Class enrichment and review activities for April 1--9th
Mrs. Linda Henry-Into to Microbiology

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<u>All assignments and materials for all classes are on Mrs. Henry's Google Classroom pages and also attached at the bottom of this PDF.</u>

April 1—read the attached summary of chapter 4 on pro- and eukaryotic cells.
April 2-3—after the summary there are the self tests on the reading that include matching, fill ins and essays. Complete the worksheet.
April 6-9—find the attached copy of the textbook pages 105-106—after reading the summary, complete the study questions on page 105 (#1-10) and the multiple choice on page 106 (#1-10)

<u>Attached are the documents needed in PDF format for the review for Chapter 4.</u>

4 Functional Anatomy of Prokaryotic and Eukaryotic Cells

COMPARING PROKARYOTIC AND EUKARYOTIC CELLS: AN OVERVIEW

The chief distinguishing characteristics of **prokaryotes** (from the Greek words meaning prenucleus) are as follows:

1. Their DNA is not enclosed within a membrane and is usually a singular circularly arranged chromosome. (Some bacteria, such as *Vibrio cholerae* have two chromosomes, and some bacteria have a linearly arranged chromosome.)
2. Their DNA is not associated with histones (special chromosomal proteins found in eukaryotes); other proteins are associated with the DNA.
3. They lack membrane-enclosed organelles.
4. Their cell walls almost always contain the complex polysaccharide peptidoglycan.
5. They usually divide by **binary fission.** During this process, the DNA is copied, and the cell splits into two cells. Binary fission involves fewer structures and processes than eukaryotic cell division.

Eukaryotes (from the Greek words meaning true nucleus) have the following distinguishing characteristics:

1. Their DNA is found in the cell's nucleus, which is separated from the cytoplasm by a nuclear membrane, and the DNA is found in multiple chromosomes.
2. Their DNA is consistently associated with chromosomal proteins called histones and with nonhistones.
3. They have a number of membrane-enclosed organelles, including mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, and sometimes chloroplasts.
4. Their cell walls, when present, are chemically simple.
5. Cell division usually involves mitosis, in which chromosomes replicate and an identical set is distributed into each of two nuclei. This process is guided by the mitotic spindle, a football-shaped assembly of microtubules. Division of the cytoplasm and other organelles follows so that the two cells produced are identical to each other.

THE PROKARYOTIC CELL

THE SIZE, SHAPE, AND ARRANGEMENT OF BACTERIAL CELLS

Most bacteria range in size from 0.2 to 2.0 µm in diameter and 2 to 8 µm in length. Basic bacterial shapes are the spherical **coccus** (meaning berry), the rod-shaped **bacillus** (meaning little staff), and the **spiral. Diplococci** form pairs; **streptococci** form chains; **tetrads** divide in two planes, forming groups of four; **sarcinae** divide in three regular planes and form cubelike packets; **staphylococci** divide in irregular, random planes and form grapelike clusters. Most bacilli are single rods, but they can appear in pairs—**diplobacilli**—or in chains—**streptobacilli. Coccobacilli** are ovals. **Vibrios**—slightly curved, commalike rods—are also included among spiral bacteria. **Spirilla** have a helical, corkscrew shape and are motile by means of flagella. **Spirochetes** are shaped like spirilla but have axial filaments for motility. **Pleomorphic** bacteria have an irregular morphology; if they maintain a single shape, they are **monomorphic.**

STRUCTURES EXTERNAL TO THE CELL WALL

Glycocalyx

The general term for substances surrounding bacterial cells is **glycocalyx,** which is usually a polysaccharide, polypeptide, or both. If organized and tightly attached, it is called a **capsule** (Figure 4.1). If unorganized and loosely attached, the glycocalyx is called a **slime layer.** A glycocalyx that helps cells in a biofilm attach to their target environment and to each other is called an **extracellular polymeric substance (EPS).** The glycocalyx aids in attachment to surfaces; capsules contribute to pathogenicity by protecting from phagocytosis, an important part of the body's defenses.

Flagella

Flagellar filaments are composed of a protein, **flagellin.** The base of the flagellar filament widens to a hook. Attached to the hook is a **basal body** (a rod with rings), which anchors the flagellum to the cell wall and plasma membrane (Figure 4.2). The basal body of gram-negative bacteria is anchored to the cell wall and plasma membrane; in gram-positive bacteria, it is anchored only at the plasma membrane. Flagella, when present, are arranged in certain ways: **peritrichous** (distributed over the entire cell) or **polar**

