



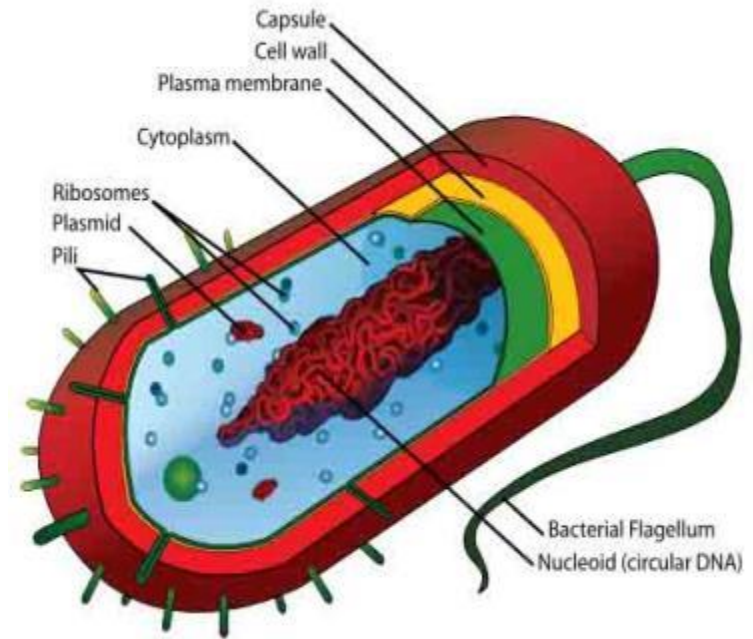
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Prokaryotic Cell Structure & Function

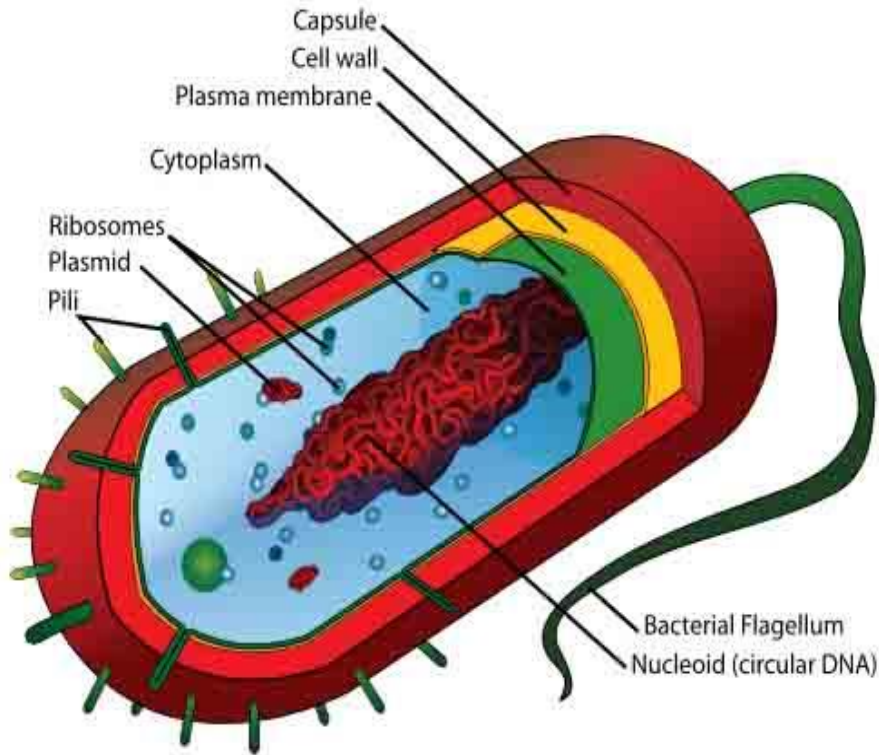


The Cellular Level of Organization

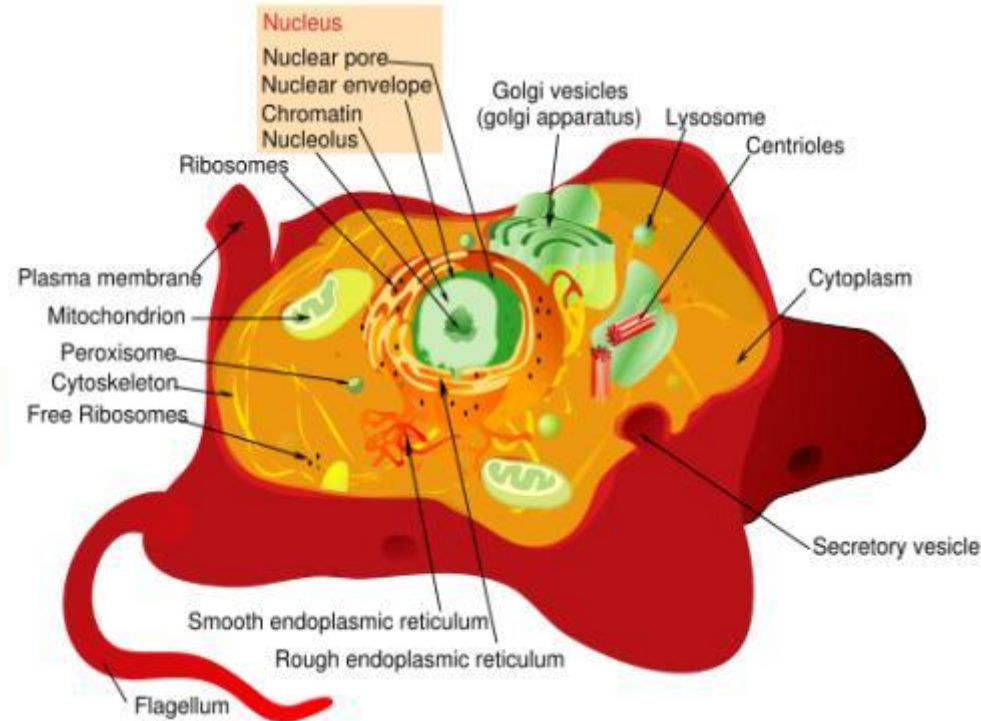


- Living things are constructed of **cells**.
- Living things may be **unicellular** or **multicellular**.
- Cell structure is diverse but all cells share common characteristics.
- Cells are **small** so they can exchange materials with their surroundings.
 - Surface area relative to the volume decreases as **size** of cell increases.
 - This limits the size of cells.
- **Cell Theory states:**
 1. All organisms are composed of one or more cells.
 2. Cells are the basic unit of structure and function in organisms.
 3. All cells come only from other cells.

Two Basic Types of Cells

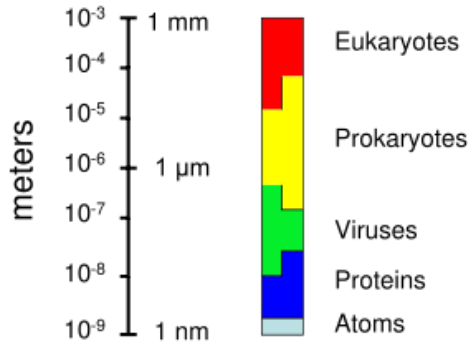
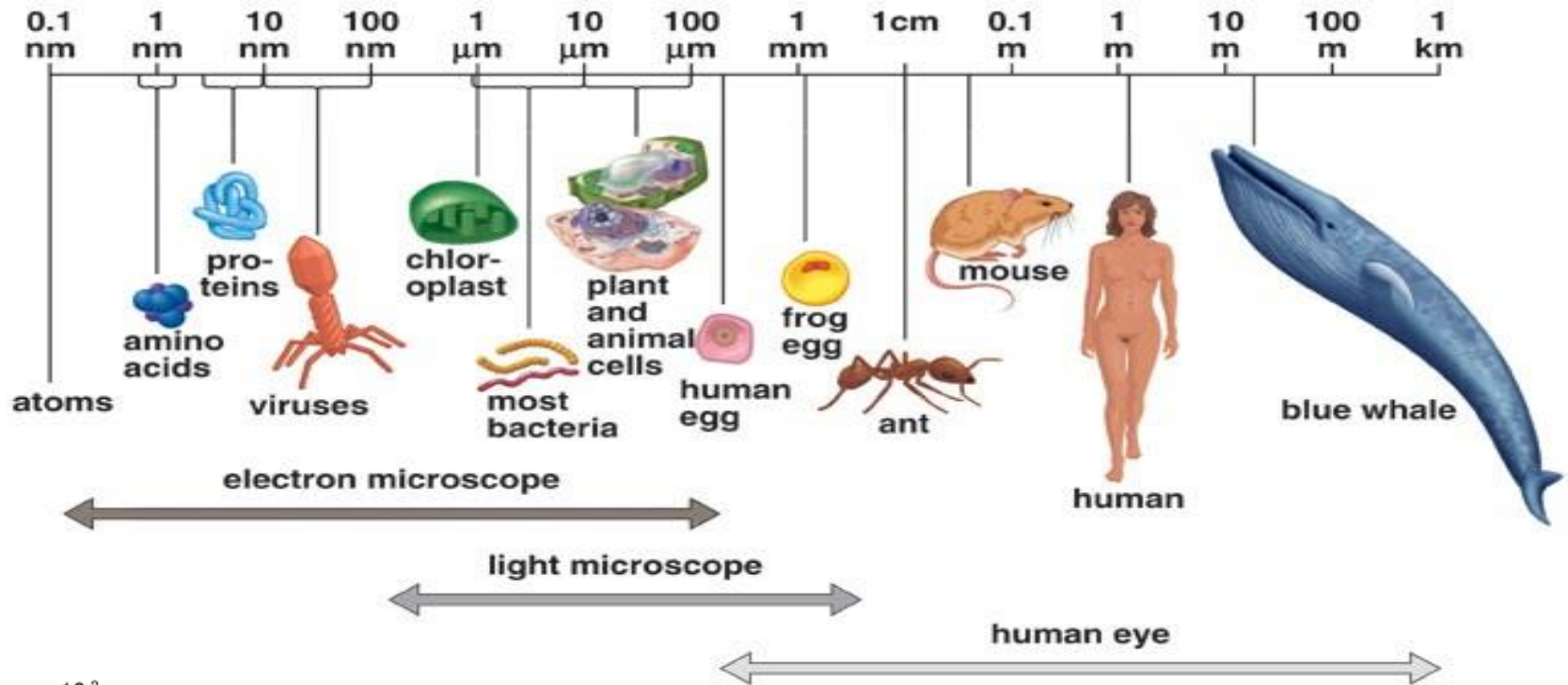


