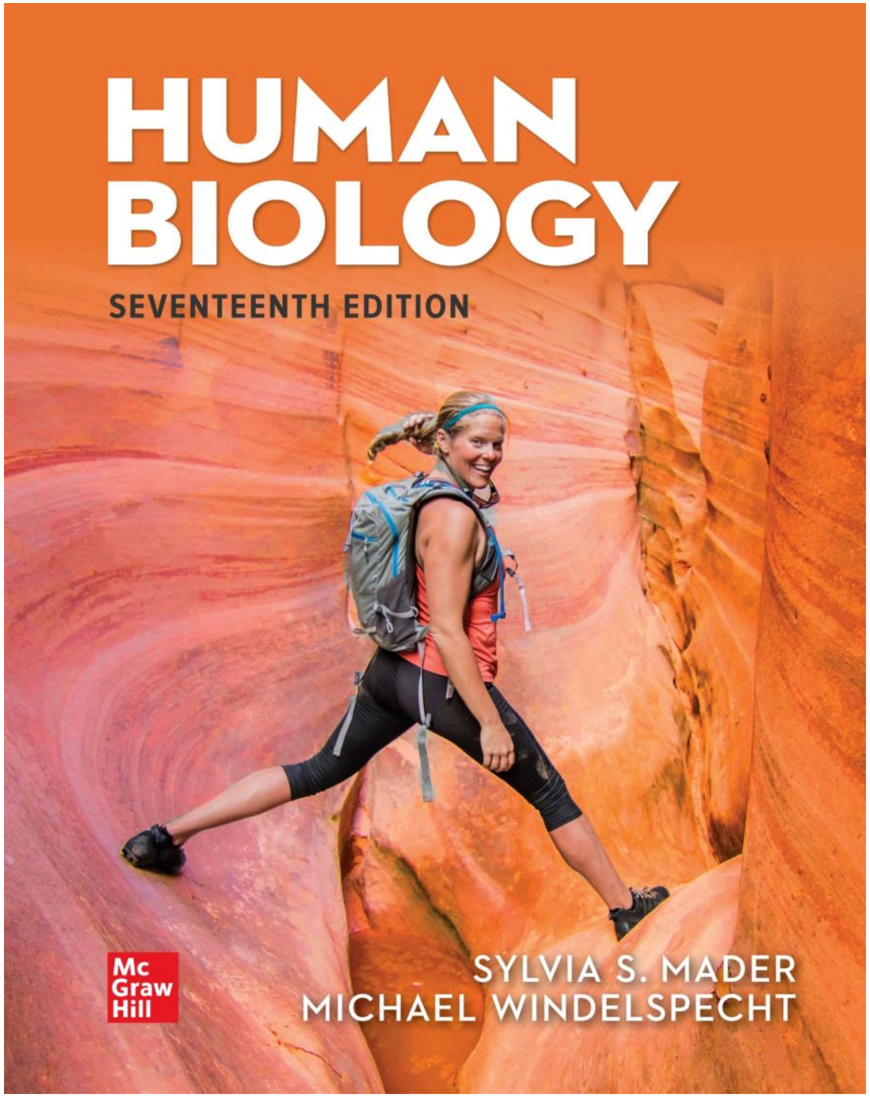


Because learning changes everything.®

HUMAN BIOLOGY

Seventeenth Edition

Sylvia S. Mader
Michael Windelspecht

Chapter 2
Chemistry of Life

2.3 Molecules of Life 1

Learning Outcomes:

- List the four classes of organic molecules found in cells.
- Describe the processes by which the organic molecules are assembled and disassembled.

2.3 Molecules of Life 2

The four major **organic molecules** in the body: carbohydrates, lipids, proteins, and nucleic acids.

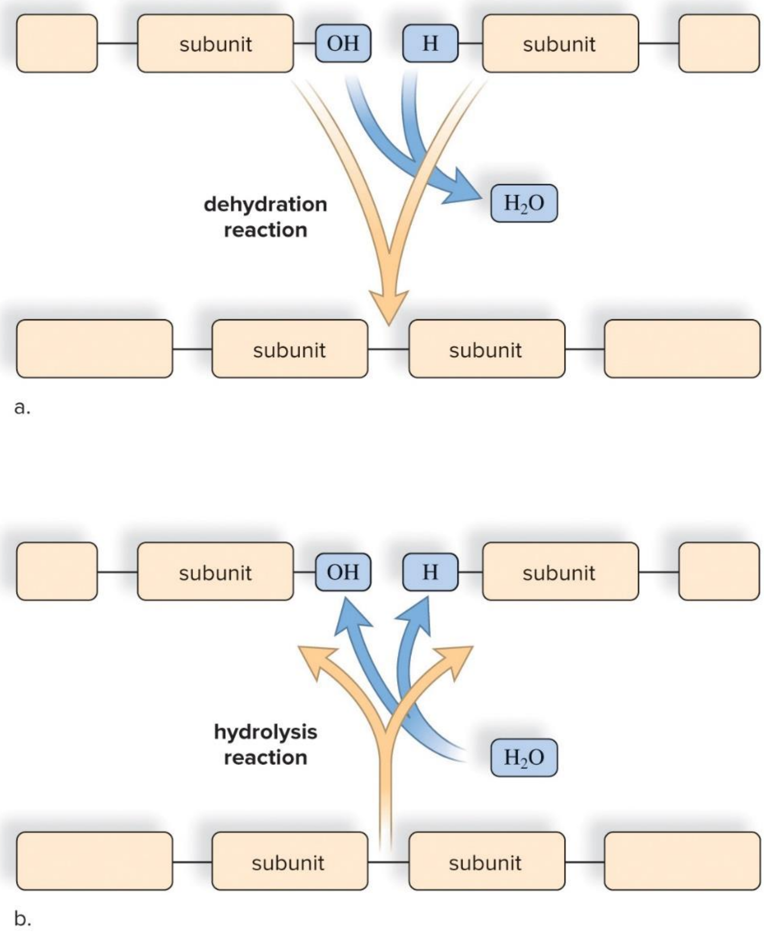
- Organic molecules contain carbon and hydrogen and are associated with cells.
- Each is composed of subunits.

2.3 Molecules of Life 3

Dehydration reaction—a type of synthesis chemical reaction that removes water, linking subunits together into **macromolecules** (large molecules).

Hydrolysis reaction—the addition of water to break macromolecules into their subunits.

The Breakdown and Synthesis of Macromolecules (Figure 2.11)



Access the text alternative for slide images.

Check Your Progress 2.3

Explain the difference between an organic and an inorganic molecule.

List the four classes of organic molecules.

Distinguish between a dehydration reaction and a hydrolysis reaction.

2.4 Carbohydrates 1

Learning Outcomes:

- Summarize the basic chemical properties of a carbohydrate.
- State the roles of carbohydrates in human physiology.
- Compare the structures of simple and complex carbohydrates.
- Explain the importance of fiber in the diet.

2.4 Carbohydrates 2

Carbohydrates

- Used as an energy source.
- In plants, can be structural.
- Made of C, H, and O; the ratio of H:O is 2:1.