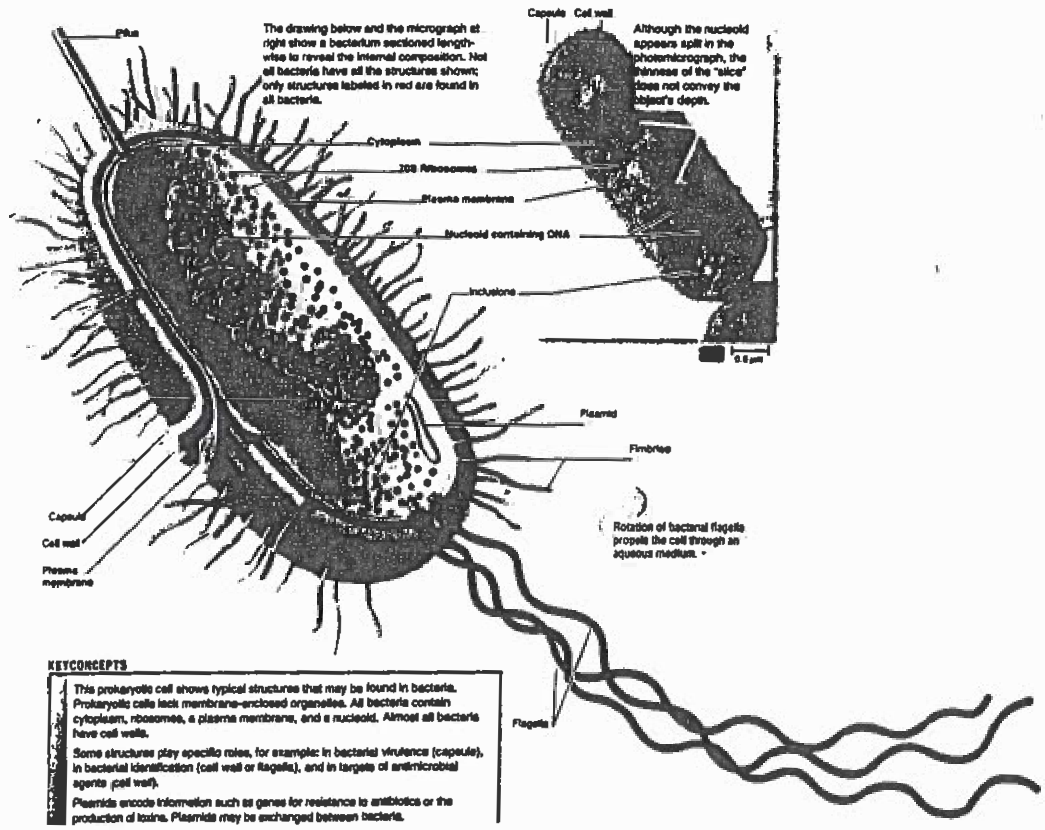


Figure 4.1 Structure of a typical prokaryotic (bacterial) cell.

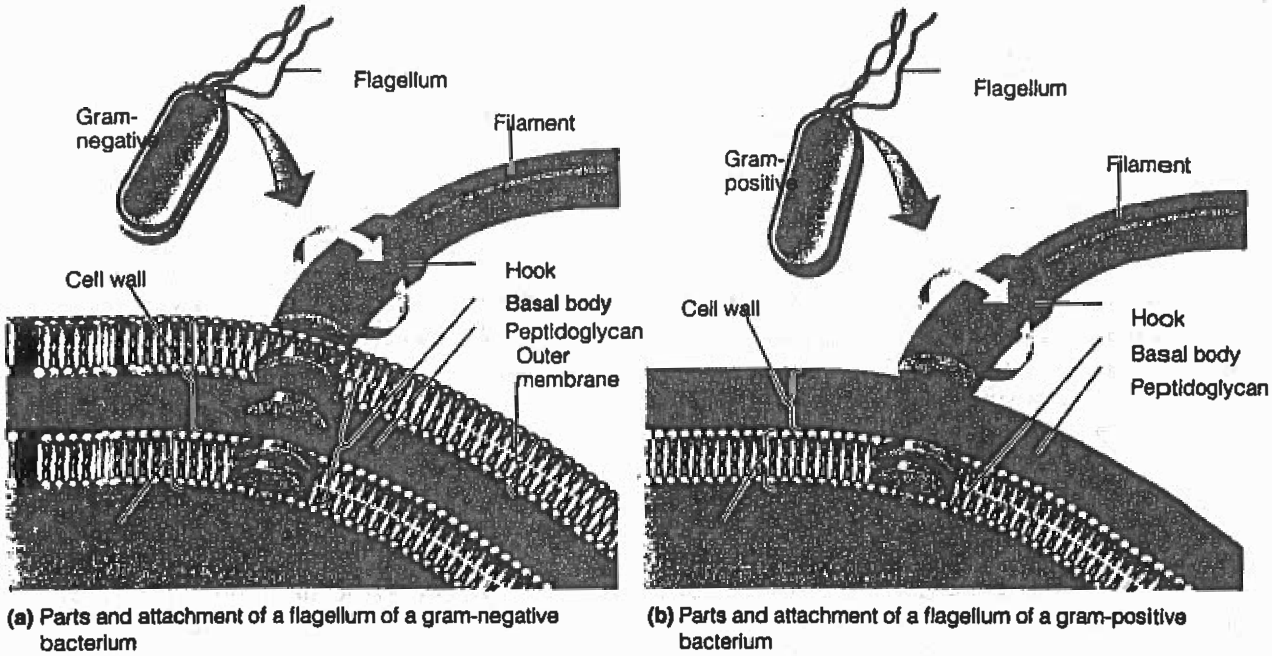


Figure 4.2 The structure of a prokaryotic flagellum. The parts and attachment of a flagellum of a gram-negative bacterium and gram-positive bacterium are shown in these highly schematic diagrams.