Prokaryotic Cell



Eukaryotic Cell

Size of Living Things



1 m = 100 cm = 1,000mm = 1,000,000 μm = 1,000,000,000nm

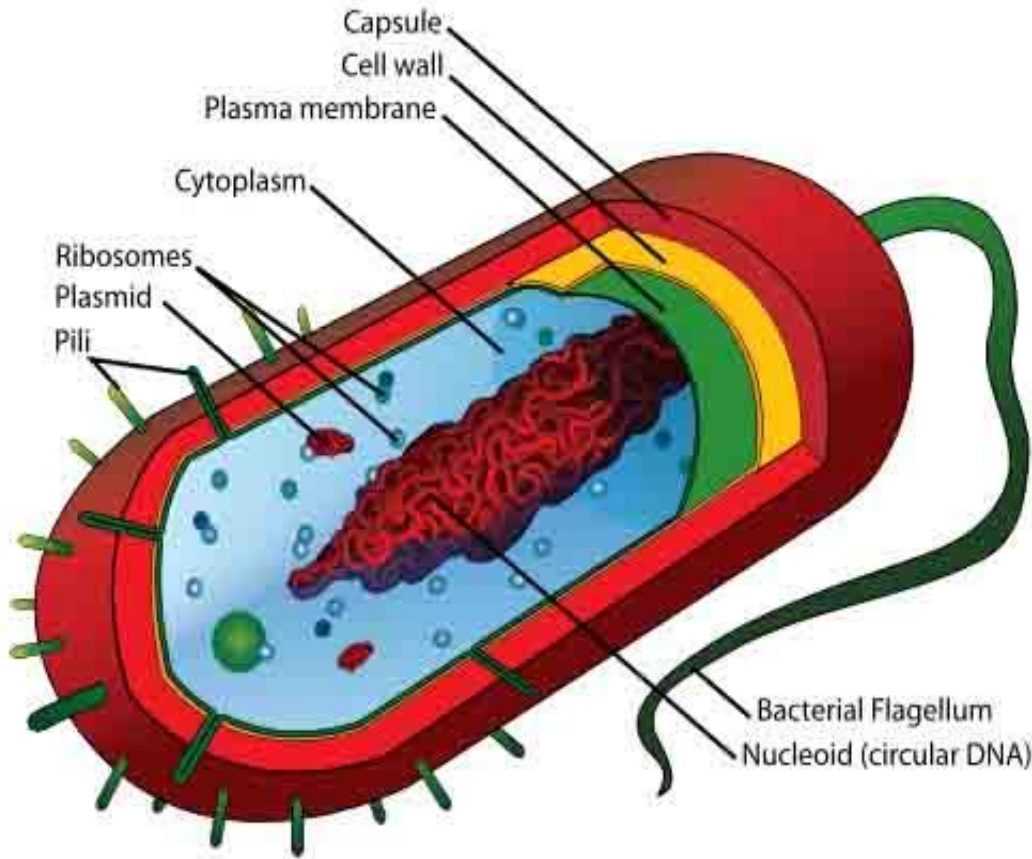
1mm = 1000 μm = 1000000nm

1 μm = 1000nm

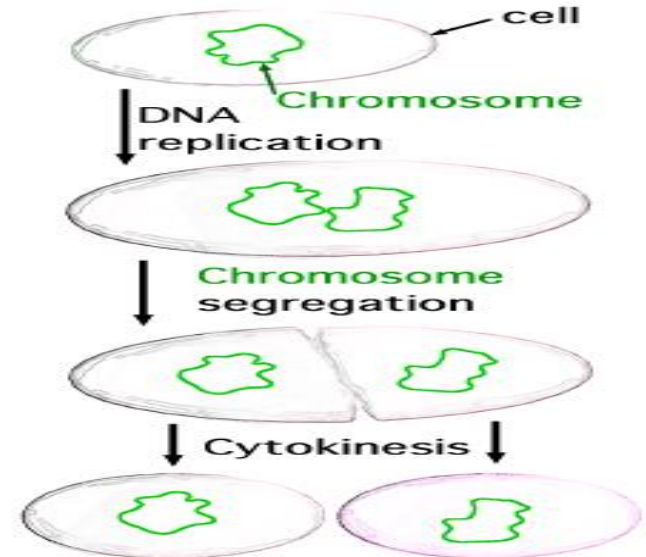
Click link for an interactive
["Size of Microscopic Things"](#)
 animation on Cells Alive.

Prokaryotes

Tell me about Prokaryotes...



Binary Fission



Check out these quick animated lessons on binary fission:

(Please watch both, as each provides different and useful information.)

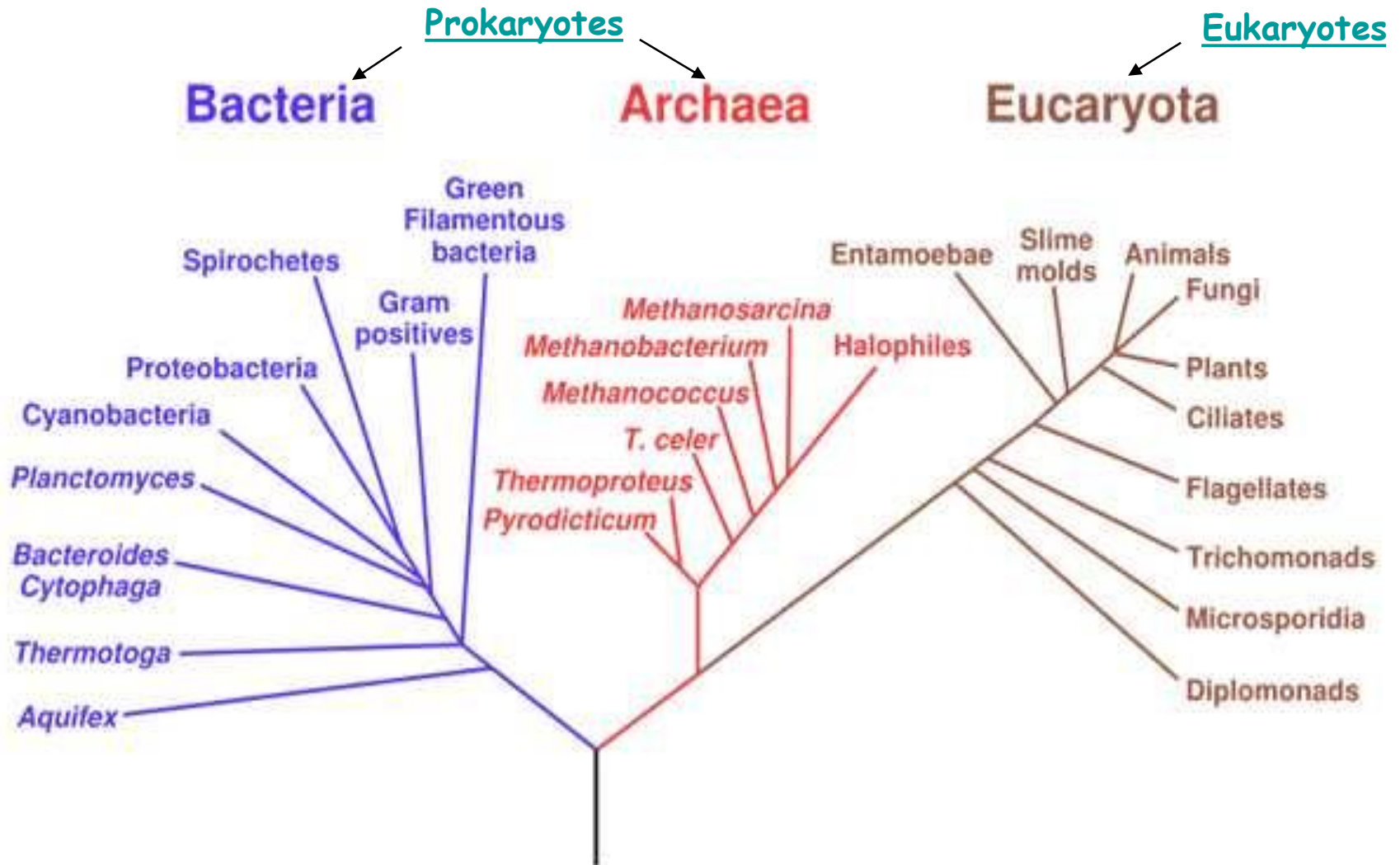
[Binary Fission Animation](#)

from ClassZone

[Binary Fission Animation](#)

From McGraw-Hill

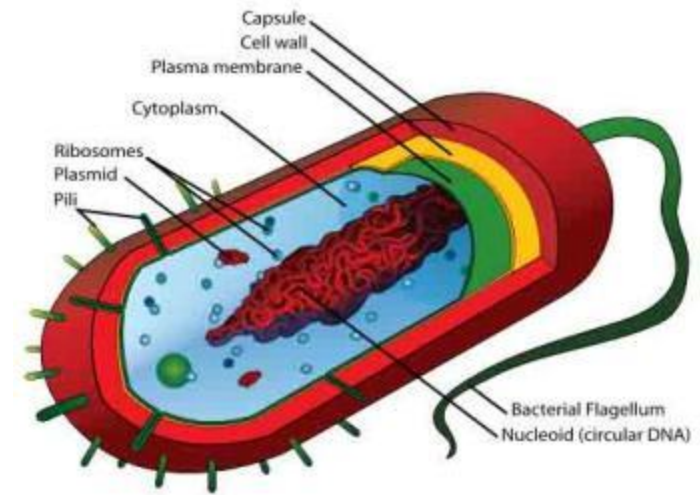
Phylogenetic Tree of Life



Prokaryote Genetics

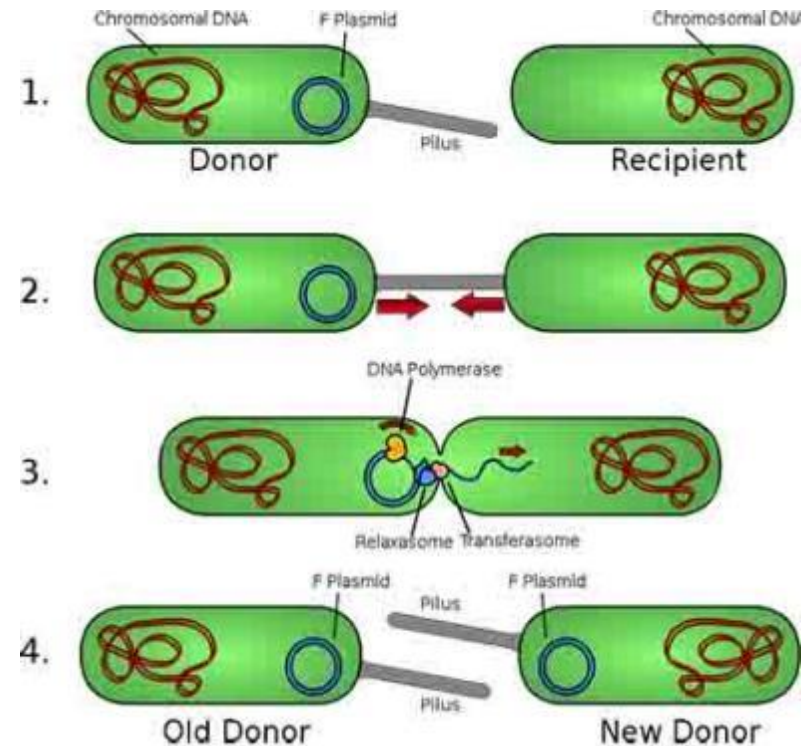
Nucleoid

- Region of cytoplasm where prokaryote's **genome** (DNA) is located.
- Usually a singular, circular chromosome.



Plasmid

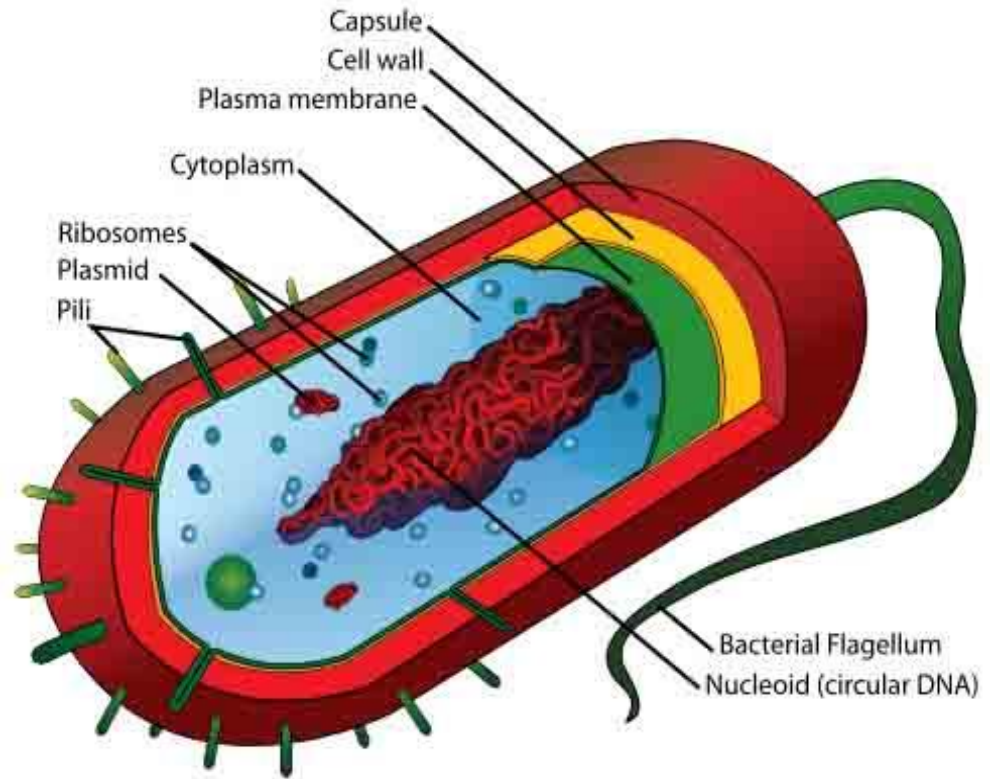
- Small extra piece of chromosome/genetic material.
- 5 - 100 genes
- Not critical to everyday functions.
- Can provide genetic information to promote:
 - Antibiotic resistance
 - Virulence factors
(molecules produced by pathogen that specifically influence host's function to allow the pathogen to thrive)
 - Promote conjugation
(transfer of genetic material between bacteria through cell-to-cell contact)



Prokaryotes

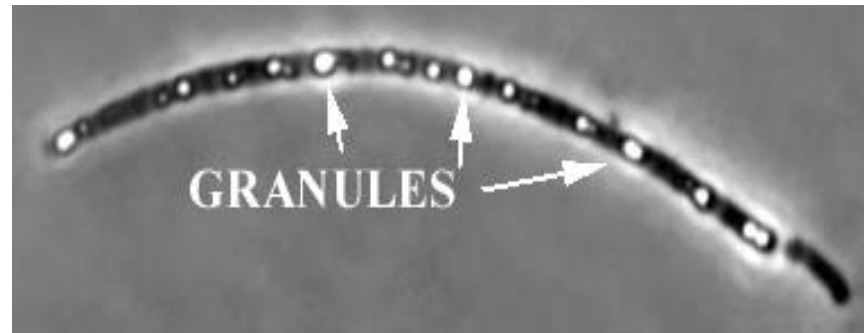
Cytoplasm

- Also known as proto-plasm.
- Gel-like matrix of water, [enzymes](#), nutrients, wastes, and gases and contains cell structures.
- Location of growth, metabolism, and [replication](#).



