Human Biology

Cell Structure and Function

First Stage

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Cell Structure and Function

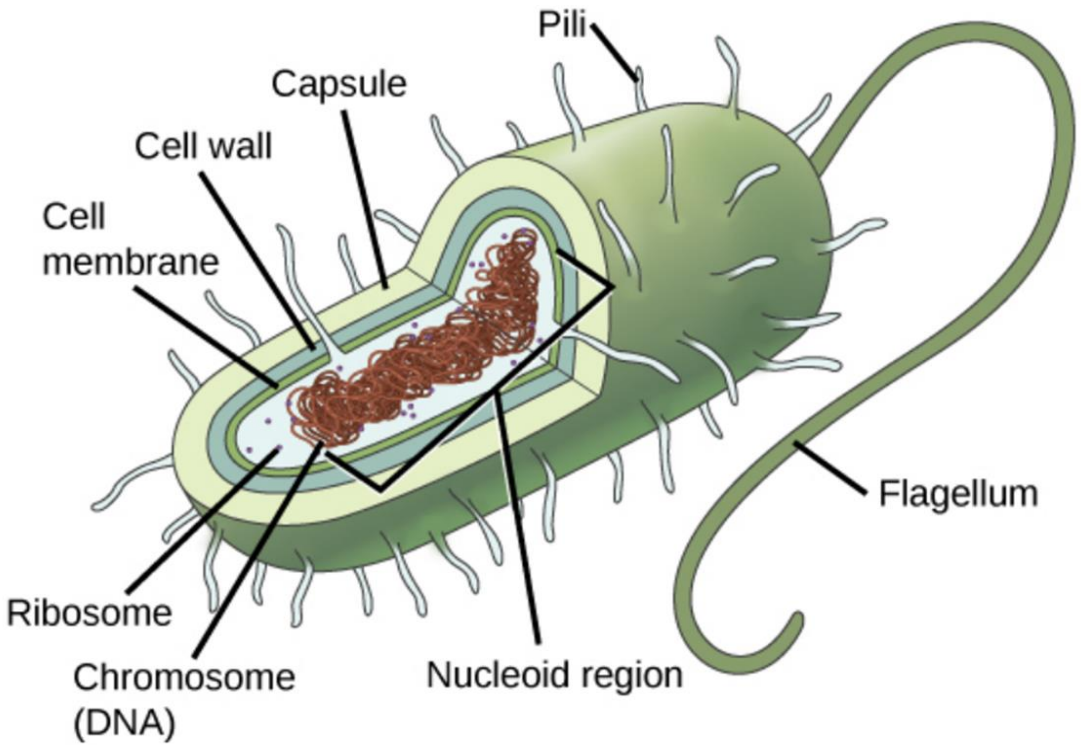
All organisms are composed of either one cell (unicellular, e.g. bacteria) or more cells (multicellular, e.g. the adult human body consists of 40 trillion cells).

- **Cells can be define as the basic structural and functional units of life.**
- **The branch of biology that deals with the structure and function of cells is called Cytology.**

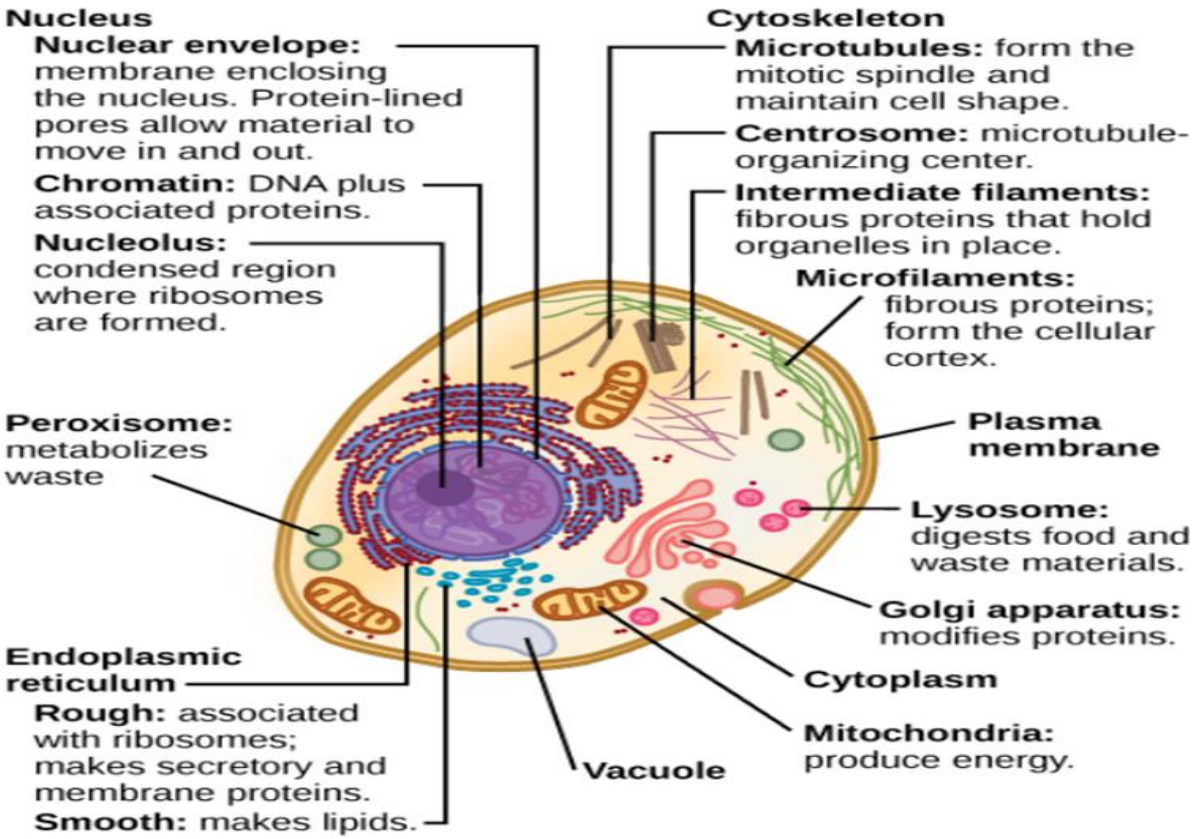
cells are classified into two groups : the prokaryotes and eukaryotes. The primary difference between them is the presence or absence of a nucleus, a membrane-bound structure that houses the DNA.

