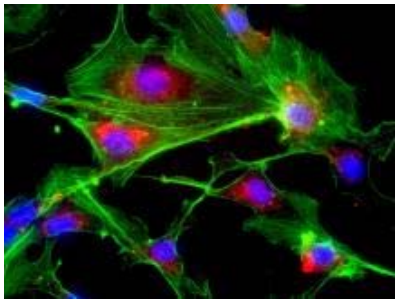


INTRODUCTION TO THE CELL

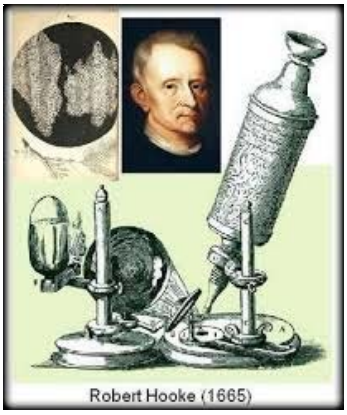
STRUCTURE AND FUNCTION

OF THE CELL

Both living and non-living things are composed of molecules made from chemical elements such as Carbon, Hydrogen, Oxygen, and Nitrogen. The organization of these molecules into cells is one feature that distinguishes living things from all other matter.

The cell is the smallest unit of matter that can carry on all the processes of life. Every living thing - from the tiniest bacterium to the largest whale - is made of one or more cells.

Cell Theory:


Robert Hooke (1665)

Before the C17th, no one knew that cells existed, since they are too small to be seen with the naked eye. The invention of the microscope enabled **Robert Hooke**, (1665) to see and draw the first '**cells**', a word coined by Hooke to describe the cells in a thin slice of cork. Cell Theory was eventually propose in 1838 by **Matthias Schleiden** and **Theodor Schwann**. However, many other scientists like **Rudolf Virchow** contributed to the theory and in 1855 'Cell Theory' came – i.e. 'cells only come from other cells'. This theory has become the foundation of modern biology.

Cell Theory consists of three principles:

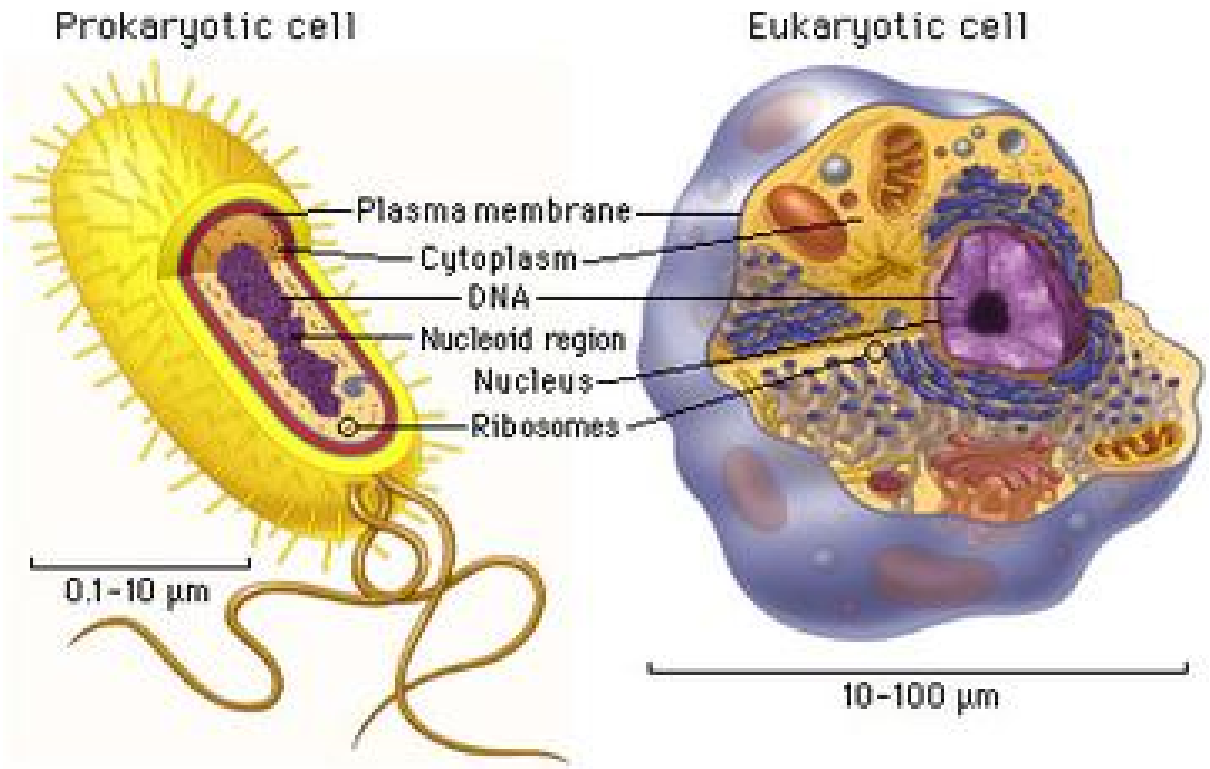
1. All living organisms are composed of one or more cells.
2. The cell is the most basic unit of life.
3. All cells come only from the replication of existing, living cells.

Prokaryotes and Eukaryotes

Organisms whose cells normally contain a nucleus are called Eukaryotes; organisms whose cells lack a nucleus and have no membrane-bound organelles are known as Prokaryotes.

Comparison between prokaryotes and eukaryotes cells

	Prokaryotes	Eukaryotes
organisms	Bacteria, Blue-green algae	fungi, plants, animals
Typical size	~1-10 µm	~ 10-100 µm
Type of nucleus	Nuclear body, No nucleus	real nucleus with nuclear envelope
Ribosomes	70S	80S
Cytoplasmatic structure	very few structures	highly structured by membranes and a cytoskeleton
Organization	usually single cells	single cells, colonies, higher multicellular organisms with specialized cells
Cell division	Binary fission (simple division)	Mitosis (normal cell replication) Meiosis (gamete production)

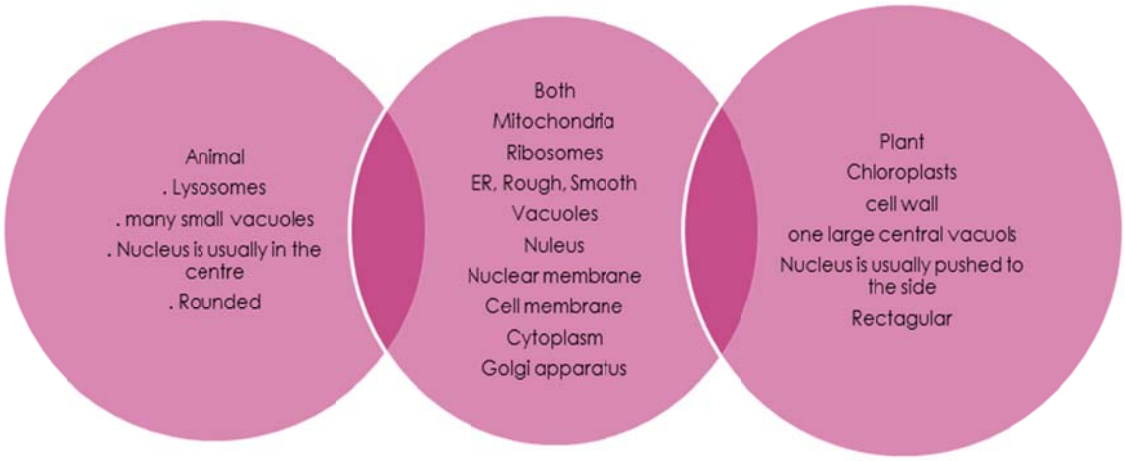


Animal and Plant cells

plant and animal cells have several differences and similarities. For example, animal cells do not have a cell wall or chloroplasts but plant cells do. Animal cells are round and irregular in shape while plant cells have fixed, rectangular shapes.