Granules

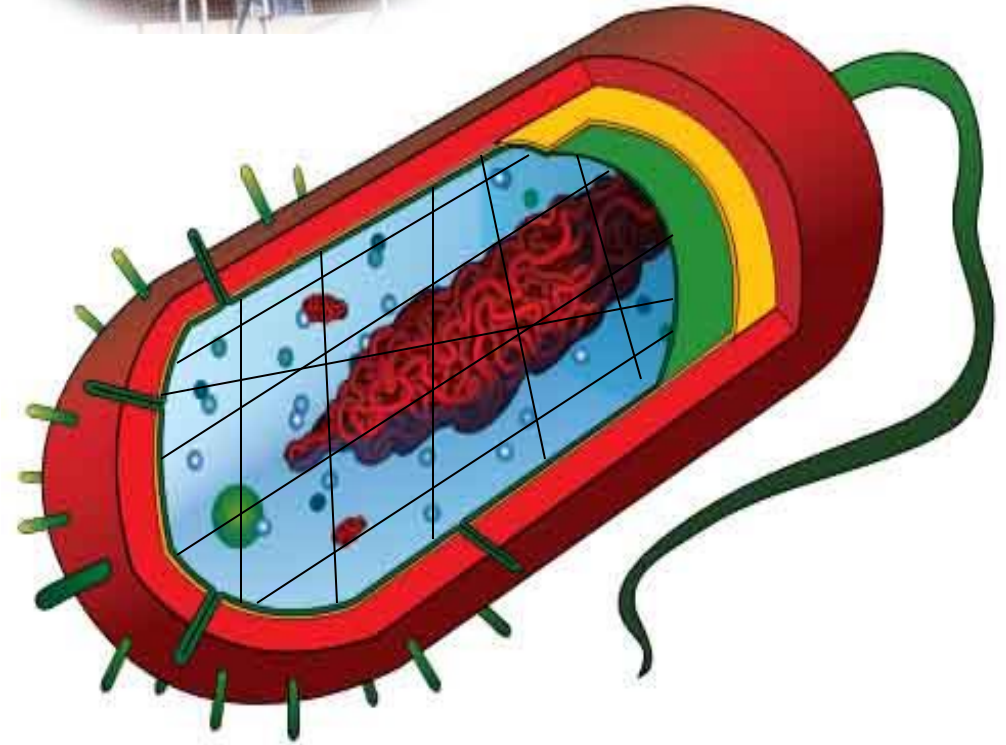
- Bacteria's way of storing nutrients.
- Staining of some granules aids in identification.



Prokaryotes

Cytoskeleton

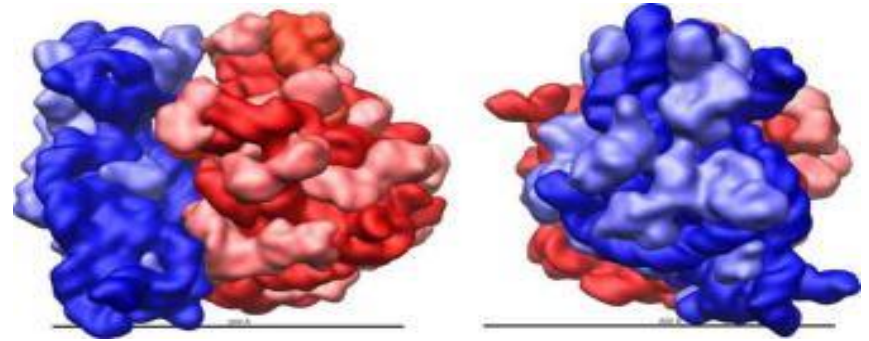
- Cellular "scaffolding" or "skeleton" within the cytoplasm.
- Major advance in prokaryotic [cell biology](#) in the last decade has been discovery of the [prokaryotic](#) cytoskeleton.
- Up until recently, thought to be a feature only of [eukaryotic](#) cells.



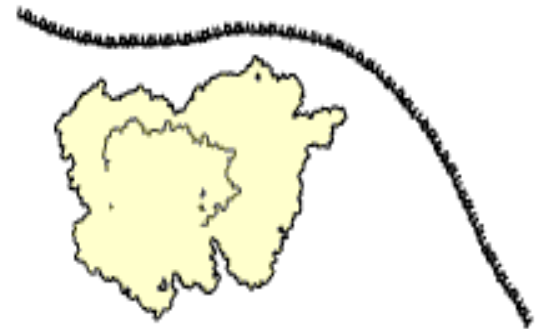
Prokaryotes

Ribosomes

- Found within cytoplasm or attached to plasma membrane.
- Made of protein & rRNA.
- Composed of two subunits.
- Cell may contain thousands .
- **Q:** *What do ribosomes do?*
- **Q:** *What's the relationship between the job that the ribosomes do and the genetic instructions (nucleic acids) of the cell?*



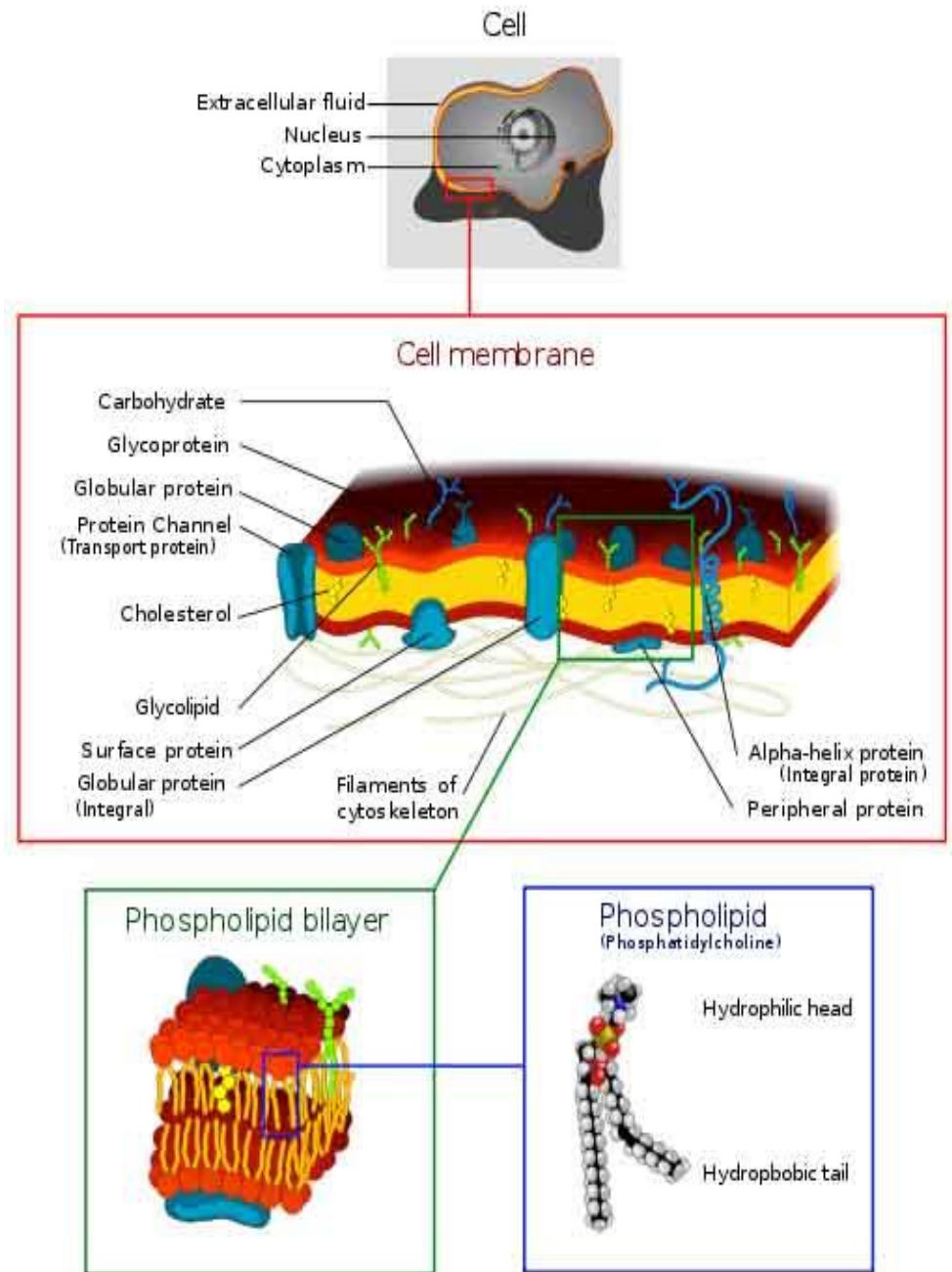
[Click here](#) for animation of ribosome building a protein.



Prokaryotes

Plasma Membrane

- Separates the cell from its environment.
- Phospholipid molecules oriented so that **hydrophilic water-loving** heads directed outward and **hydrophobic water-hating** tails directed inward.
- Proteins embedded in two layers of lipids (lipid bilayer).
- Membrane is **semi-permeable**.
Q: What does that mean?



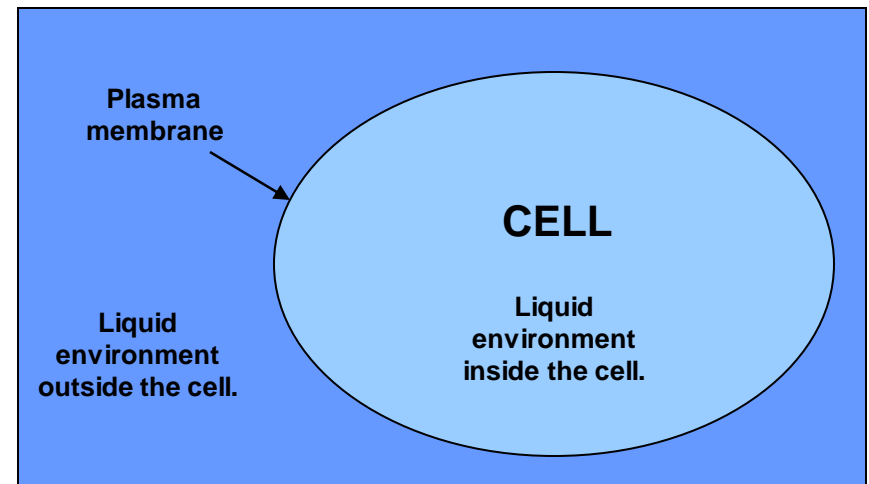
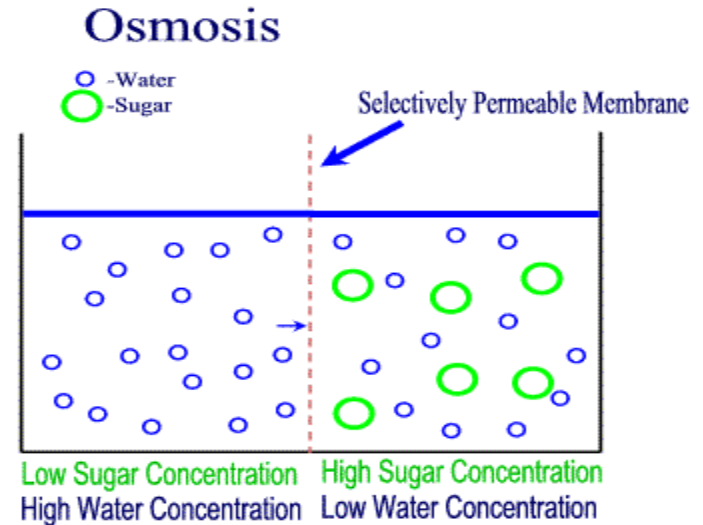
Passive Transport - Osmosis

Q: Diffusion of **what** across the plasma membrane?

