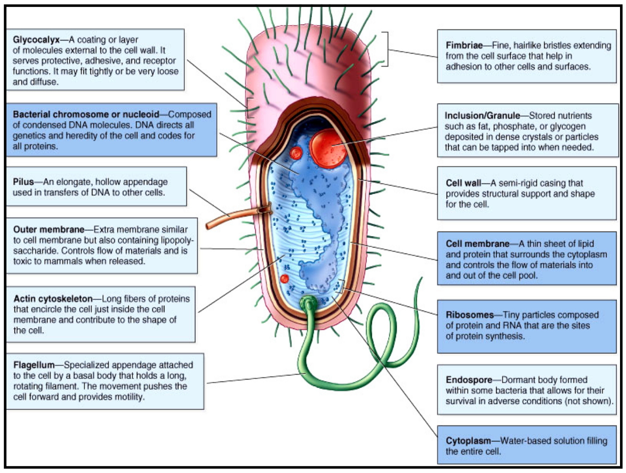
Chapter 4 – Prokaryotic Profiles

Topics:

- External Structures
- Cell Envelope
- Internal Structures
- Cell Shapes, Arrangement, and Sizes

- **Prokaryotes are unicellular organisms**
- **Prokaryotes include two small groups of organisms - the archaeobacteria and the photosynthetic cyanobacteria plus the large group of true bacteria or eubacteria**
- **Prokaryotes are generally small - in the range of 0.2 to 6.0 µm. However, there are exceptions. *Cyanobacteria* may be 60 µm long**



Procaryotic cell
- External
  - Appendages
    - Flagella
    - Pili
    - Fimbriae
  - Glycocalyx
    - Capsule, slime layer
- Cell envelope
  - (Outer membrane)
  - Cell wall
  - Cell membrane
- Internal
  - Cytoplasm
  - Ribosomes
  - Inclusions
  - Nucleoid/chromosome
  - Actin cytoskeleton
  - Endospore

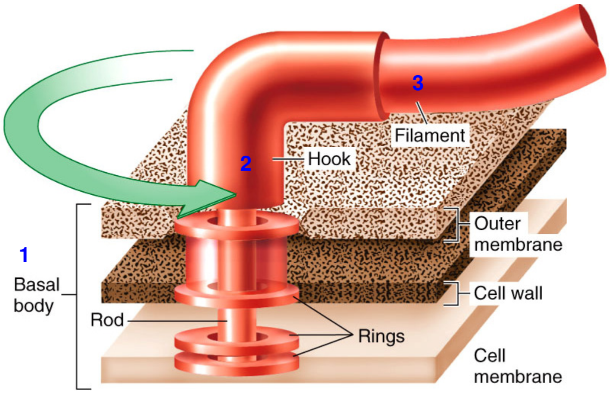
External Structures

- **Flagella**
- **Pili and fimbriae**
- **Glycocalyx**

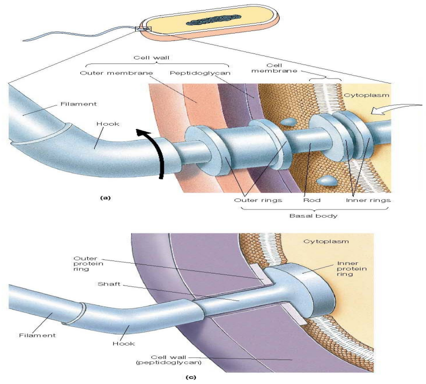
Flagella

- Composed of protein subunits
- **Role - Motility** (chemotaxis)
- Varied arrangement (ex. Monotrichous, lophotrichous, amphitrichous, peritrichous)
- Responsible for swarming in *P. aeruginosa*

Three main parts of the flagella include the basal body, hook, and filament.