Prokaryotic is a unicellular microorganism that has **no nuclear membrane,** or any other **membrane-bound organelles**. E.g. bacteria.

- **Prokaryotic DNA** is found in the central part of the cell: a darkened region called the **nucleoid**.
- They have a cell wall like plant.



Eukaryotic cell is a cell that contain a **membrane-bound nucleus** and other membrane bound compartments called **organelles**, which have specialized functions. E.g. animals, plants and fungi .



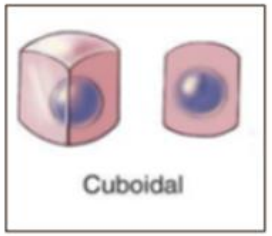
Cell size and shape

There are different size and shape of cells . Most cells though are much smaller and so we need a microscope to be able to examine them. Light microscope allows to see objects as small as 200 nm.

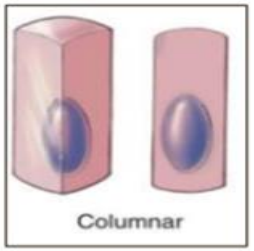
In order to see the parts of cell that are smaller than this we need to use an electron microscopes. This type of microscope allows to observe objects that are only 0.2 nm.

There are different shapes of cells such as:-

- **Cube shape e.g. Cubical cells.**

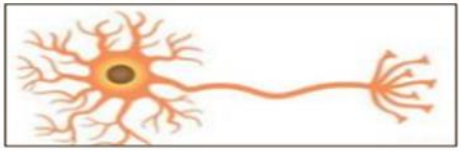


- **Long column shape e.g. Goblet cell.**

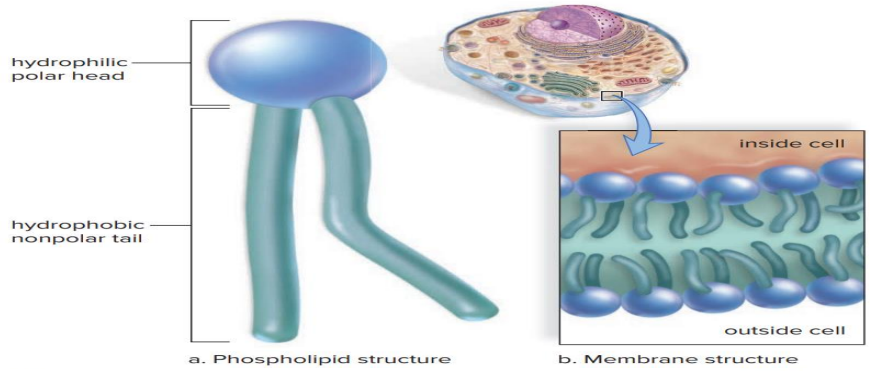


- **Spindle shape e.g. Smooth muscle cells.**

- **Cells have long projections e.g. Nerve cells.**



Cells Structures



Plasma membrane: outer surface that regulates entrance and exit of molecules

protein

phospholipid

CYTOSKELETON: maintains cell shape and assists movement of cell parts:

Microtubules: cylinders of protein molecules present in cytoplasm, centrioles, cilia, and flagella

Intermediate filaments: protein fibers that provide support and strength

Actin filaments: protein fibers that play a role in movement of cell and organelles

Centrioles: short, cylinders of microtubules

Centrosome: microtubule organizing center that contains a pair of centrioles

Lysosome: vesicle that digests macromolecules and even cell parts

Vesicle: membrane-bounded sac that stores and transports substances

Cytoplasm: semifluid matrix outside nucleus that contains organelles

b.

NUCLEUS:

Nuclear envelope: double membrane with nuclear pores that encloses nucleus

Chromatin: diffuse threads containing DNA and protein

Nucleolus: region that produces subunits of ribosomes

ENDOPLASMIC RETICULUM:

Rough ER: studded with ribosomes, processes proteins

Smooth ER: lacks ribosomes, synthesizes lipid molecules

Ribosomes: particles that carry out protein synthesis

Mitochondrion: organelle that carries out cellular respiration, producing ATP molecules

Polyribosome: string of ribosomes simultaneously synthesizing same protein

Golgi apparatus: processes, packages, and secretes modified cell products

Protoplasm

The living part of the cell is called protoplasm. Protoplasm is composed of water, proteins, lipids, carbohydrates, and electrolytes.

Protoplasm consists of two distinct regions:

1. **Cytoplasm which lies outside the nucleus.**
2. **Nucleoplasm which lies inside the nucleus.**

Cells also contain inclusions, which consist of metabolic by-products, storage forms of various nutrients and pigments.

Three main components of cells

1- Plasma membrane: is an outer membrane that separates the cell's interior from its surrounding environment.

2- Cytoplasm: It is the fluid present in the cell and surrounded by the cell membrane, which contains water, enzymes, salts, and various organelles.

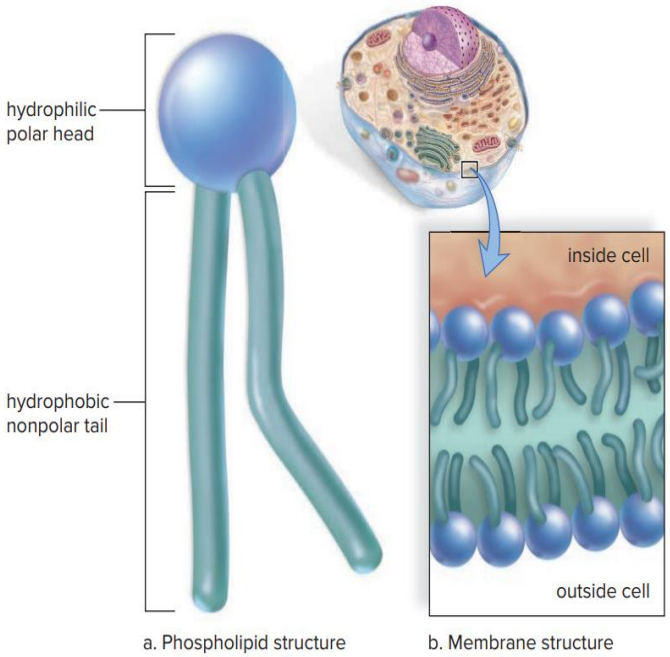
3- Nucleus: is a large organelle that may or may not be centrally within the cytoplasm.

