Ch. 5
The S & F of Macromolecules

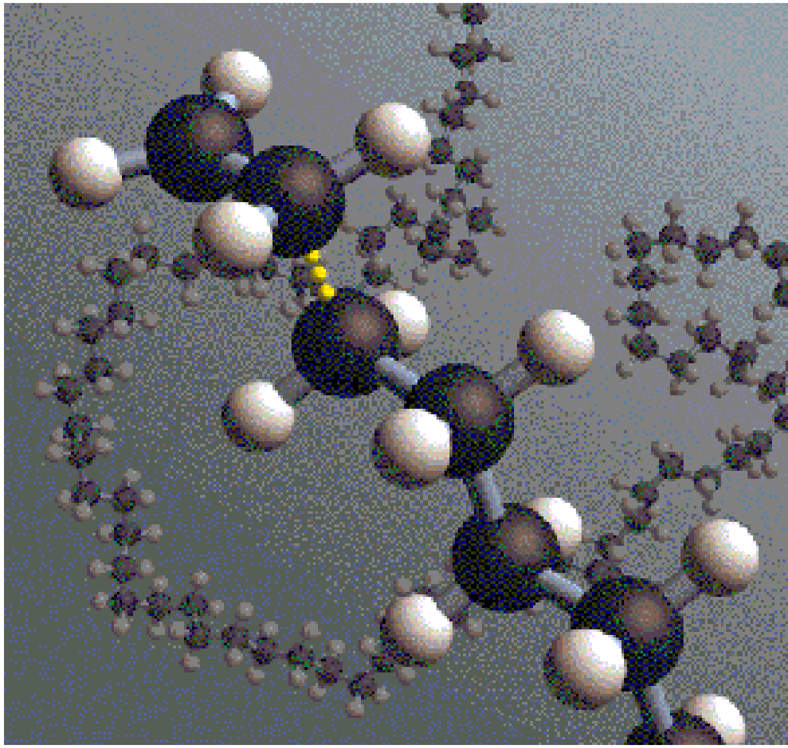
They may be extremely small but they are still macro.

Background Information

- Cells join small molecules together to form larger molecules.
- Macromolecules may be composed of 1000’s of molecules.
- Four major classes of macromolecules are: Protines, Carbohydrates, Lipids, and Nucleic Acids.
- But first some more background

Polymer Principles

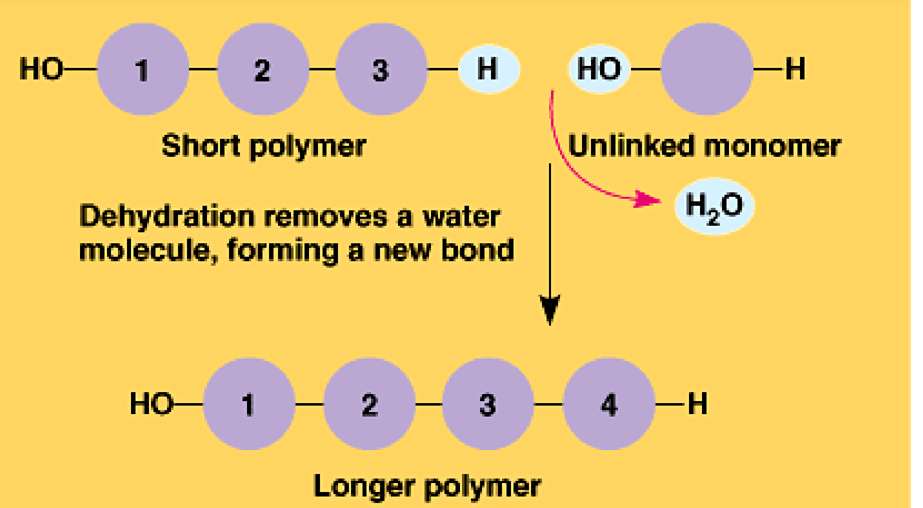
- Three of the four mm's form chain like molecules called polymers.
- **Polymers** consist of many similar or identical building blocks linked by covalent bonds.
- The repeated units are small molecules called **monomers**.
- Some monomers have other functions of their own.



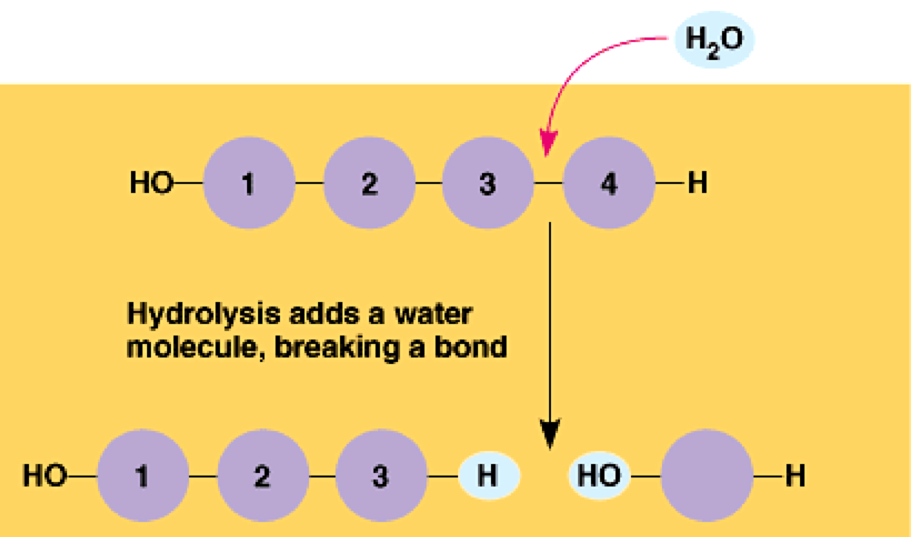
Chem. Mechanisms

- The chemical mechanisms that cells use to make and break polymers are similar for all classes of macromolecules.
- Monomers are connected by covalent bonds via a **condensation reaction** or **dehydration reaction**.
- The covalent bonds connecting monomers in a polymer are disassembled by **hydrolysis**.

Figure 5.2 The synthesis and breakdown of polymers



(a) Dehydration reaction in the synthesis of a polymer



(b) Hydrolysis of a polymer

Big Variety Few Monomers

- Each cell has thousands of different macromolecules.
- This diversity comes from various combinations of the 40-50 common monomers and other rarer ones.
- These monomers can be connected in various combinations, like the 26 letters in the alphabet can be used to create a great diversity of words.

Carbohydrates - Fuel and Building Material

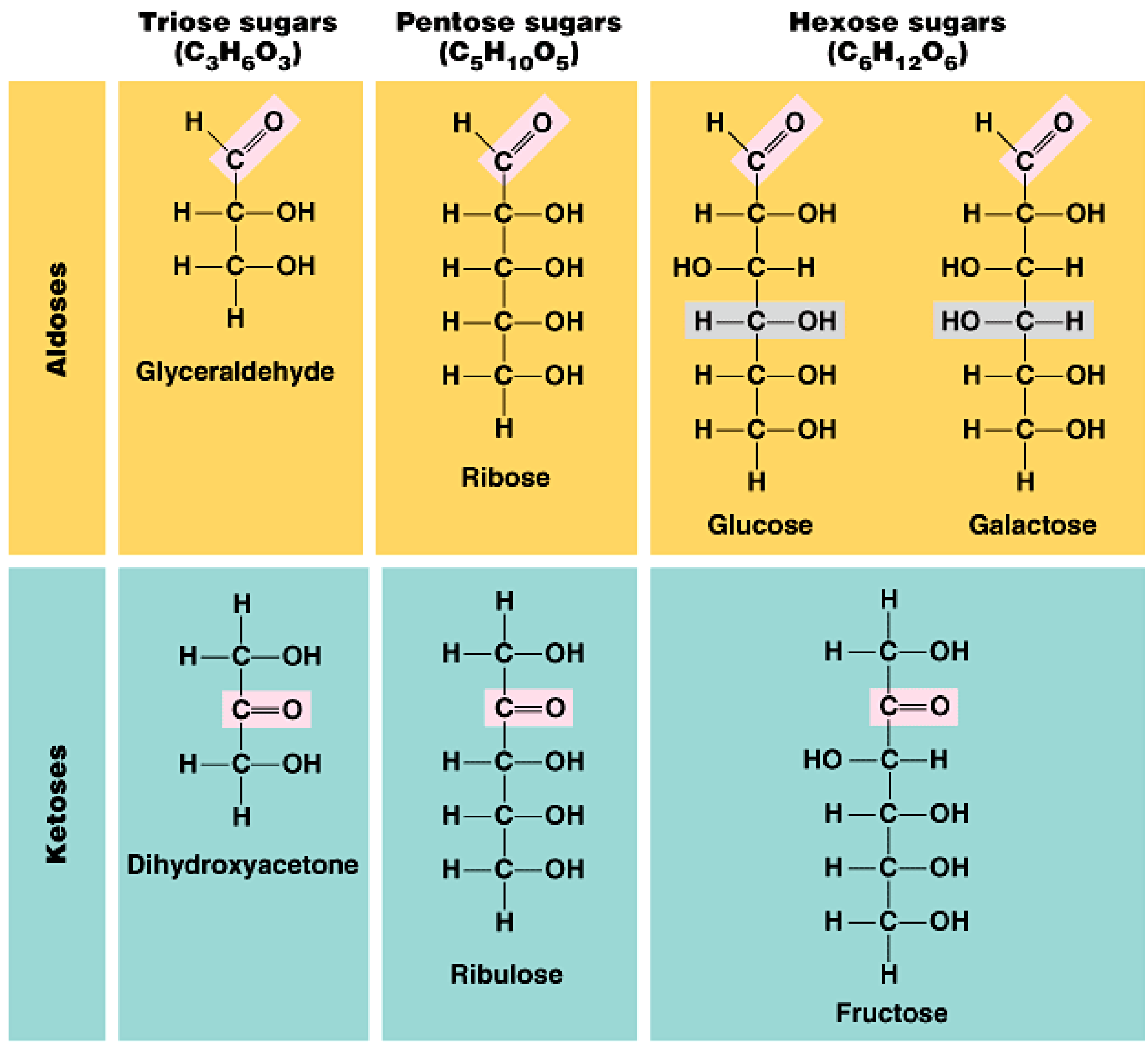
Basic Carb Info

- **Carbohydrates** include both sugars and polymers.
- The simplest carbohydrates are monosaccharides or simple sugars.
- Disaccharides, double sugars, consist of two monosaccharides joined by a condensation reaction.
- Polysaccharides are polymers of monosaccharides.

Sugars, the smallest carbohydrates

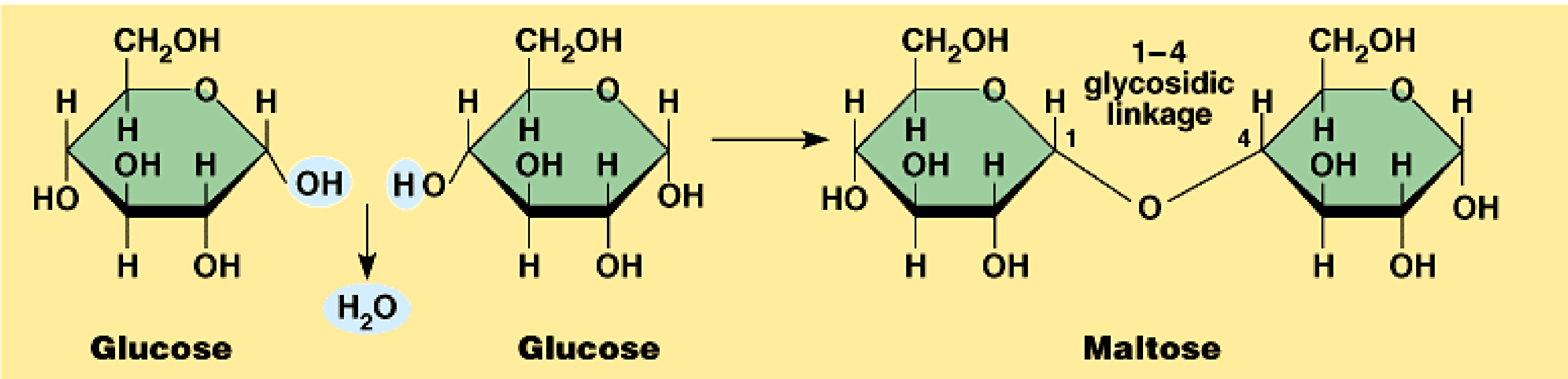
- Serve as a fuel and carbon sources.
- **Monosaccharides** generally have molecular formulas that are some multiple of CH_2O.
- For example, glucose has the formula $C_6H_{12}O_6$.
- Most names for sugars end in *-ose*.

