هذه النقطة مكملة للمحاضرة الرابعة

4- The Nucleoid

The nucleoid (meaning nucleus-like): is an irregularly shaped region within the cell of a prokaryote that contains all or most of the genetic material which is represented by DNA, and called **the bacterial chromosome.**

The nucleoid is mostly composed of multiple compacted copies of DNA in a continuous thread, with the addition of some RNA and proteins. The DNA in prokaryotes is double-stranded and generally takes a circular shape. But the DNA can sometimes also be found in other regions outside the nucleoid.

Function of Nucleoid: The nucleoid is essential for controlling the activity of the cell and reproduction. It is where transcription and replication of DNA take place.

*Most bacteria have one or two circular chromosomes (nucleoids), the numbers of nucleoids, depend on the growth conditions. Rapidly growing bacteria have more nucleoids per cell than slowly growing ones.

Plasmids

In addition to the bacterial chromosome, bacteria often contain small usually circular, double-stranded DNA molecules called **plasmids**, that contain (usually) non-essential genes.

Plasmids not connected to main bacterial chromosome but have very important functions:

Antibiotic resistance Tolerance to toxic metals Production of toxins the synthesis of enzymes.

*Plasmids can be transferred from one bacterium to another.

*In fact, plasmid DNA is used for gene manipulation in biotechnology.

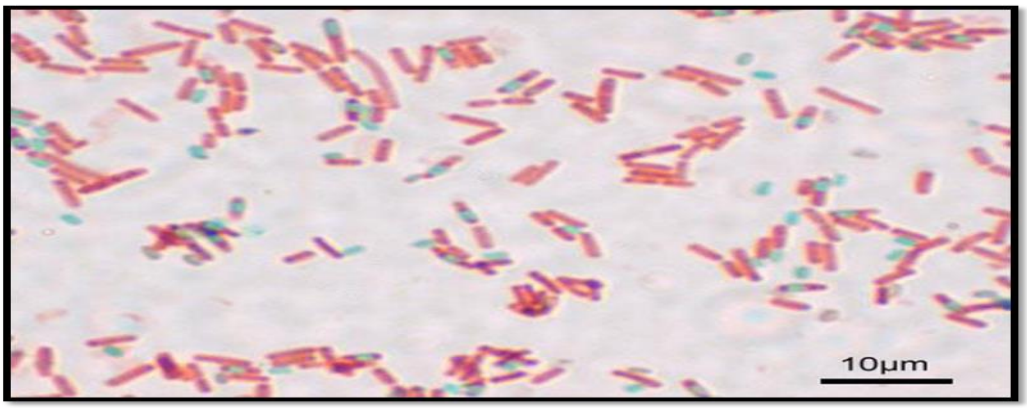
5- Endospores

When essential nutrients are depleted, certain gram-positive bacteria, such as those of the genera **Clostridium** and **Bacillus**, form specialized "resting" cells called **endospores.**

Endospores are dormant, non-reproductive and enzymatically inert forms of bacterial vegetative cells.

The primary function of most endospores is to ensure the survival of a bacterium through periods of environmental stress. They are therefore resistant to radiation, desiccation, lysozyme, temperature, starvation, and chemical disinfectants.

*For example, 7500-year-old endospores of Thermo-actinomyces vulgaris from the freezing muds of Elk Lake in Minnesota have germinated when rewarmed and placed in a nutrient medium. **(المثال للاطلاع)**



A stained preparation of the cell *Bacillus subtilis* showing endospores as green and the vegetative cell as red **(**الشكل غير مطلوب)

Bacterial endospore structure:- From the inner to the outer:

a) The core (contains the bacterial DNA).