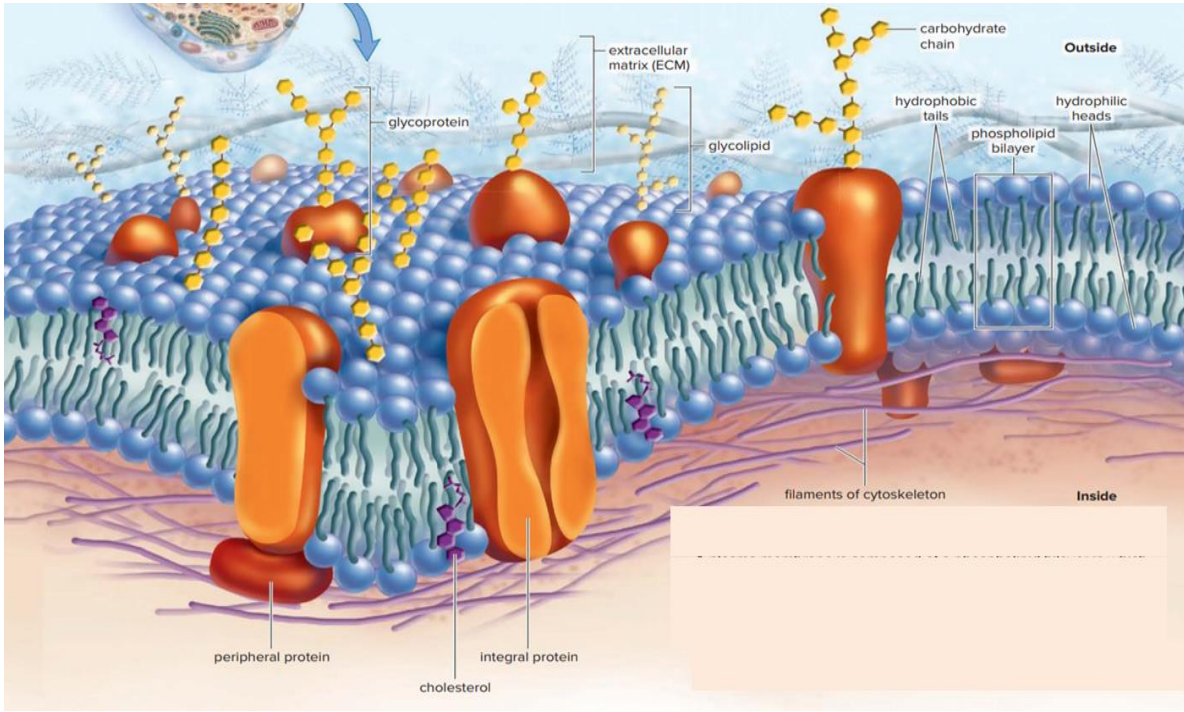
The principal components of the plasma membrane

1- Phospholipid bilayer a "sandwich" : made of two layers of phospholipids.

A phospholipid molecule consists of the polar head (hydrophilic = "water-loving") and nonpolar tails (hydrophobic ="water-fearing.").

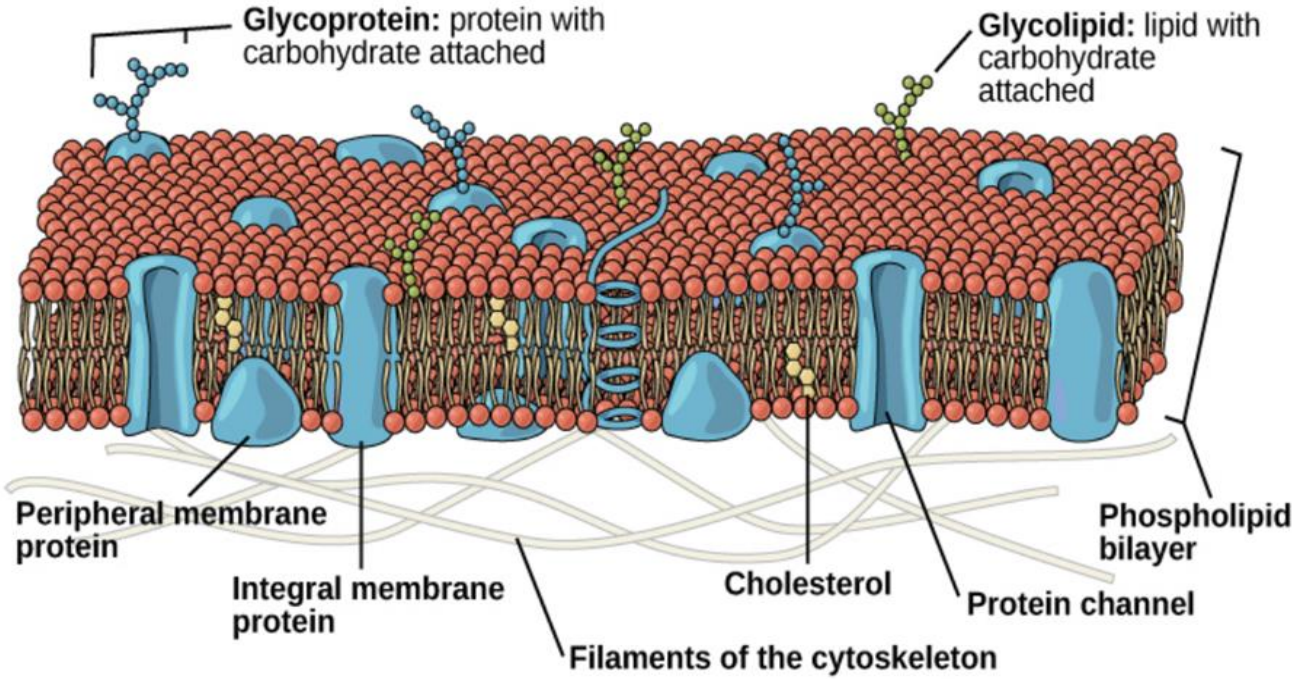
Their polar phosphate molecules form the top and bottom surfaces of the bilayer, and the nonpolar lipid lies in between.





