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Anatomy and Physiology I

1st Year, 1st Semester, 2025-2026

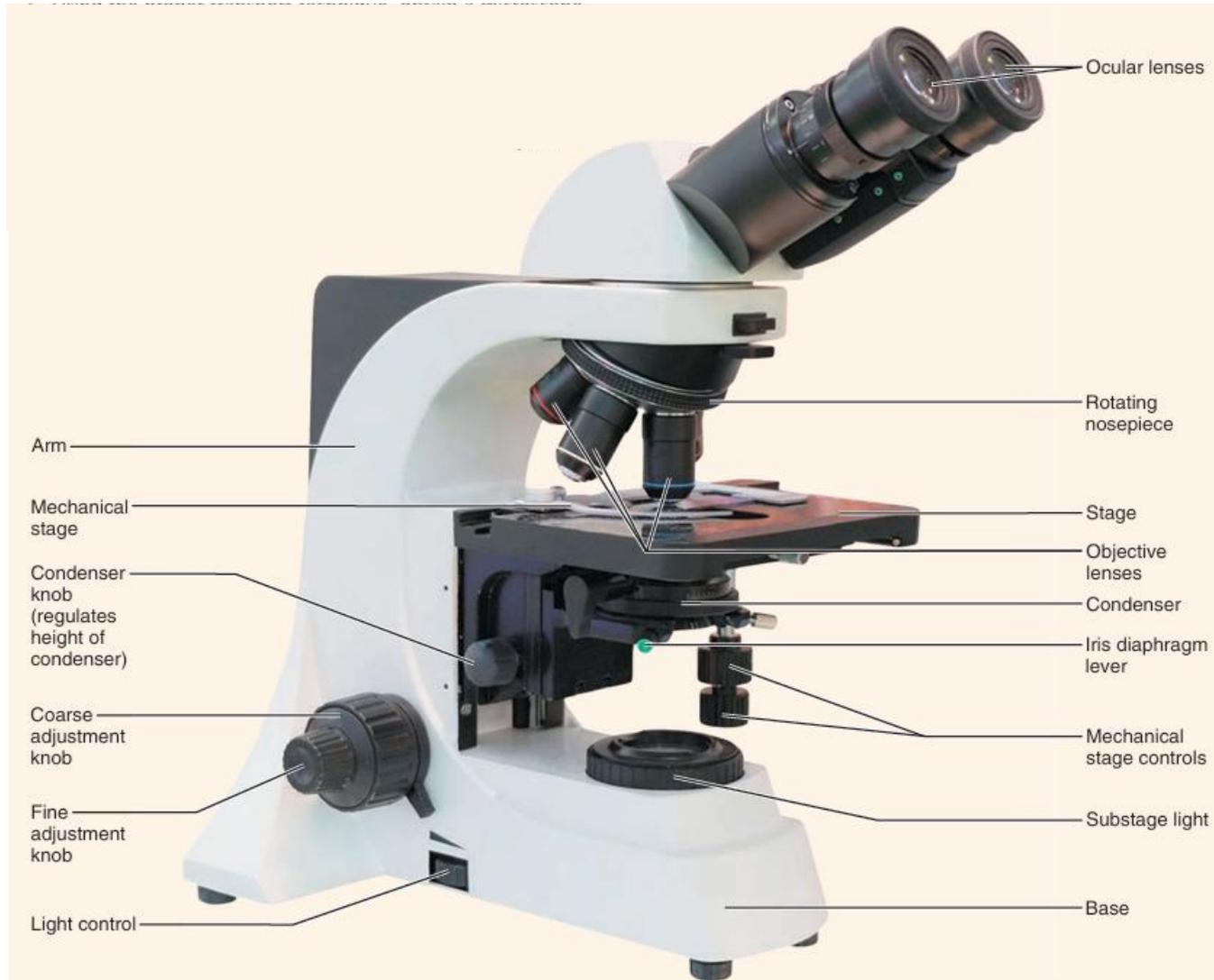
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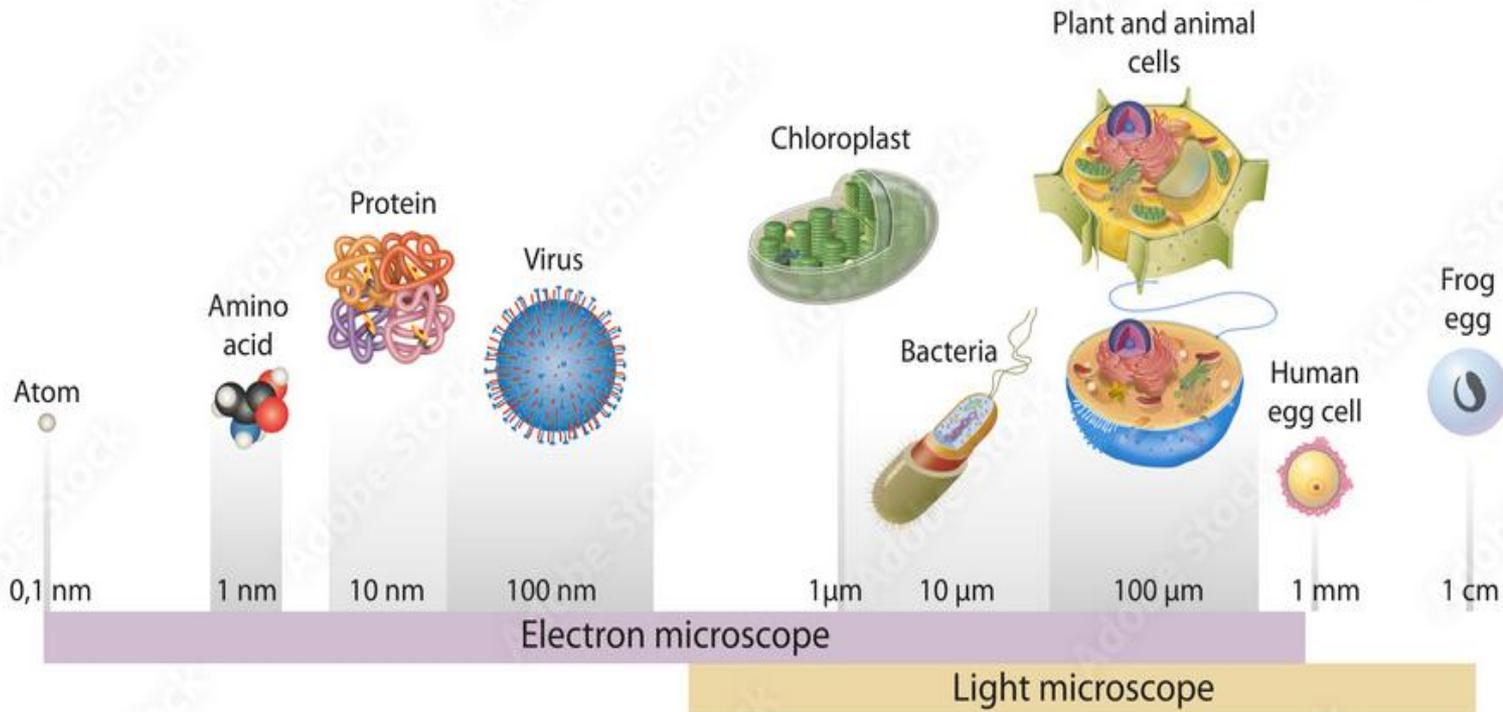
Cells, Cellular Organelle, and Transport Systems

Outlines:

- Compound microscope and its parts.
- Cell Types
- Membranes
- Membrane Structure
- Membrane Junctions
- Cell Organelles
- Cellular Transport Systems

Compound microscope and its parts.



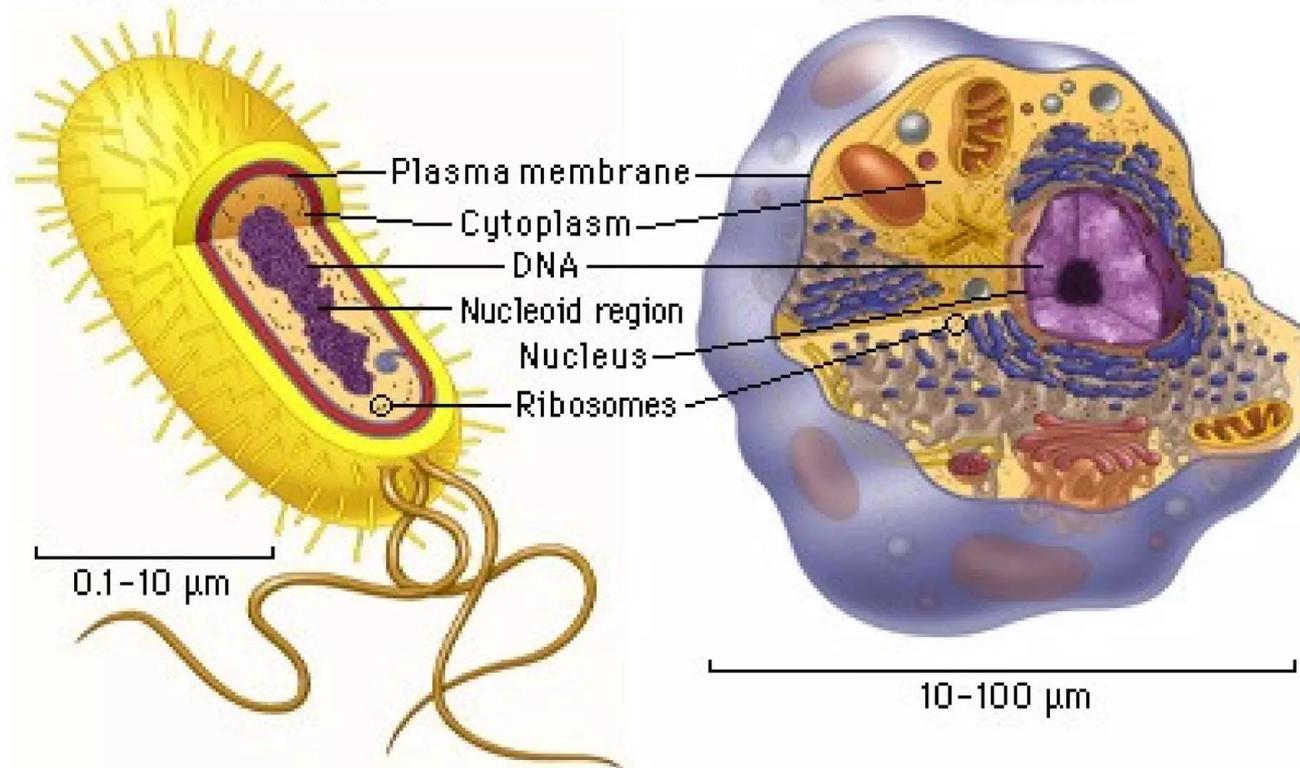


Typical sizes of cell structures, plotted on a logarithmic scale.