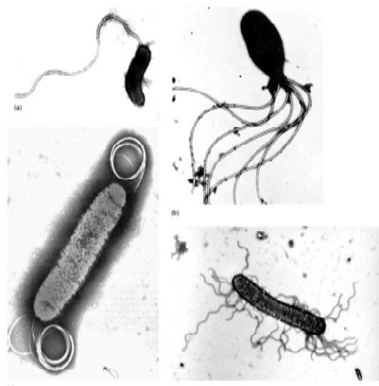


Differences in Gram (+) and Gram (-) bacteria



Mono

Lopho



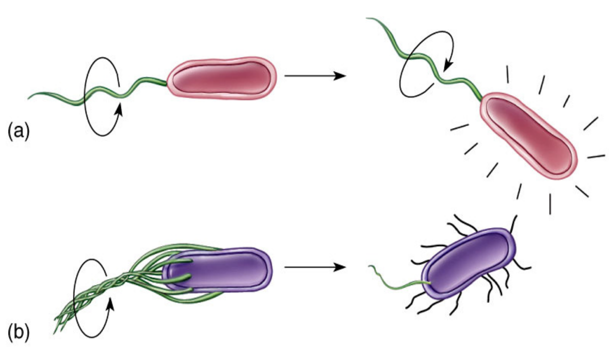
Amphi

Peri

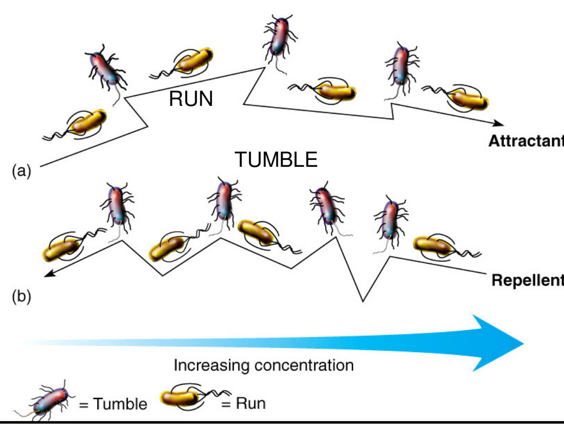
Associated with flagella is the phenomenon of chemotaxis – random ‘tumbles’ followed by directional ‘runs’

Chemotaxis - cells have the capability of responding to chemical attractants

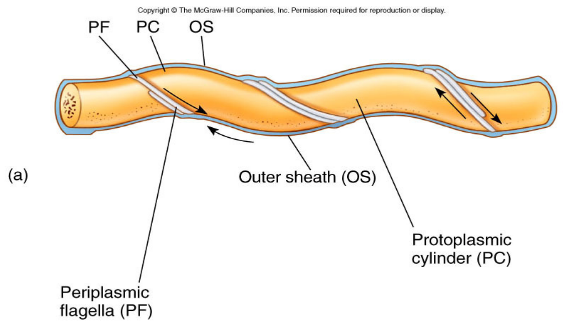
The rotation of the flagella enables bacteria to be motile



Chemotaxis - response to chemical signals



Periplasmic flagellum or **Axial filament** –present in some spirochetes



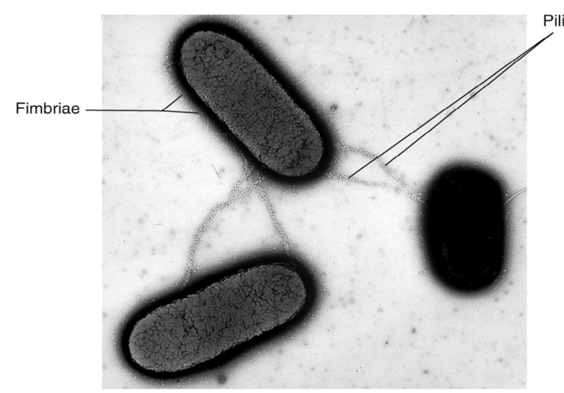
Pili and fimbriae

- Attachment
- Mating (Conjugation)

