# 3 Cell Structure and Function

## CHAPTER SUMMARY

### Processes of Life (pp. 56–57)

All living things share four processes:

- **Growth**: an increase in size
- **Reproduction**: an increase in number
- **Responsiveness**: an ability to react to environmental stimuli
- **Metabolism**: controlled chemical reactions

In addition, all living organisms share a cellular structure. Although viruses have some characteristics of living cells, they cannot grow, and they reproduce only when inside a host cell. They also depend on a host cell's metabolism, and have no cellular structure. For these reasons, microbiologists debate the question of whether viruses are truly alive.

### Prokaryotic and Eukaryotic Cells: An Overview (pp. 57–60)

Cells can be classified as prokaryotic or eukaryotic. **Prokaryotic** cells, such as bacteria and archaea, lack a nucleus and membrane-bound organelles. **Eukaryotic** cells, such as the cells of animals, plants, algae, fungi, and protozoa, have internal, membrane-bound organelles, including true nuclei. Prokaryotic and eukaryotic cells have some common structural features such as external structures, cell walls, cytoplasmic membranes, and cytoplasm.

### External Structures of Prokaryotic Cells (pp. 60–65)

The external structures of prokaryotic cells include glycocalyces, flagella, fimbriae, and pili.

#### Glycocalyces

A **glycocalyx** is a gelatinous, sticky substance that surrounds the outside of the cell. When the glycocalyx of a prokaryote is firmly attached to the cell surface, it is called a **capsule**. When loose and water-soluble, it is called a **slime layer**. Both types protect the cell from desiccation, and both increase the cell's ability to cause disease. Capsules protect cells from phagocytosis, and slime layers enable cells to adhere to each other and to environmental surfaces.

#### Flagella

The structures responsible for cell motility include **flagella**: long extensions from the cell surface and glycocalyx that propel a cell through its environment. Bacterial flagella are composed of a filament, a hook, and a basal body. Flagella covering the cell are termed peritrichous flagella, and those found at the ends of a cell are called polar flagella.

**Endoflagella** are the special flagella of spirochetes that spiral tightly around the cell instead of protruding into the environment. Together, these endoflagella form an **axial filament** that wraps around the cell and rotates, enabling it to "corkscrew" through its medium.

Flagella enable bacterial cells to move clockwise or counterclockwise, in a series of runs and tumbles. Via **taxis**, flagella move the cell toward or away from stimuli such as chemicals (**chemotaxis**) or light (**phototaxis**).

### Fimbriae and Pili

**Fimbriae** are short, sticky, proteinaceous, nonmotile extensions of some bacteria that help cells adhere to one another and to substances in the environment. They serve an important function in **biofilms**, slimy masses of bacteria adhering to a surface.

**Pili** (also called **conjugation pili**) are hollow, nonmotile tubes of a protein called *pilin* that connect some prokaryotic cells. Typically, only one or two are present per cell. They join two bacterial cells and mediate the movement of DNA from one cell to another, a process called *conjugation*.

## Prokaryotic Cell Walls (pp. 65–69)

Most prokaryotic cells are surrounded by a **cell wall** (not found in eukaryotes) that provides structure and protection from osmotic forces. Cell walls are composed of polysaccharide chains.

### Bacterial Cell Walls

A few bacteria lack cell walls entirely, but most have walls composed of **peptidoglycan**, a complex polysaccharide composed of two alternating sugars called *N-acetylglucosamine (NAG)* and *N-acetylmuranic acid (NAM)*. Chains of NAG and NAM are attached to other chains by crossbridges of four amino acids (tetrapeptides).

**Gram-positive** cells have thick layers of peptidoglycan that also contain teichoic acids. Their thick wall retains the crystal violet dye used in the Gram staining procedure, so the stained cells appear purple under magnification.

**Gram-negative** cells have only a thin layer of peptidoglycan, outside of which is a membrane containing **lipopolysaccharide (LPS)**. LPS is composed of sugars and a lipid known as lipid A. During an infection with Gram-negative bacteria, as the walls of dead cells disintegrate, lipid A accumulates in the blood and may cause shock, fever, and blood clotting. Between the cell membrane and the outer membrane is a periplasmic space containing peptidoglycan. Because the cell walls of Gram-negative organisms differ from Gram-positive organisms, Gram-negative cells appear pink.