(at one or both poles of a cell). Polar flagella may be **monotrichous** (a single flagellum at one pole), **lophotrichous** (a tuft of flagella at one pole), or **amphitrichous** (flagella at both poles). Bacteria with no flagella are **atrichous.** Flagella may spin clockwise or counterclockwise, producing directional movement (a "run" or "swim") or random changes in direction ("tumbles"). Movement to or from a stimulus is called **taxis;** the stimulus may be chemicals **(chemotaxis)** or light **(phototaxis).** A flagellar protein, **H antigen,** is useful for helping to distinguish **serovars,** or variation within a species.

Axial Filaments

Spirochetes move by means of **axial filaments (endoflagella),** bundles of fibrils that arise near cell poles beneath an outer sheath and wrap in spiral fashion around the cell. These can cause the spirochetes to move in a corkscrew manner.

Fimbriae and Pili

Many bacterial cells have numerous hairlike appendages called **fimbriae** that are shorter than flagella (see Figure 4.11 in the text) and consist of a protein, **pilin.** They help the cell adhere to surfaces such as mucous membranes—often a factor in pathogenicity. **Pili** are longer than fimbriae and number only one or two per cell. These are sometimes called **sex pili** because they can function to transfer DNA from one cell to another, called **conjugation.**

There are several types of motility. In **twitching motility,** also called the *grappling hook model,* a pilus extends by addition of subunits of pilin and contacts another cell, causing movement by retraction as subunits of pilin are removed). **Gliding motility** is used by myxobacteria; the exact mechanism is unknown.

THE CELL WALL

The bacterial cell wall is a complex, semirigid structure responsible for the characteristic shape of the cell.

Composition and Characteristics

The cell wall of gram-positive bacteria is composed of **peptidoglycan,** which consists of two sugars, N-acetylglucosamine and N-acetylmuramic acid (*murein* from *murus,* meaning wall), and also chains of amino acids. The two sugars alternate with each other, forming a carbohydrate (glycan) backbone. Peptide side chains of four amino acids attached to the N-acetylmuramic acid are cross-linked to form the macromolecule of the cell wall. Many gram-positive bacteria also contain polysaccharides called *teichoic acids.* The cell wall of acid-fast bacteria (otherwise considered gram-positive) consists of peptidoglycan and a waxy lipid, mycolic acid.

The cell wall of gram-negative bacteria also contains peptidoglycans, but only thin layers. These cells have a lipoprotein, lipopolysaccharide (**LPS**), and a phospholipid **outer membrane** surrounding their peptidoglycan layers. A **periplasm** (a fluid-filled space) is found between the outer membrane and the **plasma membrane.** The outer membrane also provides resistance to phagocytosis and the action or complement (also part of host defenses). When the cell disintegrates in the host's bloodstream, the lipid portion of the LPS (**lipid A**) is released as an **endotoxin** that can cause illness. Materials may penetrate the outer membrane through channels called **porins.** The **O polysaccharide** extends outward from the core polysaccharide and is composed of sugar molecules, which function as an antigen useful for identifying certain species of gram-negative bacteria.

Cell Walls and the Gram Stain Mechanism

The primary stain, crystal violet, stains both gram-negative and gram-positive bacteria purple because it enters the cytoplasm of both. Iodine, with crystal violet, forms large crystals that cannot be washed through the peptidoglycan wall of gram-positive cells. Alcohol makes the outer membrane of gram-negative cells permeable and allows the crystal violet-iodine crystals to wash out, making them colorless. Safranin counterstain turns gram-negative cells pink. Archaea appear gram-negative because they do not contain peptidoglycans.

Atypical Cell Walls

Mycoplasma bacteria do not have cell walls. They are unique also in having sterols in their plasma membranes. Archaea do not have peptidoglycan in their walls but have a similar substance, **pseudomurein.**

Acid-Fast Cell Walls

These bacteria contain high concentrations of a waxy lipid, **mycolic acid,** that prevents Gram staining. They are stained with red carbolfuchsin dye. The heated dye penetrates the cell wall and resists removal with acid-alcohol.

Damage to the Cell Wall

Lysozyme—an enzyme occurring in tears, mucus, and saliva—damages the cell walls of many gram-positive bacteria. Some bacteria of the genus *Proteus* may spontaneously or, in response to penicillin, lose their cell walls and become **L forms.** Later, they may spontaneously revert to walled bacteria. A bacterium that has lost its cell wall and is surrounded only by the plasma membrane is a **protoplast.** Gram-negative cells treated with lysozyme retain much of the outer membrane layer and are called **spheroplasts.** Both are sensitive to rupture by **osmotic lysis.**

STRUCTURES INTERNAL TO THE CELL WALL

The Plasma (Cytoplasmic) Membrane

The **plasma (cytoplasmic) membrane** is just internal to the cell wall and encloses the cytoplasm. In prokaryotes it consists primarily of phospholipids and proteins. Eukaryotic plasma membranes also contain sterols, making them more rigid, and carbohydrates. Both prokaryotic and eukaryotic membranes have a two-layered structure, molecules in parallel rows, called a **lipid bilayer.** One end (phosphate) is water-soluble, and the other (hydrocarbon) is insoluble. The water-soluble ends are on the outside of the bilayer. Protein molecules are embedded in the membrane; along with phospholipids, they may move freely within the membrane. This arrangement is called the **fluid mosaic model.**

The most important function of the plasma membrane is as a selective barrier. It is **selectively permeable (semipermeable),** and certain molecules and ions pass through, whereas others do not. Several factors affect permeability. Large molecules such as proteins cannot pass; smaller molecules such as amino acids and simple sugars can pass if uncharged. (The phosphate end of the bilayer is charged.) Lipid-soluble substances, because of the phospholipid content, pass more easily. Plasma membranes contain enzymes that help break down nutrients and produce more energy. The **chromatophores** or **thylakoids,** which contain pigments and enzymes for bacterial photosynthesis, are found in the plasma membranes.

