Chapter 27A:
Bacteria and Archaea

1. Extracellular Prokaryotic Structures
2. Intracellular Prokaryotic Structures
3. Genetic Diversity Prokaryotes

1. Extracellular Prokaryotic Structures

Prokaryotic Cell Shape

cocci

Spherical

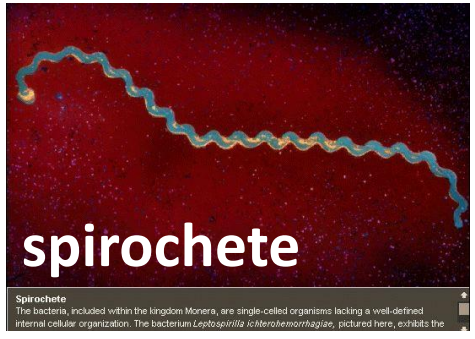
bacilli

Rod-shaped

spirilla

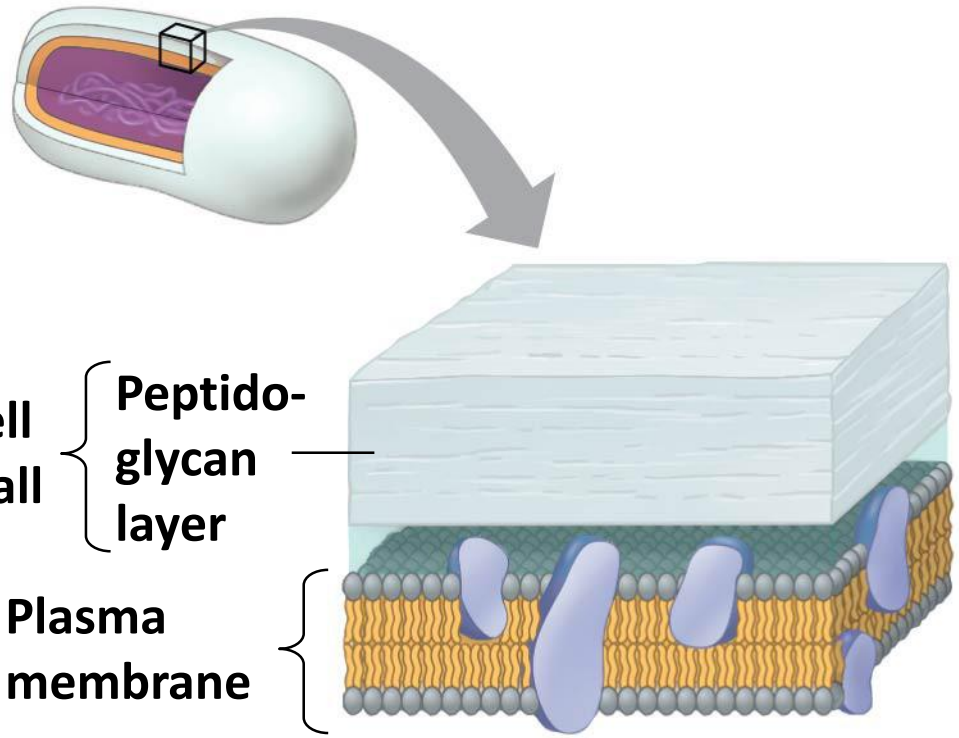
Spiral

- spherical prokaryotes are referred to as cocci
  (singular = coccus)
- rod-shaped prokaryotes are referred to as bacilli
  (singular = bacillus)
- rod-shaped cells can also be slightly curved (vibrio) or spiral (spirillum) or highly coiled (spirochete)



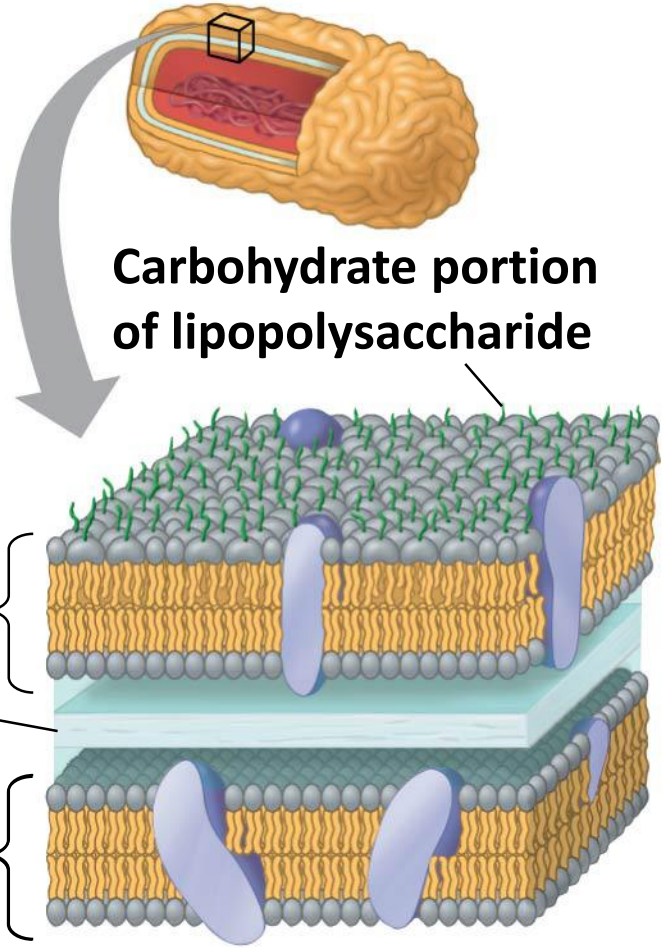
Bacterial Cell Wall Structure

(a) Gram-positive bacteria



Peptidoglycan traps crystal violet, which masks the safranin dye.

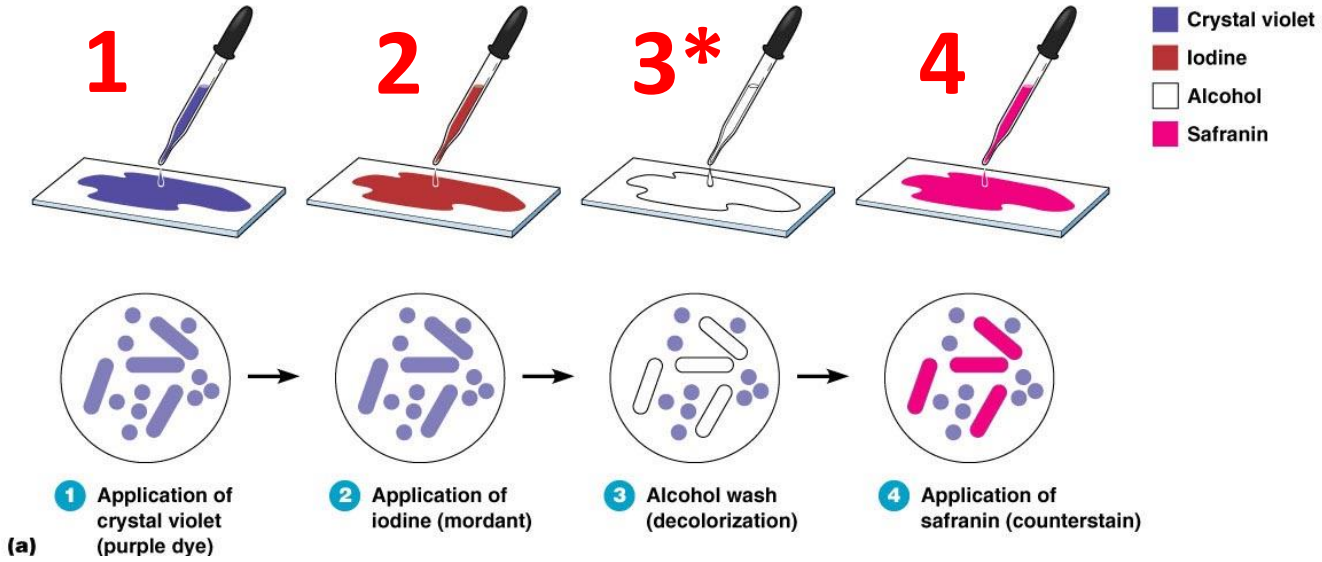
(b) Gram-negative bacteria



Crystal violet is easily rinsed away, revealing the red safranin dye.

