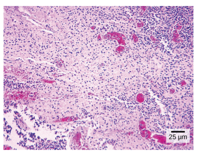
Name: ___________________

Chapter 4: Cell Structure

Studying Cells

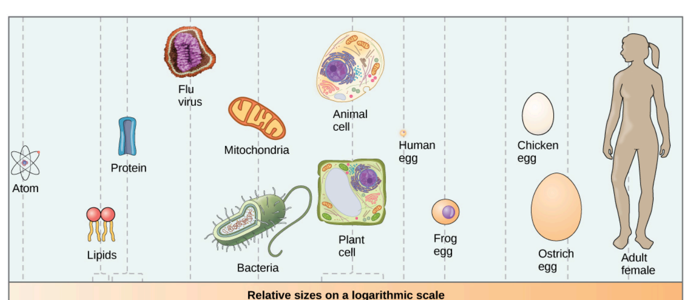
- Introduction
  - Cell - the smallest unit of a living thing; basic building blocks of all organisms made of three parts: cell membrane, cytoplasm, and DNA
- 4.1a: Microscopy
  - Microscope - an instrument that magnifies an object; used to view things that cannot be seen with the naked eye
      - *Micro* - small
      - *Scope* - to look
    - Two parameters that are important in microscopy are magnification and resolving power
      - Magnification - the process of enlarging an object in appearance
      - Resolving Power - the ability of a microscope to distinguish two adjacent structures as separate; how well a microscope can magnify
        - Higher the resolution means clearer and more detailed the image



  - Light Microscopes - an instrument that magnifies an object using a beam of visible light passed and bent through a lens system to visualize a specimen
    - *Advantageous* for viewing living organisms
    - *Disadvantageous* to viewing cells because there are generally transparent
      - To see a cell, you would have to dye ut which usually kills it
    - Commonly used in undergraduate college labs to magnify up to 400 times
  - Electron Microscopes - an instrument that magnifies an object using a beam of electrons passed and bent through a lens system to visualize a specimen
    - *Advantageous* because it offers a higher magnification and resolving power
      - A beam of electrons moves back and forth over the cell's surface, creating details of the characteristics
      - In a transmission electron microscope, the electron beam penetrates the cell and provides details of a cell's internal structures
    - *Disadvantageous* because the method used to prepare the specimen for viewing with an electron microscope kills the specimen, and they are bulky and expensive
  - The images show the salmonella virus under a light microscope and an electron microscope
- 4.1b: Cell Theory
  - Contributors
    - Antony van Leeuwenhoek
      - Dutch shopkeeper with great skills in making lenses
      - The 1600 era lenses were rudimentary but allowed him to see protista and sperm
        - Called these things animalcules
      - In the 1670s, he discovered bacteria and protozoa
    - Robert Hooke
      - Coined the term "cell" in his publication of *Micrographia* (1665) after looking at the box-like shape of cork cells
    - Matthias Schleiden and Theodor Schwann
      - Scleian was a botanist, and Schwann was a zoologist
      - They proposed the Unified Cell Theory (a biological concept that states that all organisms are composed of one or more cells; the cell is the basic unit of life; and new cells arise from existing cells)
    - Rudolf Virchow
- Eukaryotic cells are bigger than prokaryotic cells

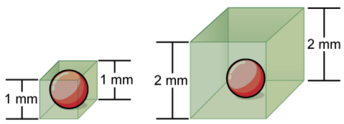
Prokaryotic Cells

- Introduction
  - Prokaryotes - a microscopic single-celled organism that has neither a distinct nucleus with a membrane nor other specialized

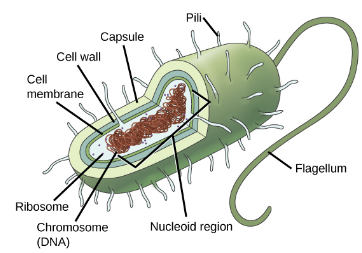


organelles; predominantly from the domains Bacteria and Archaea

- 4.2a: Cell Size
  - Prokaryotic cells are smaller than eukaryotic cells at 0.1-5.0 micrometers compared to the eukaryotic's size of 10-100 micrometers
    - Advantageous in allowing the prokaryotic cell more quickly diffuse molecules
    - Eukaryotic cells have developed structural adaptations to do this
  - Small cell size is necessary
    - If a cell grows too large, the plasma membrane will not have sufficient surface area to support the rate of diffusion required to account for the increase in volume



      - Most cells are spherical
      - As the radius increases, as does the surface area and the volume (but the volume at a much greater rate)
      - As volume *increases*, surface area *increases at a much slower rate*
        - More volume slows the efficiency of the cell; can't send things in and out of the cell, causing starvation and/or suffocation
    - Why prokaryotic cells divide or elongate and why eukaryotic cells form organelles, ruffles, or elongate
      - Bacteria reproduce by <u>binary fission</u> (asexual; replicating of DNA and dividing)
- 4.2b: Components of Prokaryotic Cells

