

## Chapter 4 – Functional Anatomy of Prokaryotic and Eukaryotic Cells

### Comparing prokaryotic and eukaryotic cells: Overview

- Prokaryotic and Eukaryotic cells are chemically similar
  - Contain nucleic acids, proteins, lipids, carbohydrates
  - Same kinds of chemical reactions
- Differences are primarily in \_\_\_\_\_ and \_\_\_\_\_ structures, cell membrane
- Chief characteristics of Prokaryotes
  - DNA is not enclosed within a membrane (nucleus)
  - DNA is usually organized into one circular chromosome
  - DNA is not associated with proteins called histones
  - No membrane-enclosed organelles
  - Cell walls usually contain complex polysaccharide, peptidoglycan
  - Usually divide by binary fission – splitting of cell in two
- Chief characteristics of Eukaryotes
  - DNA is found in the cell's nucleus
  - DNA is organized into multiple, linear chromosomes
  - DNA is associated with histones
  - Have membrane enclosed organelles
  - Cell walls, if present, are chemically simple
  - Cell division involves mitosis – complex mechanism

### The Prokaryotic Cell

#### The Size, Shape, and Arrangement of Bacterial Cells

- Bacteria come in many sizes, several shapes
- Most range from 0.2 to 2.0  $\mu\text{m}$  diameter, 2 to 8  $\mu\text{m}$  in length
- Three basic shapes
  - \_\_\_\_\_ (pl, cocci) – \_\_\_\_\_
  - \_\_\_\_\_ (pl, bacilli) – \_\_\_\_\_
  - \_\_\_\_\_ – \_\_\_\_\_ shaped
- Coccus
  - Usually round, can be \_\_\_\_\_, \_\_\_\_\_ or flattened
- Bacillus
  - Most appear as single rods
  - Bacillus (bacterial shape) not = *Bacillus* (bacterial genus)
- Spiral
  - Have \_\_\_\_\_ twists
    - Vibrio – look like \_\_\_\_\_
    - Spirilla – helical, \_\_\_\_\_ shape; rigid bodies
      - Use flagella to move
    - Spirochetes – helical and \_\_\_\_\_
      - Move using axial filaments
- Other shapes include:
  - Star shaped
  - Rectangular, flat
  - Triangular

- Genetics determines bacterial shape
  - Monomorphic – always maintain \_\_\_\_\_
    - Helps in identifying bacteria
  - Pleomorphic – can have \_\_\_\_\_
    - Often due to \_\_\_\_\_
    - More difficult to identify

### Structures external to the cell wall

- Glycocalyx – a “\_\_\_\_\_” on the \_\_\_\_\_ of bacteria
  - Viscous, \_\_\_\_\_ polymer; external to cell wall
  - Composed of polysaccharides, polypeptides, or both
  - Made inside cell, \_\_\_\_\_ to the outside
  - Two general types of glycocalyx
    - Capsule – \_\_\_\_\_, \_\_\_\_\_ attached to cell wall
    - Slime layer – \_\_\_\_\_, \_\_\_\_\_ attached to cell wall
  - Capsules can be important in contributing to \_\_\_\_\_
    - Only \_\_\_\_\_ *B. anthracis* causes anthrax
    - Can protect bacteria from \_\_\_\_\_, \_\_\_\_\_
  - Capsule made of sugars called extracellular polysaccharide (EPS)
    - Allows bacteria to \_\_\_\_\_ surfaces
    - *S. mutans* attaches to surface of teeth in mouth; causes tooth decay
- Flagella – long appendages that \_\_\_\_\_
  - Flagella (a flagellum) give bacteria \_\_\_\_\_
    - Ability to move \_\_\_\_\_
  - Three basic parts to flagellum
    - Filament
      - Long, \_\_\_\_\_ region
      - Contains protein called flagellin
    - Hook
      - Slightly wider than filament
      - Contains different protein
      - \_\_\_\_\_ to cell wall
    - Basal body
      - \_\_\_\_\_ flagellum to cell wall, plasma membrane
      - Acts as \_\_\_\_\_ to move flagellum
  - Flagella can be arranged four different ways
    - Monotrichous – \_\_\_\_\_ flagellum
    - Amphitrichous – one flagellum \_\_\_\_\_
    - Lophotrichous – \_\_\_\_\_ flagella at one or both ends
    - Peritrichous – flagella \_\_\_\_\_ cell
  - Cells without flagella are atrichous
  - Flagella move the cell by \_\_\_\_\_
    - Basal body rotates long filament
    - Movement requires continuous source of energy
    - Counterclockwise rotation = “\_\_\_\_\_” or “\_\_\_\_\_”
      - \_\_\_\_\_ movement in \_\_\_\_\_ direction