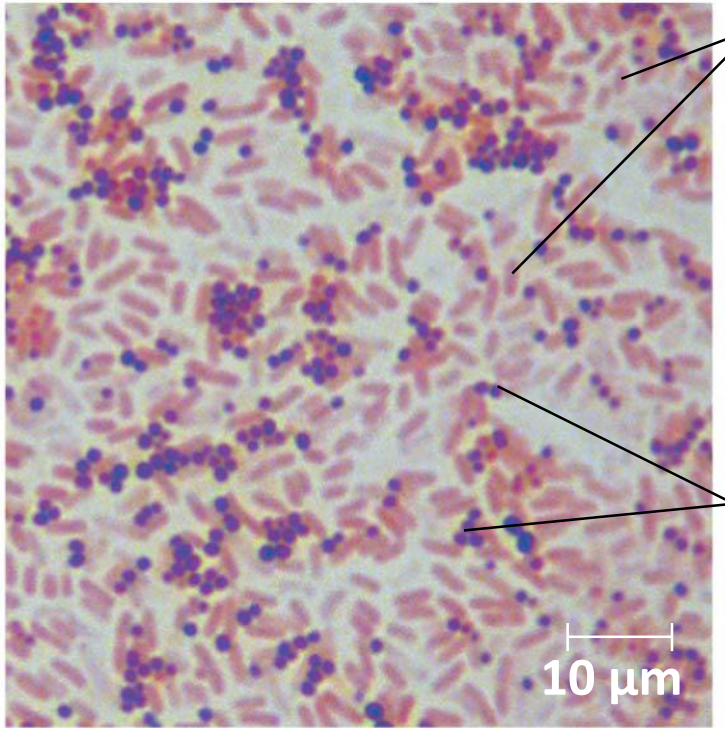
Gram Staining

A Gram stain is a very common stain to distinguish 2 bacterial types:



Gram negative

- **does NOT retain crystal violet, only the safranin**



A Gram stain of 2 distinct Bacterial Species

Gram positive

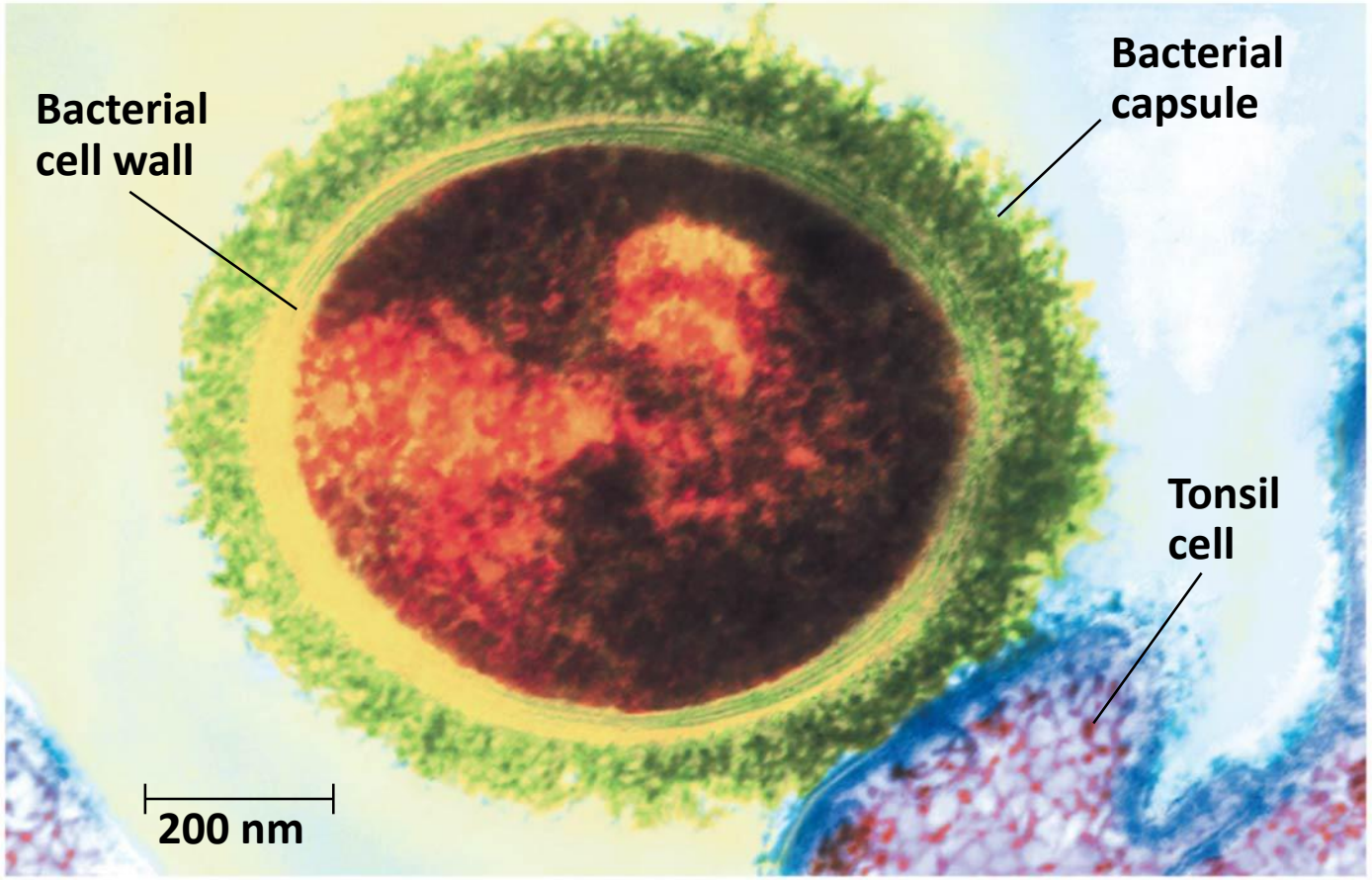
- **retains crystal violet due to *thick* peptidoglycan layer**

