

Lecture 5  
BT 206  
16/01/23

By Prof Manish Kumar

# Prokaryotic and Eukaryotic Cells

- **Prokaryote** comes from the Greek words for prenucleus.
- **Eukaryote** comes from the Greek words for true nucleus.

# Prokaryote

- One circular chromosome, not in a membrane
- No histones
- No organelles
- Peptidoglycan cell walls if Bacteria
- Pseudomurein cell walls if Archaea
- Binary fission

# Eukaryote

- Paired chromosomes, in nuclear membrane
- Histones
- Organelles
- Polysaccharide cell walls
- Mitotic spindle

# Prokaryotic Cells: Shapes

- Average size:  $0.2 - 1.0 \mu\text{m} \times 2 - 8 \mu\text{m}$
- Most bacteria are monomorphic
- A few are pleiomorphic



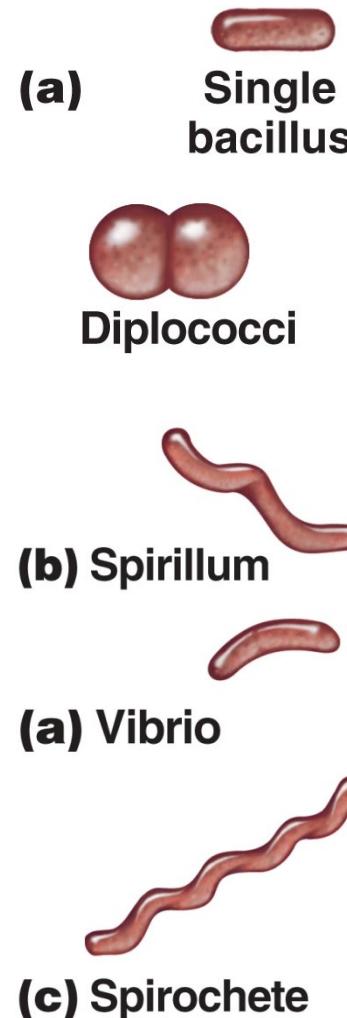
**(a) Peritrichous**

SEM

$0.5 \mu\text{m}$

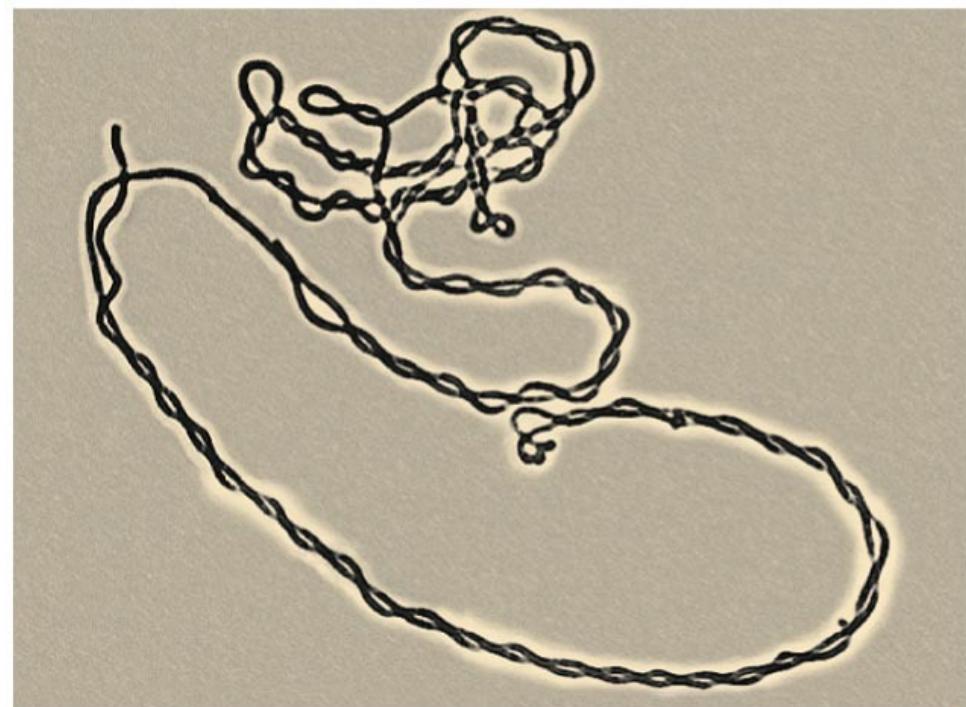
# Basic Shapes

- Bacillus (rod-shaped)
- Coccus (spherical)
- Spiral
  - Spirillum
  - Vibrio
  - Spirochete



# *Bacillus* (Specific genus) or *Bacillus* (bacterial shape)

- Scientific name: *Bacillus* (*Bacillus anthracis*)
- Shape: Bacillus

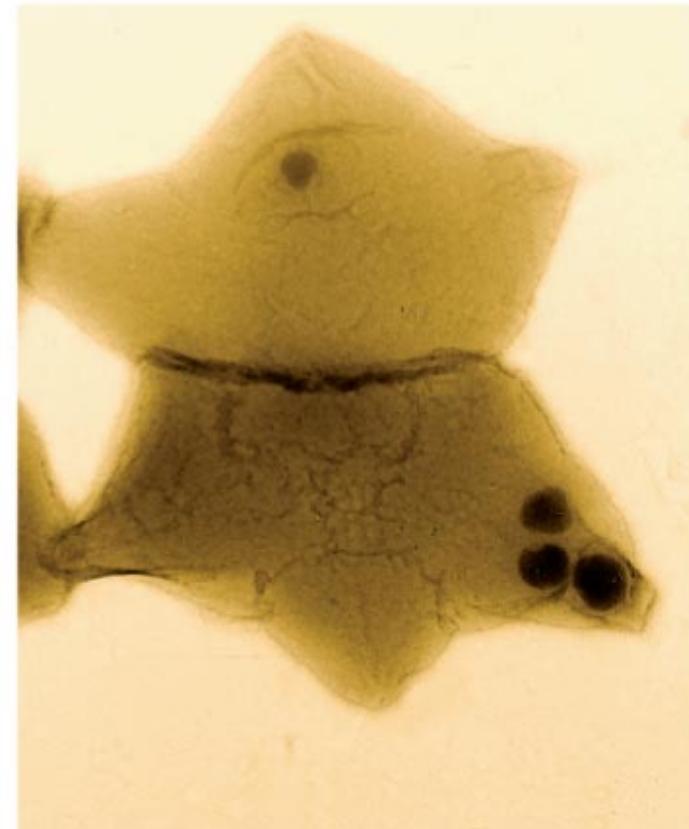
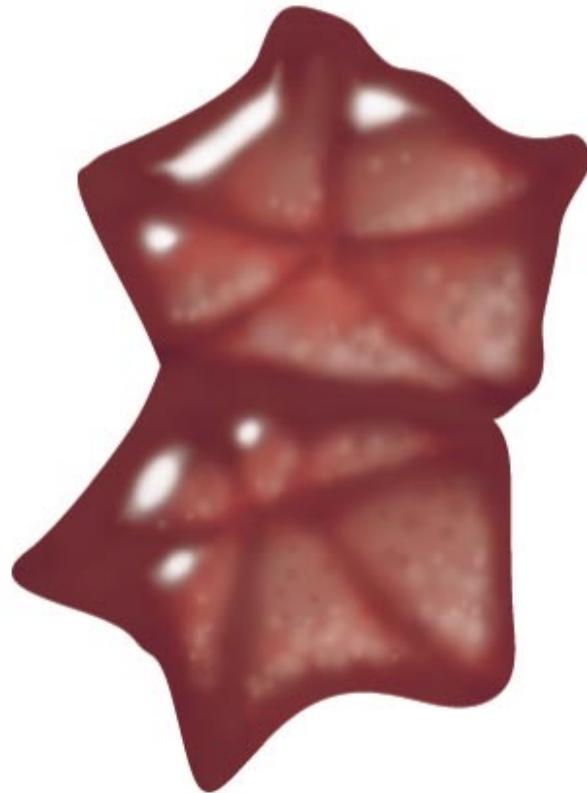