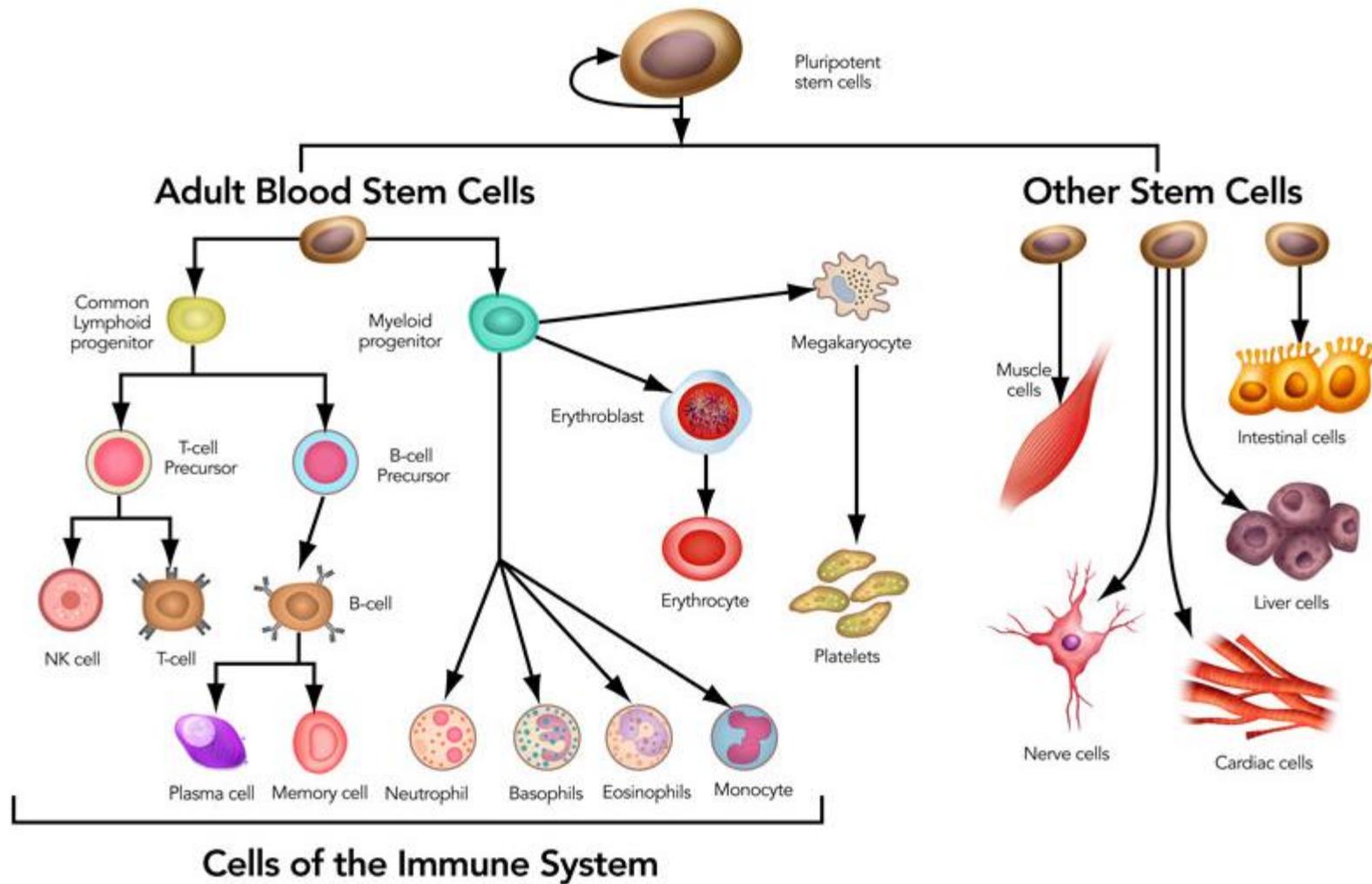
Two Basic Types of Cells

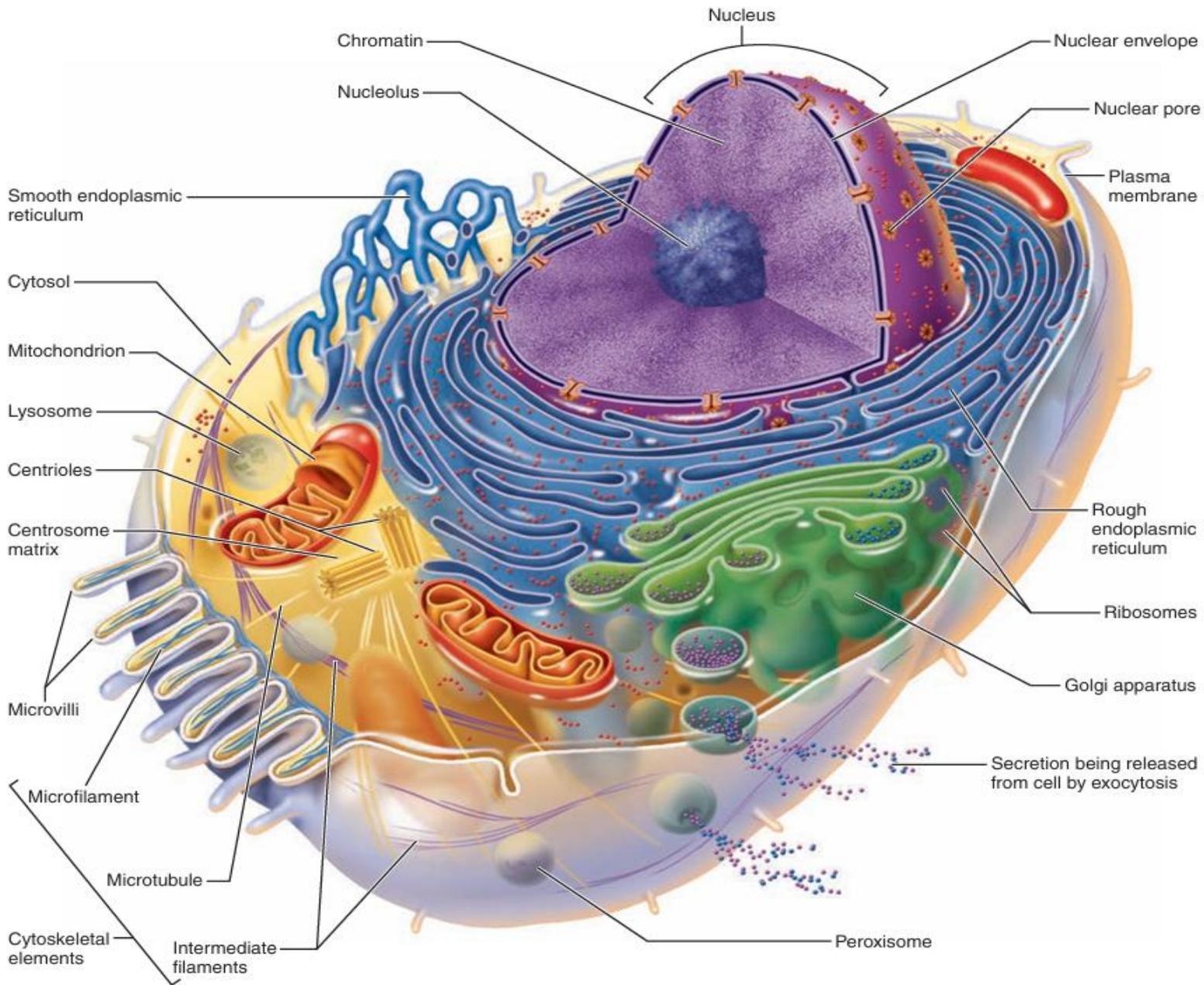
Prokaryotic cell

Eukaryotic cell

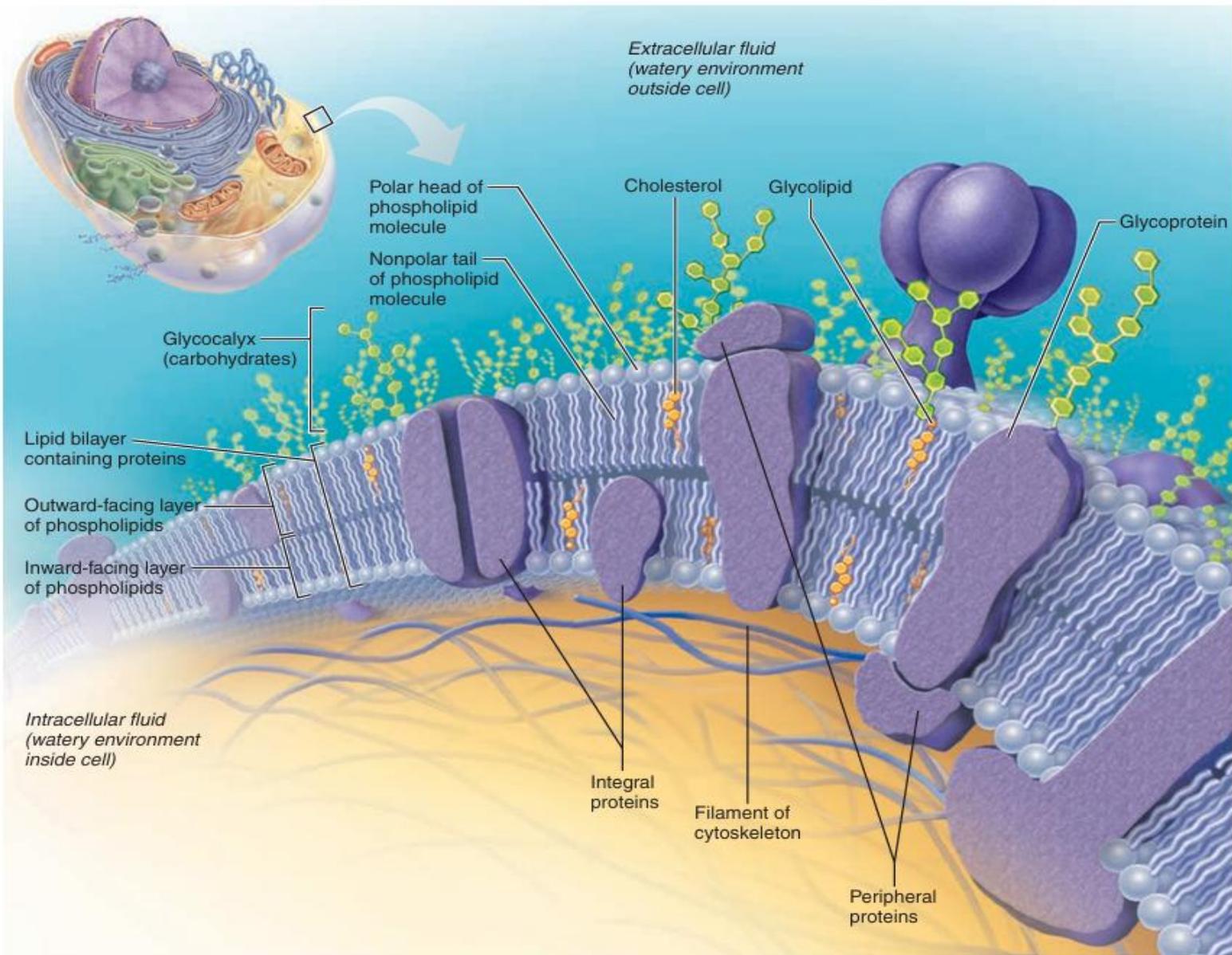


Human Cells

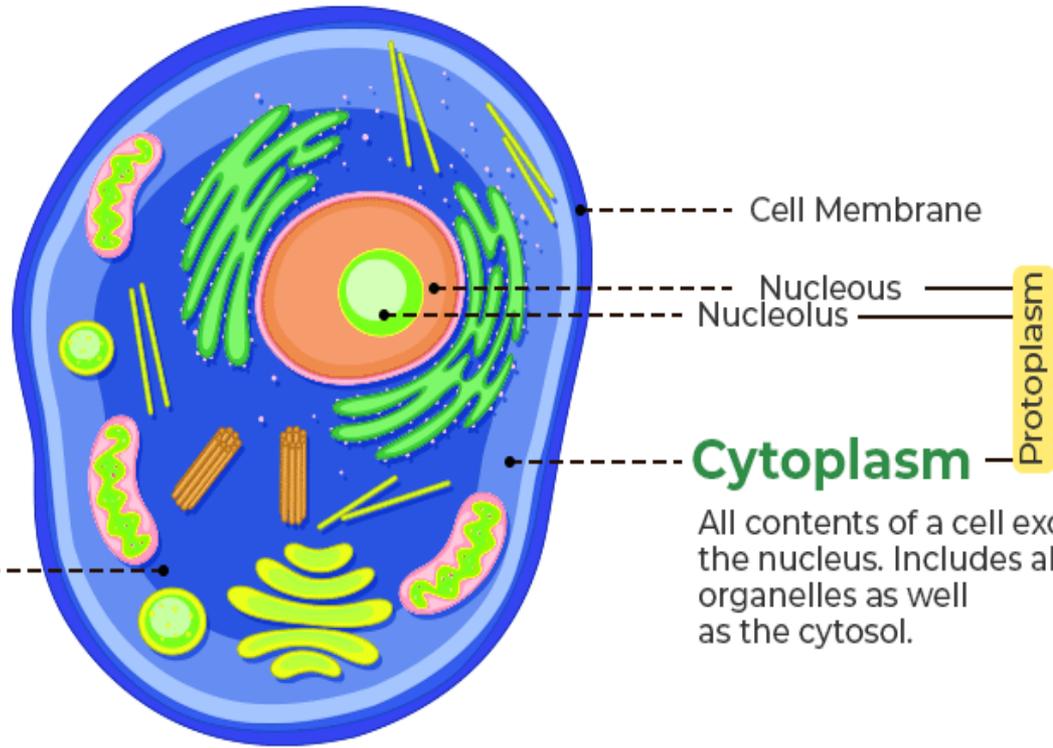




Structures found in most human cells. Not all structures are drawn to scale.



