

# CELLS

Primary Care Paramedicine

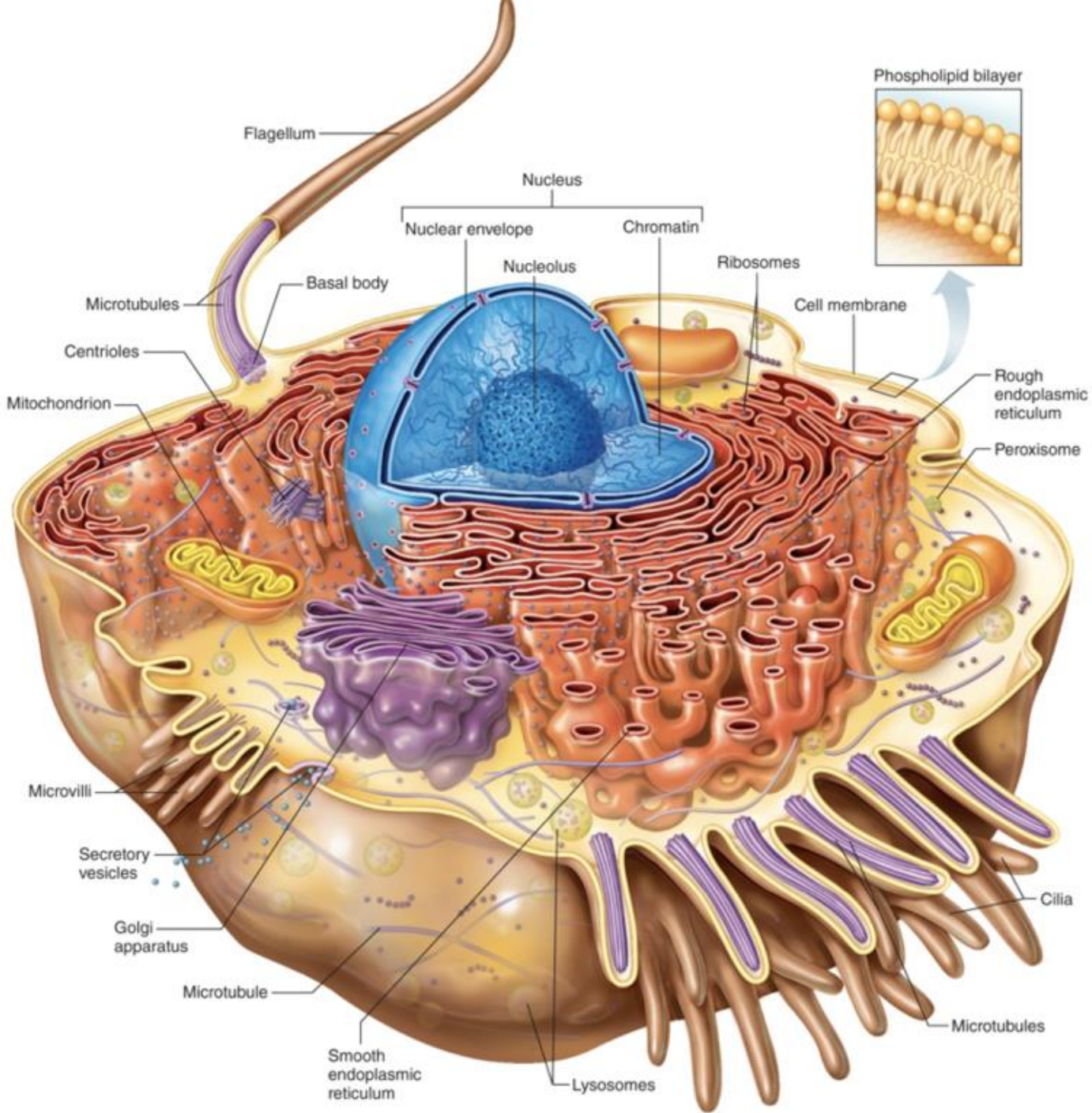
Module: 04

Section: 03



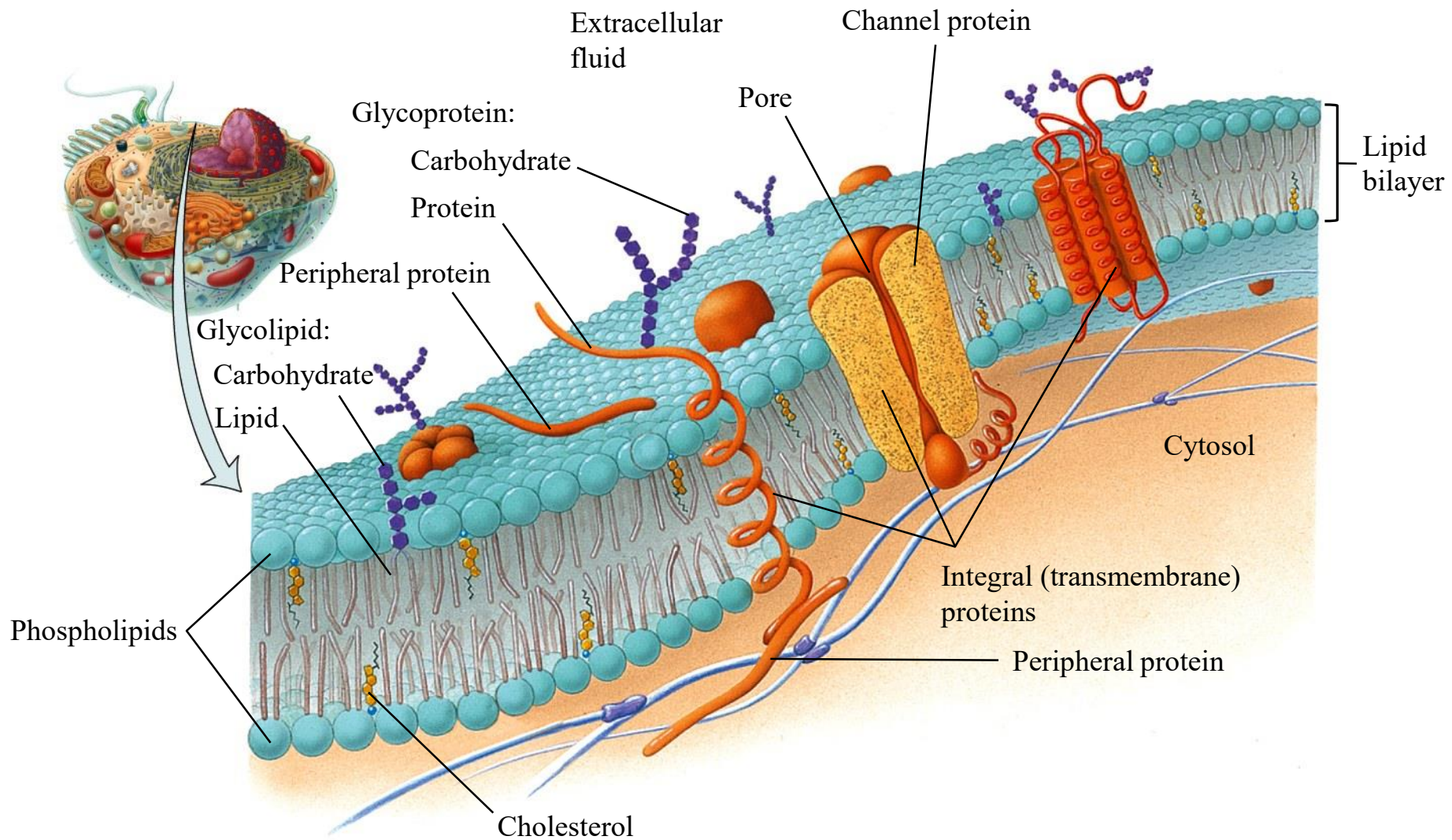
- Every individual begins as a single cell
- This divides until the human body has an estimated 100 trillion cells
- Cells are the structural and functional units of the body
- Homeostasis depends on the interaction between cells and the environment

# The Composite Cell

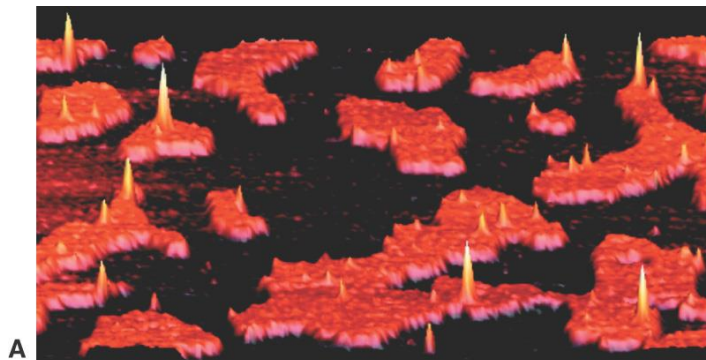


- Plasma Membrane
  - Separates the outside of the cell (extracellular) from the inside of the cell (intracellular)
  - Maintains the integrity of the cell
  - Determines what can enter and exit the cell (selectively permeable)

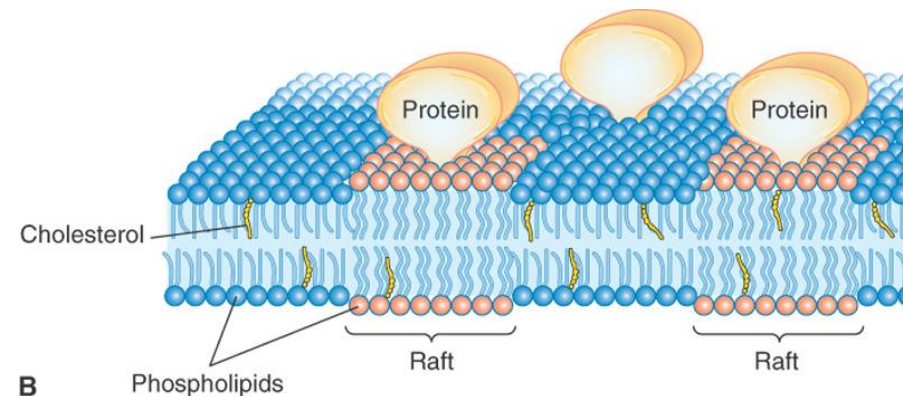
- Plasma Membrane
  - Fluid Mosaic Model
    - Arranged in a sheet
    - Plasma membrane is fluid; that is, the molecules are able to float around slowly



- Chemical attractions are the forces that hold membranes together
  - Groupings of membrane molecules form rafts, each of which float as a unit in the membrane
  - Rafts may pinch inward, bringing material into the cell or organelle