Simple Carbohydrates: Monosaccharides

Monosaccharides

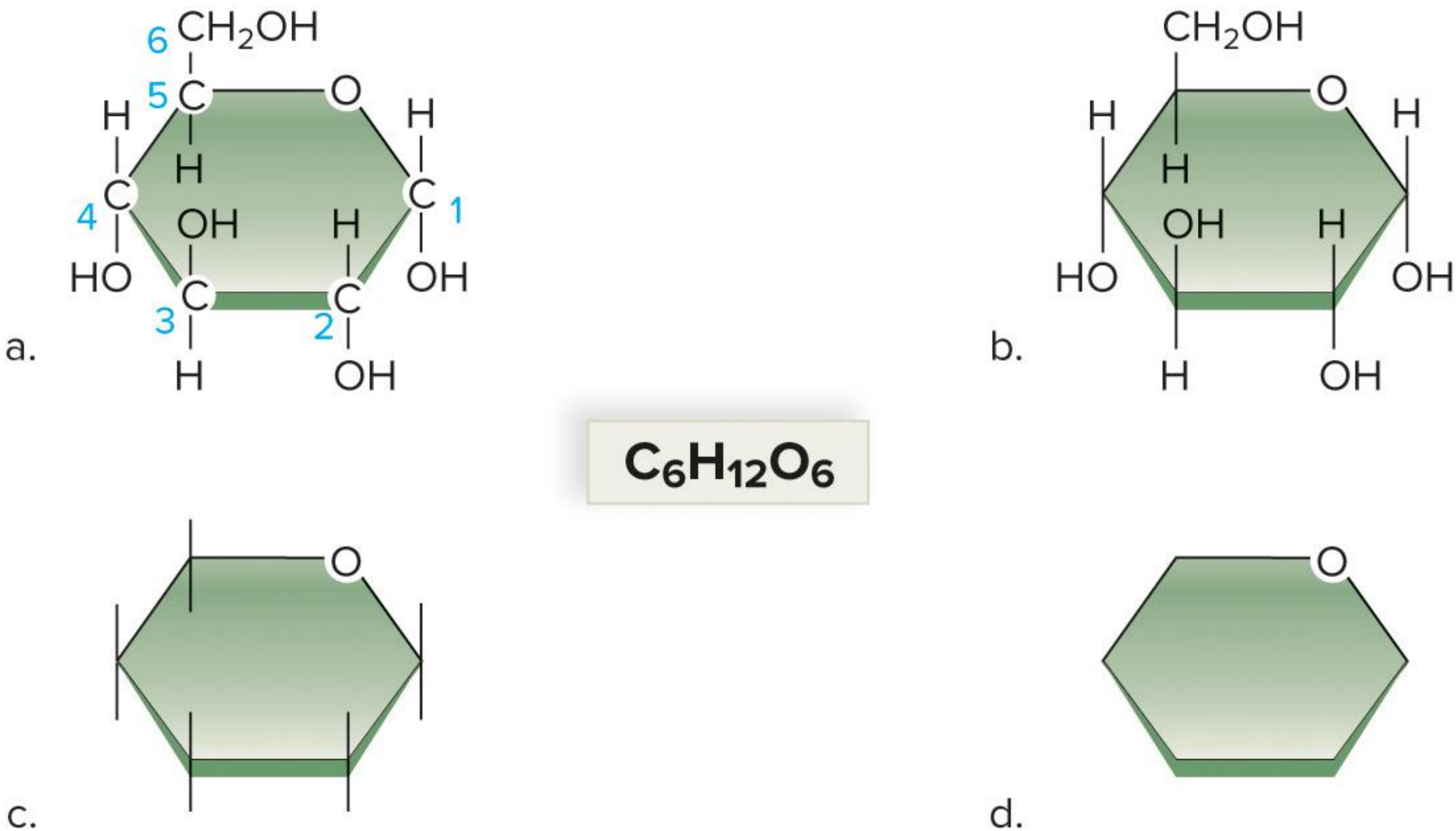
Made of a single sugar molecule.

Has a carbon backbone of three to seven carbons.

- That is, a *pent*ose has *five* carbons.

That is, **glucose** is the most common and is used as an immediate energy source in the body.

Glucose (Figure 2.12)



Access the text alternative for slide images.

Disaccharides

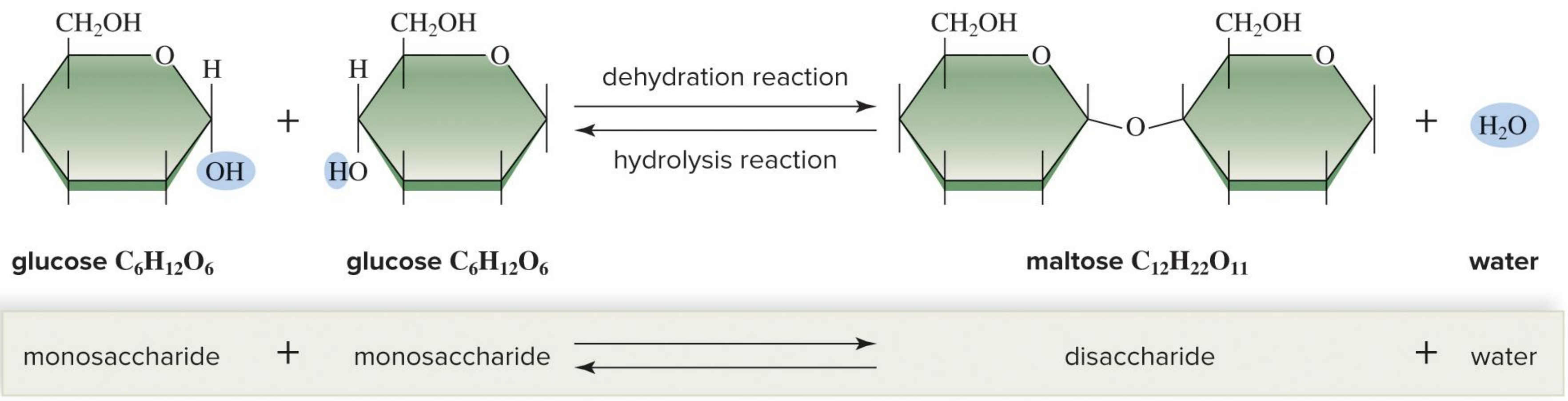
Disaccharides

Made of two monosaccharides joined by a dehydration reaction.

That is, sucrose is table sugar, lactose is milk sugar.

- Lactose intolerance results if one can't break down lactose.

The Synthesis and Breakdown of a Disaccharide (Figure 2.13)



Access the text alternative for slide images.

Complex Carbohydrates: Polysaccharides

Polysaccharides (complex carbohydrates).

Long polymers of glucose subunits.