### Archaeal Cell Walls

Archaeal cell walls lack peptidoglycan. Gram-positive archaea have thick walls that stain purple with the Gram stain, while Gram-negative archaea have a layer of protein covering the wall and stain pink.

## Prokaryotic Cytoplasmic Membranes (pp. 69–73)

Beneath the glycocalyx and cell wall is a **cytoplasmic membrane** (or *cell membrane*).

### Structure

The cytoplasmic membrane is a double-layered structure, called a **phospholipid bilayer**, composed of molecules with hydrophobic lipid tails and hydrophilic phosphate heads. Proteins associated with the membrane vary in location and function and are able to flow laterally within it. The **fluid mosaic model** is descriptive of the current understanding of the membrane. Archaea do not have phospholipid membranes, and some have a single layer of lipid instead of a bilayer.

### Function

The **selectively permeable** cytoplasmic membrane not only separates the contents of the cell from the outside environment, but also controls the contents of the cell, allowing some substances to cross it while preventing the movement of others. Although impermeable to most substances, its proteins act as pores, channels, or carriers to allow or facilitate the transport of substances the cell needs. The relative concentration of chemicals (**concentration gradients**) inside and outside the cell and of the corresponding electrical charges, or voltage (**electrical gradients**) create an overall **electrochemical gradient** across the membrane. A cytoplasmic membrane uses the energy inherent in its electrochemical gradient to transport substances into or out of the cell.

#### *Passive Processes*

Passive processes require no energy expenditure to move chemicals across the cytoplasmic membrane. **Simple diffusion** is the movement of chemicals down their concentration gradient, from an area of higher concentration to an area of lower concentration. In **facilitated diffusion,** proteins act as channels or carriers to allow certain molecules to diffuse into or out of the cell along their electrochemical gradient. Finally, **osmosis** is the diffusion of water molecules across a selectively permeable membrane in response to differing concentrations of solutes. Concentrations of solutes can be compared as follows: **hypertonic** solutions have a higher concentration of solutes than **hypotonic** solutions. For example, seawater is hypertonic to distilled water. Two **isotonic** solutions have the same concentration of solutes.

#### *Active Processes*

Active processes require cells to expend energy in the form of ATP to move chemicals across the cytoplasmic membrane against their concentration gradient. **Active transport** moves substances via transmembrane permease proteins, which may transport two substances in the same direction at once (*symports*) or move substances in opposite directions (*antiports*). **Group translocation**, which occurs only in prokaryotes, causes chemical changes to the substance being transported. The membrane is impermeable to the altered substance, which is then trapped inside the cell. One well-studied example is the phosphorylation of glucose.

## Cytoplasm of Prokaryotes (pp. 74–77)

**Cytoplasm** is the gelatinous, elastic material inside a cell. It is composed of cytosol, inclusions, ribosomes, and in many cells a cytoskeleton. Some bacterial cells produce internal, resistant, dormant forms called endospores.

### Cytosol

The liquid portion of the cytoplasm is called **cytosol**. It is mostly water, plus dissolved and suspended substances such as ions, carbohydrates, proteins, lipids, and wastes. The cytosol of prokaryotes also contains the cell's DNA in a region called the nucleoid.

### Inclusions

Deposits called **inclusions** may be found within the cytosol of prokaryotes. These may be reserve deposits of lipids, starch, or other chemicals. Inclusions called gas vesicles store gases.

### Endospores

Some bacteria produce structures called **endospores** when one or more nutrients are limited. Endospores can survive under harsh conditions, making them a concern to food processors and health care professionals.

### Nonmembranous Organelles

Two types of *nonmembranous organelles* are found in direct contact with the cytosol of prokaryotes: ribosomes and the cytoskeleton. **Ribosomes** are the sites of protein synthesis in cells. They are composed of protein and ribosomal RNA (rRNA). Their size is expressed in Svedbergs (S) and is determined by their sedimentation rate: prokaryotic ribosomes are 70S, and are smaller than 80S eukaryotic ribosomes. The **cytoskeleton** is an internal network of fibers that play a role in forming a cell's basic shape. Spherical prokaryotes appear to lack cytoskeletons.

## External Structures of Eukaryotic Cells (p. 77)

Eukaryotic cells have many external structures similar to those of prokaryotes, as well as some unique features.

### Glycocalyces

Glycocalyces are absent in eukaryotic cells with cell walls, but animal and protozoan cells—which lack cell walls—do have glycocalyces anchored to their cytoplasmic membranes. They strengthen the cell surface, provide protection against dehydration, and function in cell-to-cell recognition and communication.