A double-stranded helix  
formed by *Bacillus subtilis*



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# Unusually Shaped Bacteria



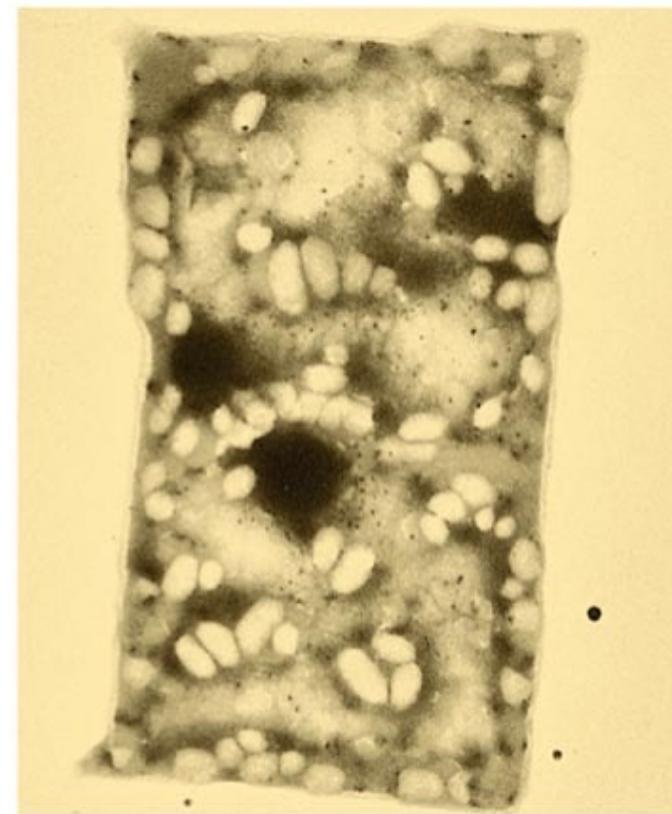
**(a)** Star-shaped bacteria

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TEM

0.5  $\mu\text{m}$

# Unusually Shaped Bacteria



TEM

0.5  $\mu\text{m}$

**(b)** Rectangular bacteria

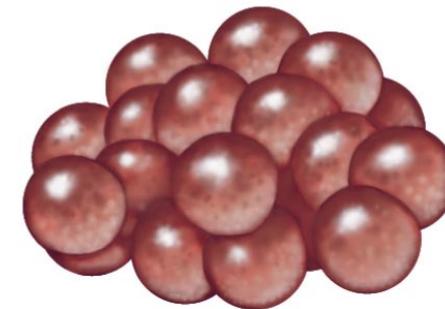
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# Arrangements