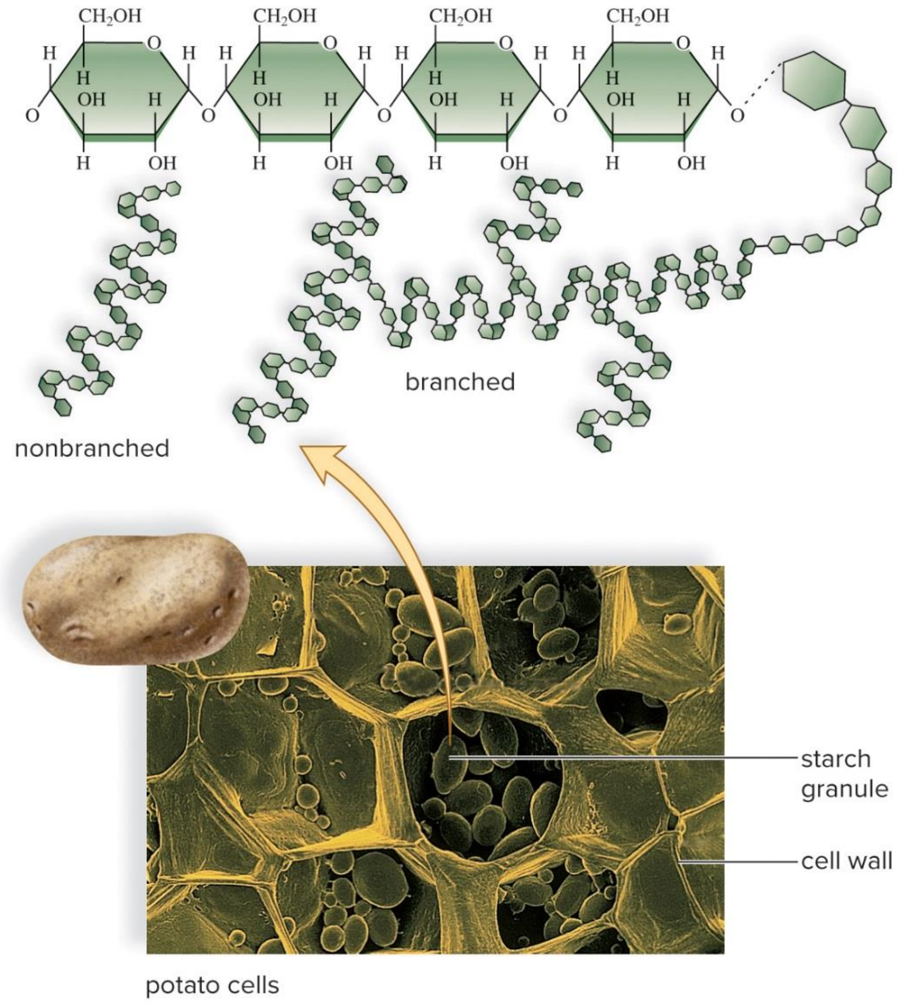
That is, starch—energy storage in plants.

That is, glycogen—energy storage in animals.

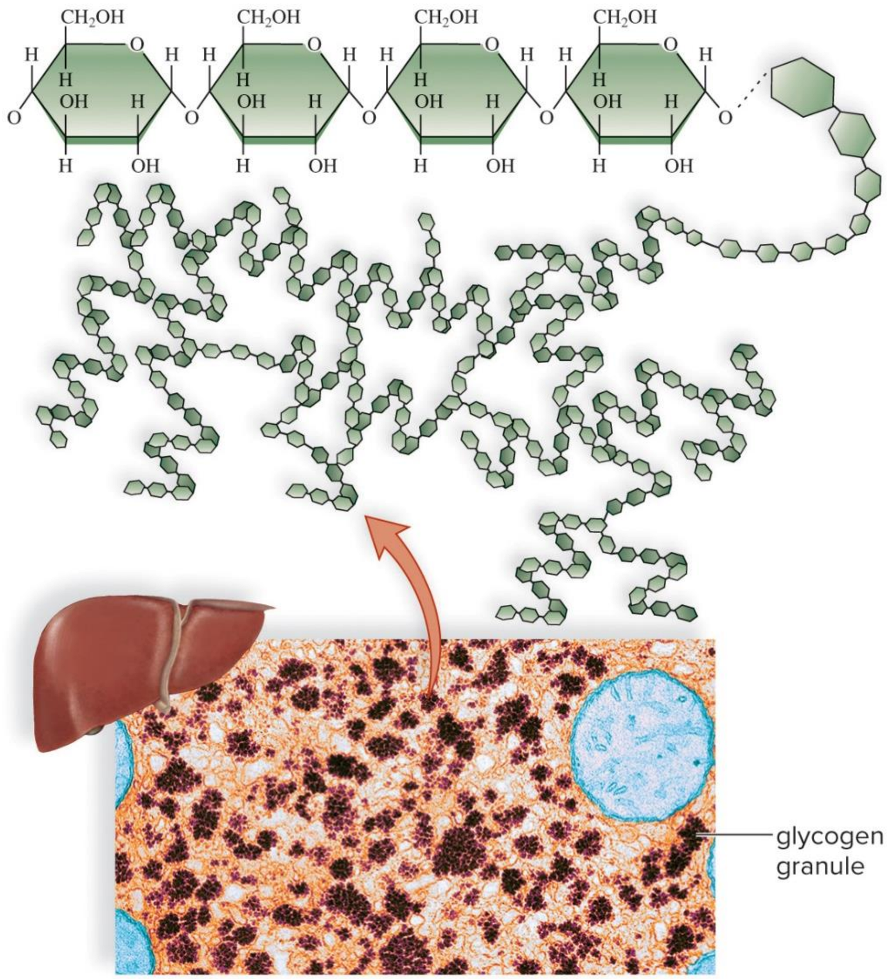
That is, cellulose—structural; in plant cell walls.

- Can’t be digested; is called “fiber.”

Starch Is a Plant Complex Carbohydrate (Figure 2.14)

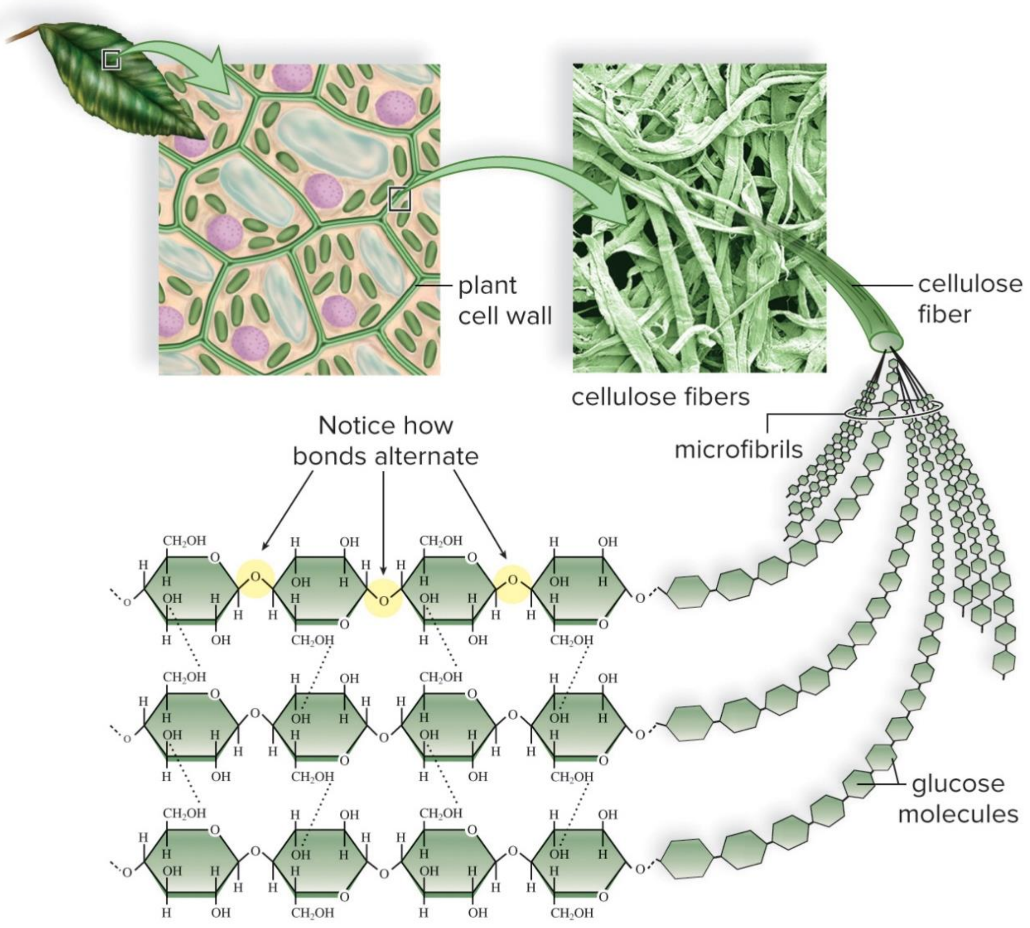


Glycogen Is an Animal Complex Carbohydrate (Figure 2.15)