Mesosomes are folds in the plasma membrane that may be only an artifact of preparation for electron microscopy.

Movement of Materials across Membranes

Material crosses plasma membranes by *passive processes* such as **simple diffusion** (movement of molecules or ions from an area of higher concentration to an area of lower concentration). At equilibrium, the concentration gradient has been eliminated. **Osmosis** is the net movement of solvent molecules across a selectively permeable membrane. **Osmotic pressure** is the force with which a solvent (such as water) moves from a solution of lower solute concentration (such as dissolved sugar) to a solution of higher solute concentration. **Isotonic (isoosmotic)** solutions have equal solute concentrations on both sides of the membrane. **Hypotonic (hypoosmotic)** solutions have a lower concentration of solutes outside the cell than inside; this is the case with most bacteria. **Hypertonic (hyperosmotic)** solutions have a higher concentration of solutes outside the cell. Bacterial cells placed in such solutions lose water by osmosis and shrink, and the cytoplasm collapses within the cell wall. **Facilitated diffusion,** an *active process,* occurs when a **carrier protein (permease** or **transporter)** combines with and transports a substance across the membrane, but only where a concentration gradient is present. **Active transport** requires cell energy (ATP) and also involves carrier proteins moving substances across the plasma membrane. In **group translocation,** the substance is chemically altered during transport. Once inside, the plasma membrane is impermeable. This is important for low-concentration substances.

Cytoplasm, Nucleoid, Ribosomes, and Inclusions

The term **cytoplasm** refers to the substance of the cell inside the plasma membrane. It has many **inclusions,** such as **metachromatic granules** of stored phosphate (volutin), **polysaccharide granules** of glycogen and starch, **lipid inclusions** such as *poly-beta-hydroxybutyric acid,* and sulfur granules. The cytoplasm also contains many **ribosomes,** the sites of protein synthesis. **Carboxysomes** are inclusions found in bacteria that use carbon dioxide as their sole source of carbon. **Gas vacuoles** or **gas vesicles** help some bacteria maintain buoyancy. The **bacterial chromosome,** which contains the genetic information, is a single, long, circular molecule of DNA found in the **nucleoid.** Small circular DNA molecules, **plasmids,** are not connected to the chromosome and replicate independently. Plasmids do not contain normally essential genes but may provide a selective advantage under abnormal conditions—antibiotic resistance, for example. **Magnetosomes** are inclusions of iron oxide formed by a few gram-negative bacteria that aid the microbe in orienting itself environmentally.

Endospores

Endospores are highly resistant bodies formed by a few bacterial species, such as *Bacillus* and *Clostridium*. *Sporulation* or **sporogenesis** is the process of their formation. First, there is an ingrowth of the plasma membrane (**spore septum**). A small portion of the cytoplasm and newly replicated bacterial chromosome is then surrounded by a membrane, the **forespore.** A thick **spore coat** of protein forms around this membrane. The endospore core is dehydrated and contains considerable *dipicolinic acid*, as well as a few essential materials necessary to return it to its vegetative state, which is accomplished through the process of **germination.**

THE EUKARYOTIC CELL

FLAGELLA AND CILIA

Eukaryotic **flagella** are relatively long; **cilia** are more numerous and are shorter. Both are involved in locomotion, and both contain small tubules of protein called **microtubules.**

THE CELL WALL AND GLYCOCALYX

Most algae and some fungi have **cell walls** containing *cellulose*, and often fungi have *chitin* as well. Yeast cell walls contain the polysaccharides *glucan* and *mannan*. No eukaryotic cell wall contains peptidoglycans. Protozoa have a flexible outer covering called a *pellicle*. In animal cells, the plasma membrane is covered by sticky carbohydrates called the **glycocalyx.**

THE PLASMA (CYTOPLASMIC) MEMBRANE

In eukaryotic cells, the **plasma membrane,** which contains sterols, may be the external cell covering. Substances cross the membrane by mechanisms similar to those in prokaryotes. In addition, a process of engulfment, **endocytosis,** brings particles, even some viruses, into the cell. Examples are **phagocytosis,** used by white blood cells to engulf and destroy bacteria and **pinocytosis,** by which liquids and dissolved substances enter cells.

CYTOPLASM

Cytoplasm is the matrix in which various cellular components are found. The complex internal structure of *microfilaments*, *intermediate filaments*, and *microtubules* is called the **cytoskeleton.** Movement of cytoplasm from one part of a cell to another, **cytoplasmic streaming,** can move a cell over a surface.