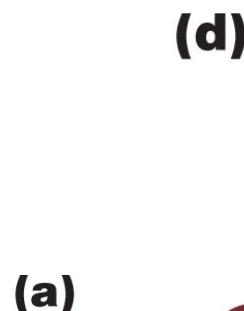
- Pairs: Diplococci, diplobacilli



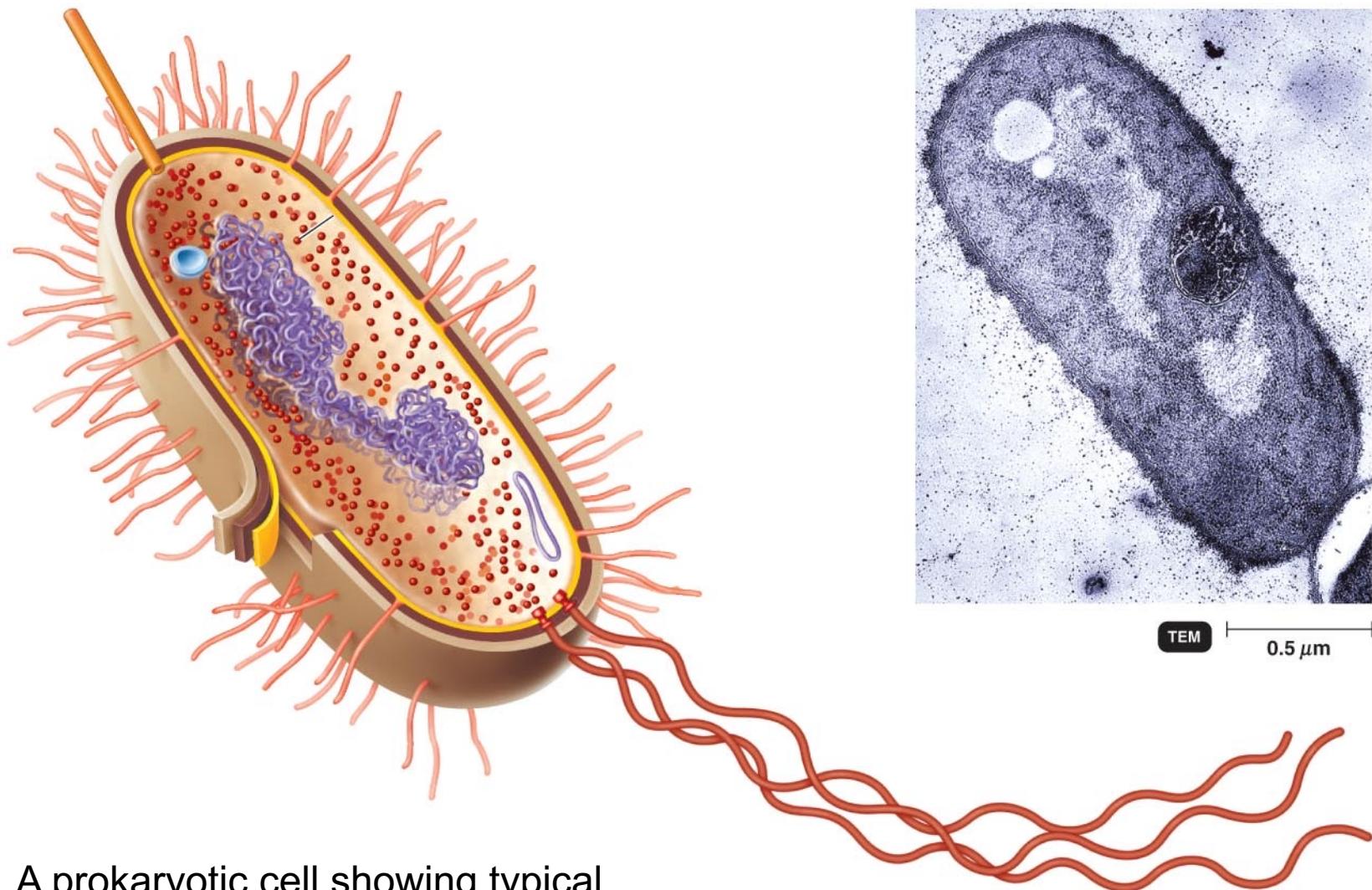
- Clusters: Staphylococci



- Chains: Streptococci, streptobacilli



# The Structure of a Prokaryotic Cell

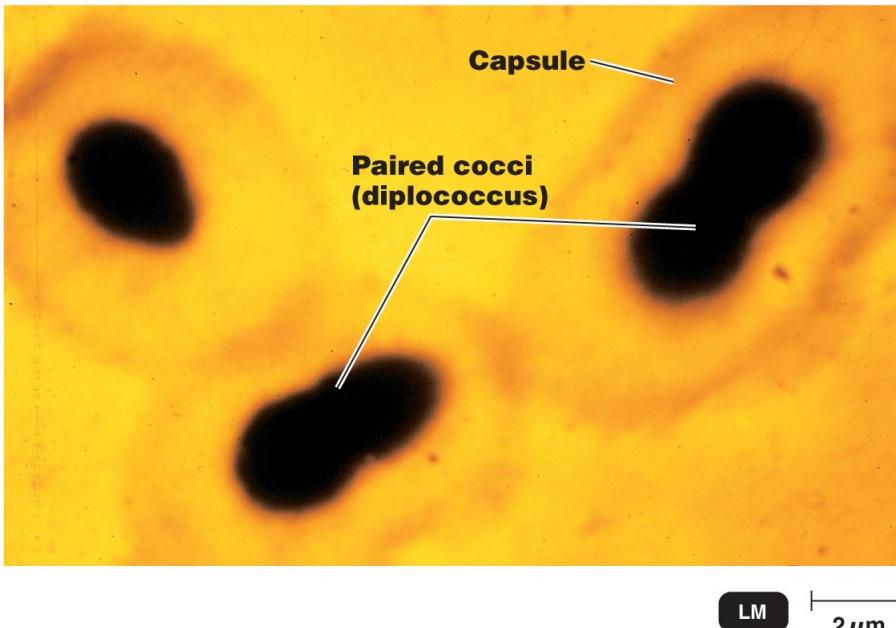


A prokaryotic cell showing typical structures

## Structures external to Cell Wall: Glycocalyx, flagella, axial filaments, fimbriae, and pili

### Glycocalyx (sugar coat)

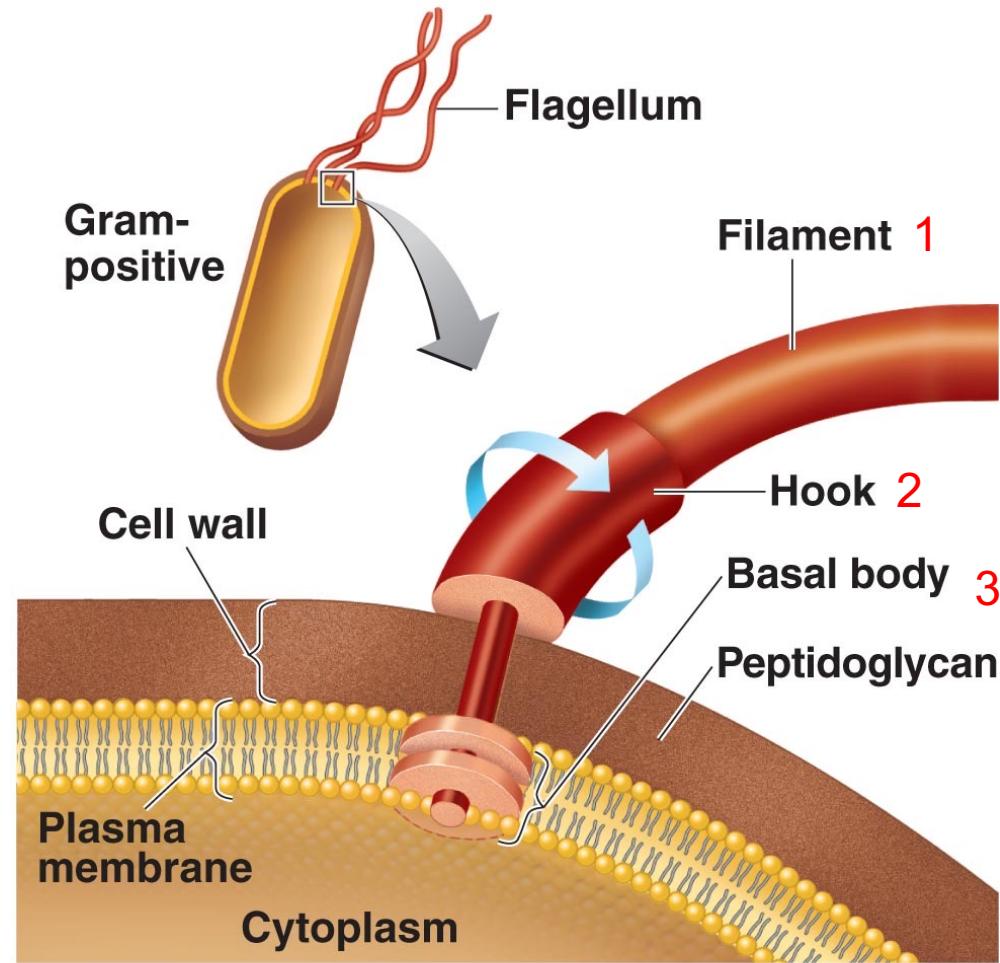
- Outside cell wall
- Usually sticky
- **Capsule:** neatly organized.  
Ex: *B. anthracis*, *S. pneumoniae*



- **Slime layer:** unorganized and loose
- Extracellular polysaccharide allows cell to attach
- Capsules prevent phagocytosis

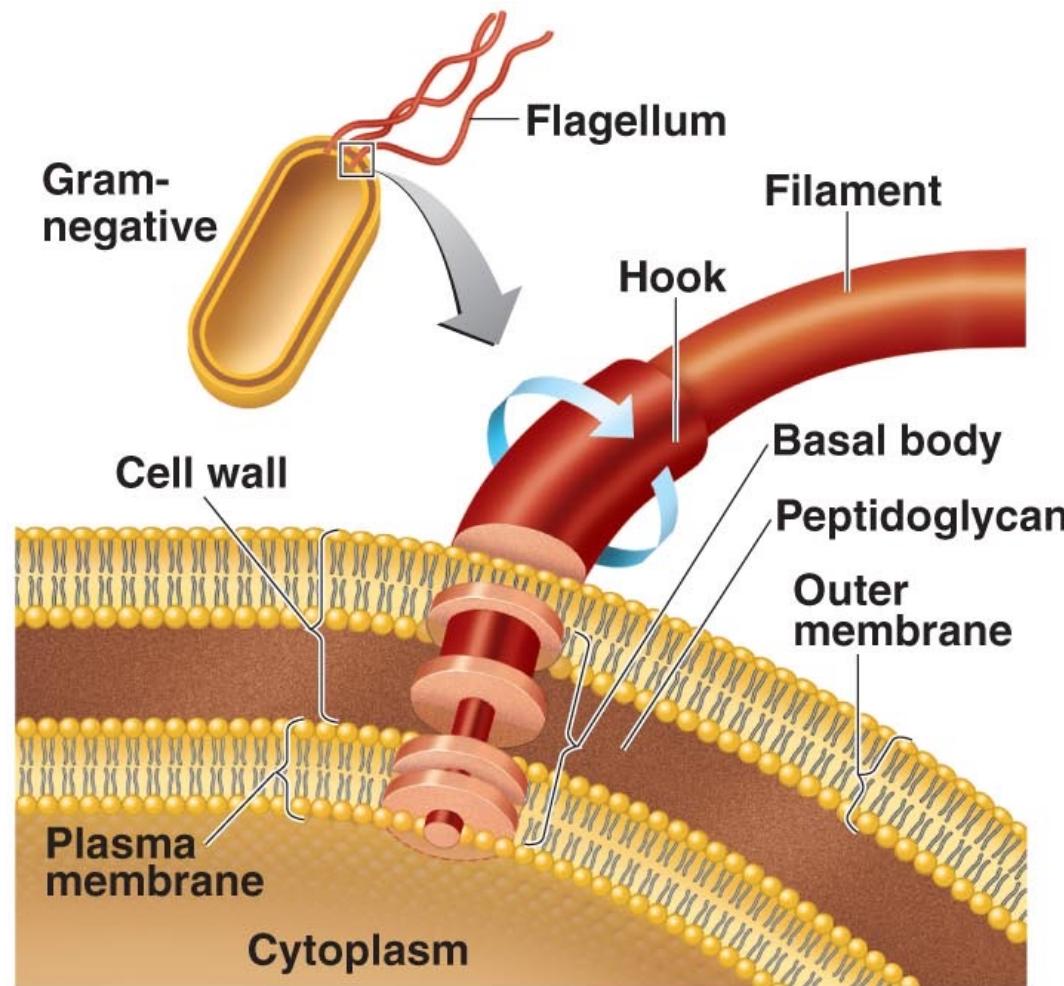
# Flagella (whip)

- Outside cell wall
- Made of chains of flagellin
- Attached to a protein hook
- Anchored to the wall and membrane by the basal body



**(b) Parts and attachment of a flagellum of a gram-positive bacterium**

# The Structure of a Prokaryotic Flagellum



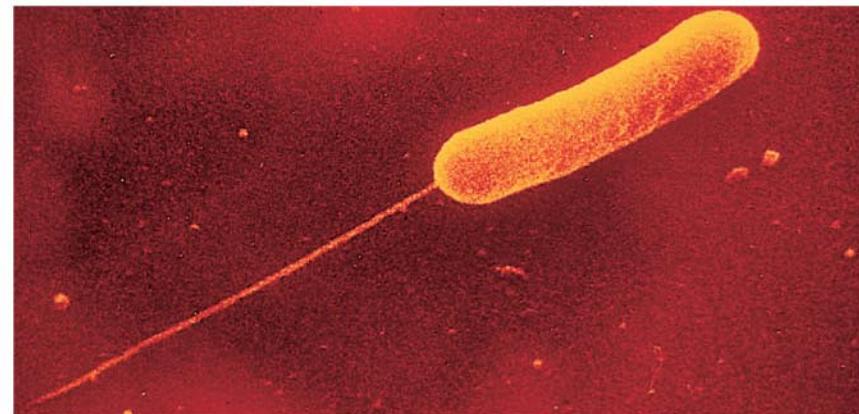
**(a) Parts and attachment of a flagellum of a gram-negative bacterium**