### Flagella

Eukaryotic flagella are within the cytoplasmic membrane. The shaft of a eukaryotic flagellum is composed of molecules of a globular protein called *tubulin* arranged in chains to form hollow *microtubules* arranged in nine pairs around a central two. The basal body also has microtubules, but in triplets with no central pair. Eukaryotic flagella have no hook and do not extend outside the cell. Rather than rotating, eukaryotic flagella undulate rhythmically to push or pull the cell through the medium. They do exhibit taxis.

### Cilia

Some eukaryotic cells are covered with **cilia**, which have the same structure as eukaryotic flagella but are much shorter and more numerous. Their rhythmic beating propels single-celled eukaryotes through their environment. More complex organisms use cilia to sweep substances in the local environment, such as dust particles, past the surface of the cell.

## Eukaryotic Cell Walls and Cytoplasmic Membranes (pp. 77–80)

The eukaryotic cells of fungi, algae, plants, and some protozoa lack glycocalyces; instead, a cell wall composed of polysaccharides provides protection from the environment. It also provides shape and support against osmotic pressure. The cell walls of plants are composed of *cellulose*, whereas fungal cell walls are composed of *chitin* or other polysaccharides. Algal cell walls contain *agar*, *carrageenan*, *algin*, or other chemicals.

All eukaryotic cells have cytoplasmic membranes. Like bacterial membranes, they are a fluid mosaic of phospholipids and proteins. Unlike bacterial membranes, they contain steroids that strengthen and solidify the membrane when temperatures rise, and help maintain fluidity when temperatures fall. Some eukaryotic cells transport substances into the cytoplasm via **endocytosis**, which is an active process requiring the expenditure of energy by the cell. In endocytosis, **pseudopodia**—moveable extensions of the cytoplasm and membrane of the cell—surround a substance and move it into the cell. When solids are brought into the cell, endocytosis is called **phagocytosis**. The incorporation of liquids is called **pinocytosis**.

## Cytoplasm of Eukaryotes (pp. 80–87)

The cytoplasm of eukaryotes is more complex than that of prokaryotes, containing a few nonmembranous and numerous membranous organelles.

### Nonmembranous Organelles

Three nonmembranous organelles are found in eukaryotes: ribosomes, a cytoskeleton, and centrioles. Eukaryotic ribosomes are 80S and are found within the cytosol as well as attached to the membranes of the endoplasmic reticulum, discussed shortly. The cytoskeleton is extensive, and composed of both fibers and tubules. It acts to anchor organelles, functions in cytoplasmic streaming and in movement of organelles within the cytosol. Cytoskeletons in some cells enable the cell to contract, move the cell membrane during endocytosis and amoeboid action, and produce the basic shapes of many cells. In addition, animal cells and some fungal cells contain two **centrioles** lying at right angles to each other near the nucleus, in a region of the cytoplasm called the **centrosome**. Centrioles are composed of nine triplets of tubulin microtubules. Centrosomes play a role in mitosis, cytokinesis, and in the formation of flagella and cilia.

### Membranous Organelles

Eukaryotic cells contain a variety of organelles that are surrounded by phospholipid bilayer membranes similar to the cytoplasmic membrane.

#### *Nucleus*

The **nucleus** is spherical to ovoid and is often the largest organelle in a cell. It contains most of the cell's genetic material in the form of DNA. The semiliquid matrix of the nucleus is called the **nucleoplasm**. Within it, one or two specialized regions of RNA synthesis, called **nucleoli**, may be present. The nucleoplasm also contains **chromatin**, a threadlike mass of DNA and associated histone proteins. Chromatin becomes visible as *chromosomes* during mitosis (Chapter 12). Surrounding the nucleus is a double membrane called the **nuclear envelope**, which contains **nuclear pores** that function to control the import and export of substances through the envelope.

#### *Endoplasmic Reticulum*

Continuous with the outer membrane of the nuclear envelope and traversing the cytoplasm is a net of flattened hollow tubules called **endoplasmic reticulum (ER)**. **Smooth endoplasmic reticulum (SER)** plays a role in lipid synthesis and transport. Ribosomes adhere to the surface of **rough endoplasmic reticulum (RER)** and produce proteins that are transported throughout the cell.