- Clockwise rotation = “ \_\_\_\_\_ ”
          - \_\_\_\_\_, random \_\_\_\_\_ in direction
  - Taxis – \_\_\_\_\_ towards (positive) or away (negative) from \_\_\_\_\_
    - Environment includes chemicals (chemotaxis), light (phototaxis)
    - Positive taxis (\_\_\_\_\_ attractant) involves more runs than tumbles (turns)
    - Negative taxis (\_\_\_\_\_ repellent) involves more tumbles (turns) than runs
    - Taxis achieved by balancing \_\_\_\_\_ to move in desired direction
- Axial filaments – bundles of \_\_\_\_\_ that \_\_\_\_\_ cell
  - Found uniquely in \_\_\_\_\_
  - Located underneath an outer sheath
    - Rotation moves outer sheath
    - Corkscrew, spiral motion
- Fimbriae and pili – Short, hairlike appendages
  - Not used \_\_\_\_\_
  - Fimbriae
    - Used to \_\_\_\_\_
    - N. gonorrhoeae (gonorrhea) sticks to mucous membranes via fimbriae
    - No \_\_\_\_\_, no \_\_\_\_\_
  - Pili
    - Used to \_\_\_\_\_ between bacteria
      - Process called \_\_\_\_\_

## The Cell Wall

- Structure responsible for shape of cell
- Provides protection to cell
- Bacterial cell wall made of \_\_\_\_\_
  - Consists of \_\_\_\_\_ (NAM or NAG); carbohydrate backbone
  - Linked by \_\_\_\_\_ to form lattice around cell
- Cell wall arrangement used to classify 2 groups of bacteria
  - Gram-positive cell walls
    - \_\_\_\_\_; \_\_\_\_\_ layers of peptidoglycan next to cell membrane
    - Also contain \_\_\_\_\_ acid
      - \_\_\_\_\_ charged
      - Functions in moving positive ions in/out of cell, prevent cell wall breakdown
  - Gram-negative cell walls
    - \_\_\_\_\_; a \_\_\_\_\_ of peptidoglycan next to cell membrane
      - More susceptible to breakage
    - Found in \_\_\_\_\_ – space in between two membranes
      - Inner plasma membrane and outer membrane
    - Outer membrane made of:
      - \_\_\_\_\_ (LPS)
      - Lipoproteins
      - Phospholipids

- Functions of outer membrane:
      - Helps evade immune system
      - Provides barrier to antibiotics, digestive enzymes
    - Proteins called \_\_\_\_\_ in outer membrane
      - Form channel
      - Allows \_\_\_\_\_ into cell
- Atypical cell walls
  - Acid-fast cell walls
    - Contain waxy lipid, \_\_\_\_\_
    - Located outside \_\_\_\_\_ of peptidoglycan
    - Found in \_\_\_\_\_, *Nocardia*
  - Archaea
    - Don't have \_\_\_\_\_; have \_\_\_\_\_ instead
    - Or may not have cell wall
  - *Mycoplasma*
    - \_\_\_\_\_ known bacteria
    - Have \_\_\_\_\_ walls
    - Have \_\_\_\_\_ in plasma membrane, protect from \_\_\_\_\_ (rupture)