# Arrangements of Bacterial Flagella



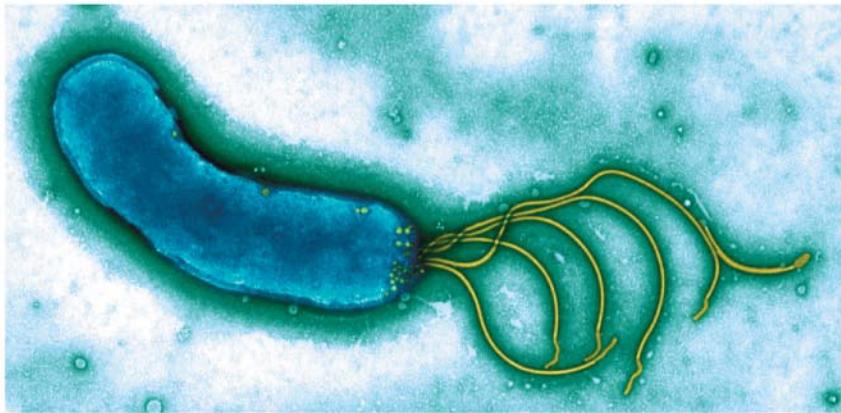
**(a) Peritrichous**

SEM 0.5  $\mu\text{m}$



**(b) Monotrichous and polar**

SEM 0.5  $\mu\text{m}$



**(c) Lophotrichous and polar**

SEM 0.5  $\mu\text{m}$



**(d) Amphitrichous and polar**

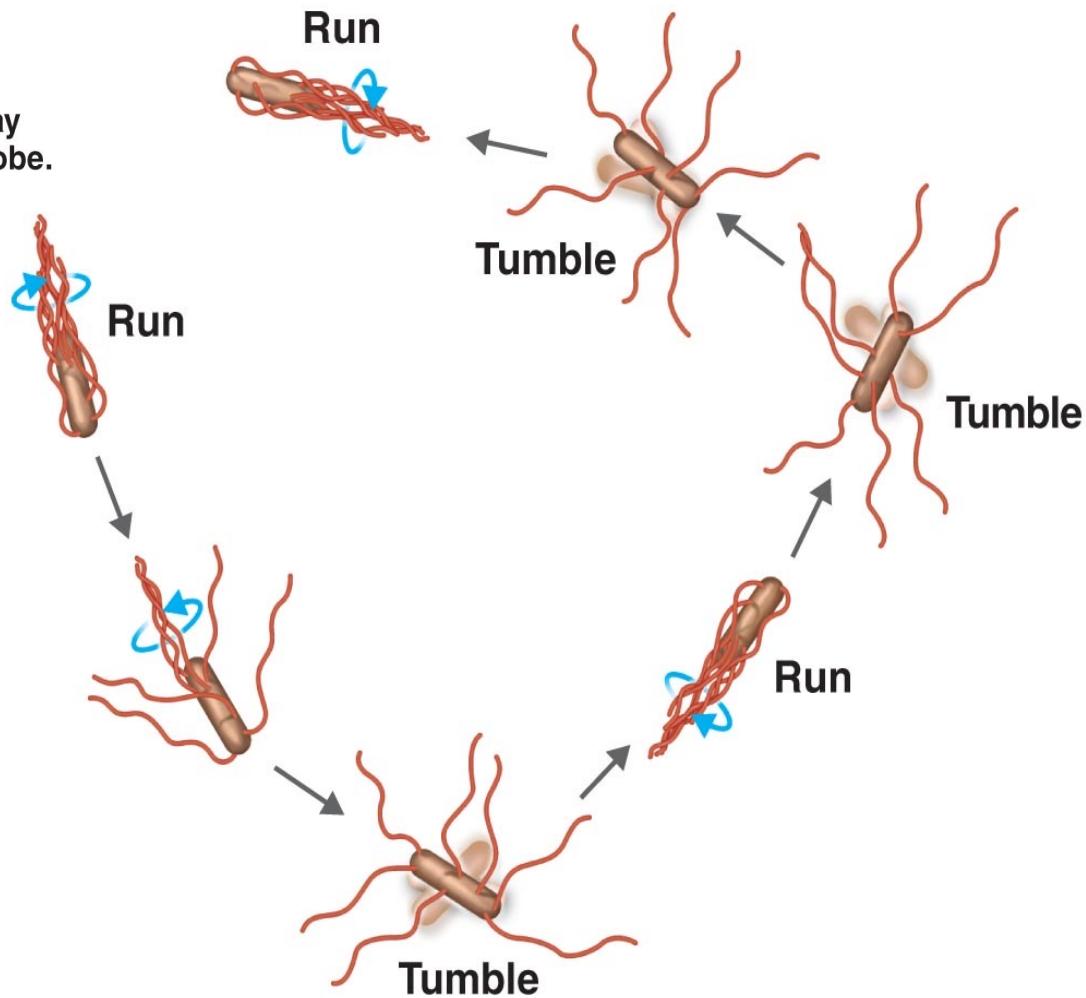
SEM 5  $\mu\text{m}$

# Motile Cells

- Rotate flagella to run or tumble
- Move toward or away from stimuli (**taxis**)
- Flagella proteins are H antigens  
(e.g., *E. coli* O157:H7)

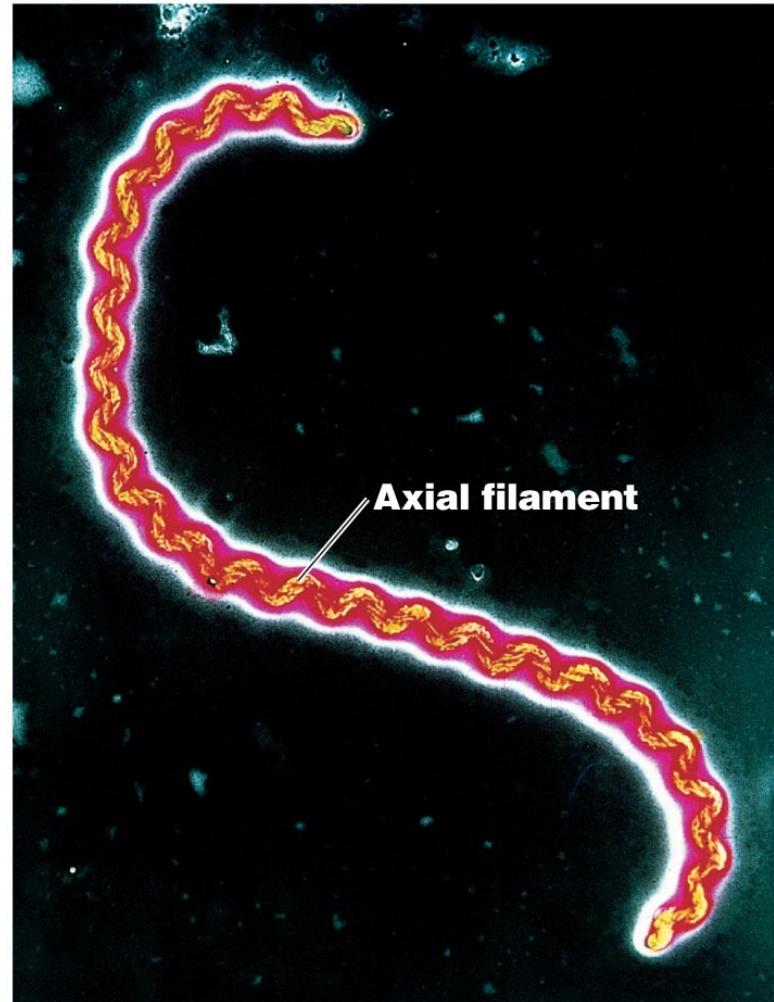
# Motile Cells

(a) A bacterium running and tumbling. Notice that the direction of flagellar rotation (blue arrows) determines which of these movements occurs. Gray arrows indicate direction of movement of the microbe.