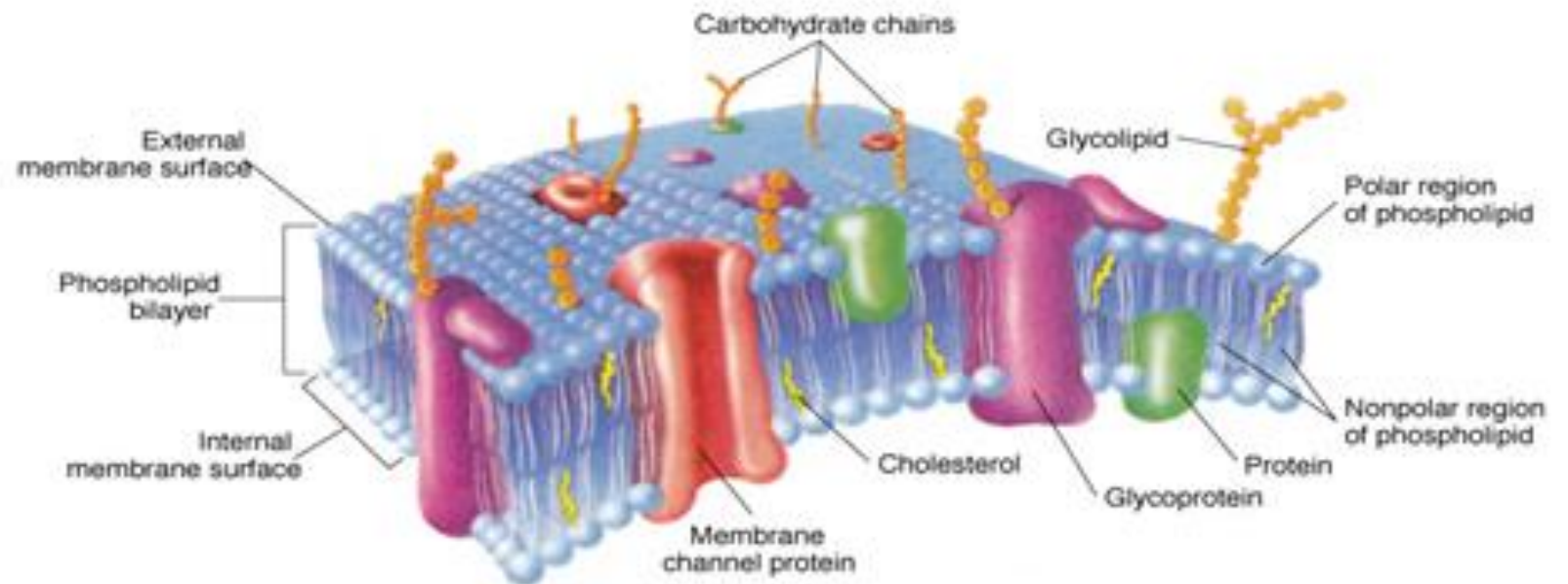


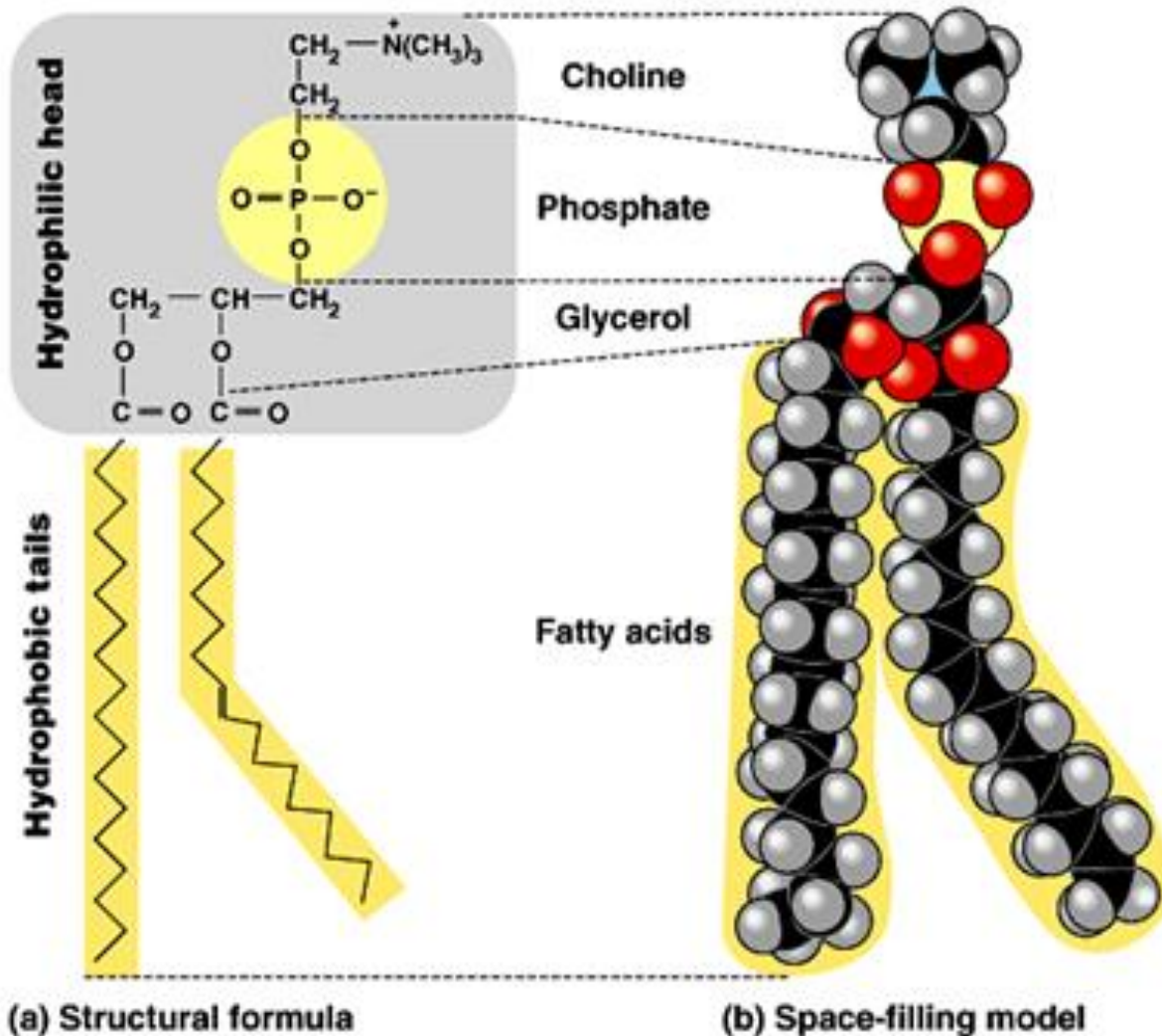
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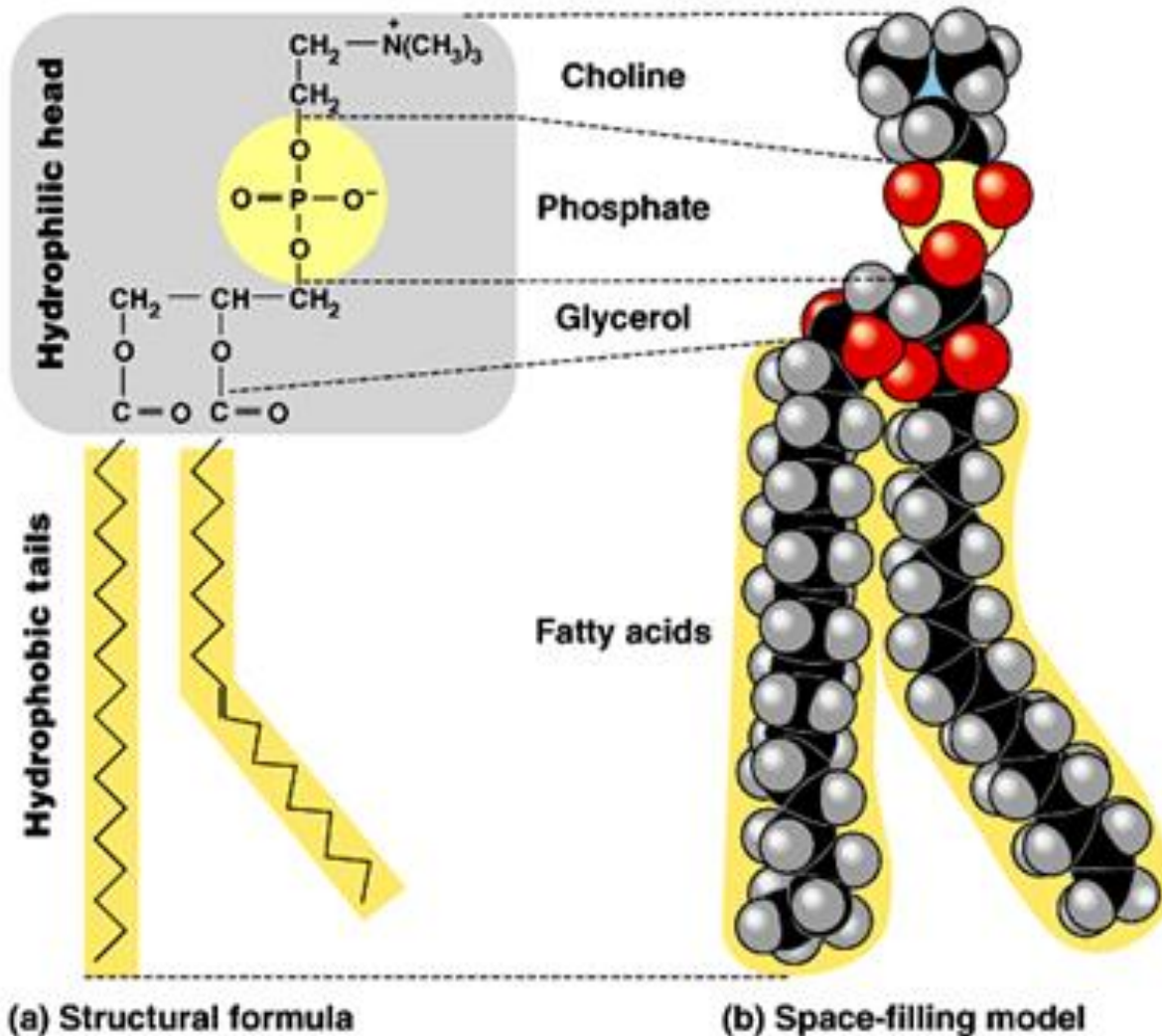
- Plasma Membrane
  - Composed of
    - Phospholipids
    - Integral Proteins
    - Peripheral Proteins
    - Cholesterol
    - Glycolipids
    - Glycoproteins





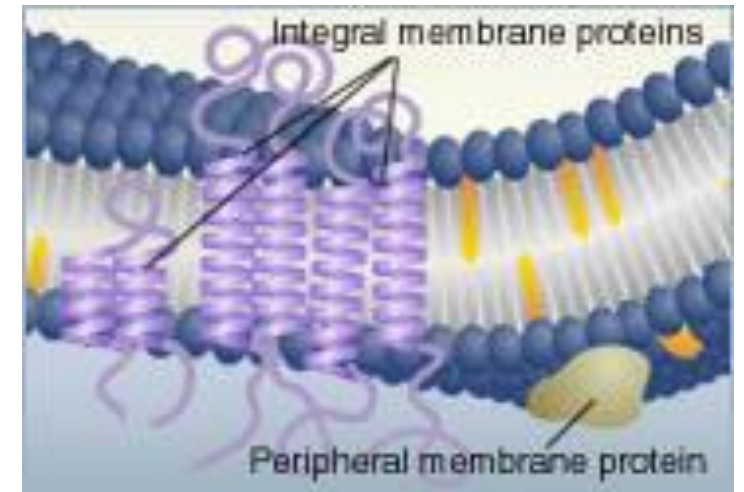
## • Phospholipid Bilayer

- Phosphate heads (polar) are hydrophilic (attract water)
- Lipid layer (non-polar) is hydrophobic (repel water)
- Nonpolar organic molecules (ether, O<sub>2</sub>, CO<sub>2</sub> etc) will dissolve readily in the lipid layer and pass through the membrane

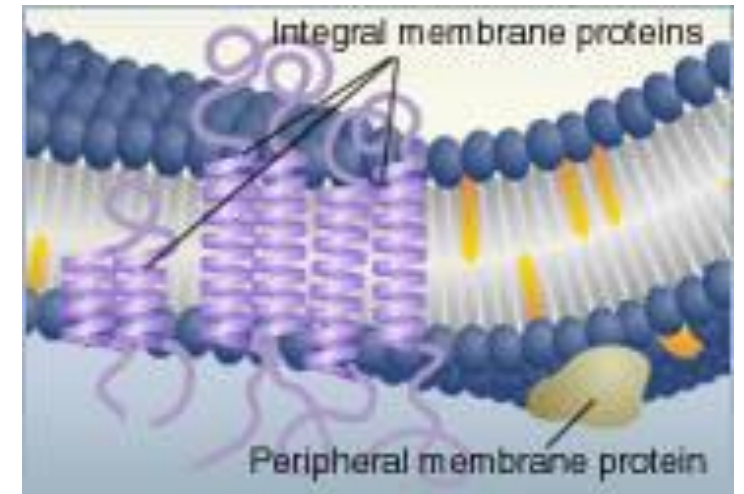


- Phospholipid Bilayer
  - Cholesterol molecules are scattered among the phospholipids to allow the membrane to function properly at body temperature
  - Most of the bilayer is hydrophobic; therefore water or water-soluble molecules do not pass through easily

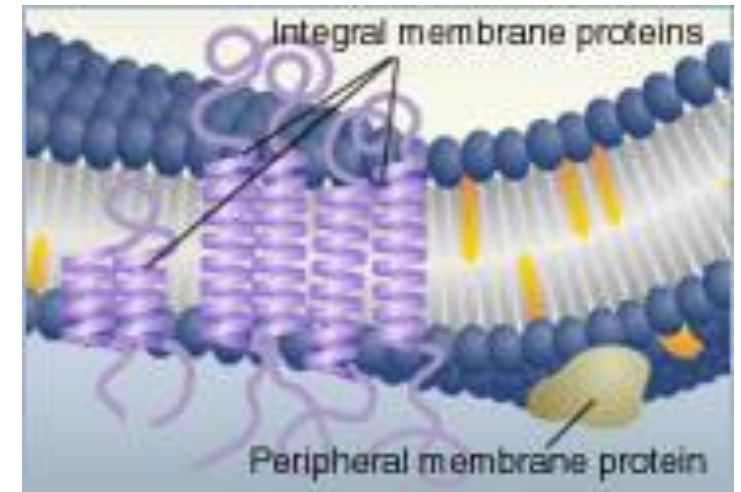
- Integral Proteins
  - Integral component of a membrane
  - Penetrate the hydrophobic region
- Peripheral Proteins
  - Associated with membranes but do not penetrate the hydrophobic core of the membrane
  - They are often found in association with integral membrane proteins



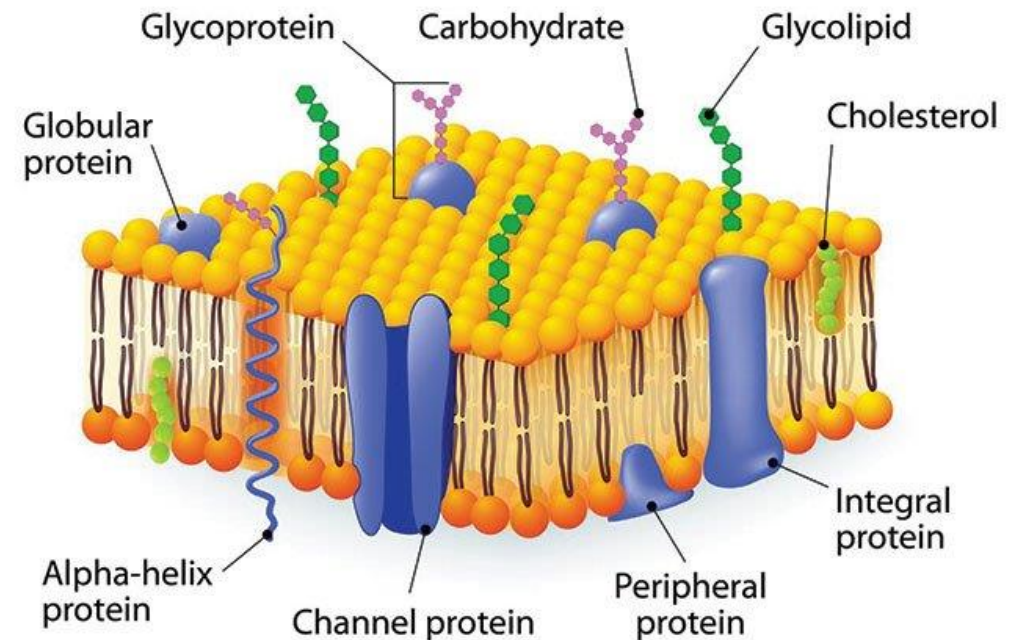
- Functions of membrane proteins include:
  - Transport of substances across membranes
  - Enzymatic activity (e.g., smooth endoplasmic reticulum)
  - Signal transduction (e.g., cell communication)
  - Intracellular joining
  - Cell-cell recognition (e.g., cell communication)
  - Attachment to the cytoskeleton and extracellular matrix



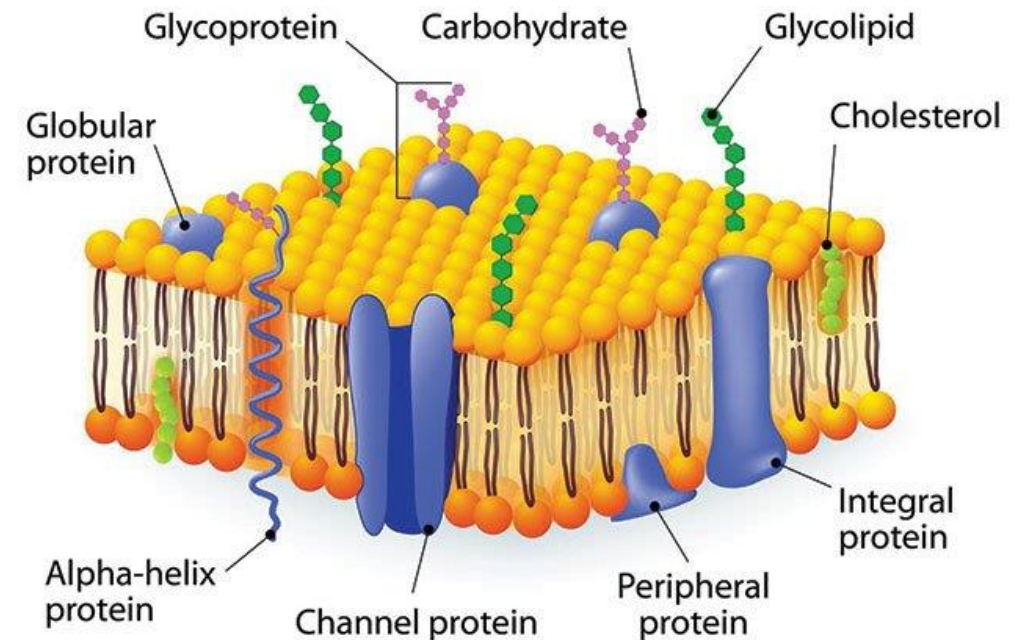
- Cholesterol
  - Steroid lipid
  - Mix with phospholipids
  - Helps maintain integrity of membrane
    - Maintains optimum membrane fluidity
    - This allows lipid soluble items to pass easily



- Glycolipids
  - Composed of lipids that are covalently bonded to monosaccharides or polysaccharides
  - One type of glycolipid found in human red blood cells is involved in the ABO blood type antigens