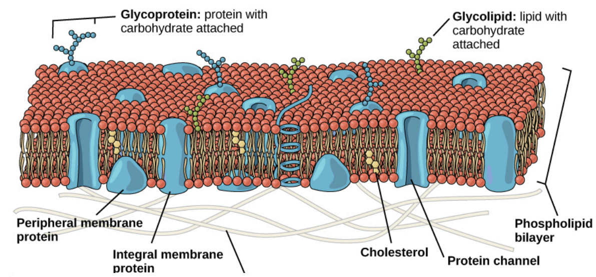


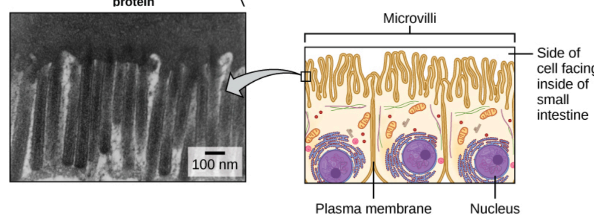
  - All cells share some components: a plasma membrane, cytoplasm, DNA, and ribosomes
    - <u>Plasma Membrane</u> - defined in 4.3a
    - <u>Cytoplasm</u> - consisting of a jelly-like cytosol within the cell in which other cellular components are found
    - <u>DNA</u> - the genetic material of the cell
    - <u>Ribosome</u> - protein synthesizers
    - Since prokaryotes don't have a nucleus, the DNA is housed in the <u>nucleoid</u> (central part of a prokaryotic cell in which the single, circular chromosome is found)
  - Prokaryote Anatomy
    - <u>Cell Wall</u> - acts as an extra layer of protection, helps the cell maintain its shape, and prevents dehydration; most bacteria but not all
    - <u>Slimy Capsule</u> - (many prokaryotes have them but not all) enables the cell to attach to surfaces in its environment; can camoflauge bacteria from immune system
    - Some prokaryotes have flagella, pili, or fimbriae
      - <u>Flagella</u> - used for locomotion in propeller form; different species have a different amount
      - <u>Pili</u> - used to exchange genetic material during a type of reproduction called conjugation
        - <u>Sex Pilus</u> - single pilus that only certain species have; allows direct <u>plasmid</u> (tiny accessory chromosome that only has a few genes and can be picked up or dropped by bacteria) transfer
        - <u>Normal Pilus</u> - extend all over the cells; allows the cell to attach to things
      - <u>Fimbriae</u> - used by bacteria to attach to a host cell
- Career Connection: Microbiologist
  - Most effective thing to do to prevent disease is wash their hands
    - Microbes are ubiquitous (present, appearing, or found everywhere)
  - Not all microbes/microorganisms cause disease
  - <u>Microbiologist</u> - scientists who study microbes
    - Can work in food, veterinary, and medical fields
    - Environmental microbiologists may look for new ways to remove pollutants
    - Can work in the field of bioinformatics

Components and Structure of Cell Membranes

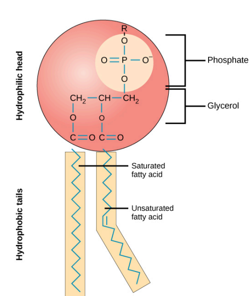
Name: __________________

- Introduction
    - Eukaryotic cells are more complex than prokaryotic and therefore need more utilities to function
        - Eukaryotic Cell - cell that has a membrane-bound nucleus and several other membrane-bound compartments
            - Has a membrane bound nucleus, numerous membrane bound organelles, and chromosomes
                - Organelles - compartment or sac within a cell such as the endoplasmic reticulum, Golgi apparatus, chloroplasts, mitochondria, and others
                    - Means “little organ”
- 4.3a: The Plasma Membrane - phospholipid bilayer that allows things in and out of the cell and separates the internal content of the cell from its surroundings

