

1 **Chapter 4**

Functional Anatomy of Prokaryotic and Eukaryotic Cells

2 **Prokaryotic and Eukaryotic Cells**

- Prokaryote comes from the Greek words for prenucleus.
- Eukaryote comes from the Greek words for true nucleus.

3 **Prokaryote**

- One circular chromosome, not in a membrane
- No histones
- No organelles
- Peptidoglycan cell walls if Bacteria
- Pseudomurein cell walls if Archaea
- Binary fission

4 **Prokaryotic Cells: Shapes**

- Average size:  $0.2 - 1.0 \mu\text{m} \times 2 - 8 \mu\text{m}$
- Most bacteria are monomorphic
- A few are pleomorphic

5 **Basic Shapes**

- Bacillus (rod-shaped)
- Coccus (spherical)
- Spiral
  - Spirillum
  - Vibrio
  - Spirochete

6 ***Bacillus* or Bacillus**

- Scientific name: *Bacillus*
- Shape: Bacillus

7 **Unusually Shaped Bacteria**8 **Unusually Shaped Bacteria**9 **Arrangements**

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

10 **The Structure of a Prokaryotic Cell**11 **Glycocalyx**

- Outside cell wall
- Usually sticky
- Capsule: neatly organized

12 **Flagella**

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

- 13  **The Structure of a Prokaryotic Flagellum**
- 14  **Arrangements of Bacterial Flagella**
- 15  **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)
- 16  **Motile Cells**
- 17  **Axial Filaments**
- Also called endoflagella
  - In spirochetes
  - Anchored at one end of a cell
  - Rotation causes cell to move
- 18  **A Diagram of Axial Filaments**
- 19  **Fimbriae and Pili**
- Fimbriae allow attachment
- 20  **Fimbriae and Pili**
- Pili
    - Facilitate transfer of DNA from one cell to another
    - Gliding motility
    - Twitching motility
- 21  **The Cell Wall**
- Prevents osmotic lysis
  - Made of peptidoglycan (in bacteria)
- 22  **Gram-positive Cell Wall**
- Thick peptidoglycan
  - Teichoic acids
- 23  **Peptidoglycan**
- Polymer of disaccharide:
    - N-acetylglucosamine (NAG)
    - N-acetylmuramic acid (NAM)
- 24  **Peptidoglycan in Gram-Positive Bacteria**
- Linked by polypeptides
- 25  **Gram-Positive Bacterial Cell Wall**
- 26  **Gram-Negative Bacterial Cell Wall**
- 27  **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

28  **Gram-Negative Cell Wall**29  **Gram-Negative Outer Membrane**

- Lipopolysaccharides, lipoproteins, phospholipids
- Forms the periplasm between the outer membrane and the plasma membrane

30  **Gram-Negative Outer 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

31  **The Gram Stain**32  **The 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

33  **Gram-Positive Cell Wall**

- Disrupted by lysozyme
- Penicillin sensitive

34  **Atypical Cell Walls**

- Acid-fast cell walls
  - Like gram-positive
  - Waxy lipid (mycolic acid) bound to peptidoglycan
  - *Mycobacterium*
  - *Nocardia*

35  **Atypical Cell Walls**

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

36  **Damage to the Cell Wall**

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

37  **The Plasma Membrane**38  **The Plasma Membrane**

- Phospholipid bilayer

- Peripheral proteins
- Integral proteins
- Transmembrane
- Proteins

39  **Fluid Mosaic Model**

- Membrane is as viscous as olive oil
- Proteins move to function
- Phospholipids rotate and move laterally

40  **The Plasma Membrane**

- Selective permeability allows passage of some molecules
- Enzymes for ATP production
- Photosynthetic pigments on foldings called chromatophores or thylakoids

41  **The Plasma Membrane**

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

42  **Movement of Materials across Membranes**

- Simple diffusion: Movement of a solute from an area of high concentration to an area of low concentration

43  **Movement of Materials across Membranes**

- Facilitated diffusion: Solute combines with a transporter protein in the membrane

44  **Movement of Materials across Membranes**

45  **Movement of Materials across Membranes**

- Osmosis: The movement of water across a selectively permeable membrane from an area of high water to an area of lower water concentration
- Osmotic pressure: The pressure needed to stop the movement of water across the membrane