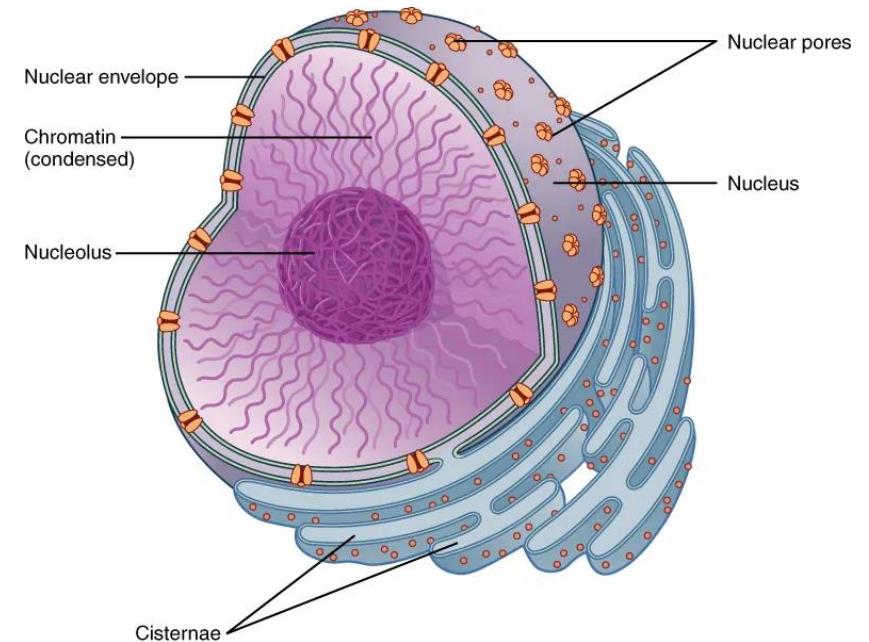
- Glycoproteins
  - Proteins that are covalently bonded to carbohydrates.
  - Act as identification markers



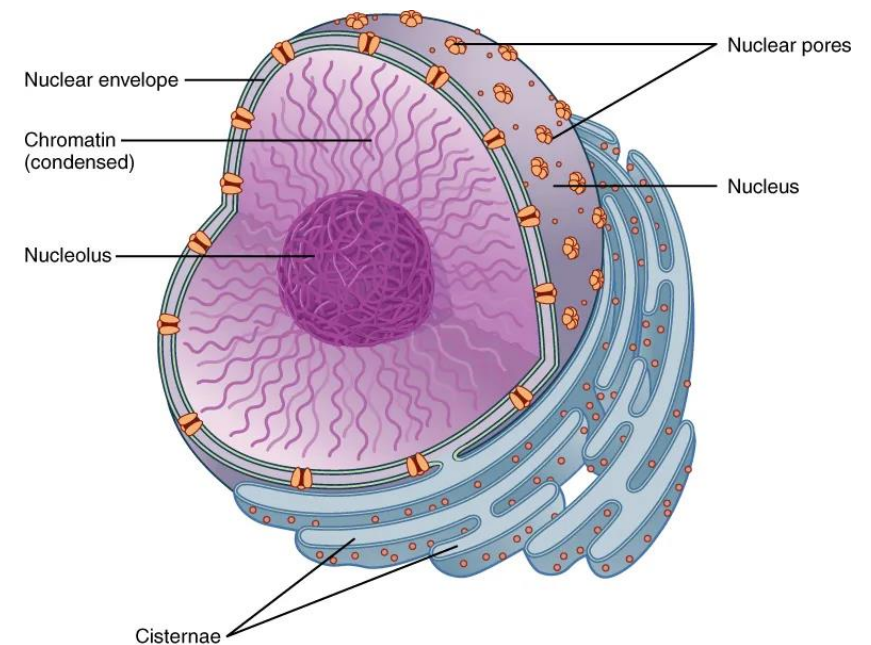
- Cytoplasm
  - Gel like intracellular fluid
  - Contains organelles, metabolic waste material, dissolved electrolytes, amino acids and simple sugars
  - Accounts for  $\frac{2}{3}$  of the bodies water
  - May include inclusions (fluid vacuoles, secretory products, glycogen granules, etc)

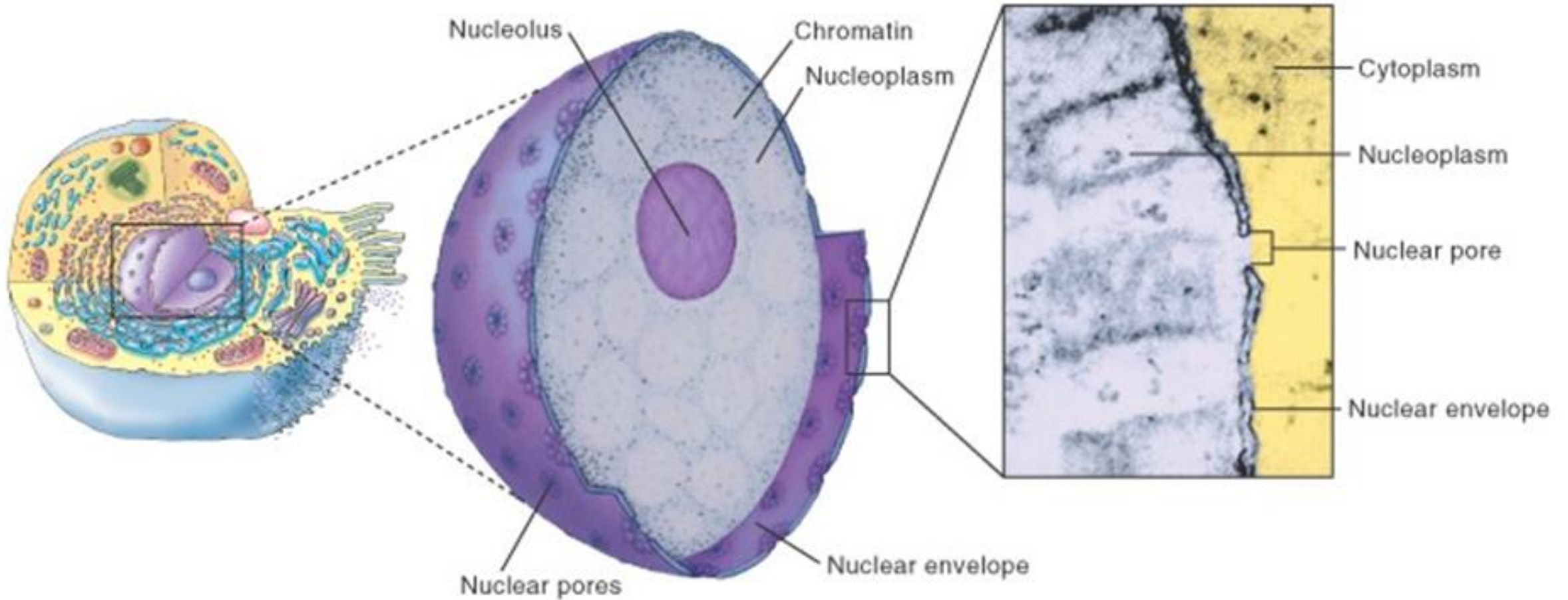
- Two major groups of :
  - Membranous organelles are specialized sacs or canals made of cell membranes
  - Non-membranous organelles are made of microscopic filaments or other non-membranous materials

- Nucleus
  - Control center of the cell directing all metabolic activities
  - All cells have at least 1 nucleus (though some, such as RBC, lose them as they mature)
  - Has a nuclear membrane that separates the nucleoplasm from the cytoplasm
  - Thins out a many points to allow for large molecules (RNA) to pass through (nuclear pores)
  - Contains DNA mixed with proteins to form chromosomes



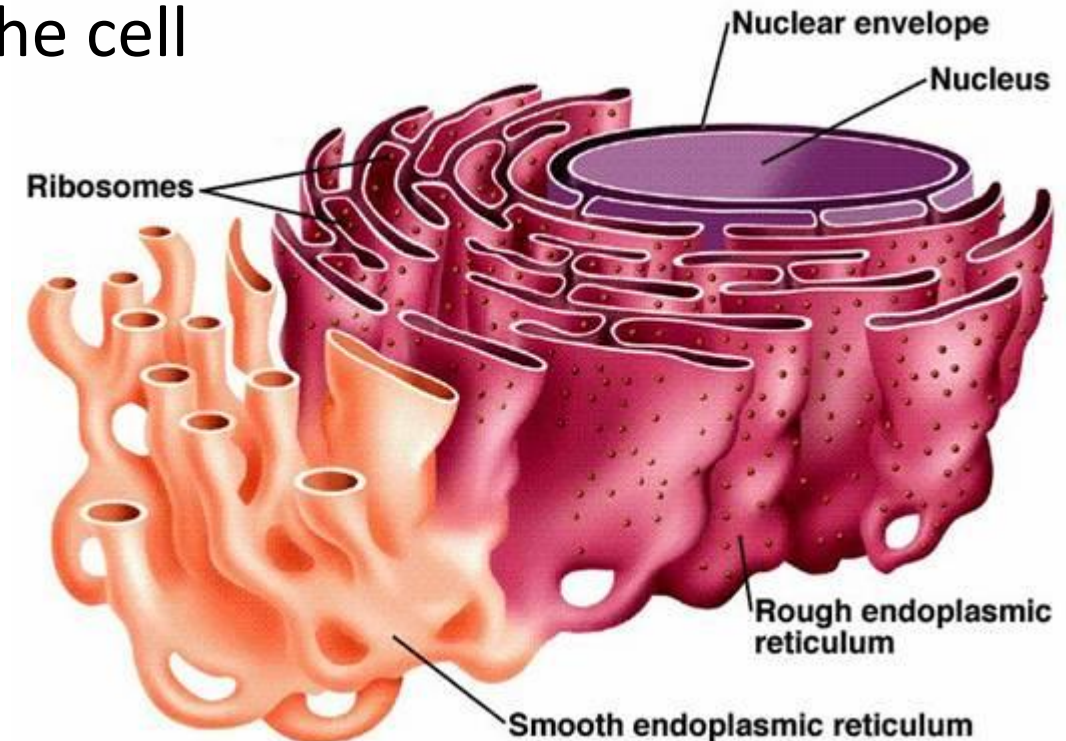
- Nucleolus
  - Found in the nucleus
  - Has no membrane
  - May vary in number (1-4)
  - A dense region of RNA and is the region of ribosome RNA (rRNA) formation
  - rRNA combine with proteins to form ribosome subunits



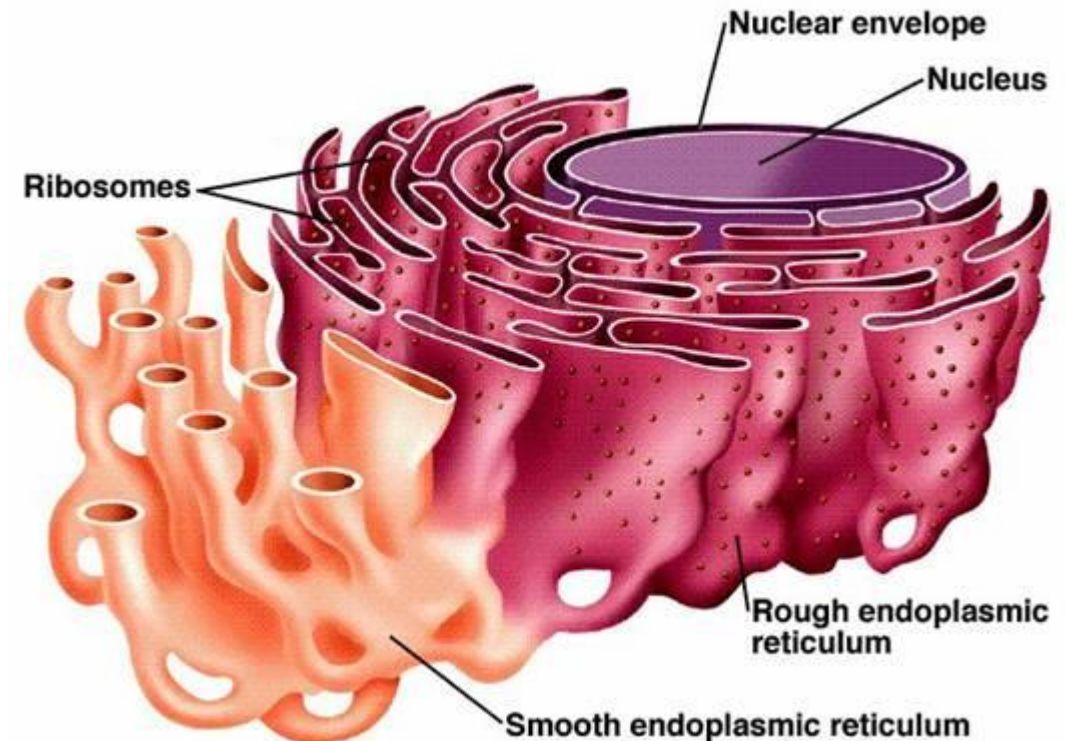


- Endoplasmic Reticulum
  - Made of canals with membranous walls and flat, curving sacs arranged in parallel rows throughout the cytoplasm; extend from the plasma membrane to the nucleus
  - Are connected to the nuclear membrane, the inner layer of the cell and to other organelles
  - Provides a path for materials from one part of the cell to another

- Rough Endoplasmic Reticulum
  - Ribosomes dot the outer surface of the membranous walls
  - Ribosomes synthesize proteins, which move toward the Golgi apparatus and then eventually leave the cell
  - Function in protein synthesis and intracellular transportation

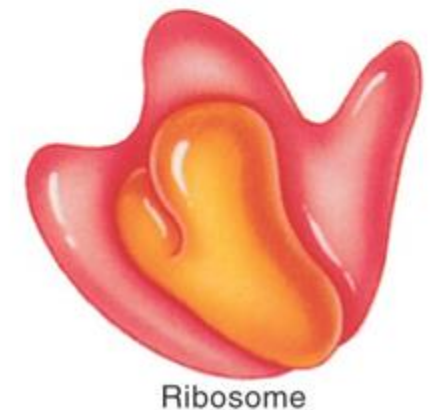
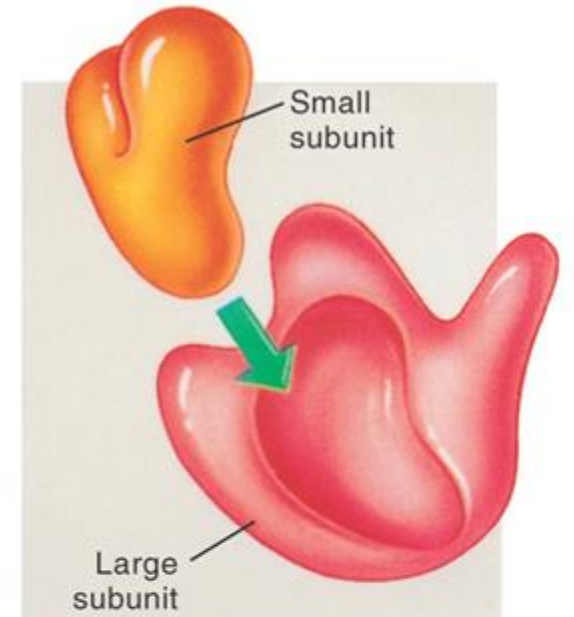


- Smooth Endoplasmic Reticulum
  - Functions are less well established and probably more varied than RER
  - Synthesizes certain lipids and carbohydrates and creates membranes for use throughout cell
  - Removes and stores  $\text{Ca}^{2+}$  from cell's interior.