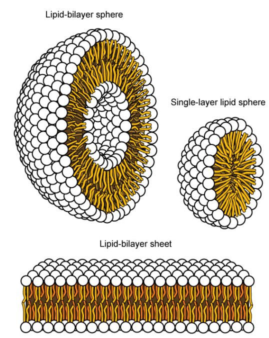




    - Phospholipid - a lipid molecule with two fatty acid chains and a phosphate-containing group
    - Plasma membranes that specialize in absorption are folded into fingerlike projections called microvilli
        - Typically found in the small intestine
    - Purposes and Abilities
        - Defines the cell, outlines its borders, and determines the nature of its interactions with the environment
        - Allows the cell to pick and choose what enters/exits the cell
        - Must be flexible to allow the cells to pass through narrow capillaries
        - Allows cells to recognize each other
            - Vital for tissue and organ formation in early development
            - Plays a role in the “self” vs “nonself” distinction of the immune response
        - Controls passage of organic molecules, ions, water, oxygen, and waste in and out of the cell
        - Can transmit signals with receptors (integral proteins)
            - Receptors act as both receivers of extracellular inputs and as activators of intracellular processes
            - Receptors provide extracellular attachment sites for effectors (like hormones and growth factors)
            - Receptors activate intracellular response cascades with their effectors are bound
            - Viruses can hijack the receptors and use them to gain entry into the cell
            - Mutations can cause the process of signal transduction to malfunction
- 4.3b: Fluid Mosaic Model - describes the structure of the plasma membrane as a mosaic of components including phospholipids, cholesterol, proteins, glycoproteins, and glycolipids (sugar chains attached to proteins or lipids, respectively), resulting in a fluid character (fluidity); pictured in 4.3a
    - Principal Components of the Plasma Membrane
        - Lipids (phospholipids and cholesterol) are near the tails of the phospholipids
        - Proteins are near the heads of the phospholipids
            - Forms hormone receptors
            - Can link cells rother (linking proteins)
            - Transport/channel proteins
        - Carbohydrates (attached to some of the lipids and proteins)
            - Present only on the exterior surface of the plasma membrane
            - Oligosaccharides attached to proteins/lipids form glycoproteins/glycolipids
                - Sugars stick out of the cell
    - Phospholipids
        - Phospholipids are composed of hydrophilic heads and hydrophobic tails; categorized as amphipathic (having hydrophilic and -phobic parts)

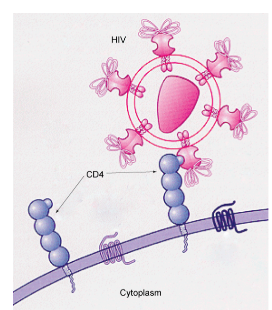


- When placed in water, the hydrophobic molecules tend to form a ball/cluster
  - Hydrophilic regions tend to form hydrogen bonds with water and other polar molecules on the interior and exterior of the cell
- Phospholipids form a bilayer-style cell membrane that separates the inside of the cell from the outside
- Phospholipid Anatomy
  - Made of three-carbon glycerol backbone with two fatty acids attached to the first two carbons; phosphate group attaches to the third
    - Creates the overall "head" of the molecule
  - Made of fatty acids
    - Creates the tail
  - Phospholipids are <u>amphiphilic</u>
  - Phospholipids heated in an aqueous solution tend to form <u>micelles</u> or <u>liposomes</u> (small spheres or droplets) with their heads on the exterior and the tails on the interior



- Proteins
  - <u>Integral Proteins</u> - protein integrated into the membrane structure that interacts exclusively with the hydrocarbon chains of membrane lipids and often spans the membrane
    - Integrated completely into the membrane structure
    - Their hydrophobic membrane-spanning regions interact with the hydrophobic region of the bilayer
  - <u>Peripheral Proteins</u> - protein found at the surface of a plasma membrane either on its exterior or interior side
- Carbohydrates
  - Third major component plasma membrane
  - Always found on the exterior surface of cells and are bound to proteins or lipids, forming glycoproteins and glycolipids respectively
    - Allow cells to recognize each other
    - Important to allow the cell to differentiate between the self and the non self so that the immune system does not attack the cell itself
    - Similar types of glycoproteins and glycolipids are found on the surfaces of viruses and may change frequently, preventing immune cells from recognizing and attacking them

- Evolution Connection: How Viruses Infect Specific Organs
  - Glycoprotein and glycolipid patterns on the cell's surface give viruses many opportunities to infect
    - Hepatitis virus attacks liver cells
    - HIV penetrates the plasma membrane of a subtype of lymphocytes (<u>T-helper cells</u>), monocytes, and central nervous system cells
    - **HIV binds to the CD4 receptor, a glycoprotein on the surface of T cells (shown right).



  - Viruses are able to invade cells because of binding sites on the bilayer that are compatible with certain viruses
  - Other recognition sites on the virus's surface interact with the human immune system, prompting the body to produce antibodies
    - <u>Antibodies</u> - made in response to the antigens or proteins associated with invasive pathogens, or in response to foreign cells, such as might occur with an organ transplant
    - The same sites serve as landing docks for the antibodies to attack and destroy/inhibit the virus
- 4.3c: Membrane Fluidity
  - The mosaic characteristic of the membrane, described in the fluid mosaic model, helps to illustrate its nature
    - Integral proteins and lipids exist in the membrane as separate, loosely attached molecules

- Resemble the separate, multicolor tiles of a mosaic
- They float, moving somewhat with respect to one another

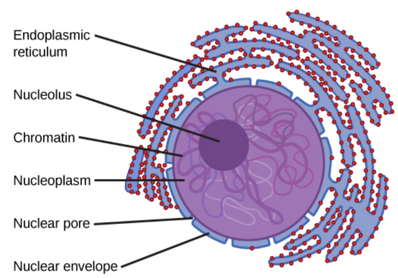
➢ Membrane can expand and contract
➢ Membrane can be penetrated by a very fine needle without bursting and it capable of healing