(photo): Don W. Fawcett/Science Source

Fiber Is a Plant Complex Carbohydrate (Figure 2.16)



Access the text alternative for slide images.

(photo): Scimat/Science Source

Check Your Progress 2.4

Explain the differences between a monosaccharide, a disaccharide, and a polysaccharide, and give an example of each.

Describe the difference in structure between a simple carbohydrate and the complex carbohydrates.

Explain why some complex carbohydrates can be used for energy but others cannot.

2.5 Lipids 1

Learning Outcomes:

- Compare the structures of fats, phospholipids, and steroids.
- State the function of each class of lipids.

2.5 Lipids 2

Lipids do not dissolve in water.

- Lack hydrophilic polar groups.
- Diverse in functions and forms.
- Found in the form of **triglycerides (fats** and **oils), phospholipids,** and **steroids.**

Triglycerides: Fats and Oils 1

Triglycerides:

Made of one glycerol and three fatty acids.

Function in energy storage, insulation, cushioning.

Come in two forms: fats and oils.

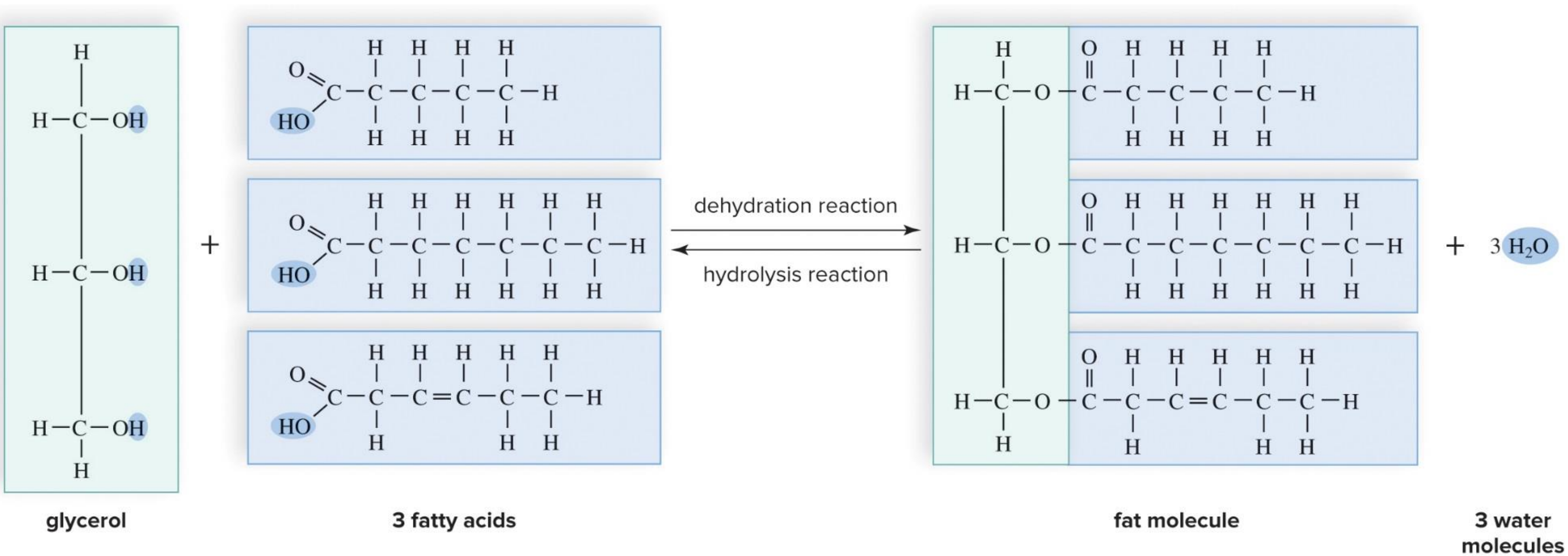
Fats.

- Usually animal origin.
- Solid at room temperature.

Oils.

- Usually plant origin.
- Liquid at room temperature.

Structure of a Triglyceride (Figure 2.17)



Access the text alternative for slide images.

Triglycerides: Fats and Oils 2

Triglycerides, continued:

Triglycerides are hydrophobic, so will clump together in body fluids.

- **Emulsifiers** are molecules that surround triglycerides and disperse, or emulsify, them.
  - That is, during digestion, this allows enzymes to fully break down triglycerides.

Waxes.

- One fatty acid attached to an alcohol.
- Prevent the loss of moisture from body surfaces.
  - That is, cerumen (ear wax).

Saturated, Unsaturated, and Trans Fatty Acids 1

Fatty acids—long chains of carbons and hydrogens.

- End in—COOH.
- Most contain 16 to 18 carbons.
- Can be saturated or unsaturated.

Saturated, Unsaturated, and Trans Fatty Acids 2

Fatty acids, continued

Saturated fatty acids have no double covalent bonds between the carbons; they are saturated with hydrogen.

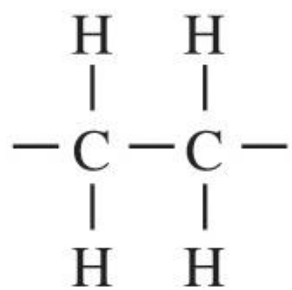
- Solid at room temperature.

Unsaturated fatty acids have one or more double covalent bond because hydrogens are “missing.”

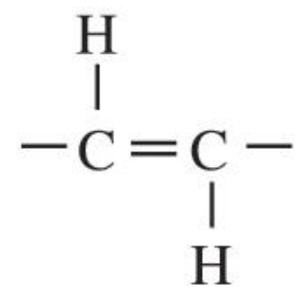
- Liquid at room temperature due to bends in the carbon chain.

Comparison of Fat Saturation (Figure 2.18)

Unsaturated fats
(oils)



Saturated fats
(butter)



Unsaturated trans fats
(hydrogenated oils)

[Access the text alternative for slide images.]()

Saturated, Unsaturated, and Trans Fatty Acids 3

Fatty acids, concluded

Saturated fats contribute to atherosclerosis, a disease of the blood vessels.

Trans fats are man-made and contribute to heart disease more than other types of fatty acids.

- Are unsaturated, but the missing hydrogens are on opposite sides of the carbon chains.

Dietary Fat

In the past, the recommendation for total amount of fat in a 2,000 calorie diet was 65 g.

- Now, though, research indicates that the type of fat eaten is more important than the quantity.