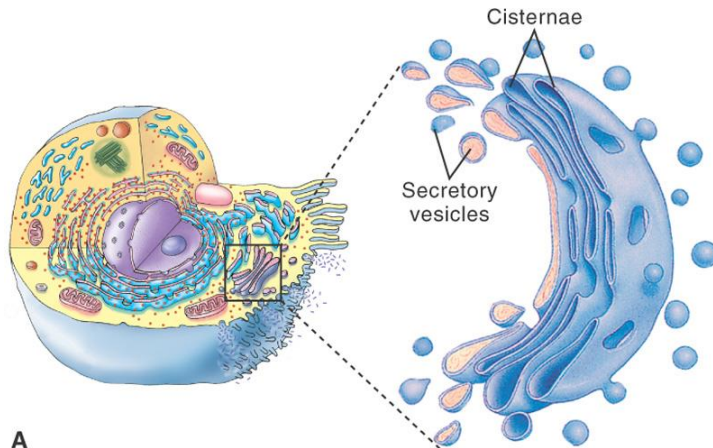
- Ribosome

- Small granules of RNA in the cytoplasm bound to protein
- Are formed in the nucleolus
- “Protein Factories”
  - Free floating (functioning to synthesize proteins for the cell)
  - RER (produce proteins for export)
  - Working ribosomes (producing proteins) tend to function in a group (polyribosome)



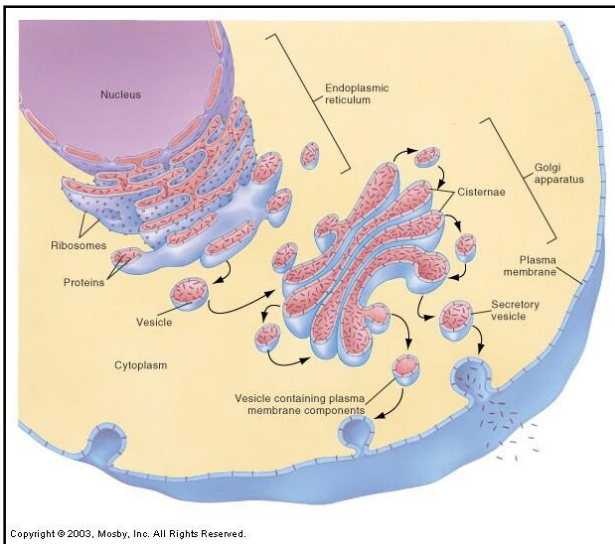
- Golgi Apparatus

- 4 to 6 flattened membranous sacs (cisternae)
- “Packages and Ships” proteins from the RER and lipids from the SER
  - Proteins are modified or concentrated or have a carbohydrate added
  - Are surrounded by a piece of GA and are pinched off as a secretory vesicle
- Are abundant in glandular cells and secrete that product
- In non-secretory cells they package enzymes in the form of lysosomes

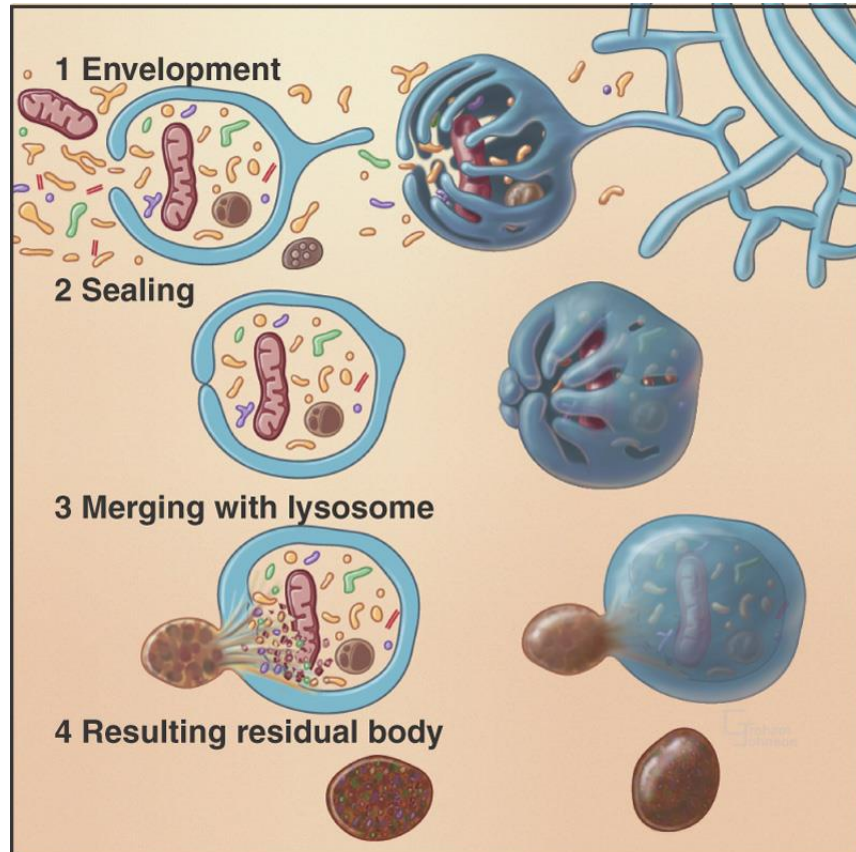


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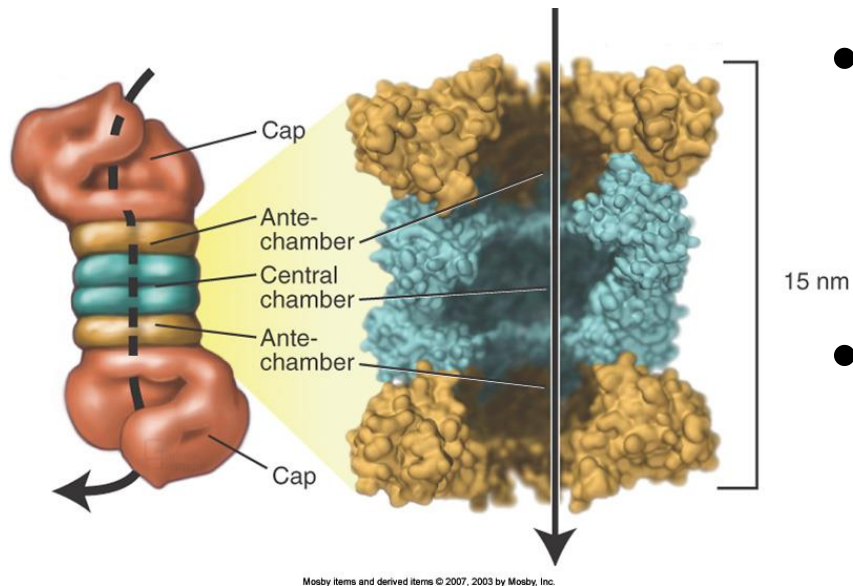


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- Lysosomes
  - Originated from the GA
  - Contains various digestive enzymes
  - Destroy cellular debris, worn-out cell parts as well as bacteria that enters the cell
  - Play a part in decreasing the size of body organs
    - Atrophy of muscle due to lack of use
    - Reduction of breast size after breast feeding
    - Decrease in uterus after parturition



- Hollow, protein cylinders found throughout the cytoplasm
- Break down abnormal/misfolded proteins and normal proteins no longer needed by the cell
- Break down protein molecules one at a time by tagging each one with a chain of ubiquitin molecules and unfolding it as it enters the proteasome, then breaking apart peptide bonds

- Small membranous sacs containing enzymes that detoxify harmful substances that enter the cells
  - Smaller than Lysosomes
  - Found in some cells (Kidney and liver)
  - Contains enzymes that help neutralize hydrogen peroxide
    - Peroxidase
    - Catalase

- Mitochondria

- “The Powerhouse”

- 95% of cell’s energy supply

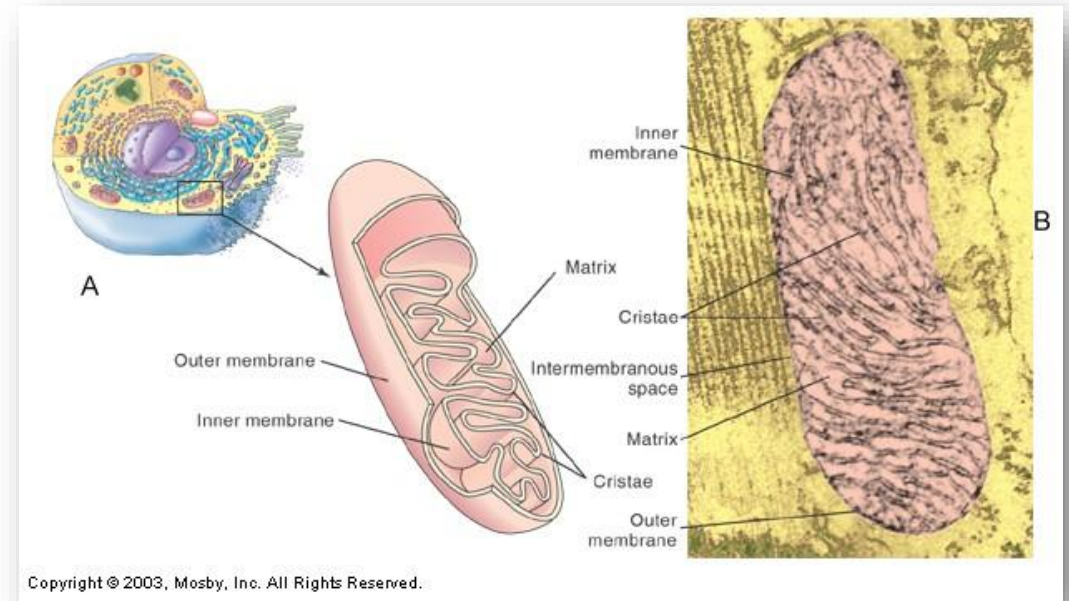
- Elongated, oval, fluid filled sacs

- Has two layers separated by fluid

- Outside layer            Smooth
- Inner layer             Invaginations (cristae)

- Contain its own DNA so it can produce its own enzymes and replicate copies of itself

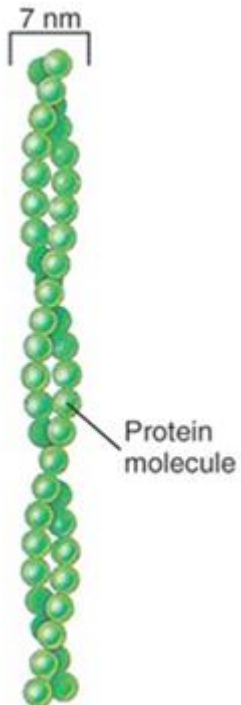
- Enzymes needed to produce ATP are located along cristae



- Cytoskeleton
  - Found in the cytoplasm
  - Helps maintain the shape
  - May anchor organelles or move them from one area to another
  - May move a portion of the cell membrane, while others may move entire cell

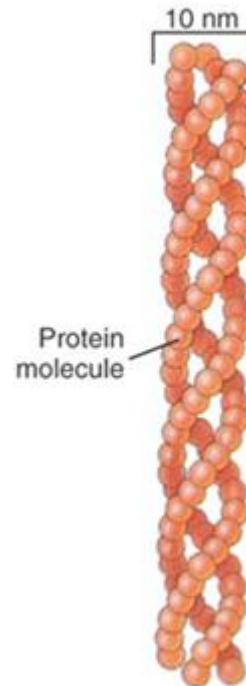
## Microfilament

- “Cellular muscles”
- Long, slender rods of proteins
- Ex: Actin filaments



## Intermediate Filament

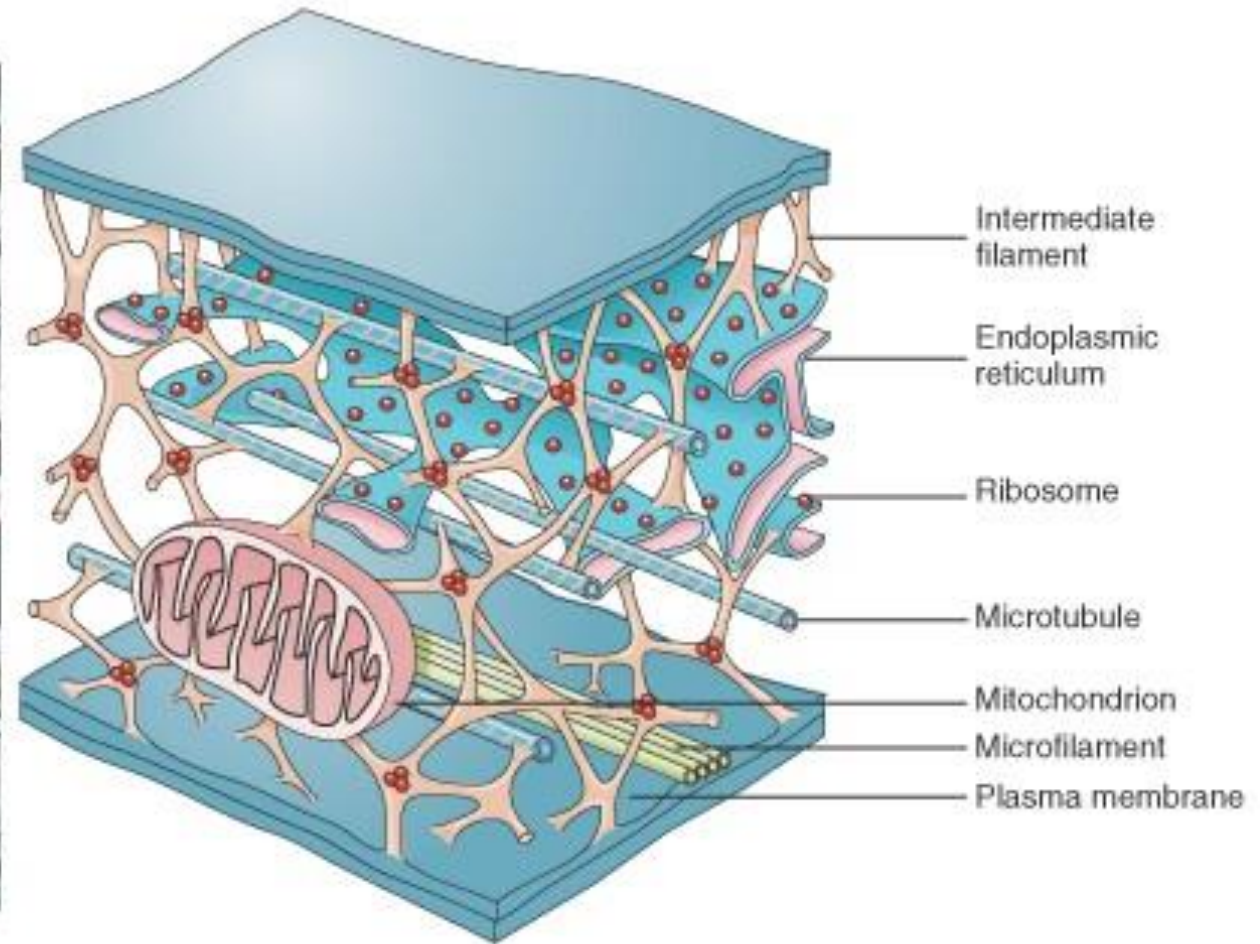
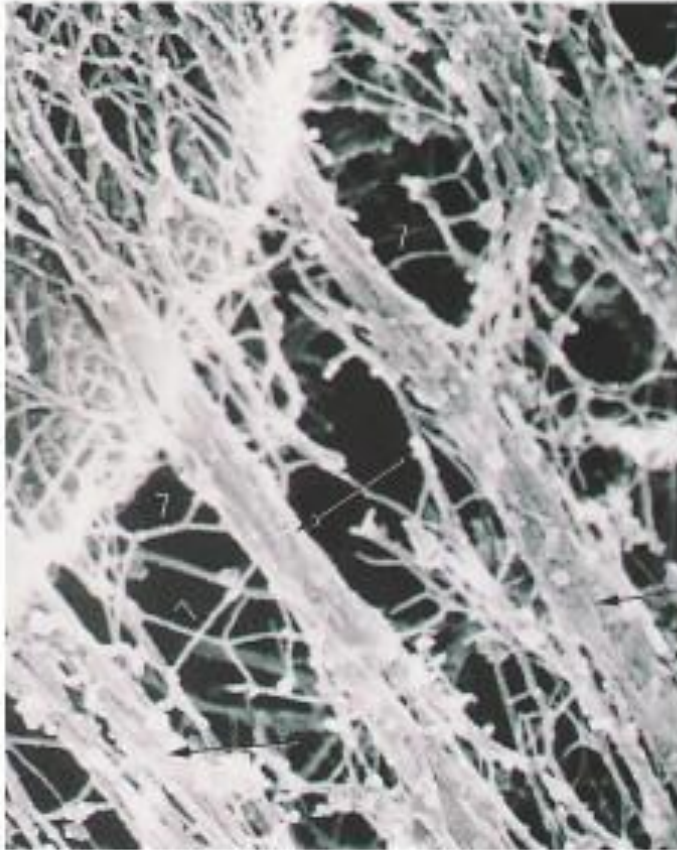
- Supporting framework