2- Proteins: Proteins scattered throughout the plasma membrane play important roles in allowing substances to enter the cell, there are many different types of proteins some lie in just one of the phospholipids layers **peripheral proteins** and some span both layers **integral Proteins.**

3- Carbohydrates: groups that are attached to some of the lipids (glycolipids) and proteins (glycoproteins) . Carbohydrates form specialized sites on the cell surface that allow cells to recognize each other.



Plasma Membrane Functions

- ❑ The plasma membrane isolates the interior of the cell from the external environment (Physical barrier).
- ❑ It allows only certain molecules and ions to enter and exit the cytoplasm freely. Therefore, the plasma membrane is said to be **selectively permeable** .
  - ✓ Small lipid-soluble molecules, such as oxygen and carbon dioxide, can pass through the membrane easily.
  - ✓ The small size of water molecules allows them to freely cross the membrane by using protein channels called **aquaporins**.
  - ✓ Ions and large molecules cannot cross the membrane without more direct assistance.

The Cytoplasm and Its Organelles

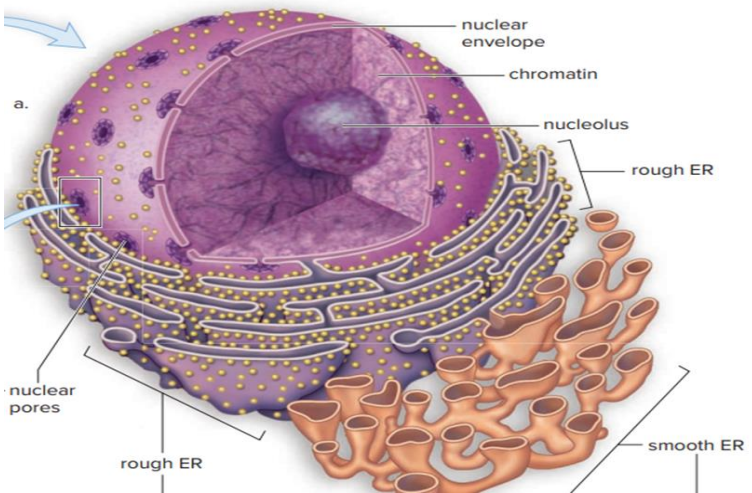
- The cytoplasm includes the contents of a cell between the plasma membrane and the nuclear envelope . It is contains organelles and cytoskeleton suspended in the gel-like called cytosol consists of 70 to 80 percent water.
- Many metabolic reactions, including protein synthesis, take place in the cytoplasm.

Most organelles are surrounded by one or two lipid membranes, similar to plasma membrane, that separate the organelles from the cytosol , such as endoplasmic reticulum, Golgi apparatus, mitochondria and lysosomes.

The nucleus

The nucleus, a prominent structure in eukaryotic cells and is a large organelle that may or may not be centrally within the cytoplasm.

- **It is enveloped in a double membrane , called nuclear envelop that has nuclear pores to control the passage of ions, molecules, and RNA between the nucleoplasm and the cytoplasm.**
- **It stores genetic information as DNA organized into linear structures called chromosomes (structures within the nucleus that are made up of DNA and proteins). This combination of DNA and proteins is called chromatin.**
- **Most nuclei contain at least one nucleolus (plural, nucleoli), this is consists of ribonucleic acid (RNA). It helps in producing structures called ribosomes.**



Ribosomes

- **Ribosomes are organelles composed of proteins and rRNA (nucleoproteins).**

Protein synthesis occurs at the ribosomes. Because protein synthesis is essential for all cells, ribosomes are found in practically every cell, although they are smaller in prokaryotic cells.

