

Bacterial Structure and Function

Lecture 5

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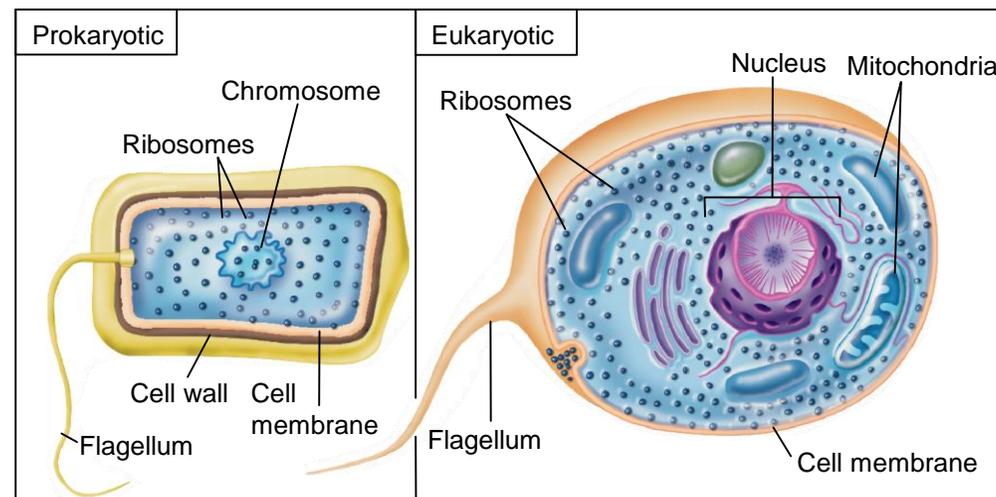
Characteristics of Cells

Eukaryotic cells: animals, plants, fungi, and protists

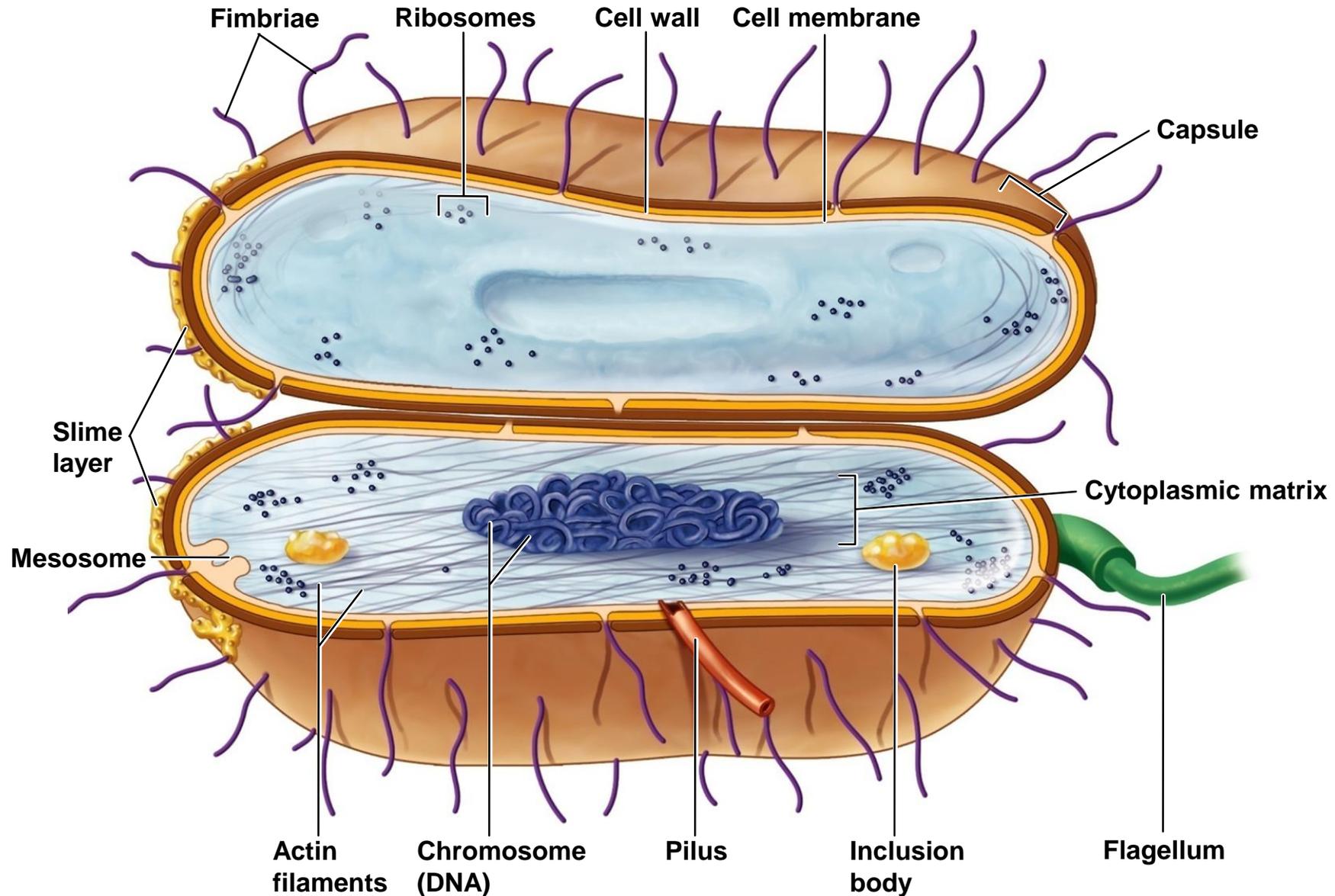
- Contain membrane-bound organelles that compartmentalize the cytoplasm and perform specific functions
- Contain double-membrane bound nucleus with DNA chromosomes