# Axial Filaments

- Also called **endoflagella**
- In spirochetes
- Anchored at one end of a cell
- Rotation causes cell to move

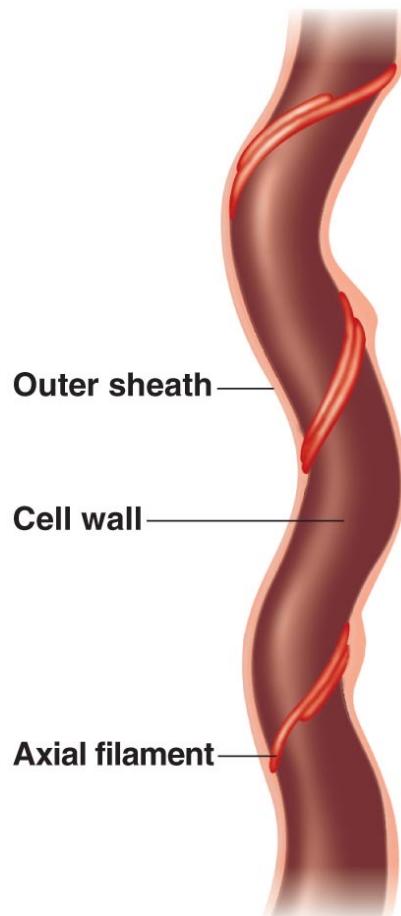


(a) A photomicrograph of the spirochete *Leptospira*, showing an axial filament

SEM 1  $\mu\text{m}$

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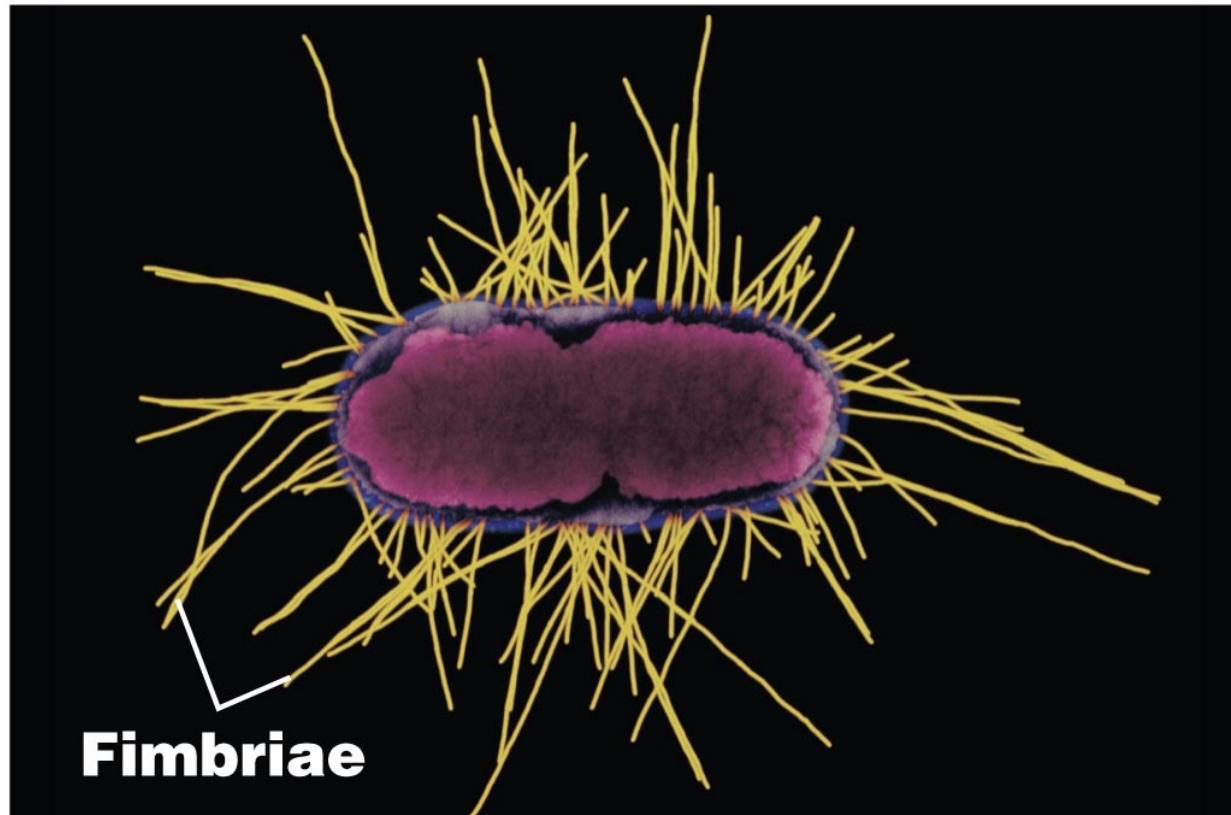
# A Diagram of Axial Filaments



**(b)** A diagram of axial filaments wrapping around part of a spirochete. (See Figure 11.24a for a cross section of axial filaments)

# Fimbriae and Pili

- Fimbriae allow attachment
- Made up of pilin protein



TEM

1  $\mu\text{m}$

Figure 4.11

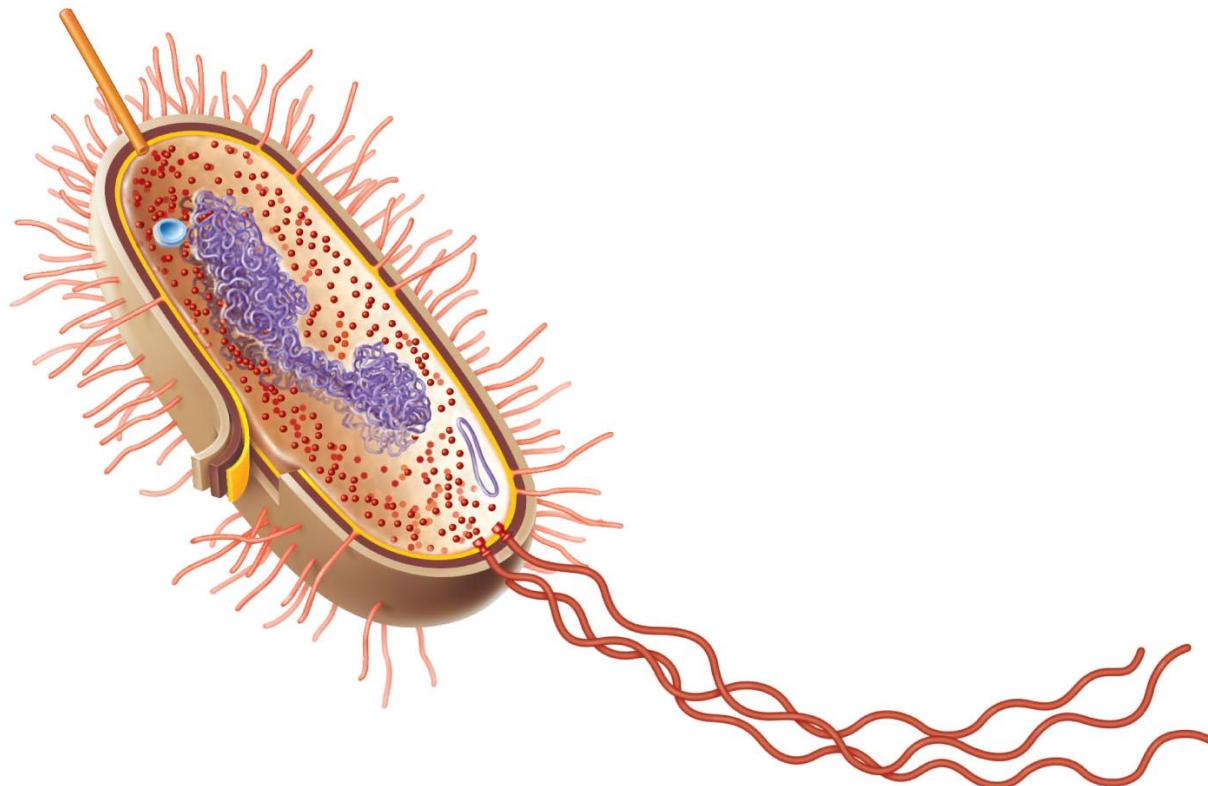
# Fimbriae (singular: fimbria) and Pili (singular: pilus)

