

Prokaryotic Profiles- the Bacteria and Archaea

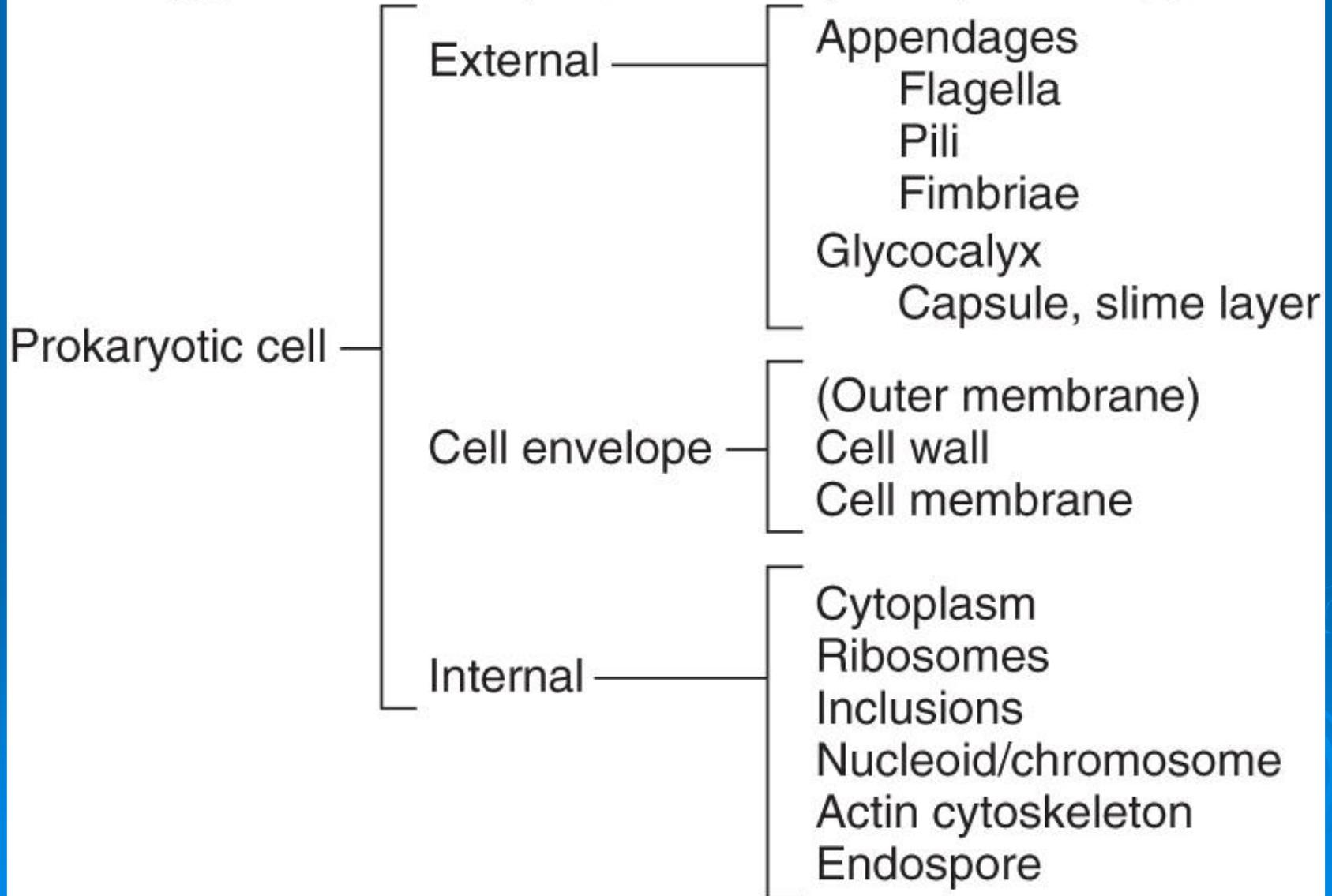


How are Prokaryotes Different from Eukaryotes?

- The way their DNA is packaged
 - No nucleus
 - Not wrapped around **histones**
- The makeup of their cell wall
 - Bacteria- peptidoglycan
 - Archae- tough and made of other chemicals, distinct to them
- Their internal structures
 - No complex, membrane-bound organelles

4.1 Prokaryotic Form and Function

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Structures common to all bacterial cells

- Cell membrane
- Cytoplasm
- Ribosomes
- One (or a few) chromosomes

Structures found in most bacterial cells

- Cell wall
- Surface coating or glycocalyx



Structures found in some bacterial cells

- Flagella
- Pili
- Fimbriae
- Capsules
- Slime layers
- Inclusions
- Actin cytoskeleton
- Endospores

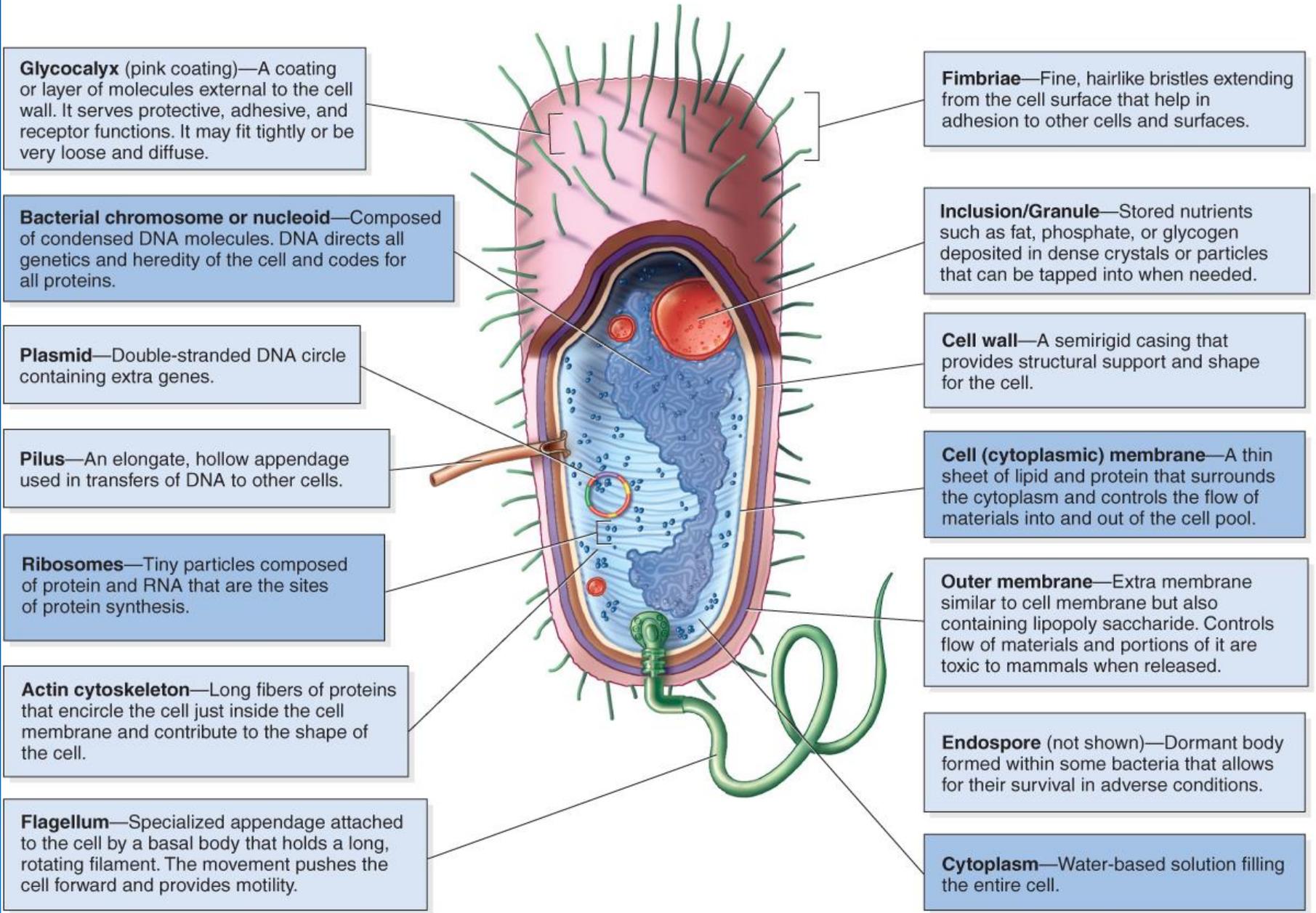


Figure 4.1

4.2 External Structures

- **Appendages:** Cell extensions
 - Common but not present on all species
 - Can provide **motility** (**flagella** and axial filaments)
 - Can be used for attachment and mating (**pili** and **fimbriae**)

Flagella

- Three parts: **Filament**, hook (sheath), and basal body
- Vary in both number and arrangement
 - Polar arrangement: flagella attached at one or both ends of the cell
 - **Monotrichous**- single flagellum
 - **Lophotrichous**- small bunches or tufts of flagella emerging from the same site
 - **Peritrichous**- dispersed randomly over the structure of the cell