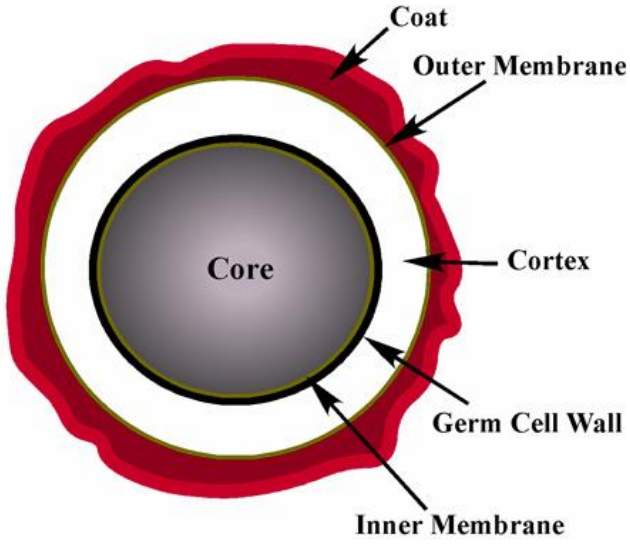
b) Inner membrane

c) Cortex

d) Outer membrane

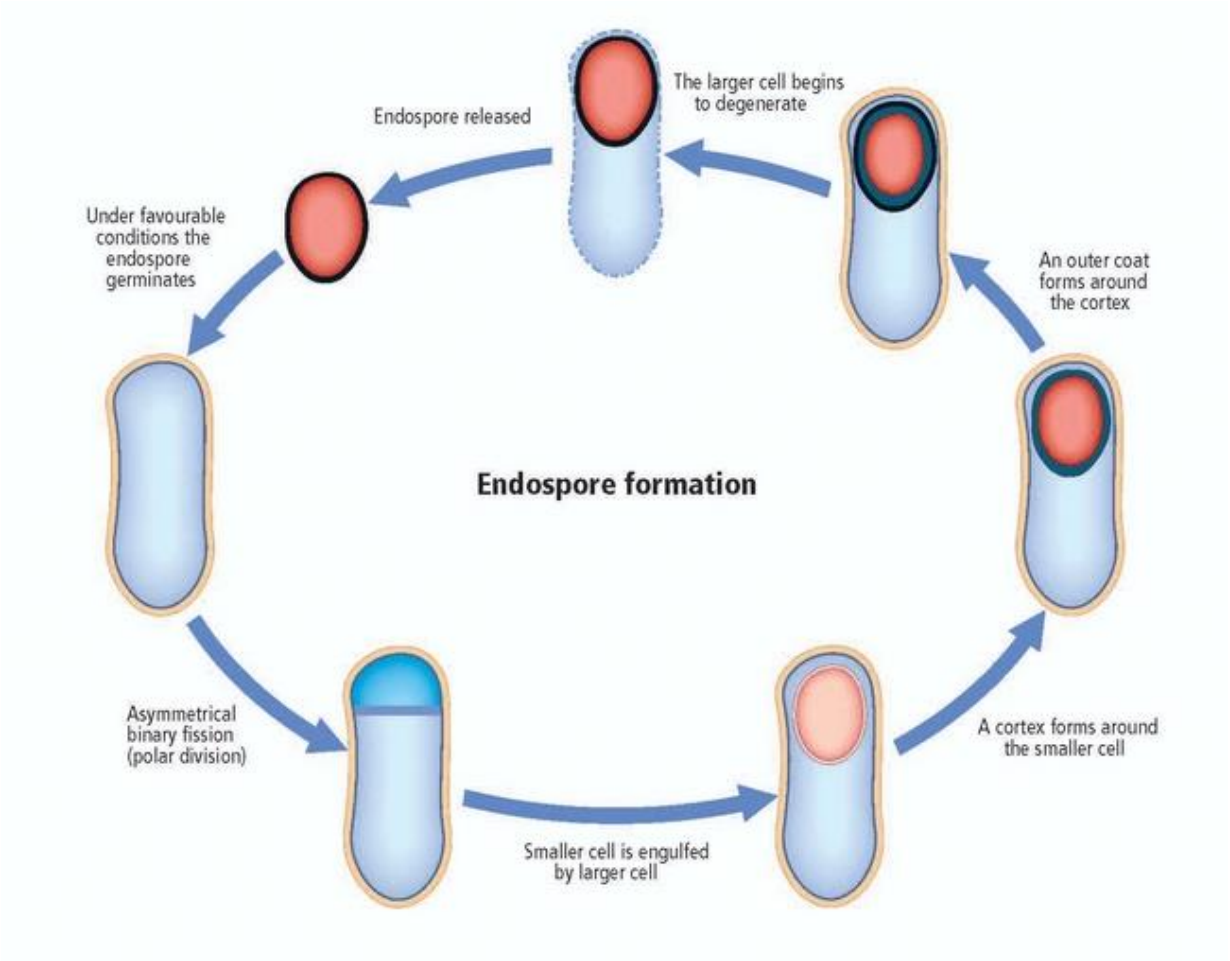
e) Coat

f) *Exosporium, a facultative external structure present only in some bacterial spores