*** key step**

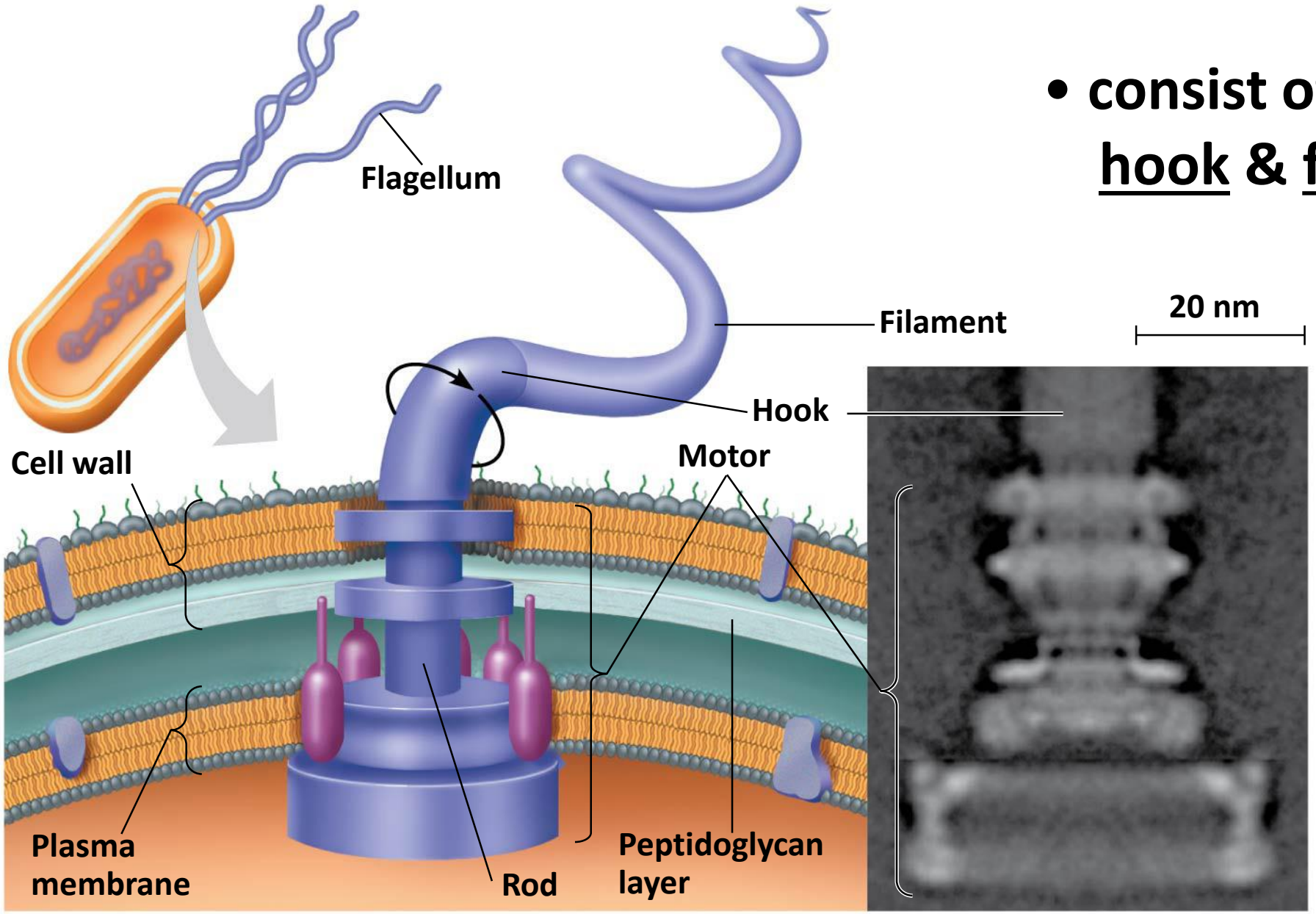
Capsules

A polysaccharide or protein layer called a capsule covers many prokaryotes.

- **mediates adhesion and the formation of biofilms**
- **protects the cell from dessication (drying out) and phagocytosis (being consumed by cells of the immune system)**



Bacterial Flagella

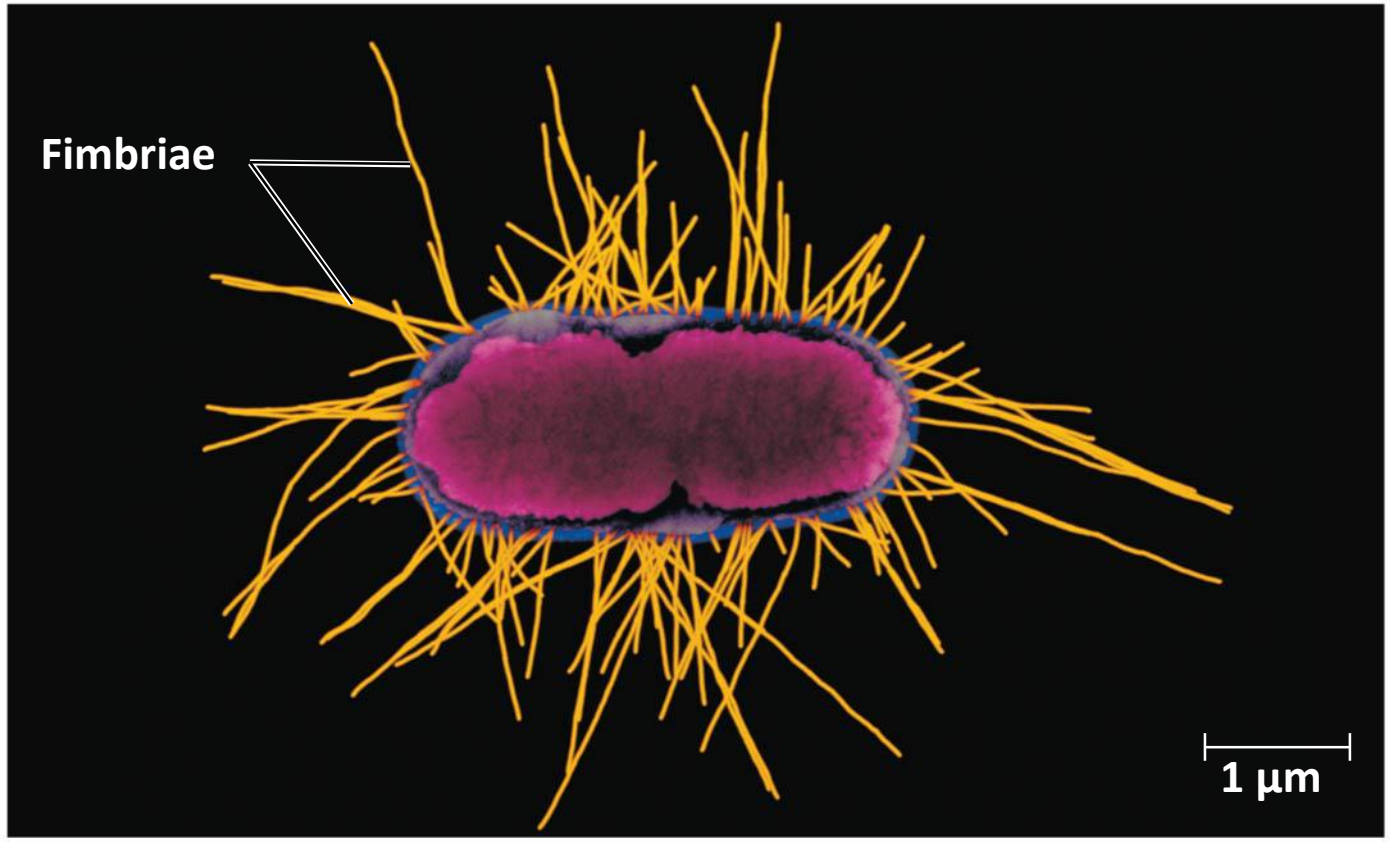


- consist of a basal body, hook & filament

- basal body anchors flagellum in the membrane and cell wall, and *rotates* the hook & filament to propel bacterium