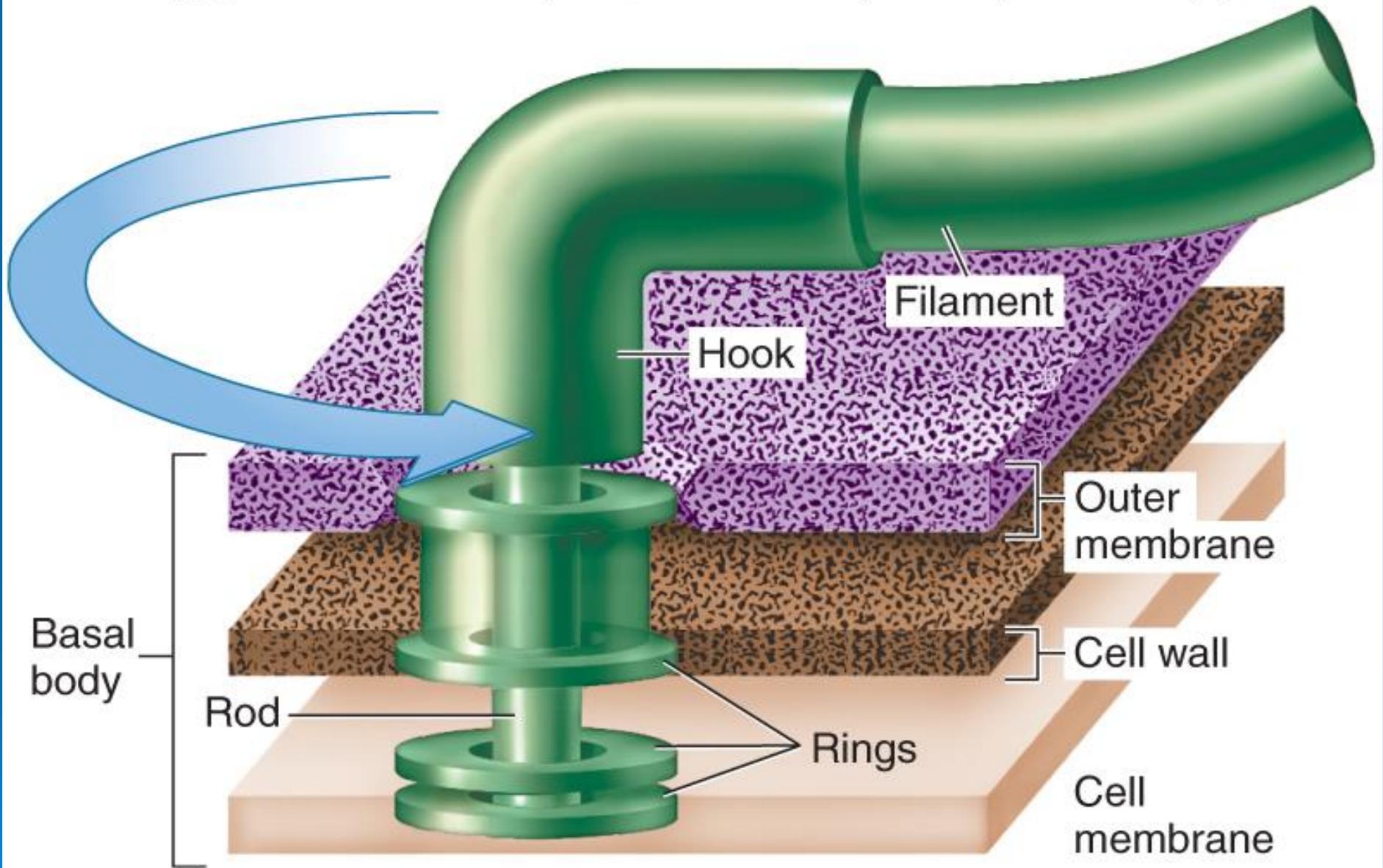
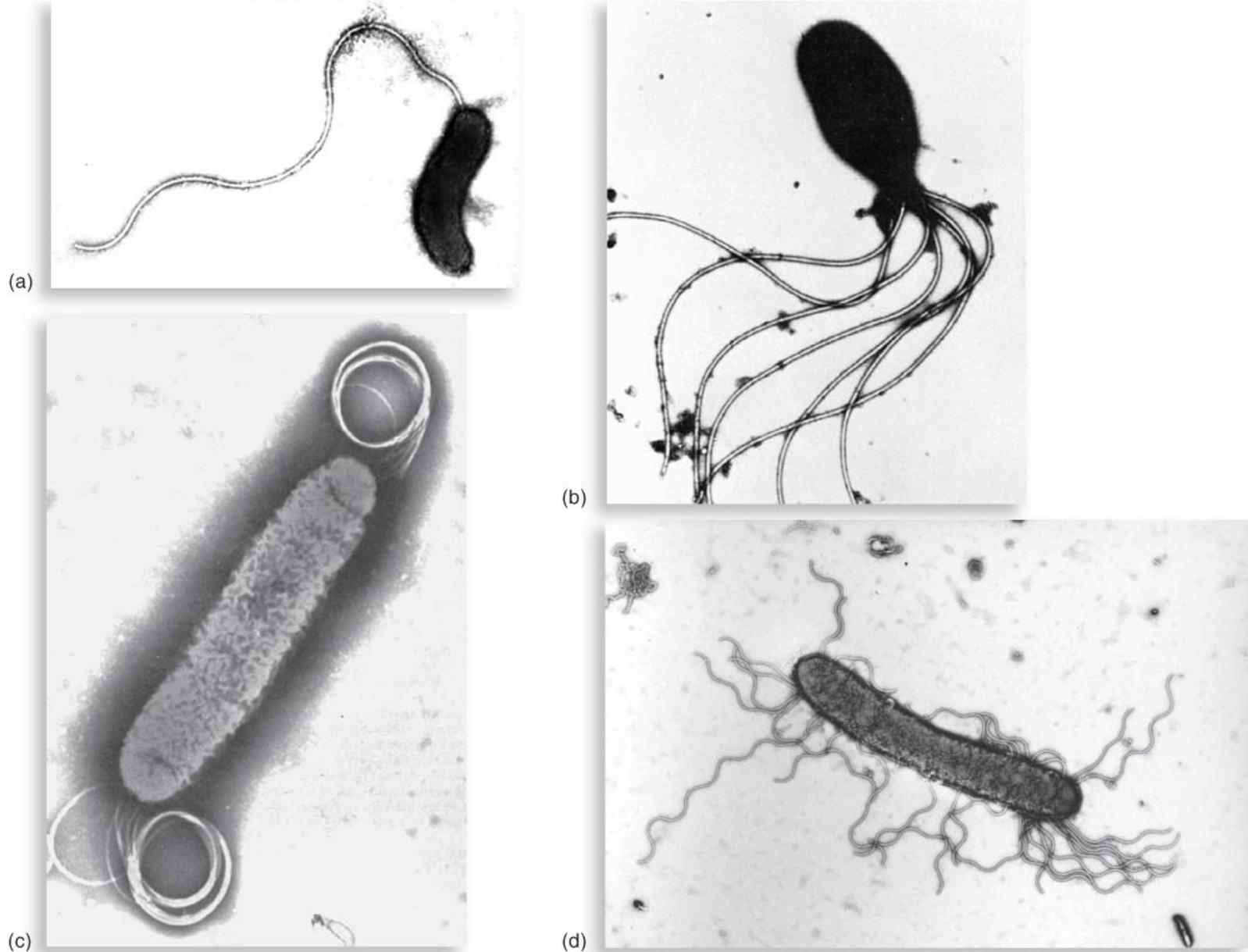