Environment surrounding cells may contain amounts of dissolved substances (solutes) that are...

- equal to
- less than
- greater than

...those found with in the cell.

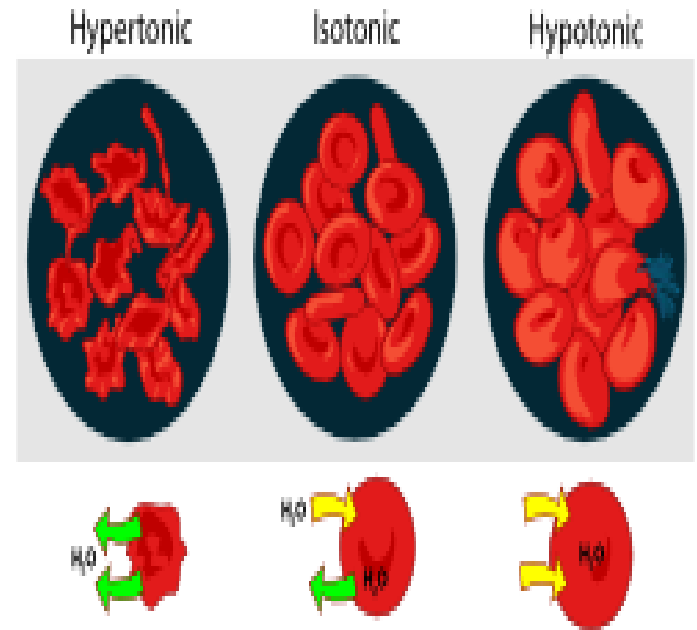


Passive Transport - Osmosis

Tonicity and Osmosis

- **isotonic:** equal concentration of a solute inside and outside of cell.
- **hypertonic:** a higher concentration of solute.
- **hypotonic:** a lower concentration of solute.

Water will always move toward a hypertonic environment!!



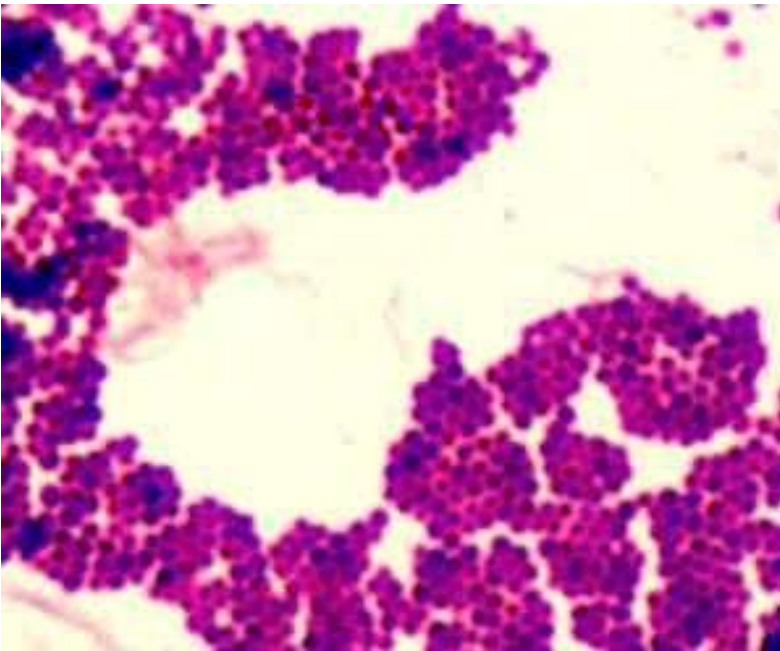
REVIEW!

- [How Osmosis Works](#) animation
- [Diffusion, Osmosis & Active Transport](#) Lecture Main Page of the [Virtual Cell Biology Classroom](#) on the [Science Prof Online](#) website

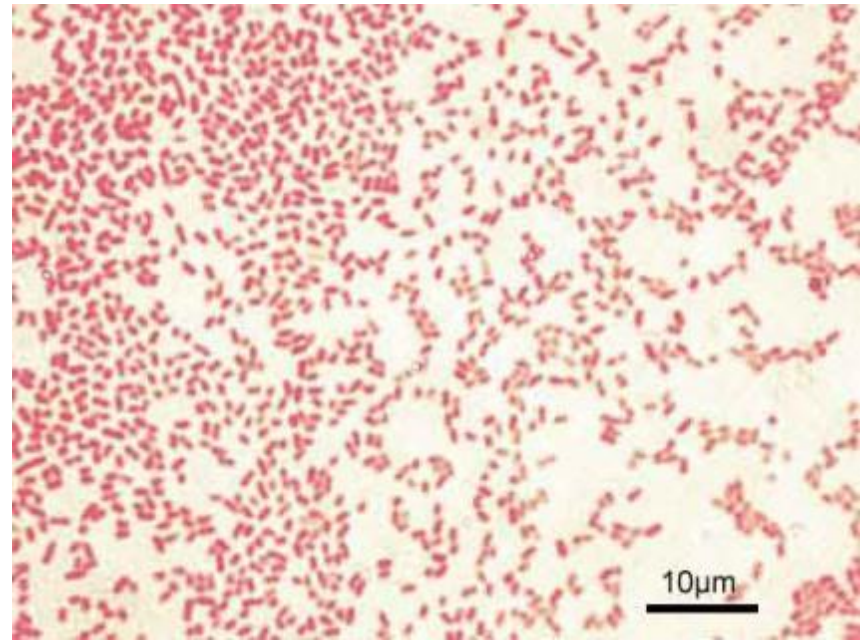
Prokaryotes - Cell Wall

From the peptidoglycan inwards all bacteria are very similar. Going further out, the bacterial world divides into two major classes (plus a couple of odd types). These are:

Gram-positive



Gram-negative



Bacterial Cell Wall

- **Peptidoglycan** is a huge polymer of interlocking chains of alternating monomers.
- Provides rigid support while freely permeable to solutes.
- Backbone of peptidoglycan molecule composed of two amino sugar derivatives of glucose. The "glycan" part of peptidoglycan:
 - N-acetylglucosamine (NAG)
 - N-acetylmuramic acid (NAM)
- NAG / NAM strands are connected by interlocking peptide bridges. The "peptid" part of peptidoglycan.

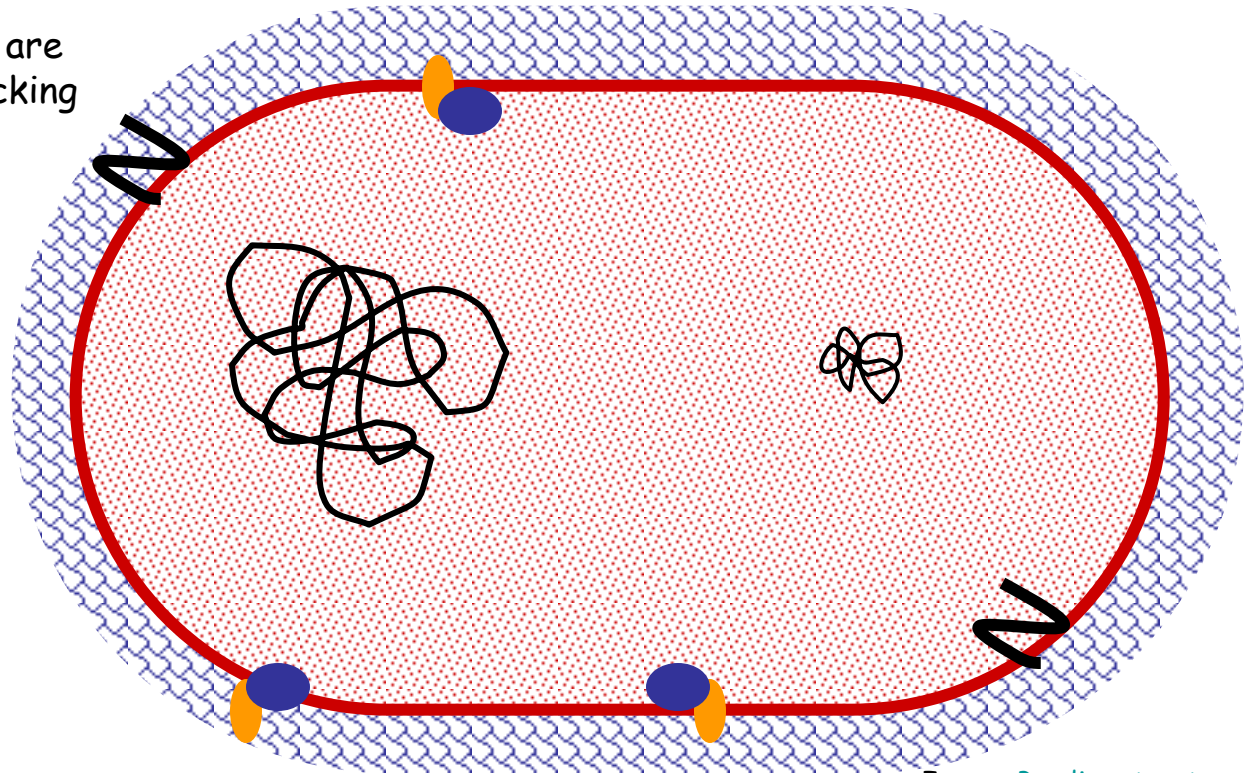
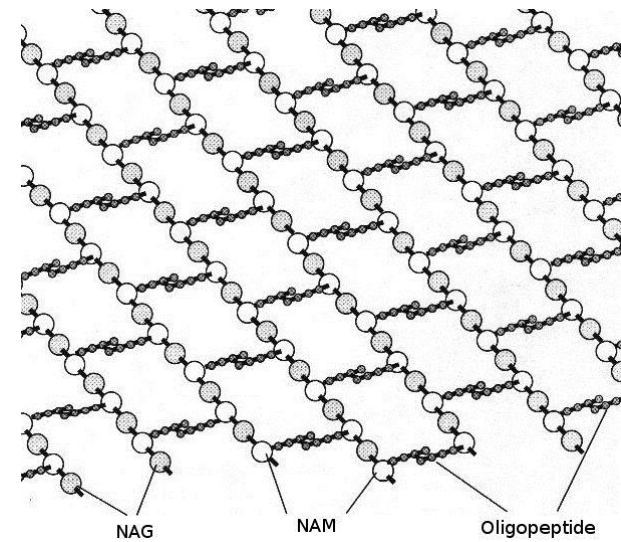
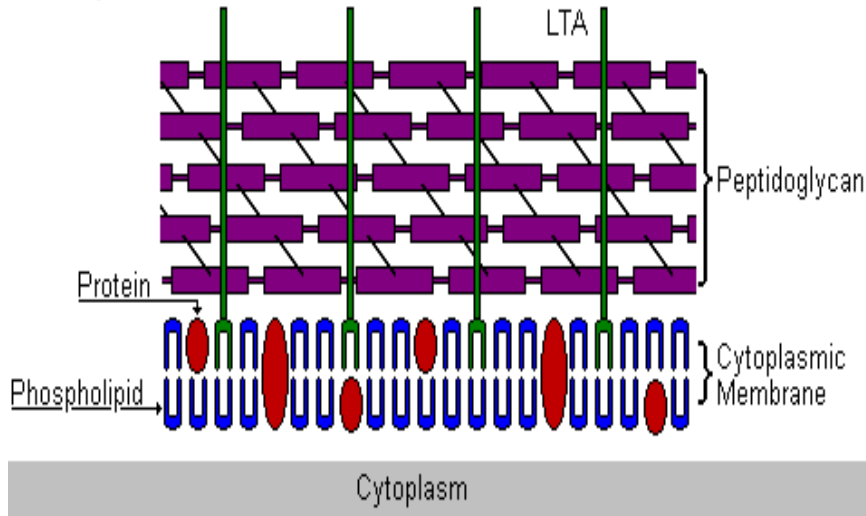