Figure 5.3 The structure and classification of some monosaccharides

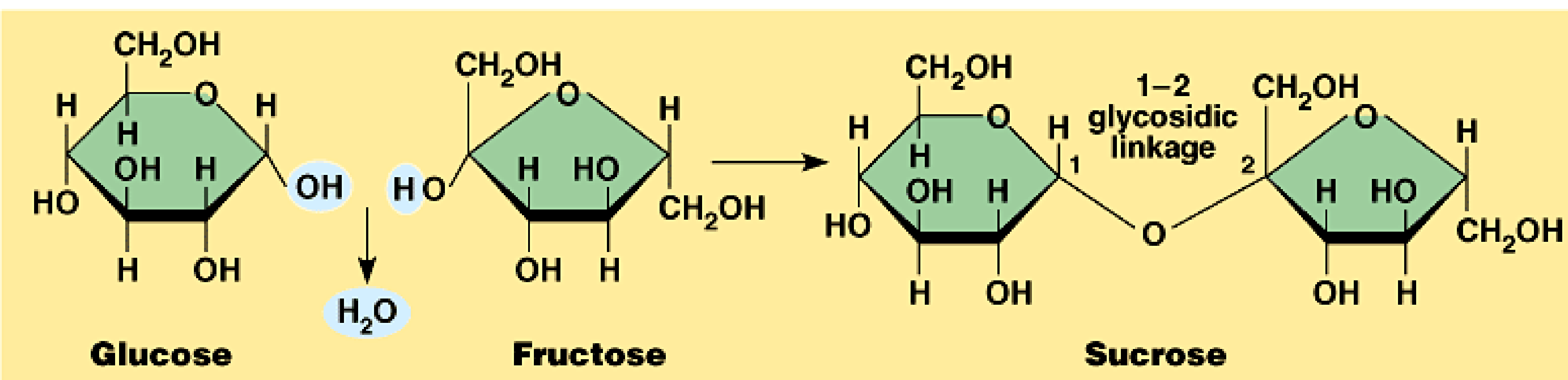


- Monosaccharides, particularly glucose, are a major fuel for cellular work.
- They also function as the raw material for the synthesis of other monomers, including those of amino acids and fatty acids.

- Two monosaccharides can join with a **glycosidic linkage** to form a **dissaccharide** via dehydration.

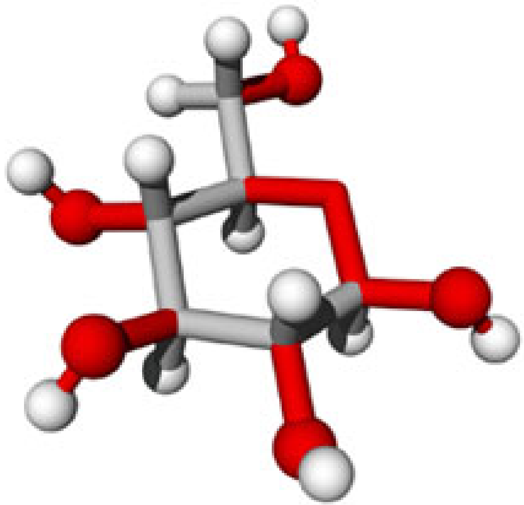


(a) Dehydration synthesis of maltose

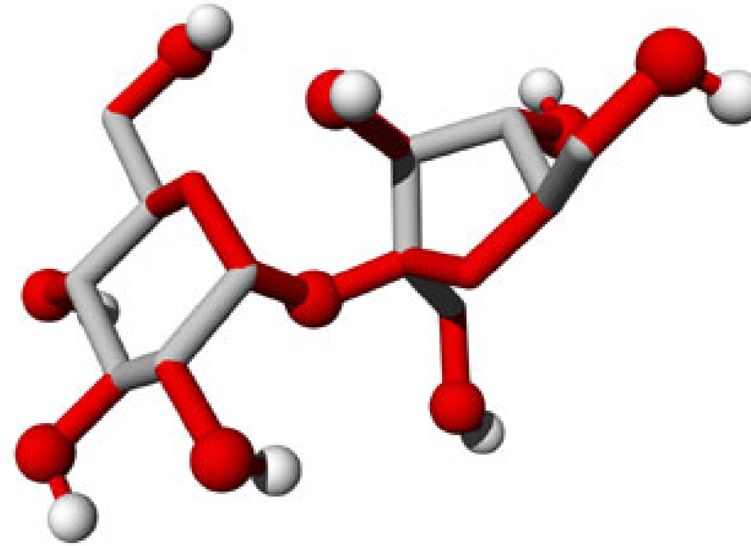


(b) Dehydration synthesis of sucrose

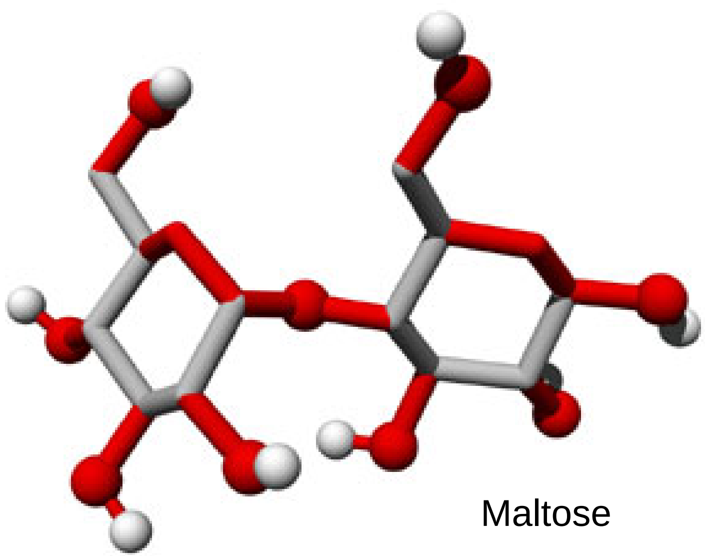
Figure 5.5x Glucose monomer and disaccharides



Glucose monomer



Sucrose



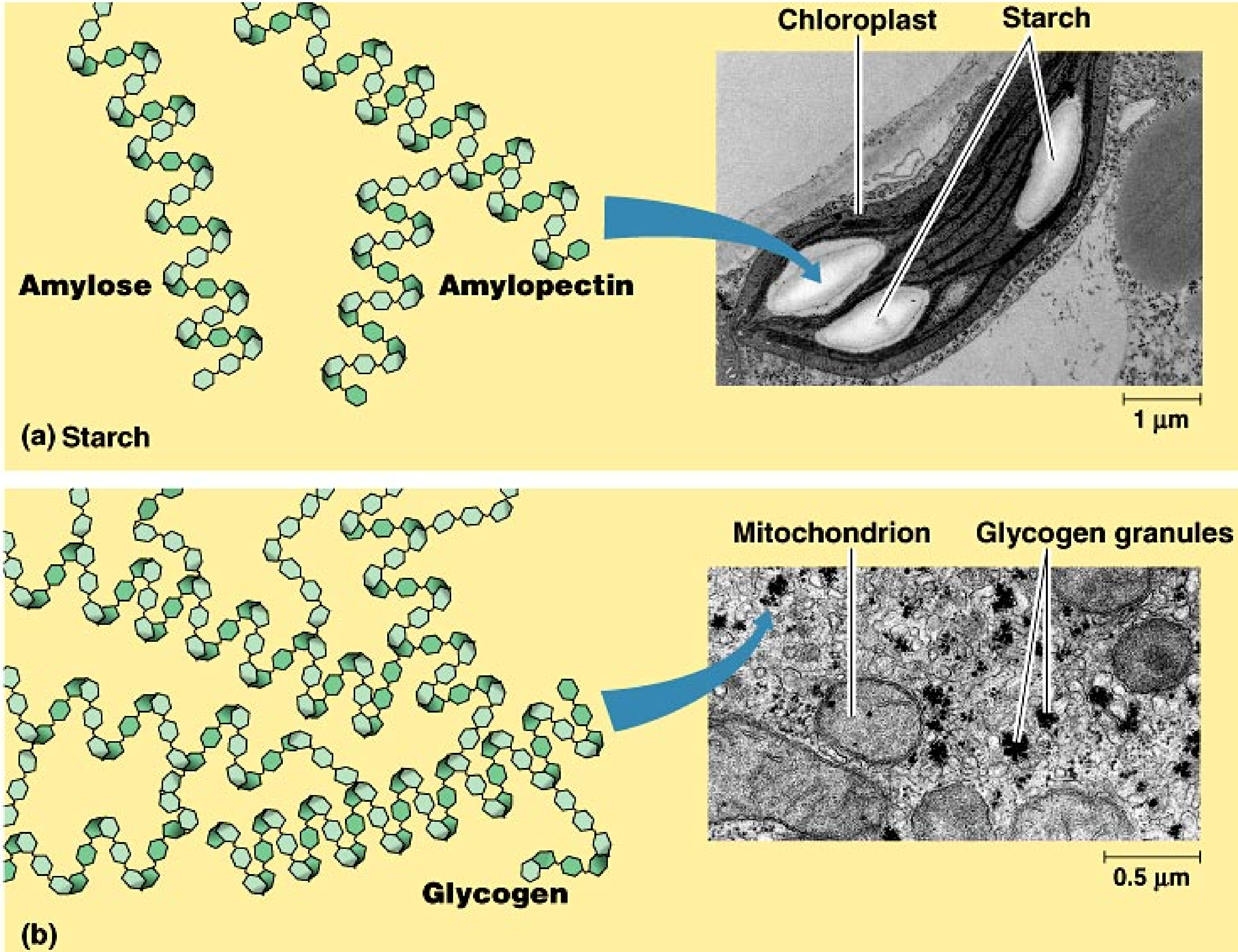
Maltose

Polysaccharides have storage and structural roles

- **Polysaccharides** are polymers of hundreds to thousands of monosaccharides joined by glycosidic linkages.
- One function of polysaccharides is as an energy storage macromolecule that is hydrolyzed as needed.

- **Starch** is a storage polysaccharide composed entirely of glucose monomers.
- One unbranched form of starch, amylose, forms a helix.
- Branched forms, like amylopectin, are more complex.
- Plants store starch within plastids, including chloroplasts.
- Plants can store surplus glucose in starch and withdraw it when needed for energy or carbon.