Unlike vegetative cells, endospores contain **dipicolinic acid** and a large quantity of **calcium ions** (Ca^{2+}). Dipicolinic acid forms a complex with calcium ions within the endospore core. This complex binds free water molecules, causing dehydration of the spore. As a result, the heat resistance of macromolecules within the core increases. The calcium-dipicolinic acid complex also functions to protect DNA from heat denaturation, thereby increasing the stability of DNA.

(الشكل الاتي غير مطلوب)



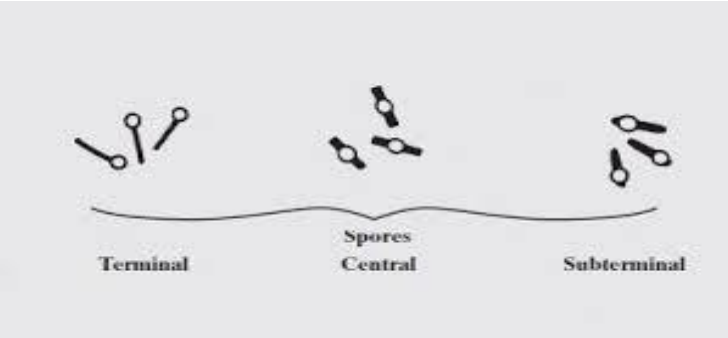
Formation of an endospore through the process of sporulation

The location of the endospores in bacterial cell:- (الامثلة غير مطلوبة)

1- Central/ e.g: *Bacillus cereus*

2- Terminal /e.g: *Clostridium tetani*

3- Subterminal/ e.g: *Clostridium botulinum*



External Structures (cell wall appendages)

1- Glycocalyx

2- Pili (Fimbriae)

3- Flagella

1- Glycocalyx (Slime Layer and Capsule)

Beyond the cell wall, some bacteria have an additional layer called the glycocalyx. The structural features and chemical composition of glycocalyces differ depending on the species of bacteria, but in general this additional layer may be composed of polysaccharides, polypeptides, or both and can come in one of two forms:

a- Slime Layer

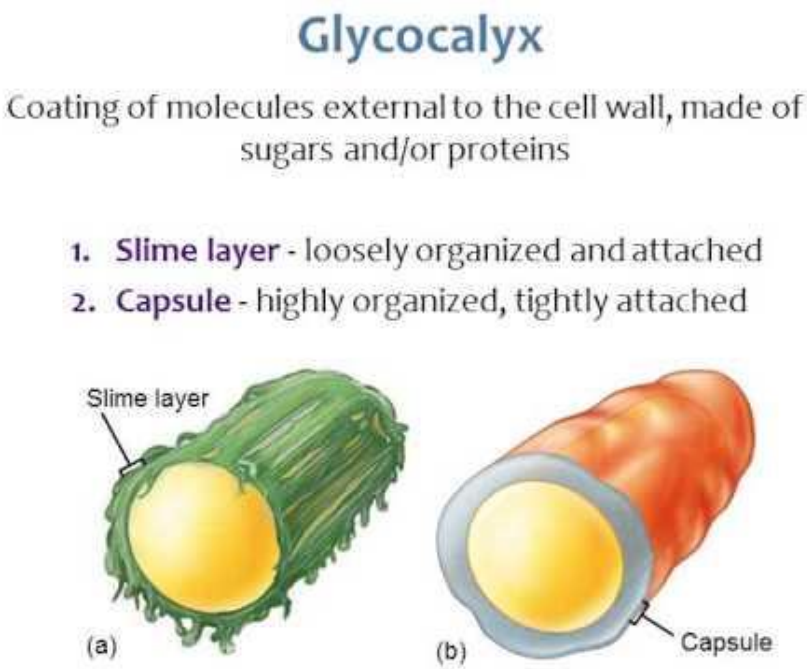
A glycocalyx is considered a slime layer when the glycoprotein molecules are loosely associated with the cell wall. Bacteria that are covered with this loose shield are protected from dehydration and loss of nutrients.