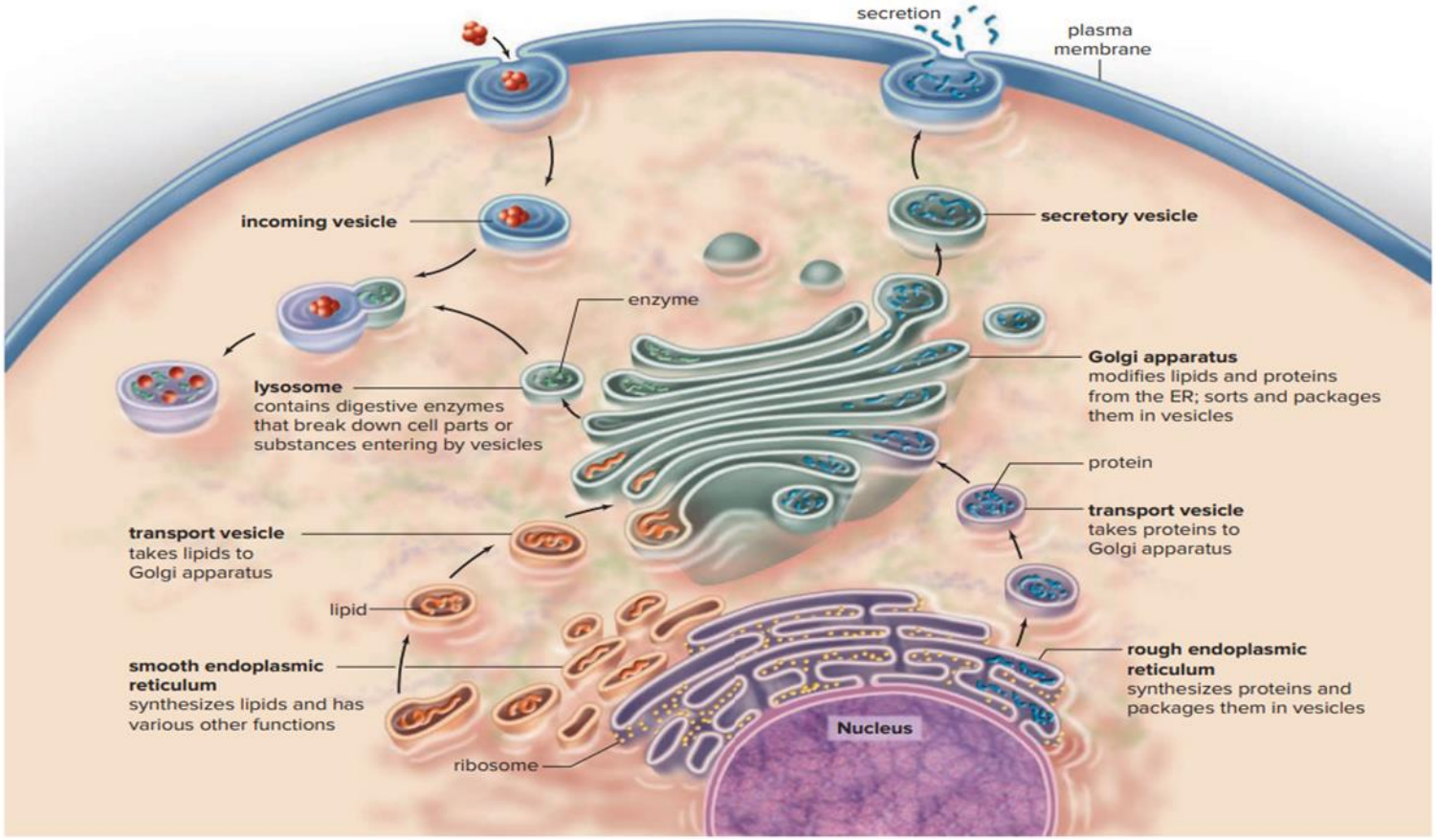
- **Ribosomes exist as :**

1. Free ribosomes within the cytoplasm either singly or in groups called polyribosomes which are involved in the synthesis of proteins, mainly enzymes that aid in the control of cell function.

2. Attached ribosomes to the membrane of the endoplasmic reticulum . Proteins synthesized at ribosomes attached to the endoplasmic reticulum have a different destination from that of proteins manufactured at ribosomes free in the cytoplasm

The Endomembrane System

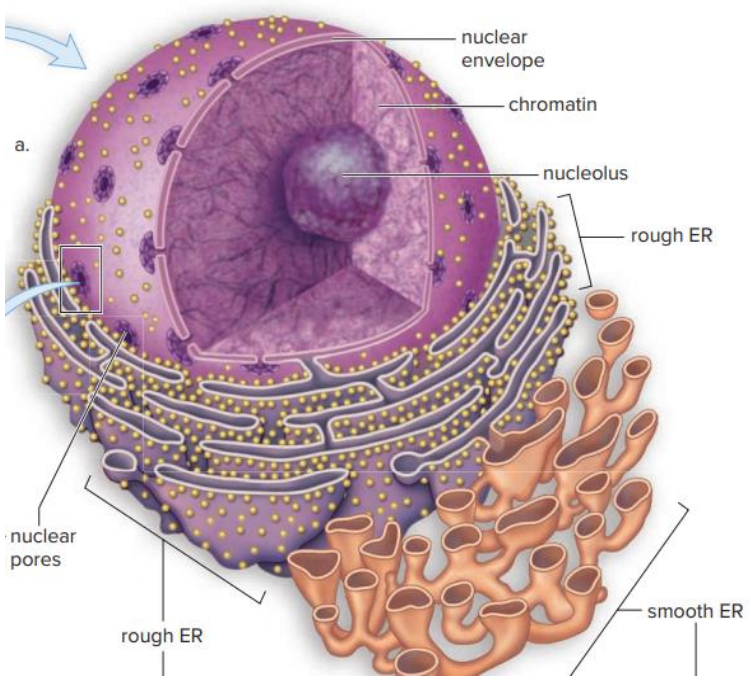
The endomembrane system (endo = within) is a group of membranes and organelles in eukaryotic cells that work together to modify, package, and transport lipids and proteins. It includes the nuclear envelope, lysosomes, and vesicles, the endoplasmic reticulum and Golgi apparatus.



The endoplasmic reticulum

The endoplasmic reticulum (ER) is a series of interconnected membranous tubules that extends from the surface of the nucleus throughout most of the cytoplasm.

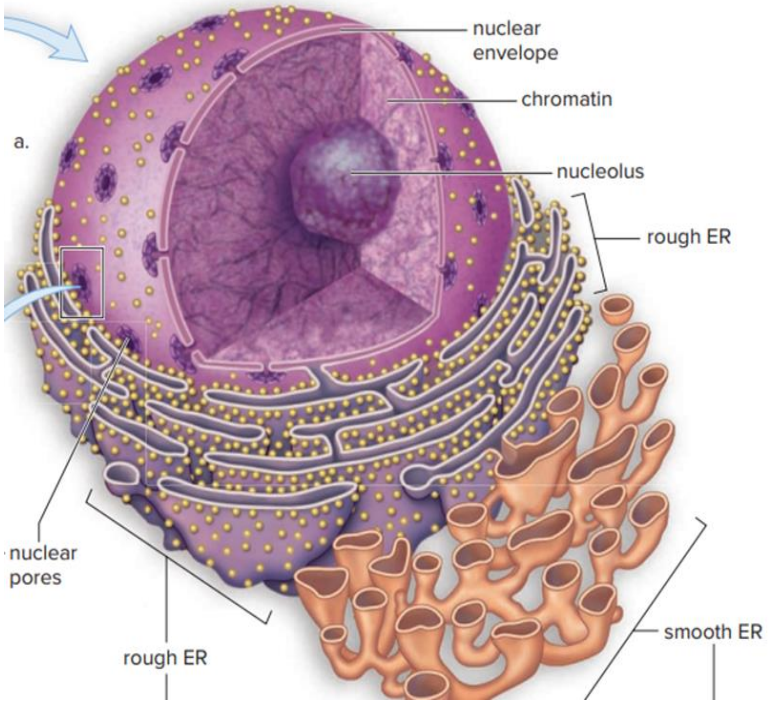
- **ER is a major site for vital cellular activities, including biosynthesis of proteins and lipids.**
- **Numerous ribosomes attached to the membrane in some regions of ER allow two types of ER to be distinguished.**



The rough endoplasmic reticulum (RER) consists of saclike as well as parallel stacks of flattened cisternae, each limited by membranes that are continuous with the outer membrane of the nuclear envelope.