Comparison of structures between animal and plant cells

	Typical animal cell	Typical Plant cell
Organelles	Nucleus	Nucleus
	• Nucleolus (within nucleus)	• Nucleolus (within nucleus)
	• Rough ER	• Rough ER
	• Smooth ER	• Smooth ER
	• 80S Ribosomes	• 80S Ribosomes
	• Cytoskeleton	• Cytoskeleton
	• Golgi apparatus	• Golgi apparatus
	• Cytoplasm	• Cytoplasm
	• Mitochondria	• Mitochondrion
	• Vesicles	• Vesicles
	• Vacuoles One or more small vacuoles (much smaller than plant cells).	• Vacuole One, large central vacuole taking up 90% of cell volume.
	• Lysosomes occur in cytoplasm.	Lysosomes usually not obvious.
	• Centrioles Present in all animal cells	• Centrioles Only present in lower plant forms.
		• Chloroplast and other plastids
Additional structures	• Flagellae • Plasma membrane	•Cellulose cell wall •Plasmodesmata



CELL VARIABILITY

Not all cells are similar. Even cells within the same organism show diffrence in size, shape, and internal organization.

CELL SIZE

A few types of cells are large enough to be seen by the eye ex chicken egg , whereas most cells are small for two main reasons:

a). the ratio of nuclear material to the cytoplasim.

b). the ratio of the surface area to volume.

CELL SHAPE

Cells come in a variety of shapes – depending on their function ex.

Blood cells are rounded disks, so that they can flow smoothly.

INTERNAL ORGANIZATION

1. Cells contain a variety of internal structures called **organelles.**

2. *An organelle* is a cell component that performs a specific function in that cell.

3. The organelles of a cell maintain the life of the cell.

4. There are many different cells; however, there are certain structures common to all cells. For example, The entire cell is

surrounded by a thin cell membrane. All membranes have the same basic structure.

5. Organelles often have their own membranes too – once again, these membranes have a similar structure.

6. The **nucleus, mitochondria** and **chloroplasts** all have double membranes, more correctly called ***envelopes*.**

Cell Function

In biological terms, a cell's main purpose is to survive – especially in the cases of single cell, so, although different types of cells generally have different specialized functions, some types of processes are common that all cells need to perform in order to survive. Thies include:

- **Transport (of molecules):** Biochemical particles such as ions and molecules need to travel through the structures, e.g. tissues, of organisms to reach locations where they are needed. There are various transport mechanisms via which particles can travel.
- **Chemical reactions: i.e. Metabolic processes** including energy conversion
- **Motility,** in general motility can refer to movement of some components of the cell or to the movement of the whole cell.
- **Reproduction,** transmission of genetic material from one generation to the next occurs via **cell division.** There are two types of cell division**, mitosis and meiosis.**

Prokaryotes

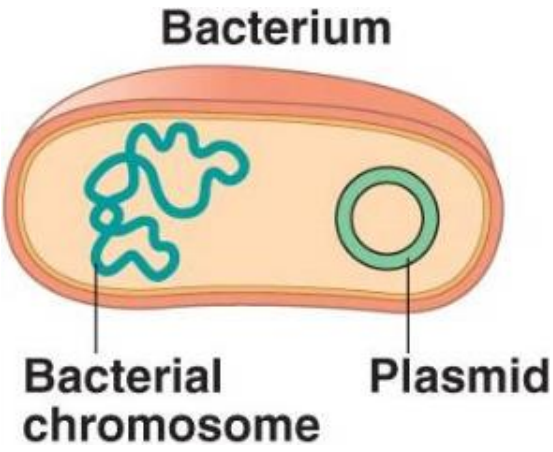
1. **They are everywhere, they exist almost everywhere, including places where eukaryotes cannot.**

2. **Prokaryotes have *no nucleus*.**

A. The nucleoid region in a prokaryotic cell consists of a concentrated mass of DNA.

B. A prokaryote may have a plasmid in addition to its major chromosome.

***Plasmid*: is a small ring of DNA that carries addition genes.**

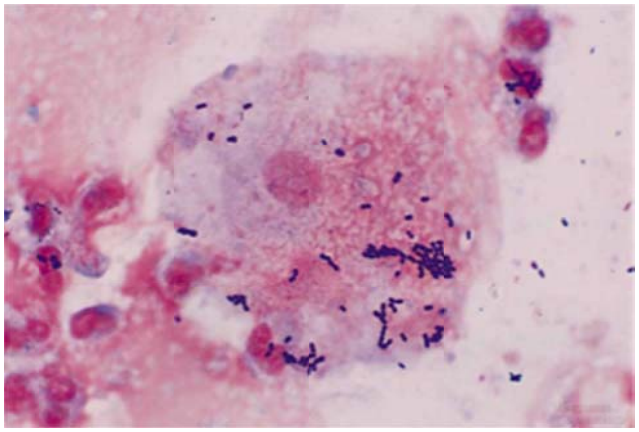


3. **Most prokaryotes are useful; we could not live without them. For example, a large ration of the oxygen we breathe comes from prokaryotes in the ocean, using the CO_2 dissolved in the water, and making more "space" for CO_2 from the atmosphere to be absorbed by the ocean. In addition, they live in our gut.**

4. **Some cause diseases; ex. There are wide varieties of diseases caused by prokaryotes...for example bacterial meningitis, salmonella, diphtheria ….many others**

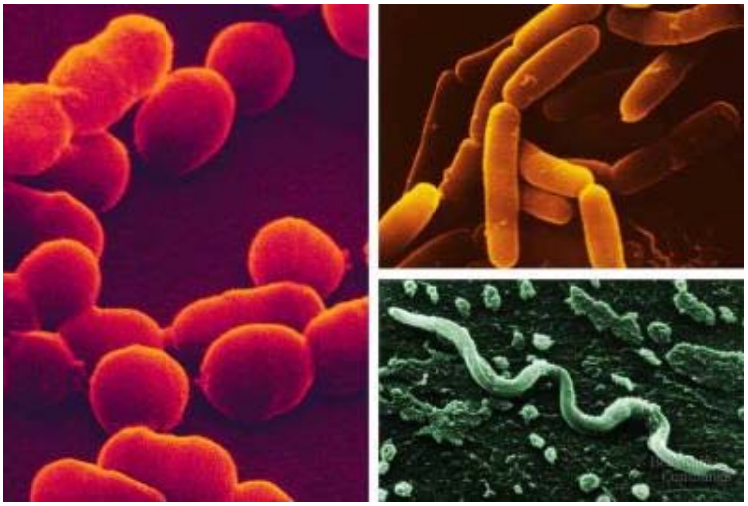
5. **Most prokaryotes are unicellular; Some species form aggregates of two or more individuals**

6. **Prokaryotes are small 1-5 µm in size; but some can be seen by the naked eye, whereas Eukaryotic cells are typically 10-100 µm in diameter.**



7. ***Bacteria*** **and** ***Cyanophytes*** **are the two main branches of prokaryote**

8. **Three (3) common shapes: cocci (round); bacilli (rod); helical (spiral)**



9. **Almost all prokaryotes have** ***cell walls*** **external to the plasma membrane.**