Phospholipids

Phospholipids

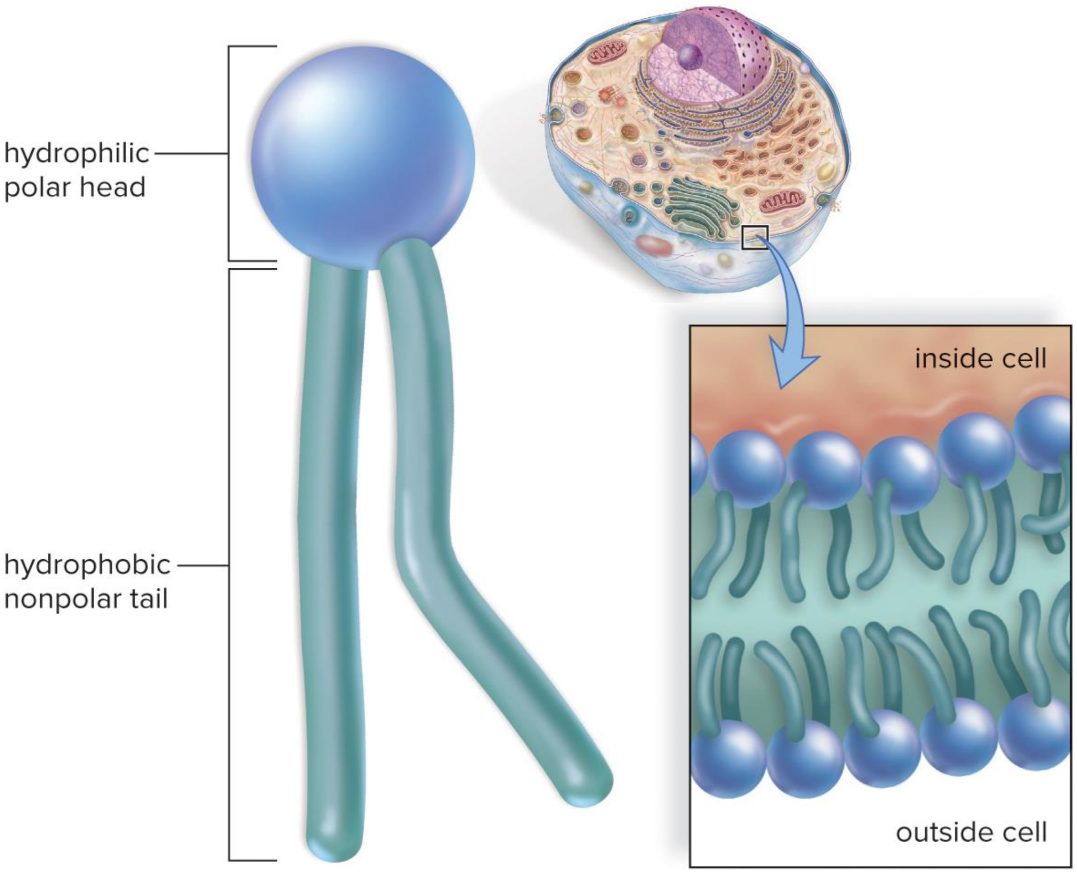
Structure is similar to a triglyceride but one fatty acid is replaced by a polar phosphate group.

Have a polar, hydrophilic "head" and nonpolar, hydrophobic "tails."

Are the primary components of plasma membranes.

- Form a bilayer; hydrophilic heads face the watery solutions in and around cells, and the hydrophobic tails face inward, away from water.

Structure of a Phospholipid (Figure 2.19)



a. Phospholipid structure

b. Membrane structure

Access the text alternative for slide images.

Steroids

Steroids

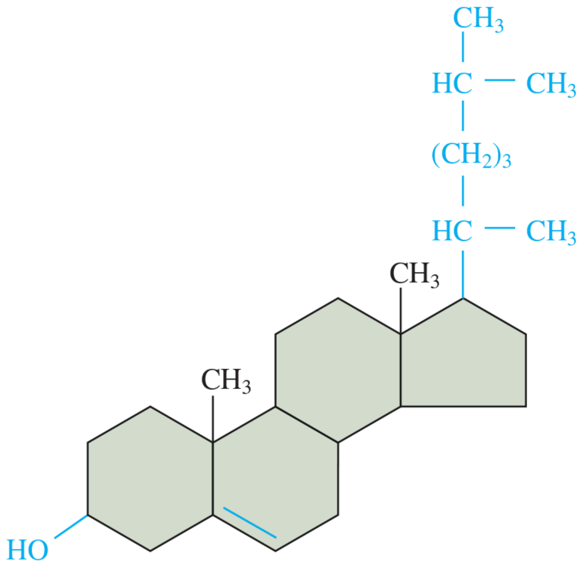
Lipids made of four fused carbon rings.

- Each type differs in the functional group attached to the rings.

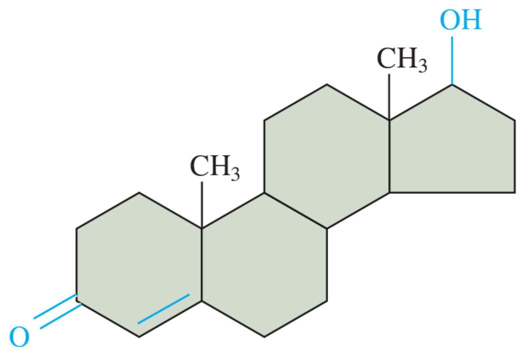
That is, cholesterol.

- Component of membranes and a precursor to other steroids like the sex hormones estrogen and testosterone.

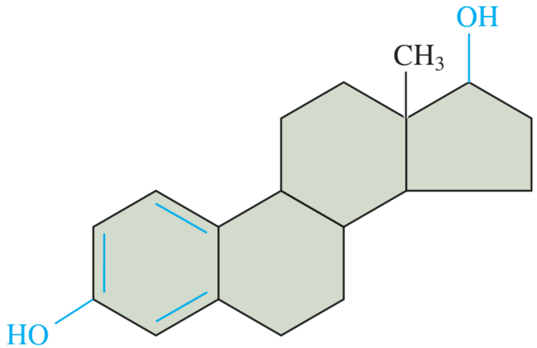
Examples of Steroids (Figure 2.20)



a. Cholesterol



b. Testosterone



c. Estrogen

Access the text alternative for slide images.

Check Your Progress 2.5

State the function of triglycerides in the human body.

List the uses of phospholipids and steroids in the body.

Summarize why not all lipids should be avoided in the diet.

2.6 Proteins

Learning Outcomes:

- Describe the structure of an amino acid.
- Explain how amino acids are combined to form proteins.
- Summarize the four levels of protein structure.

Protein Functions 1

Protein functions:

Support—that is, keratin forms hair and nails, collagen lends support to ligaments and skin.

Enzymes—speed chemical reactions.

Transport.

- That is, channel and carrier proteins in cell membranes allow substances to leave and enter the cell.
- That is, transport molecules in the blood.

Protein Functions 2

Protein functions, continued:

- **Defense**—antibodies are proteins that bind to foreign substances called antigens and disable them.
- **Hormones**—chemical messengers.
- **Motion**—contractile proteins allow parts of cells to move and muscles to contract.