Structural details of the plasma membrane.



Cytosol

The liquid component of the cytoplasm surrounds intracellular organelles.

Cell Membrane

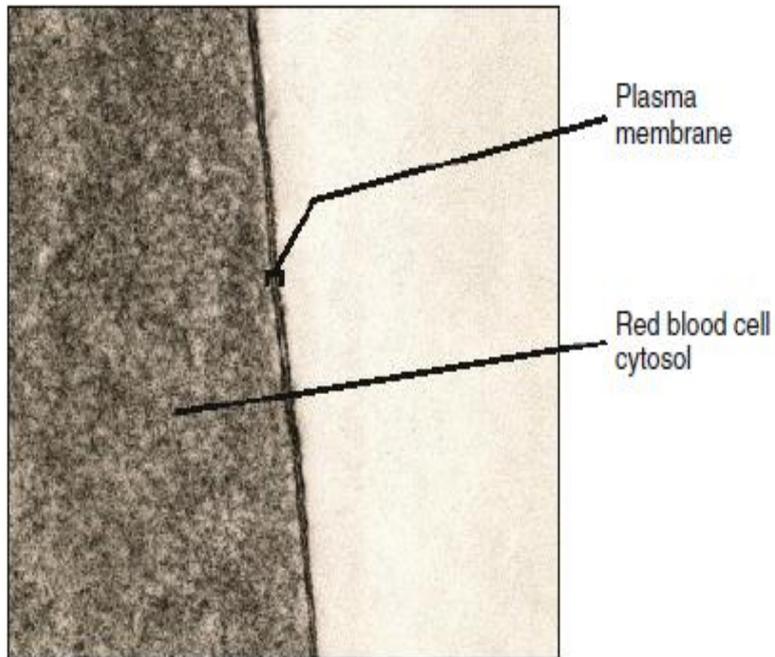
Nucleus
Nucleolus

Protoplasm

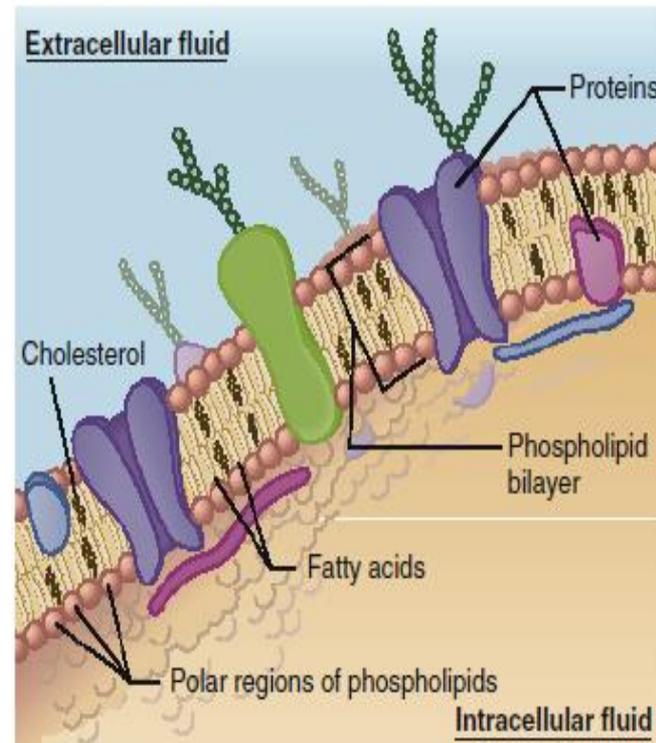
Cytoplasm

All contents of a cell except the nucleus. Includes all organelles as well as the cytosol.