The Components and Functions of the Plasma Membrane

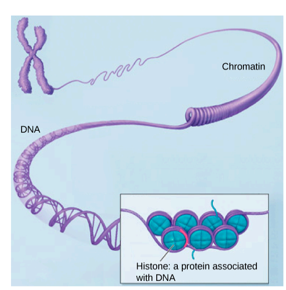
Component	Location
Phospholipid	Main fabric of the membrane
Cholesterol	Attached between phospholipids and between the two phospholipid layers
Integral proteins (for example, integrins)	Embedded within the phospholipid layer(s). May or may not penetrate through both layers
Peripheral proteins	On the inner or outer surface of the phospholipid bilayer; not embedded within the phospholipids
Carbohydrates (components of glycoproteins and glycolipids)	Generally attached to proteins on the outside membrane layer

Eukaryotic Cells

❖ 4.4a: The <u>Cytoplasm</u> - entire region between the plasma membrane and the nuclear envelope, consisting of organelles suspended in the gel-like cytosol, the cytoskeleton, and various chemicals
  ➢ Made up of organelles suspended in gel-like <u>cytosol</u> (material of the cytoplasm in which cell structures are suspended)
  ➢ Has a semi-solid consistency despite being 70-80% water
  ➢ Glucose and other simple sugars, polysaccharides, amino acids, nucleic acids, fatty acids, proteins, and derivatives of glycerol are found in the cytoplasm
  ➢ Ions of sodium, potassium, calcium, and many other elements dissolve in the cytoplasm
  ➢ Houses metabolic reactions including protein synthesis



❖ 4.4b: The <u>Nucleus</u> - cell organelle that houses the cell's DNA/linear chromosomes and directs the synthesis of ribosomes and proteins; has two phospholipid bilayers
  ➢ The <u>Nuclear Envelope</u> - double-membrane structure that constitutes the outermost portion of the nucleus
    - Punctuated with <u>pores</u> (protein structures) that control the passage of things between the <u>nucleoplasm</u> (semi-solid fluid inside the nucleus that contains the chromatin and nucleolus) and the cytoplasm
  ➢ Chromatin and Chromosomes
    - <u>Chromosomes</u> - structure within the nucleus that is made of chromatin that contains DNA, the hereditary material
      - In prokaryotes, DNA is organized into a single circular chromosomes
      - In eukaryotes, chromosomes are linear structures
        - ◆ Every eukaryotic species has a specific number of chromosomes in the nuclei of its body's cells; 46 in people
      - Only visible and distinguishable from one another when the cell is getting ready to divide
    - When the cell is in the growth and maintenance phases of its life cycle, proteins are attached to chromosomes, and they resemble an unwound, jumbled bunch of threads called <u>chromatin</u>



  ➢ The <u>Nucleolus</u> - darkly staining body within the nucleus that is responsible for synthesizing ribosomes

- 4.4c: Ribosomes - cellular structure that carries out protein synthesis to give proteins primary structure; large complexes of protein and RNA, consist of two subunits, aptly called large and small
  - Not organelles; makes peptide and polypeptide bonds
  - May be attached to the cytoplasmic side of the plasma membrane, the cytoplasmic side of the endoplasmic reticulum, and/or the outer membrane of the nuclear envelope; free-floaters produce free-floating proteins
  - Found in nearly every cell due to the essentiality of proteins
- 4.4d: Mitochondria - cellular organelles responsible for carrying out cellular respiration, resulting in the production of ATP, the cell's main energy-carrying molecule; called powerhouses or energy factories; has its own DNA and two unjoined phospholipid bilayers/compartments
  - ATP
    - Represents short-term energy stored in the cell
    - Cellular Respiration - the process of making ATP using the chemical energy found in glucose and other nutrients; metabolism of glucose
      - Uses oxygen and produces carbon dioxide as a waste product within the mitochondrion
    - Muscle cells have a very high concentration of mitochondria that produce ATP cause muscle cells need a lot of energy to keep the body moving
- 4.4e: Peroxisomes - small, round organelle that contains hydrogen peroxide, oxidizes fatty acids and amino acids, and *detoxifies* many poisons; vesicle organelle
  - Many of these oxidation reactions release hydrogen peroxide, H_2O_2 , which would be damaging to cells; however, when these reactions are confined to peroxisomes, enzymes safely break down the H_2O_2 into oxygen and water
  - Glyoxysomes - specialized peroxisomes in plants, are responsible for converting stored fats into sugars
- 4.4f: Vesicles and Vacuoles
  - Vesicles - small, membrane-bound sac that functions in cellular storage and transport; its membrane is capable of fusing with the plasma membrane and the membranes of the ER and Golgi; little bubble
    - The membranes of vesicles can fuse with either the plasma membrane or other membrane systems within the cell
  - Vacuoles - membrane-bound sac, somewhat larger than a vesicle, which functions in cellular storage and transport; cell's storage unit
    - Cannot fuse with membranes of other cellular components
    - Some agents in plant vacuoles break down macromolecules
  - 4.4g: Animal Cells vs. Plant Cells
    - The Centrosome - microtubule-organizing center found near the nuclei of animal cells; region in animal cells made of two centrioles; replicates itself before a cell divides
      - Each centriole is a cylinder of nine triplet microtubules
        - Centriole - appear to have some role in pulling the duplicated chromosomes to opposite ends of the dividing cell
          - Exact function in cellular division is unclear
          - Cells without centrosomes are still capable of dividing
      - No centrosomes in plant cells
    - The Lysosomes - organelle in an animal cell that functions as the cell's digestive component; it breaks down proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles; the cell's garbage disposal
      - Enzymes within the lysosomes aid the breakdown of proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles
        - These enzymes activate at a lower pH than the cytoplasm—the pH in lysosomes are more acidic than in the cytoplasm
      - Many reactions that take place in the cytoplasm could not occur at a low pH, so again, the advantage of compartmentalizing the eukaryotic cell into organelles is apparent