Prokaryotic cells: bacteria and archaea

- No nucleus or other membrane-bound organelles

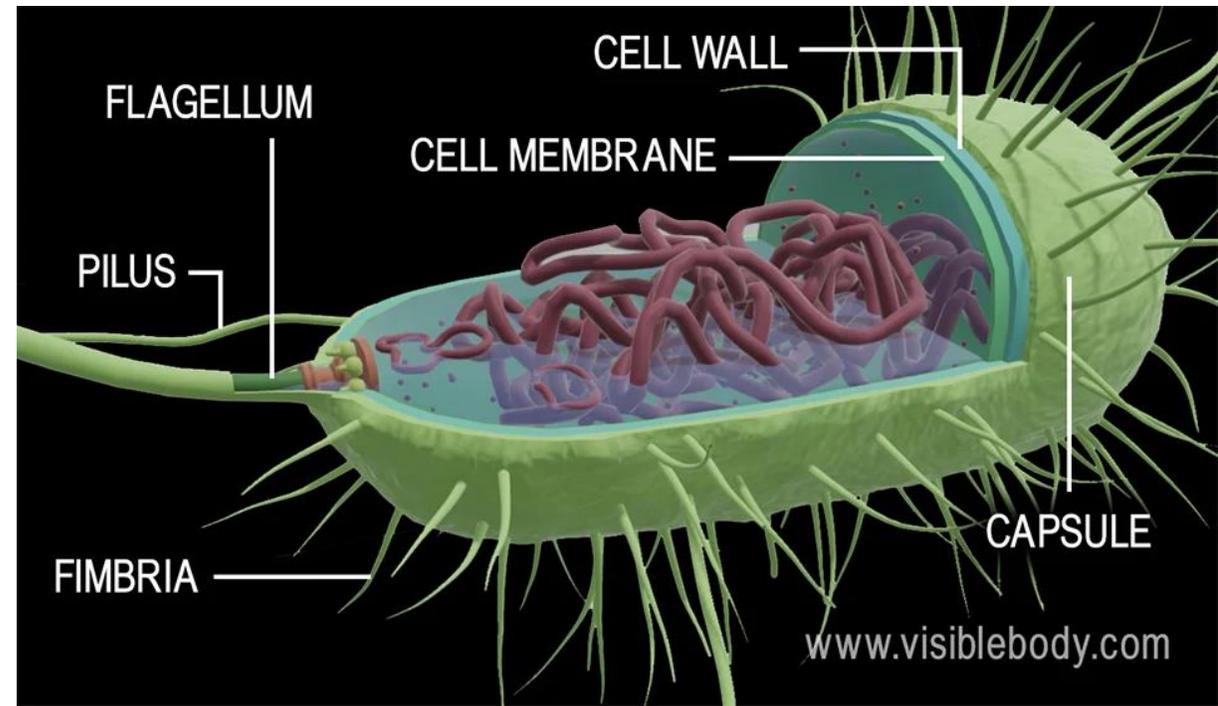


Structure of a bacterial cell



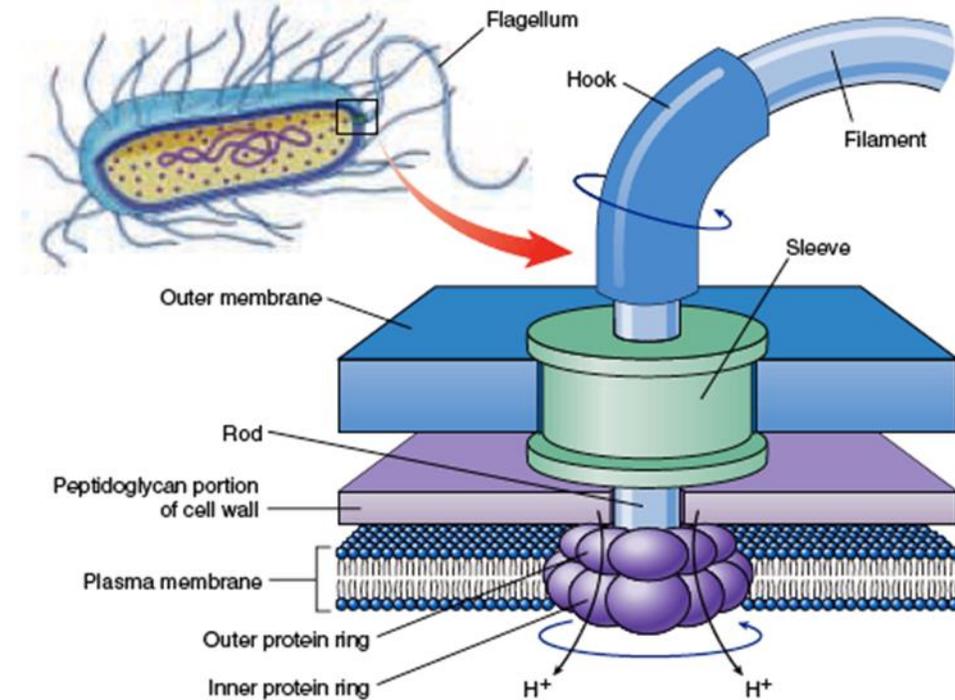
External Structures

- Appendages
 - Two major groups of appendages:
 1. **Flagella** and **axial filaments** (periplasmic flagella) for Motility
 2. **Fimbriae** and **pili** –Attachment or channels
- Glycocalyx – surface coating