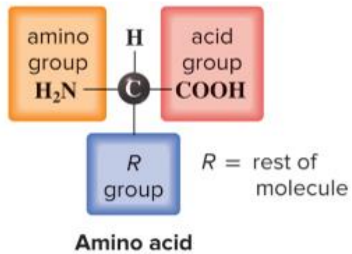
Amino Acids: Subunits of Proteins

Amino acids—the subunits of proteins.

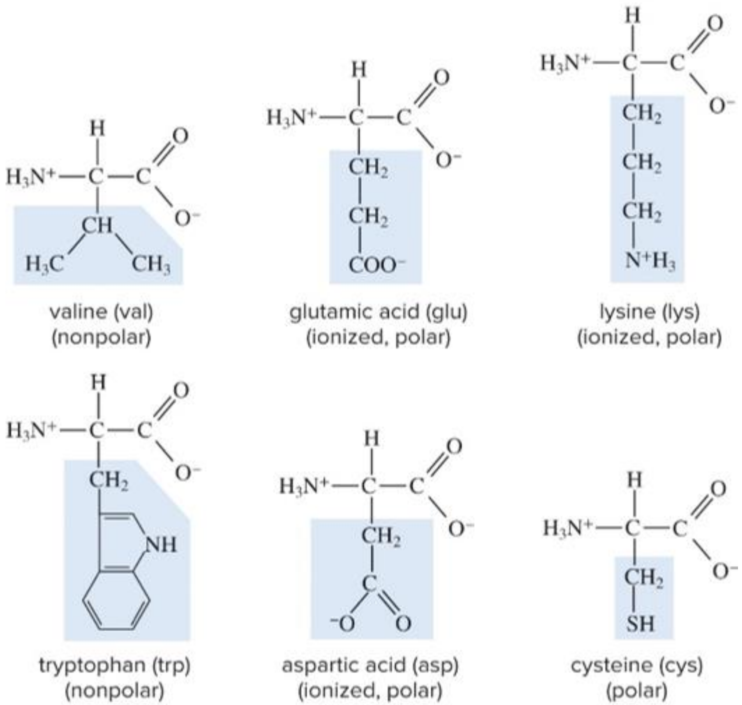
Components: an amino group, a carboxyl group, and an *R* group.

- Each amino acid differs in its *R* group.

The Structure of Amino Acids (Figure 2.21)



a. Structure of an amino acid



b. Examples of amino acids

Access the text alternative for slide images.

Peptides

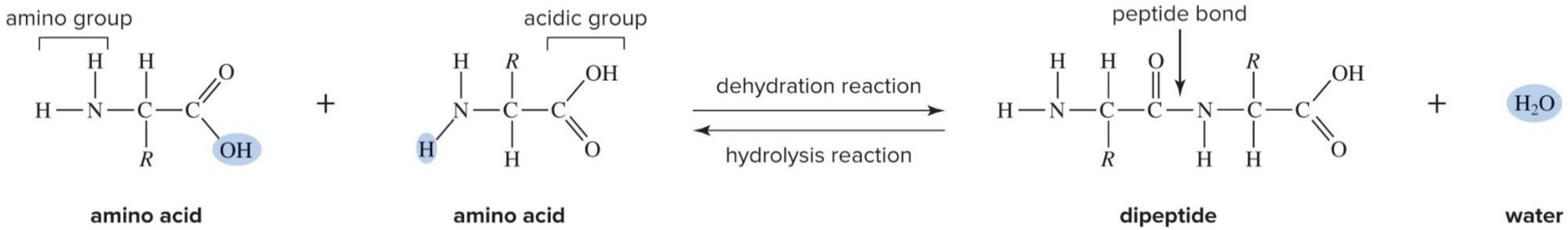
Peptide bond

- The polar covalent bond between two amino acids.

Polypeptide

- Three or more amino acids linked together.

Synthesis and Breakdown of a Protein (Figure 2.22)



Access the text alternative for slide images.

Shape of Proteins

A protein's 3-dimensional shape is closely linked to its function.

Denaturation—the change in the shape of a protein; caused by extreme heat or pH.

- Disrupts the protein's function.

Levels of Protein Organization 1

All proteins have primary, secondary, and tertiary levels of structure; only a few have quaternary structure.

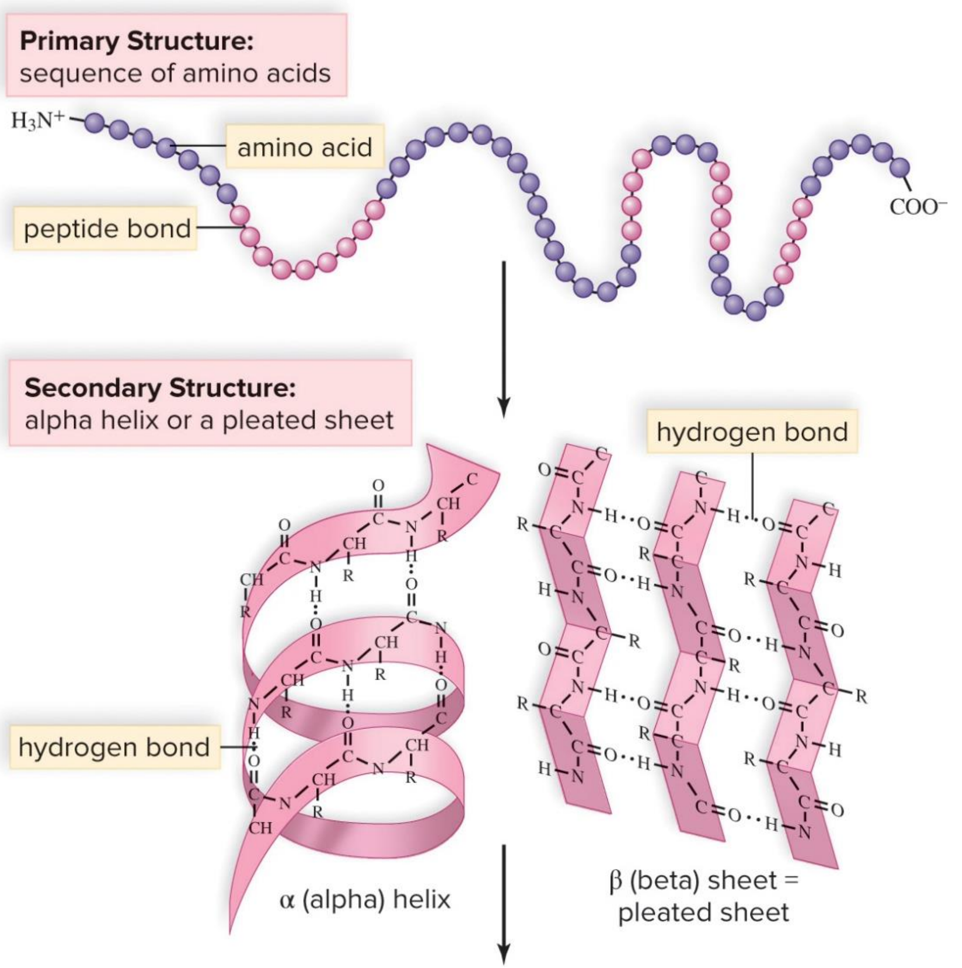
Shapes are created by hydrogen bonding between amino acids.

Primary structure—the linear order of amino acids.

Secondary structure—localized folding.

- Results in an **alpha (α) helix** or **beta (β) pleated sheet.**

Levels of Protein Structure (Figure 2.23 top)



Access the text alternative for slide images.