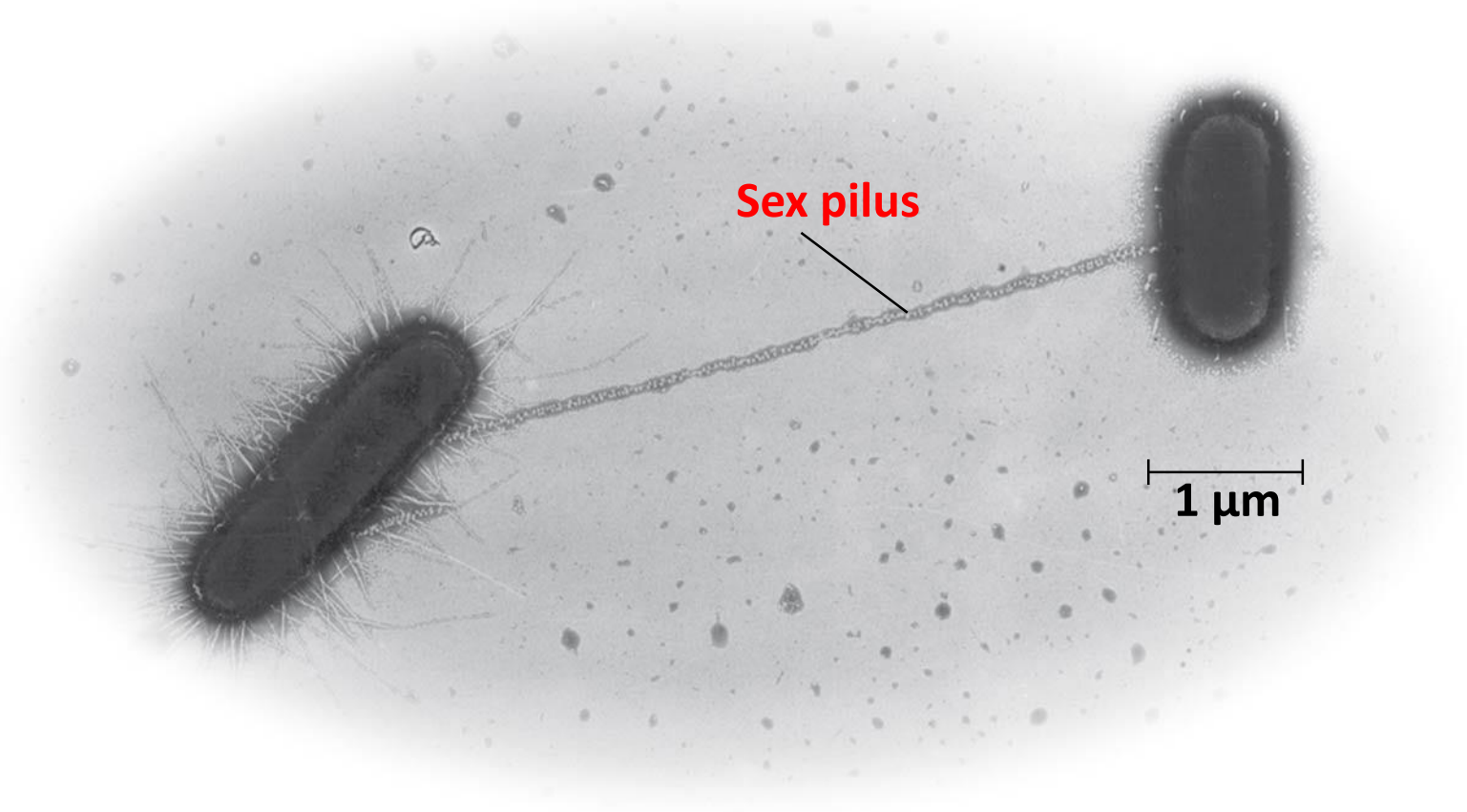
Fimbriae

Some prokaryotes have fimbriae (aka “pili”), which allow them to stick to their substrate or other individuals in a colony.



Sex Pilus

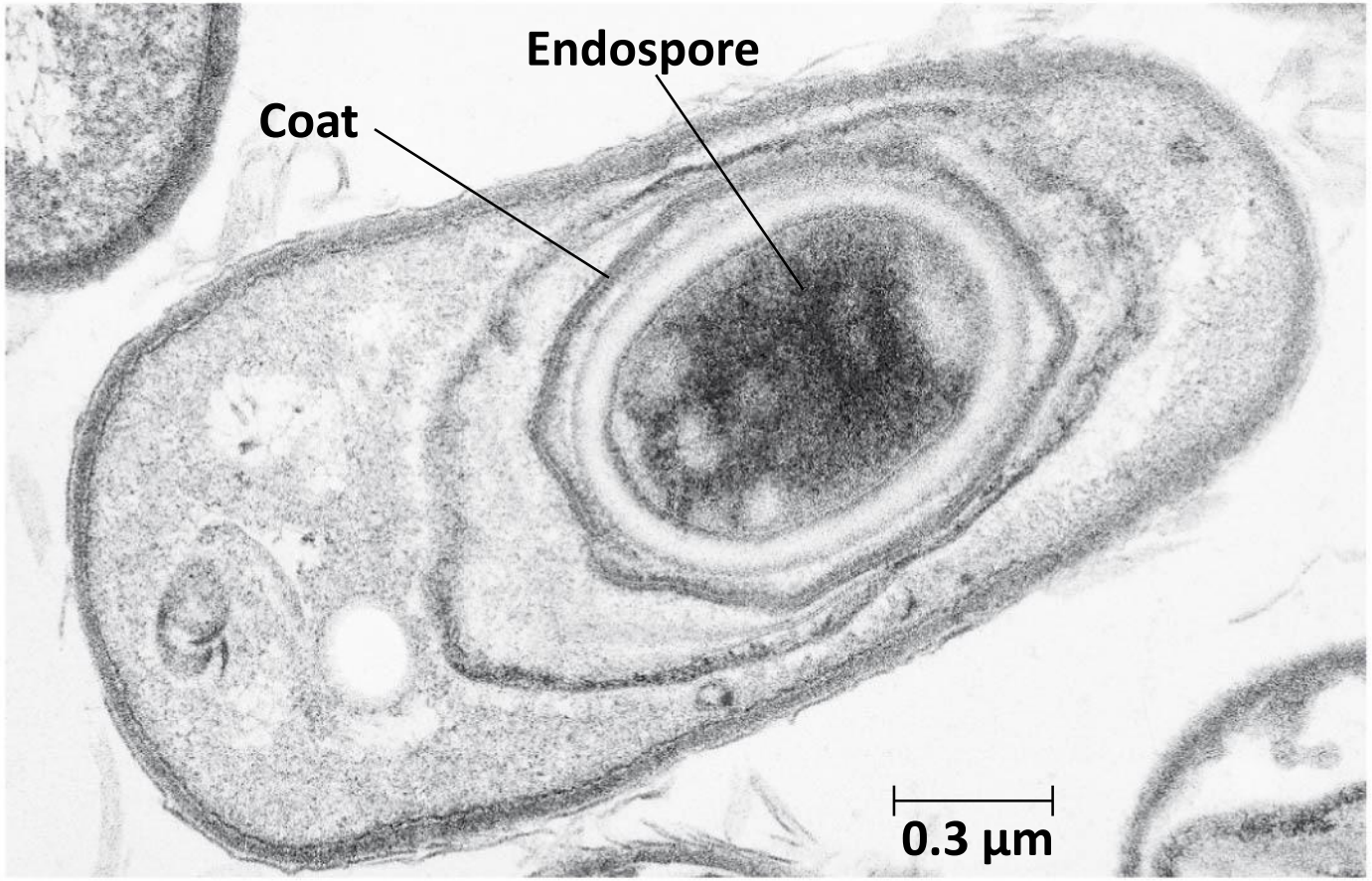
Sex pili are longer than fimbriae and allow prokaryotes to exchange DNA through a process called conjugation.