- No lysosomes in plant cells; this process is completed in the vacuole
- The Cell Wall - rigid covering that protects the cell, provides structural support, and gives shape to plant, fungak, and protist cells
  - While the chief component of prokaryotic cell walls is peptidoglycan, the major organic molecule in the plant cell wall is cellulose
  - No cell walls in animal cells
- Plastid - any of a class of small organelles, such as chloroplasts, in the cytoplasm of plant cells, containing pigment or food; chloroplasts and amyloplasts
- The Chloroplasts - plant cell organelles that carry out photosynthesis
  - Photosynthesis - series of reactions that use carbon dioxide, water, and light energy to make glucose and oxygen
    - Autotrophs - (plants) able to make their own food, like sugars
    - Heterotrophs - (animals) must ingest their food
  - Chloroplasts contain chlorophyll (green pigment that captures the light energy that drives the light reactions of photosynthesis)
    - Some bacteria perform photosynthesis, but their chlorophyll is not found in an organelle
  - No chloroplasts in animal cells
- The Amyloplasts - plastids that produce and store starch within internal membrane compartments; only found in plant cells
- The Central Vacuole - large *plant cell* organelle that regulates the cell's storage compartment, holds water, and plays a significant role in cell growth as the site of macromolecule degradation
  - Plays a key role in regulating a cell's concentration of water in changing environmental conditions
  - Why plants wilt
    - The water concentration in the soil becomes lower than the water concentration in the plant
    - Water moves out of the central vacuoles and cytoplasm
    - As the central vacuole shrinks, it leaves the cell wall unsupported
    - Lack of pressure and support results in the wilted appearance of the plant
  - The central vacuole also supports the expansion of the cell wall
    - More water means the cell gets bigger without synthesizing new cytoplasm

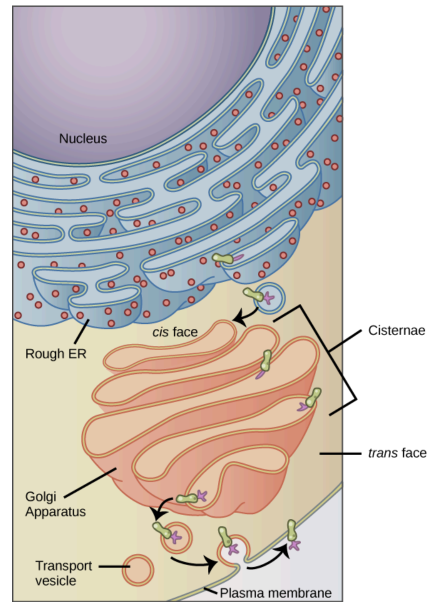
- Evolution Connection: Endosymbiosis
  - Symbiosis - relationship in which organisms from two separate species depend on each other for their survival
  - Endosymbiosis - mutually beneficial relationship in which one organism lives inside the other
    - *Endo* - within
  - May explain why mitochondria and chloroplasts have DNA and ribosomes
  - Observations
    - bacteria, mitochondria, and chloroplasts are similar in size
    - bacteria have DNA and ribosomes, just as mitochondria and chloroplasts do
  - Theory
    - Host cells and bacteria formed an endosymbiotic relationship when the host cells ingested both aerobic and autotrophic bacteria (cyanobacteria) but did not destroy them
    - Through many millions of years of evolution, these ingested bacteria became more specialized in their functions, with the aerobic bacteria becoming mitochondria and the autotrophic bacteria becoming chloroplasts