Levels of Protein Organization 2

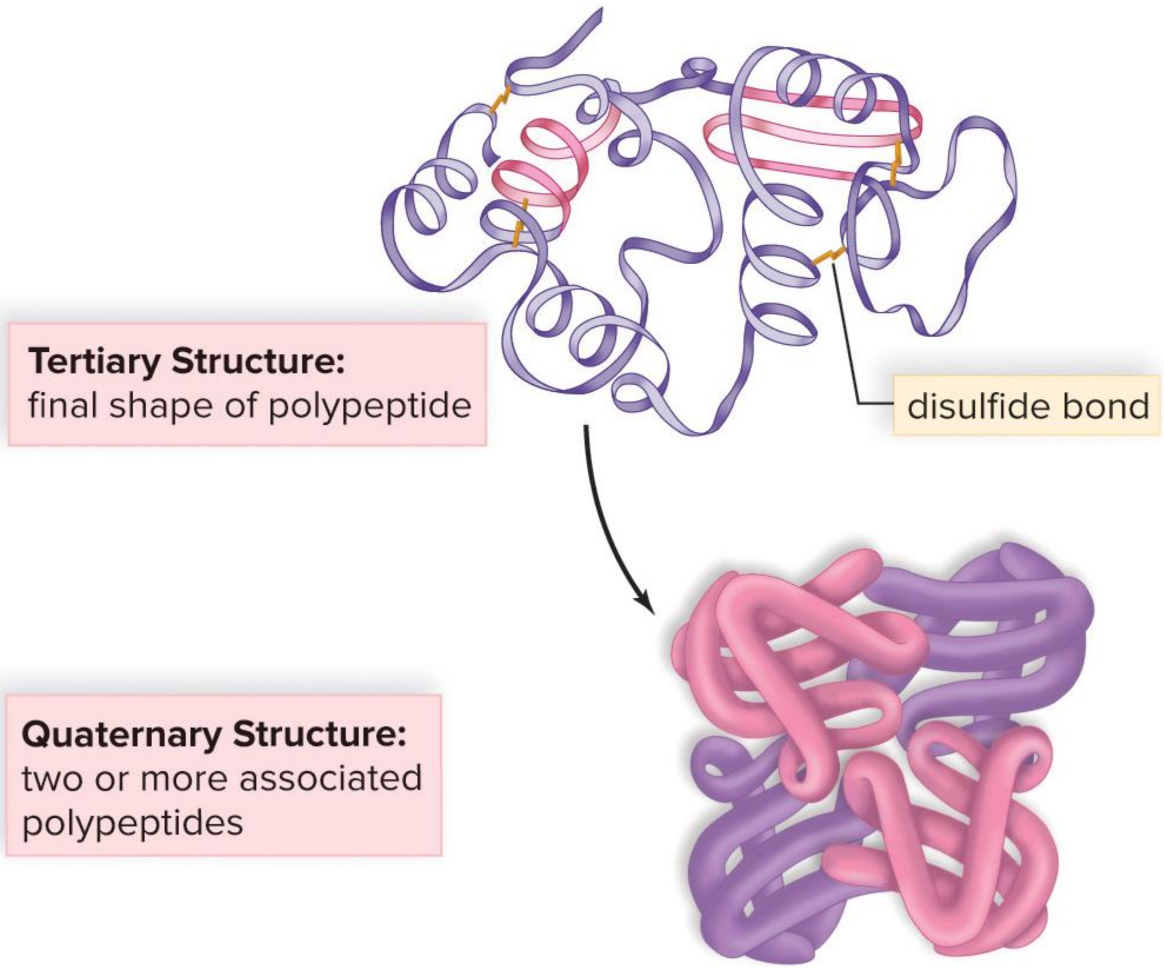
Protein structure, continued.

Tertiary structure.

- The 3-D shape of the entire protein.
- Determined by all three bond types (ionic, covalent, hydrogen).

Quaternary structure—a combination of more than one polypeptide, each with its own primary, secondary, and tertiary structure.

Levels of Protein Structure (Figure 2.23 bottom)



Access the text alternative for slide images.

Check Your Progress 2.6

Describe the major functions of proteins.

Explain the structure of an amino acid.

List the four levels of protein structure and briefly explain the factors that contribute to each level.

2.7 Nucleic Acids 1

Learning Outcomes:

- Explain the differences between RNA and DNA.
- Summarize the role of ATP in cellular reactions.

2.7 Nucleic Acids 2

Nucleic acids

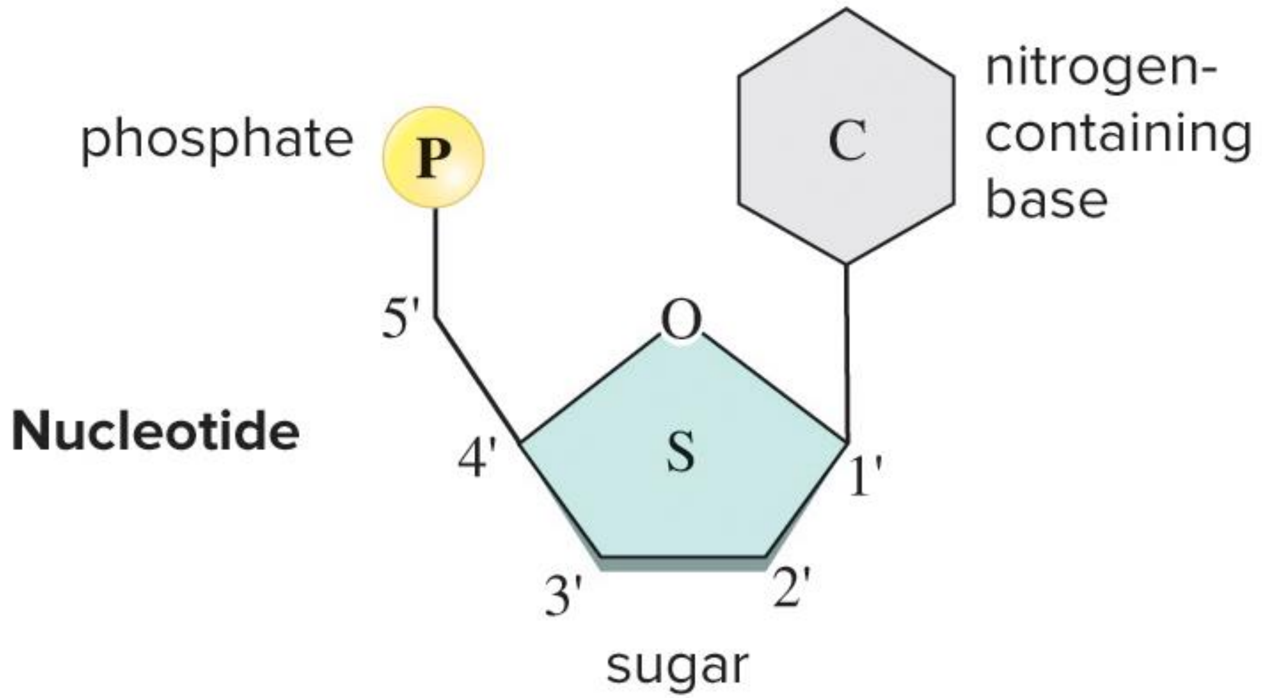
Polymers of **nucleotides.**

- Components of a nucleotide: a phosphate, a 5-carbon sugar, and a nitrogenous base.