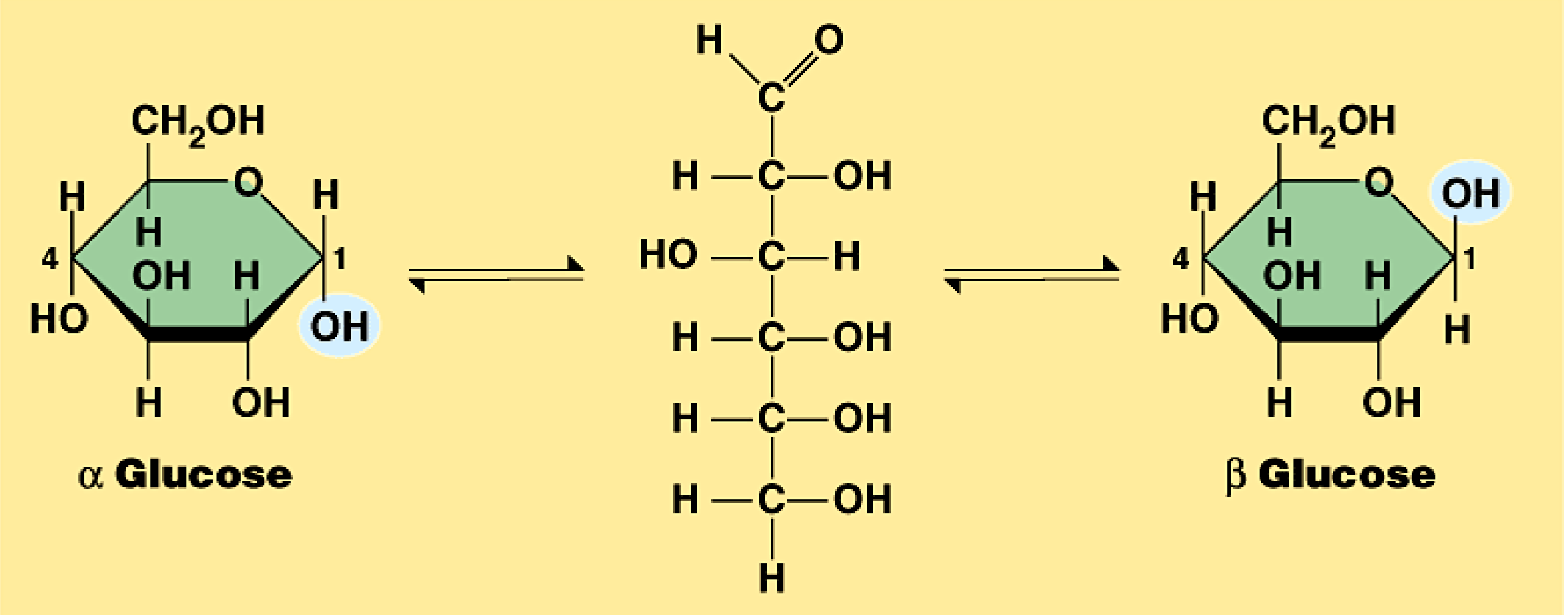
Figure 5.6 Storage polysaccharides



- Animals also store glucose in a polysaccharide called **glycogen**.
- Glycogen is highly branched, like amylopectin.
- Humans and other vertebrates store glycogen in the liver and muscles but only have about a one day supply.

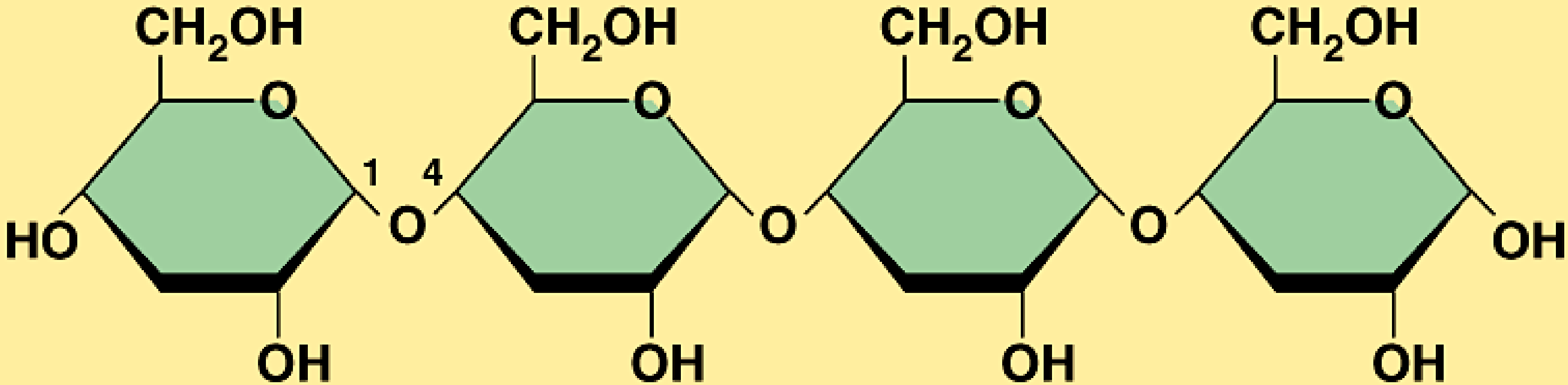
- One key difference among polysaccharides develops from 2 possible ring structures of glucose.
- These two ring forms differ in whether the hydroxyl group attached to the number 1 carbon is fixed above (beta glucose) or below (alpha glucose) the ring plane.

P.pep structure depends on glucose type.

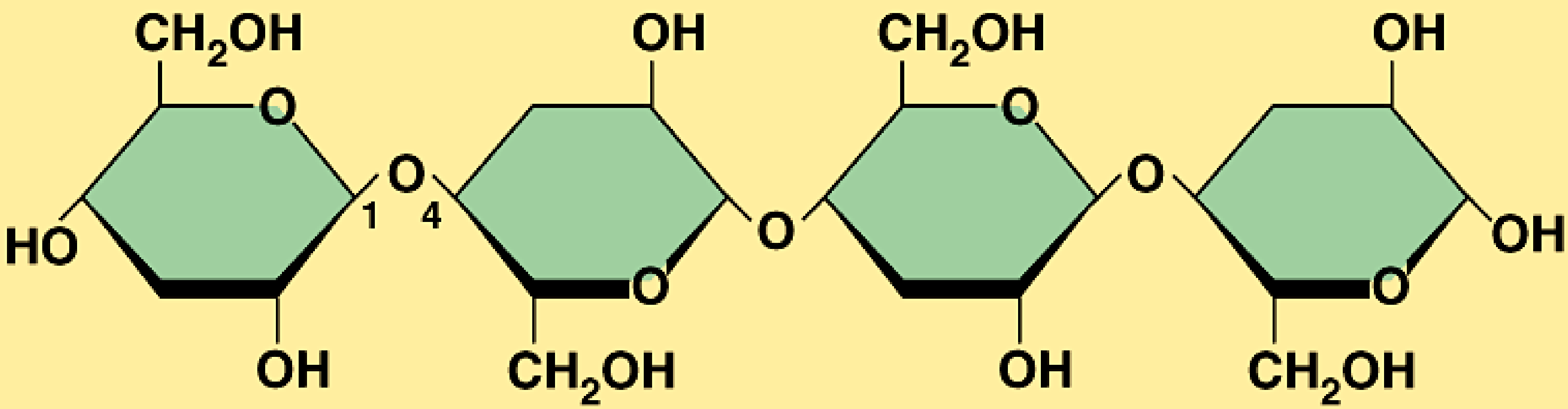


(a) α and β glucose ring structures

- Starch is a polysaccharide of alpha glucose monomers.
- Structural polysaccharides form strong building materials.
- **Cellulose** is a major component of the tough wall of plant cells.
- Cellulose is also a polymer of glucose monomers, but using beta rings.



(b) Starch: 1–4 linkage of α glucose monomers



(c) Cellulose: 1–4 linkage of β glucose monomers

While polymers built with alpha glucose form helical structures, polymers built with beta glucose form straight structures.

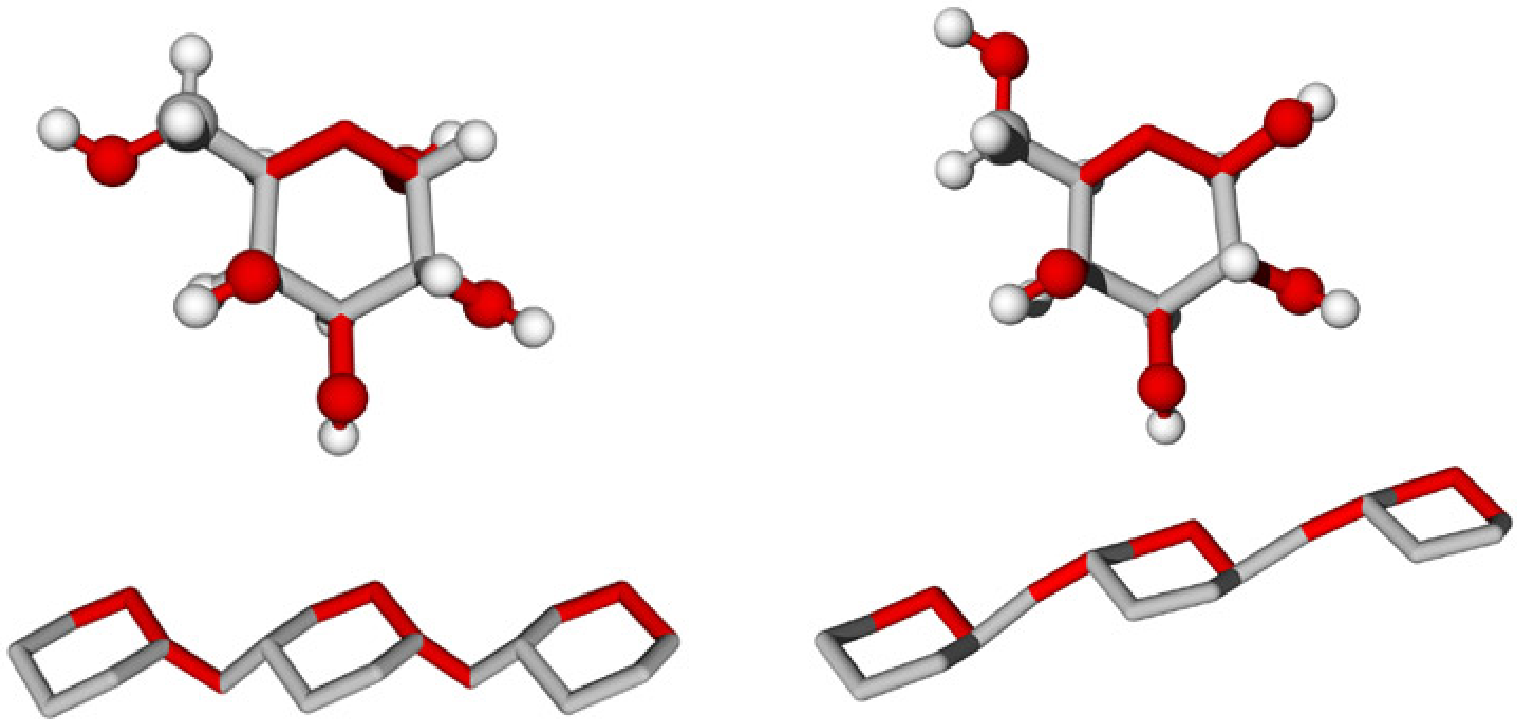
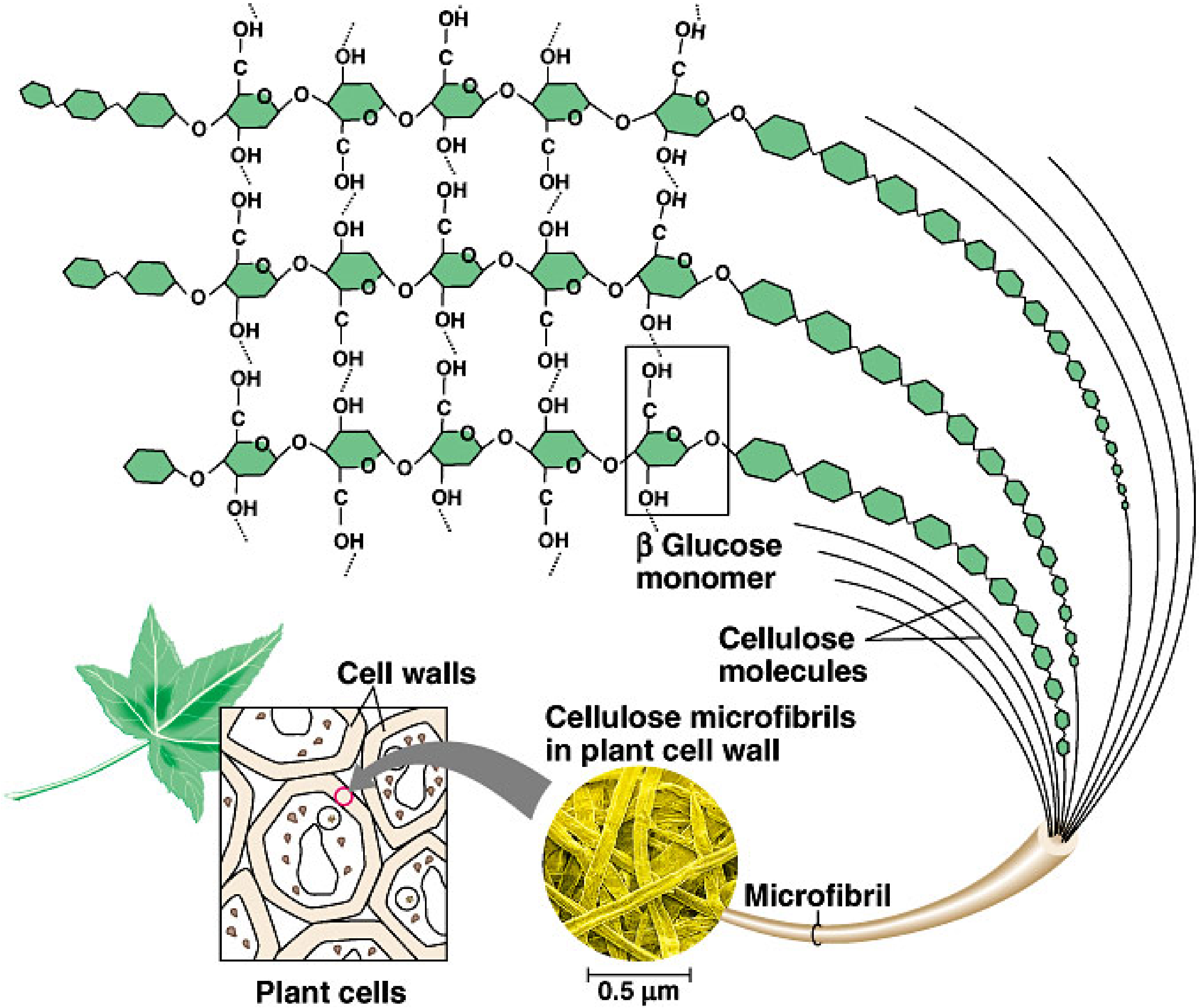


Figure 5.8 The arrangement of cellulose in plant cell walls



- MAKE SURE YOU KNOW THE DIFFERENCE BETWEEN CHITIN AND CELLULOSE!

