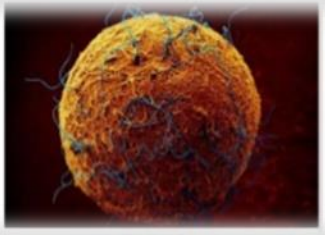
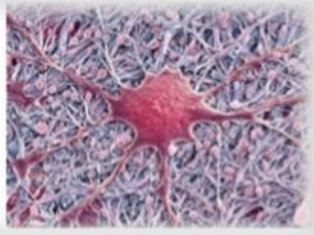
Medical Biology

Third Lecture •

Dr. Warqaa Al-Sheikh





Cell Structure and Functions

Cell : is the basic structural and functional unit of living organisms.

In the other words, cells make up living things & carry out activities

that keep a living thing alive.

*There are two main types of cells according to the complexity of cell structure (Eukaryotic& Prokaryotic), but according to the complexity of body structure or body arganization

(Unicellular & Multicellular)

These different types of cells are different in :

1.Size & shape

2.Structure

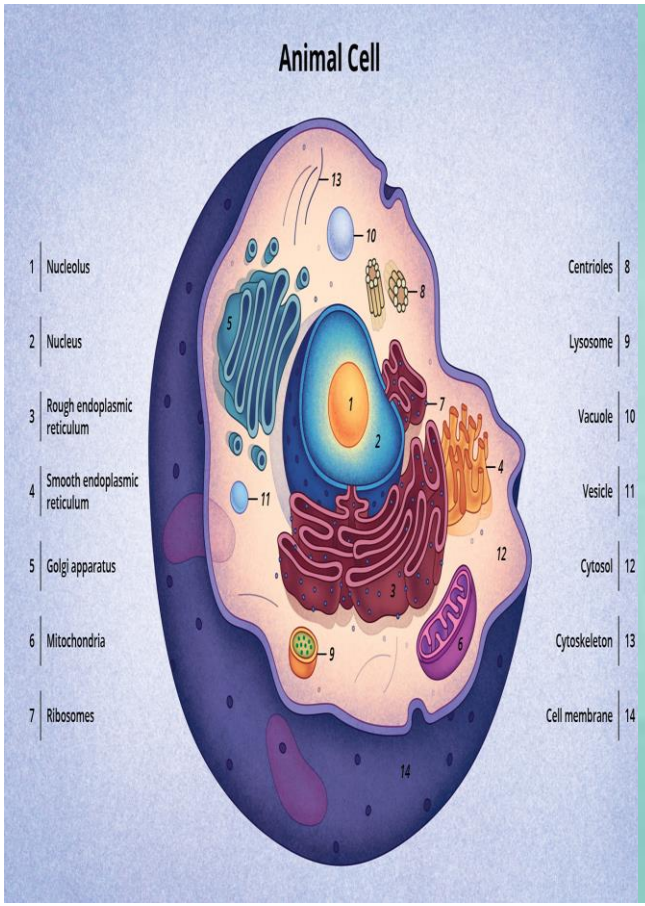
3.Organelles

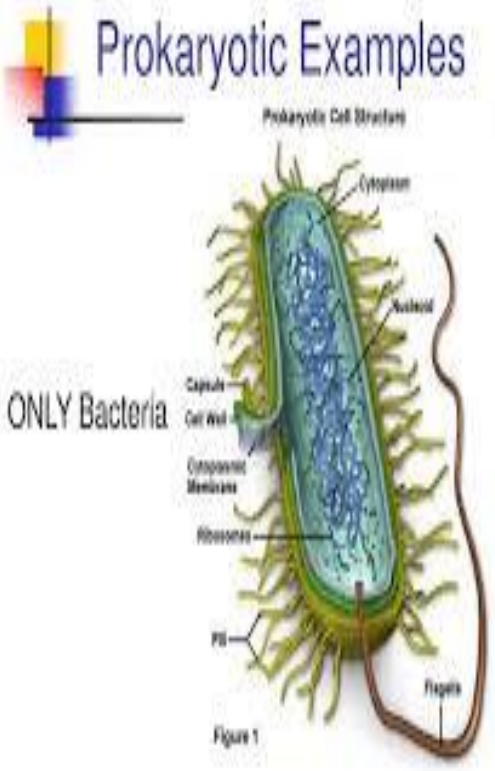
-4.Complexity •

Under observation of microscope you can find three types of cells:

Eukaryotic

Prokaryotic





Animal cell

Plant cell

Bacteria cell

Prokaryotic cell

1. Nucleus is undeveloped
2. Only one chromosome is present
3. Membrane bound organelles are absent
4. Size ranges from 0.5-5 µm
5. Examples: Bacteria and blue green algae

Eukaryotic cell

1. Nucleus is well developed
2. More than one chromosomes are present
3. Membrane bound organelles are present
4. Size ranges from 5-100 µm
5. Examples: All other organisms

Animal cell

1. Generally small in size
2. Cell wall is absent
3. Plastids are absent
4. Vacuoles are smaller in size and less in number
5. Centrioles are present

Plant cell

1. Generally large in size
2. Cell wall is present
3. Plastids are present
4. Vacuoles are larger in size and more in number
5. Centrioles are absent

Size of Cells

Cells vary in size.