RIBOSOMES

Attached to the outer surface of rough endoplasmic reticulum (ER) are **ribosomes** (see Figure 4.25 in the text), which are also found free in the cytoplasm. As in prokaryotes, ribosomes are the sites of protein synthesis in the cell. The ribosomes of eukaryotic ER and cytoplasm are somewhat larger and denser than those of prokaryotic cells. Some ribosomes, called *free ribosomes*, are unattached to any structure in the cytoplasm. Primarily, free ribosomes synthesize proteins used inside the cell. Other ribosomes, called *membrane-bound ribosomes*, attach to the nuclear membrane and the ER. These ribosomes synthesize proteins destined for insertion in the plasma membrane or for export from the cell. Ribosomes located within mitochondria synthesize mitochondrial proteins. Sometimes 10 to 20 ribosomes join together in a string-like arrangement called a *polyribosome.*

ORGANELLES

In eukaryotes, unlike prokaryotes, many important enzymes are found in, and functions carried out by, **organelles.**

Nucleus. The **nucleus** is an oval organelle containing the DNA. It is surrounded by a **nuclear envelope. Nuclear pores** in the nuclear membrane allow the nucleus to communicate with the endoplasmic reticulum of the cytoplasm. The **nucleoplasm** is a gel-like fluid in the nucleus. **Nucleoli,** which may be the center for the synthesis of ribosomal RNA, are present. DNA is combined with protein *histones* and *nonhistones.* The combination is called a **nucleosome.** When the cell is not reproducing, DNA and associated proteins are visible as a mass called **chromatin.** When reproducing, chromatin becomes visible as rodlike bodies called **chromosomes.**

Endoplasmic Reticulum. Within the cytoplasm there is a network of flattened sacs, or **cisterns,** called the **endoplasmic reticulum (ER).** Its function is to synthesize and store lipids and proteins, and to transport them. The ends of the cisterns pinch off into *secretory vesicles,* which transport substances within the cell. **Rough ER** has ribosomes bound to it, and **smooth ER** does not.

Golgi Complex. The **Golgi complex** consists of a network of flattened sacs called cisterns (see previous paragraph), stacked like dishes. Like ER, these function to export substances from the cell and transport substances within it. The Golgi complex receives proteins and lipids from the ER and delivers them to secretory vesicles.

Lysosomes. **Lysosomes** are formed from **Golgi complexes** and look like membrane-enclosed spheres. White blood cells, which destroy bacteria by phagocytosis, contain many **lysosomes.**

Vacuoles. A **vacuole** is a space (cavity) in cytoplasm that serves for storage and other functions.

Mitochondria. **Mitochondria** are organelles with a smooth outer membrane and an inner membrane arranged in a series of folds called **cristae.** The semifluid center of the mitochondrion is called the **matrix.** Enzymes forming ATP are located on the cristae—which is one reason why mitochondria are called "powerhouses" of the cell.

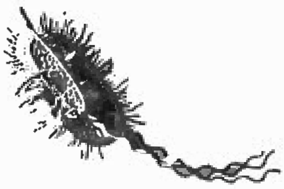
Chloroplasts. Photosynthesizing cells contain membrane-bounded structures called **chloroplasts,** which contain chlorophyll and enzymes involved in photosynthesis. The chlorophyll is found in membranes called **thylakoids.** Stacks of thylakoids are called **grana.**

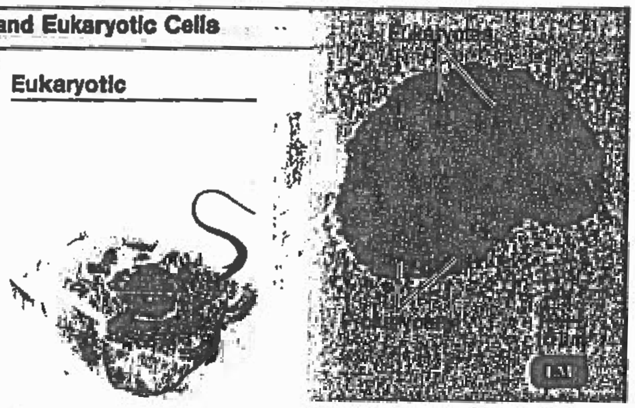
Peroxisomes. **Peroxisomes** are organelles similar in structure to lysosomes, but smaller. They contain enzymes that oxidize various organic substances. The enzyme catalase that decomposes toxic H_2O_2 (hydrogen peroxide) is also present.

Centrosomes. The **centrosome** consists of a **pericentriolar area,** which is the organizing center for the mitotic spindle that plays a critical role in cell division. Within this area are located **centrioles,** arrays of microtubules that play a role in the formation or regeneration of cilia and flagella.

Table 4.1 outlines the principal differences between prokaryotic and eukaryotic cells.