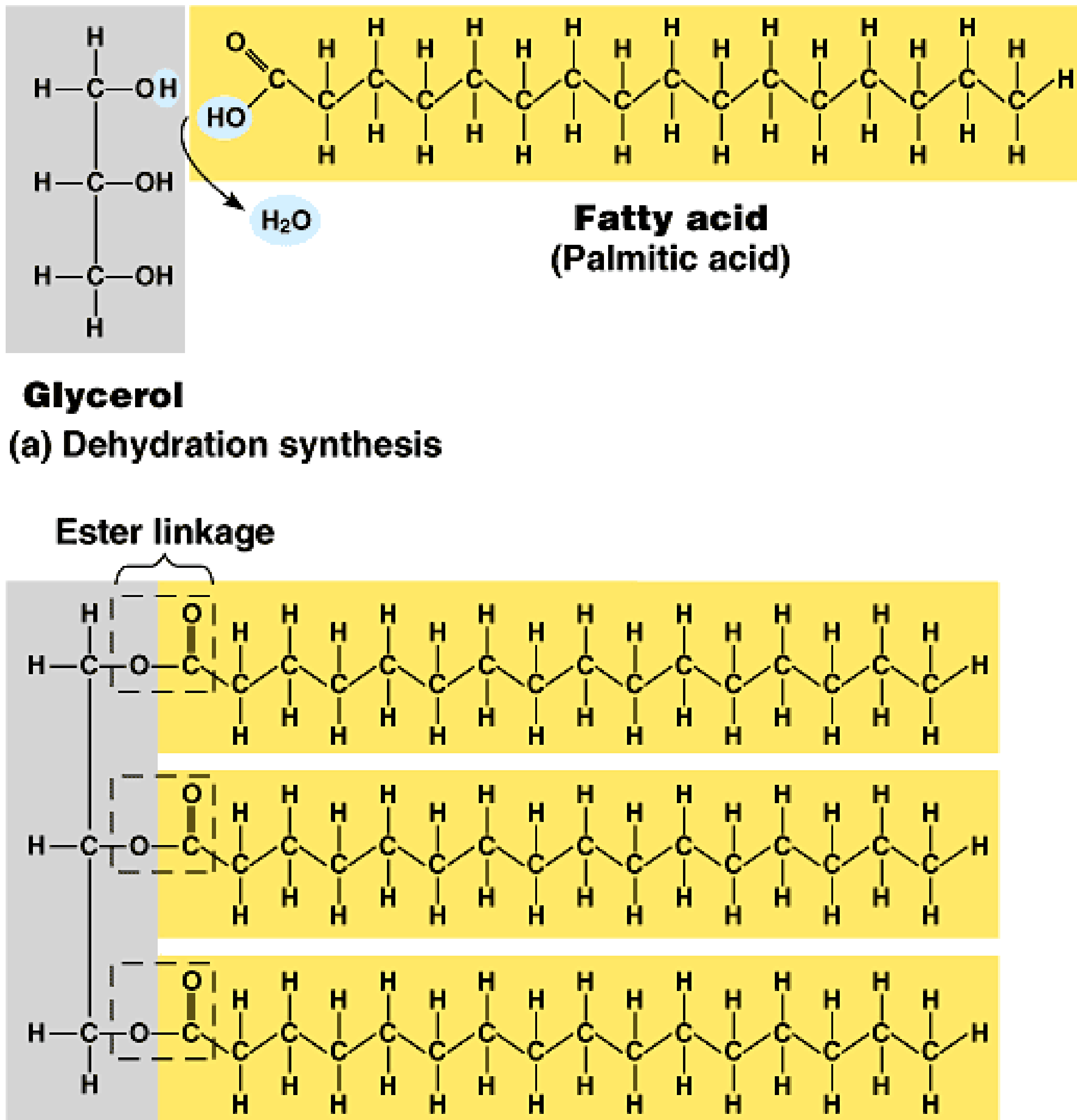
Lipids—Hydrophobic Molecules

- Lipids are an exception among macromolecules because they do not have polymers.
- The unifying feature of **lipids** is that they all have little or no affinity for water.
- This is because their structures are dominated by nonpolar covalent bonds.
- Lipids are highly diverse in form and function.

Fats store large amounts of energy

- Although fats are not strictly polymers, they are large molecules assembled from smaller molecules by dehydration reactions.
- A **fat** is constructed from two kinds of smaller molecules, glycerol and fatty acids.
- Glycerol consists of a three-carbon skeleton with a hydroxyl group attached to each.
- A **fatty acid** consists of a carboxyl group attached to a long carbon skeleton, often 16 to 18 carbons long.

Figure 5.10 The synthesis and structure of a fat, or triacylglycerol

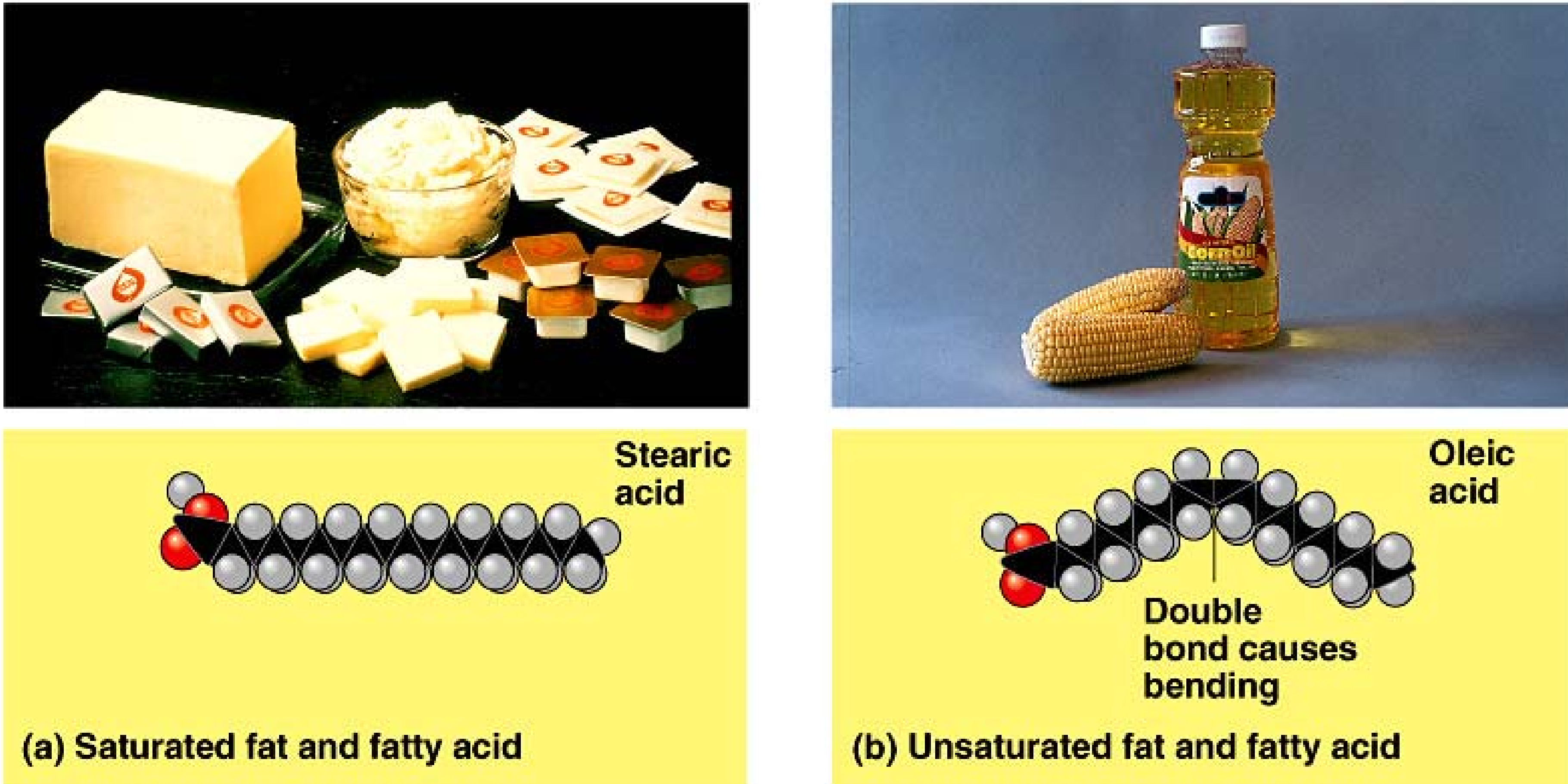


(b) Fat molecule (triacylglycerol)

triacylglycerol

- Three fatty acids joined to a glycerol.
- Fatty acids can be the same or different.
- If there are no carbon-carbon double bonds, then the molecule is a **saturated fatty acid**
- If there are one or more carbon-carbon double bonds, then the molecule is an **unsaturated fatty acid**