   A. Cell walls maintain cell shape.

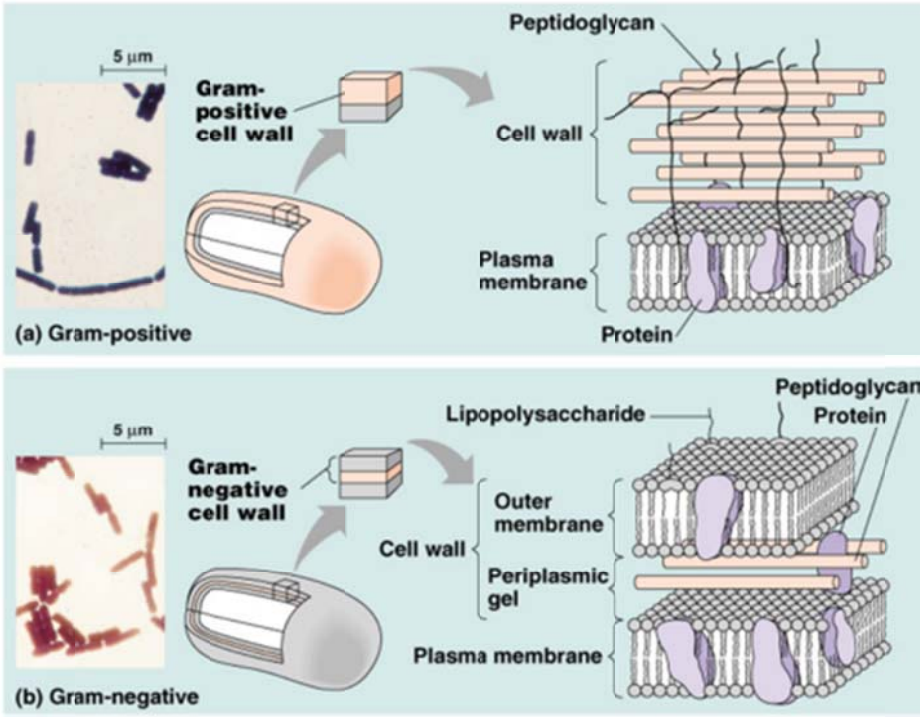
B. Cell walls are composed of peptidoglycan.

10. Bacteria are grouped according to cell wall.

a. Gram-positive bacteria: have simple, thick cell walls. Their cell walls are composed of large amount of peptidoglycan.

b. Gram-negative bacteria: bacteria have less peptidoglycan and are more complex.

- *Gram-negative bacteria are typically more resistant to host immune defenses and antibiotics.*



11. Most prokaryotes have sticky protective layer and enable them to adhere to substrates called *capsule.*

12. **Many prokaryotes are motile**

13. **Many prokaryotes move toward or away from a stimulus = taxis. *Chemotaxis* is the movement toward or away from a chemical.**

Bacteria VS Blue green algae

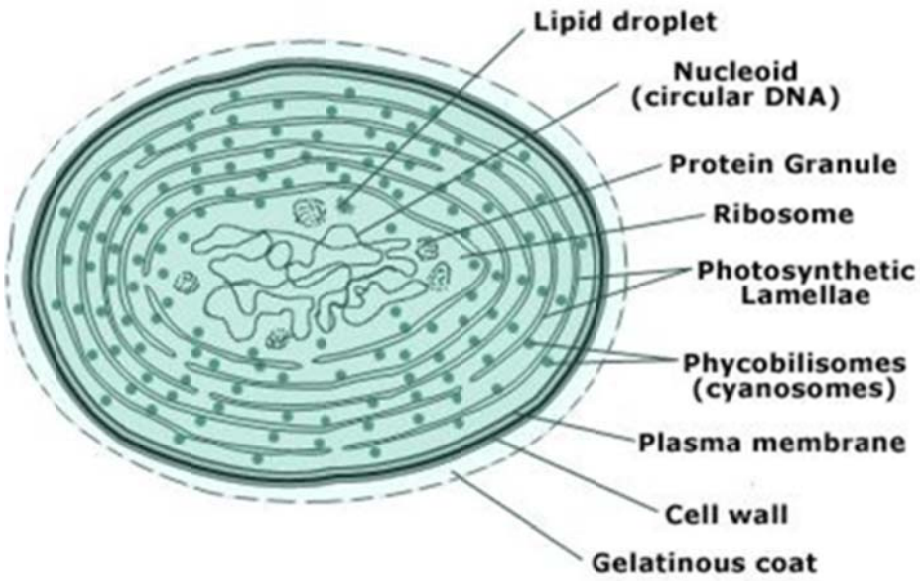


Figure (2): Blue green algae.

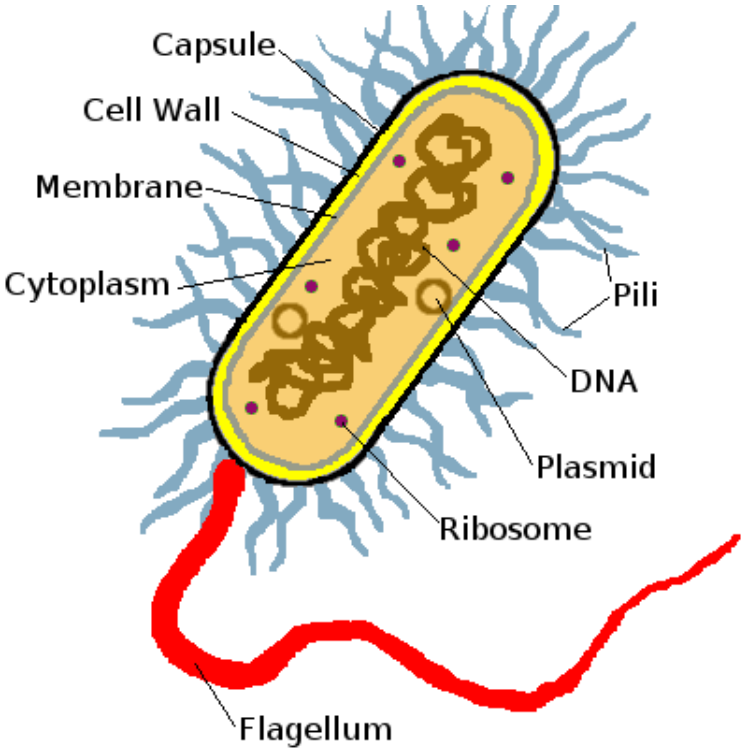


Figure (1): Bacteria

Eukaryote

What do trees, monkeys, plankton and mushrooms have in common?

They are all members of the Eukaryote domain! ***You are a member of the Eukaryote domain too!***

Plants, animals, protists, and fungi, are all members of the domain. All members of the domain Eukaryote have *eukaryotic cells*. Eukaryotic cells have three main components: cell membrane, nucleus and variety of other organelles.

The cell membrane:

The cell membrane is a complex barrier separating every cell from its external environment, regulates what passes into and out of the cell.

The nucleus:

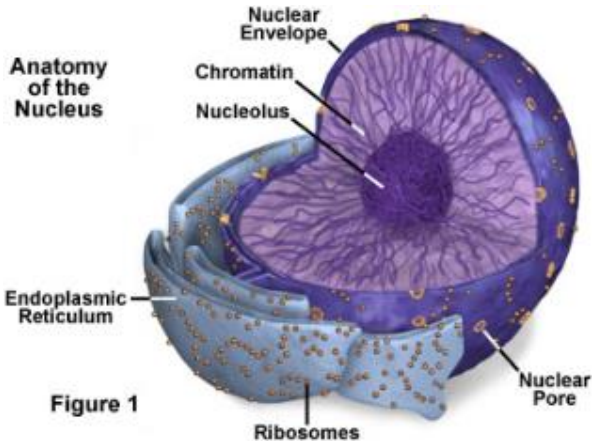


Figure 1

1. The largest organelle in a Eukaryotic cell.

2. The nucleus contains the cell's chromosomes (human 46, fruit fly 6), which contain both linear DNA and proteins known as histones.

3. Most cells have a single nucleus, some cells have more than one (fungi have many nuclei in their cytoplasm).

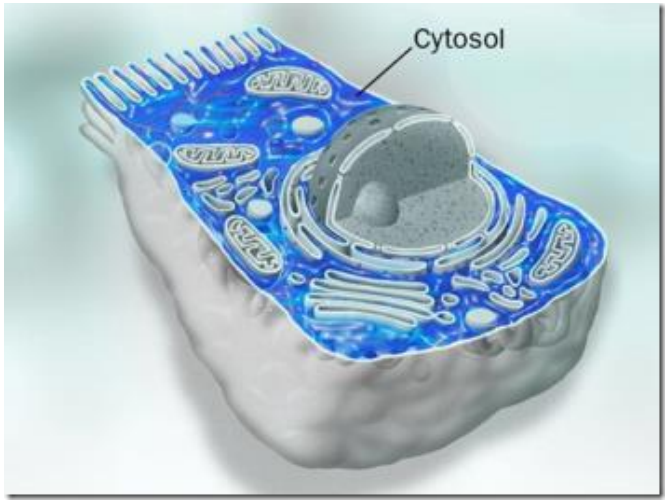
4. A double membrane called the nuclear envelope surrounds the nucleus. Which has many nuclear pore by which mRNA and proteins can pass.