- **Is so named because the ribosomes attached to its cytoplasmic surface.**

  The ribosomes synthesize proteins while attached to the ER, resulting in transfer of their newly synthesized proteins into the lumen of the RER where they undergo modifications.

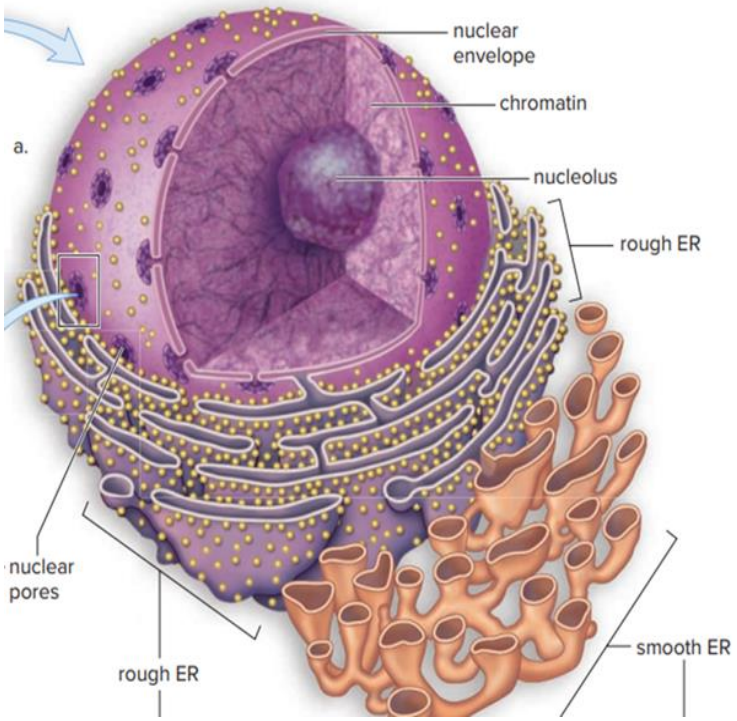


- **RER is specialized for protein secretion.**

The smooth endoplasmic reticulum SER Is a region of ER that lack bound ribosomes. It is continuous with RER but frequently less abundant. Unlike the cisternae of RER, SER cisternae are more tubular or saclike, with interconnected channels of various shapes and sizes rather than stacks of flattened cisternae.

The SER's functions include:

1. Synthesis of carbohydrates, lipids (including phospholipids)and steroid hormones.
2. Detoxification of medications and poisons.
3. Storage of calcium ions.

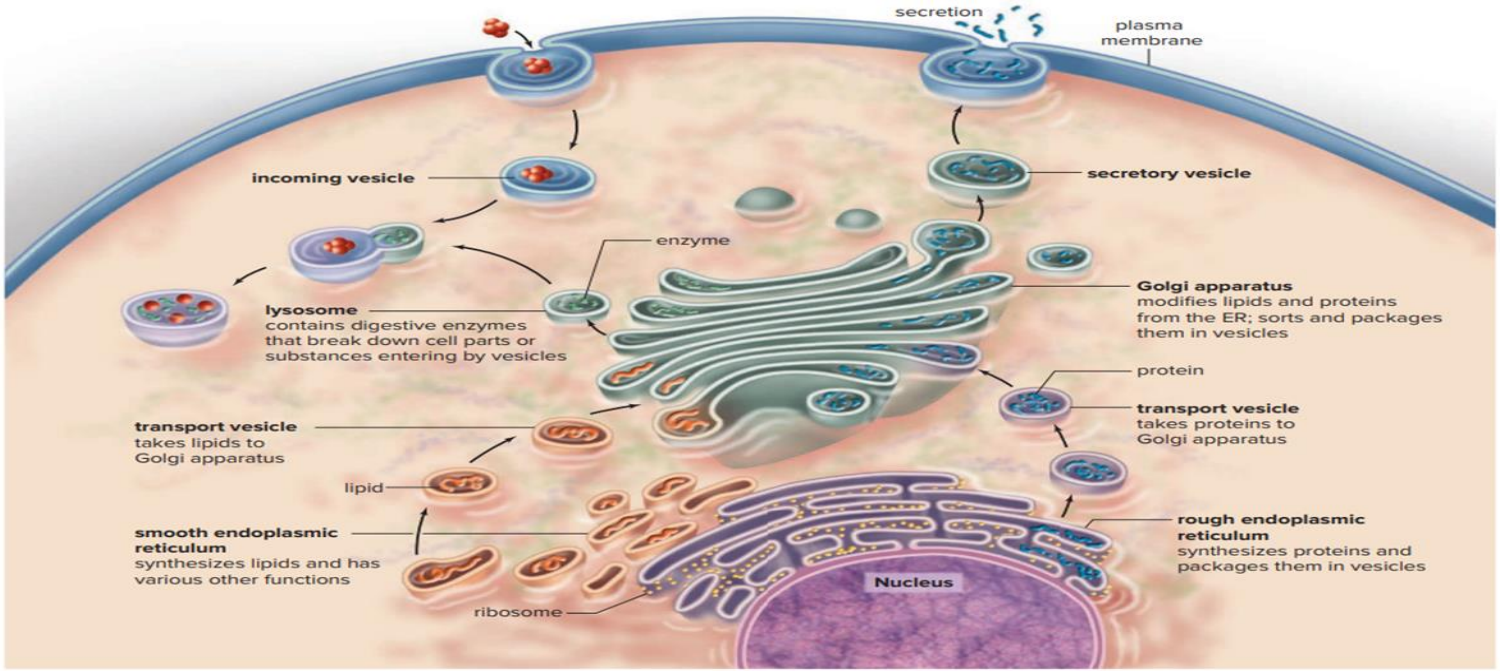


Golgi complexes

Golgi complexes are located near the nucleus in most cells and it consists of many smooth membranous saccules, some vesicular, others flattened, but all containing enzymes and proteins being processed.

The Golgi functions

Golgi complex completes posttranslational modifications of proteins produced in the RER and then packages and addresses these proteins to their proper destinations.



Lysosomes

Lysosomes, membranous sacs produced by the Golgi apparatus, contain hydrolytic enzymes.