Figure 5.11 Examples of saturated and unsaturated fats and fatty acids



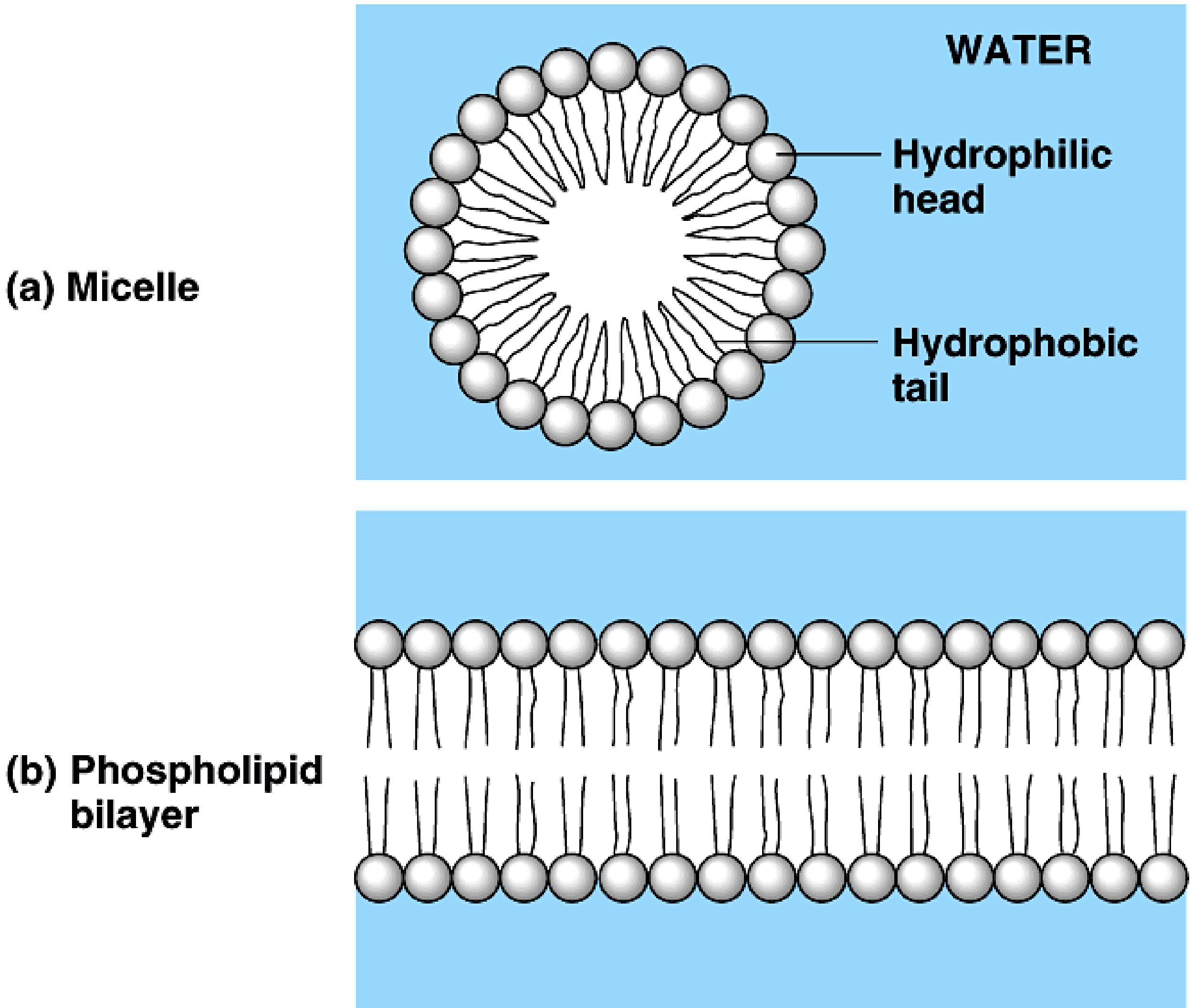
(a) Saturated fat and fatty acid

(b) Unsaturated fat and fatty acid

The major function of fats is energy storage.

- A gram of fat stores more than twice as much energy as a gram of a polysaccharide.
- Plants use starch for energy storage when mobility is not a concern but use oils when dispersal and packing is important, as in seeds.
- Humans and other mammals store fats as long-term energy reserves in adipose cells.

Phospholipids are major components of cell membranes



Interaction of phospholipids with water

- The phosphate group carries a negative charge.
- The fatty acid tails are hydrophobic, but the phosphate group and its attachments form a hydrophilic head.

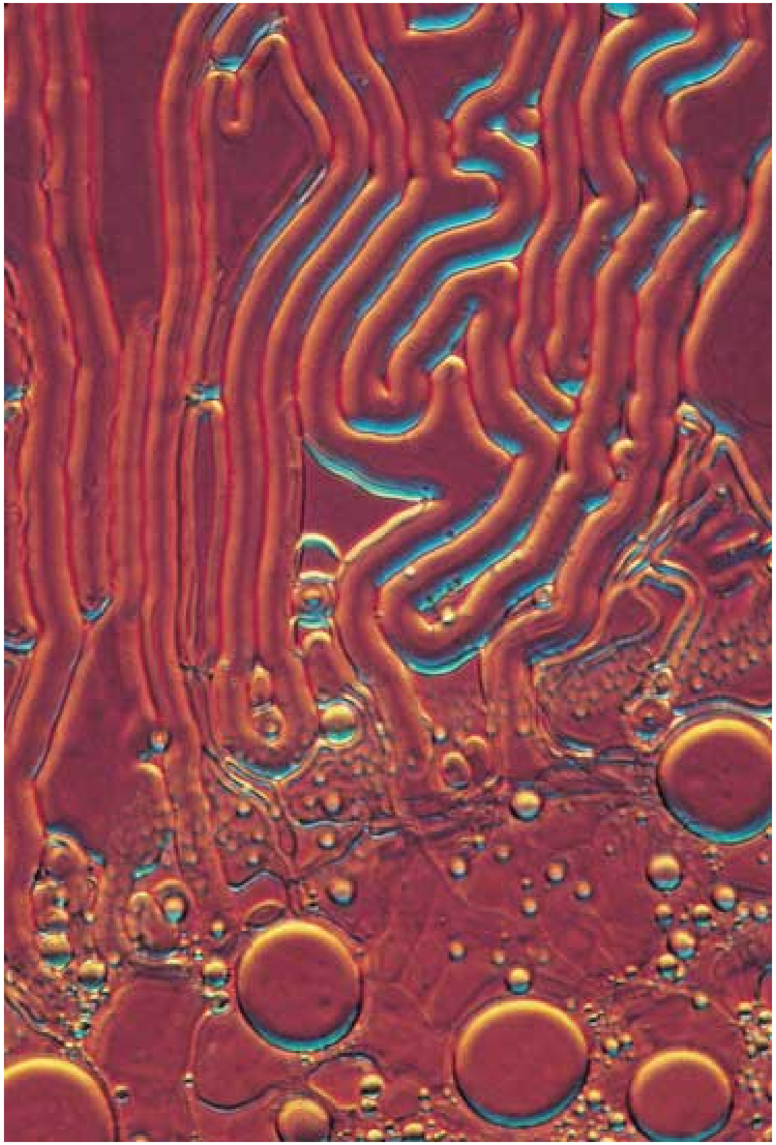
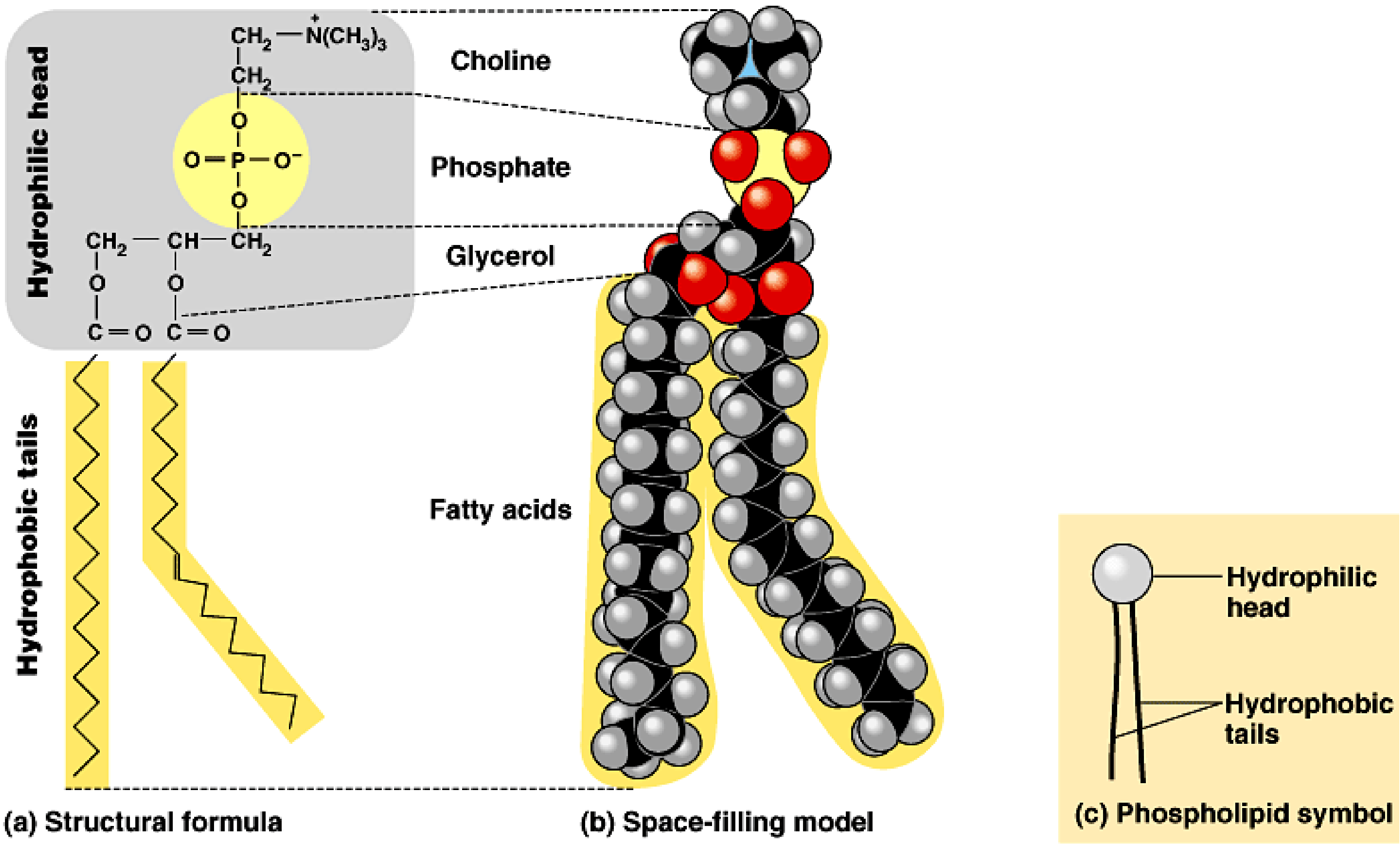


Figure 5.12 The structure of a phospholipid

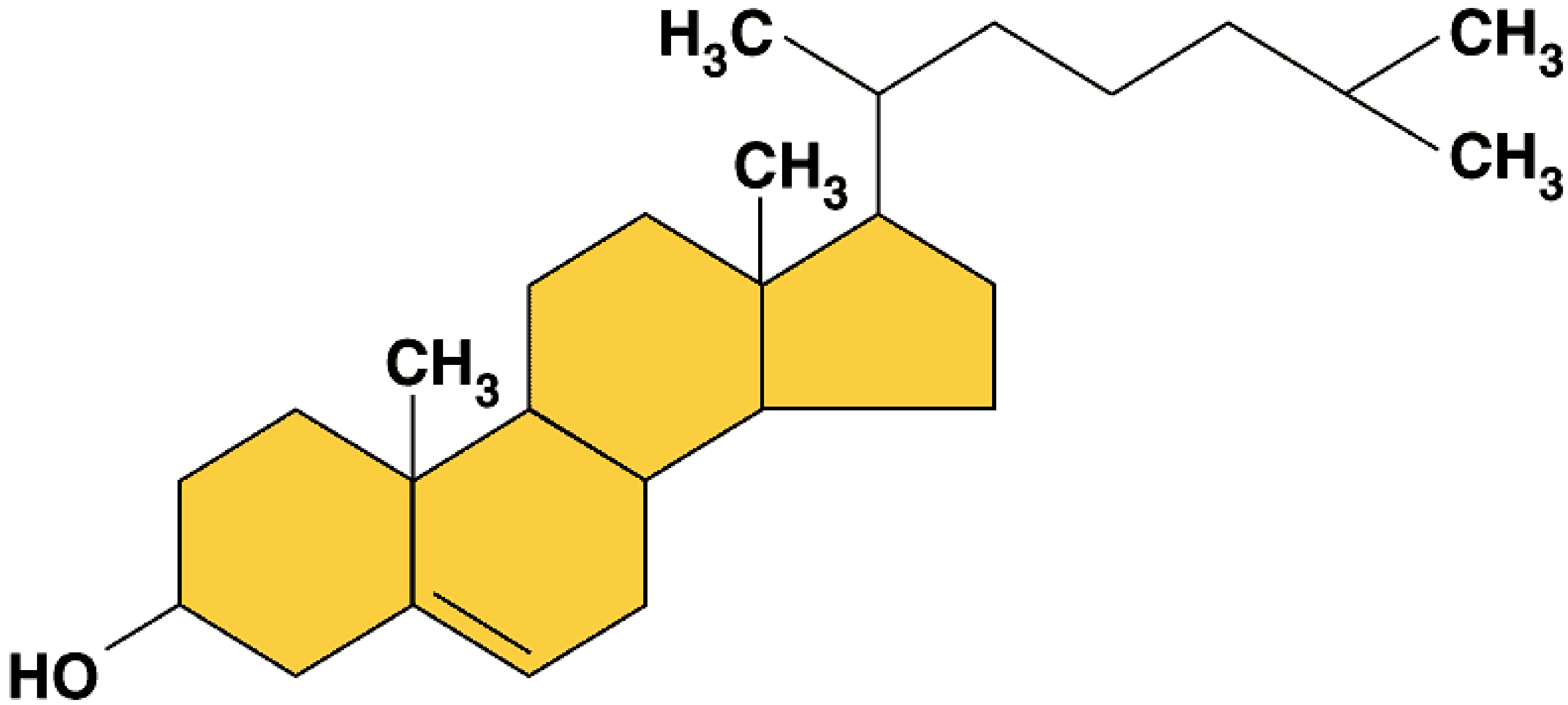


(a) Structural formula (b) Space-filling model (c) Phospholipid symbol

A baseball players dream ROIDS!