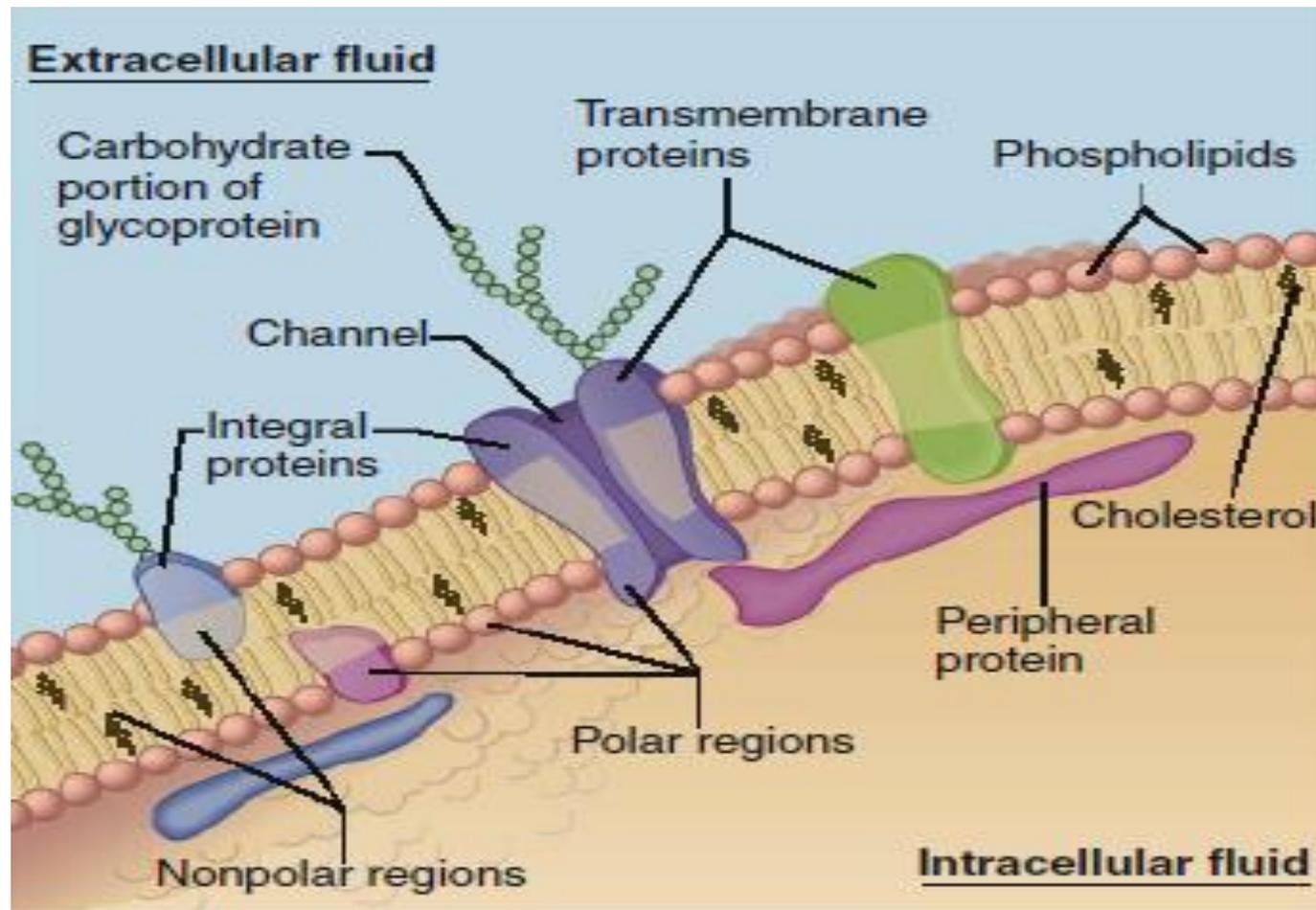


(a)

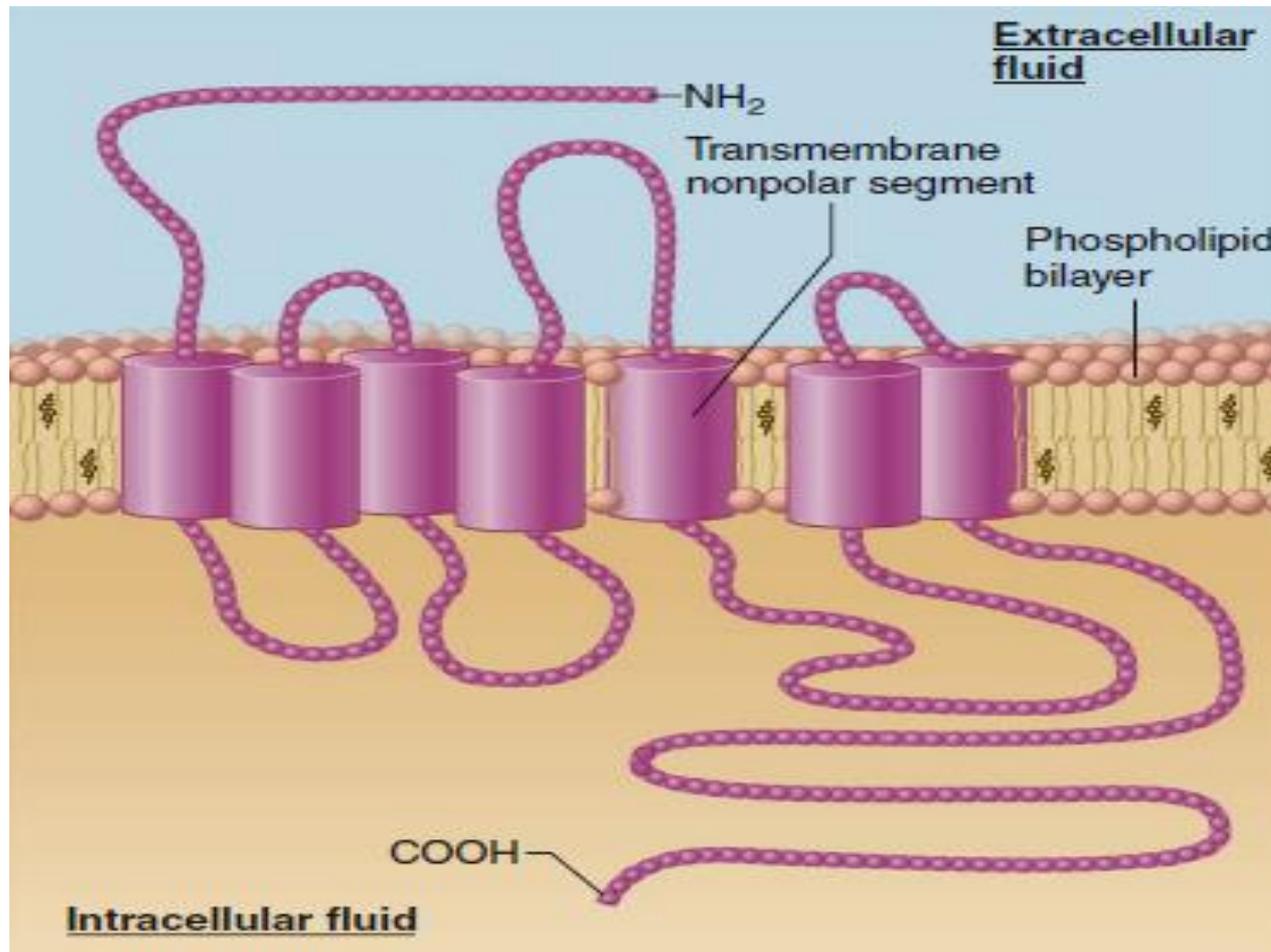


(b)

(a) Electron micrograph of a human red blood cell plasma membrane. Plasma membranes are 6 to 10 nm thick, too thin to be seen without the aid of an electron microscope. In an electron micrograph, a membrane appears as two dark lines separated by a light interspace. The dark lines correspond to the polar regions of the proteins and lipids, whereas the light interspace corresponds to the nonpolar regions of these molecules. **(b)** Schematic arrangement of the proteins, phospholipids and cholesterol in a membrane. Some proteins have carbohydrate molecules attached to their extracellular surface.

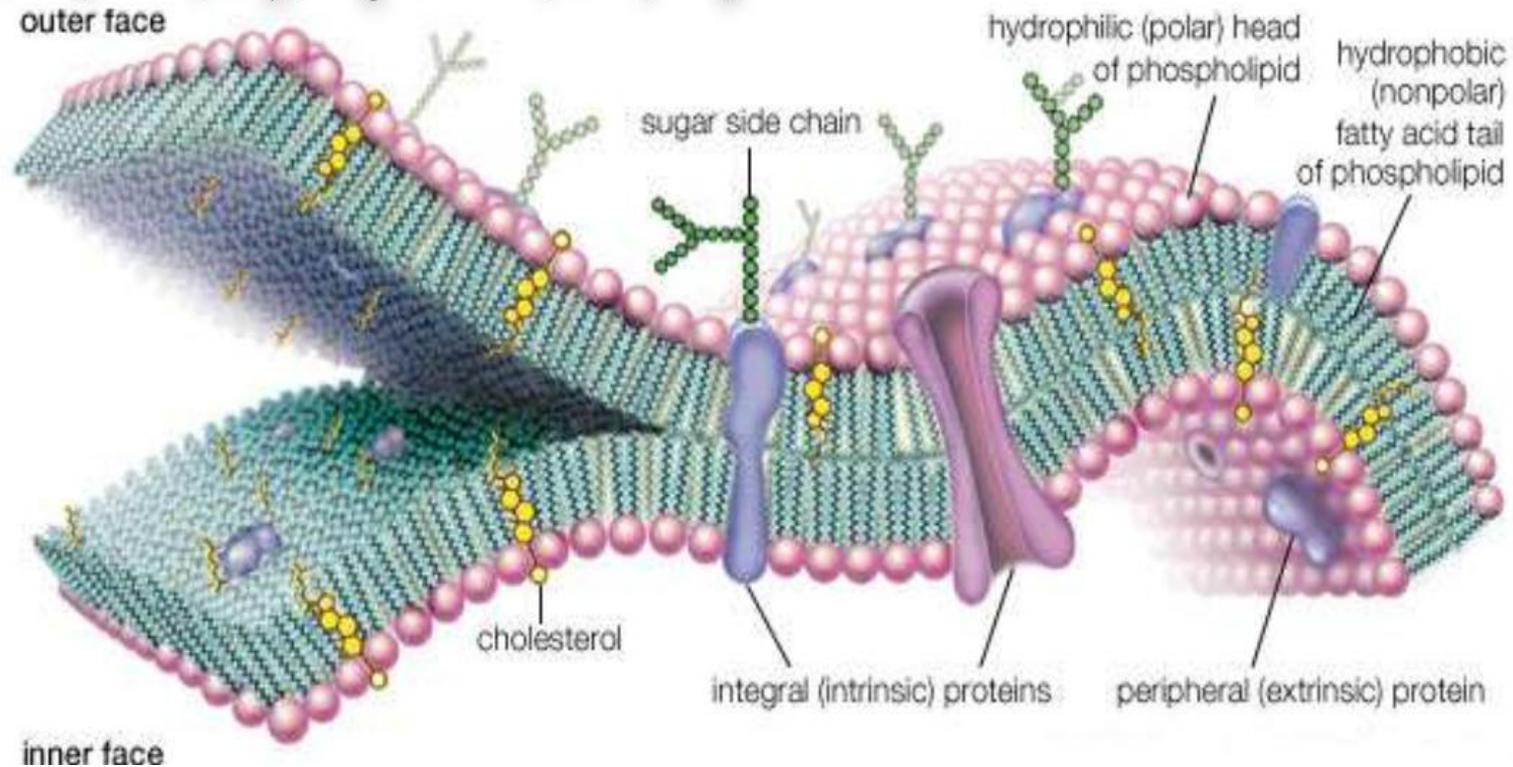


Arrangement of integral and peripheral membrane proteins in association with a bimolecular layer of phospholipids.