2. Intracellular Prokaryotic Structures

Endospores

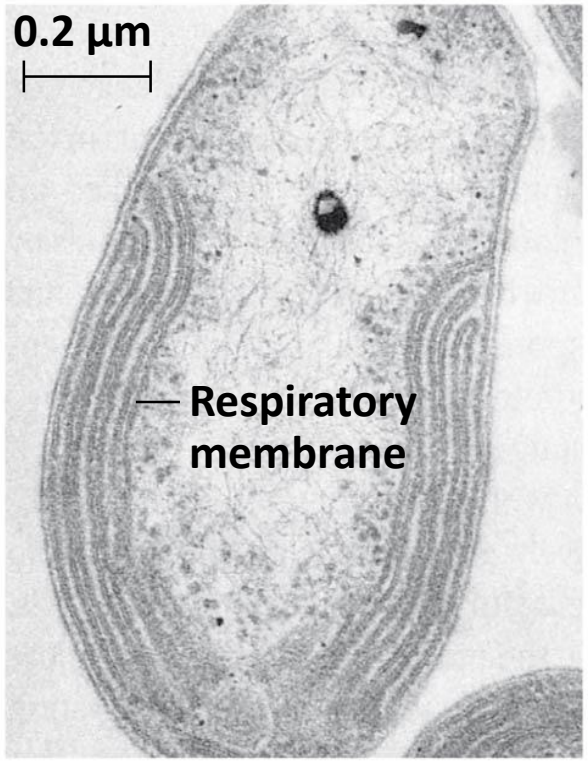
Some Gram-positive bacteria form metabolically inactive endospores which can remain viable in harsh conditions for centuries.



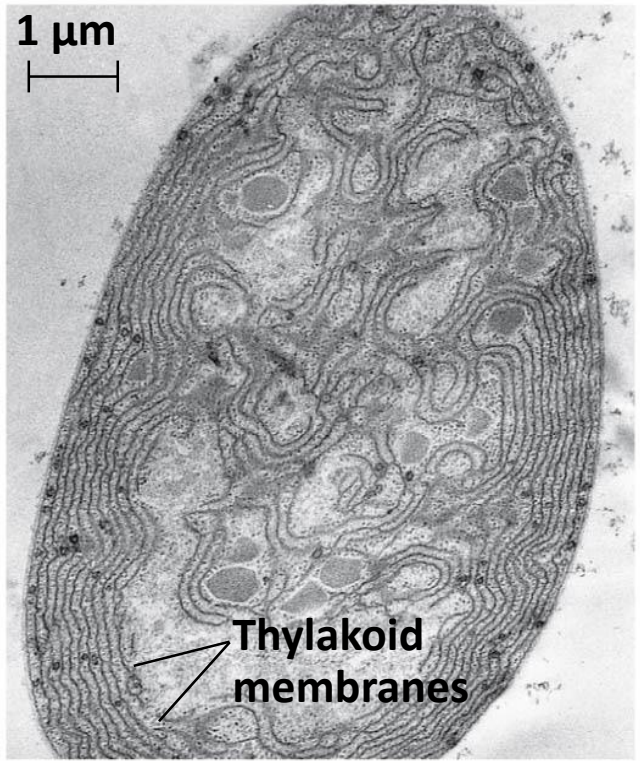
- **inactive, dormant cells enclosed in a highly resistant spore coat**
- **remain dormant until conditions improve**
- **very resistant to heating, freezing, dessication and damaging radiation (e.g. UV)**

Infoldings of the Cell Membrane

Some prokaryotes have highly folded membranes to increase the surface area for processes such as cellular respiration and photosynthesis.



(a) Aerobic prokaryote



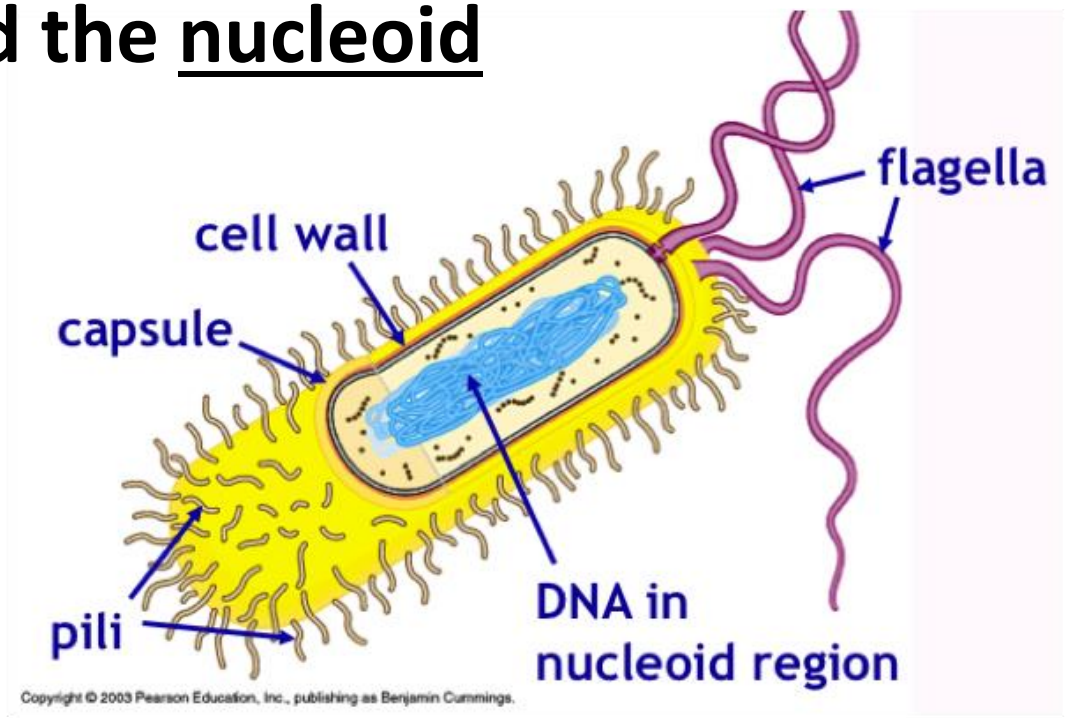
(b) Photosynthetic prokaryote

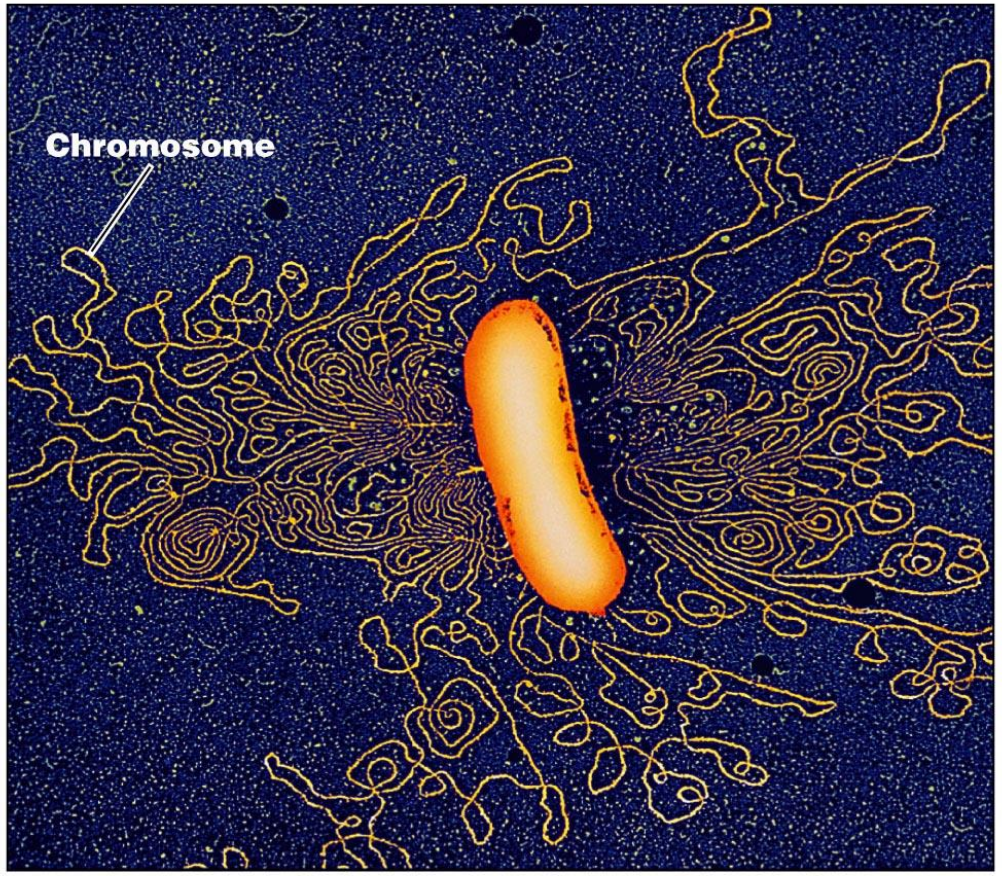
- such membrane infoldings are not considered to be true organelles such as those found in eukaryotes