- **Steroids** are lipids with a carbon skeleton consisting of four fused carbon rings.
- Different steroids are created by varying functional groups attached to the rings.
- **Cholesterol**, an important steroid, is a component in animal cell membranes.
- Cholesterol is also the precursor from which all other steroids are synthesized.

Figure 5.14 Cholesterol, a steroid



Proteins, The building blocks of life.

- Proteins are instrumental in about everything that an organism does.
- These functions include structural support, storage, transport of other substances, intercellular signaling, movement, and defense against foreign substances.
- Proteins are the enzymes in a cell and regulate metabolism by selectively accelerating chemical reactions.

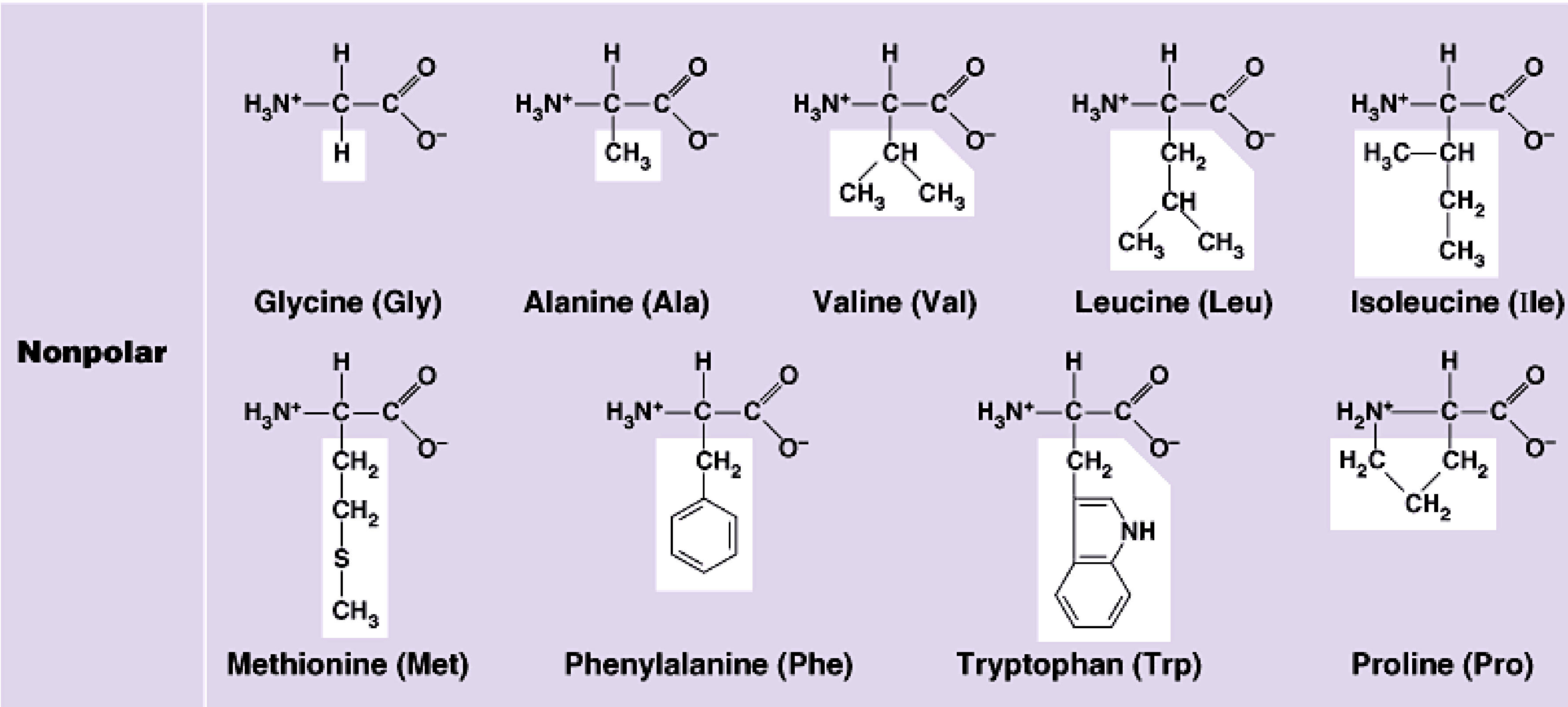
More Info for you.

- Humans have tens of thousands of different proteins, each with their own structure and function.
- Proteins are the most structurally complex molecules known.
- Each type of protein has a complex three-dimensional shape or conformation.

Amino Acids-Protein Monomers

- There are 20 Amino Acids which are the monomers of the protein molecule.
- DNA codes for these 20 A.A.s

Figure 5.15 The 20 amino acids of proteins: nonpolar



- **Amino acids** consist of four components attached to a central carbon, the *alpha carbon*.
- These components include a hydrogen atom, a carboxyl group, an amino group, and a variable R group (or side chain).