Endomembrane System and Proteins

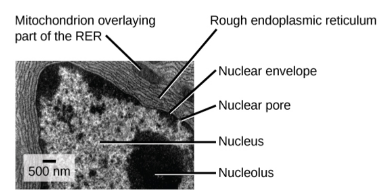
- Introduction

Name: _______________

➢ <u>Endomembrane System</u> - group of organelles and membranes in eukaryotic cells that work together *modifying, packaging, and transporting lipids and proteins*
   - Includes the nuclear envelope, lysosomes, vesicles, endoplasmic reticulum, and the Golgi apparatus
   - Also includes the plasma membrane although it is not technically in the cell
   - Excludes the membranes of mitochondria and the chloroplasts
   - Illustration (shown right)
      - Vesicles with the integral protein bud from the ER and fuse with the cis face of the Golgi apparatus
      - As the protein passes along the Golgi's cisternae, it is further modified by the addition of more carbohydrates
      - After its synthesis is complete, it exits as an integral membrane protein of the vesicles that bud from the Golgi's trans face and when the vesicle fuses with the cell membrane the protein becomes an integral portion of that cell membrane



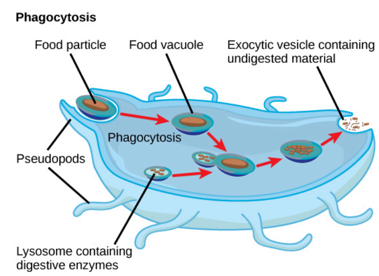
❖ 4.5a: The <u>Endoplasmic Reticulum</u> - series of *interconnected* membranous structures within eukaryotic cells that collectively modify proteins and synthesize lipids; two functions performed in separate areas of the ER: the rough ER and smooth, respectively
   ➢ The hollow portion of the ER tubules is called the <u>lumen</u> or cisternal <u>space</u>
   ➢ The membrane of the ER, which is a phospholipid bilayer embedded with proteins, is continuous with the nuclear envelope
   ➢ <u>Rough Endoplasmic Reticulum</u> (RER) - where membranes and secretory *proteins are synthesized and sometimes modified*; named because the ribosomes attached to its cytoplasmic surface give it a studded appearance
      - Ribosomes transfer the new proteins into the RER lumen for structural modification
         - Provides secondary and tertiary structure
      - The modified proteins will be incorporated into the cell membranes (the ER or other organelles) or secreted from the cell
      - RER also makes phospholipids for cellular membranes
      - If the phospholipids or modified proteins aren't supposed to stay in the ER, they are transported by the transport vesicles that bud from the RER's membrane
      - RERs are abundant in protein-secreting cells like liver cells



   ➢ <u>Smooth Endoplasmic Reticulum</u> (SER) - region of the endoplasmic reticulum that has few or no ribosomes on its cytoplasmic surface and synthesizes carbohydrates, lipids, and steroid hormones; *detoxifies certain chemicals* (like pesticides, preservatives, medications, and environmental pollutants), and stores ions

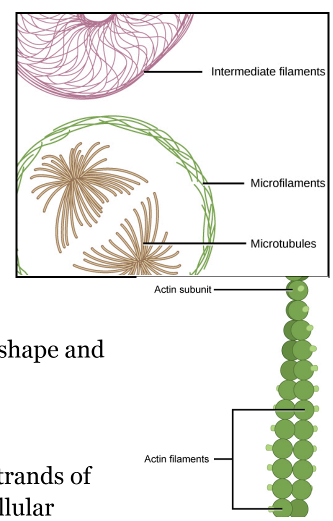
❖ 4.5b: The <u>Golgi Apparatus</u> - eukaryotic organelle made up of a series of stacked membranes that *sorts, tags, and packages lipids and proteins for distribution*; the cell's bureaucrat; tags cells with short amino acid chains to instruct the vesicles where to take the proteins
   ➢ Stack of pouches that are *not* interconnected
   ➢ <u>*Cis* Face</u> - receiving side of the Golgi Apparatus
   ➢ <u>*Trans* Face</u> - shipping side
   ➢ Process
      - The transport vesicles that formed from the ER travel to the cis face, fuse with it, and empty their contents into the lumen of the Golgi apparatus
      - Lipids and proteins undergo more modifications for sorting through the Golgi
         - Most frequent modification is the addition of short chains of sugar molecules

        - Newly modified proteins and lipids are then tagged with phosphate groups or other small molecules so that they can be routed to their proper destinations
        - Modified and tagged proteins are packaged into secretory vesicles that bud from the *trans* face of the Golgi
        - While some of these vesicles deposit their contents into other parts of the cell where they will be used, other secretory vesicles fuse with the plasma membrane and release their contents outside the cell
    - Cells with greater secretory activity (like salivary glands) have more Golgi apparatuses
    - In plant cells, the Golgi apparatus has the additional role of synthesizing polysaccharides
        - Sme of which are incorporated into the cell wall and some of which are used in other parts of the cell
- 4.5c: <u>Lysosomes</u> - organelle in an animal cell that functions as the cell's digestive component; it breaks down proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles; the cell's recycling plant
    - Small sphere part of the endomembrane system
    - Lysosomes use their hydrolytic enzymes to destroy pathogens
        - <u>Phagocytosis</u>/<u>Endocytosis</u> - process by which a section of the plasma membrane of the macrophage <u>invaginates</u> (folds in) and engulfs a pathogen; occurs in the macrophage
            - <u>Macrophages</u> - a group of white blood cells; part of the body's immune system
            - Invaginated section containing the pathogen pinches itself off from the plasma membrane and becomes a vesicle that fuses with a lysosome
            - The lysosome's hydrolytic enzymes then destroy the pathogen