Prokaryotic Chromosome

Prokaryotes typically have 1 circular DNA molecule that is the chromosome.

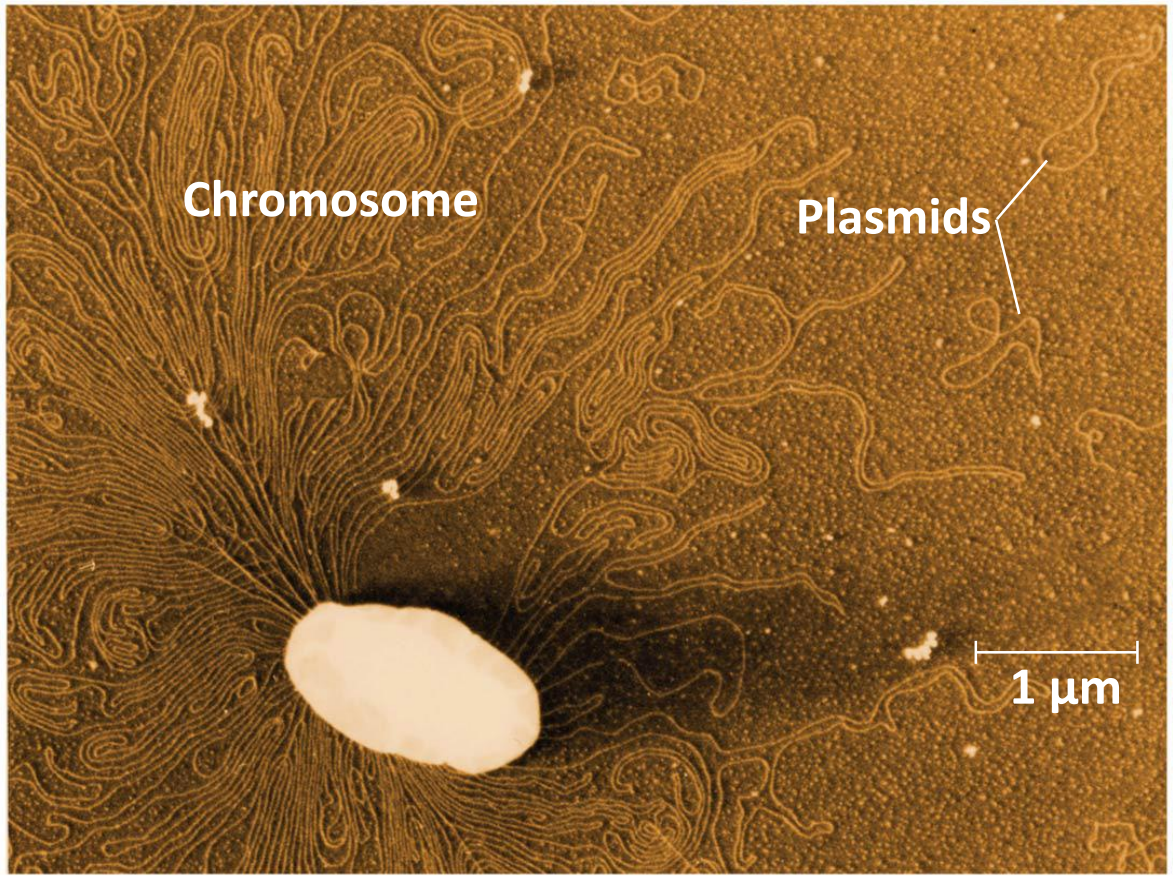
- **the prokaryotic chromosome is located in a region of the cell called the nucleoid**





Plasmids

Some bacteria have 1 or more small, extrachromosomal, non-essential circular DNA molecules called plasmids.



Plasmids generally contain genes that confer some sort of advantage for survival and reproduction:

- **protection from toxic substances (antibiotic resistance)**
- **toxins to kill competitors, enhance disease**
- **gene transfer by conjugation**

3. Genetic Diversity in Prokaryotes

Sources of Genetic Diversity in Prokaryotes

3 general factors contribute to prokaryotic diversity:

MUTATION

- **changes in DNA sequences**

RAPID REPRODUCTION

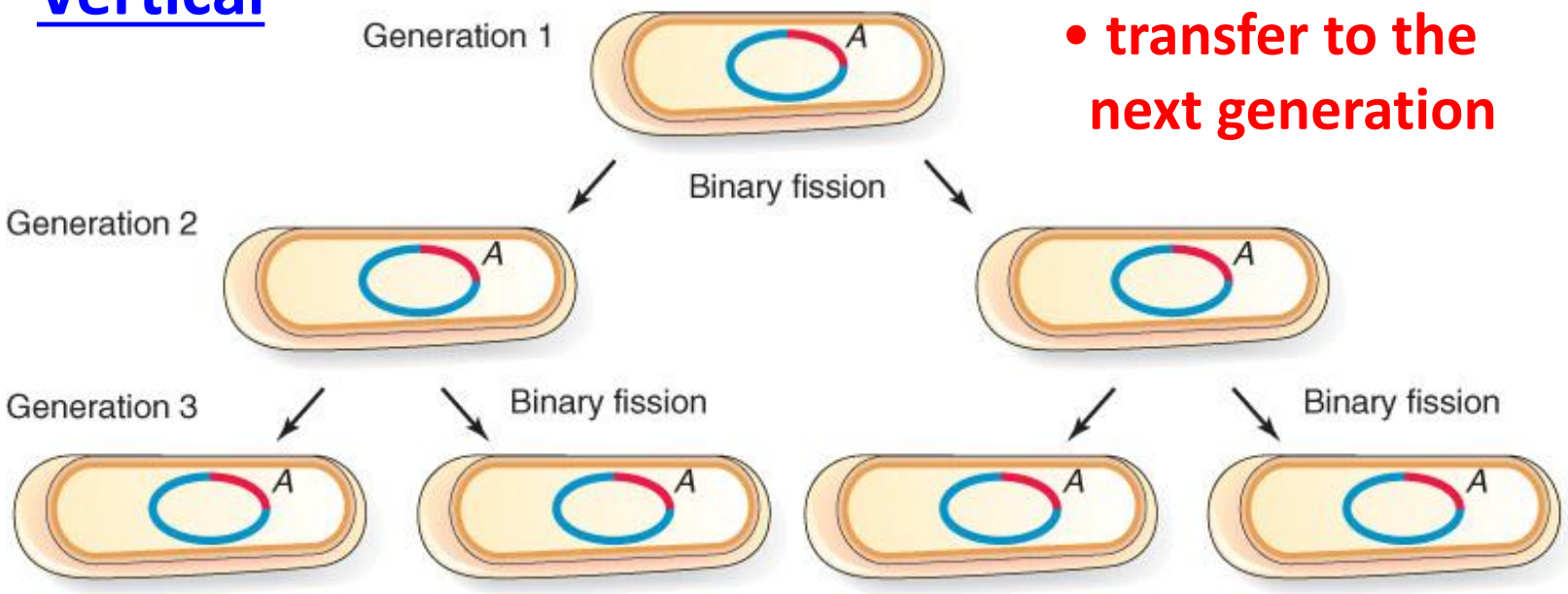
- **some prokaryotes can reproduce every 20 minutes**