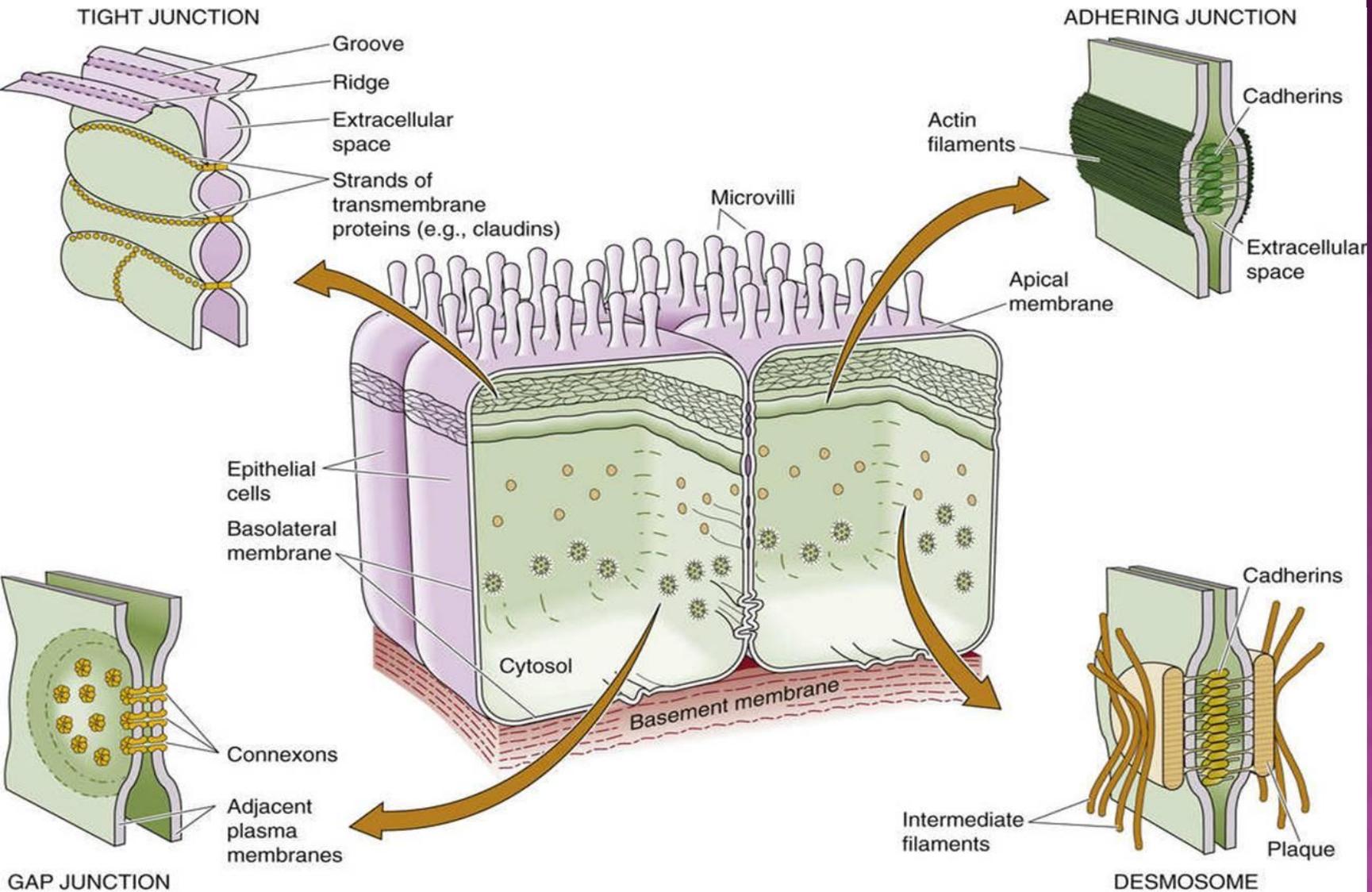


A typical transmembrane protein with multiple hydrophobic segments traversing the lipid bilayer. Each transmembrane segment is composed of nonpolar amino acids spiraled in an alpha-helical conformation (shown as cylinders).

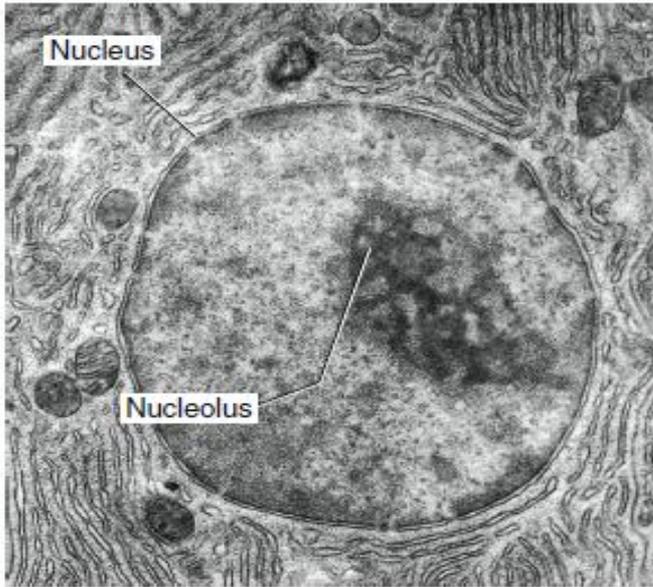
Fluid Mosaic Model



Fluid-mosaic model of plasma membrane structure. The proteins and lipids may move within the bilayer; cholesterol helps maintain intermediate membrane fluidity through the interactions of its polar and nonpolar regions with phospholipids.



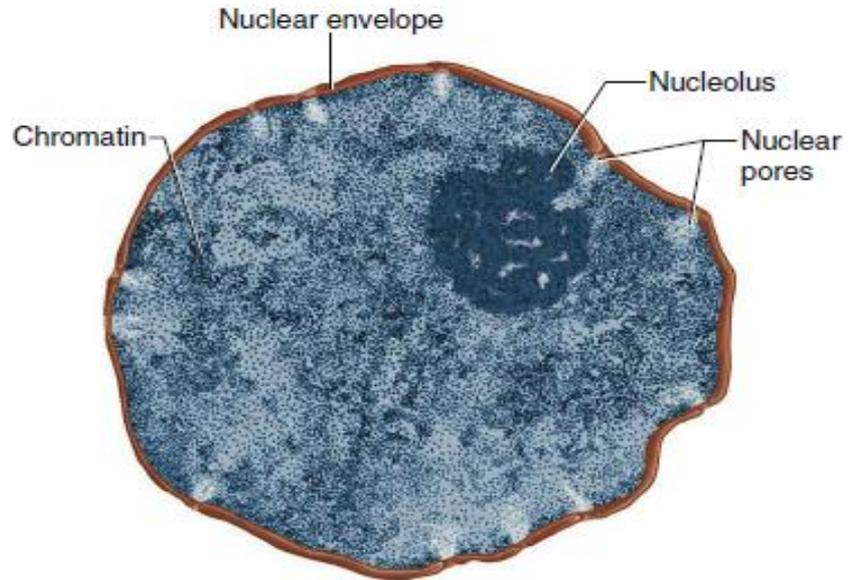
Specialized membrane junctions



Nucleus

Structure: Largest organelle. Round or oval body located near the cell center. Surrounded by a nuclear envelope composed of two membranes. Envelope contains nuclear pores; messenger molecules pass between the nucleus and the cytoplasm through these pores. No membrane-bound organelles are present in the nucleus, which contains coiled strands of DNA known as chromatin. These condense to form chromosomes at the time of cell division.

Function: Stores and transmits genetic information in the form of DNA. Genetic information passes from the nucleus to the cytoplasm, where amino acids are assembled into proteins.



Nucleolus

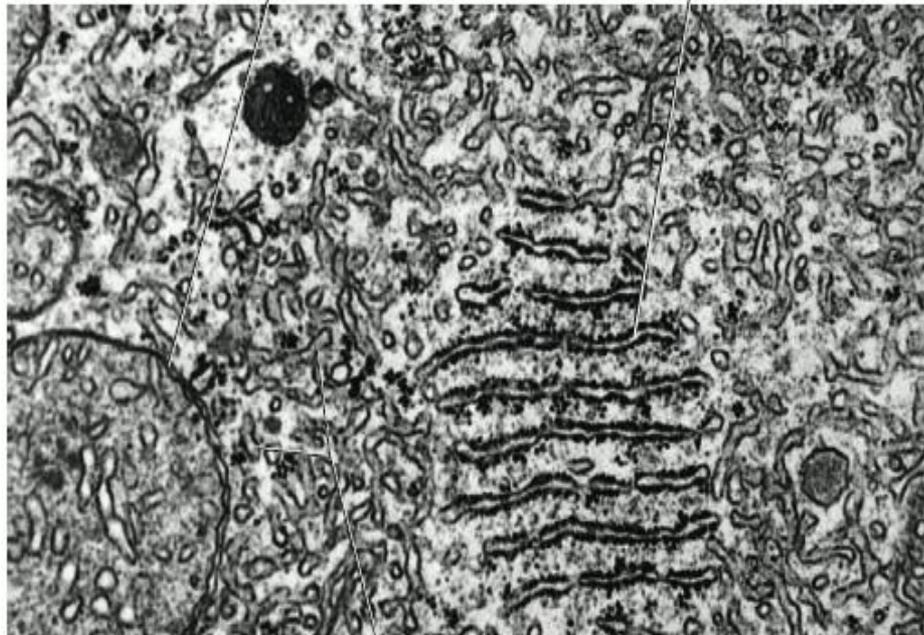
Structure: Densely stained filamentous structure within the nucleus. Consists of proteins associated with DNA in regions where information concerning ribosomal proteins is being expressed.