Figure 4.2



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Figure 4.3

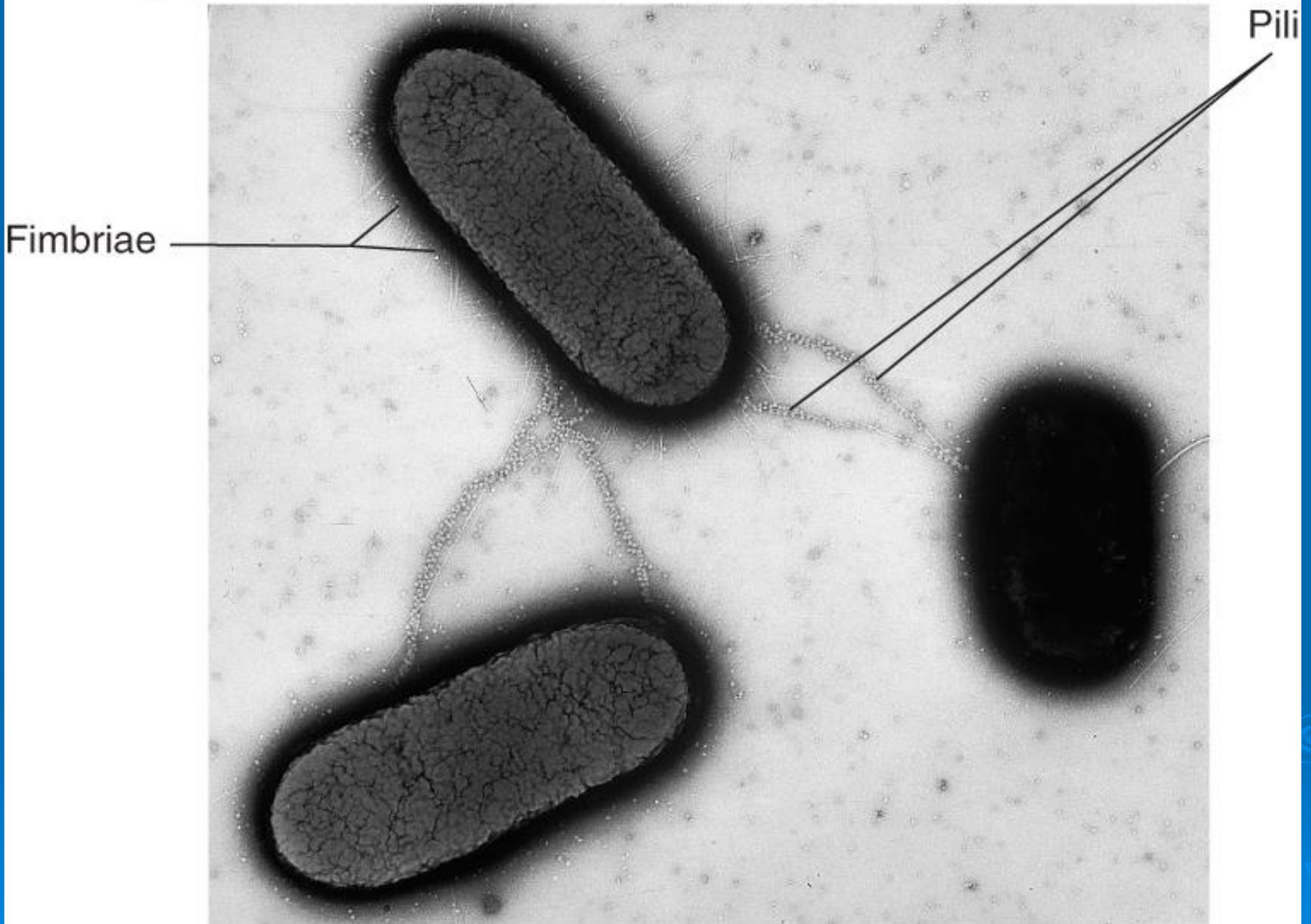
Flagellar Function

- Move by runs and tumbles



Pili

- Elongate, rigid tubular structures
- Made of the protein pilin
- Found on gram-negative bacteria
- Used in **conjugation**



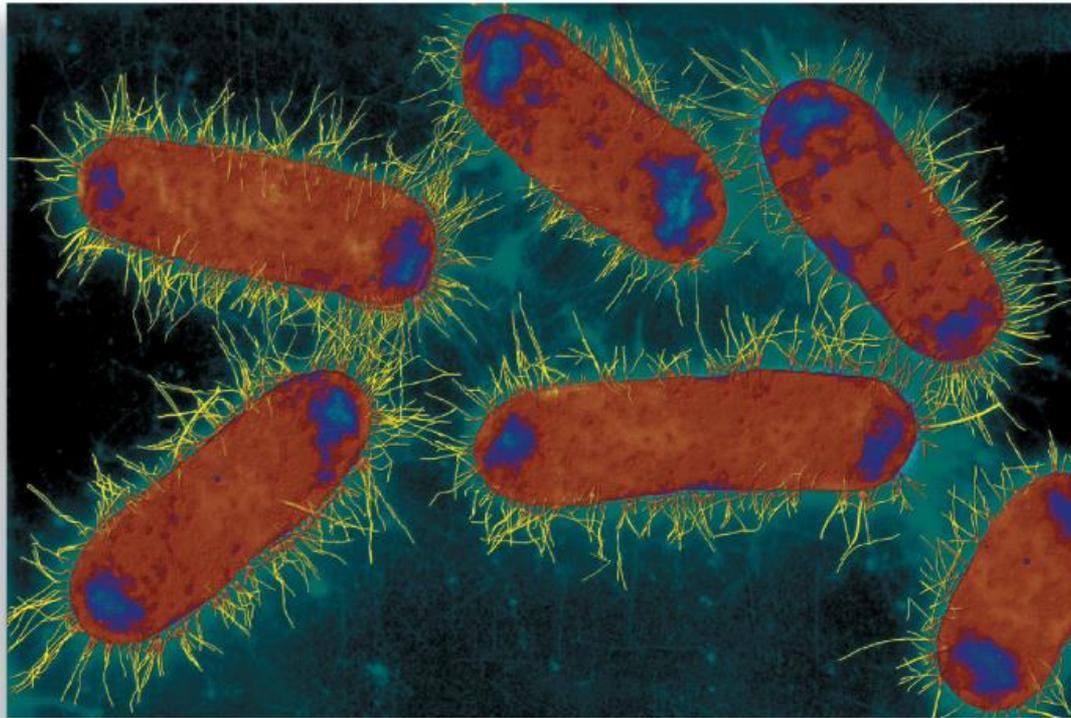
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Figure 4.8

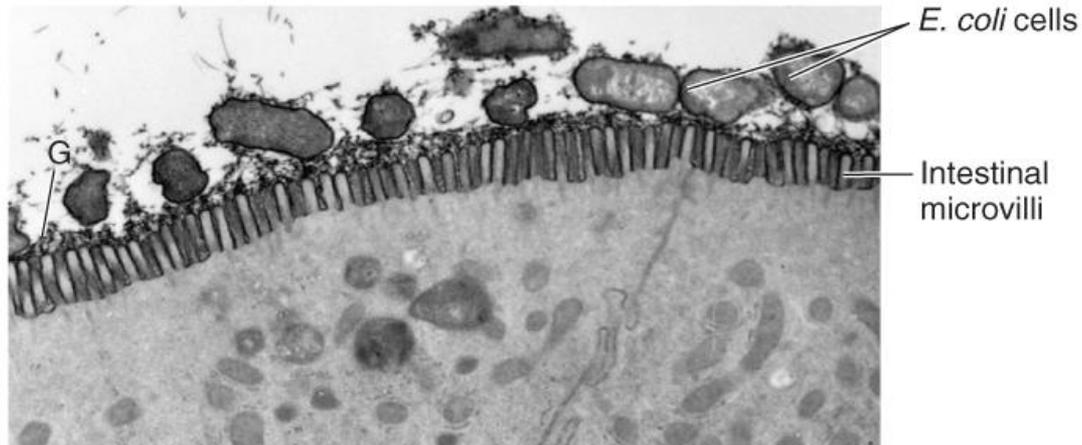
Fimbriae

- Small, bristlelike fibers
- Most contain protein
- Tend to stick to each other and to surfaces





(a)



(b)

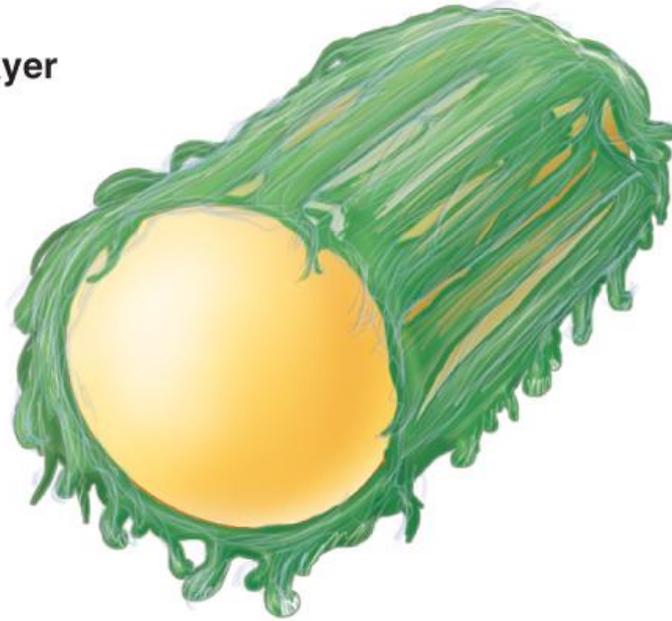
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Figure 4.7

The Glycocalyx

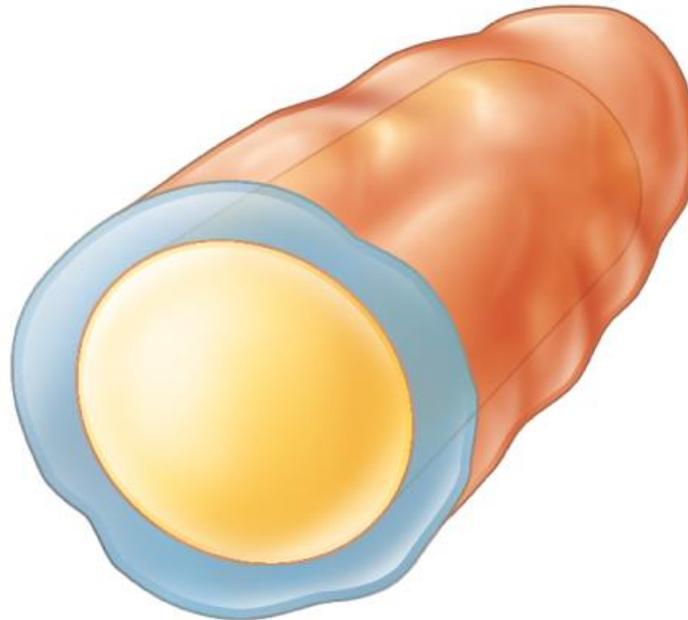
- Develops as a coating of repeating polysaccharide units, protein, or both
- Protects the cell
- Sometimes helps the cell adhere to the environment
- Differ among bacteria in thickness, organization, and chemical composition
 - **Slime layer**- a loose shield that protects some bacteria from loss of water and nutrients
 - **Capsule**- when the glycocalyx is bound more tightly to the cell and is denser and thicker