HORIZONTAL GENE TRANSFER

- **transfer of DNA from one cell to another**

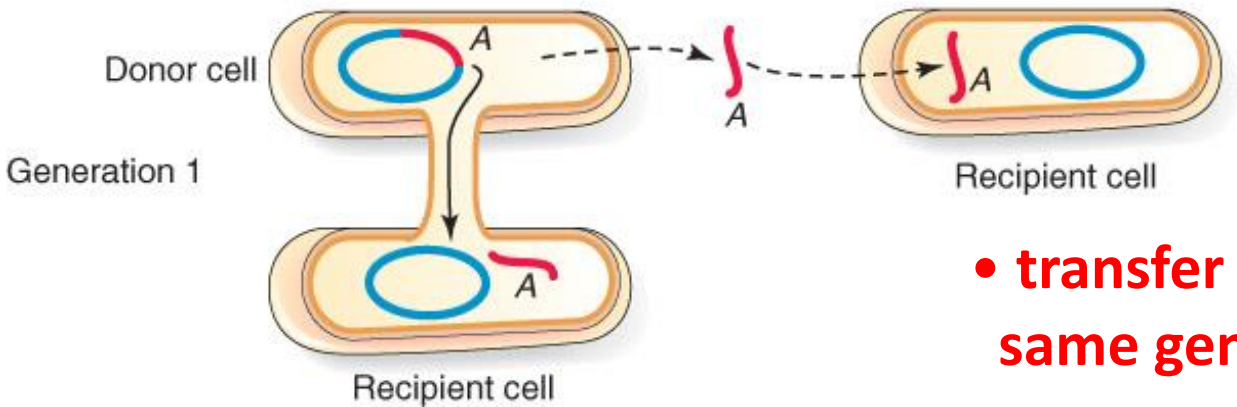
Horizontal vs Vertical Gene Transfer

Vertical



- transfer to the next generation

Horizontal (or lateral)



- transfer within the same generation

Mechanisms of Prokaryotic Gene Transfer

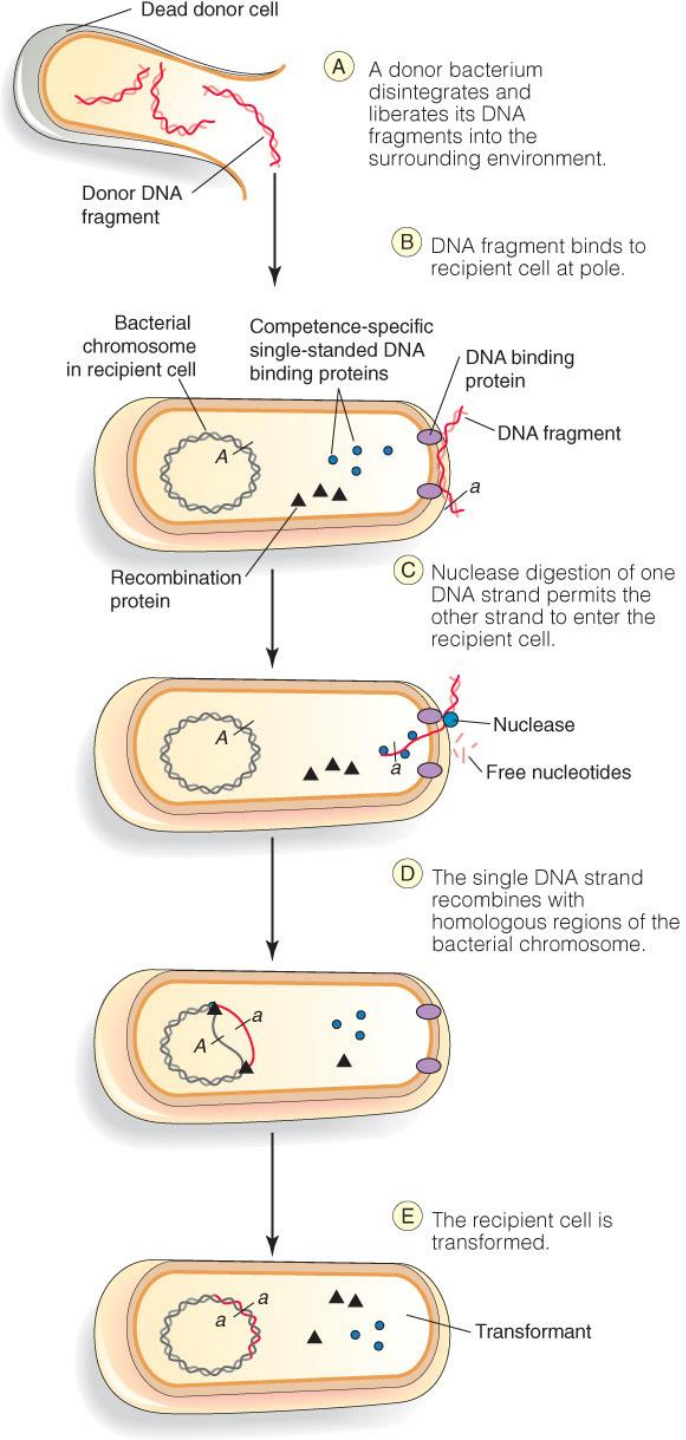
Bacteria can acquire DNA (i.e., new genes) in 3 basic ways:

1) **Transformation – the uptake and retention of external DNA molecules**

2) **Conjugation – direct transfer of DNA from one bacterium to another**
   - **"regular" conjugation**
   - **HFR conjugation**