5. Most nuclei contain at least nucleolus (nucleoli), where ribosomes are synthesised (ribosomes translate mRNA into proteins).

Cytoplasm

1. Everything within the cell membrane, which is not the nucleus, is known as the cytoplasm.

2. Cytosol is the jelly-like mixture in which the other organelles are suspended, so **cytosol + organelles = cytoplasm**.



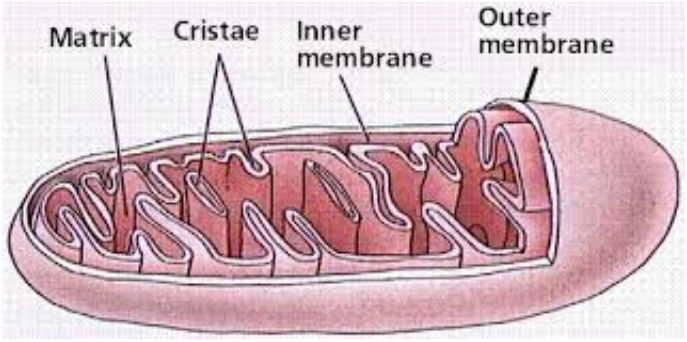
Mitochondria

1. Found scattered throughout the cytosol.

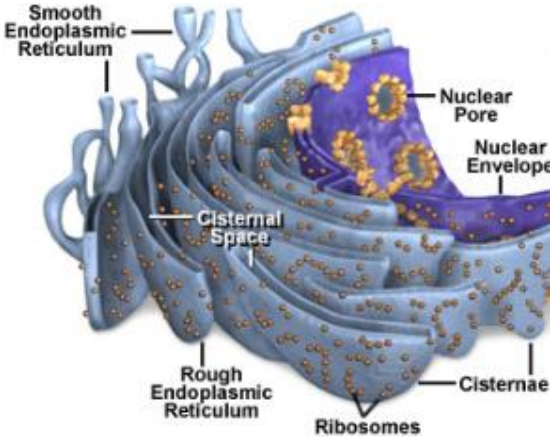
2. Mitochondria are the sites of aerobic respiration, in which energy from organic compounds is transferred to ATP (ATP is the molecule that most cells use as their main energy). For this reason, they are sometimes referred to as the **powerhouse**.

3. Mitochondria are surrounded by two membranes

   a. The smooth outer membrane serves as a boundary between the mitochondria and cytosol.
   b. The inner membrane has many long folds, known as crista.



Endoplasmic reticulum (ER)



1. The ER is a system of membranous tubules and sacs.

2. The primary function of the ER is to act as an internal transport system, allowing molecules to move from one part of the cell to another.

3. The number of ER inside a cell depending on the cell's activity.

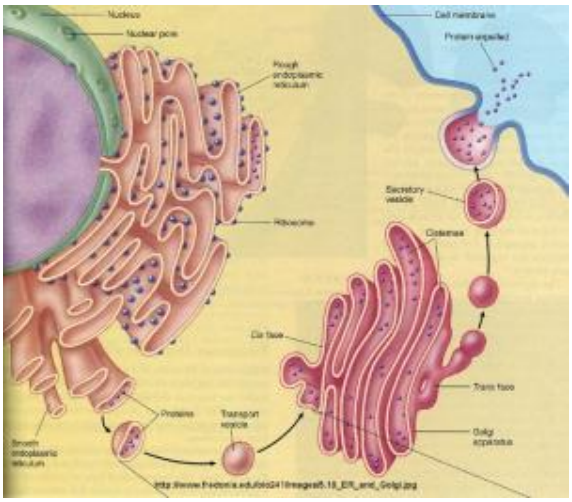
4. There are two types of ER:
   a. Rough ER
   b. Smooth ER, where polypeptide are converted into functional proteins

Ribosomes

1. Ribosomes are not surrounded by a membrane.
2. Ribosomes are the site of protein synthesis in a cell.
3. Line the membranes of Rough endoplasmic reticulum (rough ER).

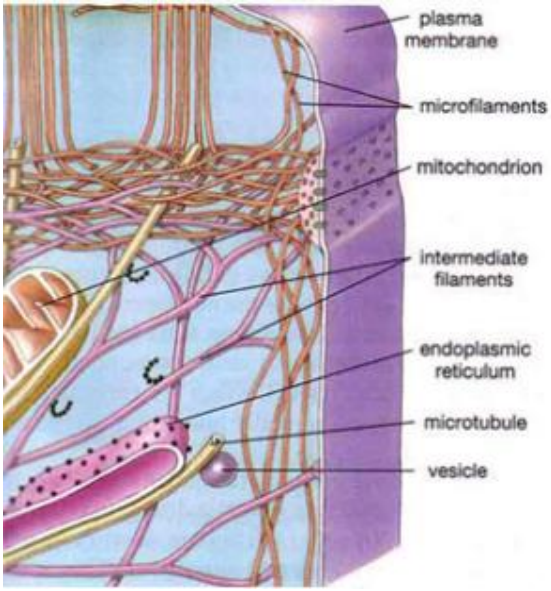
4. They exist in two sizes:
    a. 70s are found in all prokaryotes
    b. 80s found in all eukaryotic cells

Golgi apparatus



1. The Golgi apparatus is a system of membrane, made of flattened sac-like structures.

2. It works closely with the ER to modify proteins for export by the cell.



Cytoskeleton

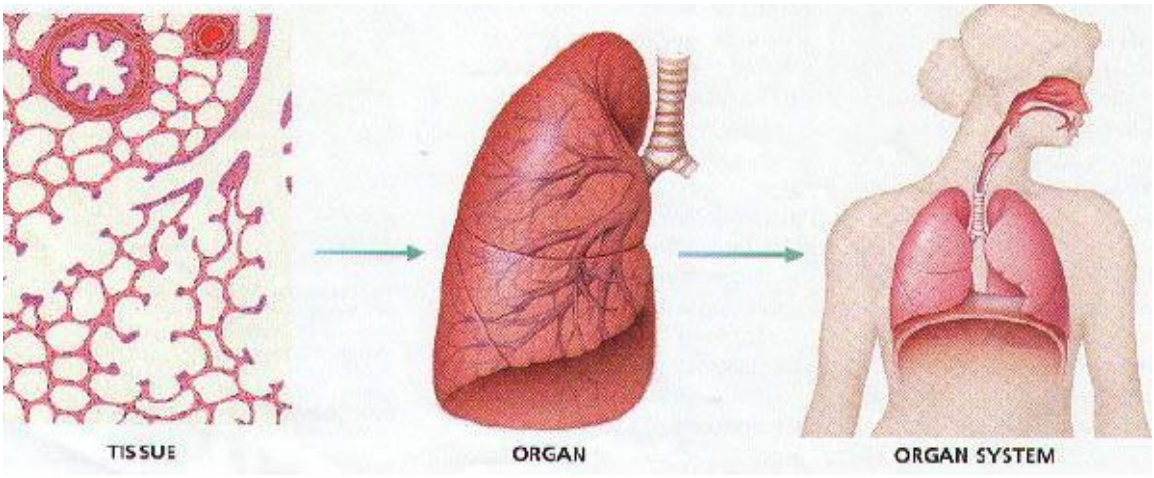
1. Just as your body depends on your skeleton to maintain its shape and size, so a cell needs structures to maintain its shape and size
2. In animal cells, which have no cell wall as in plant cell, cytoskeleton maintains the shape of the cell, and helps the cell to move
3. The cytoskeleton consists of two structures:

a. **Microfilaments**, made of actin they are common in motile cells
b. **Microtubules**, made of tubulin, they form the *centriole*.