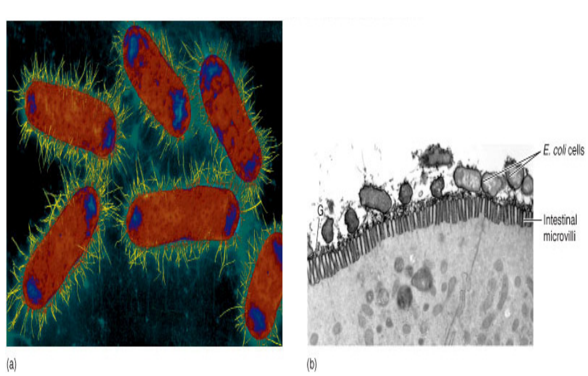
- Pili are formed on certain bacterial cells and are important for bacteriophage attachment, conjugation bridges for gene transfer (transfer of antibiotic resistance plasmids for example)

- Fimbriae are smaller and are important for attachment – *E. coli* attachment to intestinal cells

Pili enable conjugation to occur, which is the transfer of DNA from one bacterial cell to another



Fimbriae binding to epithelial cells

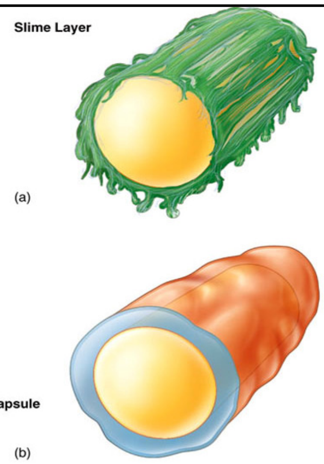


Glycocalyx – outer coating on bacteria – 2 types

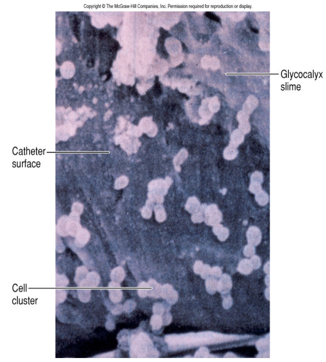
- **Capsule**
  - Protects bacteria from phagocytosis
  - *Streptococcus pneumoniae, Bacillus anthracis*
- **Slime layer**
  - Enable attachment and aggregation of bacterial cells. Source of nutrients?
  - Most often associated with the biofilm mode of growth

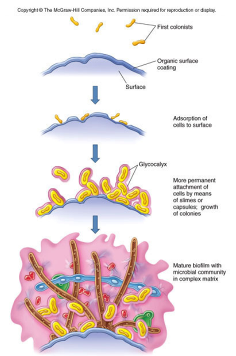
Slime layer - "Loose" surface attachment – not very thick – virulence factor of **biofilms**

Capsule - thick – **protection against phagocytosis** – often associated with increased virulence – Griffin's experiments



Bacteria Biofilms





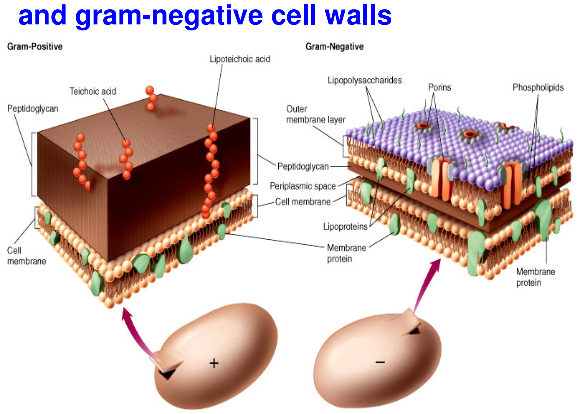
Cell envelope - the barrier that separates the environment from the 'living' cell

- Composed of cell wall, cell membrane and in Gram negative organisms, an outer cell membrane
- Cell Wall = PEPTIDOGLYCAN
- Cell Membrane = Phospholipids - just us!!!