b- Capsule

The glycocalyx is considered a capsule when the polysaccharides are more firmly attached to the cell wall. Capsules have a gummy, sticky

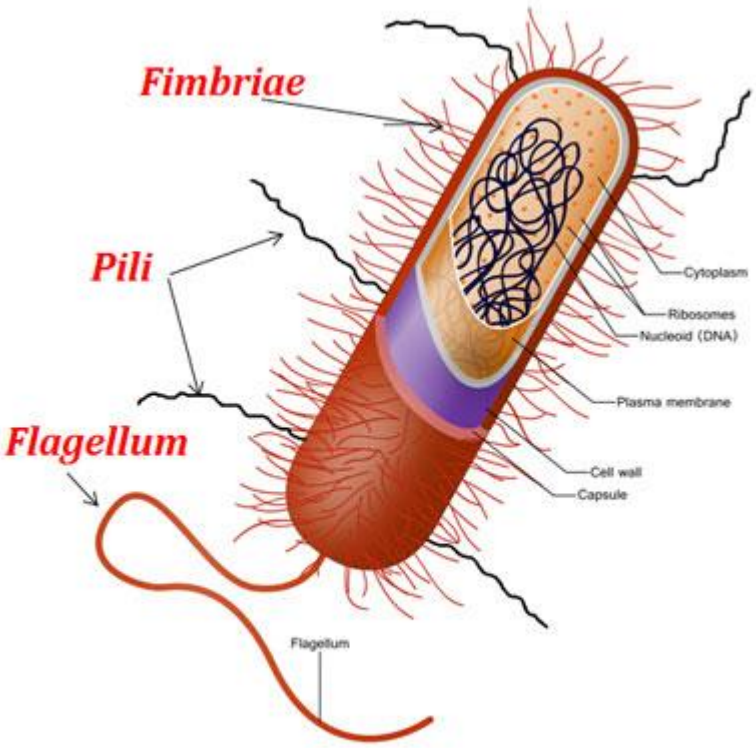
consistency and provide protection as well as adhesion to solid surfaces and to nutrients in the environment.

*Bacteria that possess capsules are considered to be encapsulated, and generally have greater pathogenicity (ability to cause disease) because capsules **protect bacteria from phagocytosis** (white blood cells of the immune system). The adhesive power of capsules is also **a major factor in the initiation of some bacterial diseases.** (الشكل غير مطلوب)



2- Pili and Fimbriae

Pili and Fimbriae are filamentous structures composed of protein , that extend from the surface of a cell and can have many functions.



Cell-Surface Appendages of a Bacterial Cell

Difference between Fimbriae and Pili

Fimbriae (S., Fimbria)	Pili (S., Pilus)
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.
Governed by bacterial genes in the nucleoid region (chromosome)	Governed by plasmid genes.
Shorter	Longer
Thin	Thicker
Less rigid	More rigid
Attach the bacterium to the substrate	Aid in bacterial conjugation

3- Flagella

Flagella (singular: flagellum): thin hair-like appendages that protrude from the cell body of certain bacteria, often much longer than the cell itself, and used for locomotion in many bacteria (move the bacteria towards nutrients and other attractants). .