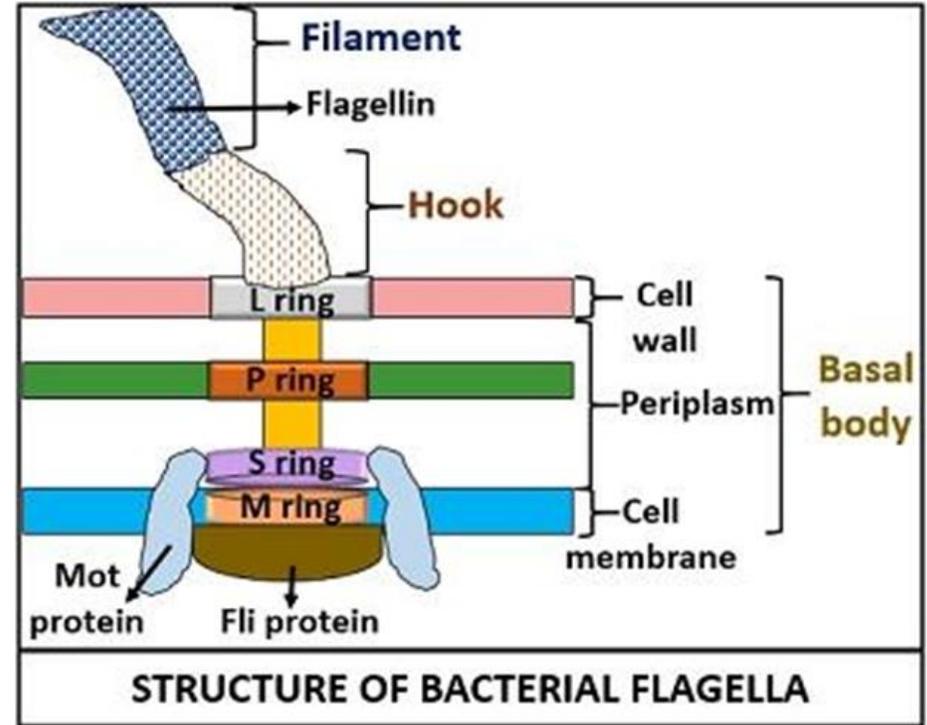
Flagella

- Hair-like structure present on the cell body that is important for different physiological functions of the cell
- Other than locomotion, flagella also regulate sensory functions in prokaryotes by **sensing** temperature and chemical variations.
- **3 parts:**
 - **Filament** – long, thin, helical structure composed of protein **flagellin**
 - **Hook** – curved sheath
 - **Basal body** – stack of rings firmly anchored in cell wall



➤ Basal Body

- It is attached to the cell wall and cell membrane and embedded with the rack of rings arranged one over the other.
- The rings possess protein sub-units. It typically (**M**, **S**, **P** and **L**) rings.
- **M** and **S** rings are associated with the cytoplasmic membrane, while **P** and **L** rings are associated with the periplasmic space and cell wall.



BIOLOGY READER

- The protein rings serve to pump protons or H^+ ions across the membrane and facilitate ATP generation. The bacterial cell harnesses ATP (Adenosine triphosphate) to rotate the rings as well as the filament.