Function: Site of ribosomal RNA synthesis. Assembles RNA and protein components of ribosomal subunits, which then move to the cytoplasm through nuclear pores.

Nucleus and nucleolus.

Portion of mitochondrion

Rough endoplasmic reticulum



Smooth endoplasmic reticulum

Rough endoplasmic reticulum

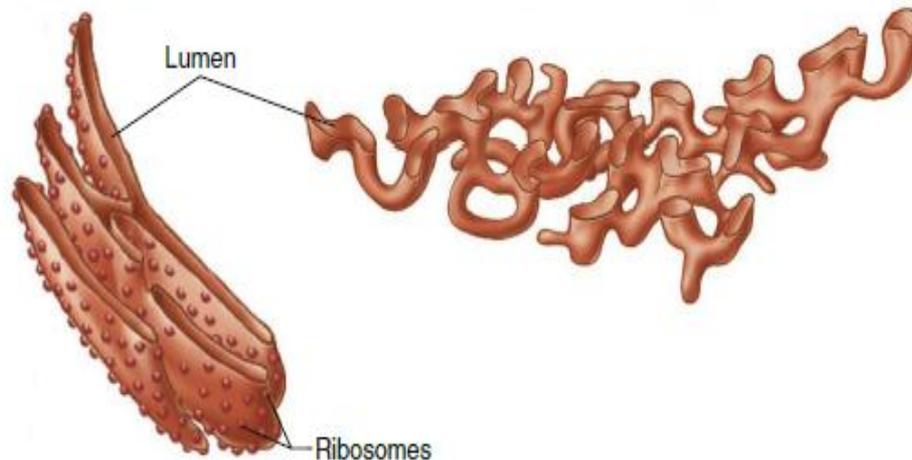
Structure: Extensive membranous network of flattened sacs. Encloses a space that is continuous throughout the organelle and with the space between the two nuclear-envelope membranes. Has ribosomal particles attached to its cytosolic surface.

Function: Proteins synthesized on the attached ribosomes enter the lumen of the reticulum from which they are ultimately distributed to other organelles or secreted from the cell.

Rough and smooth endoplasmic reticulum. For reference, a portion of a mitochondrion is labeled.

Rough endoplasmic reticulum

Smooth endoplasmic reticulum



Smooth endoplasmic reticulum

Structure: Highly branched tubular network that does not have attached ribosomes but may be continuous with the rough endoplasmic reticulum.

Function: Contains enzymes for fatty acid and steroid synthesis. Stores and releases calcium, which controls various cell activities.

Membrane-enclosed vesicle

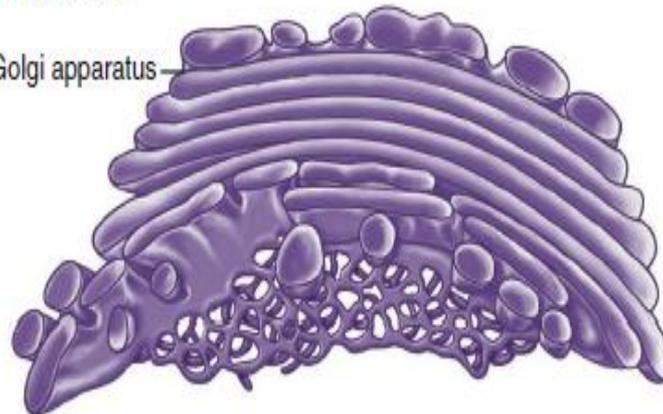


Golgi apparatus

Structure: Series of cup-shaped, closely apposed, flattened, membranous sacs; associated with numerous vesicles. Generally, a single Golgi apparatus is located in the central portion of a cell near its nucleus.

Function: Concentrates, modifies, and sorts proteins arriving from the rough endoplasmic reticulum prior to their distribution, by way of the Golgi vesicles, to other organelles or to secretion from the cell.

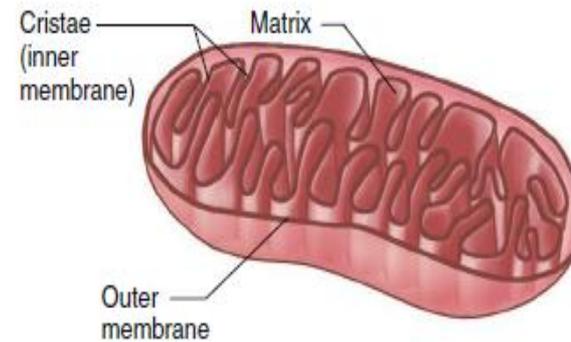
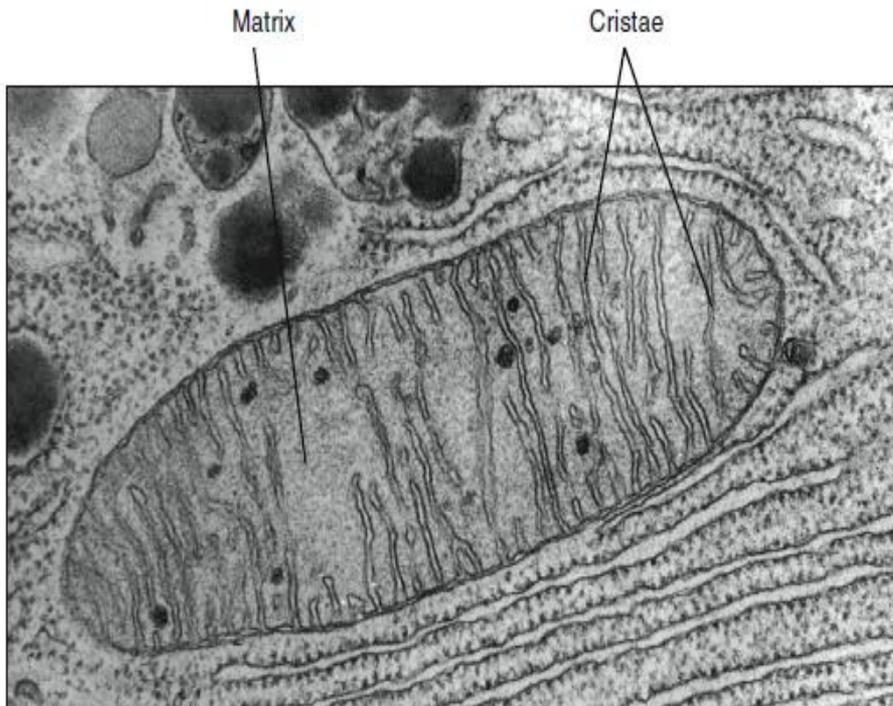
Golgi apparatus



Golgi apparatus.

Endosomes

- A number of membrane-bound vesicular and tubular structures .
- They lie between the plasma membrane and the Golgi apparatus.
- They are involved in sorting, modifying, and directing vesicular traffic in cells.



Mitochondrion

Structure: Rod- or oval-shaped body surrounded by two membranes. Inner membrane folds into matrix of the mitochondrion, forming cristae.

Function: Major site of ATP production, O_2 utilization, and CO_2 formation. Contains enzymes active in Krebs cycle and oxidative phosphorylation.

Lysosomes

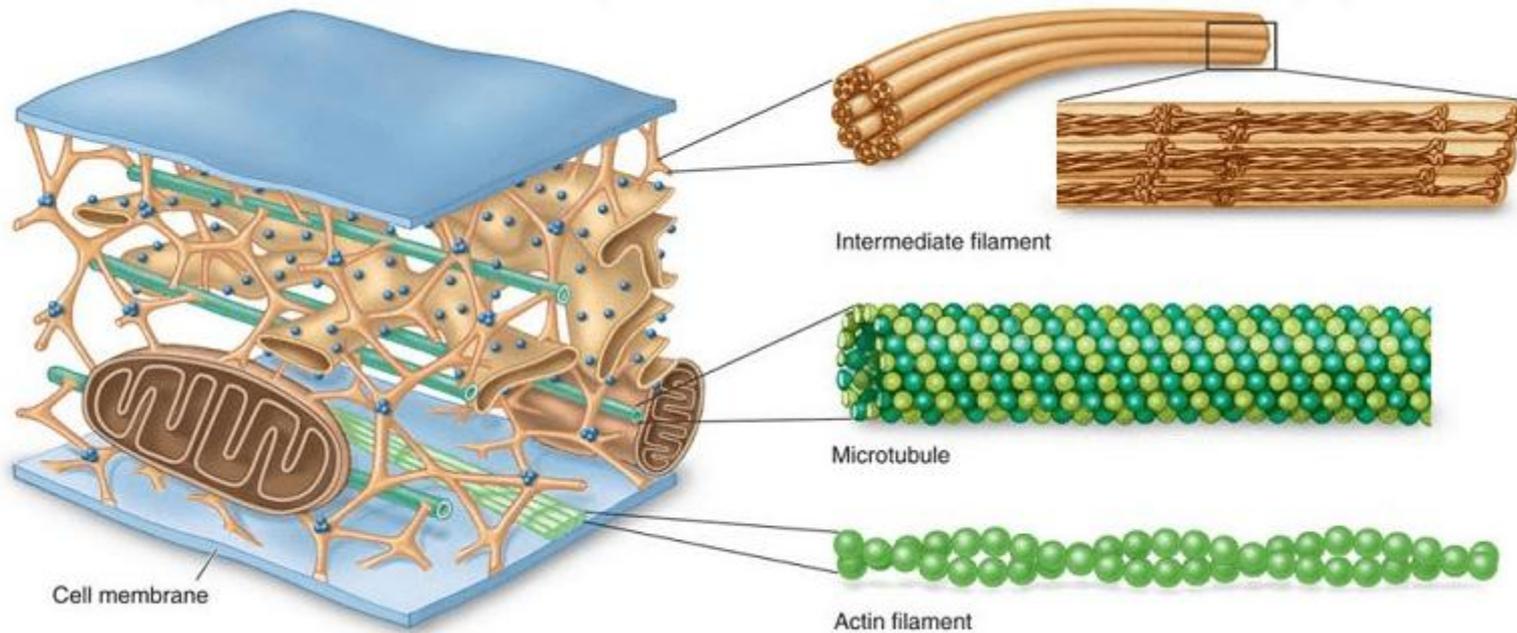
- Spherical or oval organelles surrounded by a single membrane.
- A typical cell may contain several hundred lysosomes.
- The fluid within a lysosome is acidic and contains a variety of digestive enzymes.
- Lysosomes act to break down bacteria and the debris from dead cells that have been engulfed by a cell. They may also break down cell organelles that have been damaged and no longer function normally.
- They have an especially important function in the various cells that make up the defense systems of the body.