Figure 5.15 The 20 amino acids of proteins: polar and electrically charged

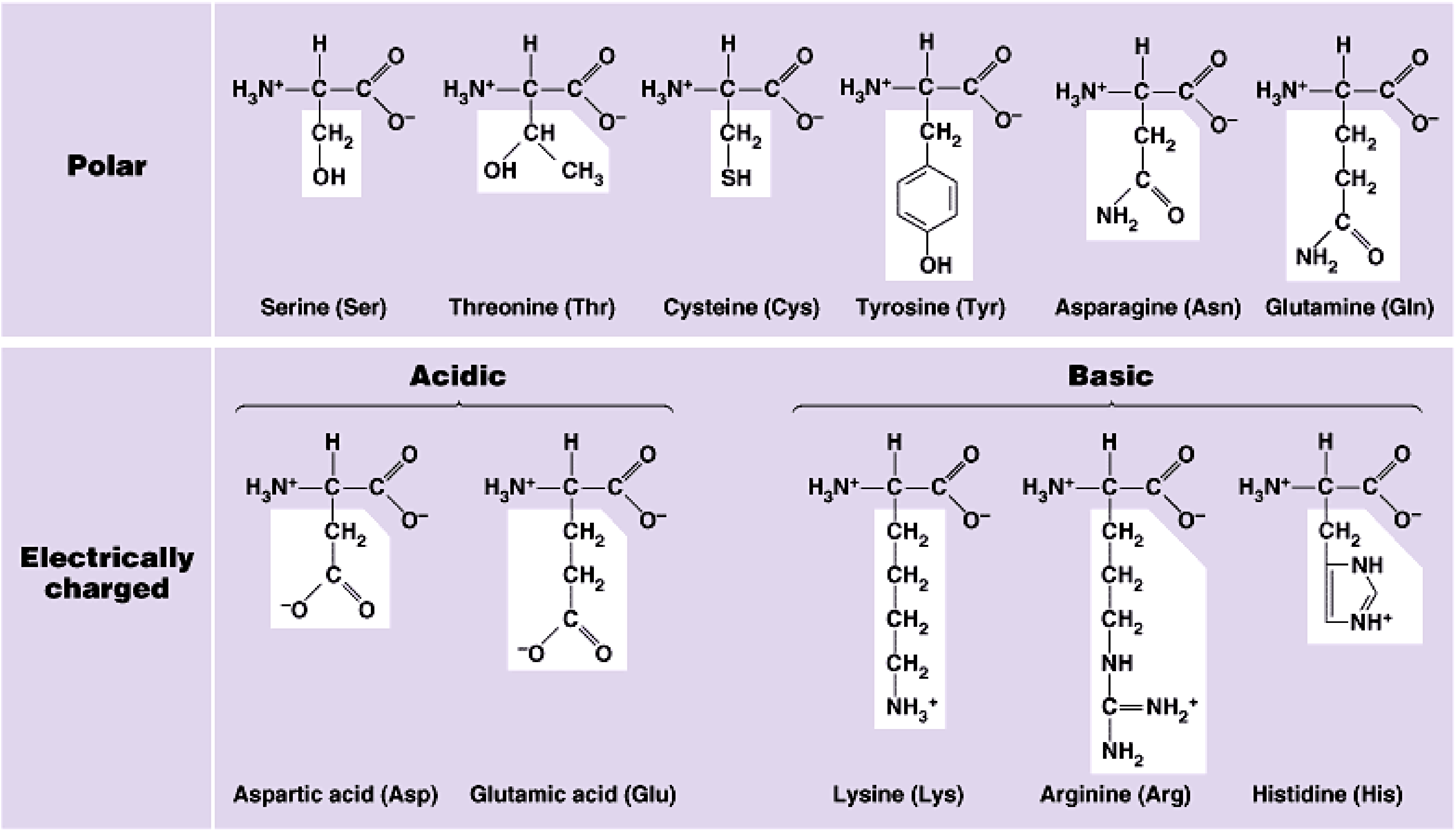


Figure 5.17 Conformation of a protein, the enzyme lysozyme

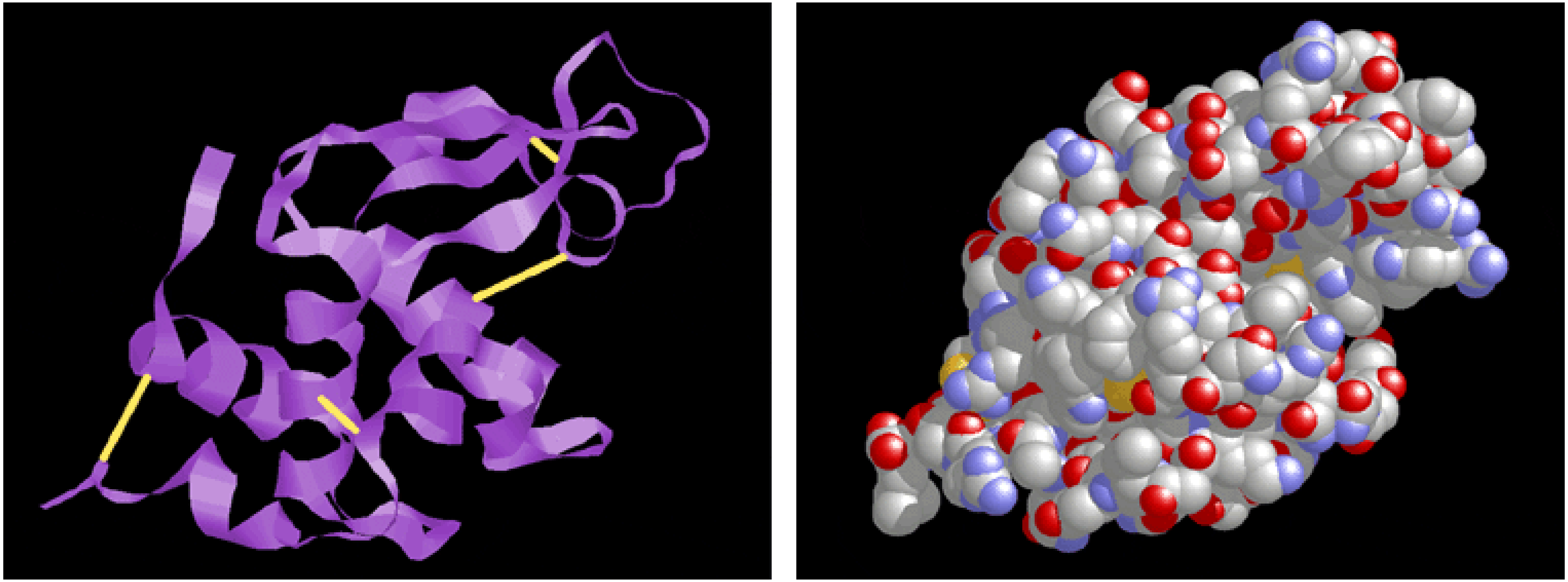


Figure 5.16 Making a polypeptide chain

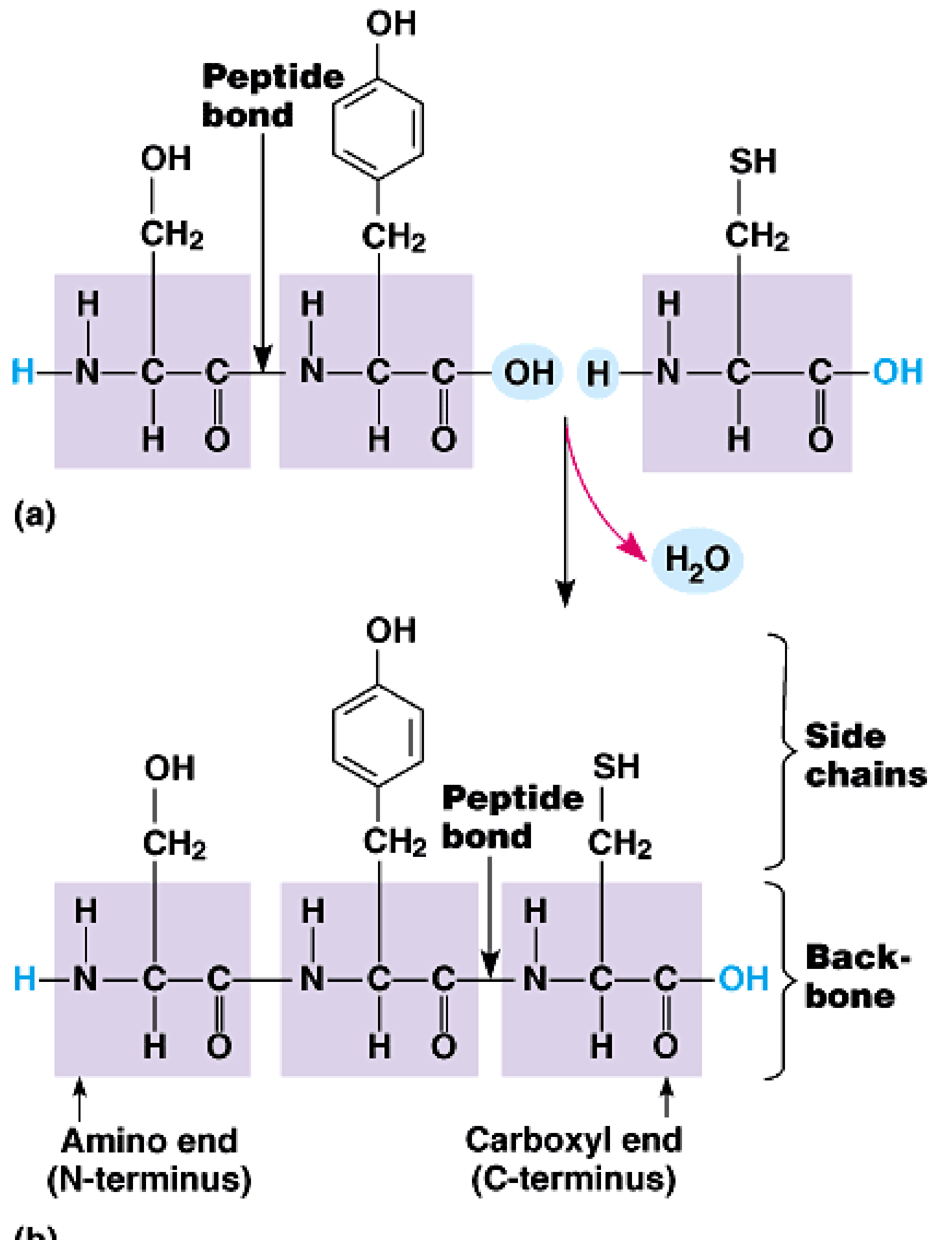


Figure 5.18 The primary structure of a protein

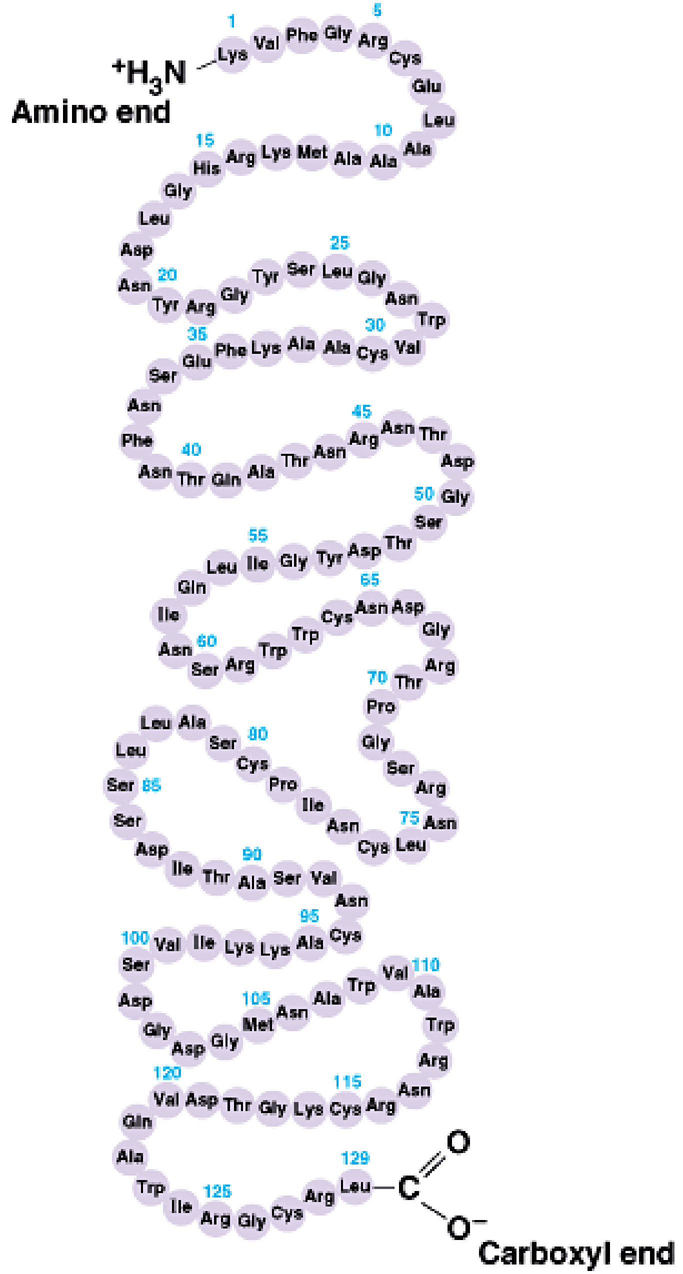
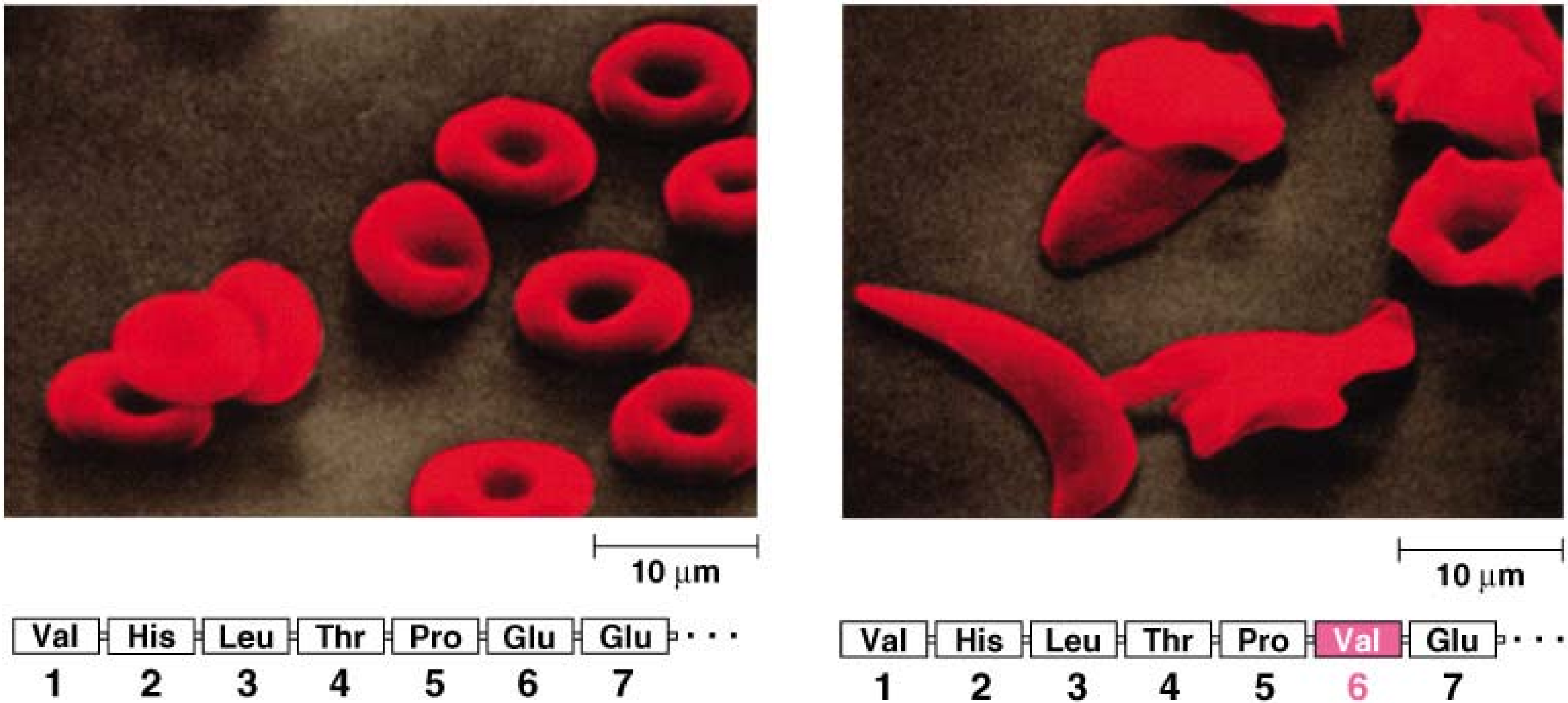


Figure 5.19 A single amino acid substitution in a protein causes sickle-cell disease