- Pili

- Facilitate transfer of DNA from one cell to another (conjugation)
- Usually longer than fimbriae and number only one or two per cell.
- **Gliding** motility
- **Twitching** motility

# The Cell Wall

- Prevents osmotic lysis
- Made of **peptidoglycan** (in bacteria)

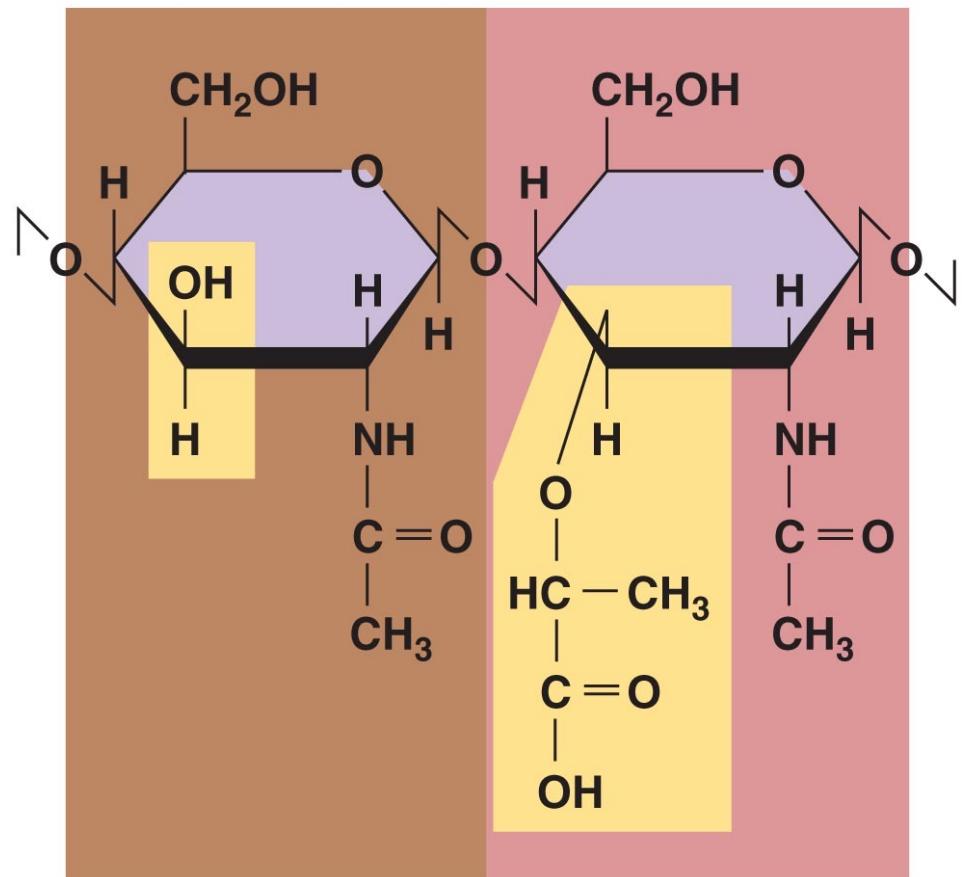


# Peptidoglycan

(also known as murein)

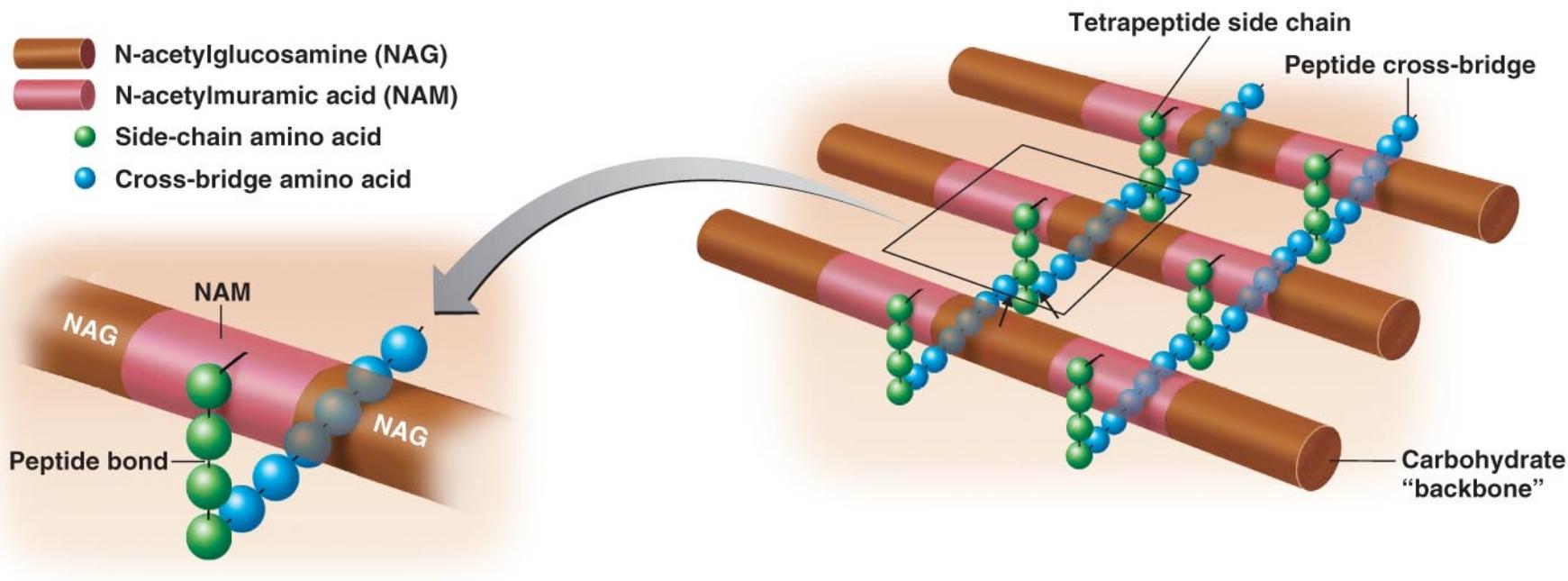
- Polymer of disaccharide:
  - N-acetylglucosamine (NAG)
  - N-acetylmuramic acid (NAM)
  - $\beta$ -1,4 linkage

N-acetylglucosamine (NAG)      N-acetylmuramic acid (NAM)



# Peptidoglycan in Gram-Positive Bacteria

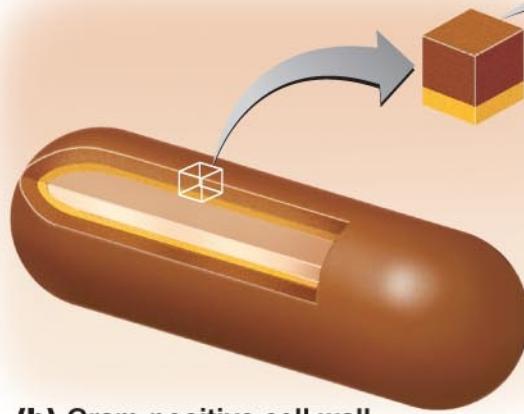
- Linked by polypeptides



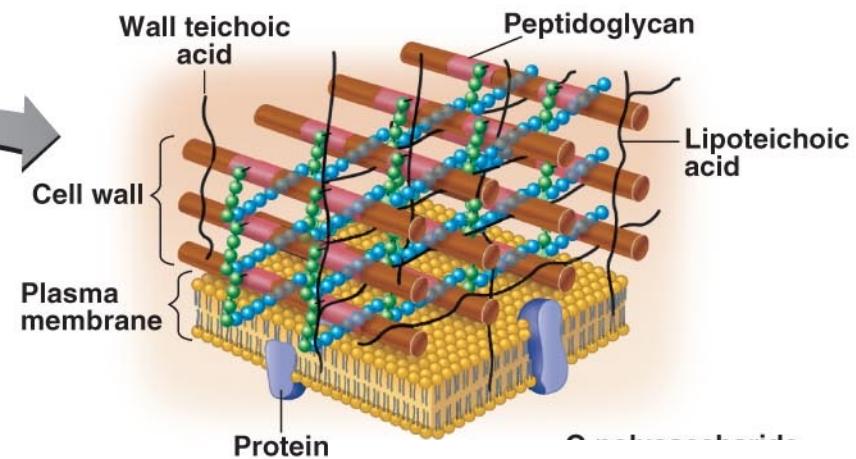
The small arrows indicate where penicillin interferes with the linkage of peptidoglycan rows by peptide cross-bridges