Slime Layer



(a)

Capsule



(b)

Figure 4.9

Functions of the Glycocalyx

Many pathogenic bacteria have glycocalyxes

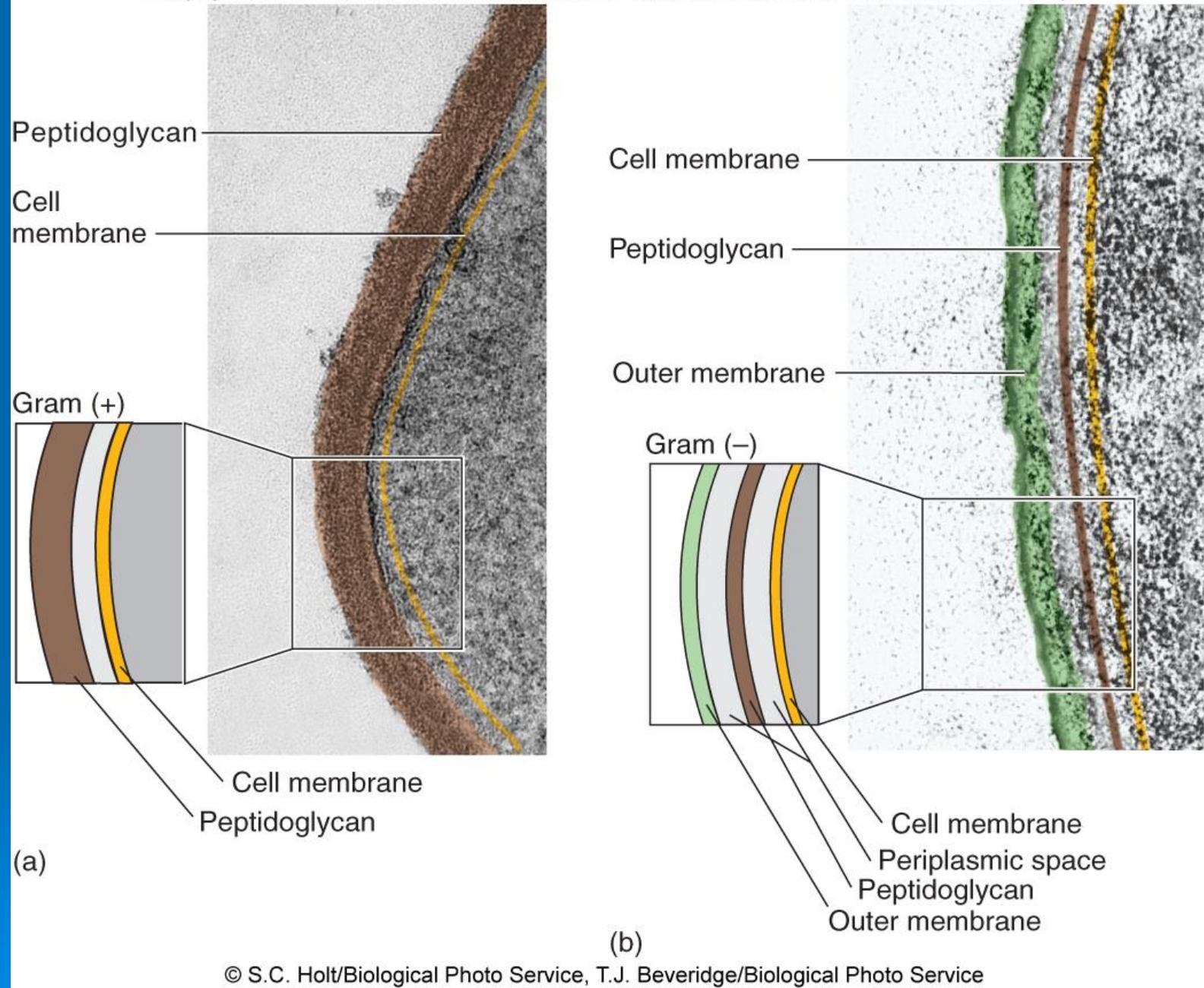
- Protect the bacteria against phagocytes
- Important in formation of biofilms

4.3 The Cell Envelope: The Boundary layer of Bacteria

- Majority of bacteria have a cell envelope
- Lies outside of the cytoplasm
- Composed of two or three basic layers
 - Cell membrane
 - Cell wall
 - In some bacteria, the outer membrane

Differences in Cell Envelope Structure

- The differences between **gram-positive** and **gram-negative** bacteria lie in the cell envelope
- Gram-positive
 - Two layers
 - Cell wall and cytoplasmic membrane
- Gram-negative
 - Three layers
 - Outer membrane, cell wall, and cytoplasmic membrane



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Figure 4.12

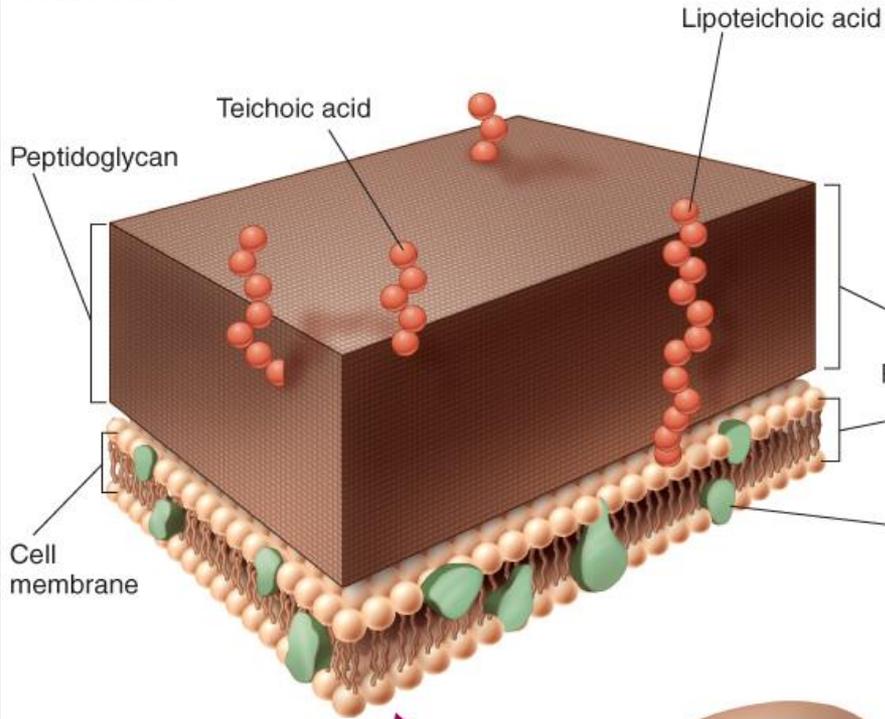
Function of the Cell Wall

- Helps determine the shape of a bacterium
- Provides strong structural support
- Most are rigid because of peptidoglycan content

Structure of the Cell Wall, cont.

- Keeps cells from rupturing because of changes in pressure due to osmosis
- Target of many antibiotics- disrupt the cell wall, and cells have little protection from **lysis**
- Gram-positive cell wall
 - A thick (20 to 80 nm), homogeneous sheath of peptidoglycan
 - Contains tightly bound acidic polysaccharides
- Gram-Negative Cell Wall
 - Single, thin (1 to 3 nm) sheet of peptidoglycan
 - Periplasmic space surrounds the peptidoglycan