#### *Golgi Body*

The **Golgi body** is a series of flattened, hollow sacs surrounded by phospholipid bilayers. It receives, processes, and packages large molecules in **secretory vesicles**, which release their contents from the cell via exocytosis.

#### *Lysosomes, Peroxisomes, Vacuoles, and Vesicles*

**Vesicles** and **vacuoles** are general terms for membranous sacs that store or carry substances. More specifically, **lysosomes** of animal cells contain digestive enzymes that damage the cell if they are released from their packaging into the cytosol. They are useful in self-destruction of old, damaged, or diseased cells. **Peroxisomes** are vesicles that contain *oxidase* and *catalase*, enzymes that degrade poisonous metabolic wastes such as free radicals and hydrogen peroxide. They are found in all types of eukaryotic cells, but are prominent in the liver and kidney cells of mammals.

#### *Mitochondria*

**Mitochondria** are spherical to elongated structures with two phospholipid bilayer membranes found in most eukaryotes. Often called the "powerhouses" of the cell, their innermost membrane is folded into numerous **cristae** that increase the surface area and produce most of the ATP in many eukaryotic cells. Mitochondria contain 70S ribosomes and a circular molecule of DNA; however, most mitochondrial proteins are coded by nuclear DNA and synthesized by cytoplasmic ribosomes.

#### *Chloroplasts*

**Chloroplasts** are light-harvesting structures found in photosynthetic eukaryotes. Their pigments gather light energy to produce ATP and form sugar from carbon dioxide. Numerous membranous sacs called *thylakoids* form an extensive surface area for their biochemical and photochemical reactions (Chapter 5). Like mitochondria, chloroplasts have two phospholipid bilayer membranes, DNA, and ribosomes.

### Endosymbiotic Theory

The **endosymbiotic theory** has been suggested to explain why mitochondria and chloroplasts have 70S ribosomes, circular DNA, and two membranes. The theory states that the ancestors of these organelles were prokaryotic cells that were internalized by other prokaryotes and then lost the ability to exist outside of their host—thus forming early eukaryotes. The theory is not universally accepted because it does not explain all of the facts.

## KEY THEMES

Function is derived from structure, both at a molecular level and at the cellular level. Changes to structure ultimately lead to changes in function and affect the overall survival of microorganisms. As you read and study this chapter, it is important to form for yourself a firm mental image of what microbial cells look like. Specifically you should focus on:

- *Prokaryotic microbes are fundamentally different from eukaryotic microbes:* Though structurally less complex, prokaryotes are nonetheless arguably the most successful organisms on Earth. Their simplicity, however, does place a greater burden of survival on their ability to function. Knowing the differences between how microbes are structured is key to understanding microbial metabolism, genetic potential, and most aspects of their relationships with us.

## QUESTIONS FOR FURTHER REVIEW

*Answers to these questions can be found in the answer section at the back of this study guide. Refer to the answers only after you have attempted to solve the questions on your own.*

### Multiple Choice

1. Prokaryotes and eukaryotes display all of the common features of living organisms, but viruses do not. Of the characteristics listed below, the one that is seen inside a host cell is:
   a. Growth
   b. Reproduction
   c. Responsiveness
   d. Metabolism
2. The key difference between prokaryotes and eukaryotes is that prokaryotes:
   a. Lack a cytoplasmic membrane
   b. Lack a nucleus
   c. Lack ribosomes
   d. Are always smaller than eukaryotes
3. Which of the following is not an external structure found in prokaryotes?
   a. Cilia
   b. Flagella
   c. Pili
   d. Fimbriae
4. Removal of the glycocalyx from a prokaryotic cell could result in the cell:
   a. Drying out
   b. Becoming unable to attach to surfaces
   c. Being recognized by the immune system
   d. All of the above
5. A bacterial cell with flagella that cover the surface of the cell is called:
   a. Amphitrichous
   b. Polar
   c. Lophotrichous
   d. Peritrichous
6. Which of the following structures in prokaryotes is not used for sticking to surfaces or other cells?
   a. Fimbriae
   b. Flagella
   c. Pili
   d. All are used for attachment
7. Of the characteristics listed below, which is true of both fimbriae and the cell wall?
   a. Both allow attachment to other cells
   b. Both offer protection from immune recognition
   c. Both allow for motility
   d. Both offer protection from antimicrobial drugs

