Functional Anatomy of Prokaryotic and Eukaryotic Cells

Prokaryotic Cells

- Comparing prokaryotic and eukaryotic cells
  - Prokaryote comes from the Greek words for prenucleus.
  - Eukaryote comes from the Greek words for true nucleus.

Prokaryote	Eukaryote
One circular chromosome, not in a membrane	Paired chromosomes, in nuclear membrane
No histones	Histones
No membrane-bound organelles	Organelles
Peptidoglycan cell walls	Polysaccharide cell walls
Binary fission	Mitotic spindle

- Average size: 0.2 -1.0 µm × 2 - 8 µm
- Basic shapes:

- Unusual shapes
  - Star-shaped *Stella*
  - Square *Haloarcula*
- Most bacteria are monomorphic
- A few are pleomorphic

Arrangements

- Pairs: Diplococci, diplobacilli
- Clusters: Staphylococci
- Chains: Streptococci, streptobacilli

Glycocalyx

- Outside cell wall
- Usually sticky
- A capsule is neatly organized
- A slime layer is unorganized and loose
- Extracellular polysaccharide allows cell to attach
- Capsules prevent phagocytosis

Flagella

- Outside cell wall
- Made of chains of flagellin
- Attached to a protein hook
- Anchored to the wall and membrane by the basal body

Flagella Arrangement

Monotrichous
Amphitrichous
Lophotrichous
Peritrichous

Motile Cells

- Rotate flagella to run or tumble
- Move toward or away from stimuli (taxis)
- Flagella proteins are H antigens (e.g., *E. coli* O157:H7)

Axial Filaments

- Endoflagella
- In spirochetes
- Anchored at one end of a cell
- Rotation causes cell to move
- Fimbriae allow attachment
- Pili are used to transfer DNA from one cell to another

Cell Wall

- Prevents osmotic lysis
- Made of peptidoglycan (in bacteria)

Peptidoglycan

- Polymer of disaccharides: N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM)
- Linked by polypeptides

Gram-Positive Cell Walls

- Thick peptidoglycan
- Teichoic acids
- In acid-fast cells, contains mycolic acid

Gram-Negative Cell Walls

Thin peptidoglycan

No teichoic acids

Outer membrane

Gram-Positive Cell Walls

- Teichoic acids
  - Lipoteichoic acid links to plasma membrane
  - Wall teichoic acid links to peptidoglycan
- May regulate movement of cations.
- Polysaccharides provide antigenic variation.

Gram-Negative Outer Membrane

- Lipopolysaccharides, lipoproteins, phospholipids
- Forms the periplasm between the outer membrane and the plasma membrane.
- Protection from phagocytes, complement, and antibiotics
- O polysaccharide antigen, e.g., *E. coli* O157:H7
- Lipid A is an endotoxin
- Porins (proteins) form channels through membrane.

Gram Stain Mechanism

- Crystal violet-iodine crystals form in cell.
- Gram-positive
  - Alcohol dehydrates peptidoglycan
  - CV-I crystals do not leave
- Gram-negative
  - Alcohol dissolves outer membrane and leaves holes in peptidoglycan.
  - CV-I washes out

Atypical Cell Walls

- Mycoplasmas
  - Lack cell walls
  - Sterols in plasma membrane
- Archaea
  - Wall-less or
  - Walls of pseudomurein (lack NAM and D amino acids)

Damage to Cell Walls

- Lysozyme digests disaccharide in peptidoglycan.
- Penicillin inhibits peptide bridges in peptidoglycan.
- Protoplast has completely lost its cell wall.
- Spheroplast is a cell that has almost completely lost its cell wall.
- L forms are wall-less cells that swell into irregular shapes.
- Protoplasts and spheroplasts are susceptible to osmotic lysis.

Plasma (Cell) Membrane

- Phospholipid bilayer
- Selectively permeability
- Damage to the membrane by alcohols, quaternary ammonium (detergents), and polymyxin antibiotics causes leakage of cell contents.

Movement Across Membranes

- What is osmosis?

- What happens to a cell when placed in a:
- Hypertonic solution?
- Hypotonic solution?
- Isotonic solution?

Cytoplasm

- Cytoplasm is the substance inside the plasma membrane.

Nuclear Area

- Nuclear area (nucleoid)

Inclusions

- Storage granules of chemicals; often energy reserves.

Endospores

- Survival mechanism
- Resting cells
- Resistant to desiccation, heat, chemicals, radiation, and “time”
- *Bacillus, Clostridium*
- Sporulation: Endospore formation
- Germination: Return to vegetative state

- Eukaryotic version:
  - fungal spores – primarily reproductive
  - Protozoan cysts – survival and part of life cycle

Study Objectives

1. Describe the 3 most common morphologies of bacteria. What are some of the other possible shapes?

2. Compare and contrast the cell walls of gram (-) and gram (+) bacteria.

3. Discuss the structure and function of the bacterial capsule, slime layer, pili and fimbriae.

4. List the four arrangements of flagella in bacteria.

5. In general, compare and contrast the similarities and differences between prokaryotic and eukaryotic cells.

6. Define protoplasts, spheroplasts and L-forms.

7. Describe the effects of lysozyme and penicillin on bacterial cell walls.