The Cytoskeleton

- Introduction
    - <u>Cytoskeleton</u> - network of protein fibers that collectively maintain the shape of the cell, secure some organelles in specific positions, allow cytoplasm and vesicles to move within the cell, and enable unicellular organisms to move independently; has three types of fibers: microfilaments, intermediate filaments, and microtubules



- 4.6a: <u>Microfilaments</u> - narrowest element of the cytoskeleton; it provides rigidity and shape to the cell and enables cellular movements
    - Made of two intertwined strands of globular protein called <u>actin</u>
        - Why they microfilaments are also called <u>actin filaments</u>
    - Provides some rigidity and shape to the cell
    - Can <u>depolymerize</u> (disassemble) and reform quickly, enabling a cell to change its shape and move
        - Utilized by white blood cells to move the the site of an infection
            - <u>White Blood Cells</u> - body's infection-fighting cells
- 4.6b: <u>Intermediate Filaments</u> - cytoskeletal component, composed of several intertwined strands of fibrous protein that bears tension, supports cell-cell junctions, and anchors cells to extracellular structures; the middle of the three
    - No role in cell movement; purely structural
    - They bear tension to maintain shape
    - Most diverse group of cytoskeleton elements
        - Several types of fibrous proteins are found in the intermediate filaments
        - Ex.: keratin (fibrous protein that strengthens hair and nails) and epidermis of skin
- 4.6c: <u>Microtubules</u> - widest element of the cytoskeleton; it helps the cell resist compression, provides a track along which vesicles move through the cell, pulls replicated chromosomes to opposite ends of a dividing cell, and is the structural element of centrioles, cilia, and flagella
    - Can dissolve and reform quickly; disassembles behind protein vesicle packages

Name: ___________________

- Used as scaffolding during cell growth/division
- Structural elements of the flagella, cilia, centrosomes
    - Centrosome - organelle that organizes the microtubules; made of two centrioles; not in plants
    - Cilia and centrioles are the two perpendicular bodies of the centrosome
    - In animal cells, the centrosome is the microtubule-organizing center
    - In eukaryotic cells, flagella and cilia are quite different structurally from their counterparts in prokaryotes
- Flagella and Cilia
    - On some eukaryotic cells
    - Flagella - long, hair-like structures that extend from the plasma membrane and are used to move a cell
        - When present, the cell has just one flagellum or a few flagella
    - Cilia - short, hair-like structures that extend from the plasma membrane in large numbers and are used to move cells and/or substances
        - Ex.: the cilia of cells lining the Fallopian tubes that move the egg cell toward the uterus, or cilia lining the cells of the respiratory tract that trap particles and move it toward your nostrils

Components of Prokaryotic and Eukaryotic Cells

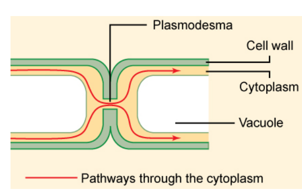
Cell Component	Function	Present in Prokaryotes?	Present in Animal Cells?	Present in Plant Cells?
Plasma membrane	Separates cell from external environment; controls passage of organic molecules, ions, water, oxygen, and wastes into and out of cell	Yes	Yes	Yes
Cytoplasm	Provides turgor pressure to plant cells as fluid inside the central vacuole; site of many metabolic reactions; medium in which organelles are found	Yes	Yes	Yes
Nucleolus	Darkened area within the nucleus where ribosomal subunits are synthesized.	No	Yes	Yes
Nucleus	Cell organelle that houses DNA and directs synthesis of ribosomes and proteins	No	Yes	Yes
Ribosomes	Protein synthesis	Yes	Yes	Yes
Mitochondria	ATP production/cellular respiration	No	Yes	Yes
Peroxisomes	Oxidizes and thus breaks down fatty acids and amino acids, and detoxifies poisons	No	Yes	Yes
Vesicles and vacuoles	Storage and transport; digestive function in plant cells	No	Yes	Yes
Centrosome	Unspecified role in cell division in animal cells; source of microtubules in animal cells	No	Yes	No
Lysosomes	Digestion of macromolecules; recycling of worn-out organelles	No	Yes	No
Cell wall	Protection, structural support and maintenance of cell shape	Yes, primarily peptidoglycan	No	Yes, primarily cellulose
Chloroplasts	Photosynthesis	No	No	Yes

Endoplasmic reticulum	Modifies proteins and synthesizes lipids	No	Yes	Yes
Golgi apparatus	Modifies, sorts, tags, packages, and distributes lipids and proteins	No	Yes	Yes
Cytoskeleton	Maintains cell's shape, secures organelles in specific positions, allows cytoplasm and vesicles to move within cell, and enables unicellular organisms to move independently	Yes	Yes	Yes
Flagella	Cellular locomotion	Some	Some	No, except for some plant sperm cells
Cilia	Cellular locomotion, movement of particles along extracellular surface of the plasma membrane, and filtration	Some	Some	No