Cell wall- made up of linked N-acetyl glucosamine (NAG) and N-acetyl muramic acid (NAM)

- **Gram POSITIVE cell wall**
  - **Thick** peptidoglycan (PG) layer
  - Acidic polysaccharides
  - Teichoic acid and lipoteichoic acid
- **Gram NEGATIVE cell wall**
  - **Thin** PG layer
  - Outer membrane
  - Lipid polysaccharide
  - Accentuated periplasmic space

Structures associated with gram-positive and gram-negative cell walls



- **Teichoic acid** consisting of glycerol, phosphates and ribitol is found in polymers in gram-positives.

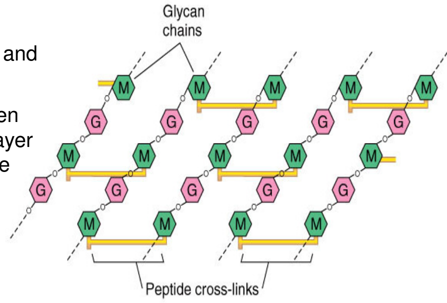
- Outer membrane - found primarily in **Gram negatives** - lipopolysaccharide (LPS) is a major component - also called endotoxin - **lipid A** is a major component of LPS and causes the toxic events of fever and blood vessel dilation observed in Gram-negative infections.

- Periplasmic space - a gap between the cell membrane and the cell wall - particularly evident in Gram negative bacteria.

Cartoon of the NAG and NAM polymers

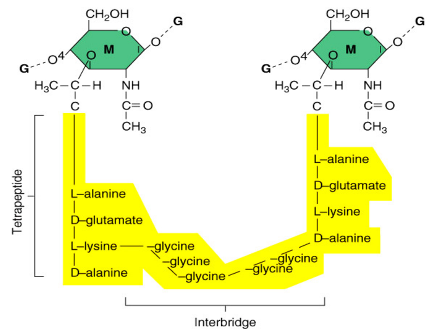
- Layers of alternating NAM and NAG

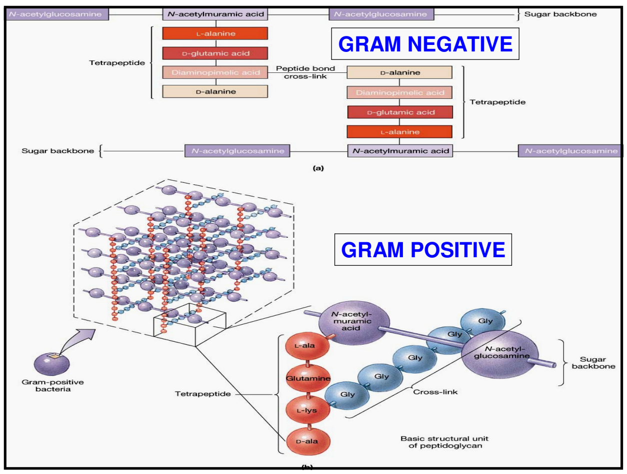
- Linkage between NAM from one layer to the NAM of the other one



Linkage of two polymer chains through NAM in Gram positive bacteria

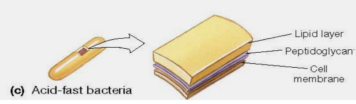
NAN to NAM tetrapeptide bridge





Nontypical Cell Walls

- **Mycobacteria**
- **Non Gram positive or Negative**
- **Increased amounts of LIPIDS**
- **Special staining → ACID-FAST STAINING**

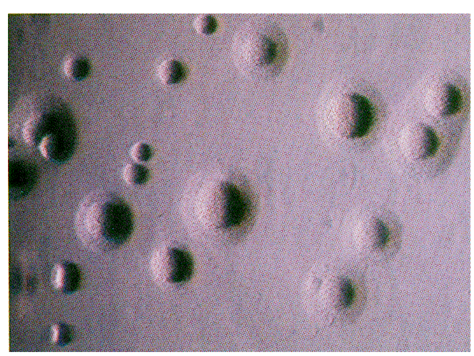


(waxy coat)

Mycobacteria

No cell wall = No Peptidoglycan

- Cell membrane contain **sterols** for stability
  - classical example is *Mycoplasma* - a common cause of atypical pneumonia
  - on agar, *Mycoplasma* looks like a 'fried egg'