# Gram-Positive Bacterial Cell Wall

- N-acetylglucosamine (NAG)
- N-acetylmuramic acid (NAM)
- Side-chain amino acid
- Cross-bridge amino acid



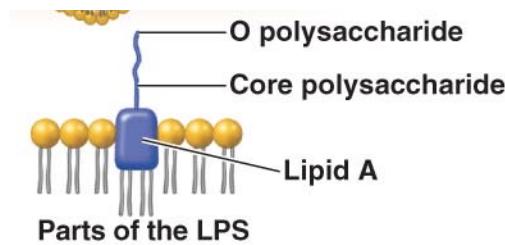
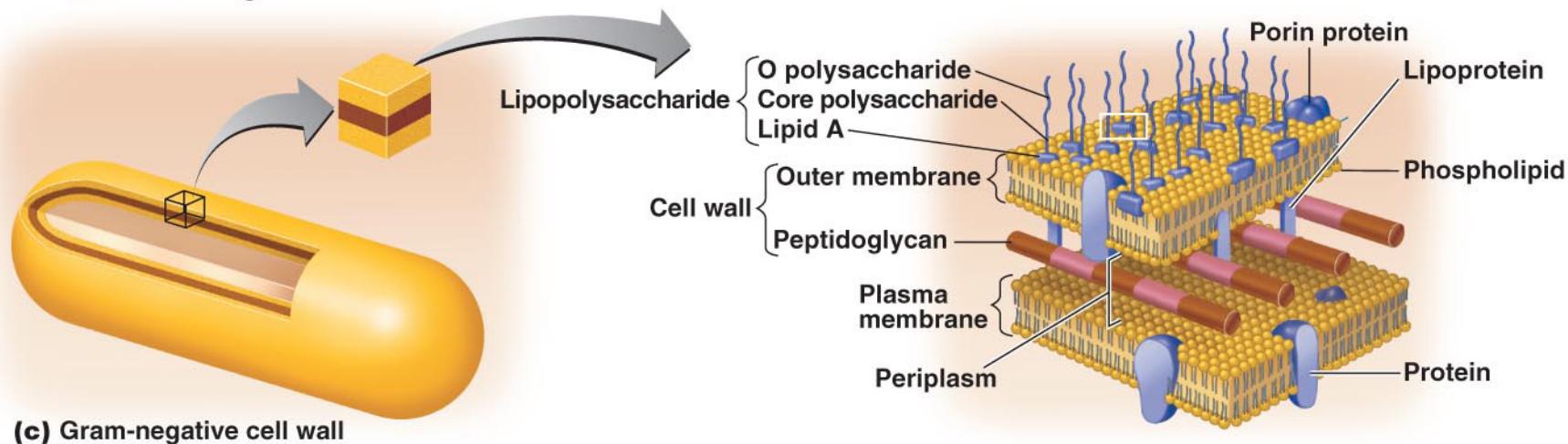
**(b)** Gram-positive cell wall



Parts of the cell wall

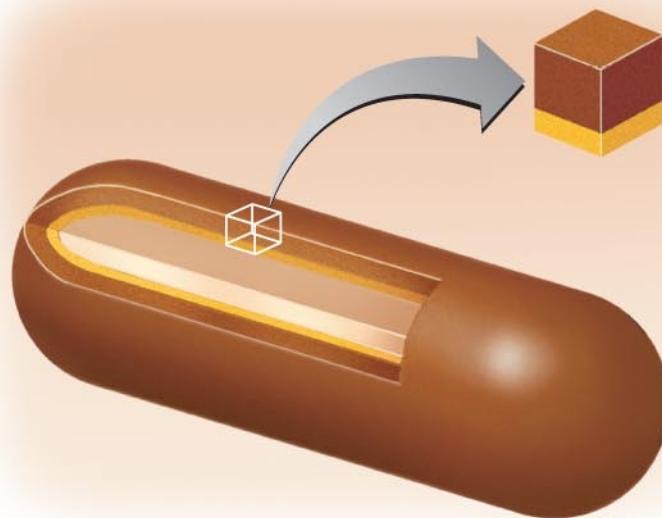
# Gram-Negative Bacterial Cell Wall

- N-acetylglucosamine (NAG)
- N-acetylmuramic acid (NAM)
- Side-chain amino acid
- Cross-bridge amino acid