46  **Movement of Materials across Membranes**

- Through lipid layer
- Aquaporins (water channels)

47  **The Principle of Osmosis**

48  **The Principle of Osmosis**

49  **Movement of Materials across Membranes**

- Active transport: Requires a transporter protein and ATP
- Group translocation: Requires a transporter protein and PEP

50  **Cytoplasm**

- The substance inside the plasma membrane

51  **The Nucleoid**

- Bacterial chromosome

52  **Ribosomes**

53  **The Prokaryotic Ribosome**

- Protein synthesis
- 70S
  - 50S + 30S subunits

54  **Magnetosomes**55  **Inclusions**

- 1
  - Metachromatic granules (volutin)
  - Polysaccharide granules
  - Lipid inclusions
  - Sulfur granules
  - Carboxysomes
  - 
  - Gas vacuoles
  - Magnetosomes
- 2
  - Phosphate reserves
  - 
  - Energy reserves
  - Energy reserves
  - Energy reserves
  - Ribulose 1,5-diphosphate carboxylase for CO<sub>2</sub> fixation
  - Protein-covered cylinders
  - Iron oxide  
(destroys H<sub>2</sub>O<sub>2</sub>)

56  **Endospores**

- Resting cells
- Resistant to desiccation, heat, chemicals
- *Bacillus, Clostridium*
- Sporulation: Endospore formation
- Germination: Return to vegetative state

57  **Endospores**58  **Formation of Endospores by Sporulation**59  **The Eukaryotic Cell**60  **Flagella and Cilia**61  **Flagella and Cilia**

- Microtubules
- Tubulin
- 9 pairs + 2 array

62  **The Cell Wall and Glycocalyx**

- Cell wall
  - Plants, algae, fungi
  - Carbohydrates
- Cellulose, chitin, glucan, mannan
- Glycocalyx
  - Carbohydrates extending from animal plasma membrane
  - Bonded to proteins and lipids in membrane

63  **The Plasma Membrane**

- Phospholipid bilayer
- Peripheral proteins
- Integral proteins
- Transmembrane proteins

- Sterols
- Glycocalyx carbohydrates

64  **The Plasma Membrane**

- Selective permeability allows passage of some molecules
- Simple diffusion
- Facilitative diffusion
- Osmosis
- Active transport
- Endocytosis
  - Phagocytosis: Pseudopods extend and engulf particles
  - Pinocytosis: Membrane folds inward, bringing in fluid and dissolved substances

65  **Cytoplasm**

66  **Cytoplasm**

- Cytoplasm membrane: Substance inside plasma and outside nucleus
- Cytosol: Fluid portion of cytoplasm
- Cytoskeleton: Microfilaments, intermediate filaments, microtubules
- Cytoplasmic streaming: Movement of cytoplasm throughout cells

67  **Ribosomes**

- Protein synthesis
- 80S
  - Membrane-bound: Attached to ER
  - Free: In cytoplasm
- 70S
  - In chloroplasts and mitochondria

68  **Organelles**

- Nucleus: Contains chromosomes
- ER: Transport network
- Golgi complex: Membrane formation and secretion
- Lysosome: Digestive enzymes
- Vacuole: Brings food into cells and provides support

69  **Organelles**

- Mitochondrion: Cellular respiration
- Chloroplast: Photosynthesis
- Peroxisome: Oxidation of fatty acids; destroys  $H_2O_2$
- Centrosome: Consists of protein fibers and centrioles

70  **The Eukaryotic Nucleus**

71  **The Eukaryotic Nucleus**

72  **Rough Endoplasmic Reticulum**

73  **Detailed Drawing of Endoplasmic Reticulum**

74  **Micrograph of Endoplasmic Reticulum**

75  **Golgi Complex**

76  **Lysosomes and Vacuoles**

77  **Mitochondria**

78  **Chloroplasts**

- 79  **Chloroplasts**
- 80  **Chloroplasts**
- 81  **Peroxisome and Centrosome**
- 82  **Endosymbiotic Theory**
- 83  **Endosymbiotic Theory**
  - What are the fine extensions on this protozoan?
- 84  **Endosymbiotic Theory**