Multicellular organization

In most multicellular organisms, we find the following organization:

1. Cellular level: the smallest unit of life capable of carrying out all the function of living things.
2. Tissue level: a group of cells that performs a specific function in an organism.
3. Organ level: several different types of tissue that function together for a specific purpose.
4. Organ system level: several organs working together to perform function. The different organ system in a multicellular organism interact to carry out the processes of life.
5. ***Plants*** have four organs they are: **roots, stems, leaves and flowers**.



The cell membrane

1. A cell cannot survive if it is completely isolated from its environment.

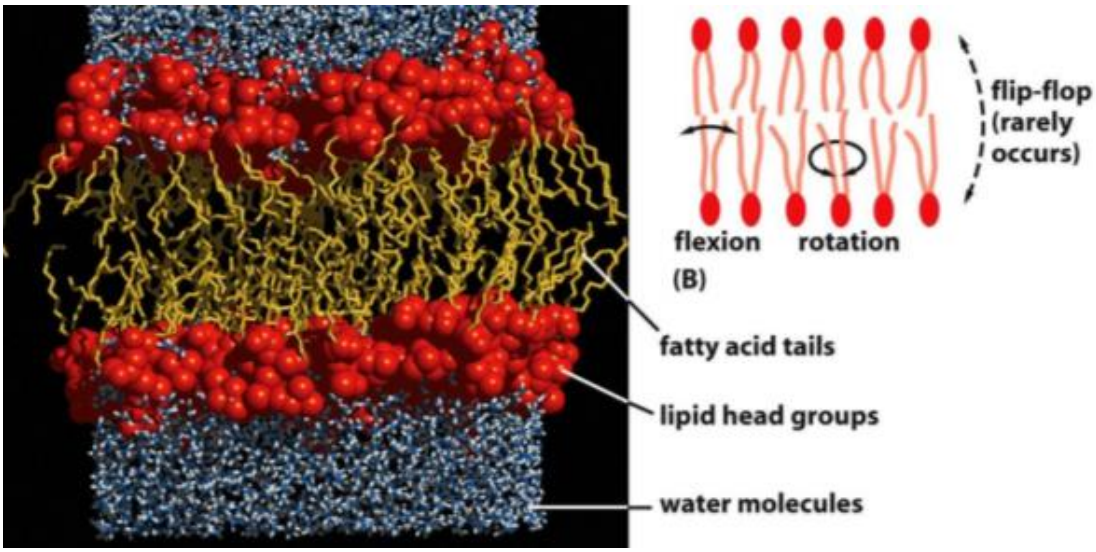
2. The cell membrane is a fluid mosaic of proteins moving in a phospholipid bilayer.

3. The cell membrane functions like a gate, controlling which molecules can enter and leave the cell.

How do proteins stay embedded?

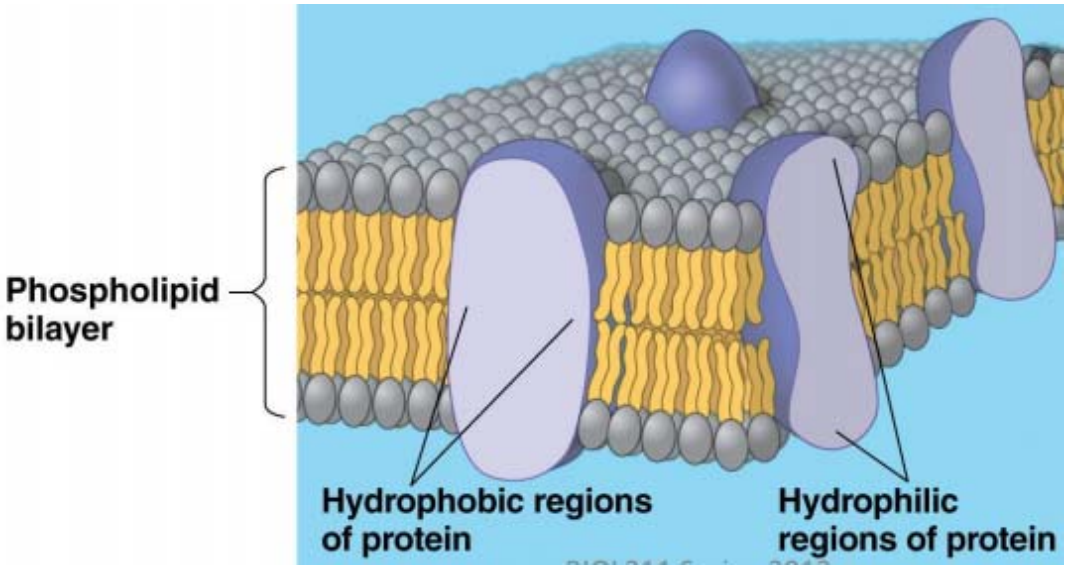
4. The head is charged and so polar; the tails are not charged and so are non-polar. Thus, the two ends of the phospholipid molecule have different properties in water. The phosphate head is **hydrophilic** and so the head will position itself so that it is as close as possible to water molecules. The fatty acid tails are **hydrophobic** and so will tend to orient themselves away from water.

5. Therefore, when in water, phospholipids line up on the surface with their phosphate heads sticking into the water and fatty acid tails pointing up from the surface.



6. Cells are bathed in an aqueous environment and since the inside of a cell is also aqueous, both sides of the cell membrane are surrounded by water molecules.

7. This causes the phospholipids of the cell membrane to form two layers, known as a phospholipid bilayer. In this, the heads face the watery fluids inside and outside the cell, whilst the fatty acid tails are sandwiched inside the bilayer.



9. Membrane Proteins

• A membrane's function is defined by the proteins embedded in it

• **Two types** of membrane proteins:

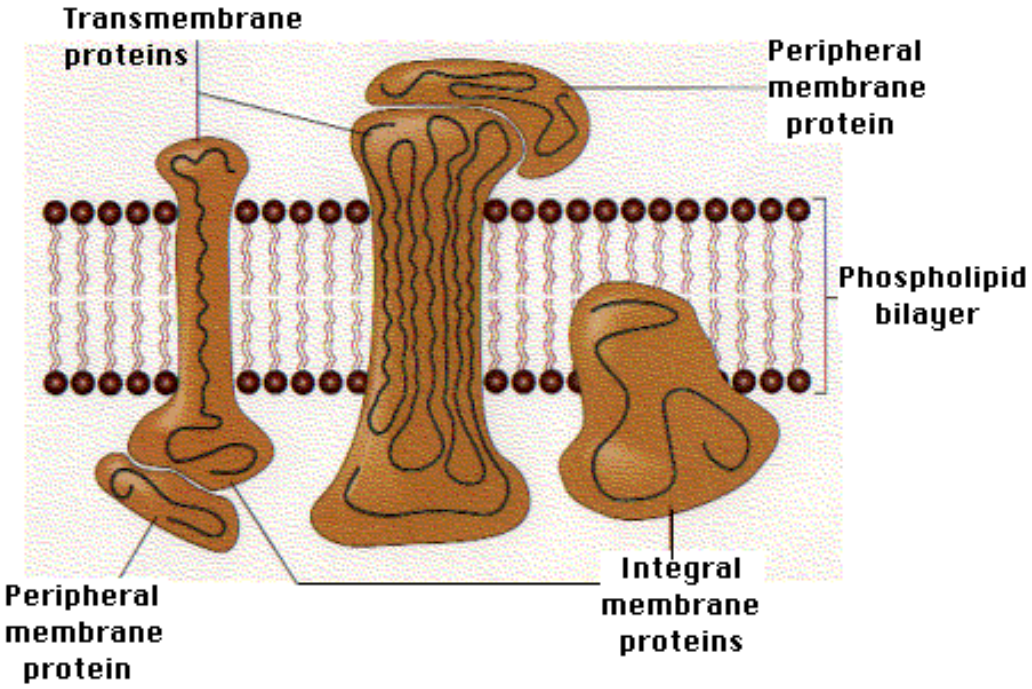
– **Integral protein**

• Penetrate the hydrophobic interior; can stick out of the surface

• Integral proteins that extent the membrane are called *transmembrane proteins*

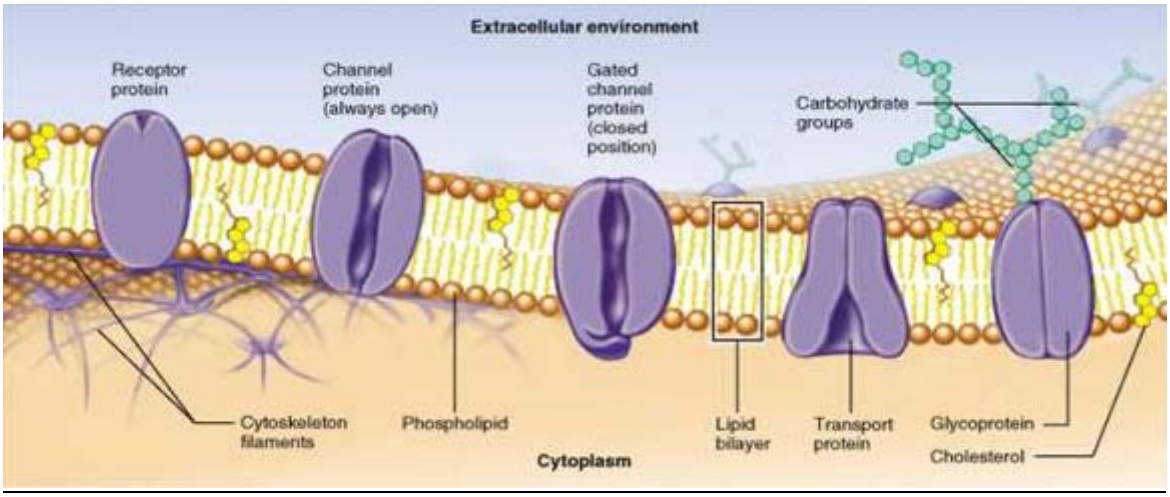
– **Peripheral protein**

• Stick to the surface of the membrane



11. Integral proteins types are:

- **Channel proteins:** They have a channel that allows a substance to simply move across the membrane.
- **Carrier proteins:** They combine with a substance and help it move across the membrane.
- **Cell recognition proteins:** These proteins help the body recognize when it is being invaded by pathogens so that an immune reaction can occur.
- **Receptor proteins:** have a shape that allows a specific molecule to bind to it.
- **Enzymatic proteins:** carry out metabolic reactions directly.



12. Types of Cell Transport

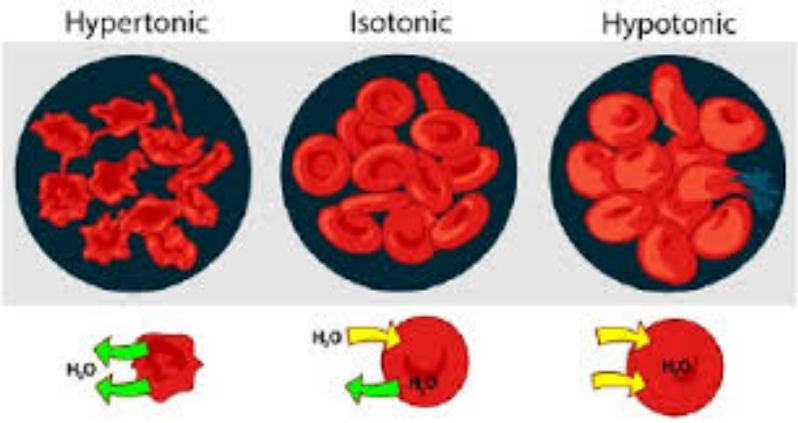
• Passive transport

– Diffusion: which is the movement of molecules down their concentration gradient without the use of energy.

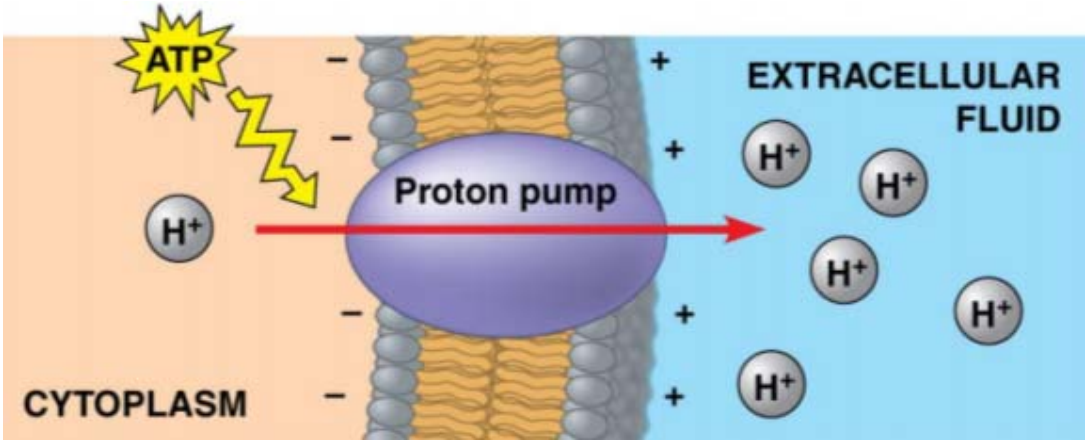
– Facilitated diffusion: that is, the diffusion of particles across a selectively permeable membrane with the assistance of the membrane's transport proteins, this process does not require the input of energy.

– Osmosis: which is the passive diffusion of water. Water moves from a region of high water concentration to a region of low water concentration. Thinking about osmosis another way, water will flow

from a region with a lower solute concentration (hypotonic) to a region with a higher solute concentration (hypertonic).



- **Active transport**
  - **Uses energy to move molecules against their gradients**
  - **All carrier proteins**
  - **Includes *ion pumps* and *endocytosis*/*exocytosis***



Types of Cell Transport

NOT Require ATP **Require ATP**

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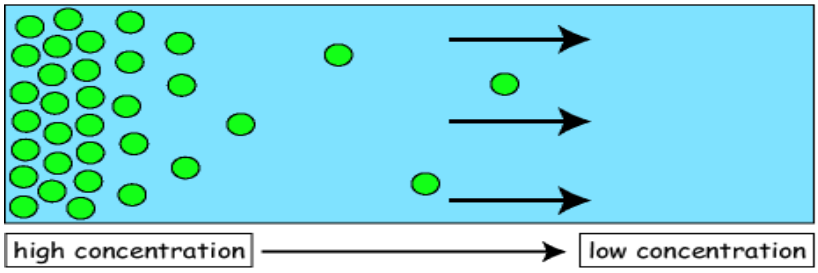