Lysosomes are found in all cells of the body but are particularly numerous in white blood cells that engulf disease-causing microbes. When a lysosome fuses with such an endocytic vesicle, its contents are digested by lysosomal enzymes into simpler subunits, which then enter the cytoplasm.

In a process called autodigestion, parts of a cell may be broken down by the lysosomes.

Mitochondria

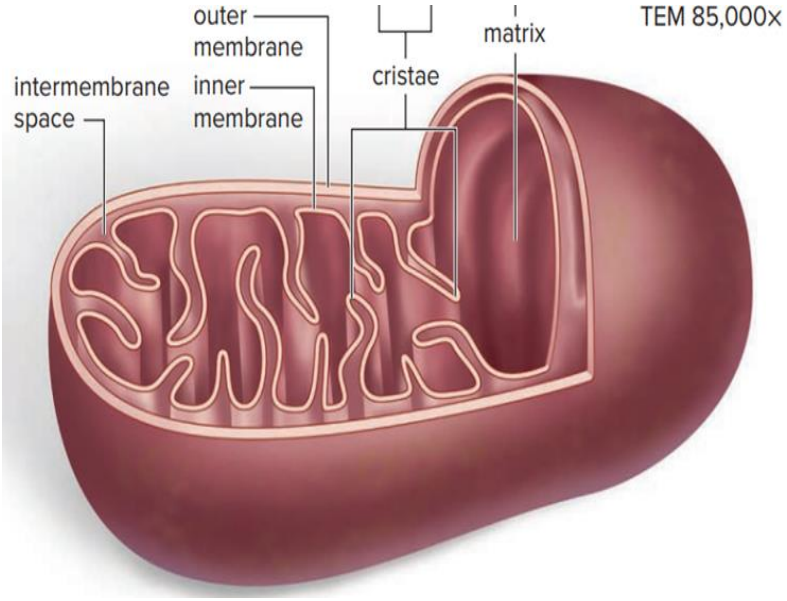
Mitochondria (sing. = mitochondrion) are often called the powerhouses or energy factories of a cell because they are responsible for making adenosine triphosphate (ATP), the cell's main energy-carrying molecule.

Mitochondria are oval-shaped, double-membrane organelles,

- **an outer membrane encloses the intermembrane space .**
- **an inner membrane with many folds (cristae)**

enclosing a gel-like matrix.

Mitochondria are abundant in cells or cytoplasmic regions where large amounts of energy are expended.

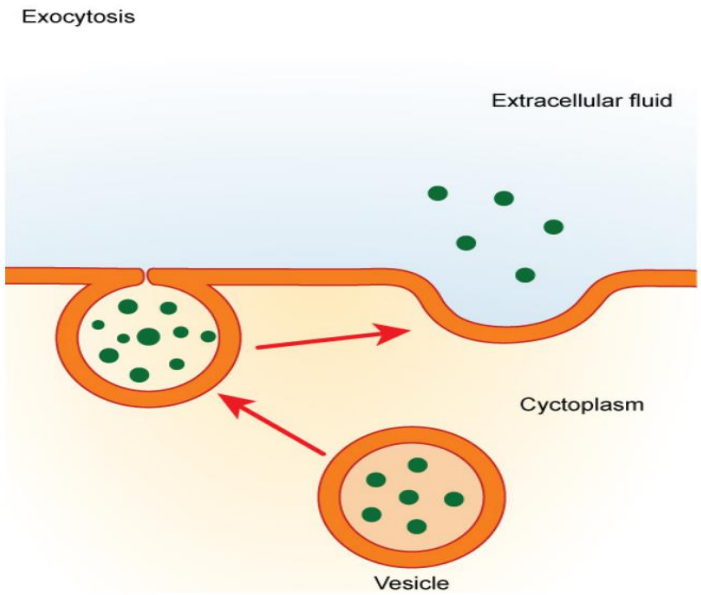


Mechanisms of transport across the plasma membrane

Bulk Transport (Vesicular transport)

Cells use bulk transport to move large molecules, such as polysaccharides or polypeptides, across the membrane. These processes use vesicles rather than channel or transport proteins this type of transport include Exocytosis and Endocytosis.

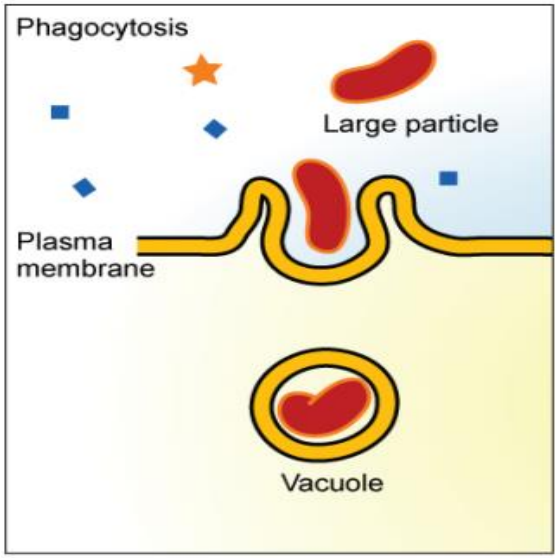
Exocytosis : There are many substances that must exit from a cell , the secretions or enzymes are packaged into vesicles and then moved towards the cell membrane where they are discharged , a vesicle fuses with the plasma membrane as secretion occurs. For example, the secretions produced by Golgi complex need to leave the cell.



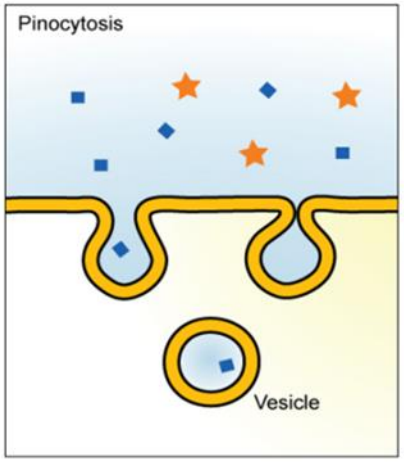
Endocytosis: The large molecules or other materials can enter the cell by this method. During endocytosis, a portion of the plasma membrane invaginates, or forms a pouch, to envelop a substance and fluid.