Image: [Bonding structure peptidoglycan](#),
Mouagip; Other Image Source Unknown

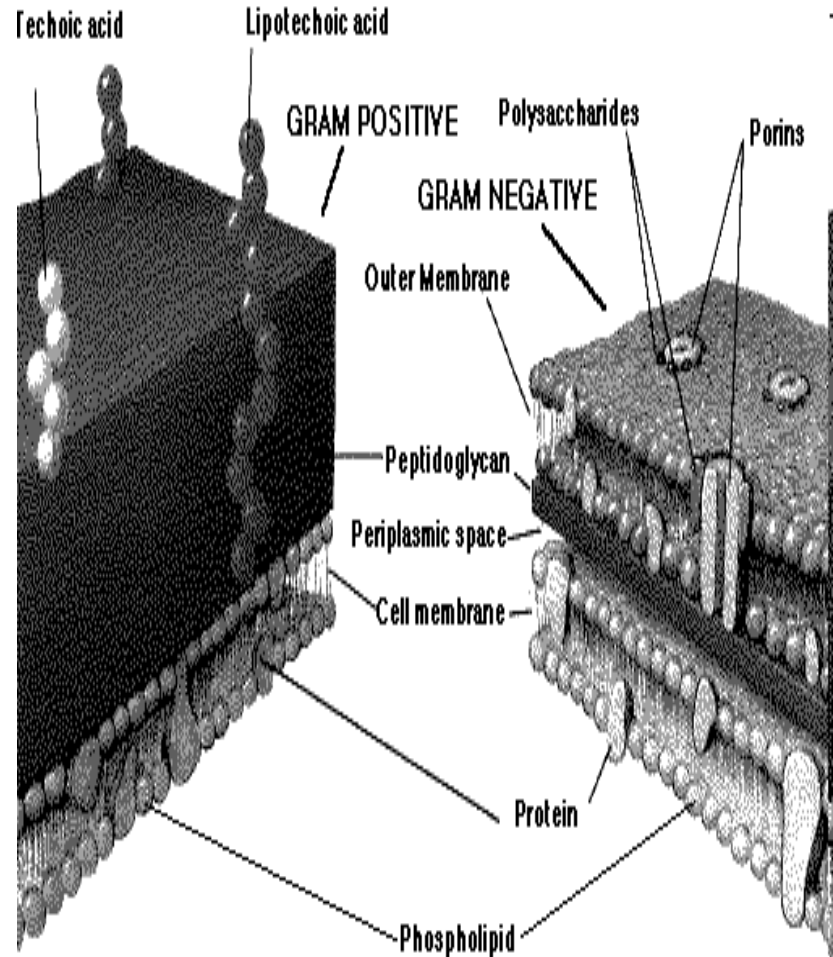
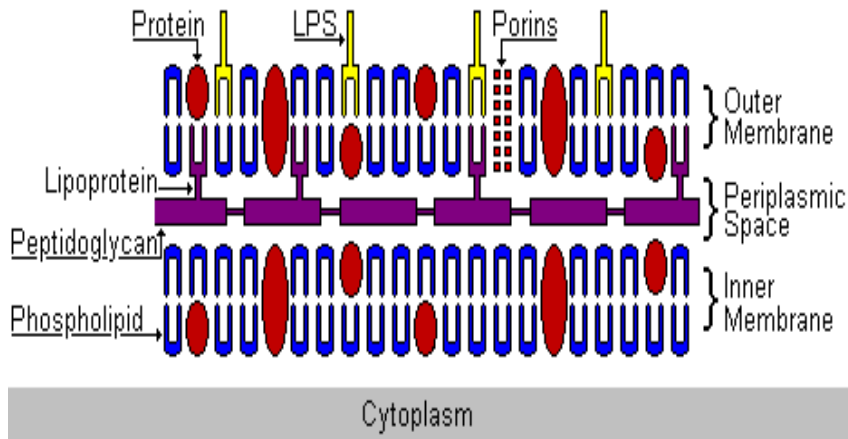
Prokaryotes - Cell Wall

Gram-Positive & Gram-Negative

Gram-positive Cell Wall

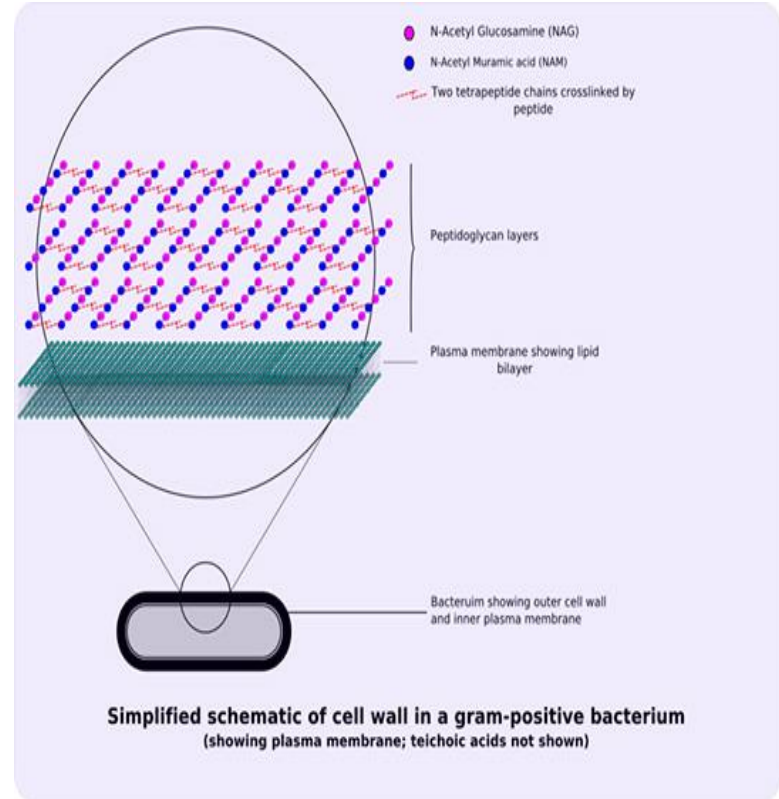
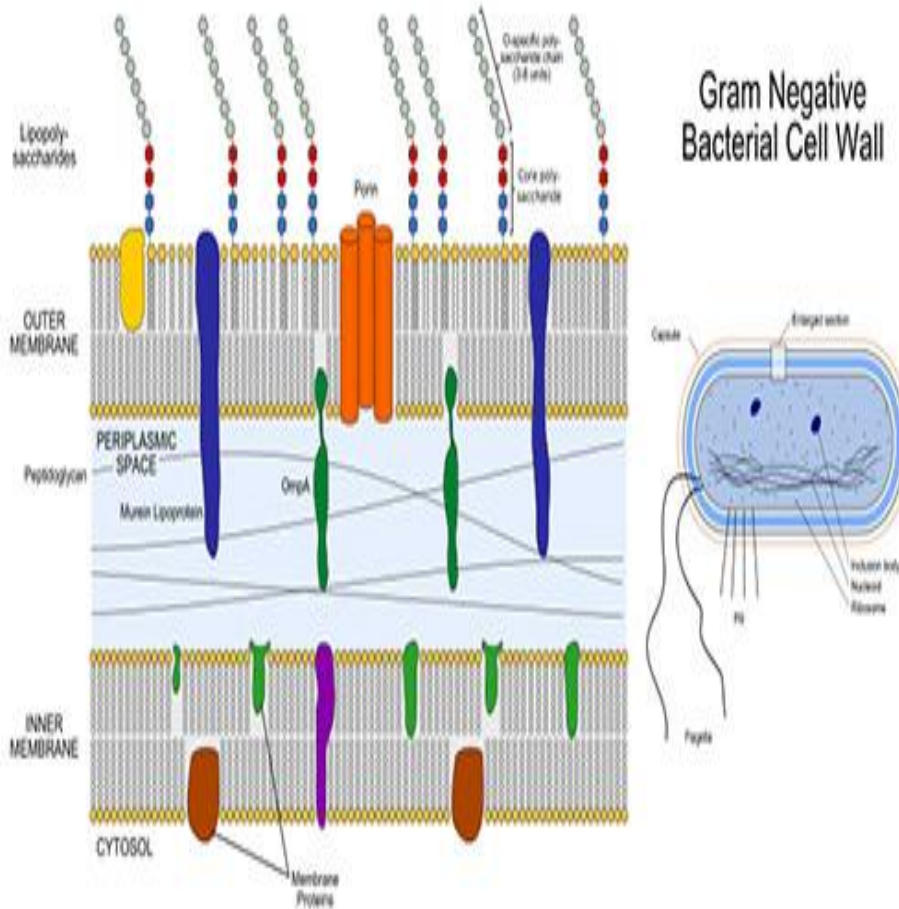
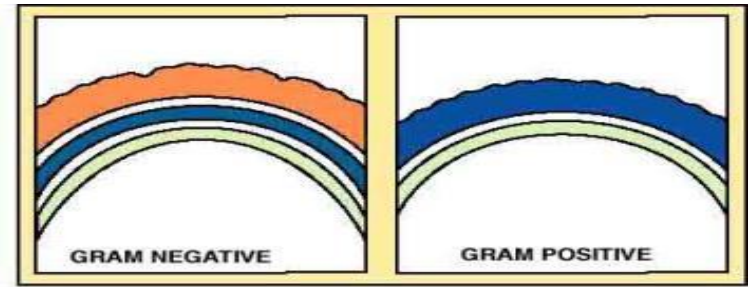


Gram-negative Cell Wall



Prokaryotes - Cell Wall

Gram-Positive & Gram-Negative



FYI: The bacterial plasma membrane and cell wall together are called the cell envelope.

Image: [Gram-positive cell wall schematic](#), Wiki; [Gram-negative cell wall schematic](#), Jeff Dahl



Q: Why are these differences in bacterial cell wall structure so important?

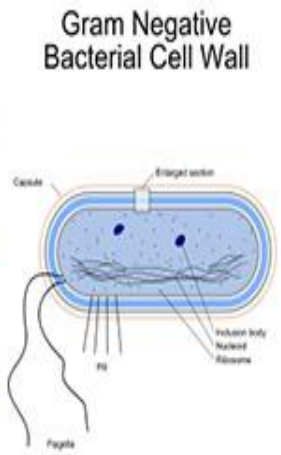
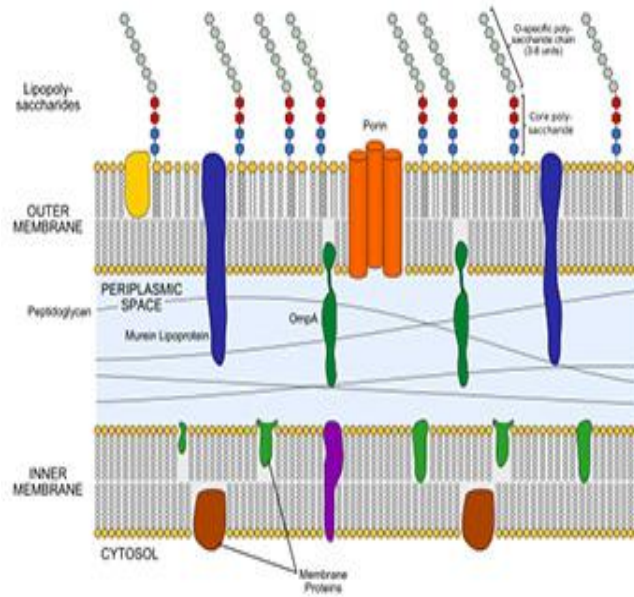
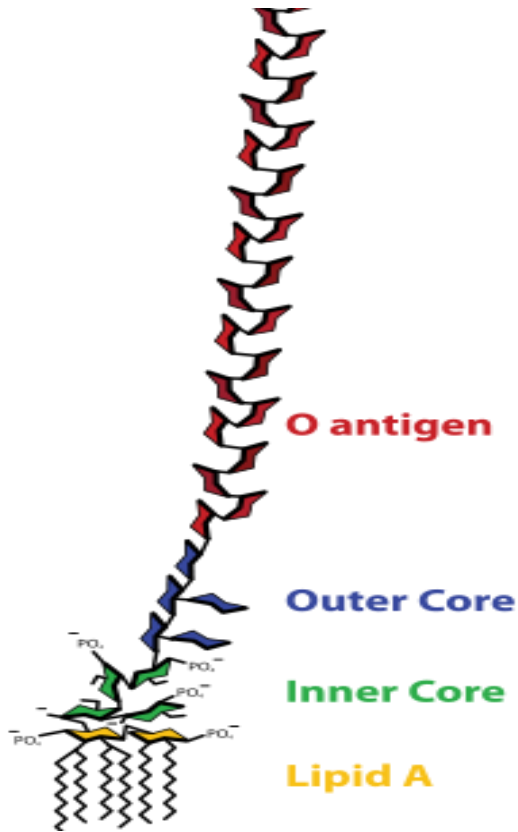
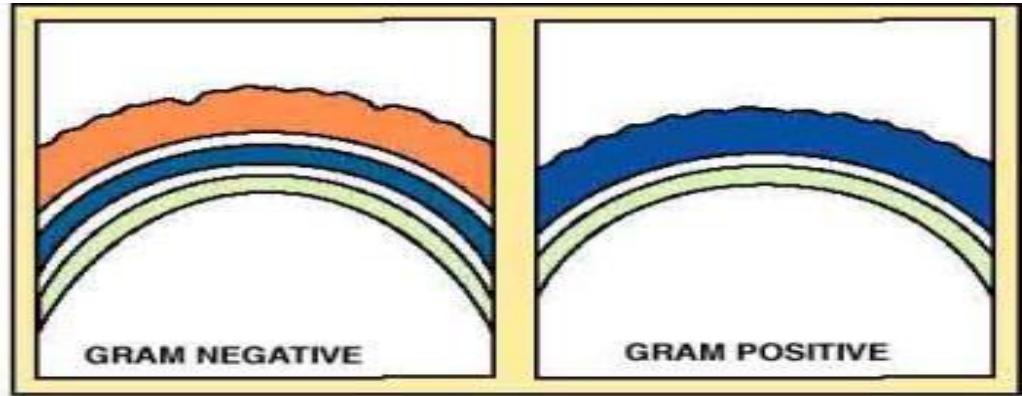


Image: [Lipopolysaccharide](#), Wiki; Gram+ and Gram- cell wall diagram, source unknown; ; [Gram-negative cell wall schematic](#), Jeff Dahl



Prokaryotes - **Glycocalyx**

Some bacteria have an additional layer outside of the cell wall called the **glycocalyx**.