## Microtubule

- Cylinders/“Engines”
- Cause movement of globules, chromosomes (Ex: cilia and flagella)



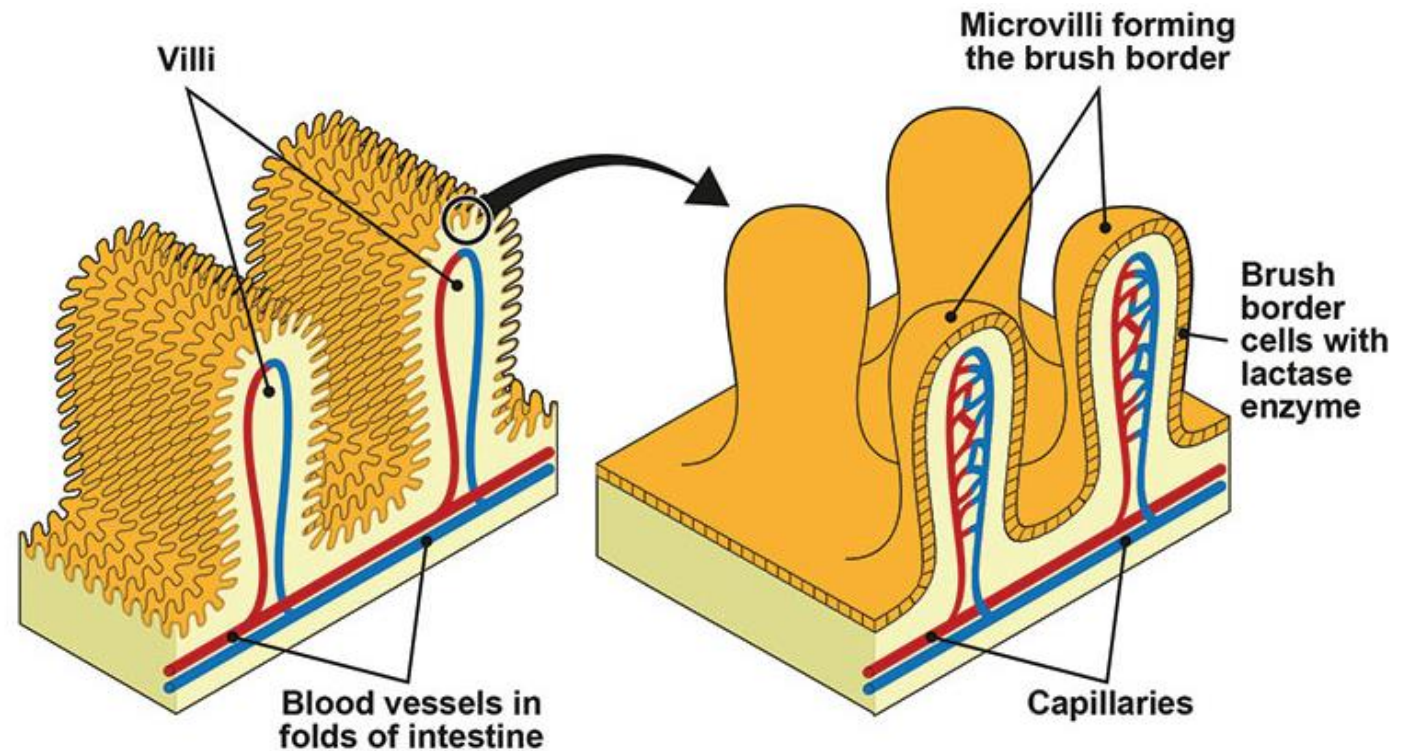


- Centrosome
  - An area of the cytoplasm near the nucleus that coordinates the building and breaking of microtubules in the cell
  - Non-membranous structure also called the microtubule-organizing center (MTOC)
  - Plays an important role during cell division
  - The general location of the centrosome is identified by the centrioles

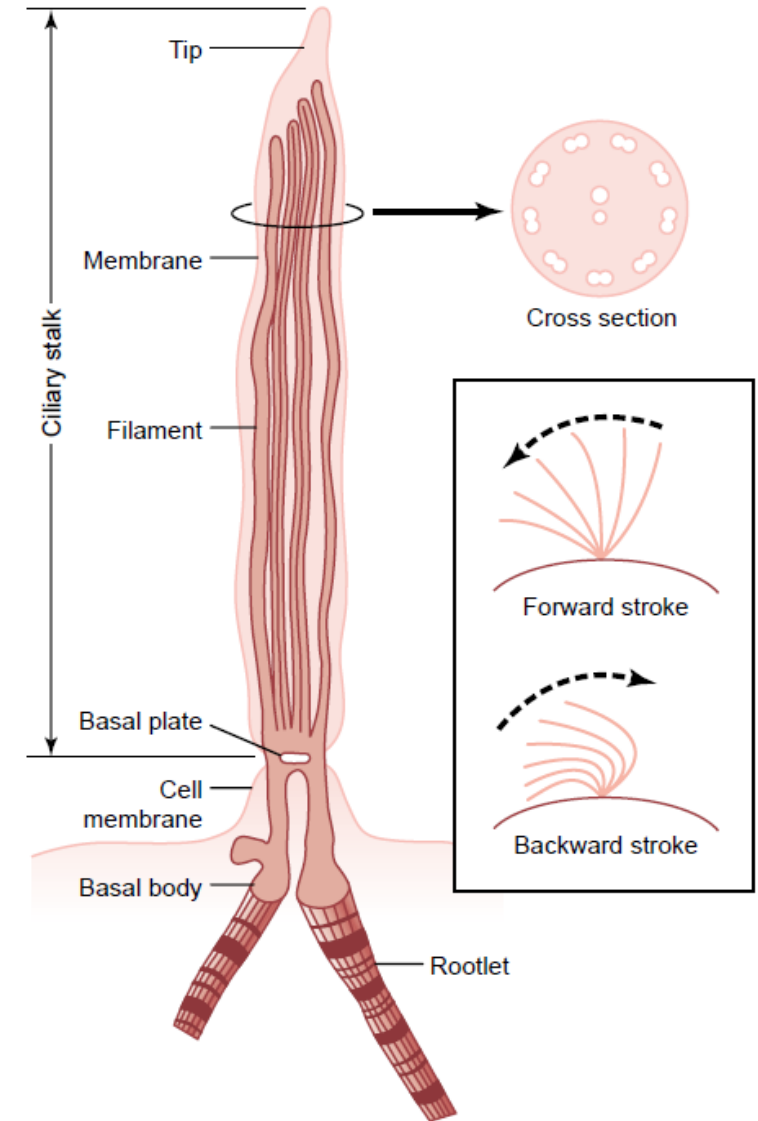
- Centrioles
  - A dense area near the nucleus called the centrosome contain a pair of centrioles
  - Rod-shaped structure composed of microtubules at right angles to each other
  - Function in cell reproduction by distributing chromosomes to the daughter cells

- Cell extensions
  - Cytoskeleton forms projections that extend the plasma membrane outward to form tiny, fingerlike processes
    - Microvilli
    - Cilia
    - Flagella

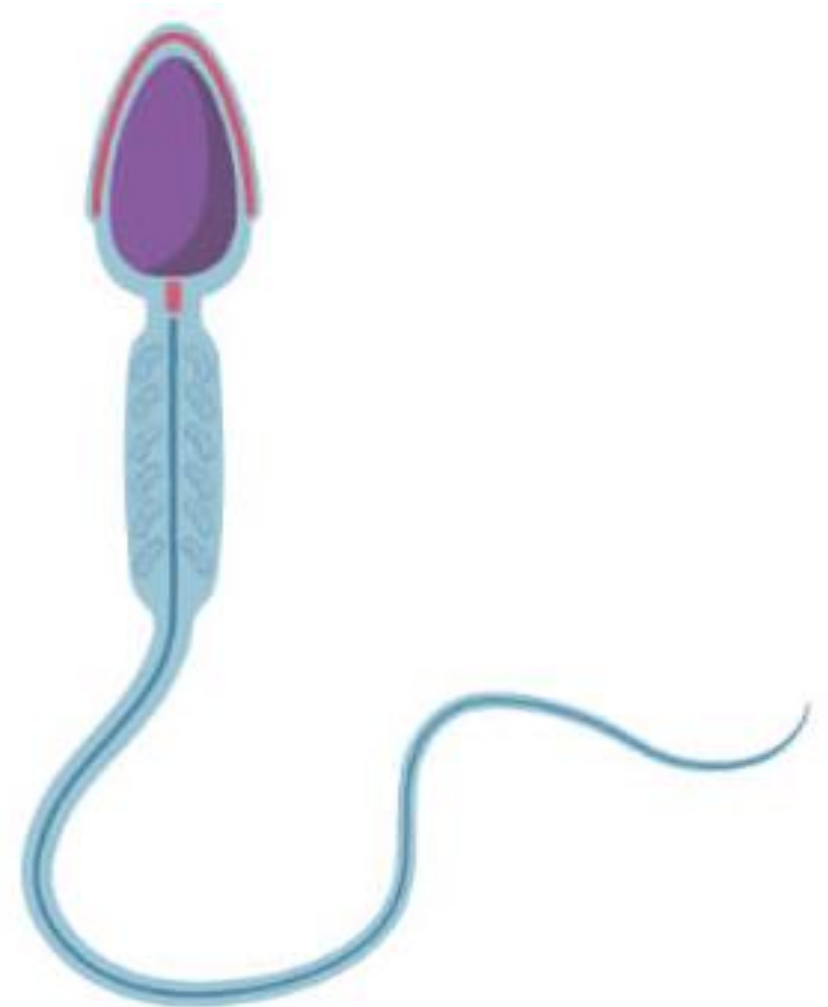
- Microvilli
  - Found in areas of absorption
  - Line the surface to increase surface area for the them to be absorbed
  - Increases the absorption rate by doing this



- Cilia
  - Short, cylindrical hair like structure projecting outward from the cell
  - Anchored under the cell membrane
  - Wave like motion to move substances across the surface

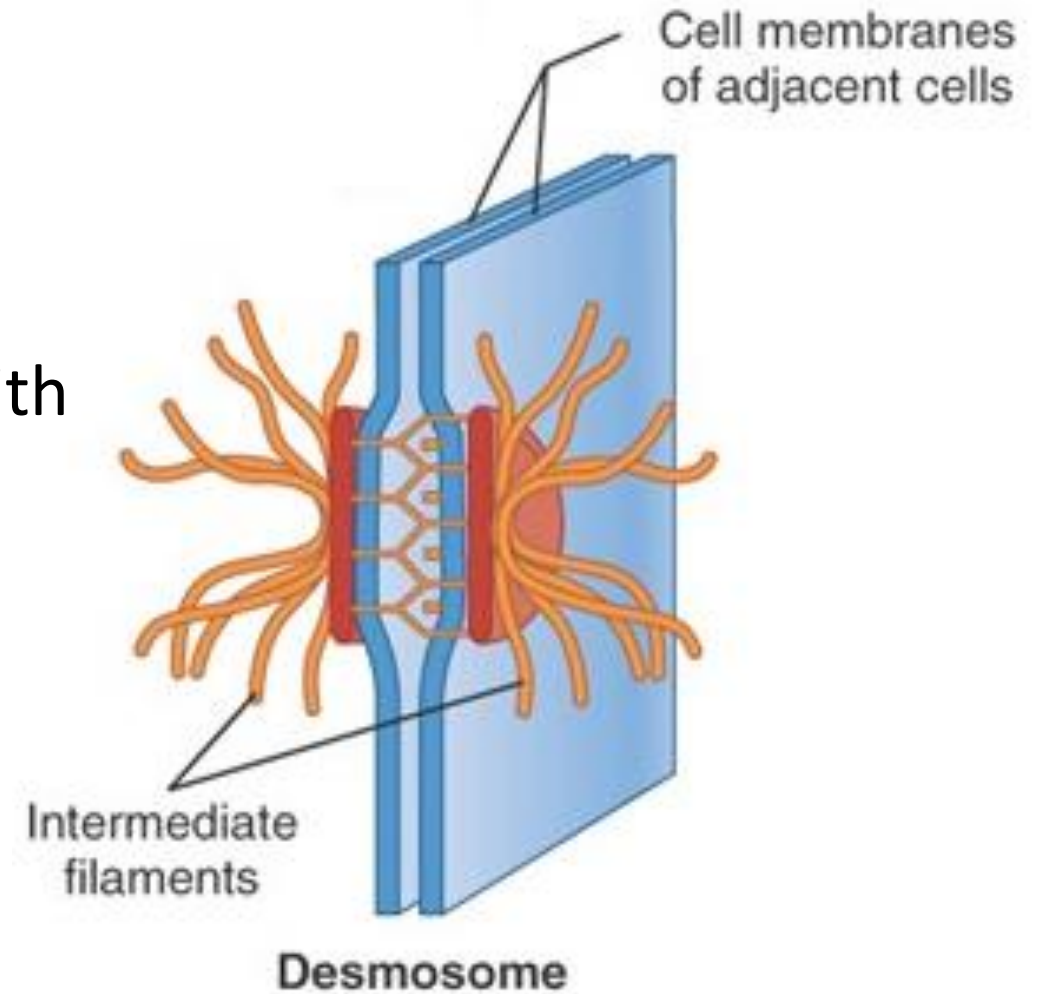


- Flagella
  - Similar to the cilia
  - Much longer and fewer in number
  - Beat like a whip to produce movement