Peroxisomes

- Like lysosomes, **peroxisomes** are moderately dense oval bodies enclosed by a single membrane.
- Like mitochondria, peroxisomes consume molecular oxygen, although in much smaller amounts.
- They produce hydrogen peroxide, H_2O_2 .
- Peroxisomes are also involved in the process by which fatty acids are broken down into two-carbon fragments, which the cell can then use as a source for generating ATP.

Vaults

- **Vaults** are cytoplasmic structures composed of protein and a type of untranslated RNA called vault RNA (vRNA).
- These tiny structures have been described as barrel-shaped but also as resembling vaulted cathedrals, from which they get their name.
- Although the functions of vaults are not certain, studies using electron microscopy and other methods have revealed that vaults **tend to be associated with nuclear pores**.
- In addition, at least one vault protein is believed to function in regulating a cell's sensitivity to certain drugs.



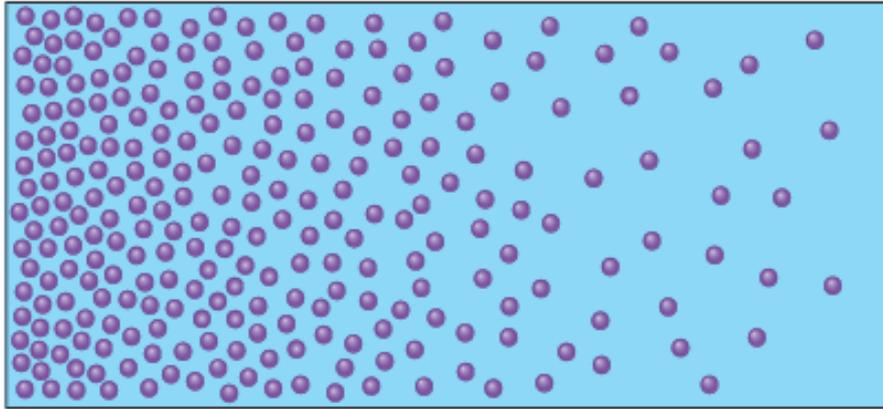
Cytoskeletal filaments associated with cell shape and motility.

<u>Cytoskeletal filaments</u>	<u>Diameter (nm)</u>	<u>Protein subunit</u>
Actin filament	7	G-actin
Intermediate filament	10	Several proteins
Microtubule	25	Tubulin

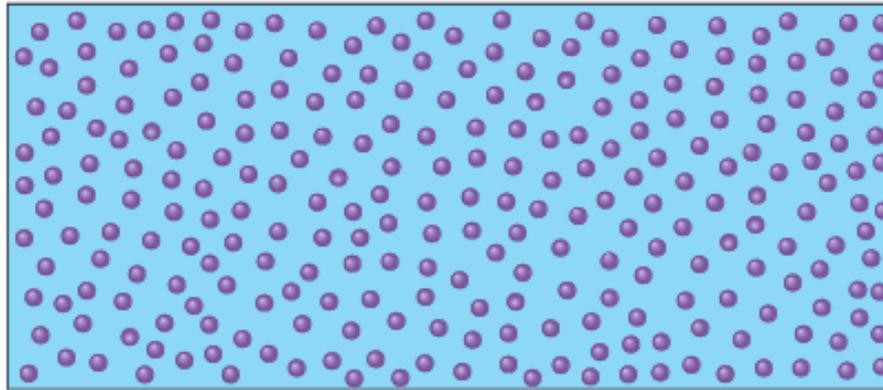
Cellular Transport Systems:

Passive Processes:

- The two important passive processes of membrane transport are **diffusion** and **filtration**. Diffusion is an important transport process for every cell in the body. By contrast, filtration usually occurs only across capillary walls.
- **Diffusion** is the movement of molecules from a region of their higher concentration to a region of their lower concentration.
- In general, molecules diffuse passively through the plasma membrane if they can dissolve in the lipid portion of the membrane, as CO₂ and O₂ can. The unassisted diffusion of solutes (dissolved substances) through a selectively permeable membrane is called **simple diffusion**. Certain molecules, glucose for example, are transported across the plasma membrane with the assistance of a protein carrier molecule. The substances move by a passive transport process called **facilitated diffusion**.

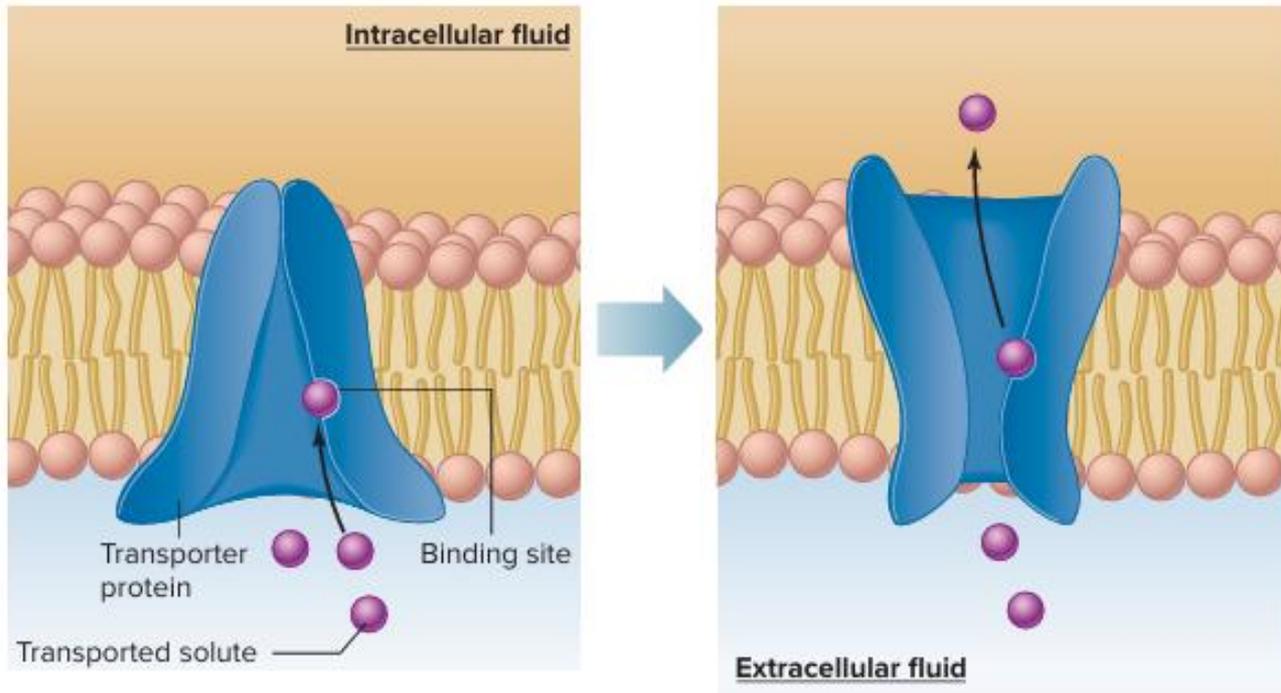


(a)



(b)

Simple diffusion. (a) Molecules initially concentrated in one region of a solution will, due to random thermal motion, undergo net diffusion from the region of higher concentration to the region of lower concentration. (b) With time, the molecules will become uniformly distributed throughout the solution; that is, the system will achieve maximum entropy.



Facilitated Diffusion, highly schematic model of mediated transport. A change in the conformation of the transporter exposes the transporter binding site first to one surface of the membrane then to the other, thereby transferring the bound solute from one side of the membrane to the other. This model shows net mediated transport from the extracellular fluid to the inside of the cell. In many cases, the net transport is in the opposite direction.

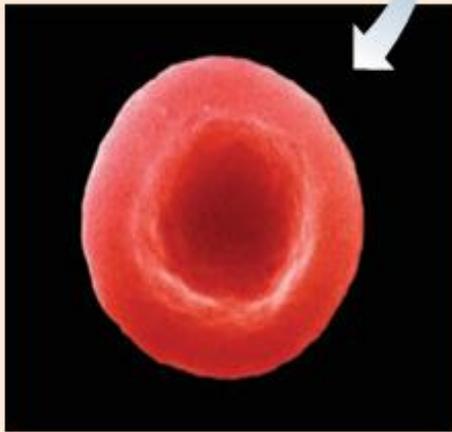
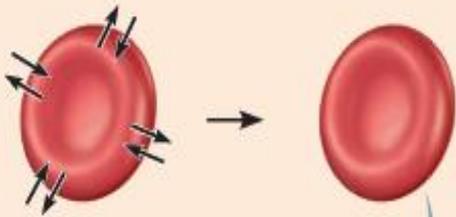
Cellular Transport Systems:

Passive Processes:

- The flow of water across a selectively permeable membrane is called **osmosis**.
- During osmosis, water moves down its concentration gradient. The **concentration of water** is **inversely** related to the **concentration of solutes**. If the solutes can diffuse across the membrane, both water and solutes will move down their concentration gradients through the membrane. If the particles in solution are nonpenetrating solutes (prevented from crossing the membrane), water alone will move by osmosis and in doing so will cause changes in the volume of the compartments on either side of the membrane.