➤ **Hook**

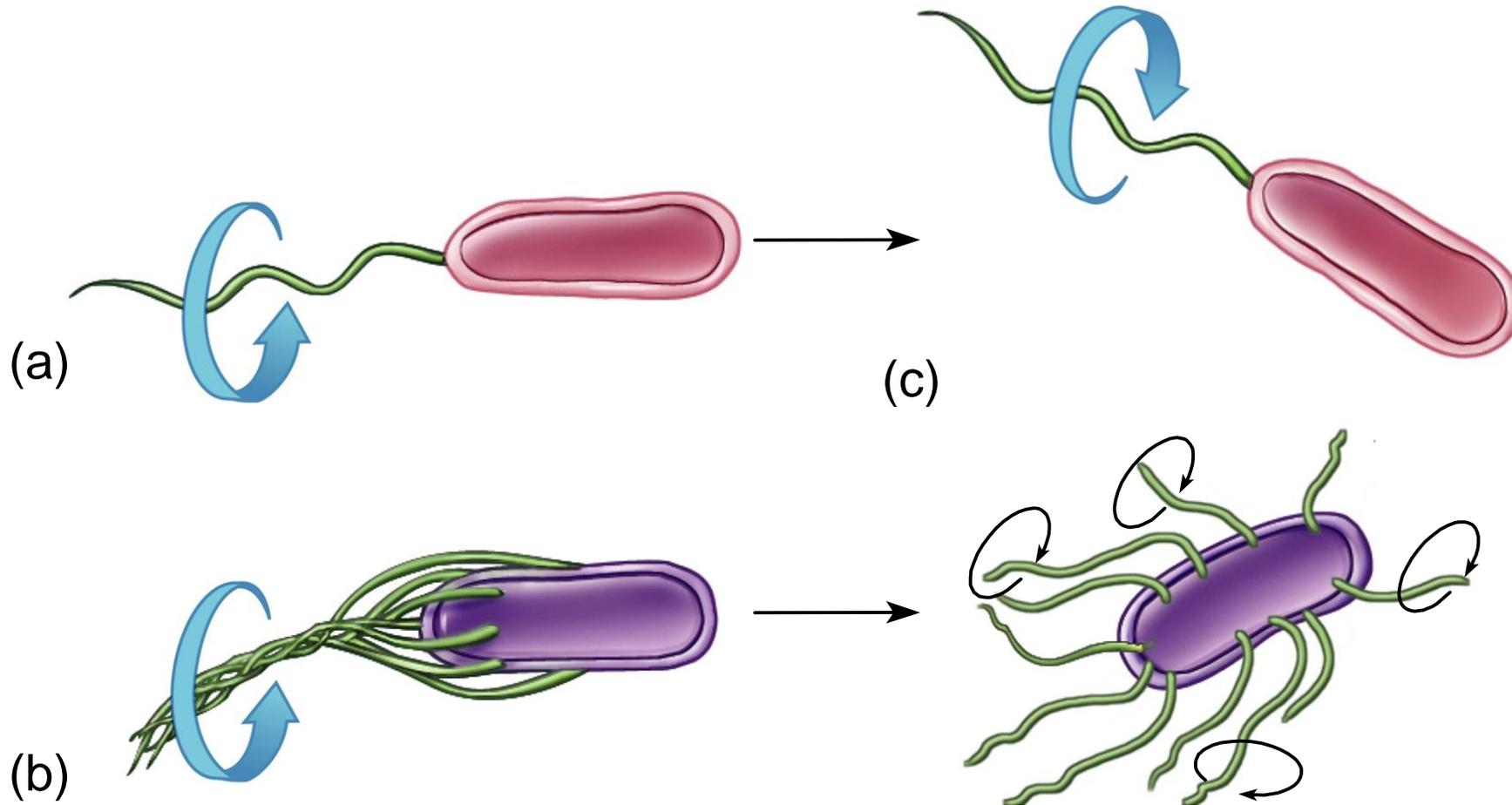
- It is the broader region present at the flagellum base.
- Hook performs a key role in **connecting** filament to the motor region or basal body.

➤ **Filament**

- It appears like a **whip-like** structure.
- Filament seems long, coiled, thin.
- The composition of filament includes **flagellin** protein sub-units.
- Filament participates in the propulsion of bacteria.
- The bacterial flagella can move in either **anticlockwise** or **clockwise** direction.

Flagella

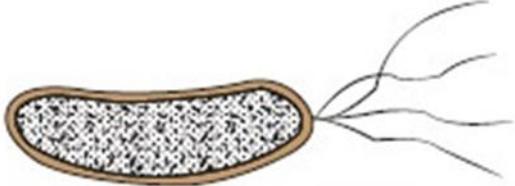
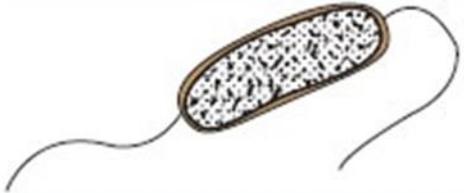
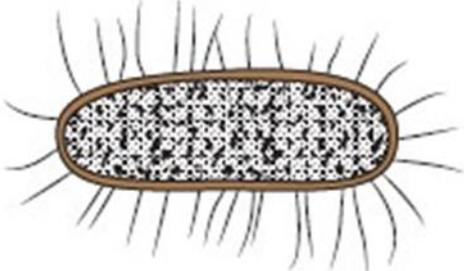
- Rotates 360°
- Functions in motility of cell through environment



Flagella Types

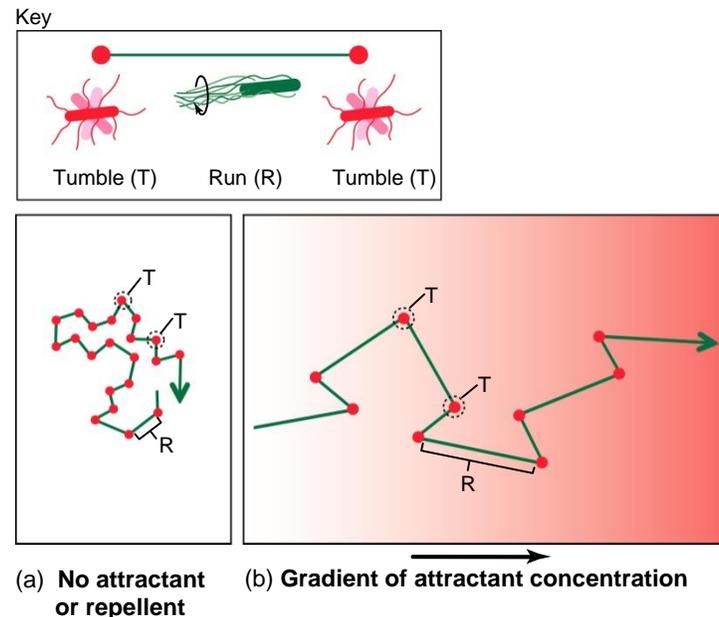
The flagella in prokaryotes are categorized into the following types, depending on their cell surface arrangement.

