**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

**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

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

**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

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**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!!!

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**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

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**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

**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’
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*

### Cell shapes, arrangements and sizes

<table>
<thead>
<tr>
<th>Bacterial Morphologies</th>
<th>Example</th>
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<tbody>
<tr>
<td>Straight rod</td>
<td><em>Echerichia</em></td>
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<tr>
<td>Club-shaped rod</td>
<td><em>Corynebacterium</em></td>
</tr>
<tr>
<td>Branched rod</td>
<td><em>Actinomyces</em></td>
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<tr>
<td>Gamma form</td>
<td><em>Vibrio</em></td>
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<tr>
<td>Spherical form</td>
<td><em>Bacillus</em></td>
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<tr>
<td>Spiral form</td>
<td><em>Spirochaeta</em></td>
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<tr>
<td>Coccolith</td>
<td><em>Staphylococcus</em></td>
</tr>
</tbody>
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### Bacterial Arrangement

- Gram-positive
- Gram-negative

### Endosporulation

- A survival mechanism for lean times

- During vegetative phase:
  - Peptidoglycan fragments
  - Core
  - Cortex
  - Spore coat

- During sporulation phase:
  - Germination
  - Free spore
  - Spore coat, Cortex, Spore membrane

- Endospore:
  - Core
  - Cortex
  - Spore coat
You must know at least 3 features between the 3 domains