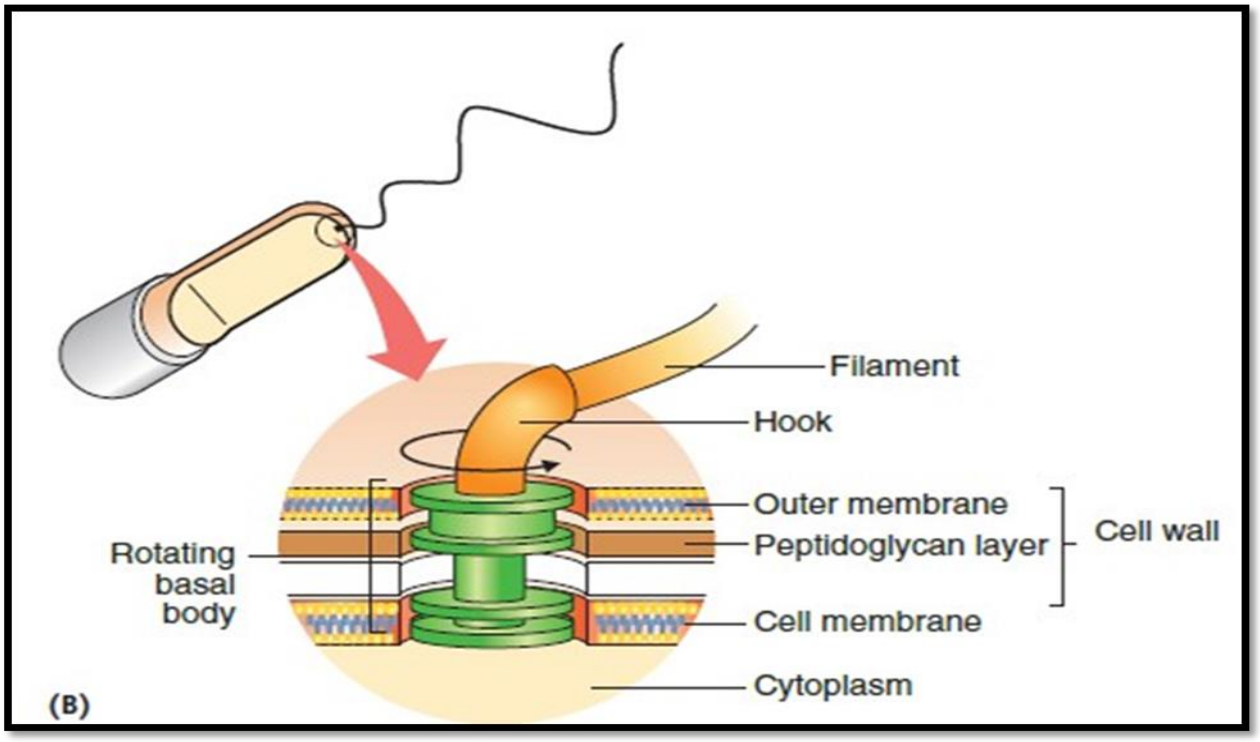
They consist of the three main components:

1- **Filament (helical propeller)**

2- **Hook (universal joint)**

3- **Basal body (rotary motor)**

(الشكل الاتي غير مطلوب)