Gram-Positive



Gram-Negative

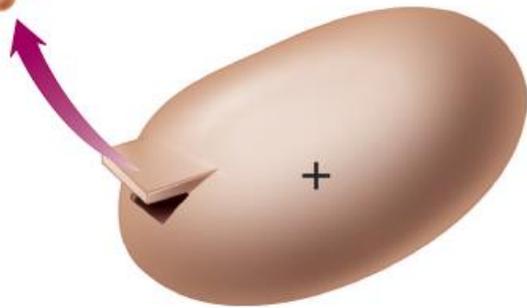
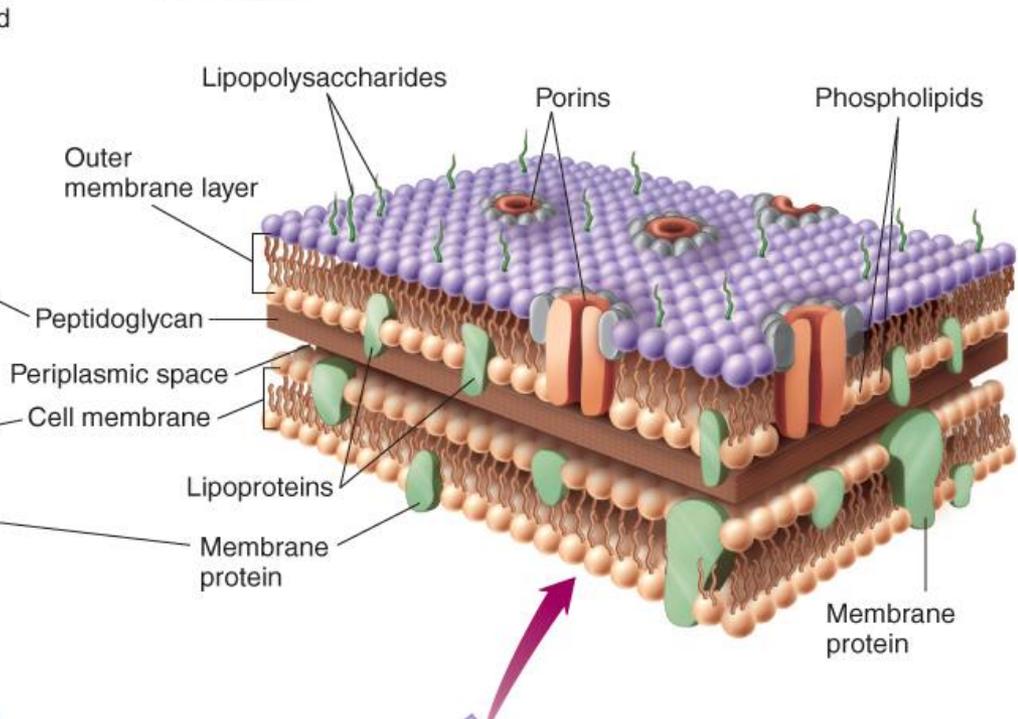
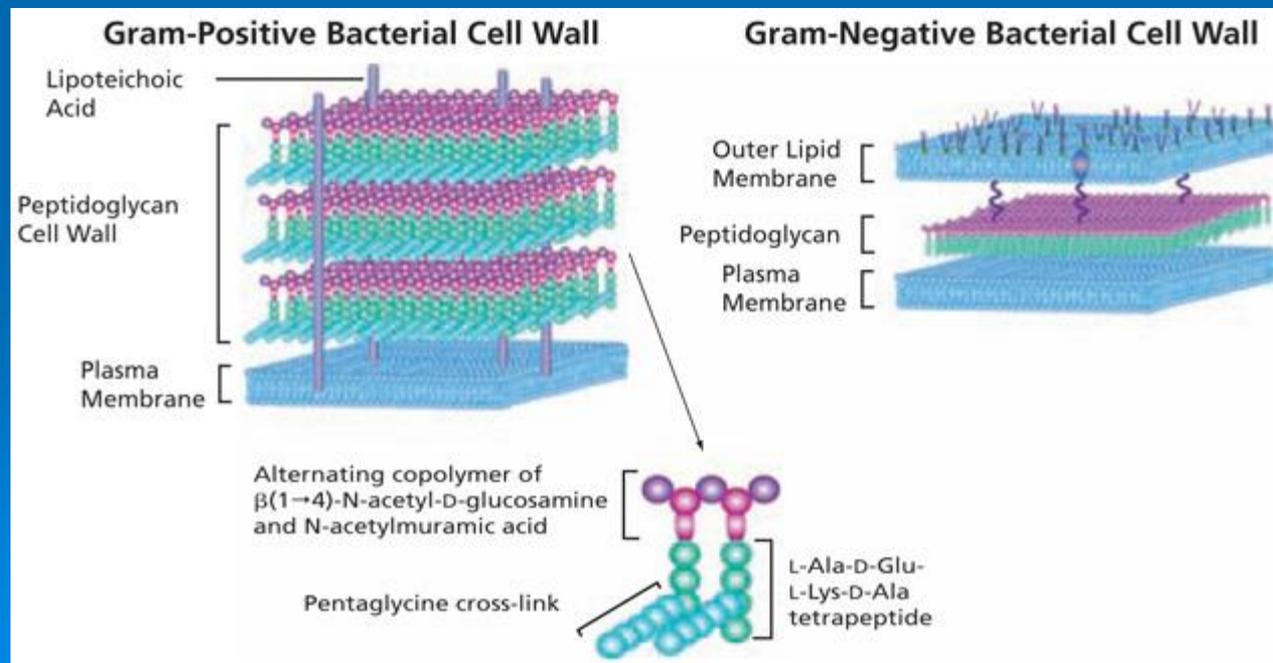


Figure 4.14

Peptidoglycan (murein) is a polymer consisting of sugars and amino acids that forms a mesh-like layer outside the plasma membrane of most bacteria, forming the cell wall. The sugar component consists of alternating residues of β -(1,4) linked N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM). Peptidoglycan serves a structural role in the bacterial cell wall, giving structural strength, as well as counteracting the osmotic pressure of the cytoplasm. Peptidoglycan is also involved in binary fission during bacterial cell reproduction.

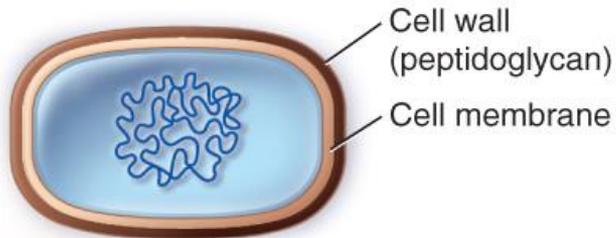


- Some bacteria lose their cell wall during part of their life cycle
 - **L-forms**
 - Arise naturally from a mutation in the wall-forming genes
 - Can be induced artificially by treatment with a chemical that disrupts the cell wall
 - When this occurs with gram-positive cells, the cell becomes a **protoplast**
 - With gram-negative cells, the cell becomes a **spheroplast**

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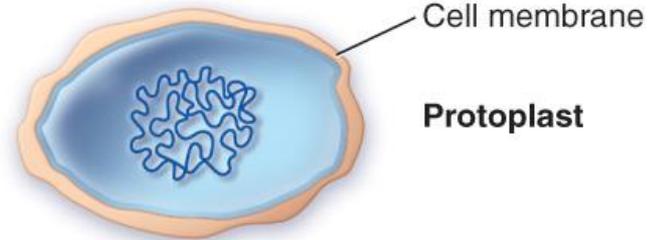
Mutation or chemical treatment

Gram-Positive



Cell wall
(peptidoglycan)
Cell membrane

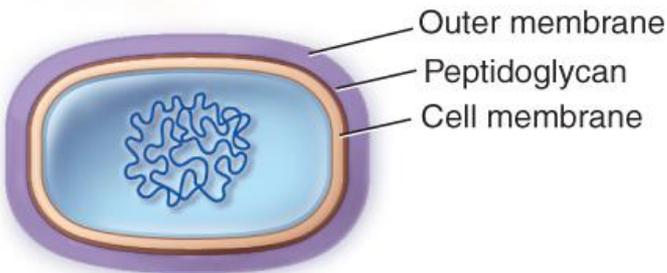
Peptidoglycan
lost



Cell membrane
Protoplast

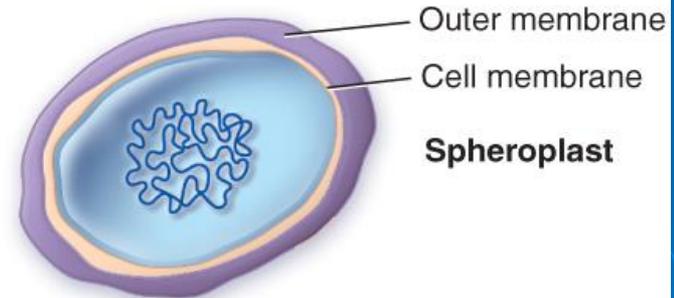
(a)

Gram-Negative



Outer membrane
Peptidoglycan
Cell membrane

Peptidoglycan
lost



Outer membrane
Cell membrane
Spheroplast

(b)

Figure 4.16

Cell Membrane Structure

- Also known as the **cytoplasmic membrane**
- Very thin (5-10 nm)
- Contain primarily phospholipids and proteins
- The exceptions: mycoplasmas and archaea
- Functions
 - Provides a site for functions such as energy reactions, nutrient processing, and synthesis
 - Regulates transport (selectively permeable membrane)
 - Secretion

4.4 Bacterial Internal Structure

➤ Contents of the Cell **Cytoplasm**

- Gelatinous solution
- Site for many biochemical and synthetic activities
- 70%-80% water
- Also contains larger, discrete cell masses (chromatin body, ribosomes, granules, and actin strands)

Bacterial Chromosome

- Single circular strand of DNA
- Aggregated in a dense area of the cell- the **nucleoid**