This additional layer can come in one of two forms:

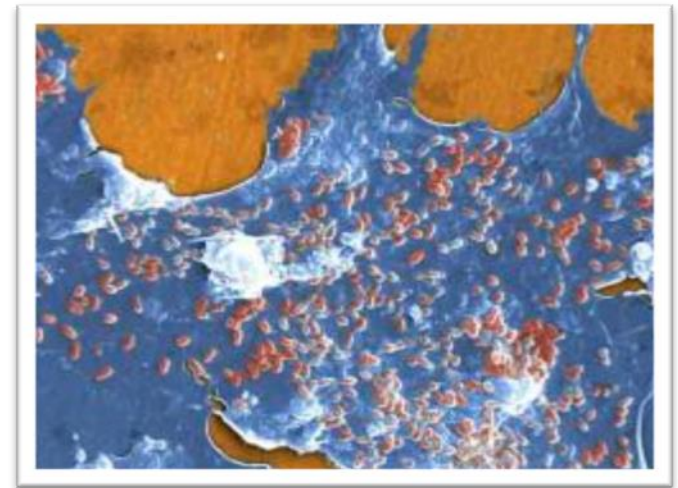
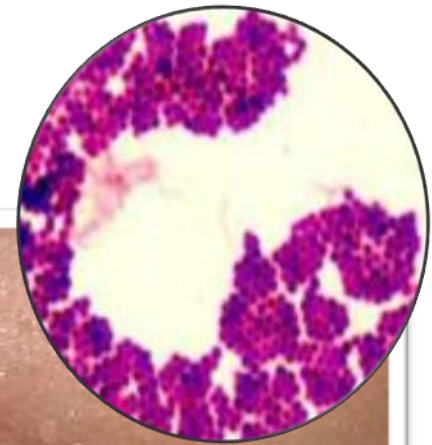
1. Slime Layer

- Glycoproteins loosely associated with the cell wall.
- Slime layer causes bacteria to adhere to solid surfaces and helps prevent the cell from drying out.

- *Streptococcus*

The slime layer of **Gram+** *Streptococcus mutans* allows it to accumulate on tooth enamel (yuck mouth and one of the causes of cavities).

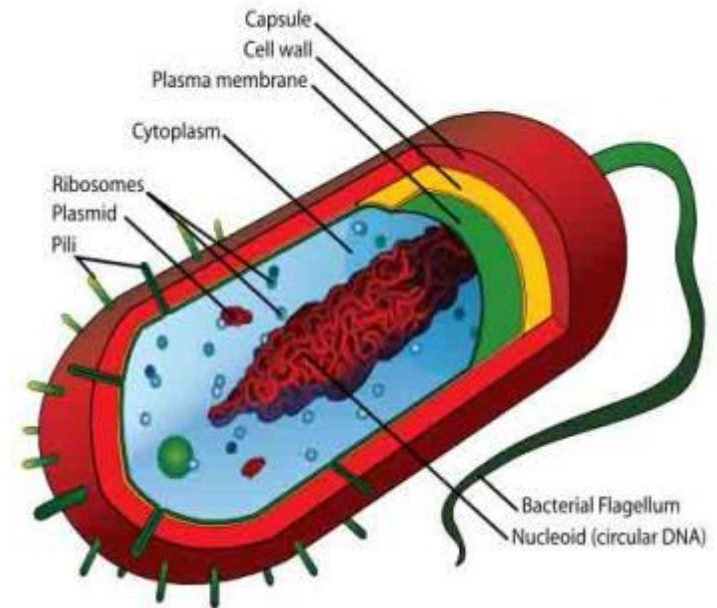
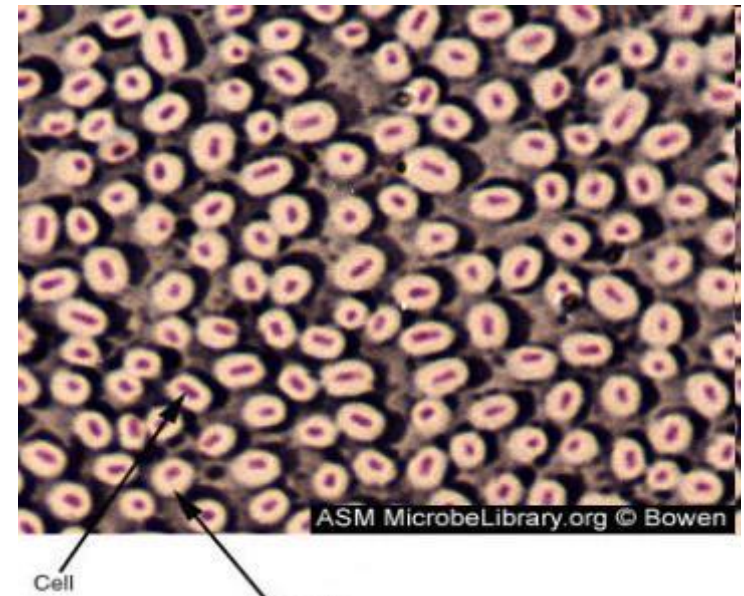
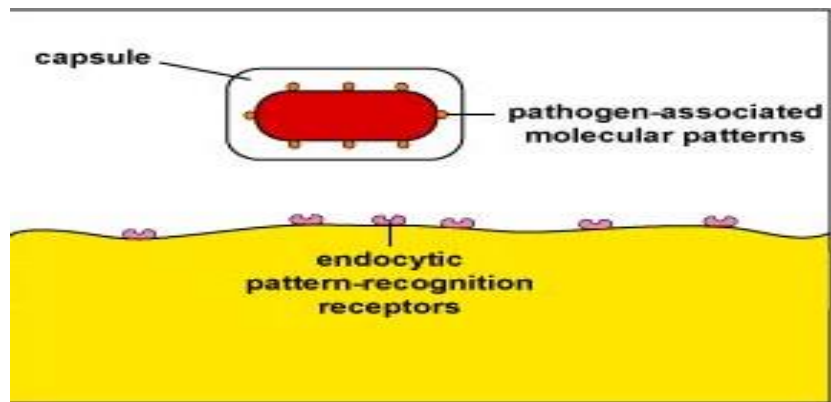
Other bacteria in the mouth become trapped in the slime and form a biofilm & eventually a buildup of plaque.



Prokaryotes - Glycocalyx

2. Capsule

- Polysaccharides firmly attached to the cell wall.
- Capsules adhere to solid surfaces and to nutrients in the environment.
- Adhesive power of capsules is a major factor in the initiation of some bacterial diseases.
- Capsule also protect bacteria from being phagocytized by cells of the hosts immune system.

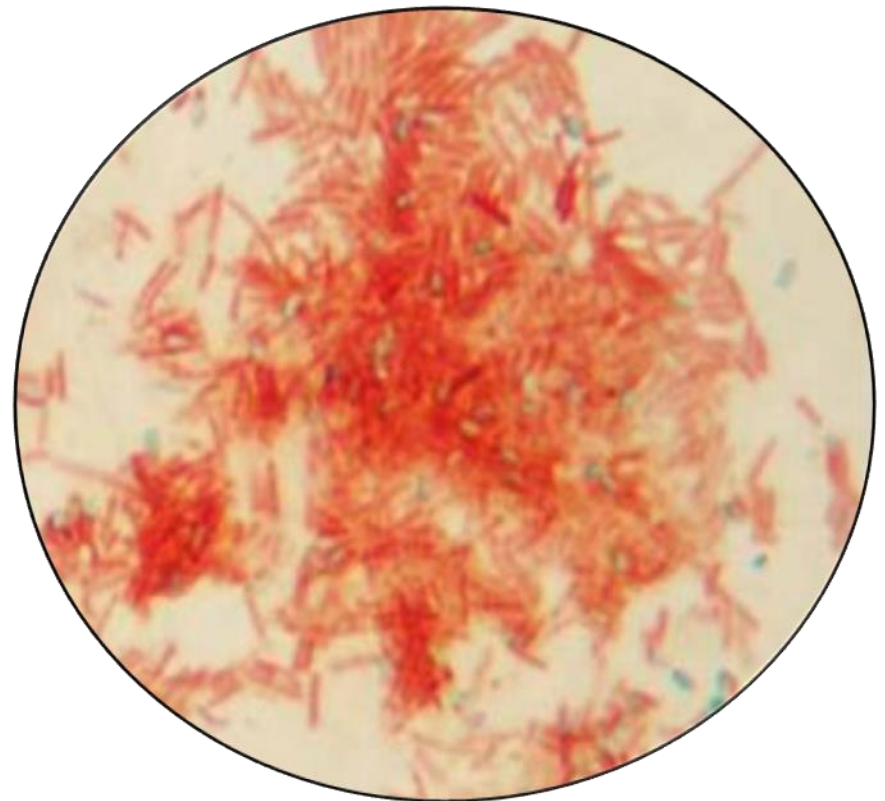




Prokaryotes - Endospores

- Dormant, tough, non-reproductive structure produced by small number of bacteria.
- Resistant to radiation, desiccation, lysozyme, temperature, starvation, and chemical disinfectants.
- Endospores are commonly found in soil and water, where they may survive for very long periods of time.
- **Q:** How and why do endospores form? Watch the animated lesson "Bacterial Spore Formation" to find out. Link also provides quiz questions to test your understanding of the material.

An endospore stained bacterial smear of *Bacillus subtilis* showing **endospores** as green and **vegetative cells** as red.



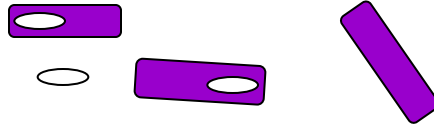
Bacterial Genus : Clostridium

GRAM-POSITIVE

Obligate anaerobes


bacillus-shaped

endospore producer



- The members of this genus have a couple of bacterial "superpowers" that make them particularly tough pathogens.
- All have a strictly **fermentative** mode of metabolism (Don't use oxygen).
- Vegetative cells are **obligate anaerobes** killed by exposure to O₂, but their **endospores** are able to survive long periods of exposure to air.
- Known to produce a variety of toxins, some of which are fatal.
 - *Clostridium tetani* = agent of tetanus
 - *C. botulinum* = agent of botulism
 - *C. perfringens* = one of the agents of gas gangrene
 - *C. difficile* = part of natural intestinal flora, but resistant strains can proliferate and cause pseudomembranous colitis.



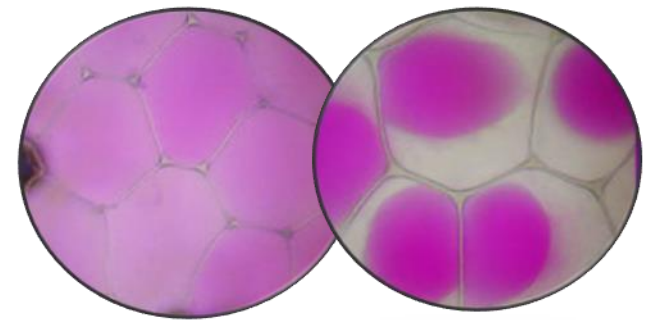


More About Cells & Water... Osmotic Pressure

Q: What is the impact of osmotic pressure on cells?

