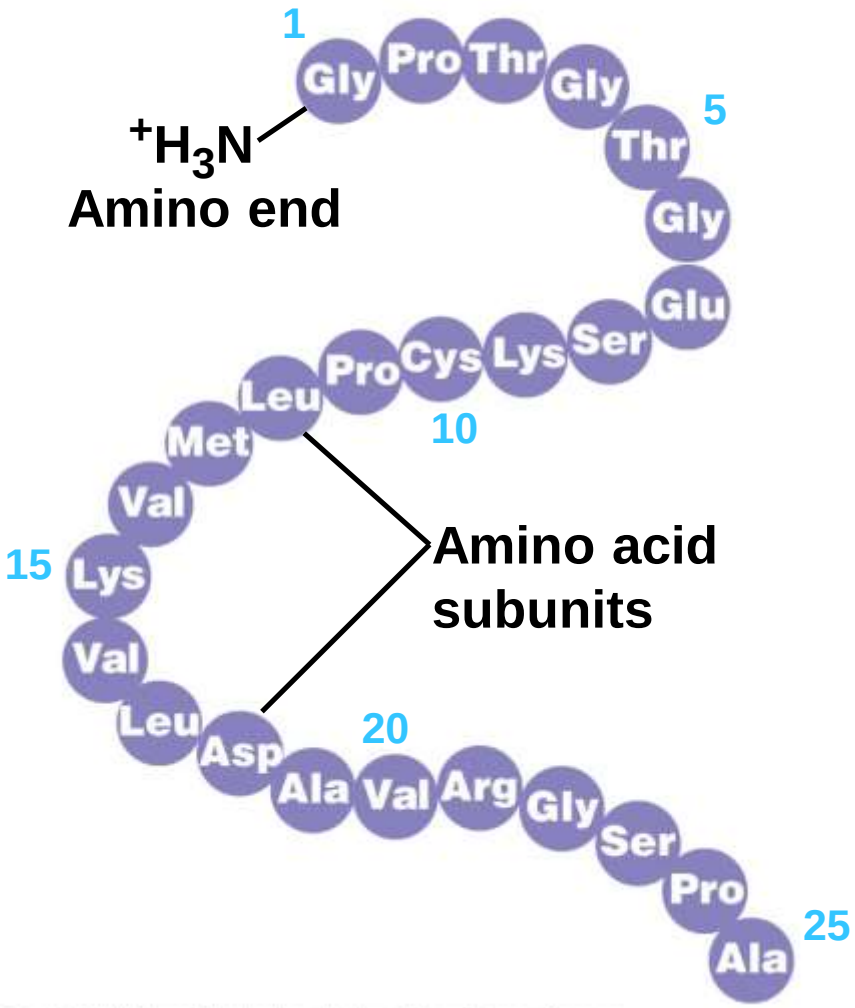
Four Levels of Protein Structure

- The primary structure of a protein is its unique sequence of amino acids
- Secondary structure, found in most proteins, consists of coils and folds in the polypeptide chain
- Tertiary structure is determined by interactions among various side chains (R groups)
- Quaternary structure results when a protein consists of multiple polypeptide chains

- **Primary structure**, the sequence of amino acids in a protein, is like the order of letters in a long word
- Primary structure is determined by inherited genetic information



Primary Structure



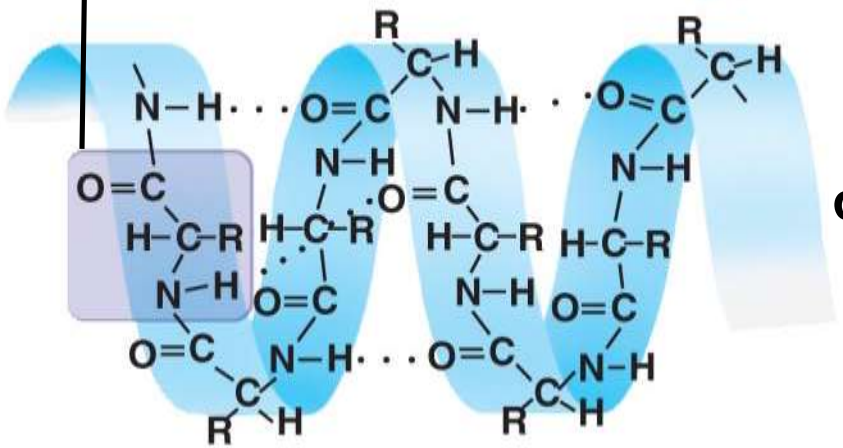
- The coils and folds of **secondary structure** result from hydrogen bonds between repeating constituents of the polypeptide backbone
- Typical secondary structures are a coil called an **α helix** and a folded structure called a **β pleated sheet**

Fig. 5-21c

Secondary Structure

β pleated sheet

Examples of amino acid subunits



α helix

Abdominal glands of the spider secrete silk fibers made of a structural protein containing β pleated sheets.

The radiating strands, made of dry silk fibers, maintain the shape of the web.

The spiral strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.