Table 7.1: Arrangement of bacterial flagella

Structure	Flagella type	Example
	Monotrichous (single flagella on one side)	<i>Vibrio cholera</i>
	Lophotrichous (tuft of flagella on one end)	<i>Pseudomonas fluorescens</i>
	Amphitrichous (single or tuft on both ends)	<i>Aquaspirillum serpens</i>
	Peritrichous (flagella throughout the cells)	<i>Salmonella typhi</i>

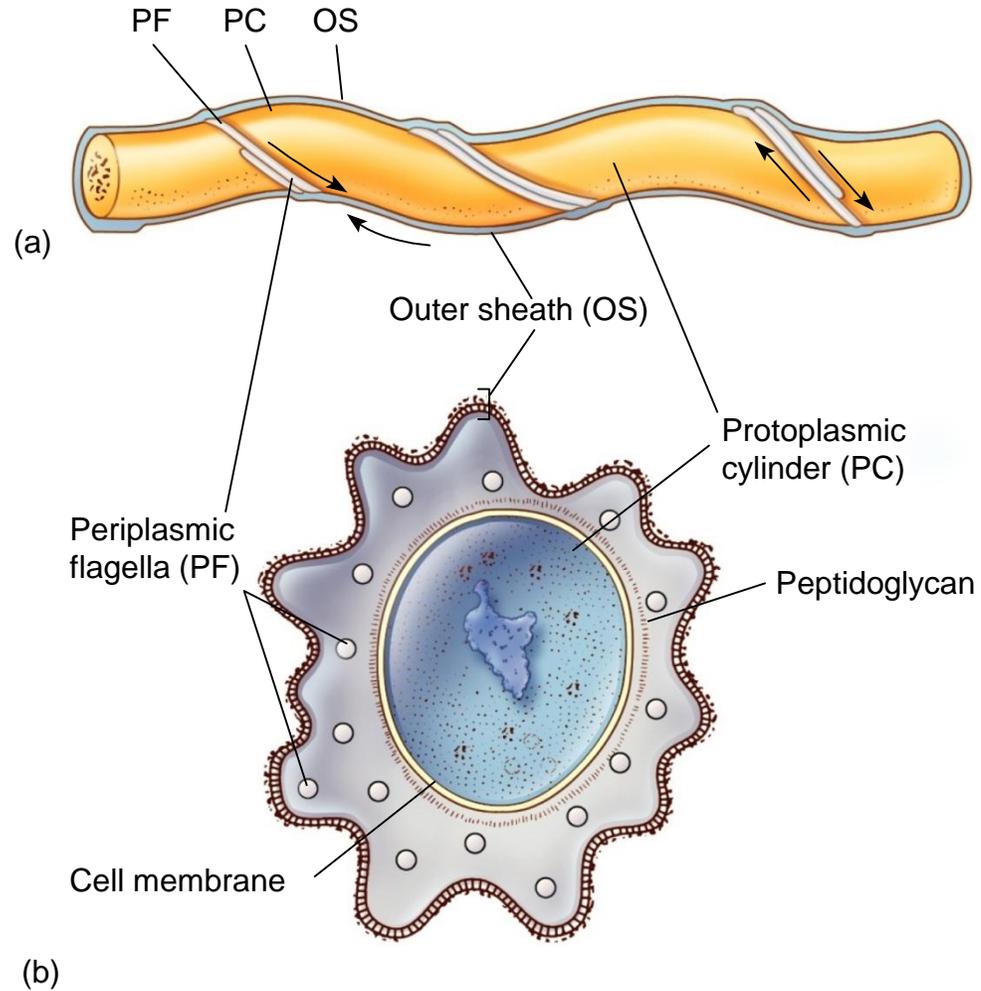
Flagellar Responses

- ✓ Guide bacteria in a direction in response to external stimulus:
 - **Chemical stimuli** – **chemotaxis**; positive and negative
 - **Light stimuli** – **phototaxis**
- ✓ **Signal** sets flagella into motion clockwise or counterclockwise:
 - Counterclockwise – results in smooth linear direction – **run**
 - Clockwise – **tumbles**



Periplasmic Flagella

- **Internal flagella**, enclosed in the space between the outer sheath and the cell wall peptidoglycan
- **Produce cellular motility** by contracting and imparting twisting or flexing motion



Difference Between Prokaryotic and Eukaryotic flagella

Prokaryotic flagella	Eukaryotic flagella
They have rotary movement	They have bending movement (Back and forth movement)
Flagella are thin and small	Flagella are thick and large
Do not contains microtubules, "9+0": No central microtubules, only a simple structure.	Contains the microtubules, "9+2": Two central microtubules surrounded by nine outer doublets.
Made up of the protein flagellin	Made up of the protein tubulin
Smaller and simpler structure	The large and complex structure
It is proton driven	It is ATP driven
They consist of three parts basal body, hook, and filament	They consist of two parts basal body and shaft
The basal body contains rings that help in locomotion	The basal body is made up of centriole like structures
For example, Bacteria	For example, Chlamydomonas (green algae)