Table 4.1 Principal Differences Between Prokaryotic and Eukaryotic Cells





Characteristic	Prokaryotic	Eukaryotic
Size of cell	Typically 0.2–2.0 μm in diameter	Typically 10–100 μm in diameter
Nucleus	No nuclear membrane or nucleoli	True nucleus, consisting of nuclear membrane and nucleoli
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, and chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple (includes cellulose and chitin)
Plasma membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA)	Usually single circular chromosome; typically lacks histones	Multiple linear chromosomes with histones
Cell division	Binary fission	Involves mitosis
Sexual recombination	None; transfer of DNA only	Involves meiosis

THE EVOLUTION OF EUKARYOTES

The theory explaining the origin of eukaryotes from prokaryotes, pioneered by Lynn Margulis, is the **endosymbiotic theory.** Larger bacterial (prokaryotic) cells are presumed to have engulfed smaller bacterial cells (one organism living within another is called *endosymbiosis*) and eventually evolved into eukaryotic cells. Mitochondria and chloroplasts in eukaryotic cells are considered evidence for the theory. They resemble prokaryotic cells and can reproduce independently of their eukaryotic host cell.

SELF-TESTS

In the matching section, there is only one answer to each question; however, the lettered options (a, b, c, etc.) may be used more than once or not at all.

I. Matching

___ 1. Helical; move by flagella, if present.

___ 2. Spherical; in chains.

___ 3. Divide in three regular planes; spheres form cubelike packets.

___ 4. Helical; axial filaments for motility.

___ 5. A simple, commalike curve.

___ 6. Name means "little staff."

___ 7. Ovals.

a. Sarcinae
b. Tetrads
c. Streptococci
d. Spirochetes
e. Vibrios
f. Bacilli
g. Cocci
h. Spirilla
i. Diplococci
j. Coccobacilli

II. Matching

___ 1. Golgi complex.

___ 2. Meiosis occurs in reproduction.

___ 3. Usually single circular chromosome without histones.

___ 4. Sterols generally present in cell membrane.

___ 5. Cell wall almost always contains peptidoglycans.

___ 6. Nucleus bounded by a membrane.

___ 7. DNA contained in a nucleoid.

a. Eukaryotic cell
b. Prokaryotic cell

III. Matching

___ 1. Contain pigments for photosynthesis by bacteria; found in the plasma membrane.

___ 2. Gram-negative bacterial cells after their treatment with lysozyme.

___ 3. Specialized external structures that assist in the transfer of genetic material between cells.

___ 4. Numerous short, hairlike appendages that help in attachment to mucous membranes.

___ 5. General term for substances surrounding bacterial cells.

___ 6. Polysaccharides found in the cell wall of many gram-positive bacteria.

___ 7. Inclusions of iron oxide.

a. Glycocalyx
b. Flagellin
c. Fimbriae
d. Sex pili
e. Capsules
f. Teichoic acids
g. Spheroplasts
h. Protoplasts
i. Chromatophores
j. Chloroplasts
k. Magnetosomes

IV. Matching

___ 1. Metachromatic granules of stored phosphate in prokaryotes.

___ 2. Entrance of fluids and dissolved substances into eukaryotic cells.

___ 3. Membrane-enclosed spheres in phagocytic cells that contain powerful digestive enzymes.

___ 4. The "powerhouses" of the cell.

___ 5. A gel-like fluid found in the eukaryotic nucleus.

___ 6. A folded inner membrane found in mitochondria.

___ 7. Sometimes contributes to movement of a cell.

___ 8. Found in walls of acid-fast bacteria.

a. Volutin
b. Plasmids
c. Cristae
d. Zymogens
e. Ribosomes
f. Nucleoplasm
g. Lysosomes
h. Mitochondria
i. Phagocytosis
j. Pinocytosis
k. Cytoplasmic streaming
l. Mycolic acid

V. Matching

___ 1. Arrangement of flagella distributed over the entire cell.

___ 2. Flagella at both poles of the cell.

___ 3. A widening at the base of the flagellar filament.

___ 4. An enzyme affecting gram-positive cell walls; found in tears.

___ 5. A compound found in bacterial endospores.

___ 6. A compound frequently found in the cell walls of yeasts.

___ 7. No flagella.

___ 8. A tuft of flagella at one pole of the cell.

___ 9. Twitching motility.

a. Exocytosis
b. Dipicolinic acid
c. Chitin
d. Lysozyme
e. Hook
f. Peritrichous
g. Amphitrichous
h. Lophotrichous
i. Monotrichous
j. Atrichous
k. Grappling hook model
l. Flagellin