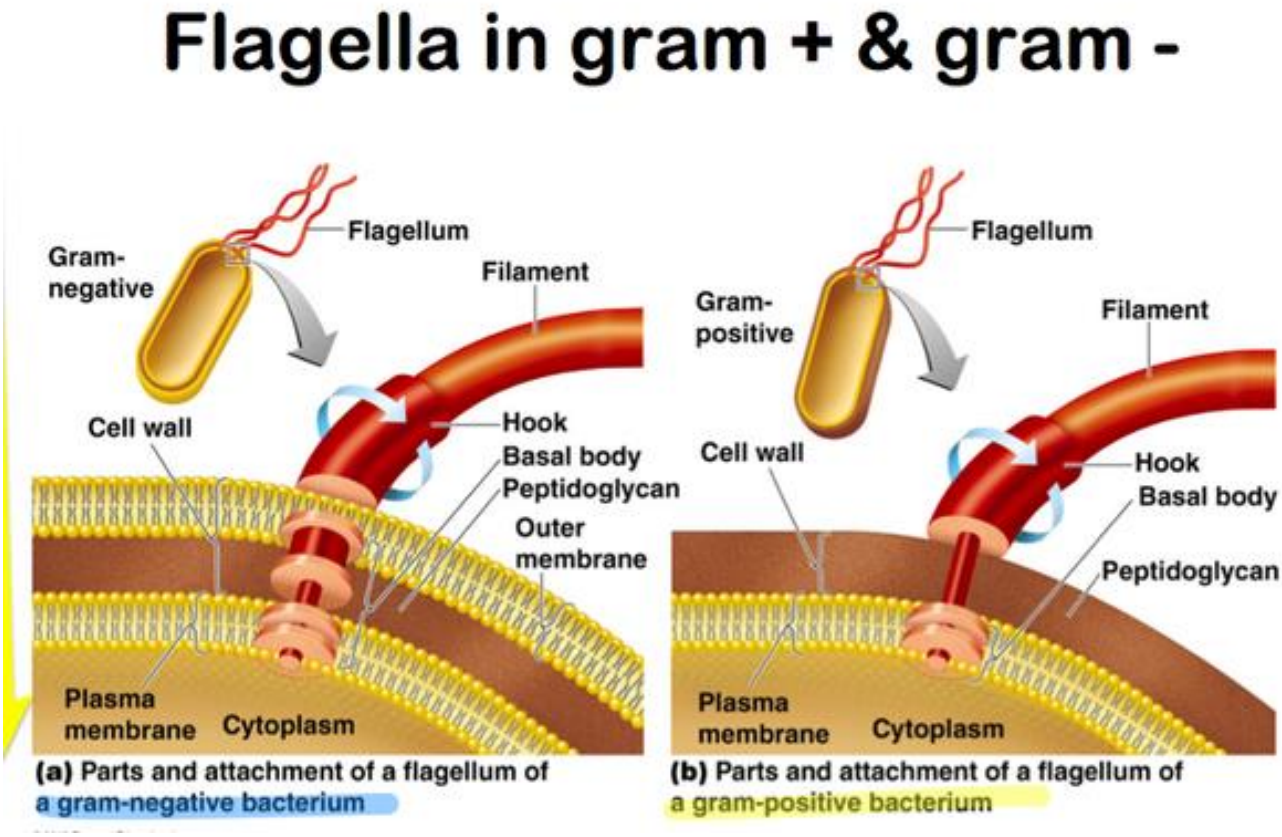
Structure of bacterial flagellum

***The filament** is the largest part, is about 20 nm in diameter, extends out to the cell's environment, and usually composed of many subunits of a single protein called **flagellin**.

***The hook:** is a short tubular structure, It is different in structure than that of the filament, It is connects the filament to the basal body.

***The basal body** consists of a central rod or shaft surrounded by a set of rings.

The flagellar structure of **Gram-positive bacteria** has two rings in the basal body. The flagellar structure of **Gram-negative bacteria** has four rings in the basal body. (الشكل الاتي غير مطلوب)



Gram Positive 2 rings in basal body -Gram Negative 4 rings in basal body.

Flagella arrangement schemes

Different species of bacteria have different numbers and arrangements of flagella:

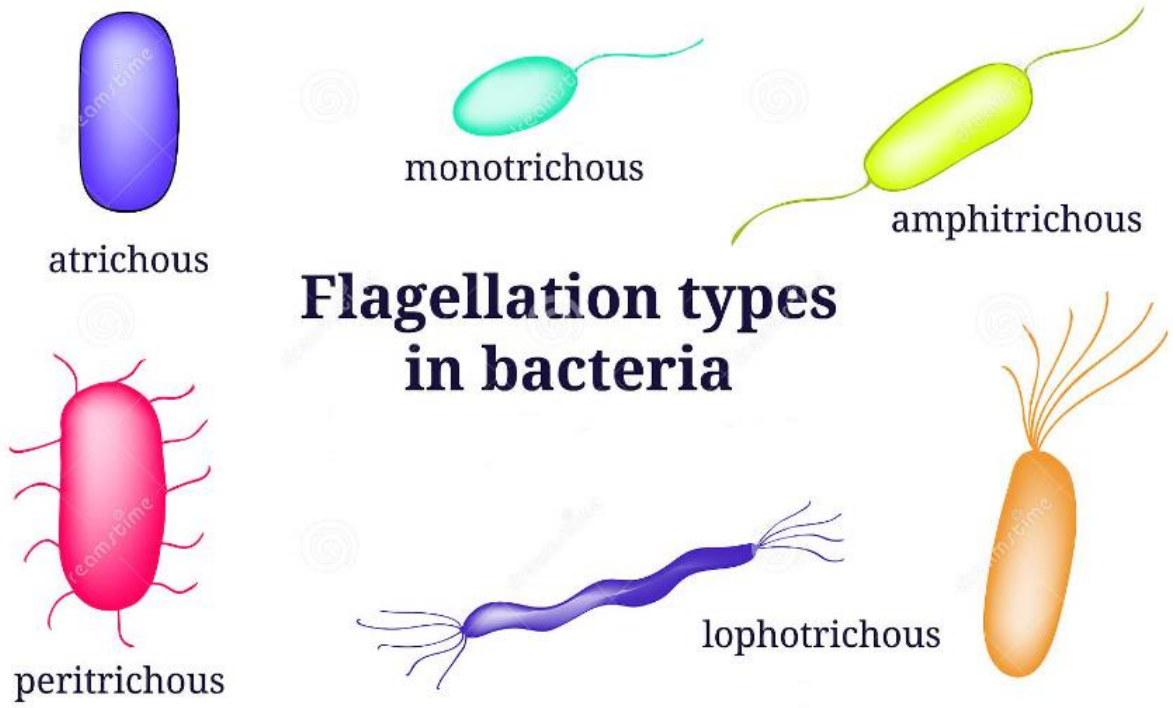
1- **Atrichous bacteria:** Flagella absent