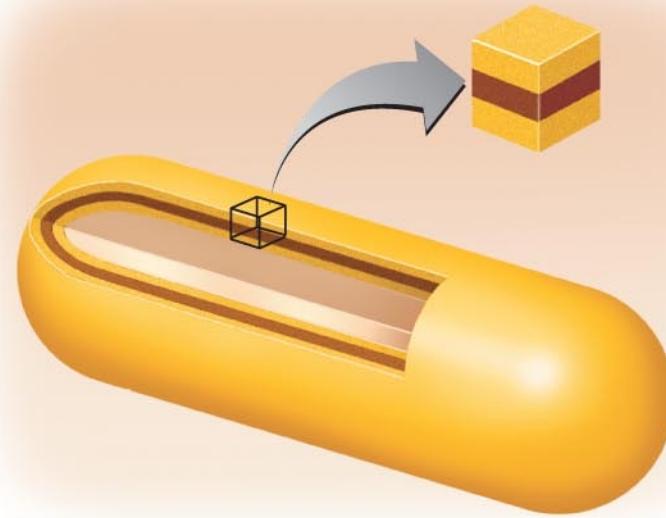
# Gram-positive Cell Wall

- Thick peptidoglycan
- Teichoic acids



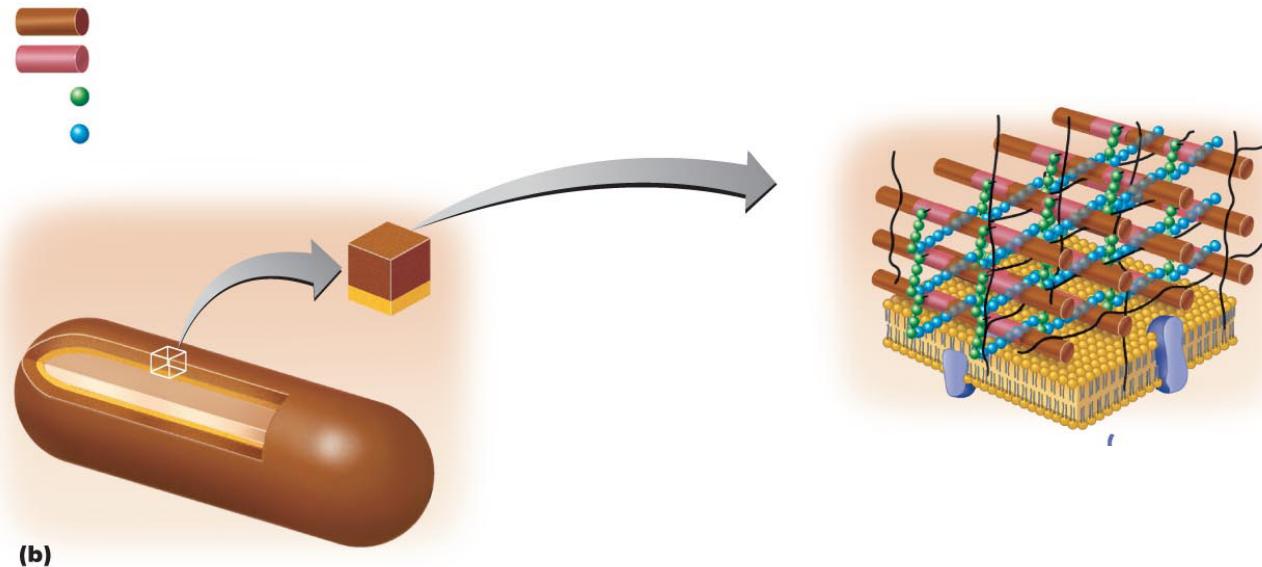
# Gram-negative Cell Wall

- Thin peptidoglycan
- Outer membrane
- Periplasmic space

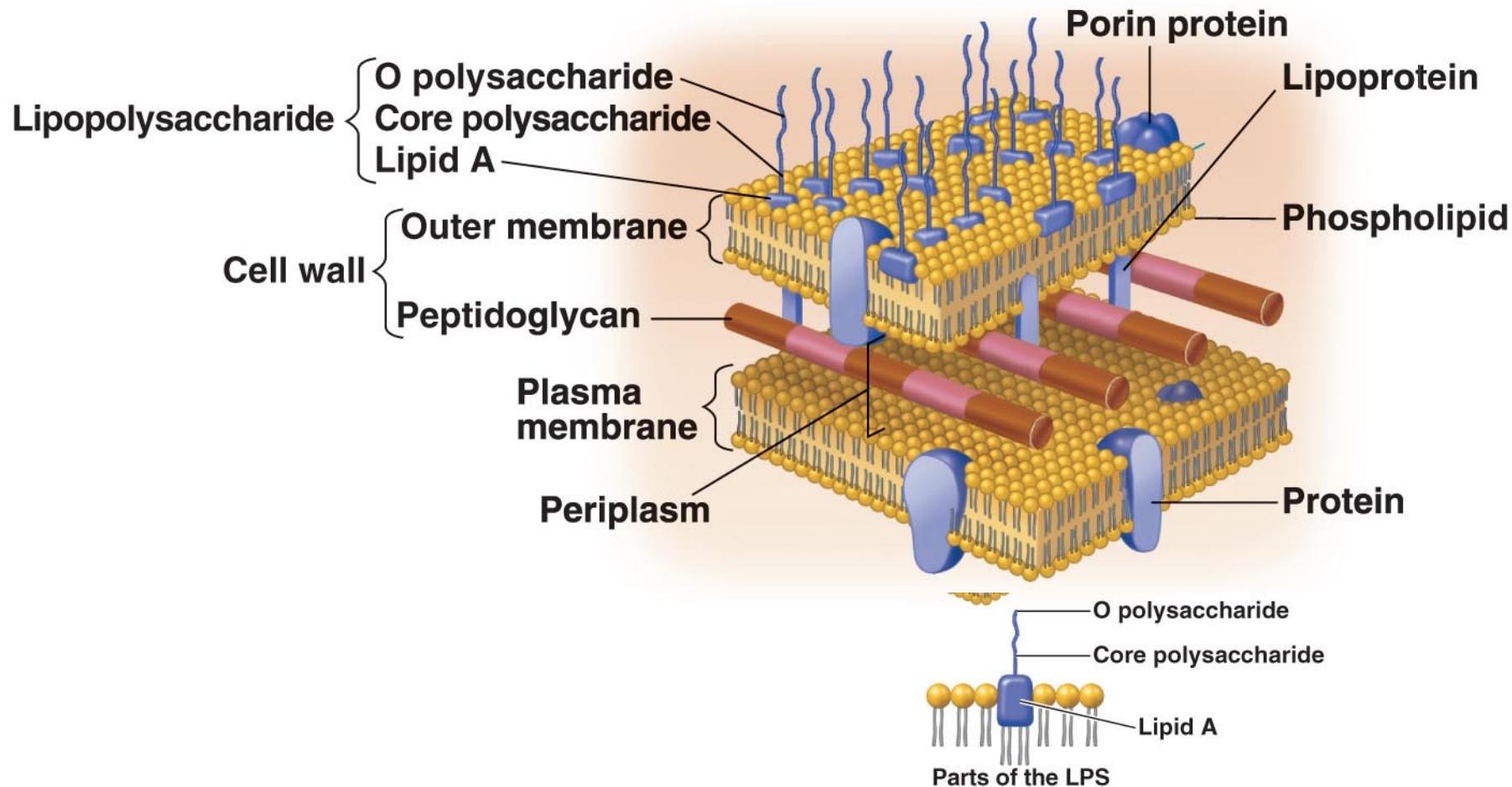


# Gram-Positive Cell Walls

- Teichoic acids
  - Lipoteichoic acid links to plasma membrane
  - Wall teichoic acid links to peptidoglycan
- May regulate movement of cations
- Polysaccharides provide antigenic variation

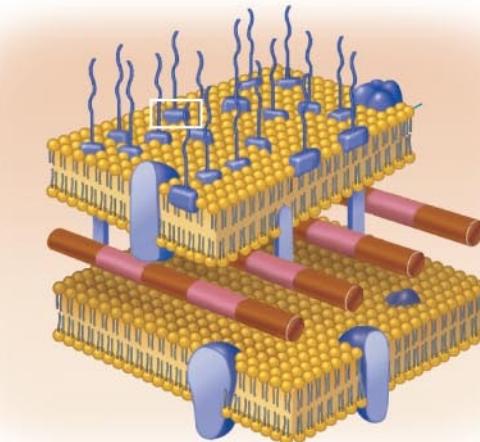
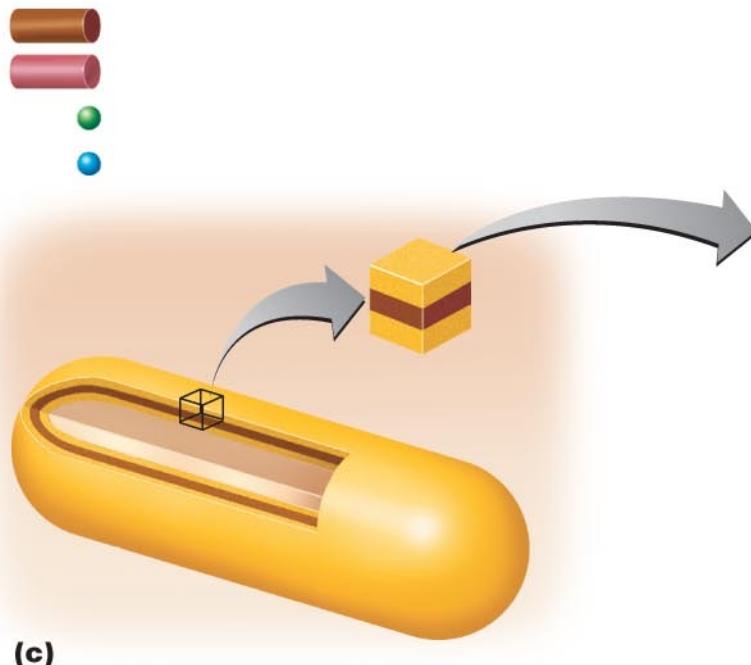


# Gram-Negative Cell Wall



# Gram-Negative Outer Membrane

- Lipopolysaccharides, lipoproteins, phospholipids
- Forms the periplasm between the outer membrane and the plasma membrane



# Gram-Negative Outer Membrane

- Protection from phagocytes, complement, and antibiotics
- **O polysaccharide** antigen, e.g., *E. coli* O157:H7
- **Lipid A** is an endotoxin
- **Porins** (proteins) form channels through membrane

# The Gram Stain



LM  
4  $\mu$ m

**(a) Gram-Positive**



LM  
4  $\mu$ m

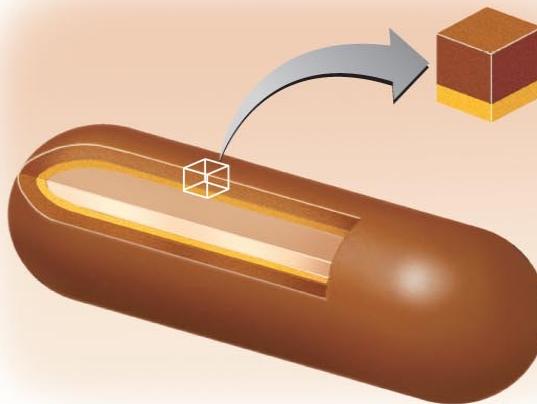
**(b) Gram-Negative**

# The Gram Stain Mechanism

- Crystal violet-iodine crystals form in cell
- Gram-positive
  - Alcohol dehydrates peptidoglycan
  - CV-I crystals do not leave
- Gram-negative
  - Alcohol dissolves outer membrane and leaves holes in peptidoglycan
  - CV-I washes out

# Gram-Positive Cell Wall

- 2-ring basal body
- Disrupted by lysozyme
- Penicillin sensitive



# Gram-Negative Cell Wall

- 4-ring basal body
- Endotoxin
- Tetracycline sensitive