### Structures Internal to Cell wall

- Plasma (cytoplasmic) membrane
  - Thin layer, encloses \_\_\_\_\_ of cell
  - Consists primarily of \_\_\_\_\_
  - Phospholipids arranged in \_\_\_\_\_ parallel rows called \_\_\_\_\_
    - \_\_\_\_\_ "heads" on two surfaces of membrane
    - \_\_\_\_\_ "tails" in \_\_\_\_\_ of membrane
  - \_\_\_\_\_ within membrane perform various functions
    - Channels, structure, transport
  - Phospholipids and proteins are \_\_\_\_\_
    - Constantly in \_\_\_\_\_
    - Viscosity of olive oil
      - Referred to as fluid mosaic model
  - Functions of membrane:
    - Selective barrier for materials into/out of cell
      - Selective permeability – \_\_\_\_\_ molecules can pass barrier
      - \_\_\_\_\_ (ie proteins) \_\_\_\_\_ pass – too big to squeeze through
      - \_\_\_\_\_ pass – \_\_\_\_\_ on hydrophilic heads repel ions
      - \_\_\_\_\_ molecules (ie oxygen, carbon dioxide, nonpolar organic molecules) \_\_\_\_\_ pass – core of membrane is hydrophobic
      - \_\_\_\_\_ proteins allow specific molecules to pass
    - Involved in metabolism - breakdown of nutrients to produce ATP
- Cytoplasm
  - Substance of cell \_\_\_\_\_ the membrane
  - Contains:
    - About 80% water
    - Proteins

- Carbohydrates
    - Lipids
    - Inorganic ions
  - Protein filaments help maintain shape of some bacteria
- Nuclear Area
  - Sometimes called \_\_\_\_\_
  - Contains cell's DNA molecule called a \_\_\_\_\_
    - Chromosome attached to plasma membrane
  - Bacteria also contain \_\_\_\_\_ – \_\_\_\_\_ DNA molecules
    - Not connected to chromosome
    - Often carry useful genes, ie antibiotic resistance
    - Can be \_\_\_\_\_ between bacteria
- Ribosomes
  - Responsible for \_\_\_\_\_
  - Ribosomes are composed of proteins and \_\_\_\_\_ (rRNA)
  - Bacterial ribosomes (\_\_\_\_\_) consist of two subunits:
    - Small subunit; 30S subunit
    - Large subunit; 50S subunit
    - "S" a reference to size
- Inclusions
  - \_\_\_\_\_ found within cytoplasm
  - Can include stores of \_\_\_\_\_
  - Others provide specific functions
    - Magnetosomes, gas vacuoles, carboxysomes
- Endospores
  - Specialized "resting" cell; bacterial seed
  - Highly durable; can survive long time, extreme conditions
  - Found in some gram-positive bacteria
    - Eg, Some species of \_\_\_\_\_, \_\_\_\_\_
  - Endospores form inside "vegetative" or growing cell
    - Process called sporulation or sporogenesis
    - Occurs when some nutrients are low
  - Endospore returns to \_\_\_\_\_ state via germination
  - Important in food industry
    - Resistant to many processes such as heating, freezing, chemicals
    - Can cause disease

### **The Eukaryotic cell**

Typically \_\_\_\_\_, structurally more \_\_\_\_\_ than prokaryotic cells

- Flagella and Cilia
  - Extensions from cell used for cellular locomotion
  - Flagella
    - Long, few in number
    - Move in \_\_\_\_\_ manner (not rotational)
    - *Euglena*, an algae, use flagellum