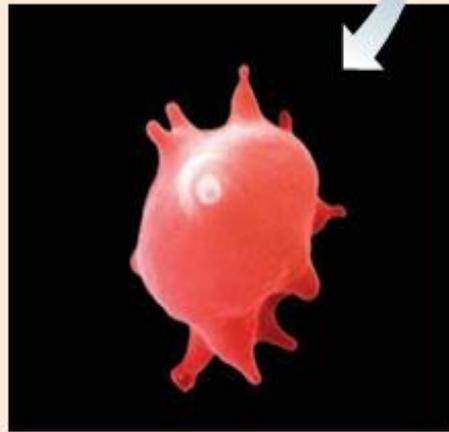
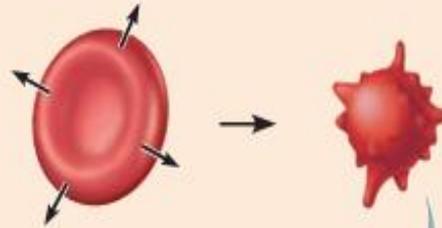
(a) Isotonic solutions

Cells retain their normal size and shape in isotonic solutions (same solute/water concentration as inside cells; no net osmosis).



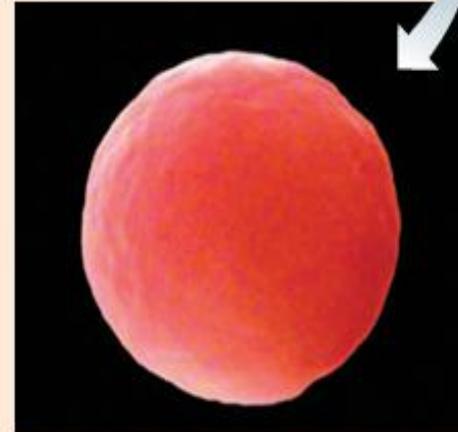
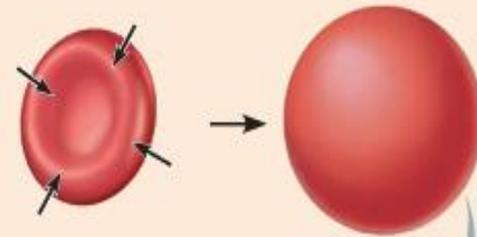
(b) Hypertonic solutions

Cells lose water by osmosis and shrink in a hypertonic solution (contains a higher concentration of nonpenetrating solutes than are present inside the cells).



(c) Hypotonic solutions

Cells take on water by osmosis until they become bloated and burst (lyse) in a hypotonic solution (contains a lower concentration of nonpenetrating solutes than are present in cells).



Influence of isotonic, hypertonic, and hypotonic solutions on red blood cells.

Cellular Transport Systems:

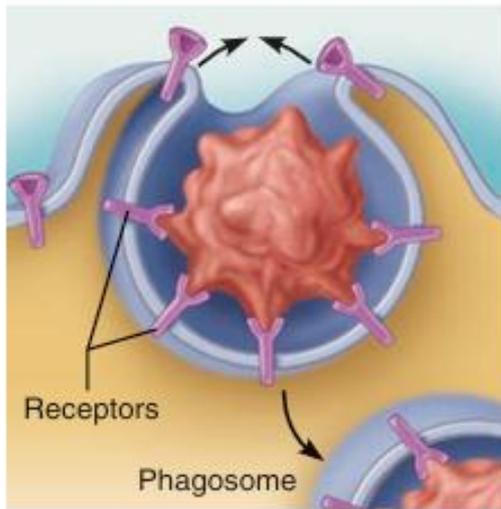
Active Processes:

- Whenever a cell uses the bond energy of ATP to move substances across its boundaries, the process is an **active process**.
- Substances moved by active means are generally unable to pass by diffusion. They may not be lipid soluble; they may be too large to pass through the membrane channels; or they may have to move against rather than with a concentration gradient. There are two types of active processes: **active transport** and **vesicular transport**.
- **Active Transport**, like carrier-mediated facilitated diffusion, active transport **requires carrier proteins** that combine specifically with the transported substance. Active transport may be primary, driven **directly by hydrolysis of ATP**, or secondary, driven **indirectly by energy stored in ionic gradients**. In most cases, the substances move against concentration or electrochemical gradients or both. These substances are insoluble in lipid and too large to pass through membrane channels but are necessary for cell life.

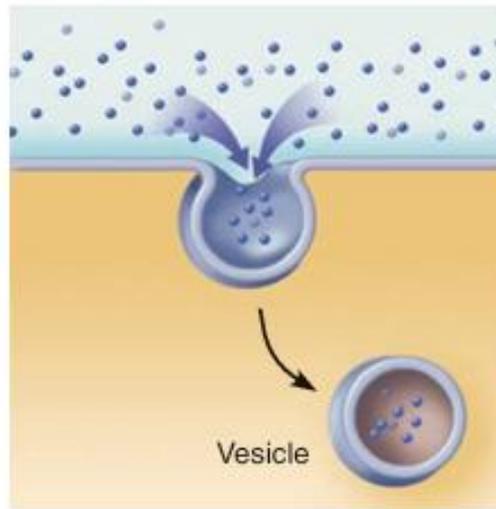
Cellular Transport Systems:

Vesicular Transport:

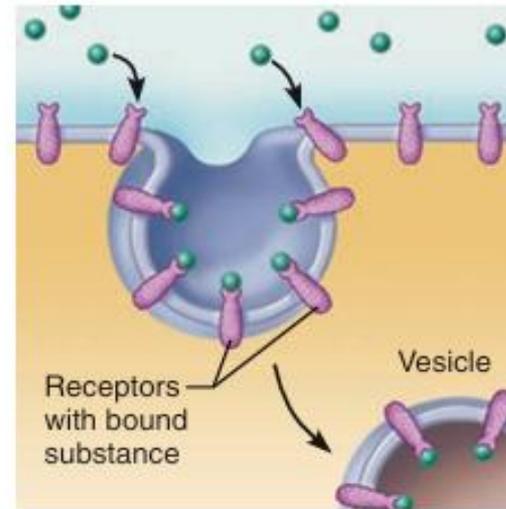
- In **vesicular transport**, fluids containing large particles and macromolecules are transported across cellular membranes inside membranous sacs called **vesicles**. Like active transport, vesicular transport moves substances into the cell (**endocytosis**) and out of the cell (**exocytosis**). Vesicular transport **requires energy**, usually in the form of **ATP**, and all forms of vesicular transport involve **protein-coated vesicles** to some extent.
- There are three types of **endocytosis**: **phagocytosis**, **pinocytosis**, and **receptor-mediated endocytosis**.
- **Exocytosis** is a vesicular transport process that ejects substances from the cell into the extracellular fluid. The substance to be removed from the cell is first enclosed in a protein-coated vesicle called a **secretory vesicle**. In most cases, the vesicle migrates to the plasma membrane, fuses with it, and then ruptures, spilling its contents out of the cell. Exocytosis is used for hormone secretion, neurotransmitter release, mucus secretion, and ejection of wastes.



(a) Phagocytosis



(b) Pinocytosis



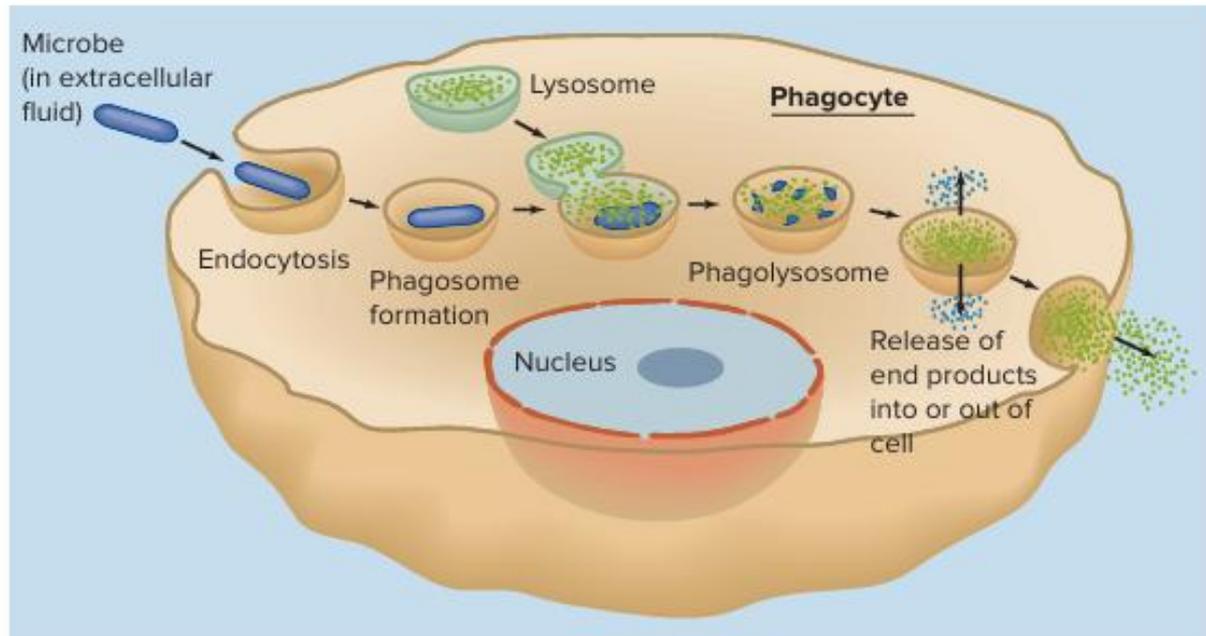
(c) Receptor-mediated endocytosis

Three types of endocytosis.

(a) In **phagocytosis**, cellular extensions flow around the external particle and enclose it within a phagosome.

(b) In **pinocytosis**, fluid and dissolved solutes enter the cell in a tiny vesicle.

(c) In **receptor-mediated endocytosis**, specific substances attach to cell-surface receptors and enter the cell in protein-coated vesicles.



Phagocytosis and intracellular destruction of a microbe. After destruction has taken place in the phagolysosome, the end products are released to the outside of the cell by **exocytosis** or used by the cell for its own metabolism.

THANK YOU