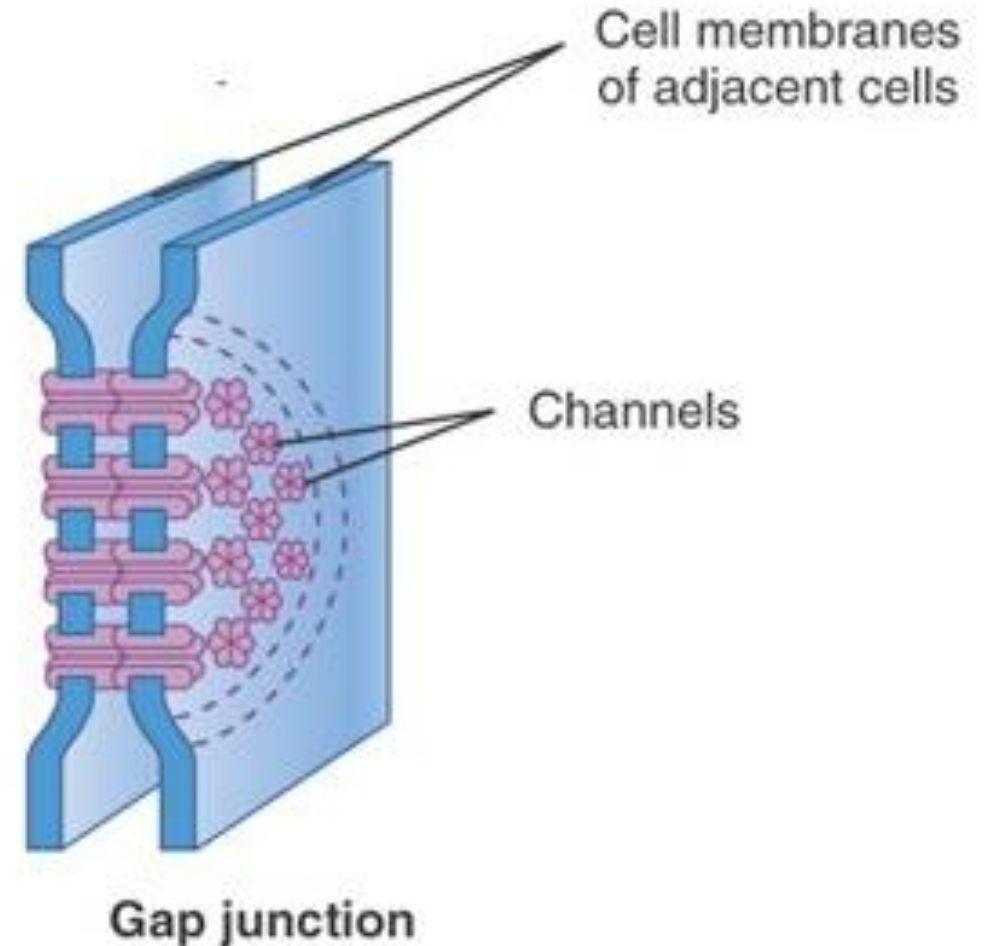


- Connections
  - Cells are held together by fibrous nets that surround groups of cells (e.g., muscle cells), or cells have direct connections to each other
  - Hold cells together to form tissue
  - Group of proteins (integrins) hold cells in place
    - Desmosomes
    - Gap junctions
    - Tight junctions

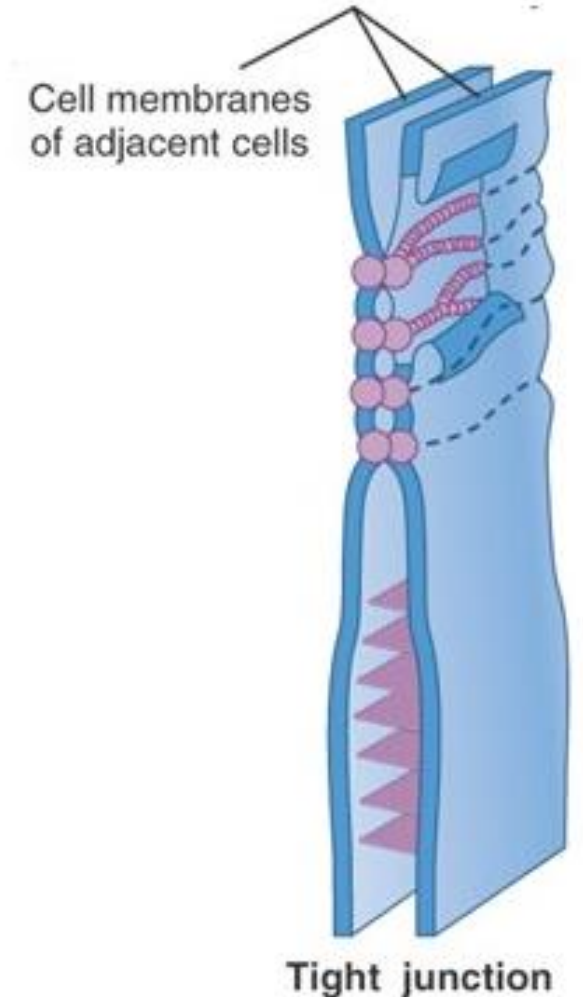
- Desmosomes
  - “Spot welds”
  - Skin cells are an example
  - Fibers on the outer surface interlock with one another (Velcro)



- Gap Junctions
  - Formed when adjacent plasma membranes adhere to each other
  - Form tunnels
    - Allows molecules to move from one cell to another
    - Allows for impulses to travel from cell to cell



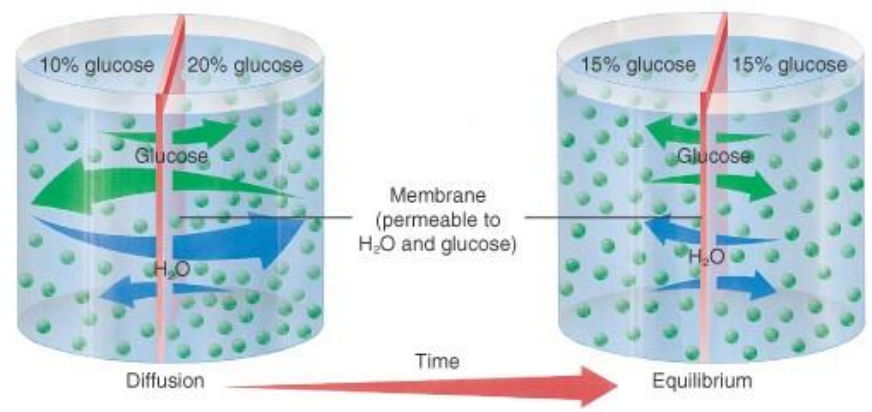
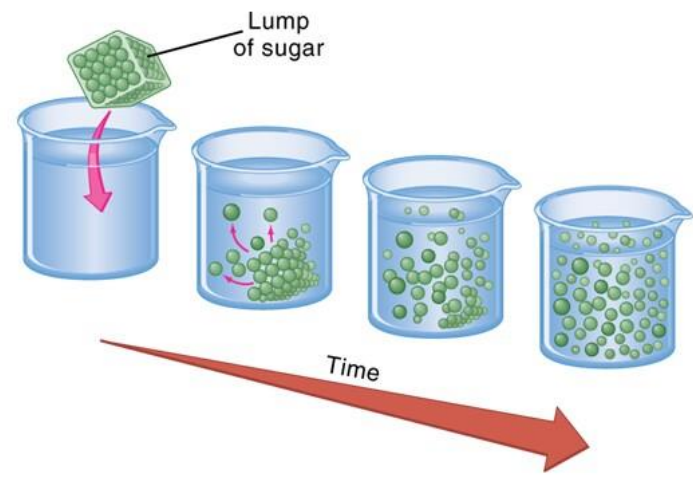
- Tight Junctions
  - Occur where cells are joined by tightly fused membranes
  - Molecules cannot penetrate the membranes at this point
  - Occur in areas where it is important to limit what enters
    - Molecule must then pass through a controlled channel



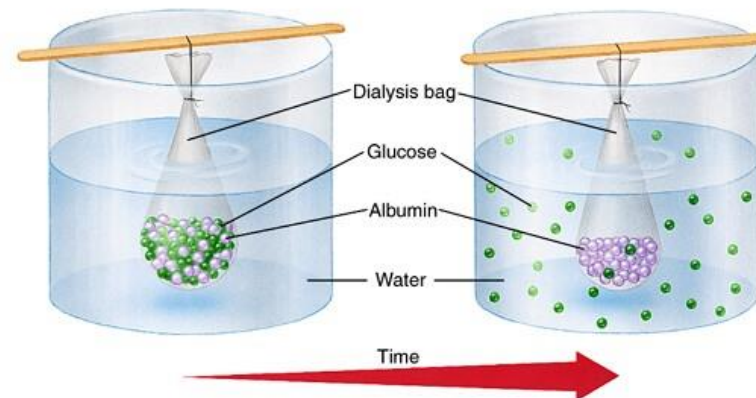
- The structure and function of each cell is determined by the proteins present
- Cell functions include
  - Movement of substances across the membrane
  - Cell division
  - Protein synthesis

- Types:
  - Diffusion
  - Dialysis
  - Facilitated diffusion
  - Osmosis
  - Filtration
  - Active transport
  - Endocytosis
  - Exocytosis

- Movement of atoms, ions or molecules from a region of high concentration to a region of low concentration
- If two solutions have different concentrations then a concentration gradient exists
- Anything that increases the speed of movement of the molecules will increase the rate of diffusion

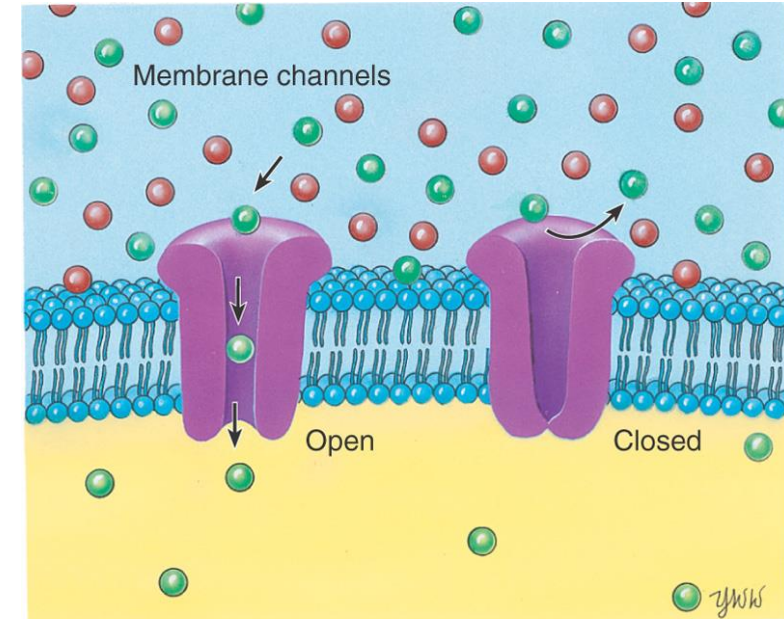


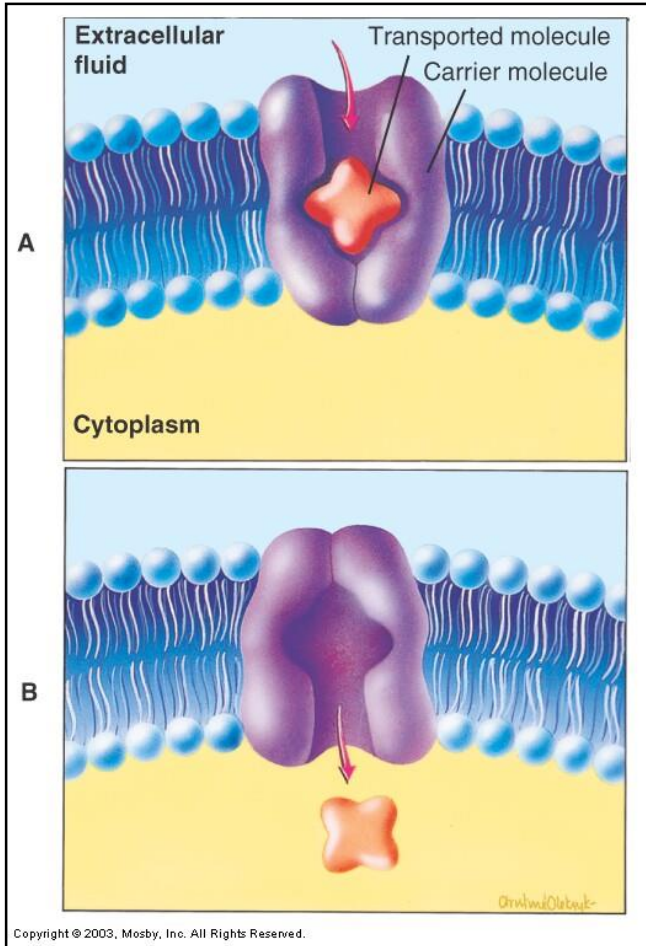
- A form of diffusion where a selectively permeable membrane exists
- Membrane only allows for smallest particles to pass
- Moves down the gradient (concentration driven)



- “Mediated Passive Transport”
- Special kind of diffusion whereby movement of molecules is made more efficient by the action of transporters embedded in a cell membrane
- Moves substances down the gradient
- “Carrier” protein remains unchanged
- Two types:
  - Channel-mediated passive transport
  - Carrier-mediated passive transport

- Channel-mediated passive transport
  - Channels are specific
    - allow only one type of solute to pass through
  - Gated channels may be open or closed (or inactive)
    - may be triggered by any of a variety of stimuli
  - Channels allow membranes to be selectively permeable
  - Aquaporins are water channels that permit rapid osmosis



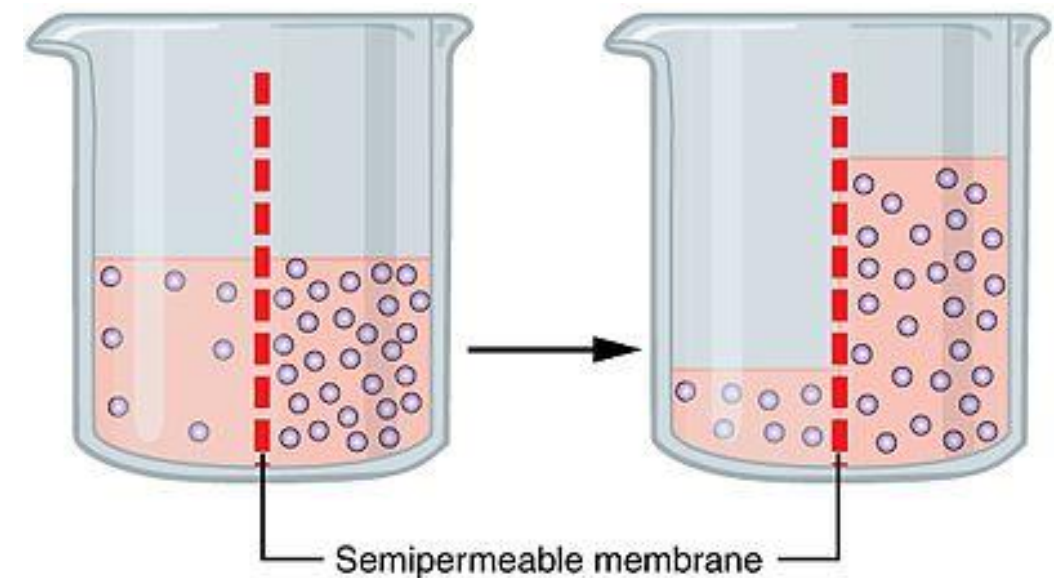


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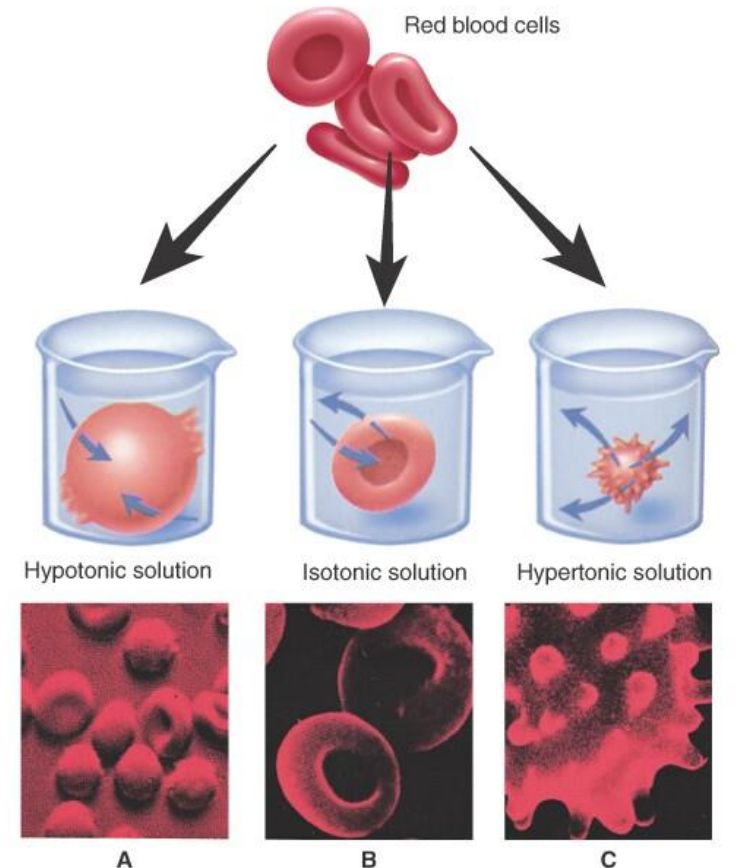
- Carrier-mediated passive transport
  - Carriers attract and bind to the solute, change shape, and release the solute out the other side of the carrier
  - Carriers are usually reversible, depending on the direction of the concentration gradient