- Cilia
  - Short, numerous
  - Protozoa, such as *Tetrahymena*, use cilia to move
  - Cilia in lungs move foreign material out of lungs
- Flagella and cilia are:
  - anchored to membrane by basal body
  - made up of microtubules
- Cell wall and glycocalyx
  - Cell walls generally \_\_\_\_\_ than prokaryotic cell walls
    - Plants and algae have polysaccharide (\_\_\_\_\_) cell wall
    - Fungi have polysaccharide (\_\_\_\_\_) cell wall
    - Many eukaryotes have no cell walls
    - Some eukaryotes have \_\_\_\_\_ covering
      - Help strengthen cell surface, attach cells together
- The plasma (cytoplasmic) membrane
  - Very similar in structure, function to \_\_\_\_\_ membranes
  - Differences in proteins found in membrane
  - Also contain carbohydrates, \_\_\_\_\_ (a lipid) in membrane
- Cytoplasm
  - Substances inside membrane, outside of nucleus
  - Cytosol refers to \_\_\_\_\_ portion of cytoplasm
  - Major differences:
    - Presence of complex internal structures called \_\_\_\_\_
      - Provides support, shape, movement
    - \_\_\_\_\_ (ie, metabolism) are found in organelles
- Ribosomes
  - Found \_\_\_\_\_ or attached to \_\_\_\_\_
  - Responsible for \_\_\_\_\_
  - Larger than prokaryotic ribosomes (\_\_\_\_\_)
    - Small subunit, 40S subunit
    - Large subunit, 60S subunit
  - Free floating ribosomes make proteins for use inside the cell
  - Membrane-bound ribosomes make proteins to be attached to membranes or for outside the cell

## Organelles

- Structures with specialized functions
  - Not found in prokaryotic cells
- Nucleus
  - Stores the cell's \_\_\_\_\_
    - DNA is linear, not circular
  - Surrounded by double membrane called \_\_\_\_\_
    - Both look like plasma membrane
  - \_\_\_\_\_ – channels in membrane
    - Allow molecules to move into and out of nucleus

- \_\_\_\_\_ – a structure within nucleus
  - \_\_\_\_\_ for ribosomes made here
- DNA in cell combined with proteins called histones
  - Histones not found in prokaryotes
- Endoplasmic reticulum, ER
  - Network of flattened \_\_\_\_\_
  - \_\_\_\_\_ from nucleus
  - Two types of ER:
    - Rough ER
      - Covered with \_\_\_\_\_
      - Synthesizes \_\_\_\_\_, phospholipids
    - Smooth ER
      - Synthesizes phospholipids, \_\_\_\_\_, \_\_\_\_\_
- Golgi complex
  - Stack of membranes
  - \_\_\_\_\_ and \_\_\_\_\_ proteins
    - Forms glycol proteins, glycolipids
- Lysosomes
  - \_\_\_\_\_ formed from Golgi complex
  - Contain \_\_\_\_\_ enzymes
    - \_\_\_\_\_ various molecules, including \_\_\_\_\_
- Peroxisomes
  - Similar to lysosomes, smaller
  - Metabolize some molecules, ie \_\_\_\_\_, \_\_\_\_\_
  - Destroy \_\_\_\_\_ (alcohol, hydrogen peroxide)
- Vacuoles
  - A space in the cytoplasm
  - Can be used to \_\_\_\_\_
  - Plant cells can store metabolic wastes, toxins; provide cell strength
- Mitochondria
  - Location of \_\_\_\_\_
  - Double membraned
    - Metabolic enzymes that make ATP located on \_\_\_\_\_
  - Mitochondria contain own DNA, \_\_\_\_\_ ribosomes
- Chloroplasts
  - Site of \_\_\_\_\_
    - Makes food using \_\_\_\_\_, \_\_\_\_\_
  - Double membrane
  - Also contain own DNA, \_\_\_\_\_ ribosomes

### Evolution of eukaryotes

- Biologists believe that \_\_\_\_\_ evolved from \_\_\_\_\_ cells
  - Pro- and eukaryotes very \_\_\_\_\_
  - Main difference is that eukaryotes have \_\_\_\_\_
- Endosymbiotic theory
  - \_\_\_\_\_ bacteria \_\_\_\_\_ smaller bacteria

- Smaller bacteria perform special function, like \_\_\_\_\_
- Chloroplasts and mitochondria \_\_\_\_\_
  - Contain own DNA
  - Contain 70S ribosomes, similar to that found in bacteria