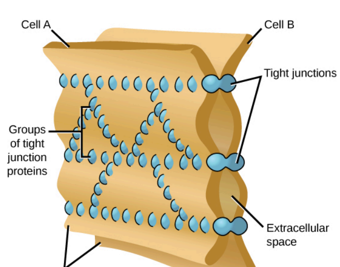
Connections Between Cells and Cellular Activities

❖ 4.7a: Extracellular Matrix of Animal Cells
- ➢ Extracellular Matrix - material (primarily collagen, glycoproteins, and proteoglycans) secreted from animal cells that provides mechanical protection and anchoring for the cells in the tissue
  - ■ Allows molecules to reach the cell membrane
  - ■ Anchors cells to each other; necessary for multicellular organisms
  - ■ Collagen Fibers - interwoven with carbohydrate-containing protein molecules called proteoglycans
  - ■ Extracellular matrix holds cells together to form tissues
  - ■ Allows cells within the texture to communicate with each other
    - ● Done through protein receptors on the extracellular surfaces of their plasma membranes
    - ● When a molecule within the matrix binds to the receptor, it changes the molecular structure of the receptor
    - ● The receptor changes the conformation of the microfilaments positioned just inside the plasma membrane
    - ● These conformational changes induce chemical signals inside the cell that reach the nucleus and turn "on" or "off" the transcription of specific sections of DNA, which affects the production of associated proteins, changing the activities within the cell
    - ● Ex.: blood clotting
      - ◆ When the cells lining a blood vessel are damaged, they display a protein receptor called tissue factor
      - ◆ When tissue factor binds with another factor in the extracellular matrix, it causes platelets to adhere to the wall of the damaged blood vessels, stimulates the adjacent smooth muscle cells in the blood vessels to contract (thus constricting the blood vessel)
      - ◆ Initiates a series of steps that stimulate the platelets to produce clotting factors

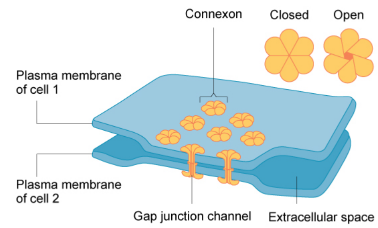
❖ 4.7b: Intercellular Junctions - communication between cells via direct contact
- ➢ Plasmodesmata - junction between *plant* cells; channel that passes between the cell walls of adjacent plant cells, connects their cytoplasm, and allows materials to be transported from cell to cell



- ➢ In animal cells, there are tight junctions, gap junctions, and desmosomes
  - ■ Tight Junctions - firm, watertight seal between two adjacent animal cells created by protein adherence; links cytoskeletons
    - ● Prevents materials from leaking between cells



    - Typically found in epithelial tissue (lines organs and cavities; comprises most of the skin)
  - Gap Junctions - channel between two adjacent *animal* cells that allows ions, nutrients, and low molecular weight substances to pass between cells, enabling the cells to communicate; links cytoplasms
    - Develope when a set of 6 proteins (connexins) in the plasma membrane arrange themselves in a connexon (elongated donut-like configuration)
    - When the pores ("donut holes") of the connexons align in adjacent animal cells, a channel between the cells form
    - Particularly important in the cardiac muscle
      - The electrical signal for the muscle to contract is passed efficiently through gap junctions, allowing the heart muscle cells to contract in tandem



  - Adhering Junctions/Desmosomes - act like spot welds between adjacent epithelial cells; links cytoplasms by short proteins called cadherins in the plasma membrane connect to intermediate filaments
    - The cadherins join two adjacent cells together and maintain the cells in a sheet-like formation in organs and tissues that stretch, like the skin, heart, and muscles

Nobel Honors Discoveries on How Cells Eat Each Other

- Nobel Prize in Physiology or Medicine awarded to Yoshinori Oshumi (cell biologist at the Tokyo Institute of Technology's Frontier Research Center)
  - Awarded for his work on autophagy (process in which cells degrade and recycle cellular components)
- Previously, scientists knew about autophagy but had little idea of how the process worked
- Answering the Question
  - Oshumi and his team used yeast due to its biochemical similarities to animal cells
  - Tested by developing strains of yeast missing certain enzymes
  - When they starved the yeast, some of the mutants developed unusually large vacuoles
  - Ohsumi them used chemicals to induce more mutations, looking for cells that failed to form large vacuoles even during starvation
    - These cells were missing key genes for autophagy
    - He and his team identified 15 essential genes
  - Further studies showed that these genes controlled the process in animal cells
    - Helped piece together how the genes function in keeping the cell's recycling centers running
- Since then, Oshumi and others have shown how important autophagy is in embryo development, cell differentiation, and the immune system
- Breakdown of autophagy can lead to many diseases such as cancer, diabetes, and Huntington's disease