- Osmosis is the diffusion of water through a selectively permeable membrane
- This exchange of water will equalize the concentrations of the solutes on both sides of the membrane
- The introduction of water to the area through osmosis creates an increase in volume and thus the pressure (osmotic pressure)

- Movement of a solvent through a selectively permeable membrane from a region of high concentration (where the solute concentration is low) to a region of low concentration (where the solute concentration is high) until equilibrium is reached
- Solutions on both sides now have same concentration but the solution that was higher in concentration initially will now have more volume
- Water will continue to move in both directions at an equal rate after equilibrium has been reached



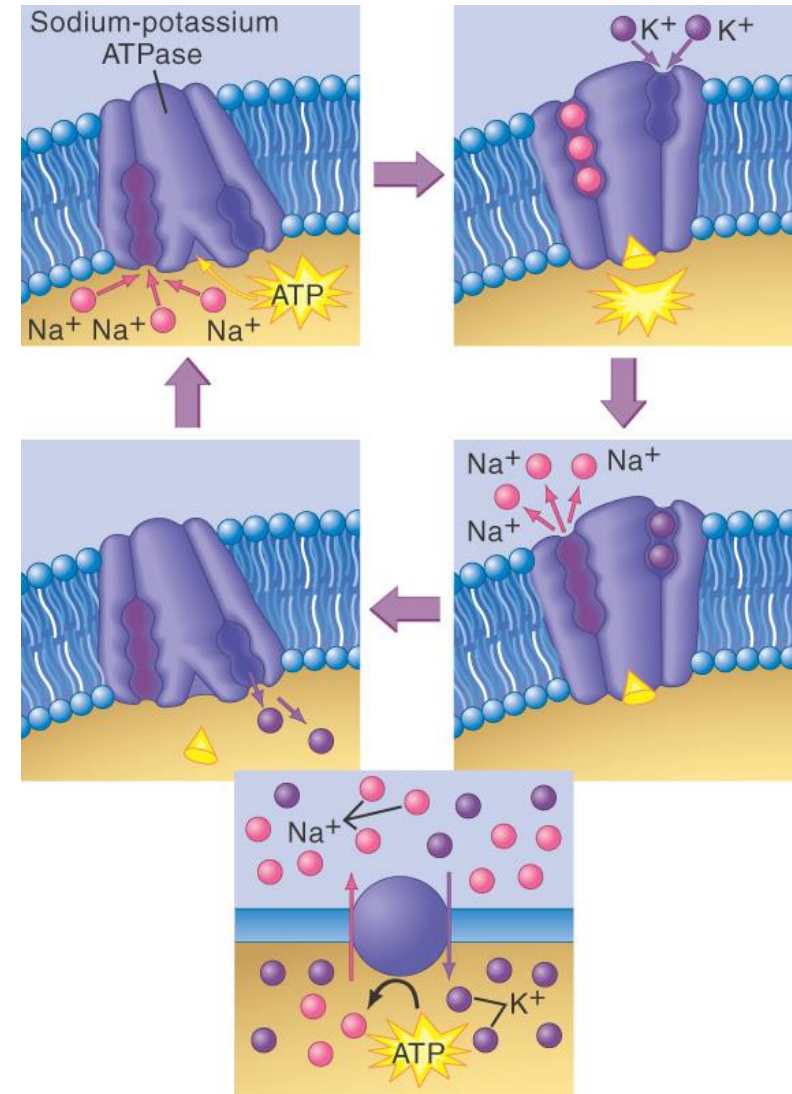
- Isotonic
  - Same potential osmotic pressure
  - Water moves but no change in the [ ] or pressure
- Hypertonic
  - “Higher osmotic pressure”
  - Water moves from RBC into solution (crenate)
- Hypotonic
  - “Lower osmotic pressure”
  - Water moves into cell (lysis)



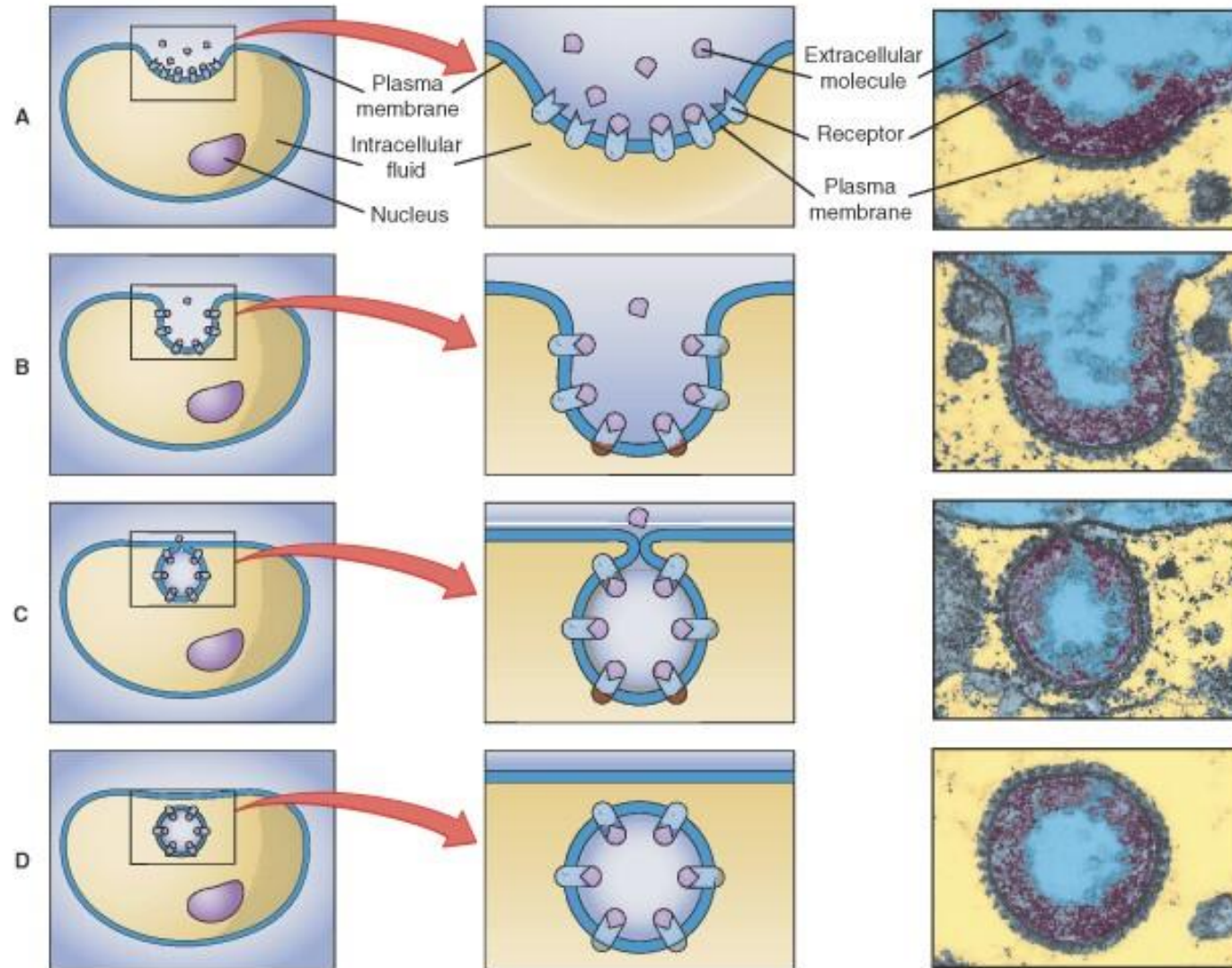
- Pressure caused by the weight or force of the water pushing on a surface is known as hydrostatic pressure
- Filtration is passing of water and permeable solutes through a membrane by the force of hydrostatic pressure
- Size of the pores in the membrane determine the size of the particle that will pass through it
- Similar to dialysis except this is pressure driven

- Require the expenditure of metabolic energy by the cell
- Moves substances against (“uphill”) a concentration gradient
  - Transport by pumps
  - Transport by vesicles
    - Endocytosis
    - Exocytosis

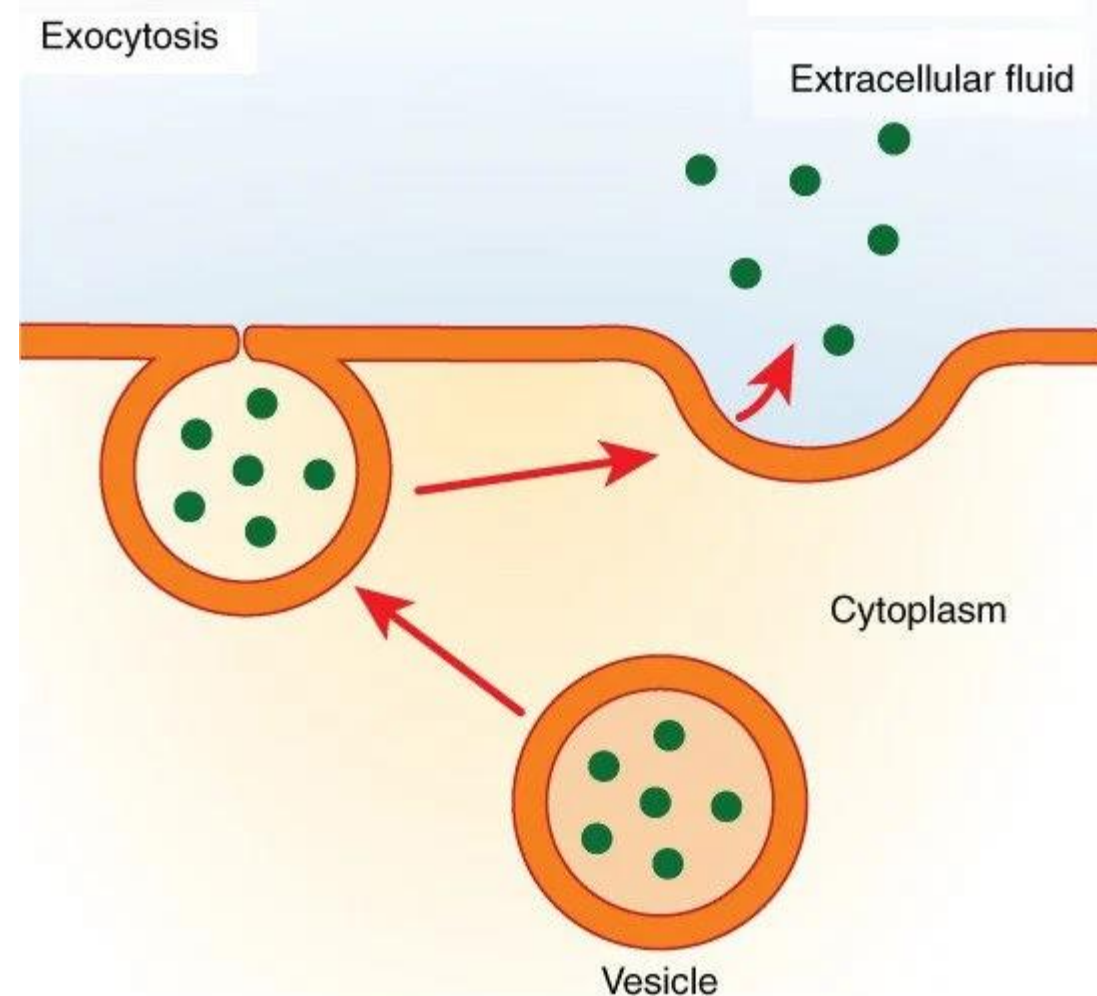
- Transport by pumps
  - Pumps are membrane transporters that move a substance



- Refers to the formation of vesicles to transfer particles from outside the cell to the inside
- Requires ATP
- The cell membrane surrounds the particle and pinches it off in the cytoplasm
  - Phagocytosis (“cell eating”)      Solids
  - Pinocytosis (“cell drinking”)      Fluids



- Refers to the formation of vesicles to transfer particles from inside the cell to the outside
- Packaged by the GA
- Requires ATP