2- **Monotrichous bacteria:** Single polar flagellum (e.g., *Vibrio cholera*).

3- **Amphitrichous bacteria:** Single flagellum at both ends.

4- **Lophotrichous bacteria:** tuft of flagella at one or both ends.

5- **Peritrichous bacteria:** Many flagella all over the body (e.g., *E. coli*).



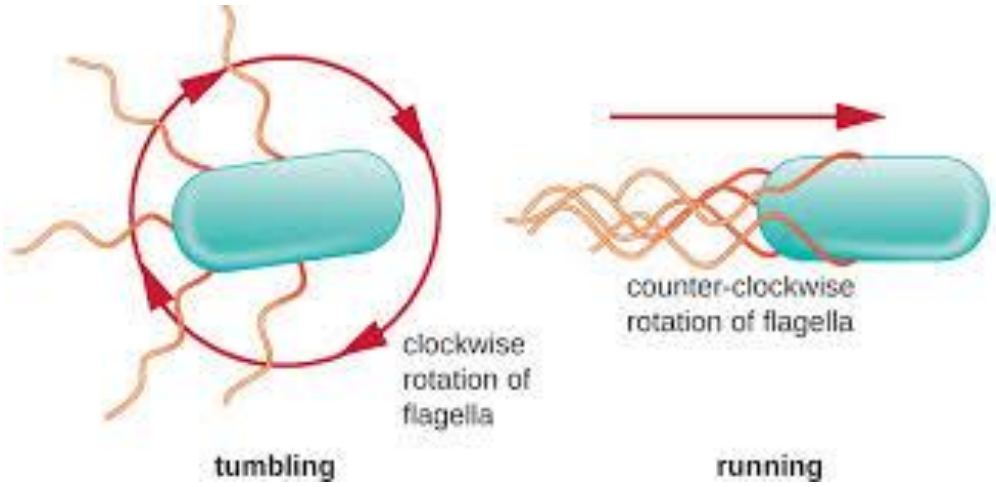
Types of flagellar arrangement

Rotation of the flagellum is an energy-dependent process driven by the basal body, and the direction of rotation determines the nature of the resulting cellular movement.

When flagella bundle together they rotate counterclockwise, and the bacteria run, or move in a straight line.

When the flagella rotate clockwise, the flagellar bundle comes apart, causing the bacterium to tumble randomly.

(الشكل الاتي غير مطلوب)



Bacterial movement occurs in response to stimuli (taxis).In the presence of favorable stimuli, the receptors that found on the surface of the cells, send signals to the flagella, which then adjust their speed and direction of rotation.

The stimulus may be:

- Light: **Phototaxis**
- Chemical like glucose: **Chemotaxis**
- Presence of Oxygen: **Aerotaxis**
- Response to magnetic field: **Magnetotaxi**