There are three major types of endocytosis:-

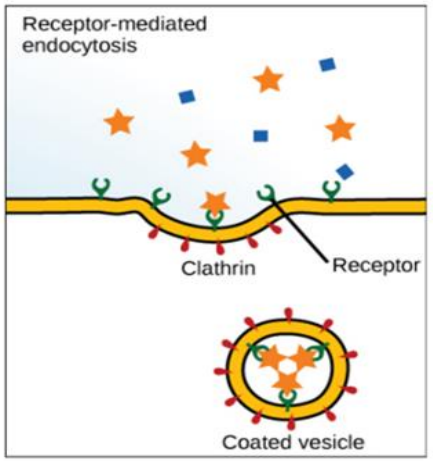
1. **Phagocytosis: ("cell eating")** is the ingestion of particles such as bacteria or dead cell remnants. Then the membrane pinches off to form an endocytic vesicle inside the cell. Some white blood cells such as macrophages and neutrophils are able to take up pathogens by endocytosis.



2. **Pinocytosis: (“cell drinking”) liquid can be packaged into a vacuole or vesicle which is then taken into the cell.**



3. **Receptor-mediated endocytosis: Type of endocytosis in which plasma membrane receptors first bind specific substances; receptor and bound substance then taken up by the cell.**



Diffusion

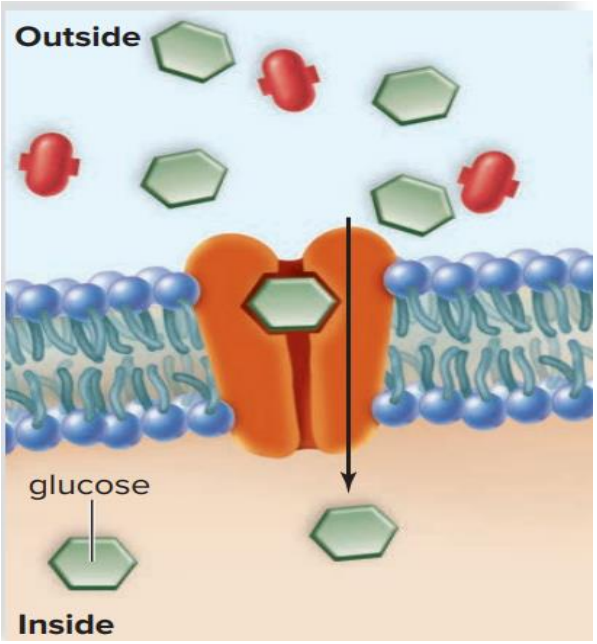
- **Diffusion is the random movement of molecules from an area of higher concentration to an area of lower concentration, until they are equally distributed.**
- **Diffusion is a passive way for molecules to enter or exit a cell. This type of transport does not require energy to move substances.**

Lipid-soluble material can easily slip through the hydrophobic lipid core of the membrane. Substances such as the fat-soluble vitamins A, D, E, and K readily pass through the plasma membranes in the digestive tract and other tissues.

Facilitated Transport

Many solutes do not simply diffuse across a plasma membrane. They are transported by means of protein carriers within the membrane called a transporter, binds only to a particular molecule, such as glucose.

- **During facilitated transport, a molecule is transported across the plasma membrane from the side of higher concentration to the side of lower concentration .**
- **This is a passive means of transport, because the cell does not need to expend energy to move a substance down its concentration gradient.**

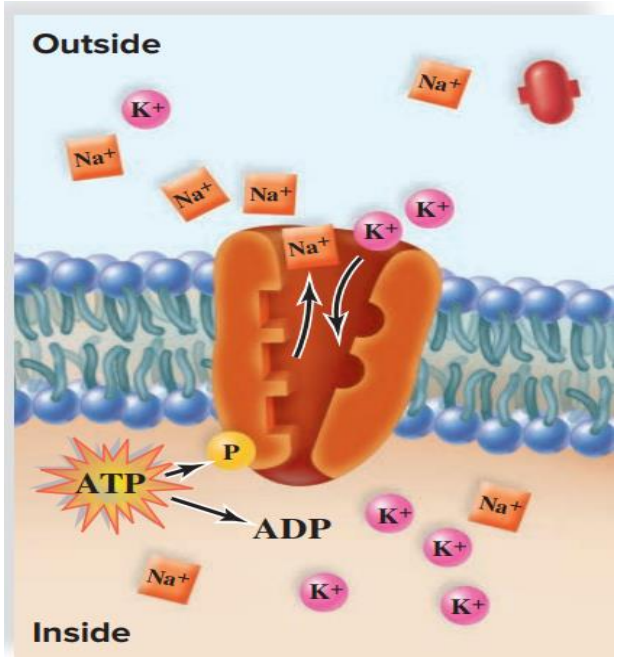


Active Transport

During active transport, a molecule is moving from an area of lower to an area of higher concentration.

- **Active transport requires a protein carrier and use energy to pump materials into the cell against the concentration gradient.**
- **Proteins involved in active transport often are called pumps.**

One type of pump active in all cells moves sodium ions (Na+) to the outside and potassium ions (K+) to the inside of the cell.



Osmosis

- Osmosis is a special case of diffusion and is the net movement of water across a selectively permeable membrane.

The direction by which water will diffuse is determined by the tonicity of the solutions inside and outside the cell.

- Tonicity is based on dissolved particles, called solutes, within a solution. The higher the concentration of solutes in a solution, the lower the concentration of water, and vice versa.

Typically water will diffuse from the area that has less solute (low tonicity, and therefore more water) to the area with more solute (high tonicity, and therefore less water).

Tonicity describes the amount of solute in a solution. Three terms hypotonic, isotonic, and hypertonic are used to relate the concentration of solutes inside of a cell compared to the concentration of solutes in the fluid that contains the cells.

Hypotonic solution: the extracellular fluid has a lower concentration of solutes than the fluid inside the cell, and water enters the cell. Therefore, water passes into the cells by osmosis and causes them to swell up and eventually burst.

Isotonic solution: the extracellular fluid has the same concentration of solutes of the fluid inside the cell. They therefore cause neither shrinking nor swelling of cells and tissue.

Hypertonic solution: the extracellular fluid having a higher concentration of solutes than the fluid inside the cell the fluid contains less water than the cell does. Therefore, the water will leave the cell by osmosis and causes them to shrink.