(a) Normal red blood cells and the primary structure of normal hemoglobin

(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

Figure 5.20 The secondary structure of a protein

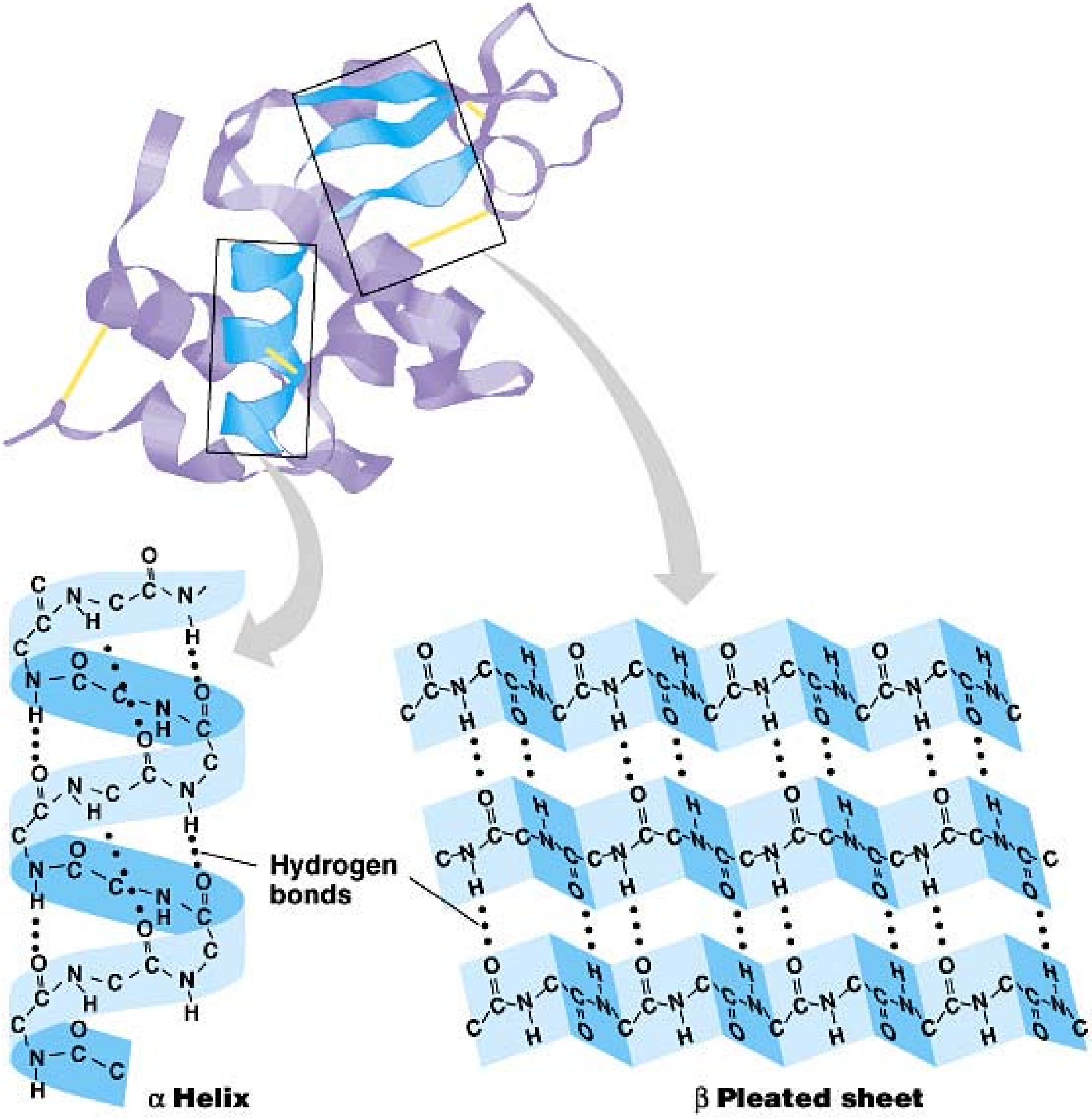


Figure 5.22 Examples of interactions contributing to the tertiary structure of a protein

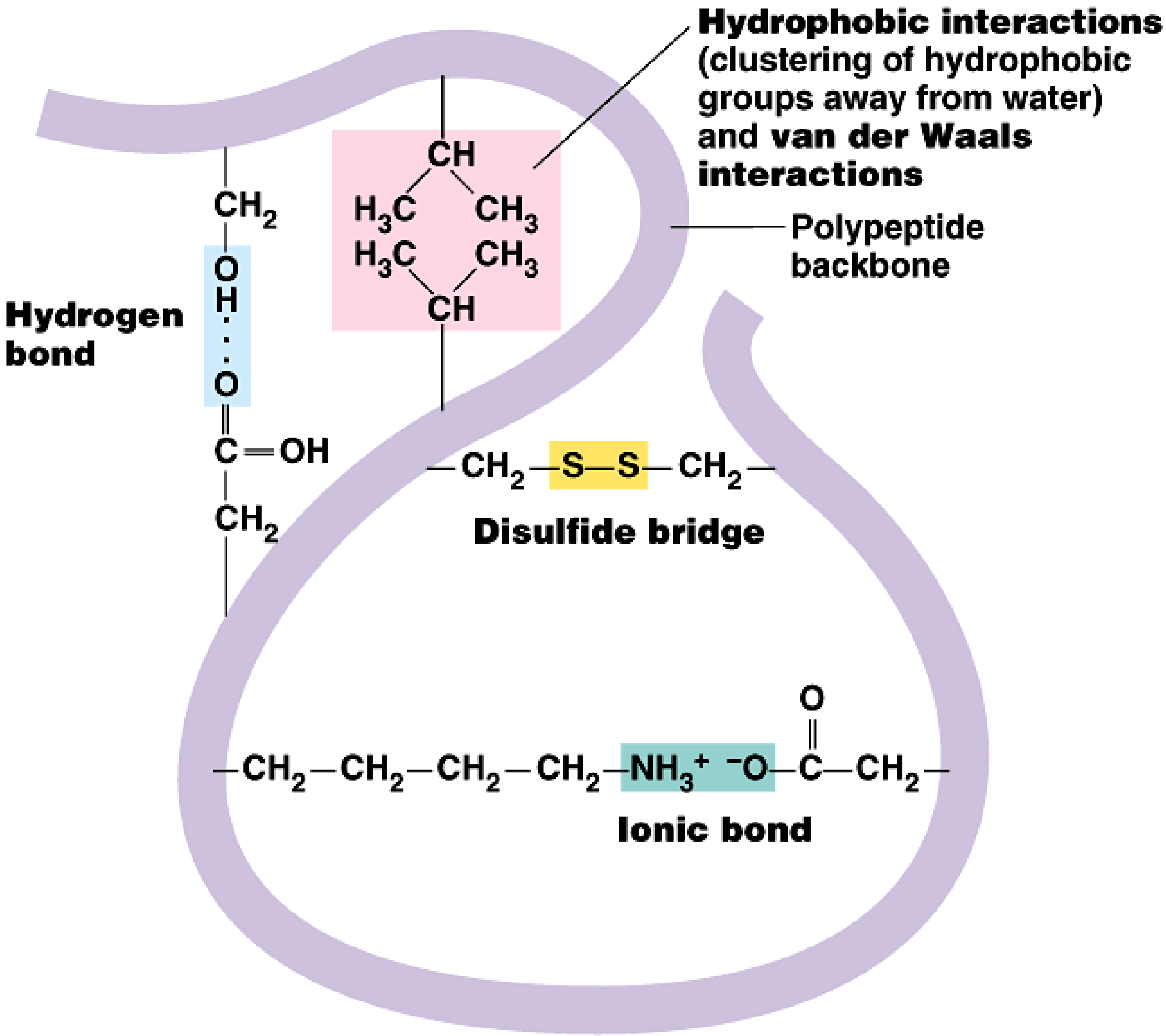
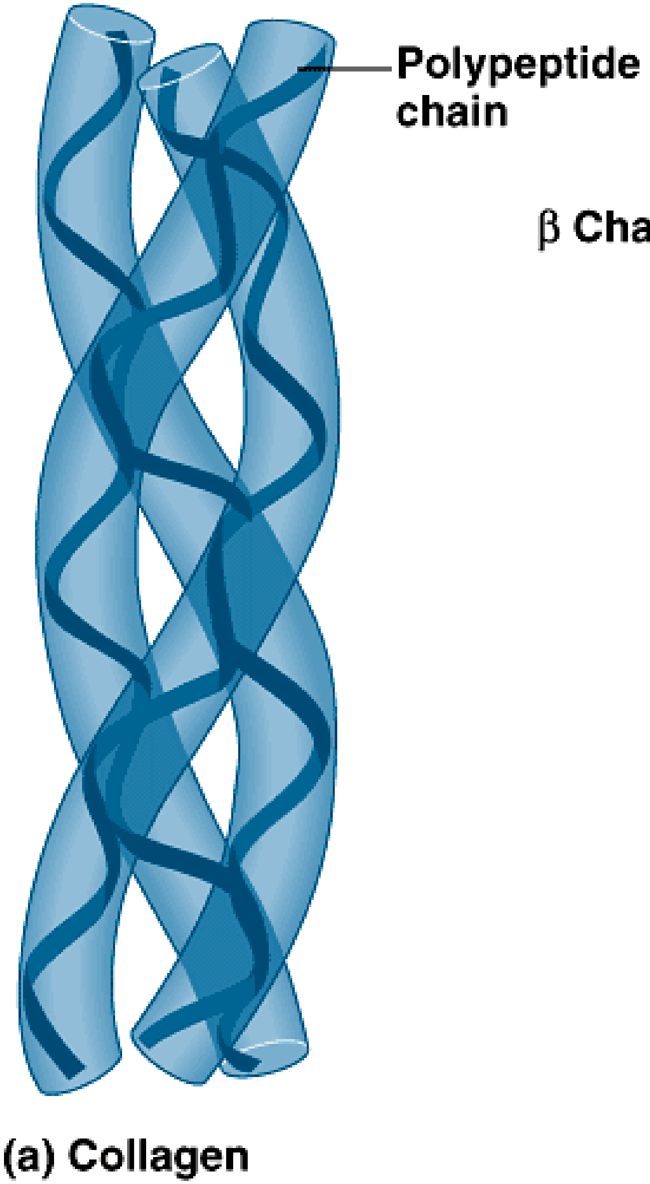


Figure 5.23 The quaternary structure of proteins



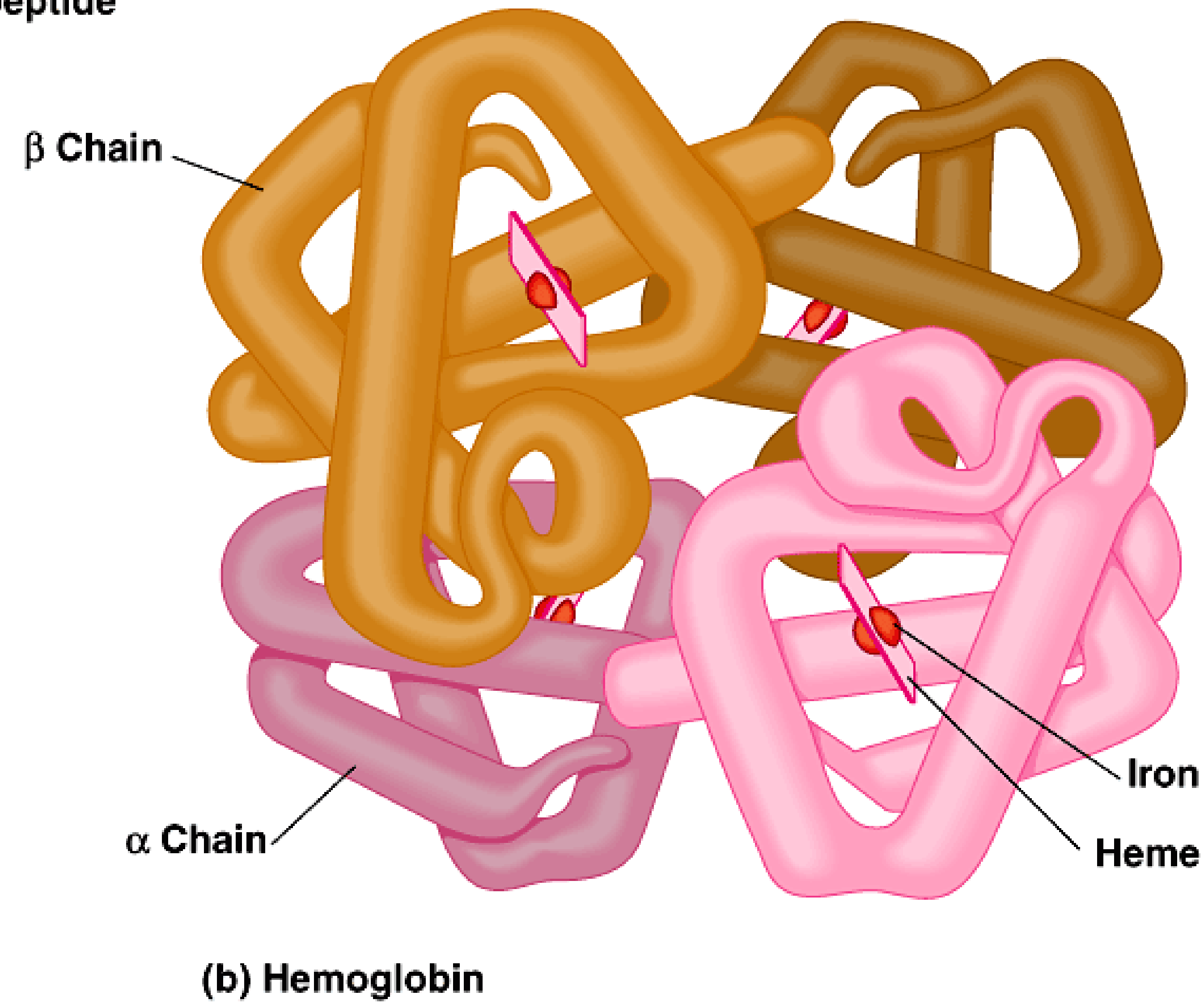


Figure 5.24 Review: the four levels of protein structure