Scanning electron micrograph of *Mycoplasma pneumoniae*

Cell Membrane

- Phospholipid bilayer and integral proteins
- *Mycoplasma* – STEROLS
- Function:
  1) Selective permeability
  2) Energy reactions
  3) Synthesis of molecules

Internal Structures

- Cytoplasm
- Genetic structures
- Endospore

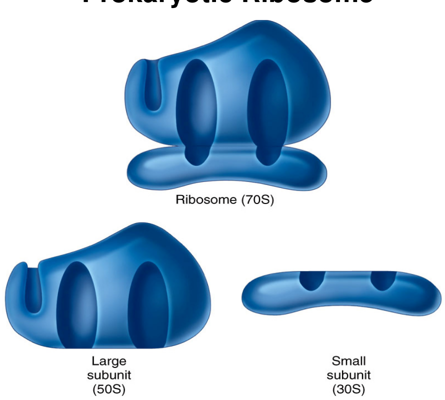
Cytoplasm

- Gelatinous solution containing water (70-80%), nutrients, proteins, and genetic material.
- Presence of ACTIN-like filaments = Cytoskeleton

Genetic material and structures

- Single circular bacterial chromosome
- Nucleoid
- **PLASMIDS** – Independent circular DNA structures
- **Ribosomes** - 'structures' that have multiple components - responsible for protein synthesis

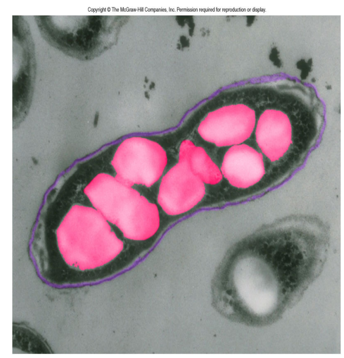
Prokaryotic Ribosome



Storage Bodies

- **NUTRITIONAL SOURCE** – Glycogen, Starch, β-hydroxybutyrate

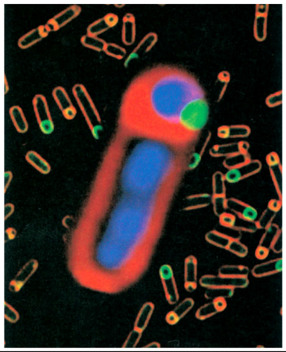
- **Gas vesicles**

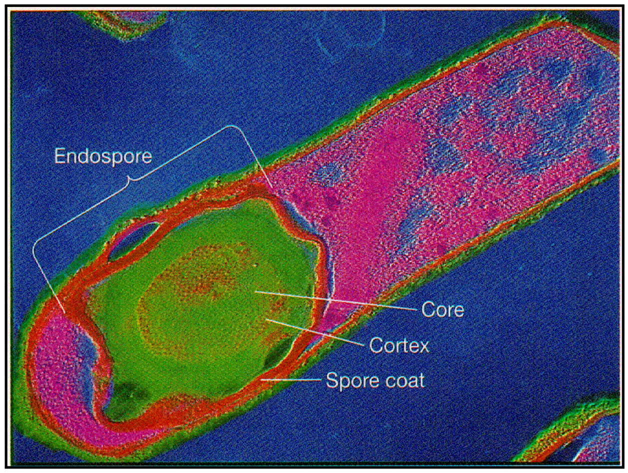


During nutrient depleted conditions, some bacteria (vegetative cell) form into an endospore in order to survive

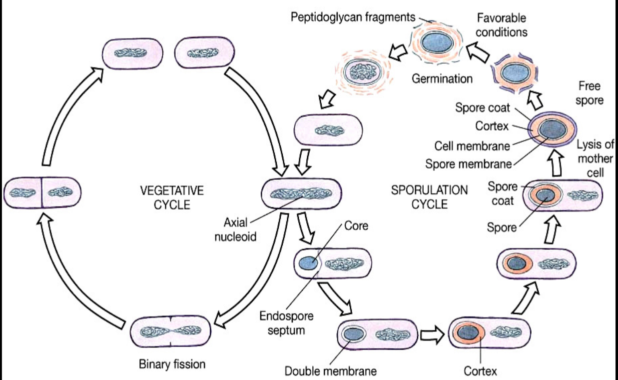
- Specific endospore staining techniques often make the endospores look like a "safety pin"