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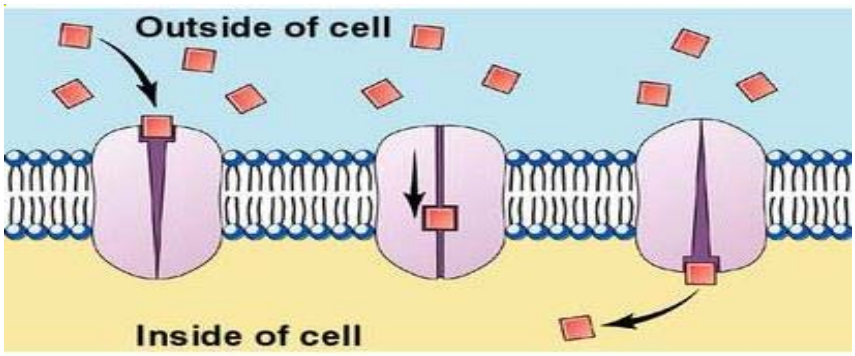
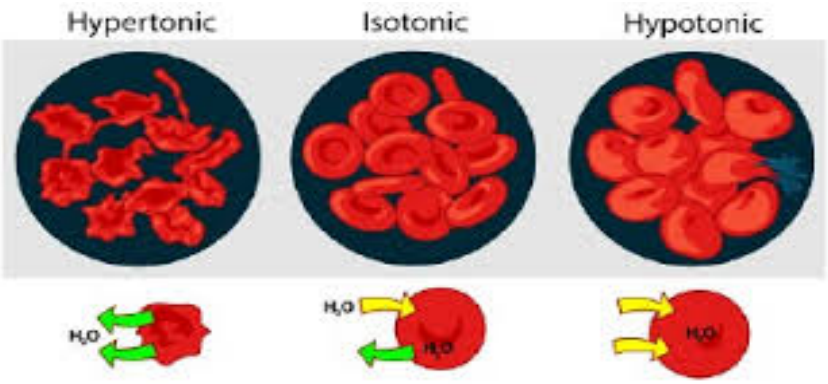


– **Osmosis**: which is the passive diffusion of water. Water moves from a region of high water concentration to a region of low water concentration. Thinking about osmosis another way, water will flow from a region with a lower solute concentration (hypotonic) to a region with a higher solute concentration (hypertonic).

- **Hypertonic**:
  Solution having a high conc. of solute.
- **Hypotonic:**
  Solution having a low conc. of solute.
- **Isotonic:**
  Both solutions have equal solute conc.



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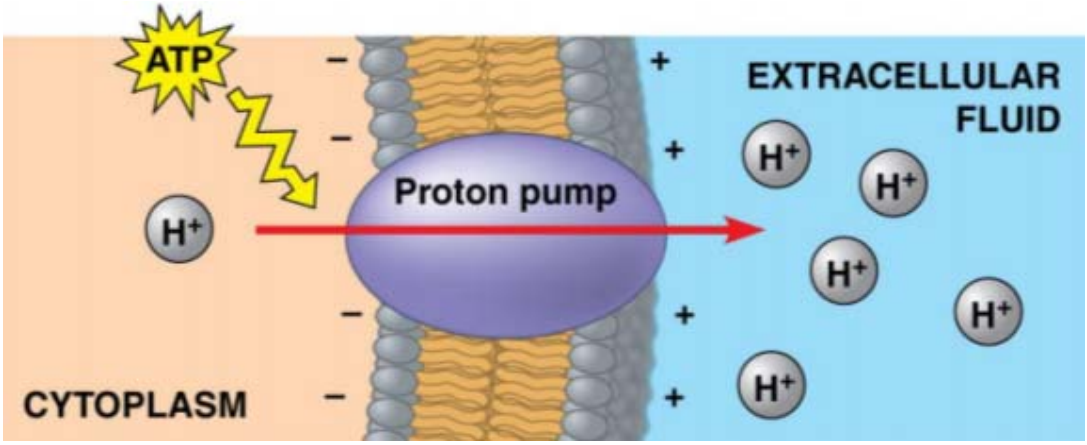


- **Ion pumps: ex. Sodium-Potassium Pump**

The Sodium-Potassium Pump is a structure known as ***a cell-membrane pump*** that uses energy to transport Sodium and Potassium ions in and out of the cell. There are other varieties of cell membrane pump; however, the sodium-potassium pump plays a vital role in **maintaining a cell's homeostasis.**

The pump is powered by a molecule of ATP. **The ATP allows the shape of the pump to change**, emptying its contents either into or out of the cell.

Below are the steps that the sodium-potassium pump uses to function:

1. Three sodium ions form inside the cell bind to the pump.

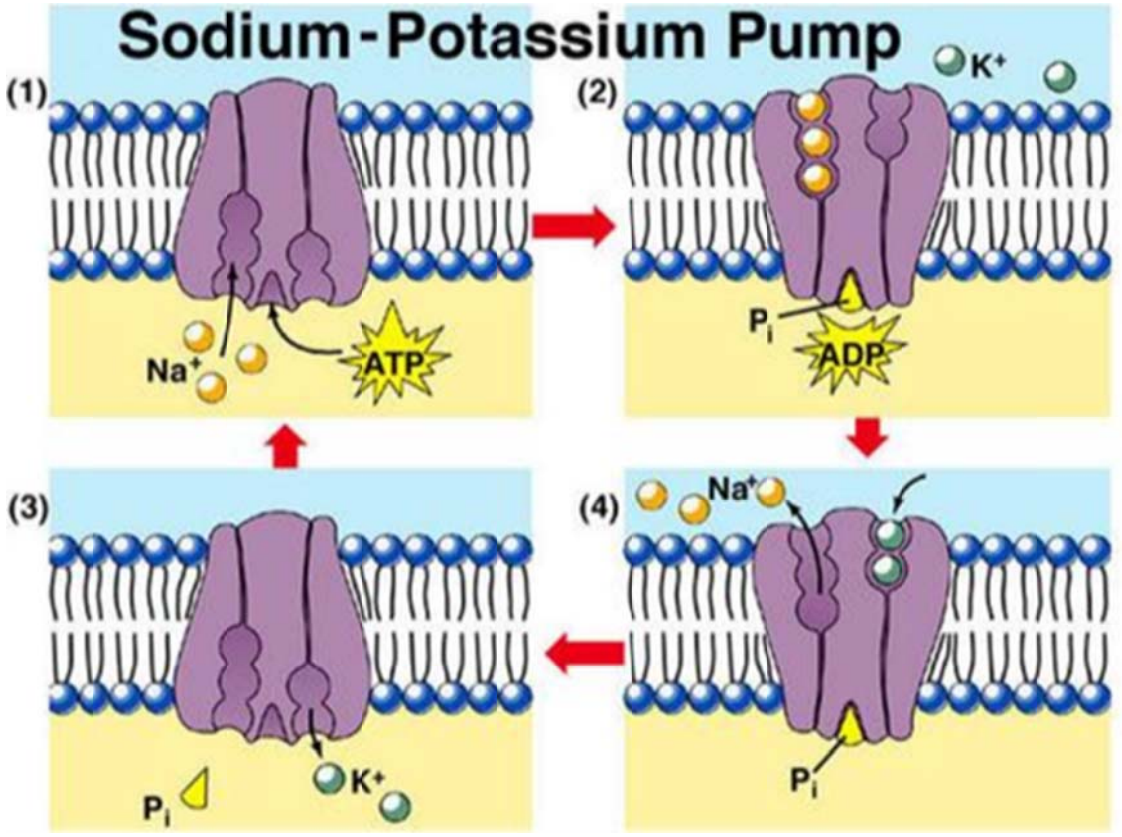
2. The Phosphate group form a molecule of ATP binds to the pump.

3. The pump changes shape and the sodium ions are released outside the cell.

4. Two potassium ions bind to the pump.

5. The phosphate group is released form the pump and the pump again changes shape and releases the ions into the inside of the cell.

- 3 Na+ pumped out of the cell
- 2 K+ pumped into the cell

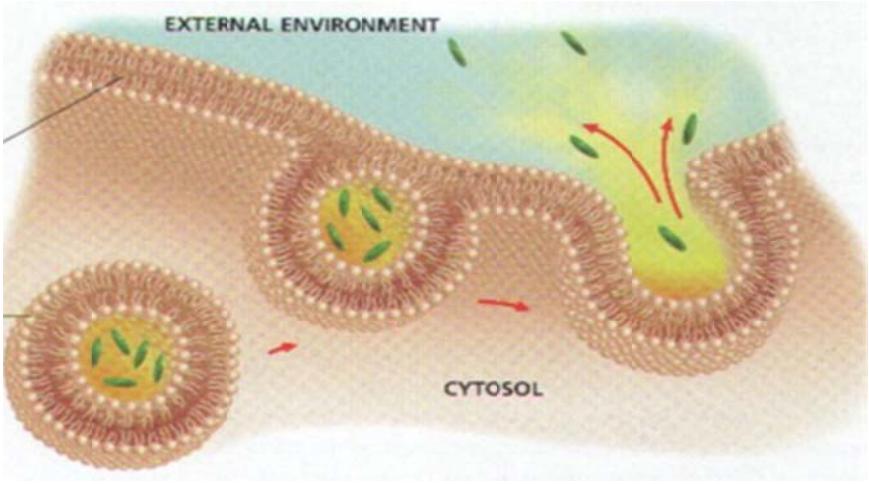


Exocytosis / endocytosis

The movement of macromolecules such as proteins or polysaccharides into or out of the cell is called **bulk transport**. There are two types of bulk transport, **exocytosis** and **endocytosis**, and both require energy (ATP).