8. Peptidoglycan is found in the cell walls of:
   a. Archaea
   b. Bacteria
   c. Fungi
   d. Algae
9. Which of the following is not a function of the proteins found on the cytoplasmic membrane of any given cell?
   a. Transport
   b. Recognition
   c. Macromolecular synthesis
   d. Receptors
10. Of the following functions of the cytoplasmic membrane, which is found in prokaryotes but not in eukaryotes?
    a. Selective permeability
    b. Energy storage
    c. Photosynthesis
    d. Both b and c
11. Based on the electrical gradient that forms across the cytoplasmic membrane, what types of molecules would be attracted to the inside of the cell?
    a. Positively charged molecules
    b. Negatively charged molecules
    c. Neutral molecules
    d. Both positively and negatively charged molecules
12. In passive transport mechanisms, energy is provided by:
    a. ATP
    b. Concentration gradients
    c. Electrochemical gradients
    d. Energy is not required in any form
13. Which of the following could diffuse through the cytoplasmic membrane?
    a. A protein
    b. Oxygen
    c. A phospholipid
    d. Glucose
14. Group translocation is found in:
    a. Archaea
    b. All prokaryotes
    c. Some prokaryotes
    d. Eukaryotes
15. Inclusions within prokaryotes are used primarily for:
    a. Containing the nuclear material
    b. Containing excess nutrient materials
    c. Containing ribosomes for protein synthesis
    d. Inclusions form only in eukaryotes, not in prokaryotes
16. Which of the following microbes can possess a glycocalyx?
    a. Bacteria
    b. Protozoa
    c. Viruses
    d. Both a and b
17. Which of the following is a true statement regarding eukaryotic flagella?
    a. They are composed of flagellin
    b. They are constructed exactly the same way as prokaryotic flagella
    c. They are composed of tubulin
    d. They move in a manner similar to the way in which prokaryotic flagella move
18. Which of the following transport mechanisms occurs in eukaryotes but not in prokaryotes?
    a. Facilitated diffusion
    b. Active transport with symporters
    c. Active transport with antiporters
    d. Endocytosis

19. In eukaryotes, the closest structure to the prokaryotic nucleoid is:
    a. The nucleus
    b. The nucleoplasm
    c. The nucleolus
    d. The chromatin
20. The rough endoplasmic reticulum is rough because it contains:
    a. Lipids
    b. Proteins
    c. Ribosomes
    d. Vesicles

### *Fill in the Blanks*

1. If the glycocalyx of a prokaryote is well organized and firmly attached to the cell, it is called a ____________________. Loosely constructed glycocalyces are called ____________________.
2. Bacterial flagella are composed of proteins called ________________, whereas eukaryotic flagella are composed of ________________.
3. The glycan portion of peptidoglycan is composed of alternating units of ____________________ and ____________________.
4. The toxic part of a Gram-negative cell wall corresponds to ____________________ which, along with sugar, forms this larger molecule ____________________.
5. The sterol-like molecules used by bacteria to stabilize the cytoplasmic membrane are called ____________________.
6. For each scenario below, indicate the direction of movement for the molecules specified (use: "moves into the cell," "moves out of the cell," "does not move" to fill in the blanks).
    a. The concentration of sodium outside a cell is 25 µm and the concentration of sodium inside the same cell is 2 µm. With respect to the cell, sodium ____________________.
    b. The concentration of potassium outside the cell is 10 µm and the concentration of potassium inside the same cell is 10 µm. With respect to the cell, potassium ____________________.
    c. Outside the cell, the concentration of sodium chloride is 20 µm and the concentration of potassium chloride is 10 µm. Inside the cell, the

concentration of sodium chloride is 30 μm and the concentration of potassium chloride is 2 μm. If these compounds move as compounds, sodium chloride ____________________ and potassium chloride ____________________. If these compounds move as ions, sodium ____________________, potassium ____________________, and chlorine ____________________.

7. Solutions across a cytoplasmic membrane with the same concentration of solutes and water are said to be ____________________. If a hypertonic solution is outside the cytoplasmic membrane, water will move ____________________ (into/out of) the cell causing the cell to ____________________ (shrink/burst).

8. Symporters move two substances in ____________________ (the same/different) directions across a membrane. Antiporters move two substrates in ____________________ (the same/different) direction(s). Both of these transporters are examples of ______________ (active/passive) transport.

9. Prokaryotic ribosomes are ____________________ (larger/smaller) than eukaryotic ribosomes. Overall, the prokaryotic ribosome is ________S. The individual subunits are ________S and ________S.