- ***Bacillus*** **and** ***Clostridium***

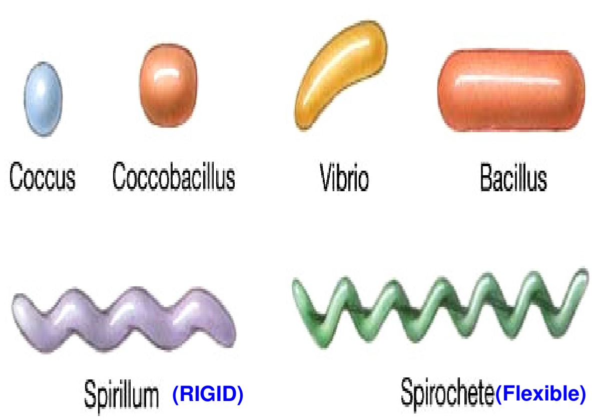


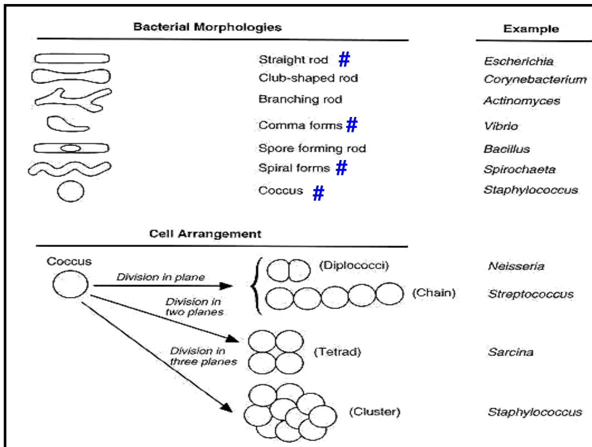


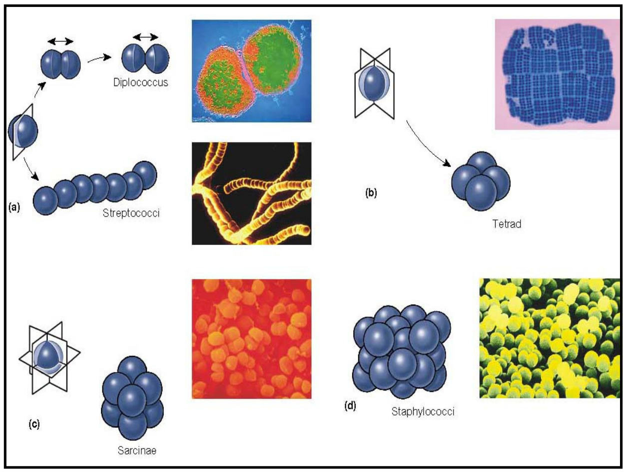
Endosporulation - a survival mechanism for lean times



Cell shapes, arrangements and sizes







You must know at least 3 features between the 3 domains

TABLE 4.5 Comparison of Three Cellular Domains

Characteristic	Bacteria	Archaea	Eukarya
Cell type	Procaryotic	Procaryotic	Eucaryotic
Chromosomes	Single, or few, circular	Single, circular	Several, linear
Types of ribosomes	70S	70S but structure is similar to 80S	80S
Contains unique ribosomal RNA signature sequences	+	+	+
Number of sequences shared with Eukarya	1	3	(all)
Protein synthesis similar to Eukarya	−	+	
Presence of peptidoglycan in cell wall	+	−	−
Cell membrane lipids	Fatty acids with ester linkages	Long-chain, branched hydrocarbons with ether linkages	Fatty acids with ester linkages
Sterols in membrane	− (some exceptions)	−	+

The End