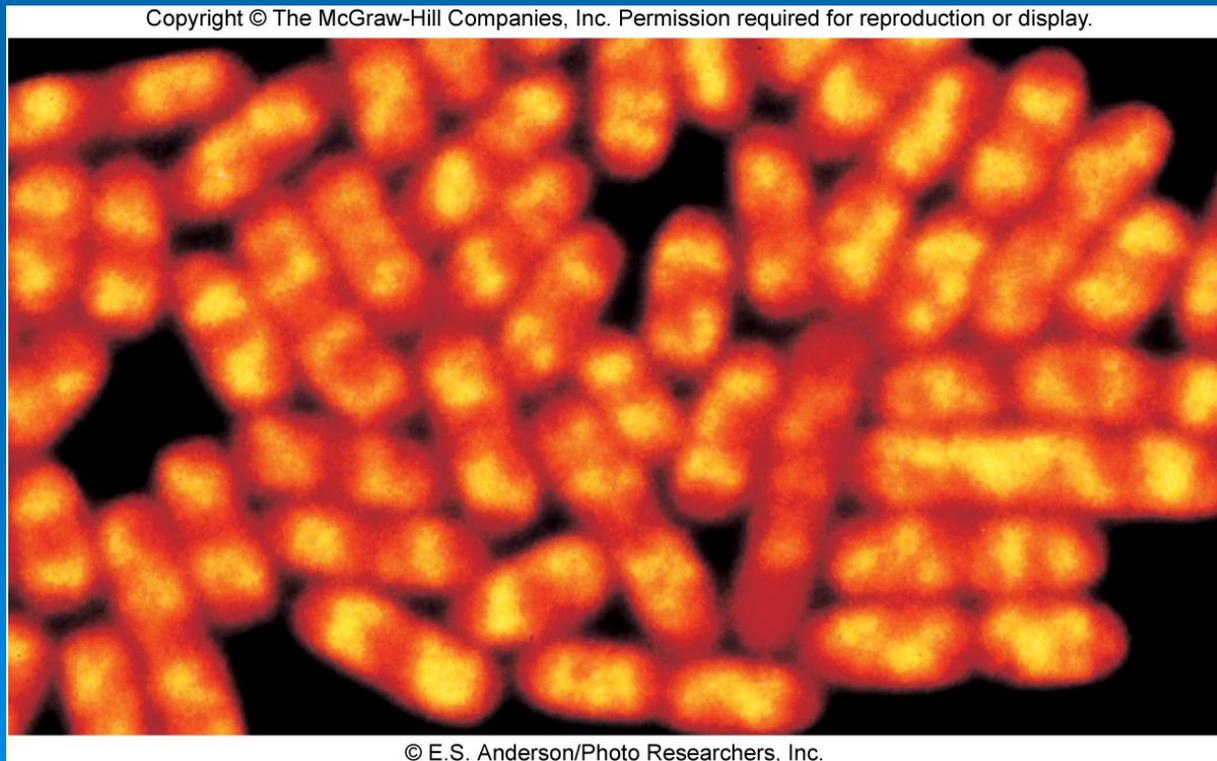


Figure 4.17

Plasmids

- Nonessential, double-stranded circles of DNA
- Present in cytoplasm but may become incorporated into the chromosomal DNA
- Often confer protective traits such as drug resistance or the production of toxins and enzymes

Ribosomes

- Made of RNA and protein
- Special type of RNA-ribosomal RNA (rRNA)
- Characterized by S (for Svedberg) units- the prokaryotic ribosome is 70S

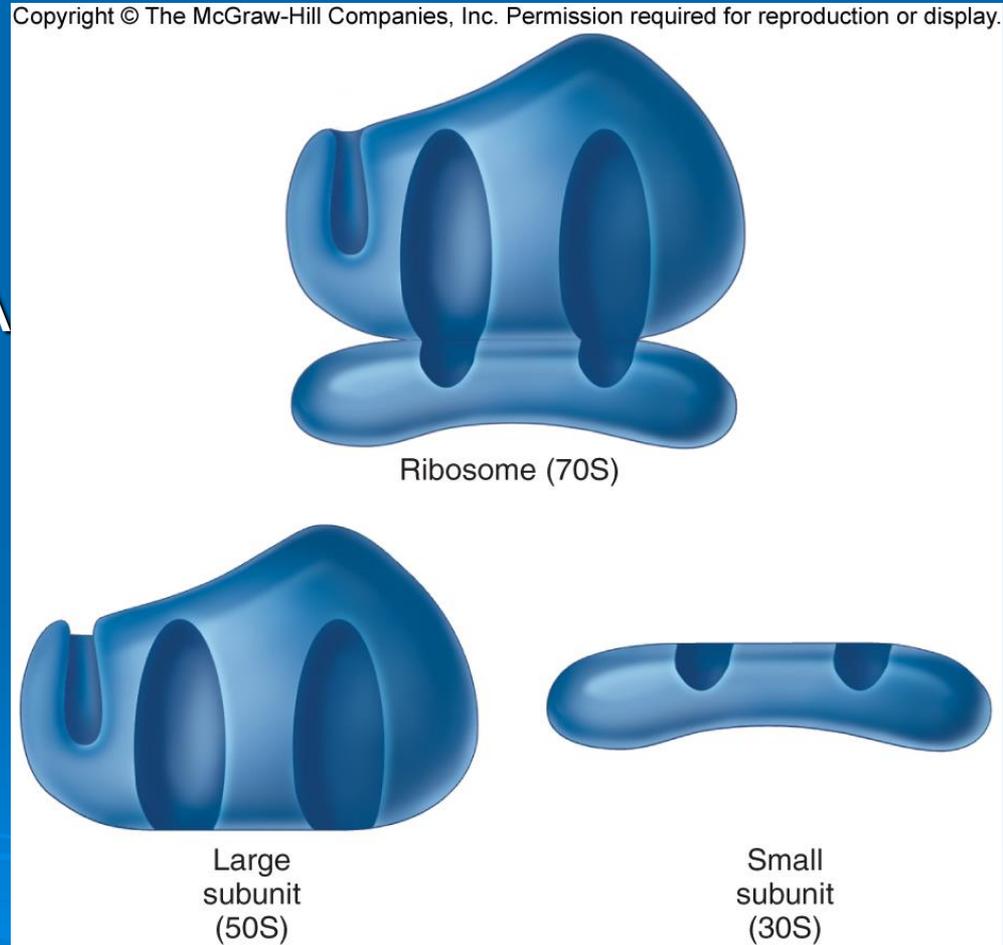


Figure 4.18

Inclusions

- Inclusions- also known as **inclusion bodies**
 - Some bacteria lay down nutrients in these inclusions during periods of nutrient abundance
 - Serve as a storehouse when nutrients become depleted
 - Some enclose condensed, energy-rich organic substances
 - Some aquatic bacterial inclusions include gas vesicles to provide buoyancy and flotation

Granules

- A type of inclusion body
- Contain crystals of inorganic compounds
- Are not enclosed by membranes
- Example- sulfur granules of photosynthetic bacteria



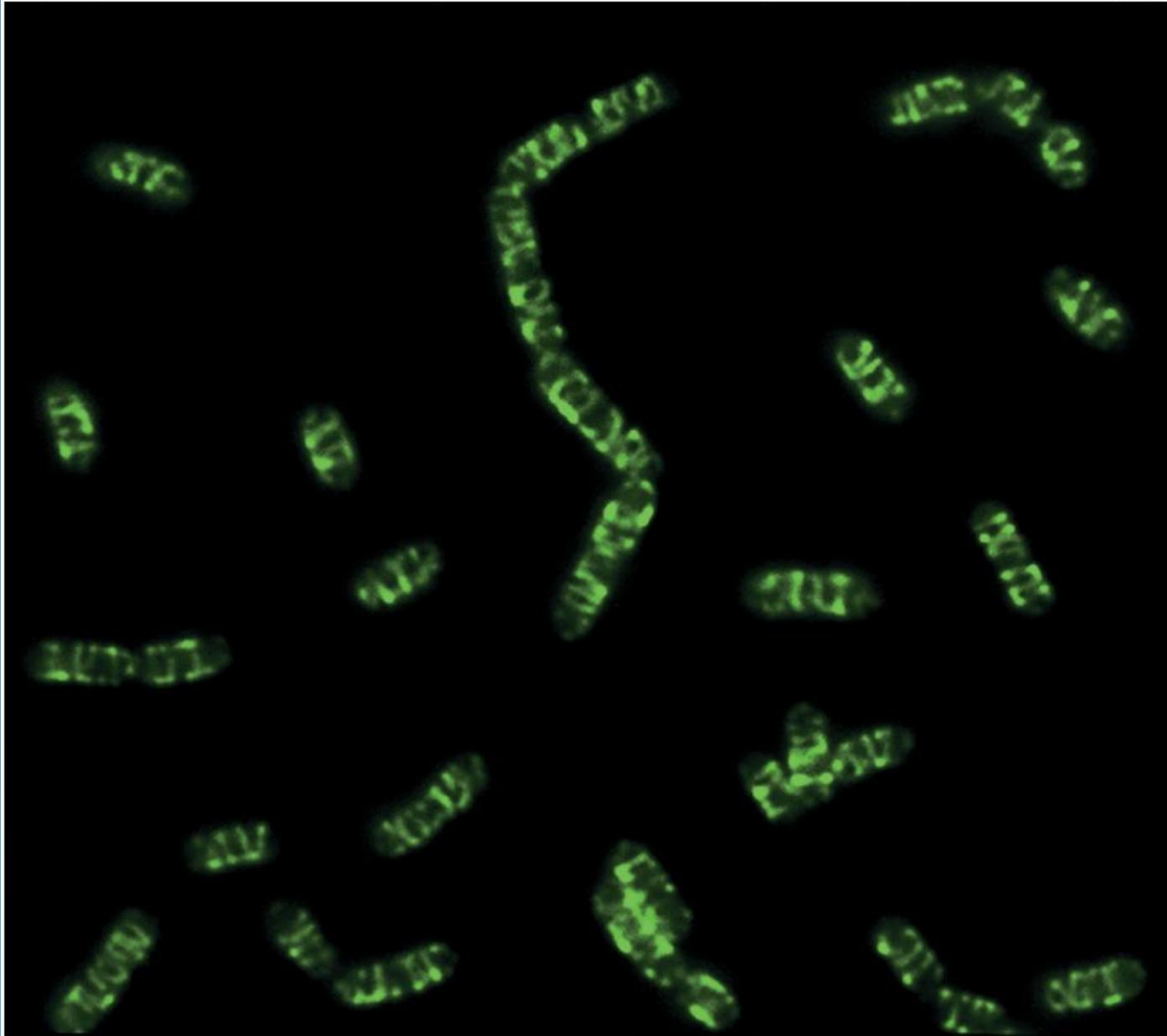
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Figure 4.19