10. The cell walls of eukaryotes are not composed of the same materials as are seen in prokaryotic cell walls. Instead, plant cell walls are made of ____________________, fungal cell walls are made of ____________________ and/or ____________________, and algal cell walls are composed of many different chemicals.

11. Membrane fluidity in eukaryotes is facilitated by sterols such as ____________________.

12. The cytoskeleton of eukaryotic cells is composed of ____________________, ____________________, and ____________________. (Give the names of the fibers and tubules, not the proteins from which they are made.)

13. The Golgi body packages molecules into ____________________ which travel to the cytoplasmic membrane, fuse, and release their contents by the process of ____________________.

14. Within eukaryotic cells, the control center is the ____________________ and the powerhouse is the ____________________.

15. The endosymbiotic theory is used to try and explain the origins of two eukaryotic organelles: ____________________ and ____________________.

### *Matching*

(Match the structure on the left with the correct function or description on the right. Answers will be used only once.)

1. ____ Glycocalyx
2. ____ LPS
3. ____ Cytoplasmic membrane
4. ____ Lysosome
5. ____ Mitochondria
6. ____ Golgi body
7. ____ Vacuoles
8. ____ Flagella
9. ____ Nucleoid
10. ____ Fimbriae

A. Movement involving taxis
B. Generates energy in the form of ATP for the cell
C. Sacs used for cytoplasmic storage
D. Bristle-like appendages on the surface of prokaryotic cells
E. Area of the cytosol where DNA can be found
F. Protection and attachment for prokaryotic and eukaryotic cells
G. Involved in secretion of molecules to the outside of the cell by exocytosis
H. Selectively permeable barrier designed to regulate movement of molecules into and out of the cell
I. Breaks down nutrients, aids in the disposal of cellular material
J. Part of the outer membrane of Gram positive prokaryotes; the Lipid A portion is toxic

### *Short-Answer Questions for Thought and Review*

1. Figure 3.2 shows a comparison between prokaryotic and eukaryotic cells. Group the terms in the figure according to function, with each functional category containing both prokaryotic and eukaryotic counterparts.

2. Explain the process of positive taxis where a bacterium moves toward a nutrient source.

3. Why might the corkscrew motility of spirochetes such as *Borrelia burgdorferi* aid in tissue invasion? What causes this motility?

4. Any internal bacterial infection is bad, but why would infections with Gram-positive bacteria be less damaging, in general, than those with Gram-negative bacteria? Specifically relate your answer to the structure of the cell walls in these groups of organisms.

5. Diagram a cytoplasmic membrane showing an arrangement of active and/or passive transport mechanisms involving $H^+$ and glucose with the ultimate goal of getting glucose into the cell.

6. When using antimicrobial drugs, why is it best to use drugs that are specific to either microbial structure or function?

7. Why can't Gram positive bacteria bring molecules into the cell by phagocytosis?

### *Critical Thinking*

1. Of the general characteristics of living things—growth, reproduction, responsiveness, and metabolism—which one do you think is most important to the determination of whether something is alive or not? Why?
2. Eukaryotes are generally larger than prokaryotes, though there are exceptions (see Highlight: Unusual Giants). Why might the presence of organelles inside eukaryotes allow them to consistently achieve a larger, more complex form?
3. During group translocation, glucose is converted to glucose 6-phosphate as it travels across the cytoplasmic membrane and enters the cell. What does the concentration gradient of glucose look like in this situation? In which direction will glucose flow—into the cell or out of the cell? Why?

4. Mitochondria and chloroplasts retain some DNA. If both organelles originated from engulfed prokaryotes, what types of gene remnants might you look for to help support the idea that they were once free-living? Refer to the general characteristics used to define living organisms to help you answer this question.

### *Concept Building Questions*

1. In Chapter 2 we learned about various types of chemical bonds that form between atoms, molecules, compounds, and macromolecules. What types of bonds hold the bacterial cytoplasmic membrane together? In extremely hot environments, why would the single layer of branched lipids in archaea be more stable than the traditional lipid bilayer found in other cells? Answer in terms of chemical bonding.
2. How could Leeuwenhoek, with his primitive microscopes, have been able to discern differences between prokaryotic and eukaryotic cells? (Based on the structures described in this chapter, which of them could he have seen that would have allowed him to make the distinction?)