- H₂O important reactant in many metabolic reactions.
- Most cells die in absence of water.
- Cell walls of bacteria and plants prevent them from exploding in a **hypotonic** environment, but most bacteria are vulnerable in **hypertonic** environments.
- Many bacteria can be plasmolyzed by high concentrations of solutes.
- You salty perspiration protects you from bacteria that cannot handle the high sodium chloride concentration.
- Water moves out of the bacterium and it dies of 'hyperosmotic shock' (desiccation).

Q: What protects cells in a *hypertonic* environment?

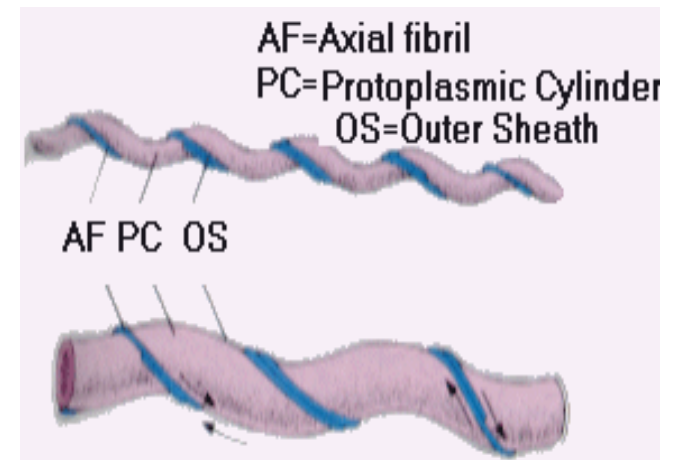
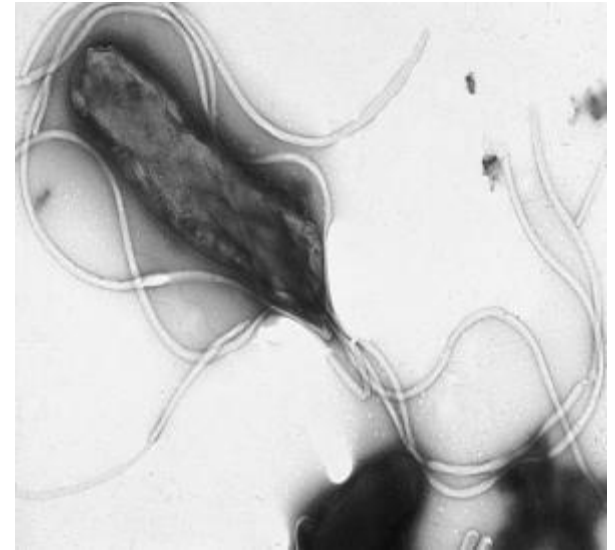


Q: Why can you keep honey on the cupboard for months, even years, without it spoiling?

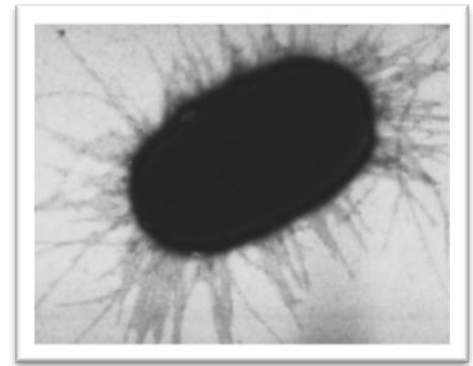


Prokaryotes - Surface Appendages

- Some prokaryotes have distinct appendages that allow them to move about or adhere to solid surfaces.
- Consist of delicate stands of proteins.
- **flagella**: Long, thin extensions that allow some bacteria to move about freely in aqueous environments.
(singular: flagellum)
- **axial filament (endoflagella)**: Wind around bacteria, causing movement in waves.



Prokaryotes - Surface Appendages

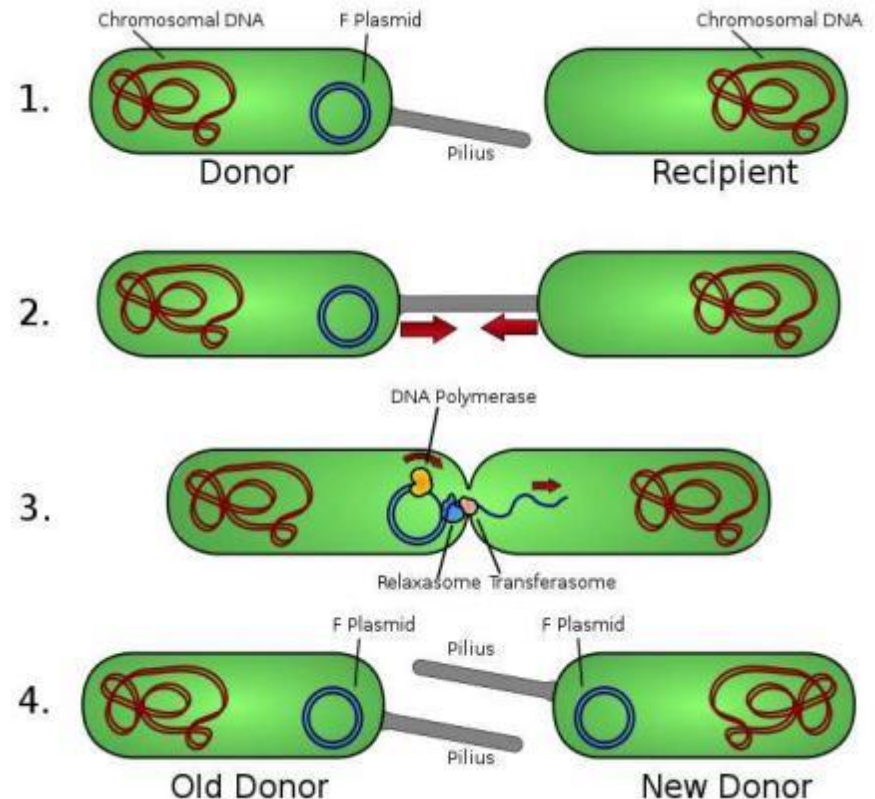


- **fimbriae:** Most Gram-negative bacteria have these short, fine appendages surrounding the cell. Gram+ bacteria don't have.

No role in motility. Help bacteria adhere to solid surfaces. Major factor in virulence.
(singular: fimbria)

- **pili:** Tubes that are longer than fimbriae, usually shorter than flagella.

Use for movement, like grappling hooks, and also use conjugation pili to transfer plasmids. (singular = pilus)



Meet the Microbe! *Neisseria* and its Fimbriae

- **Gram-** diplococci, resemble coffee beans when viewed microscopically.
- *Neisseria gonorrhoeae* causes sexually transmitted disease gonorrhoeae.
- Antibiotics applied to the eyes of neonates as a preventive measure against gonorrhoea.
- One of the most communicable disease in the U.S.
- 125 cases per 100,000. Teens 15-19 yo 634 cases per 100,000. Young adults 20-25 460 per 100,000.
- *N. meningitidis* most common causes of bacterial meningitis in young adults.

Q: What makes Neisseria so tough?

- Lipopolysaccharide (LPS) of the cell wall of *Neisseria* acts as an endotoxin.
- Polysaccharide **capsule** prevents host phagocytosis and aids in evasion of the host immune response.
- Use **fimbriae** to attach onto host cells; avirulent without. **Fimbriae** have adhesion proteins (adhesins) on their tips that match, lock and key, with **proteins** on host epithelial cell surface.

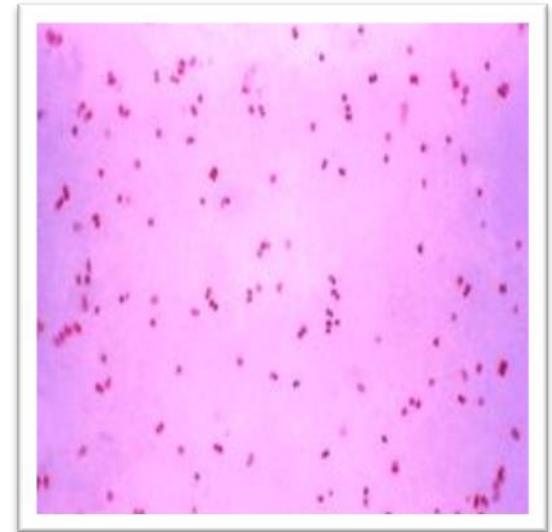
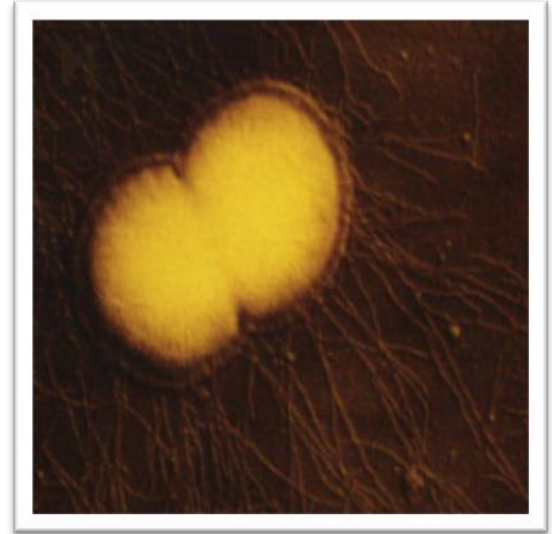


Image: [Neisseria](#) photo, Textbook of Bacteriology, Gram stain of *Neisseria gonorrhoeae*, Souce [PHIL](#) #3798

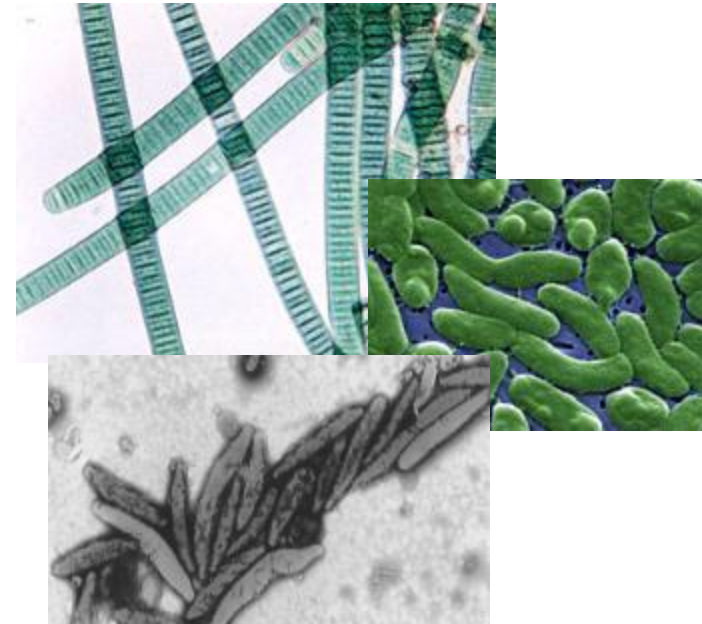
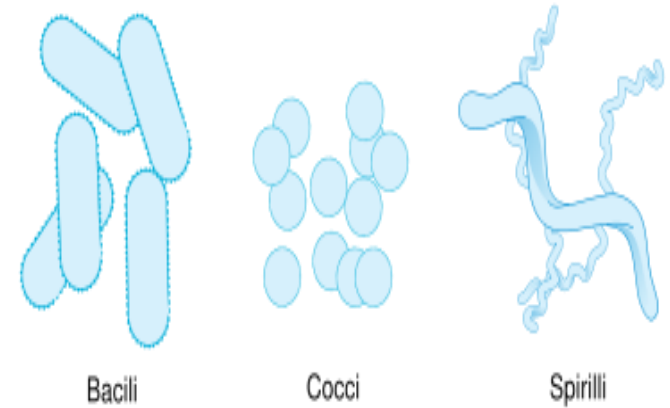
Prokaryotes - Cell Shapes

Most bacteria are classified according to shape:

1. **bacillus** (*pl. bacilli*) = rod-shaped
2. **COCCUS** (*pl. cocci ... sounds like cox-eye*) = spherical
3. spiral shaped
 - a. **spirillum** (*pl. spirilla*) = spiral with rigid cell wall, flagella
 - b. **spirochete** (*pl. spirochetes*) = spiral with flexible cell wall, axial filament

There are many more shapes beyond these basic ones.
A few examples:

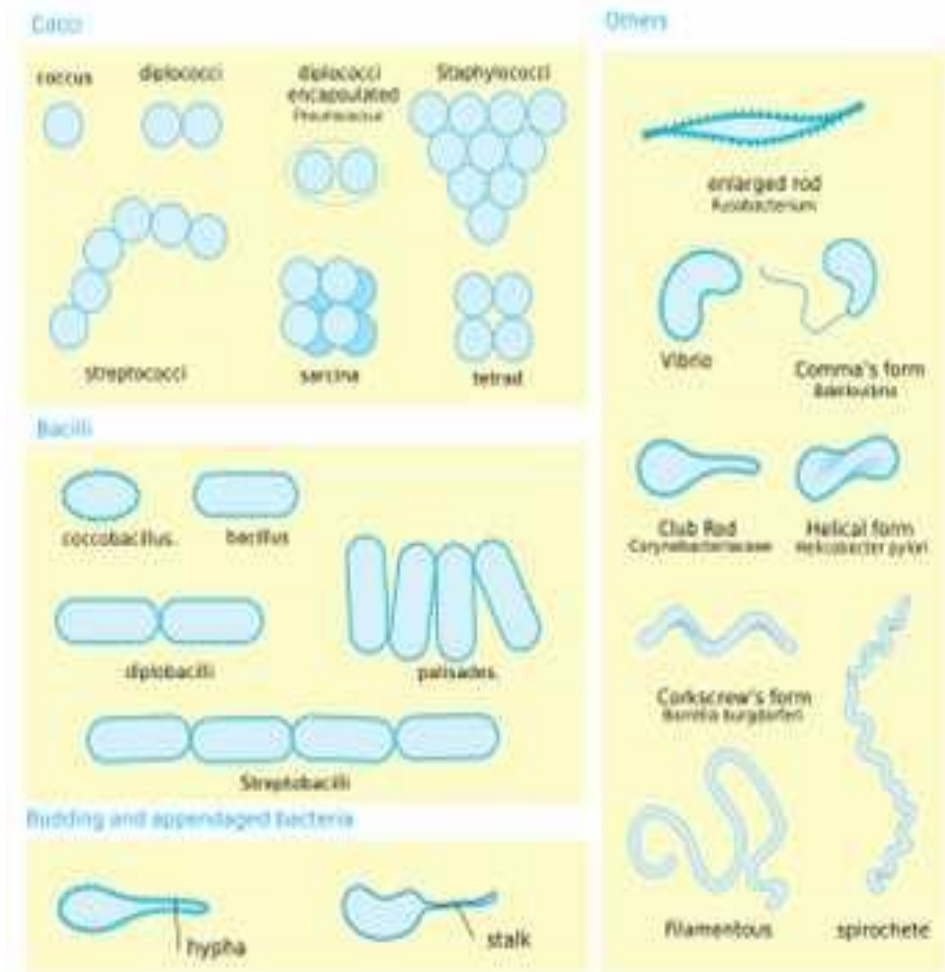
- Coccobacilli = elongated coccal form
- Filamentous = bacilli that occur in long threads
- Vibrios = short, slightly curved rods
- Fusiform = bacilli with tapered ends



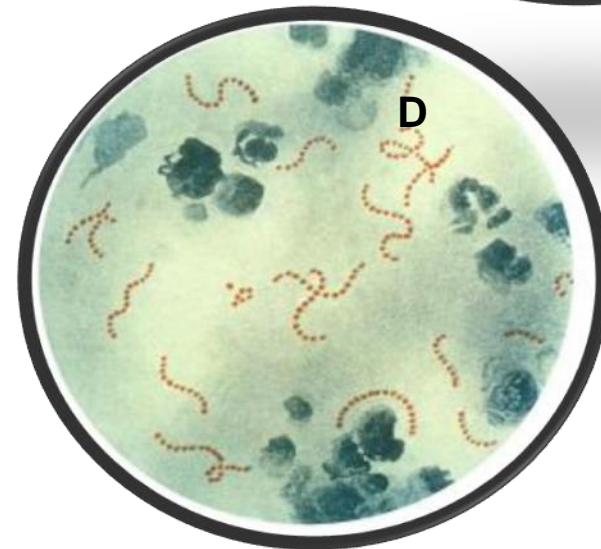
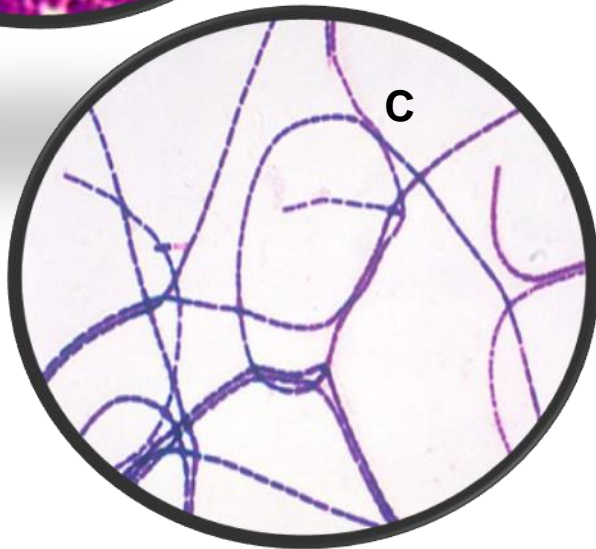
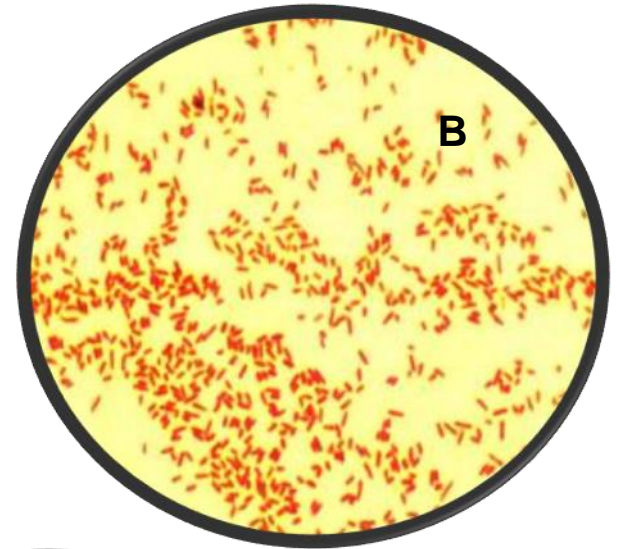
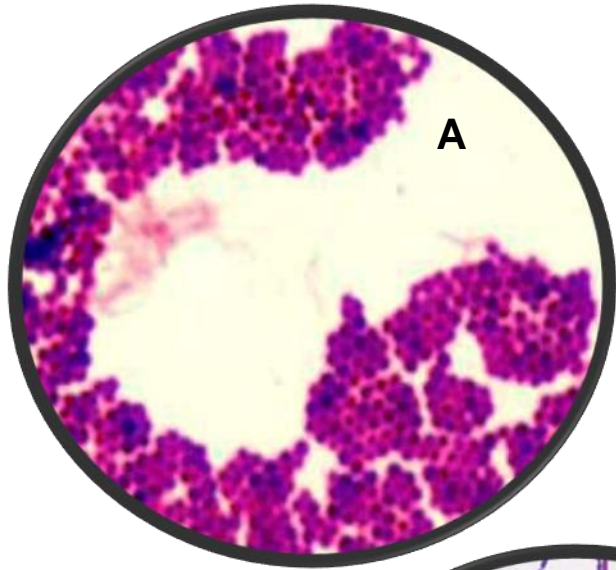
Images: Basic bacterial shapes, Mariana Ruiz,
Other examples of bacterial shapes, FDA, Gov.

Prokaryotes - Arrangements of Cells

- Bacteria sometimes occur in groups, rather than singly.
- **bacilli** divide along a single axis, seen in pairs or chains.
- **cocci** divide on one or more planes, producing cells in:
 - pairs (diplococci)
 - chains (streptococci)
 - packets (sarcinae)
 - clusters (staphylococci).
- Size, shape and arrangement of cells often first clues in identification of a bacterium.
- Many "look-alikes", so shape and arrangement not enough for id of genus and species.

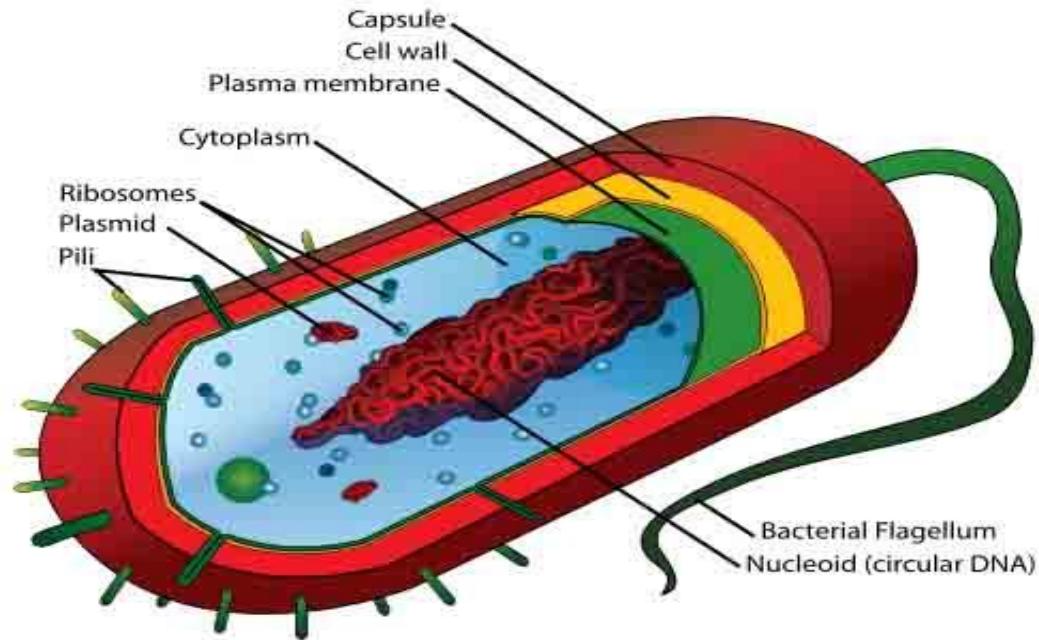


Identify Each Type of Cell Shape & Arrangement



REVIEW!

Here's an excellent interactive lesson on [Prokaryote Cell Structure](#)



Confused?

Here are some links to fun resources that further explain Cell Biology:

Smart Links



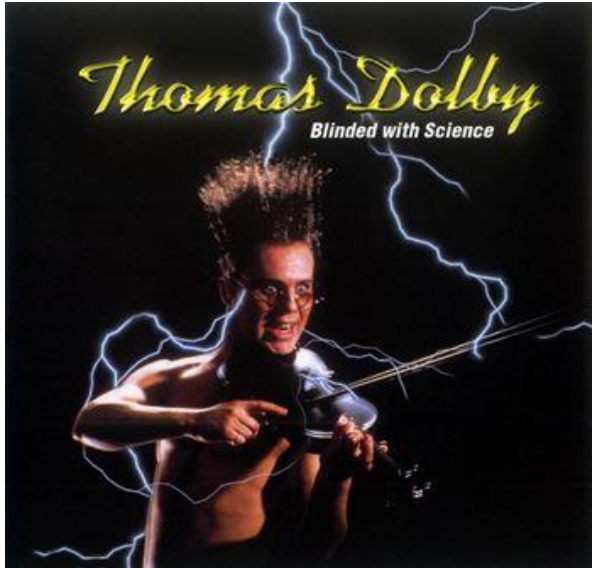
- [Prokaryotic Cells Main Page](#) on the Virtual Cell Biology Classroom of [Science Prof Online](#) website.
- [Prokaryotic Cell: Structures, Functions & Diagrams](#), an article from SPO.
- [Prokaryotic & Eukaryotic: Two Types of Biological Cells](#), an article from SPO.
- [Prokaryotic Cell](#) interactive diagram from [Cells Alive](#) website.
- ["How big is a..."](#) interactive diagram from [Cells Alive](#) website.
- [Cell Structure](#) tutorials and quizzes from Interactive Concepts in Biochemistry.
- ["Germs"](#). Music by Weird Al Yankovic. Video by RevLucio.
- [Evolution of the Three Domains](#) Animated Science Tutorial.
- Biology4Kids - [Cell Biology Main Page](#) by Raders.
- ["She Blinded Me With Science"](#) music video Thomas Dolby.

(You must be in PPT slideshow view to click on links.)

Are you feeling blinded by science?

Do yourself a favor. Use the...

Virtual Cell Biology Classroom (VCBC)!



The VCBC is full of resources to help you succeed,
including:



- practice test questions
- review questions
- study guides and learning objectives
- PowerPoints on other topics

You can access the VCBC by going to the Science Prof Online website
www.ScienceProfOnline.com