The Actin Cytoskeleton

- Long polymers of **actin**
- Arranged in helical ribbons around the cell just under the cell membrane
- Contribute to cell shape





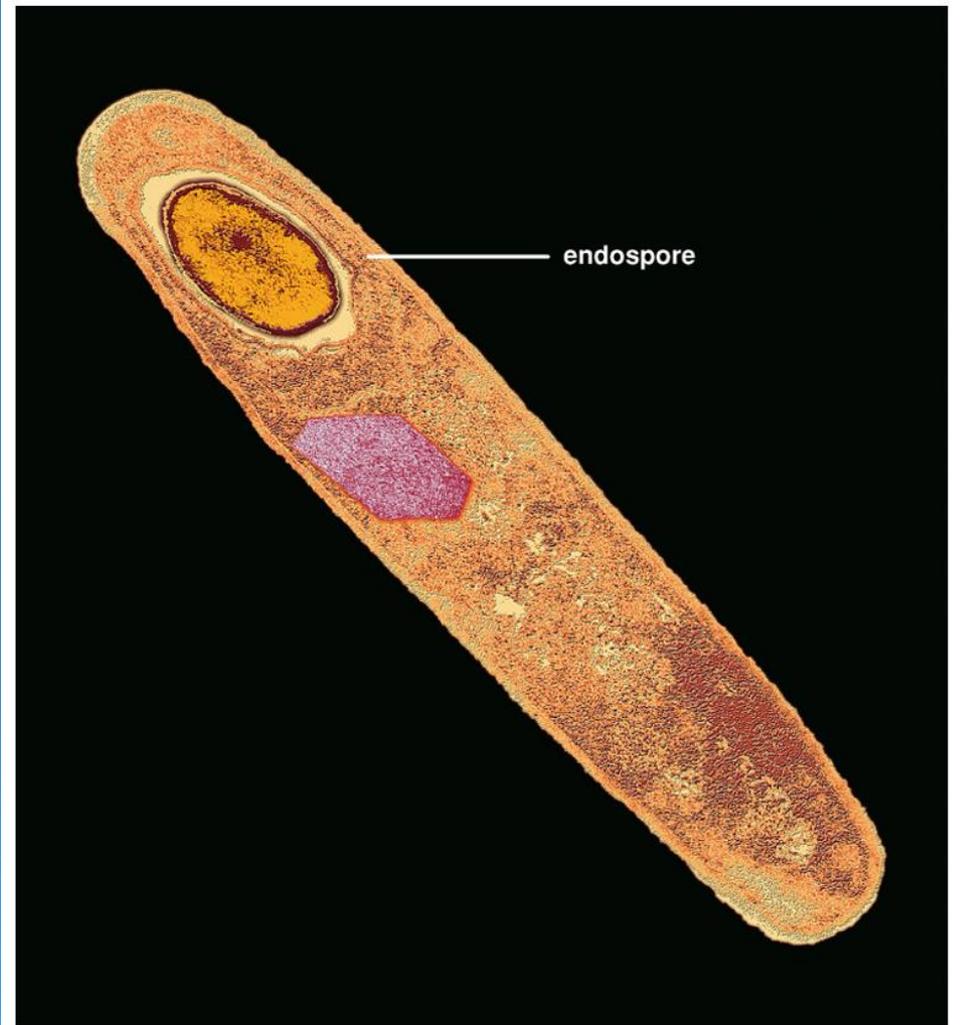
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Figure 4.20

Bacterial Endospores: An Extremely Resistant Stage

- Dormant bodies produced by *Bacillus*, *Clostridium*, and *Sporosarcina*

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Figure 4.21

Endospore-Forming Bacteria

- These bacteria have a two-phase life cycle
 - Phase One- Vegetative cell
 - Metabolically active and growing
 - Can be induced by the environment to undergo spore formation (**sporulation**)

4.5 Bacterial Shapes, Arrangements, and Sizes

➤ Three general shapes

- **Coccus**- roughly spherical
- **Bacillus**- rod-shaped
 - **Coccobacillus**- short and plump
 - **Vibrio**- gently curved
- **Spirillum**- curviform or spiral-shaped
- **Pleomorphism**- when cells of a single species vary to some extent in shape and size

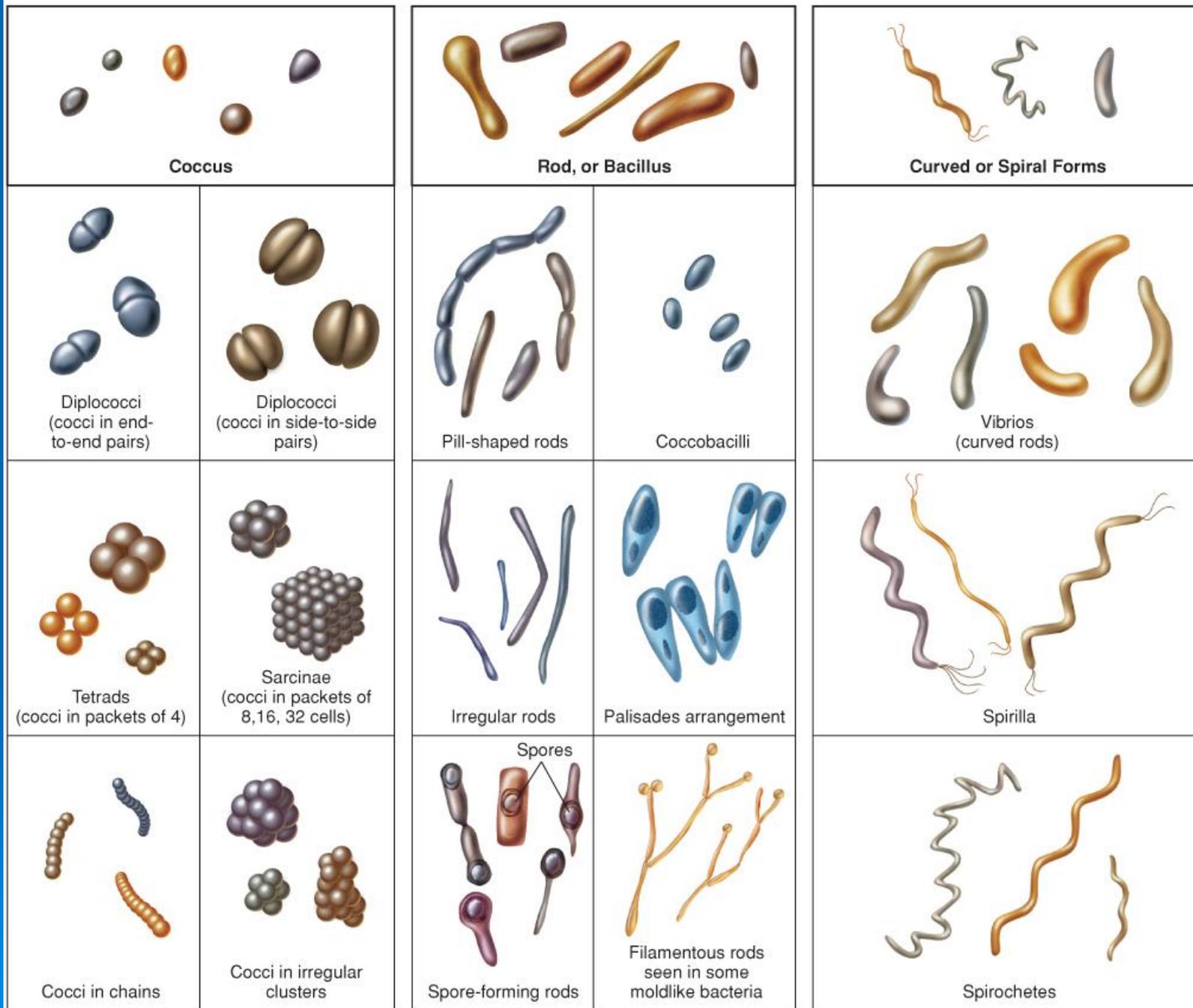
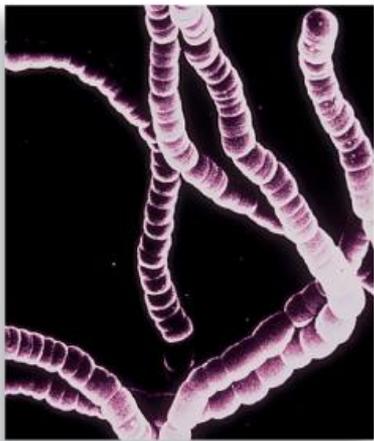
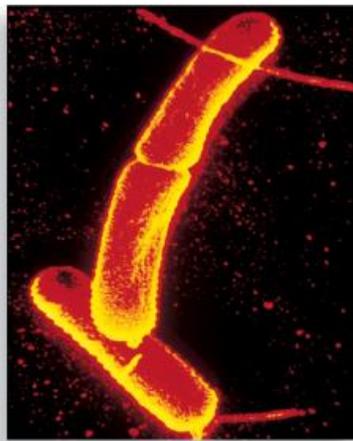