Ultrastructure of Cilia and Flagella

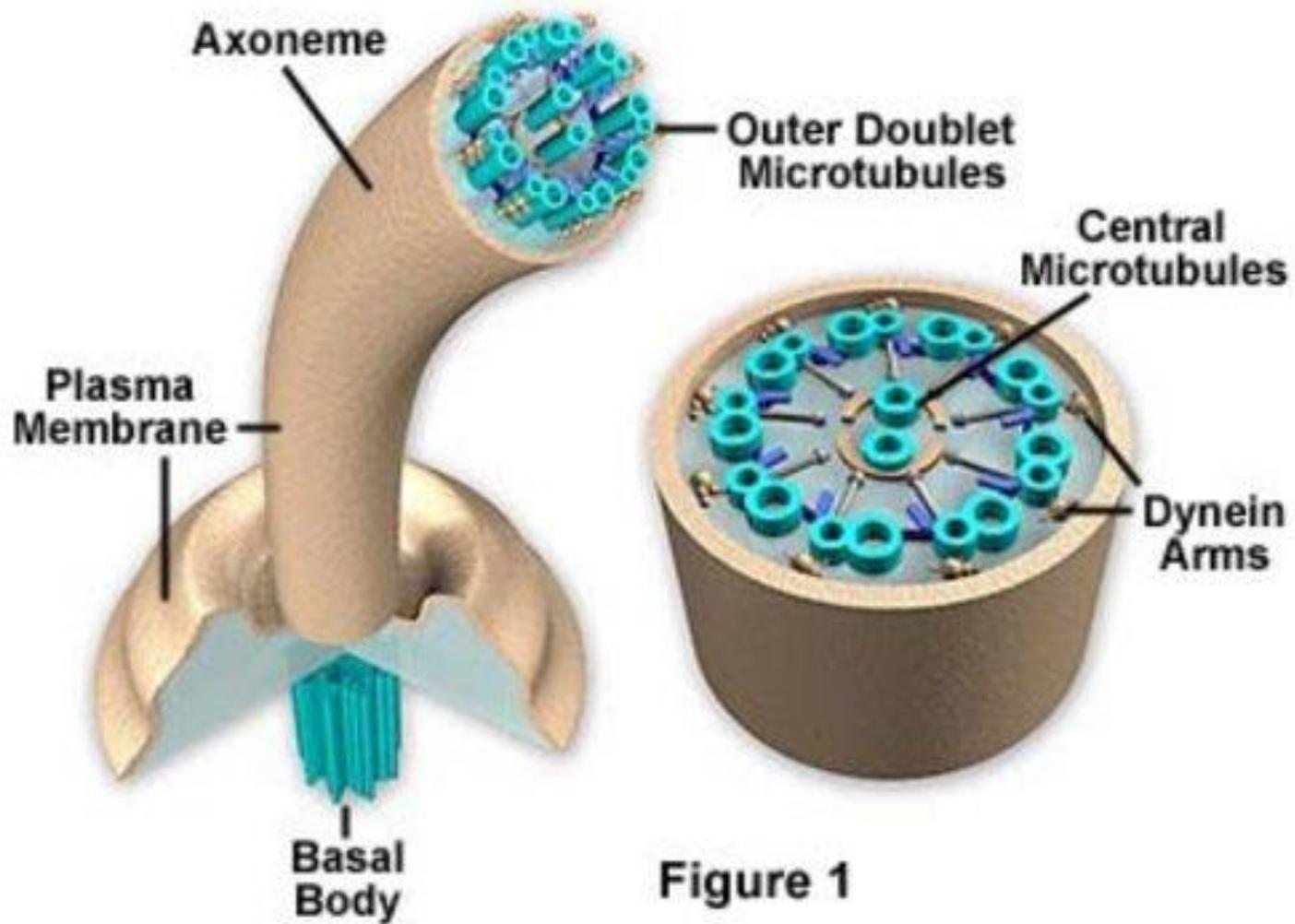
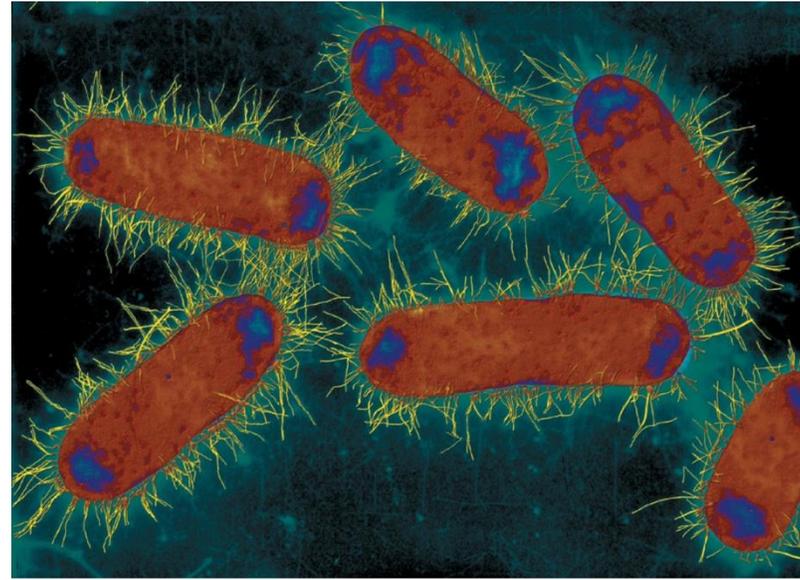