Exocytosis, **materials are move out of the cell** via secretory vesicles. In this process, the Golgi complex packages macromolecules into transport vesicles that travel to and fuse with the plasma membrane. This fusion causes the vesicle to spill its contents out of the cell.

Exocytosis is important in **removal of waste materials** out of the cell and in the **secretion of cellular products** such as digestive **enzymes or hormones**.

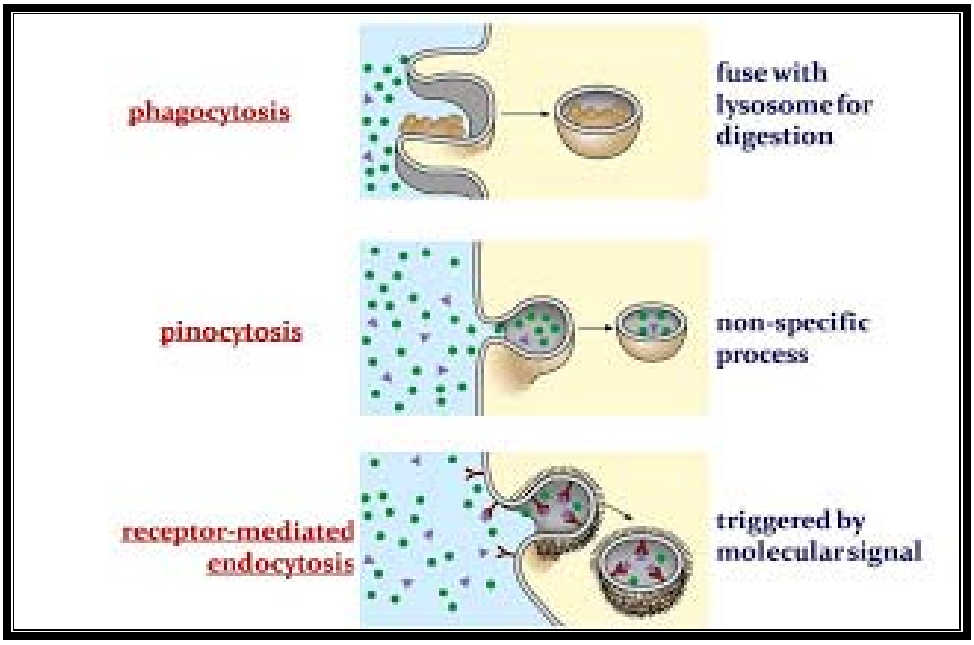


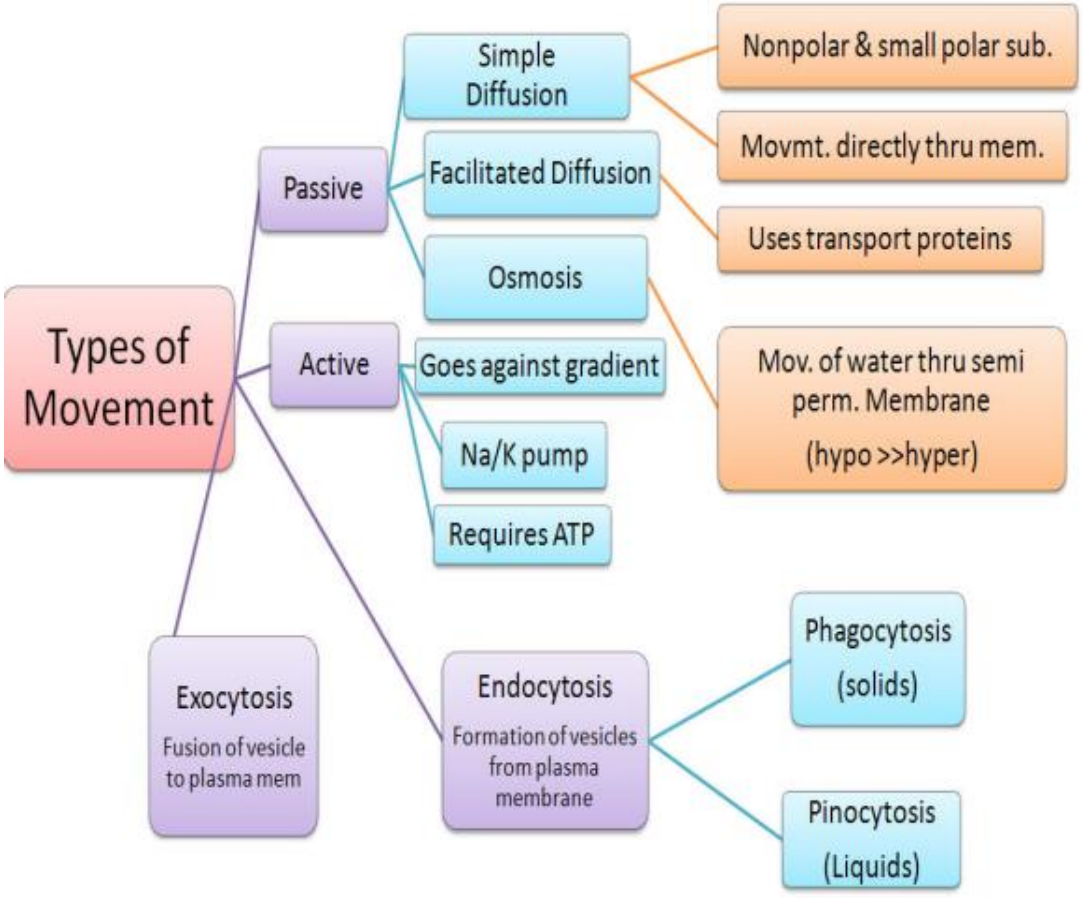
Endocytosis, is the process by which **materials move into the cell**. There are three types of endocytosis:

1- **phagocytosis** or "**cellular eating**," the cell's plasma membrane surrounds food – buds off a vacuole. Lysosomes then secrete enzymes into vacuole to digest food.

2- **pinocytosis** or "**cellular drinking**," smaller infolding of phagocytosis allows droplets of liquid to enter.

3- **receptor-mediated endocytosis** in this highly specific process, the cell takes in only certain molecules, this specificity is mediated by receptor proteins located on the cell plasma membrane. Once bound, a vesicle formed, and fuses with a lysosome to digest the engulfed material and release it into the cytosol. Mammalian cells use receptor-mediated endocytosis to take cholesterol into cells. Cholesterol in the blood is usually found in lipid-protein complexes called low-density lipoproteins (LDL). LDL bind to specific receptor proteins on the cell surface..


phagocytosis
fuse with lysosome for digestion
pinocytosis
non-specific process
receptor-mediated endocytosis
triggered by molecular signal


Types of Movement
Passive
Simple Diffusion
Nonpolar & small polar sub.
Facilitated Diffusion
Movmt. directly thru mem.
Osmosis
Uses transport proteins
Mov. of water thru semi perm. Membrane (hypo >>hyper)
Active
Goes against gradient
Na/K pump
Requires ATP
Exocytosis
Fusion of vesicle to plasma mem
Endocytosis
Formation of vesicles from plasma membrane
Phagocytosis (solids)
Pinocytosis (Liquids)