Figure 4.22

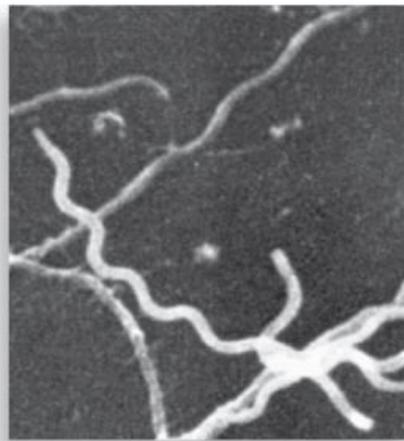
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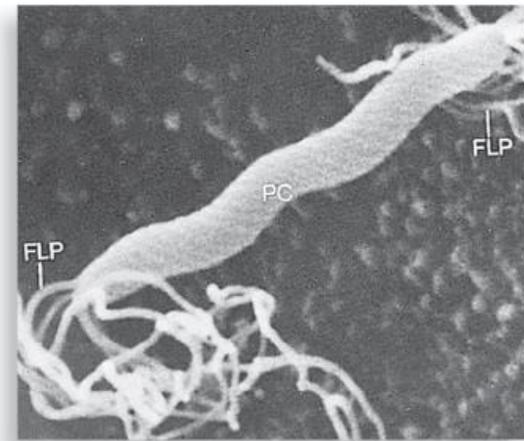
(a)



(b)

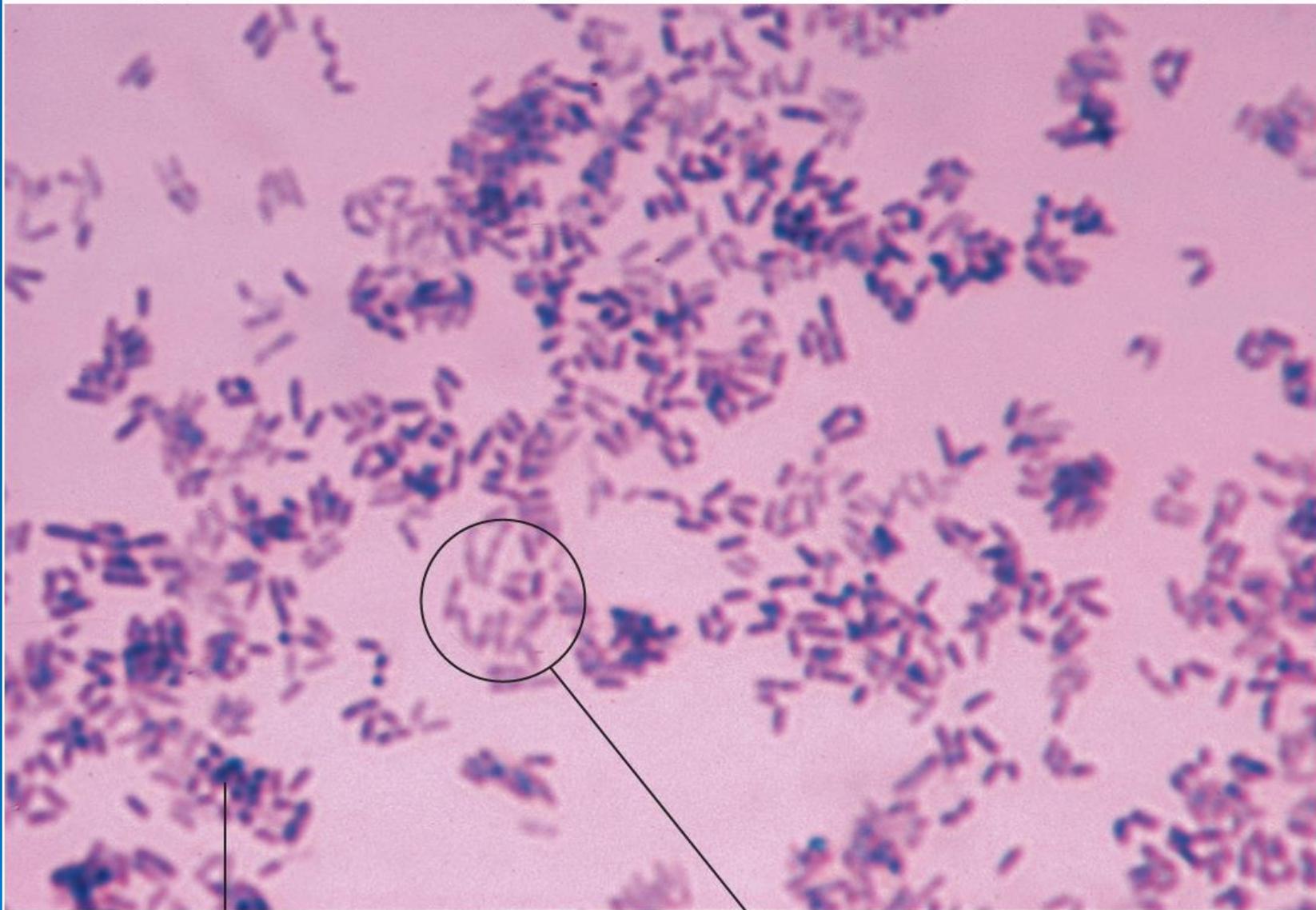


(c)



(d)

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Granules

Palisades arrangement

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Figure 4.24

Arrangement, or Grouping

- Cocci- greatest variety in arrangement
 - Single
 - Pairs (diplococci)
 - Tetrads
 - Irregular clusters (staphylococci and micrococci)
 - Chains (streptococci)
 - Cubical packet (**sarcina**)
- Bacilli- less varied
 - Single
 - Pairs (diplobacilli)
 - Chain (streptobacilli)
 - Row of cells oriented side by side (**palisades**)
- Spirilla
 - Occasionally found in short chains

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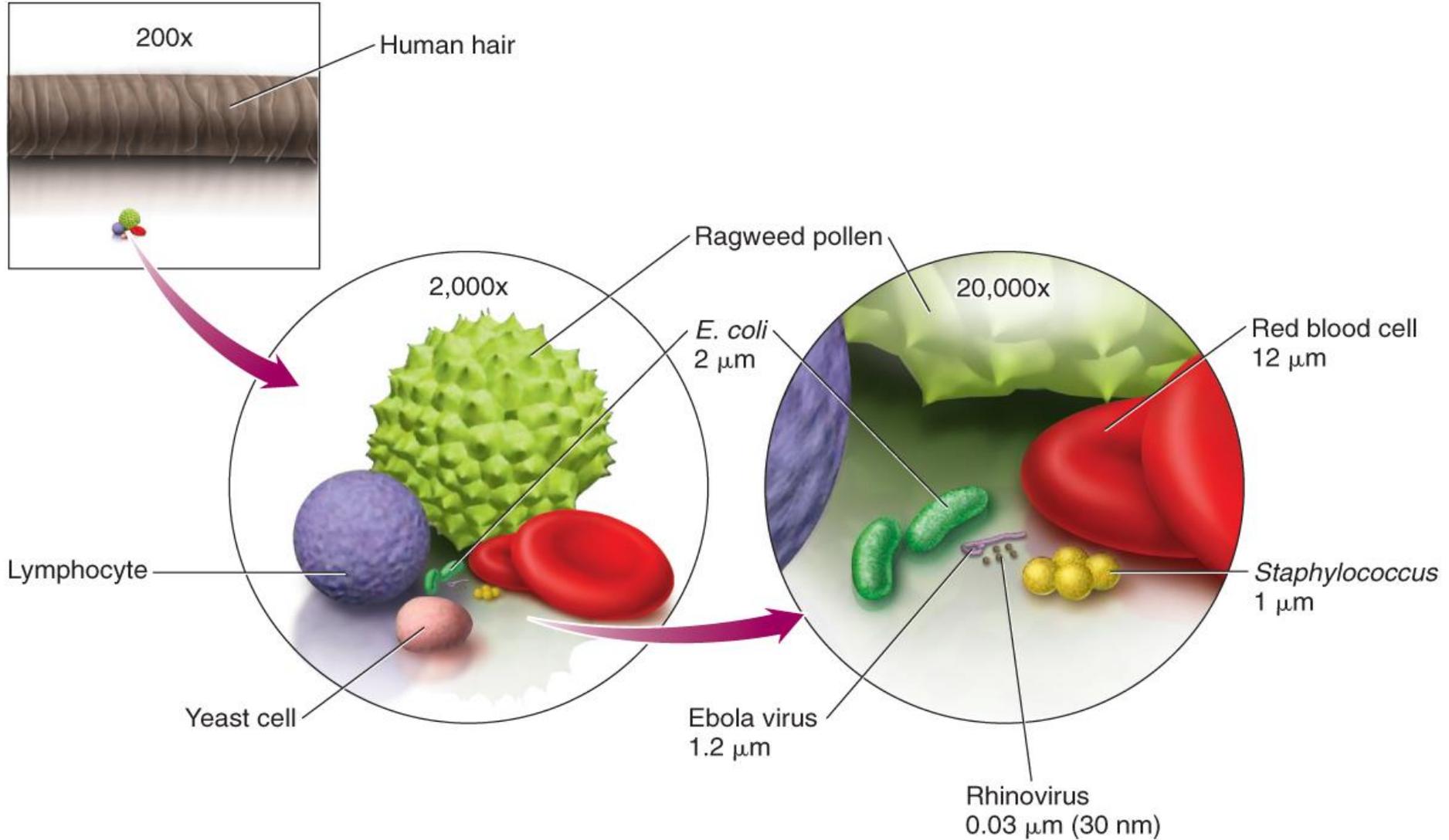


Figure 4.25