VI. Matching

___ 1. Closely involved in protein synthesis.

___ 2. Structure(s) characteristic of both eukaryotic and prokaryotic plasma membranes.

___ 3. Found in the flagella and cilia of eukaryotic cells.

a. Phospholipid bilayer
b. Transverse septum
c. Microtubules
d. Ribosomes

VII. Matching

___ 1. Highly resistant bodies formed by a few bacterial species.

___ 2. Small circular DNA molecules that are not connected with the main chromosome.

___ 3. The semifluid center portion of the mitochondrion.

___ 4. A substance similar to peptidoglycan that is found in the cell wall of archaea.

___ 5. Bacteria with irregular morphology.

a. Plasmids
b. Endospores
c. Pseudomurein
d. Matrix
e. Pleomorphic

VIII. Matching

___ 1. Extracellular polymeric substances on some bacterial cells; may help cells adhere to surfaces.

___ 2. Bacterial cell with thin peptidoglycan layer, outer membrane of lipopolysaccharide.

___ 3. Protein that forms fimbriae.

___ 4. Bundles of microtubules that probably play a role in cell division of eukaryotic cells.

___ 5. Bacteria that have lost their cell walls and may later spontaneously regain them.

___ 6. Lipid A and O polysaccharide are found on this type of bacteria.

a. Glycocalyx

b. Pilin

c. Gram-positive

d. Gram-negative

e. Centrioles

f. L forms

IX. Matching

___ 1. ER associated with ribosomes.

___ 2. Ingrowth of plasma membrane before endospore formation.

___ 3. Anchors the flagella of bacteria to the cell wall and plasma membrane.

a. Septum

b. Forespore

c. Rough ER

d. Smooth ER

e. Basal body

Fill in the Blanks

1. Chemically, the capsule is a(n) ________________, a polypeptide, or both.
2. Capsules protect pathogenic bacteria from ________________, a process by which protective host cells engulf and destroy microorganisms.
3. The Golgi complex consists of flattened sacs called ________________ that are connected to the endoplasmic reticulum.
4. The ________________ complex consists of four to eight flattened sacs connected to the endoplasmic reticulum. The function is largely secretion of proteins, lipids, and carbohydrates.
5. The term ________________ means a lower concentration of solutes outside the cell than inside.
6. Three examples of passive diffusion across membranes are ________________, ________________, and ________________.
7. The protein in the flagellar filaments of bacteria is called ________________.
8. DNA in eukaryotic cells is combined with protein ________________ and nonhistones.

Critical Thinking

1. What is a glycocalyx? How is the presence of a glycocalyx related to bacterial virulence?

2. What substances are able to cross the plasma membrane most easily?

3. Describe how a bacterial cell will respond to the following osmotic pressures: isotonic, hypotonic, hypertonic.

4. How is the presence of peptidoglycan in bacterial cells clinically significant?

7. Vacuoles are membrane-enclosed cavities derived from the Golgi complex or endocytosis. They are usually found in plant cells that store various substances and provide rigidity to leaves and stems.
8. Mitochondria are the primary sites of ATP production. They contain 70S ribosomes and DNA, and they multiply by binary fission.
9. Chloroplasts contain chlorophyll and enzymes for photosynthesis. Like mitochondria, they contain 70S ribosomes and DNA and multiply by binary fission.
10. A variety of organic compounds are oxidized in peroxisomes. Catalase in peroxisomes destroys H_2O_2.
11. The centrosome consists of the pericentriolar material and centrioles. Centrioles are 9 triplet microtubules involved in formation of the mitotic spindle and microtubules.

The Evolution of Eukaryotes (pp. 102–103)

1. According to the endosymbiotic theory, eukaryotic cells evolved from symbiotic prokaryotes living inside other prokaryotic cells.

Study Questions

For answers to the Knowledge and Comprehension questions, turn to the Answers tab at the back of the textbook.

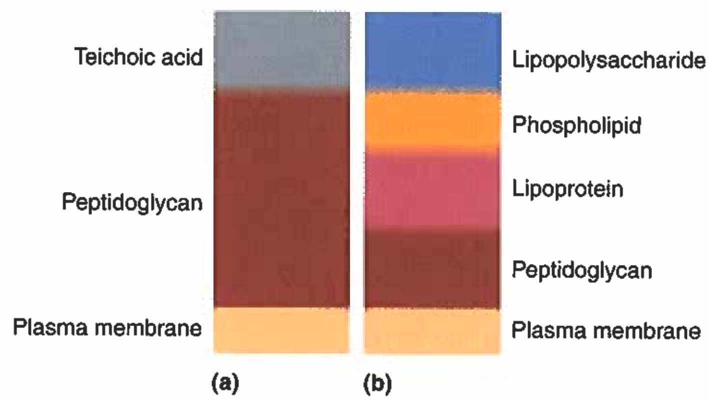
Knowledge and Comprehension

Review

1. DRAW IT Diagram each of the following flagellar arrangements:
   a. lophotrichous
   b. monotrichous
   c. peritrichous
   d. amphitrichous
   e. polar
2. Endospore formation is called (a) __________. It is initiated by (b) __________. Formation of a new cell from an endospore is called (c) __________. This process is triggered by (d) __________.
3. DRAW IT Draw the bacterial shapes listed in (a), (b), and (c). Then draw the shapes in (d), (e), and (f), showing how they are special conditions of a, b, and c, respectively.
   a. spiral
   b. bacillus
   c. coccus
   d. spirochetes
   e. staphylococci
   f. streptobacilli
4. Match the structures in column A to their functions in column B.

Column A	Column B
__________ a. Cell wall	1. Attachment to surfaces
__________ b. Endospore	2. Cell wall formation
__________ c. Fimbriae	3. Motility
__________ d. Flagella	4. Protection from osmotic lysis
__________ e. Glycocalyx	5. Protection from phagocytes
__________ f. Pili	6. Resting
__________ g. Plasma membrane	7. Protein synthesis
__________ h. Ribosomes	8. Selective permeability
	9. Transfer of genetic material

5. Why is an endospore called a resting structure? Of what advantage is an endospore to a bacterial cell?
6. Compare and contrast the following:
   a. simple diffusion and facilitated diffusion
   b. active transport and facilitated diffusion
   c. active transport and group translocation
7. Answer the following questions using the diagrams provided, which represent cross sections of bacterial cell walls.
   a. Which diagram represents a gram-positive bacterium? How can you tell?



   b. Explain how the Gram stain works to distinguish these two types of cell walls.
   c. Why does penicillin have no effect on most gram-negative cells?
   d. How do essential molecules enter cells through each wall?
   e. Which cell wall is toxic to humans?
8. Starch is readily metabolized by many cells, but a starch molecule is too large to cross the plasma membrane. How does a cell obtain the glucose molecules from a starch polymer? How does the cell transport these glucose molecules across the plasma membrane?
9. Match the characteristics of eukaryotic cells in column A with their functions in column B.