Figure 1

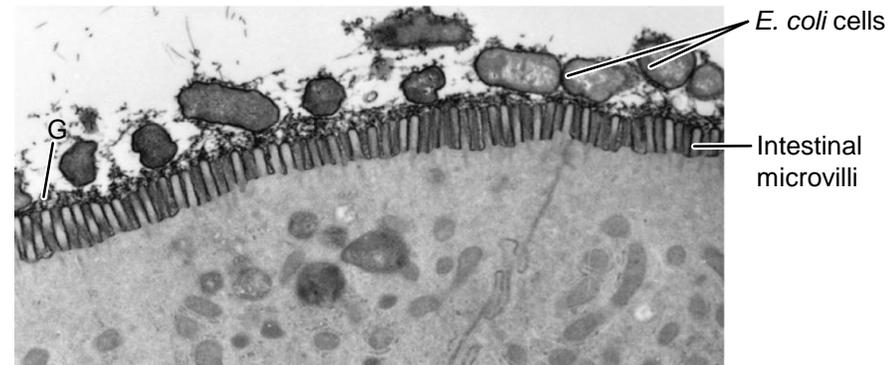
Fimbriae

- Fimbriae are tiny bristle-like fibers arising from the surface of bacterial cells.
- Made up of **Fimbrillin** protein.
- Function crucial for colonization and infection.
- Adhesion to other cells and surfaces



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(a)

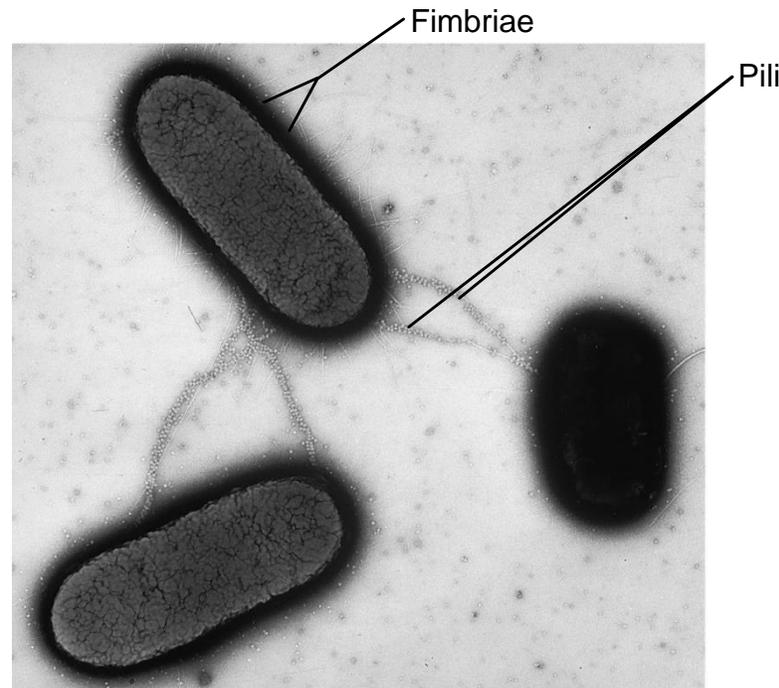


Dr. S. Knutton from D.R. Lloyd and S. Knutton, Infection and Immunity, January 1987, p 86-92. © ASM

(b)

Pili

- Rigid tubular structure made of **pilin** protein
- Found only in **gram-negative** cells
- Two basic function of pili.
- They are:
 - ✓ gene transfer called **conjugation**
 - ✓ and **attachment**.