3) **Transduction – the transfer of DNA between bacteria by a virus**

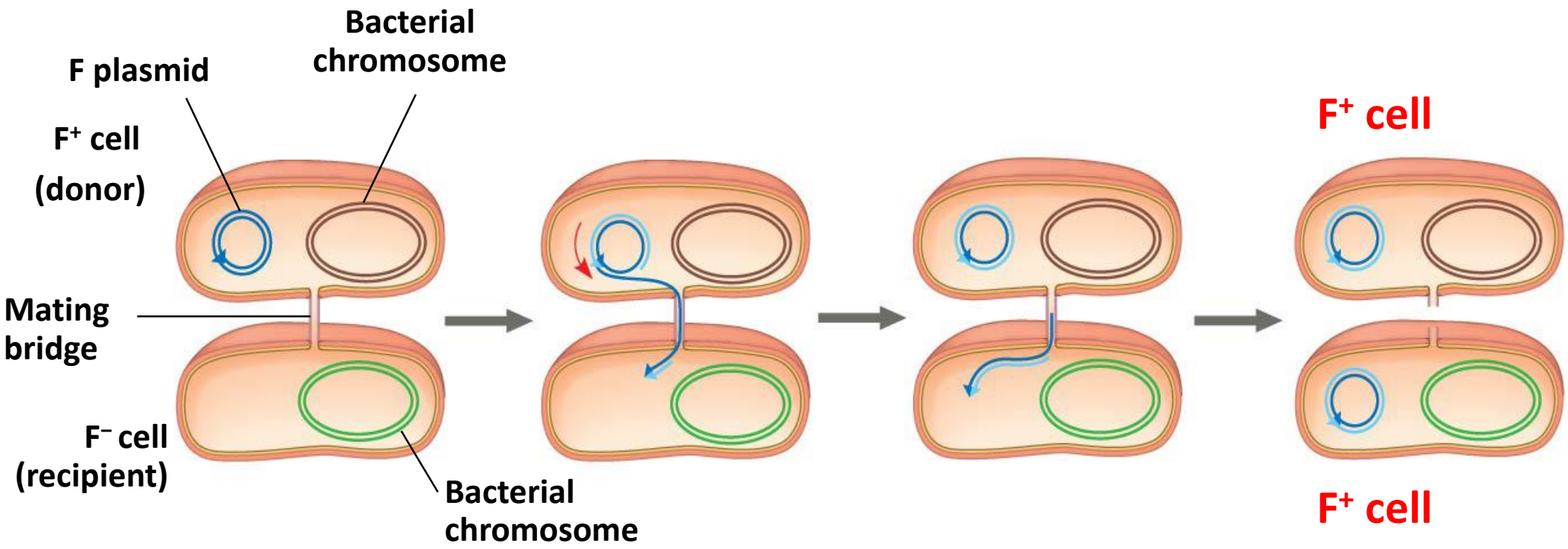
Transformation



Under the right conditions, bacteria can "take in" external DNA fragments (or plasmids) by <u>transformation</u>.

- **DNA binding proteins transfer external DNA across cell wall and membrane**
- **recombination with the chromosomal DNA can then occur**

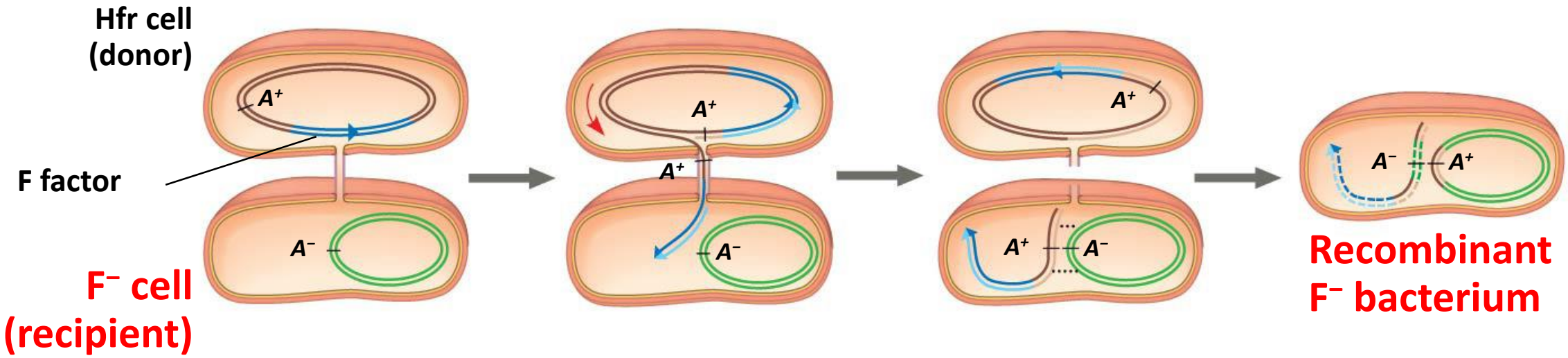
Bacterial Conjugation



1. One strand of F^+ cell plasmid DNA breaks at arrowhead.
2. Broken strand peels off and enters F^- cell.
3. Donor and recipient cells synthesize complementary DNA strands.
4. Recipient cell is now a recombinant F^+ cell.

Conjugation and transfer of an F plasmid

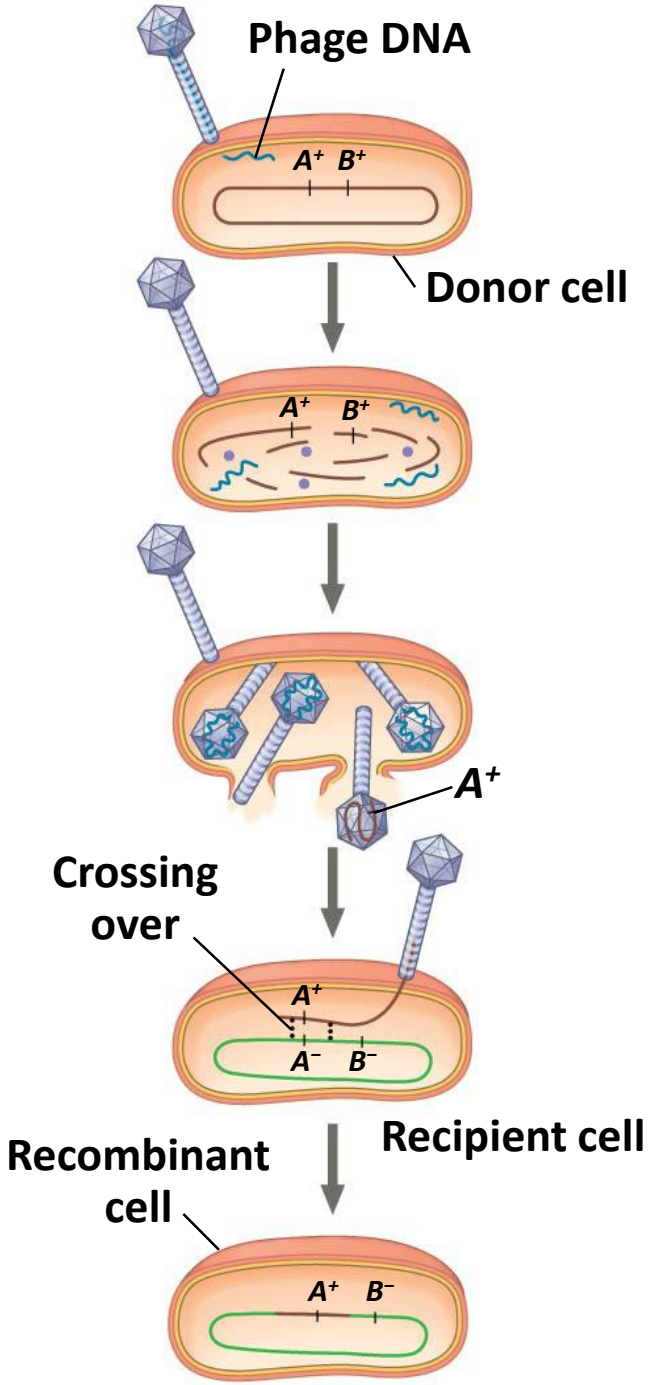
Hfr Conjugation



1. An Hfr cell forms a mating bridge with an F⁻ cell.
2. A single strand of the F factor breaks and begins to move through the bridge.
3. Crossing over can result in exchange of homologous genes.
4. Enzymes degrade and DNA not incorporated. Recipient cell is now a recombinant F⁻ cell.

Conjugation and transfer of part of an Hfr bacterial chromosome, resulting in recombination

1. Phage infects bacterial donor cell with A^+ and B^+ alleles.
2. Phage DNA is replicated and proteins synthesized.
3. Fragment of DNA with A^+ allele is packaged within a phage capsid.
4. Phage with A^+ allele infects bacterial recipient cell.
5. Incorporation of phage DNA creates recombinant cell with genotype A^+ B^-.



Transduction

A bacteriophage virus can transfer DNA fragments from one host cell to another followed by recombination:

- requires a virus to be packaged with bacterial DNA "by mistake"
- infection of another cell by such a virus facilitates the gene transfer followed by recombination