Functions:

- Store information.
- Contain the instructions for the activities essential to life.
- Conduct chemical reactions.

Structure of a Nucleotide (Figure 2.24)



[Access the text alternative for slide images.]

2.7 Nucleic Acids 3

Nucleic acids, concluded

That is, **deoxyribonucleic acid (DNA).**

- Stores information on how to copy itself.
- Specifies the order of amino acids in proteins.

That is, **ribonucleic acid (RNA).**

- Various types, with many functions.

That is, some are components of **coenzymes**, which help regulate enzyme action.

That is, **adenosine triphosphate (ATP),** which stores energy.

DNA Structure Compared to RNA Structure (Table 2.1)

Table 2.1 DNA Structure Compared to RNA Structure.

	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Adenine, guanine, thymine, cytosine	Adenine, guanine, uracil, cytosine
Strands	Double-stranded with base pairing	Single-stranded
Helix	Yes	No

How the Structures of DNA and RNA Differ 1

The backbone of DNA and some forms of RNA is alternating phosphate-sugar-phosphate-sugar.

- The bases project to one side of the backbone.

Nucleotides are commonly identified by their base, since that is the only component that differs within a nucleic acid.

How the Structures of DNA and RNA Differ 2

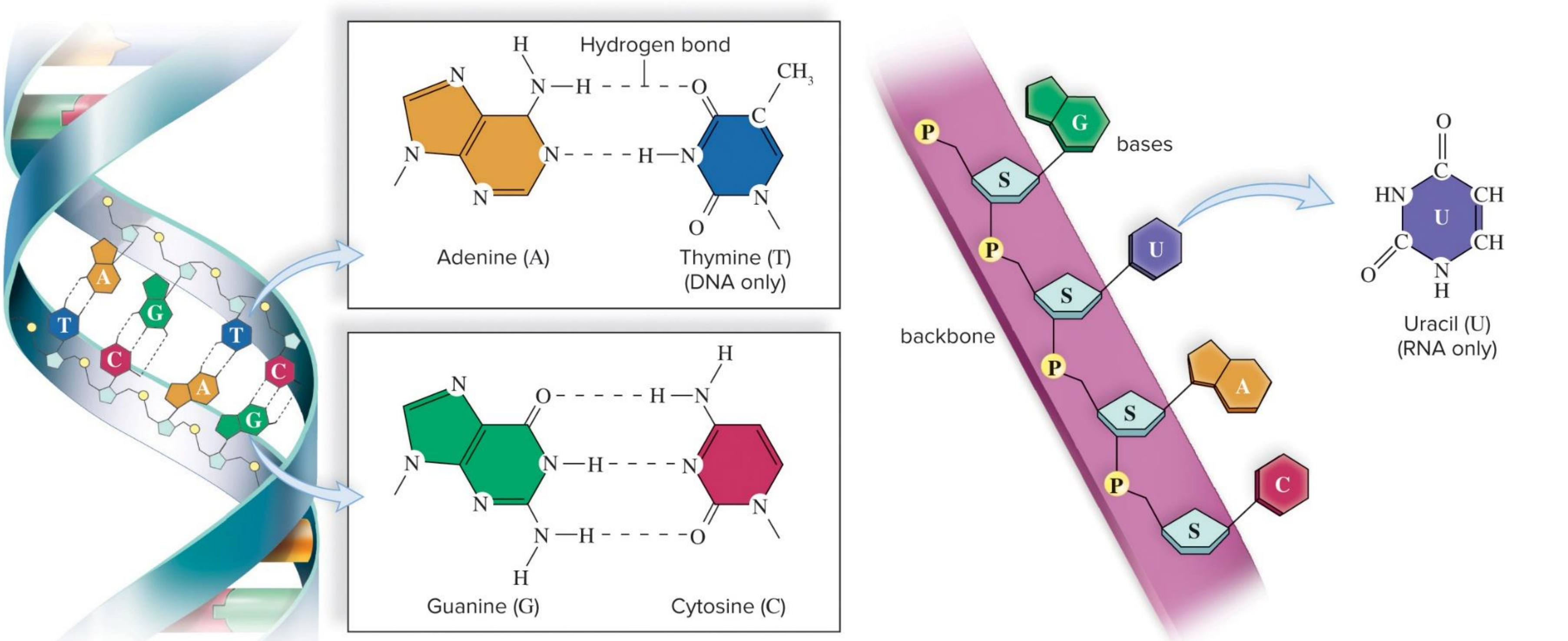
DNA is double-stranded.

The two strands twist around each other in a **double helix**, held together by hydrogen bonds between the bases.

Complementary base pairing.

- Adenine always binds to thymine.
- Cytosine always binds to guanine.

The Structures of DNA and RNA (Figure 2.25)



a. DNA structure with base pairs: A with T and G with C

b. RNA structure with bases G, U, A, C

Access the text alternative for slide images.

ATP: An Energy Carrier

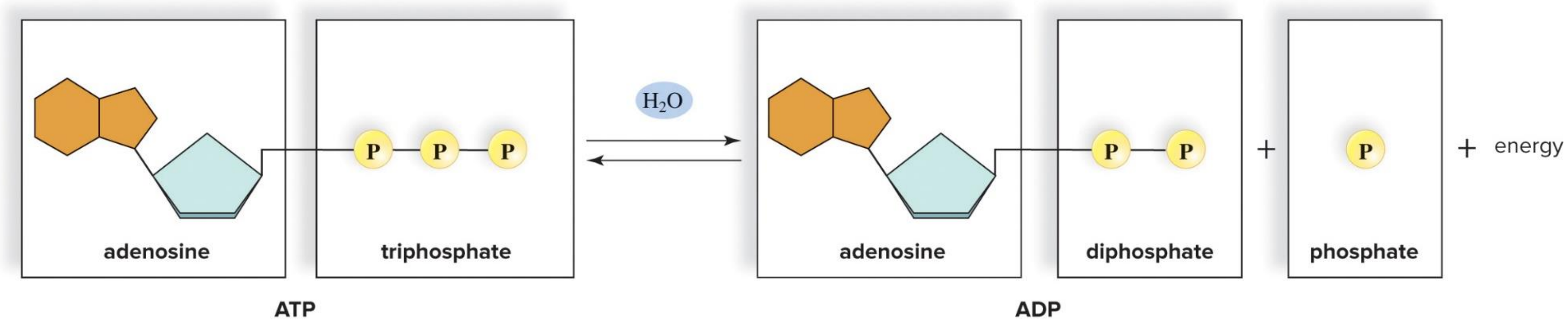
Structure of ATP Suits Its Function

ATP is a high-energy molecule.

Breaking of the bond between the 2^{nd} and 3^{rd} phosphates releases energy that can be used in other chemical reactions.

- That is, synthesis of macromolecules, muscle contraction, nerve conduction.
- Produces **adenosine diphosphate (ADP)**, which is recycled.
  - A phosphate is added back to ADP to form ATP.

ATP Is the Universal Energy Currency of Cells (Figure 2.26)



Access the text alternative for slide images.

Check Your Progress 2.7

Describe the structure of a nucleotide.

Compare the structures of DNA and RNA. What impact do these differences have on their function?

Explain how ATP is used as an energy carrier.

Because learning changes everything.®

www.mheducation.com