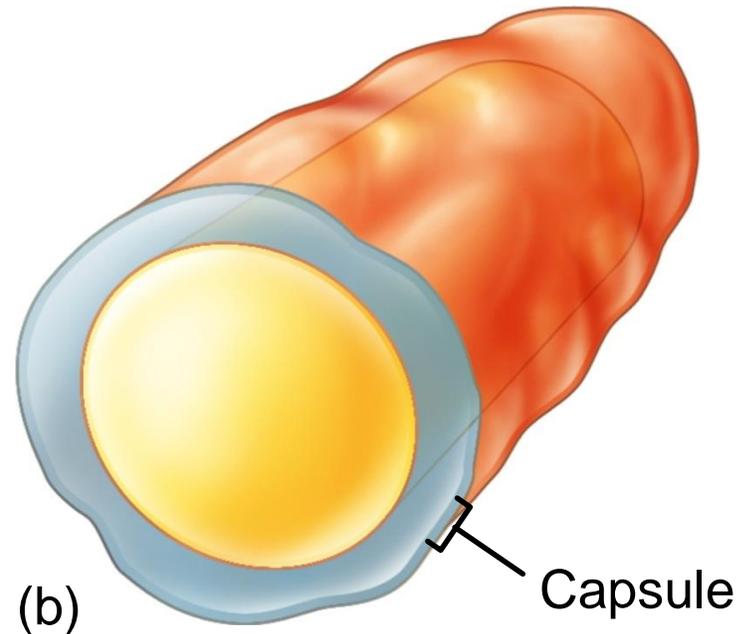
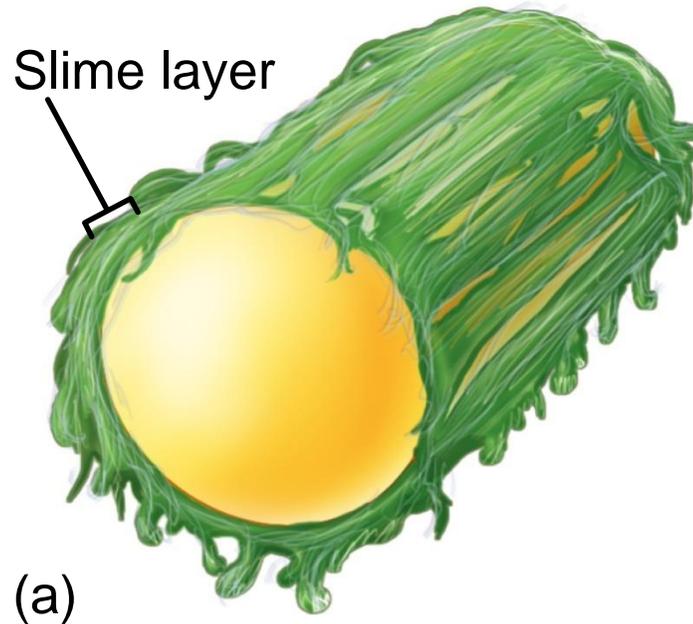


FIMBRIAE VERSUS PILI

FIMBRIAE	PILI
Tiny, bristle-like fibers arising from bacterial cells	Hair-like microfibers on the surface of bacteria
Occur in both Gram-positive and Gram-negative bacteria	Occur in Gram-negative bacteria
Around 200-400 fimbriae occur per bacterial cell	Only 1-10 pili occur per bacterial cell
Made up of fimbrillin protein	Made up of pilin protein
Genes responsible for the formation occur in the bacterial chromosome	Genes in the plasmids are responsible for the formation
Shorter	Longer
Thin	Thick
Attach the bacterium to the substrate	Aid in bacterial conjugation

Glycocalyx

- is the outer or surface layer that lines the cell membrane.
- Glycocalyx is made up of proteoglycans, glycosaminoglycans, glycoproteins, and associated plasma proteins.
- **Two types:**
 1. Slime layer - loosely organized and attached
 2. Capsule - highly organized, tightly attached



Examples:

- **Bacterial** cells that have a glycocalyx layer surrounding their cell surface, which may be a sugar coat surrounding the cell wall (such as a bacterial capsule) or a slime layer.
- **Human** cells also exhibit a glycocalyx; examples are vascular endothelial cells and cells of the digestive system.
- The various functions of glycocalyx of a cell include the following:
 - ✓ Cell recognition
 - ✓ Cell adhesion
 - ✓ Protection from dehydration and from WBCs attacks
 - ✓ Permeability barrier

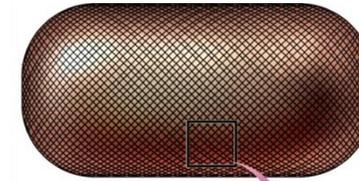
The Cell Envelope

- External covering outside the cytoplasm
- **Composed of two basic layers:**
 - ✓ Cell wall
 - ✓ Cell membrane
- Maintains cell integrity
- Two different groups of bacteria demonstrated by **Gram stain:**
 - **Gram-positive bacteria:** thick cell wall composed primarily of peptidoglycan and cell membrane
 - **Gram-negative bacteria:** outer cell membrane, thin peptidoglycan layer, and cell membrane

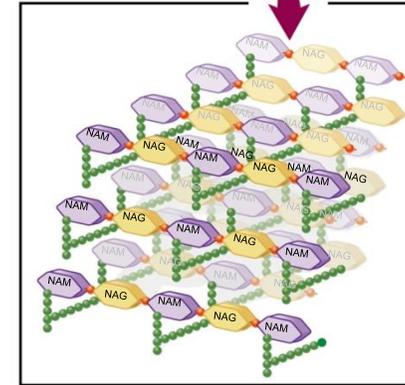
Structure of Cell Walls

- Determines cell **shape**, prevents **lysis** due to changing osmotic pressures
- **Peptidoglycan** is the primary component:
 - Unique macromolecule composed of a repeating framework of long glycan chains cross-linked by short peptide fragments

(a) The peptidoglycan of a cell wall is a huge, 3-dimensional lattice work that is actually one giant molecule to surround and support the cell.



(b) This shows the molecular pattern of peptidoglycan. It has alternating glycans (**NAG** and **NAM**) bound together in long strands. The **NAG** stands for **N-acetyl glucosamine**, and the **NAM** stands for **N-acetyl muramic acid**. Adjacent muramic acid molecules on parallel chains are bound by a cross-linkage of peptides (**green spheres**)



(c) An enlarged view of the links between the NAM molecules. Tetrapeptide chains branching off the muramic acids connect by amino acid **Interbridges**. The amino acids in the interbridge can vary or may be lacking entirely. This linkage that provides rigid yet flexible support to the cell.