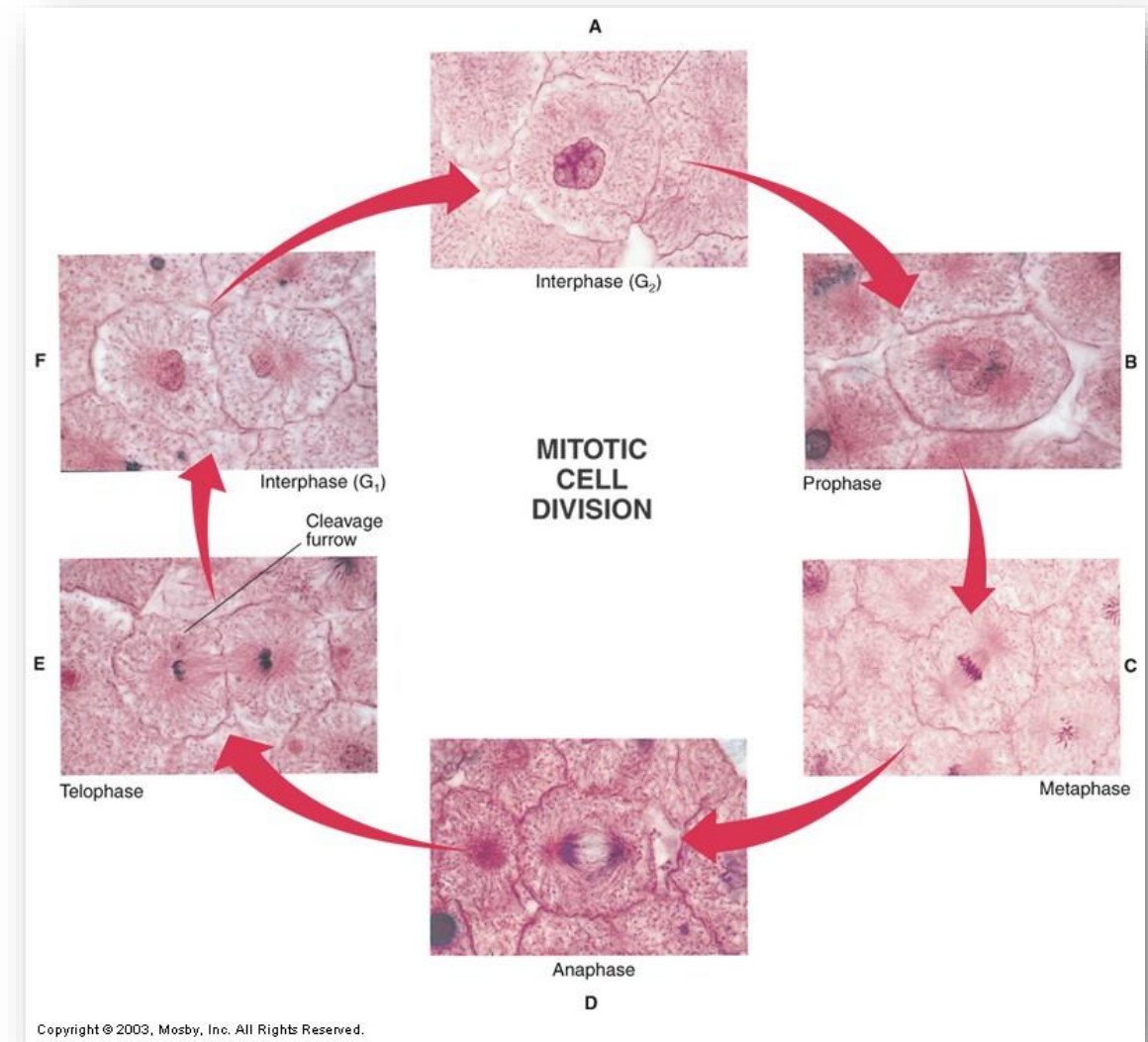


- Cell growth and reproduction of cells are the most fundamental of all living functions and together constitute the cell life cycle
  - Cell growth
    - Depends on using genetic information in DNA to make the structural and functional proteins needed for cell survival
  - Cell reproduction
    - Ensures that genetic information is passed from one generation to the next

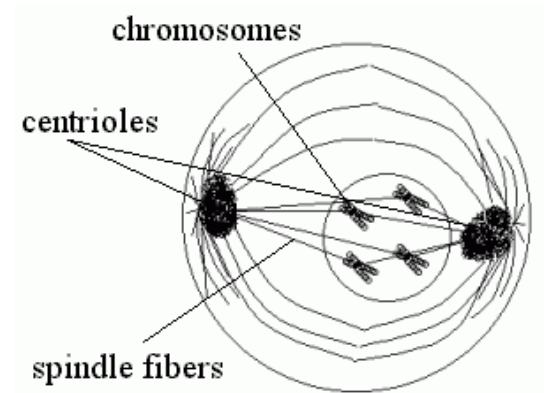
- As a cell grows it needs to produce additional cytoplasm and the membrane to contain it
  - Cytoplasm
    - From protein synthesis
  - Membrane
    - Enzymes from protein synthesis are used to make additional carbohydrates and lipids

- All human cells (except sex cells) reproduce by mitosis, in which cells divide to multiply
- This splitting results in 2 daughter cells from 1 parent cell
- The splitting of the plasma membrane and the cytoplasm into two equal parts is called “cytokinesis”
  - Many cells undergo division throughout life of the individual
    - Epithelial cells, liver cells, bone marrow cells
  - Other cells divide until near the time of birth
    - Nerve cells, skeletal muscle cells

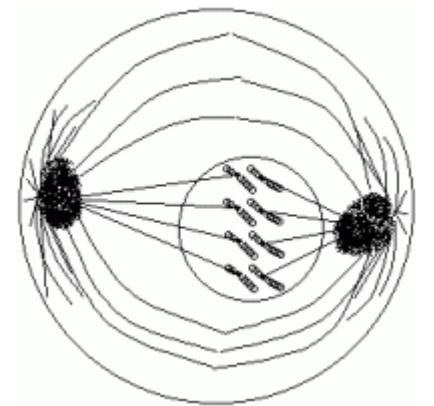
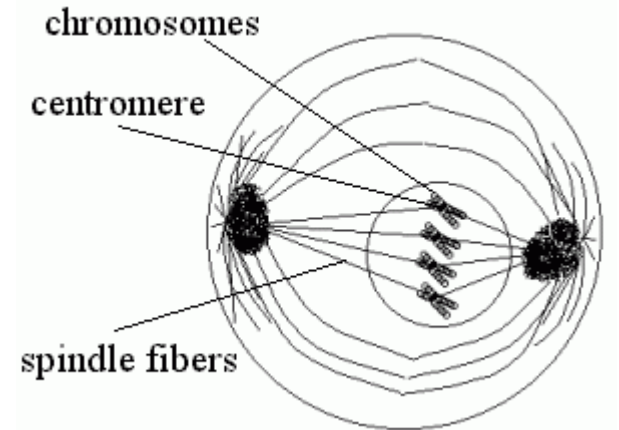
- Single cell divides into two daughter cells
- Stages of mitosis
  - Interphase
  - Prophase
  - Metaphase
  - Anaphase
  - Telophase



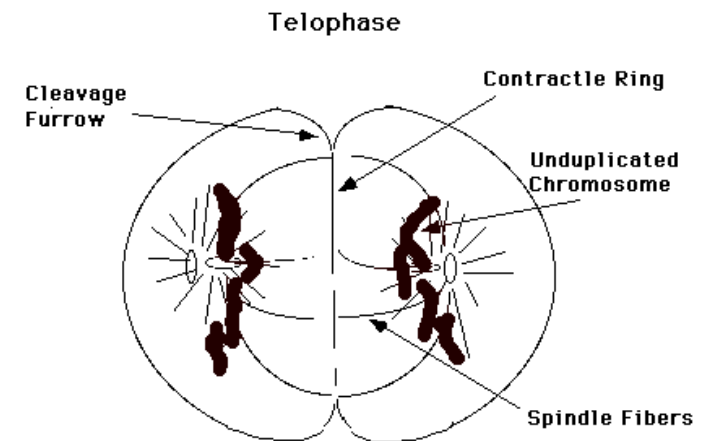
- Interphase
  - The period between successive cell divisions
  - The longest period of the cycle
- Prophase
  - The chromosomes condense and become visible
  - The centrioles form and move toward opposite ends of the cell ("the poles")
  - The nuclear membrane dissolves
  - The mitotic spindle forms (from the centrioles in animal cells)
  - Spindle fibers from each centriole attach to each sister chromatid

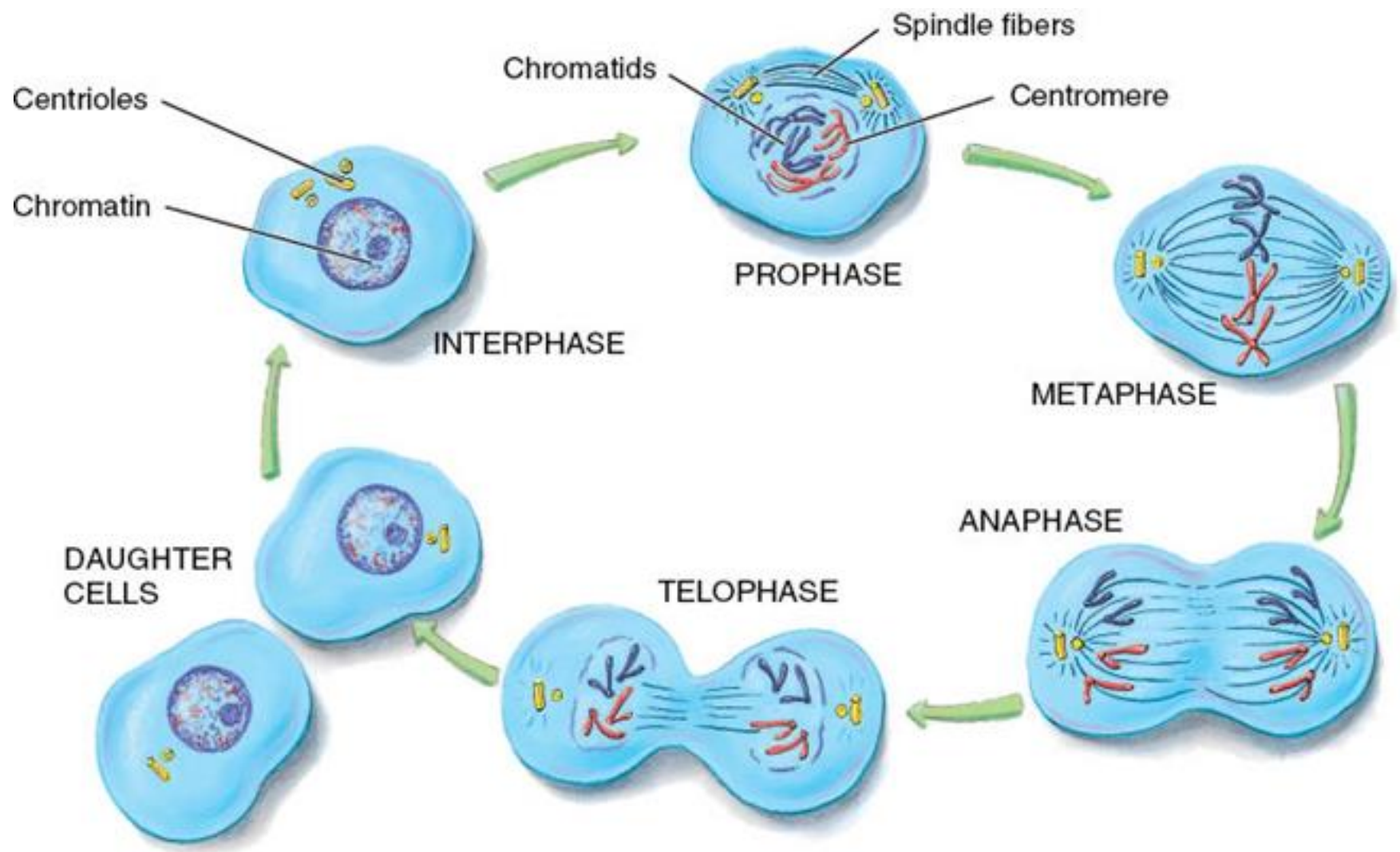


- Metaphase
  - The centrioles complete their migration to the poles
  - The chromosomes line up in the middle of the cell ("the equator")
- Anaphase
  - Spindles attached to kinetochores begin to shorten.
  - This exerts a force on the sister chromatids that pulls them apart.
  - Spindle fibers continue to shorten, pulling chromatids to opposite poles.
  - This ensures that each daughter cell gets identical sets of chromosomes



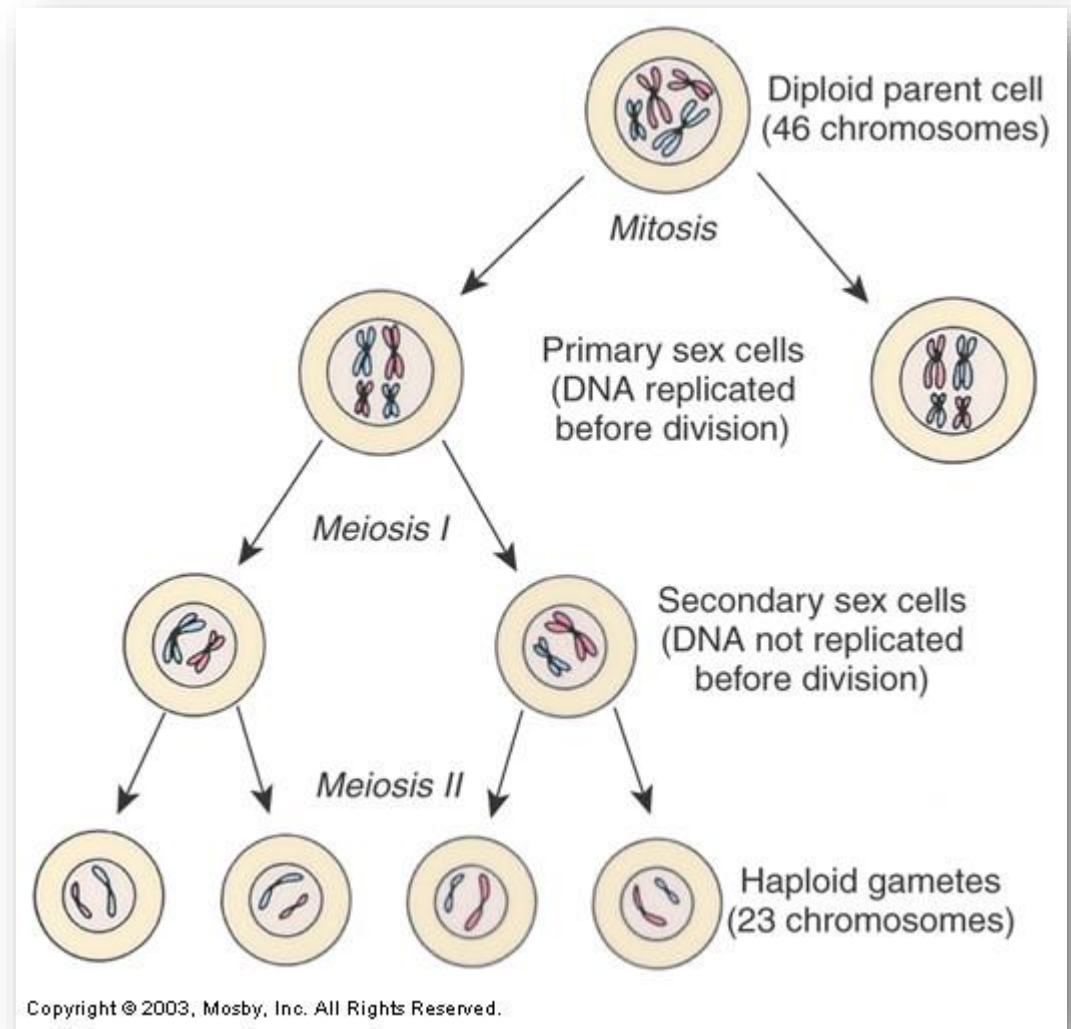
- Telophase
  - Almost the reverse of prophase
  - A new nuclear membrane forms around the chromosomes on each end of the cell
  - Spindle fibers disappear
  - Chromosomes uncoil to form chromatin
  - Nucleoli appear
  - Cell membrane constricts in the middle and divides (cytokinesis)





- **I**nterphase: cell is **I**DLE
- **P**rophase: cells **P**REPARE to divide
- **M**etaphase: chromosomes **M**EET in the middle
- **A**naphase: chromatids move **A**PART
- **T**elophase: cell **T**EARS into two

- Two divisions of the cell with only one replication of the DNA
- Results in 4 daughter cells with 23 chromosomes



Mitosis	Meiosis
Occurs in all somatic cells	Occurs only in reproductive (sex) cells
Chromosome number remains same, i.e., diploid (2n), hence it is equational division	Chromosome number reduces to half, i.e., haploid (n), hence it is reductional division
Two daughter cells are produced	Four daughter cells are produced
One cell division involves four phases	Consists of two sub-divisions: Meiosis - I and Meiosis - II each involving four phases. Prophase - I is again subdivided into five sub-stages
No crossing over	Crossing over takes place
Daughter cells have identical chromosomes to parent cell, i.e., genetic material remains constant	Daughter cells have chromosomes with combined genetic material from both parents i.e., genetic variability occurs