Column A	Column B
__________ a. Pericentriolar material	1. Digestive enzyme storage
__________ b. Chloroplasts	2. Oxidation of fatty acids
__________ c. Golgi complex	3. Microtubule formation
__________ d. Lysosomes	4. Photosynthesis
__________ e. Mitochondria	5. Protein synthesis
__________ f. Peroxisomes	6. Respiration
__________ g. Rough ER	7. Secretion

10. NAME IT What group of microbes is characterized by cells that form filaments, reproduce by spores, and have peptidoglycan in their cell walls?

Multiple Choice

1. Which of the following is *not* a distinguishing characteristic of prokaryotic cells?
   a. They usually have a single, circular chromosome.
   b. They have 70S ribosomes.
   c. They have cell walls containing peptidoglycan.
   d. Their DNA is not associated with histones.
   e. They lack a plasma membrane.

Use the following choices to answer questions 2–4.
   a. No change will result; the solution is isotonic.
   b. Water will move into the cell.
   c. Water will move out of the cell.
   d. The cell will undergo osmotic lysis.
   e. Sucrose will move into the cell from an area of higher concentration to one of lower concentration.

2. Which statement best describes what happens when a gram-positive bacterium is placed in distilled water and penicillin?
3. Which statement best describes what happens when a gram-negative bacterium is placed in distilled water and penicillin?
4. Which statement best describes what happens when a gram-positive bacterium is placed in an aqueous solution of lysozyme and 10% sucrose?
5. Which of the following statements best describes what happens to a cell exposed to polymyxins that destroy phospholipids?
   a. In an isotonic solution, nothing will happen.
   b. In a hypotonic solution, the cell will lyse.
   c. Water will move into the cell.
   d. Intracellular contents will leak from the cell.
   e. Any of the above might happen.
6. Which of the following is *false* about fimbriae?
   a. They are composed of protein.
   b. They may be used for attachment.
   c. They are found on gram-negative cells.
   d. They are composed of pilin.
   e. They may be used for motility.
7. Which of the following pairs is *mismatched*?
   a. glycocalyx—adherence
   b. pili—reproduction
   c. cell wall—toxin
   d. cell wall—protection
   e. plasma membrane—transport
8. Which of the following pairs is *mismatched*?
   a. metachromatic granules—stored phosphates
   b. polysaccharide granules—stored starch
   c. lipid inclusions—poly-β-hydroxybutyric acid
   d. sulfur granules—energy reserve
   e. ribosomes—protein storage
9. You have isolated a motile, gram-positive cell with no visible nucleus. You can assume this cell has
   a. ribosomes.
   b. mitochondria.
   c. an endoplasmic reticulum.
   d. a Golgi complex.
   e. all of the above
10. The antibiotic amphotericin B disrupts plasma membranes by combining with sterols; it will affect all of the following cells *except*
   a. animal cells.
   b. gram-negative bacterial cells.
   c. fungal cells.
   d. *Mycoplasma* cells.
   e. plant cells.

Analysis

1. How can prokaryotic cells be smaller than eukaryotic cells and still carry on all the functions of life?
2. The smallest eukaryotic cell is the motile alga *Ostreococcus*. What is the minimum number of organelles this alga must have?
3. Two types of prokaryotic cells have been distinguished: bacteria and archaea. How do these cells differ from each other? How are they similar?
4. In 1985, a 0.5-mm cell was discovered in surgeonfish and named *Epulopiscium fishelsoni* (see Figure 11.20, page 313). It was presumed to be a protozoan. In 1993, researchers determined that *Epulopiscium* is actually a gram-positive bacterium. Why do you suppose this organism was initially identified as a protozoan? What evidence would change the classification to bacterium?
5. When *E. coli* cells are exposed to a hypertonic solution, the bacteria produce a transporter protein that can move K^+ (potassium ions) into the cell. Of what value is the active transport of K^+, which requires ATP?

Clinical Applications and Evaluation

1. *Clostridium botulinum* is a strict anaerobe; that is, it is killed by the molecular oxygen (O_2) present in air. Humans can die of botulism from eating foods in which *C. botulinum* is growing. How does this bacterium survive on plants picked for human consumption? Why are home-canned foods most often the source of botulism?
2. A South San Francisco child enjoyed bath time at his home because of the colorful orange and red water. The water did not have this rusty color at its source, and the water department could not culture the *Acidithiobacillus* bacteria responsible for the rusty color from the source. How were the bacteria getting into the household water? What bacterial structures make this possible?
3. Live cultures of *Bacillus thuringiensis* (Dipel®) and *B. subtilis* (Kodiak®) are sold as pesticides. What bacterial structures make it possible to package and sell these bacteria? For what purpose is each product used? (*Hint*: Refer to Chapter 11.)