Most cells are very small (microscopic), some may be very large (macroscopic).

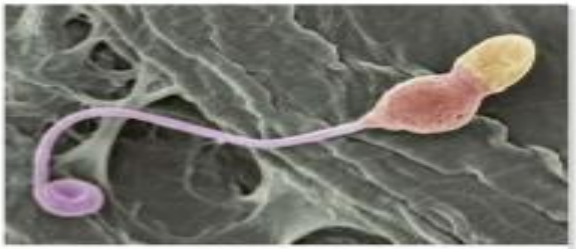
The unit used to measure size of a cell is micrometer.

1 µm = 1/1000 millimeter

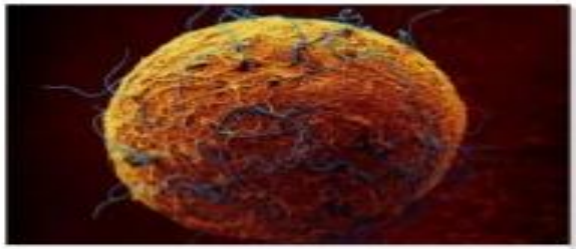
- Smallest cell
- Mycoplasma
- Size: 0.1 µm

- Largest cell
- Ostrich egg
- Size: 18 cm

Size of Cells in Humans



Smallest cell
Sperm cell
Size: 5 µm



Largest cell
Ovum cell
Size: 120 µm

Longest cell
Nerve cell
Size: 1 m

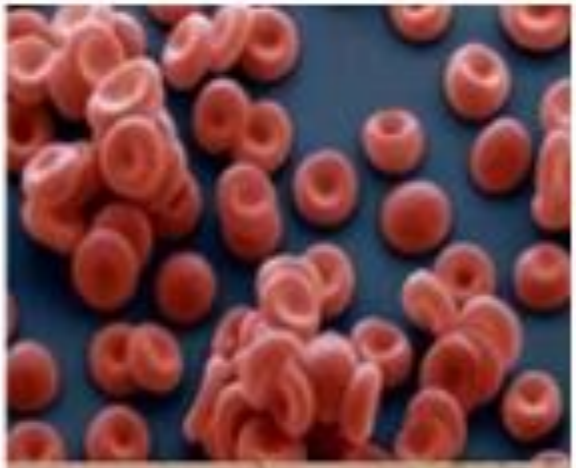
Shape of Cells

Cells vary in shape.

Variation depends mainly upon the function of cells.

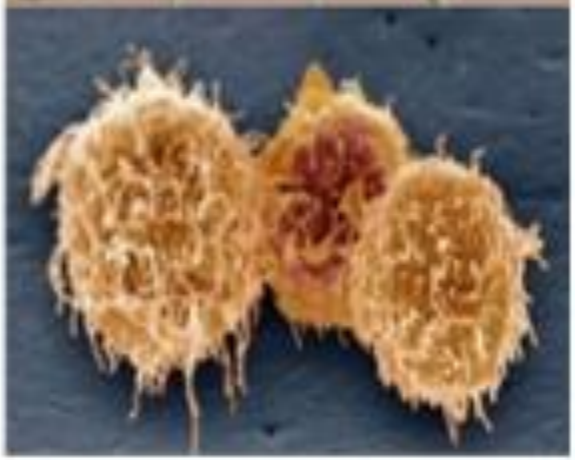
Some cells like Euglena and Amoeba can change their shape, but most cells have a fixed shape.

Human RBCs are circular biconcave for easy passage through human capillaries.



Nerve cells are branched to conduct impulses from one point to another.

Human WBCs can change their shape to engulf the microorganisms that enter the body.



Unicellular Organisms

An organism that is made up of only one cell is called as unicellular organism.

Euglena

Paramecium

Yeast

Multicellular Organisms

An organism that is made up of more than one cell is called as multicellular organism.

Plants

Animals

Fungus

The Structure And Function Of Cell Organelles

Most eukaryotic cells contain Three main components:

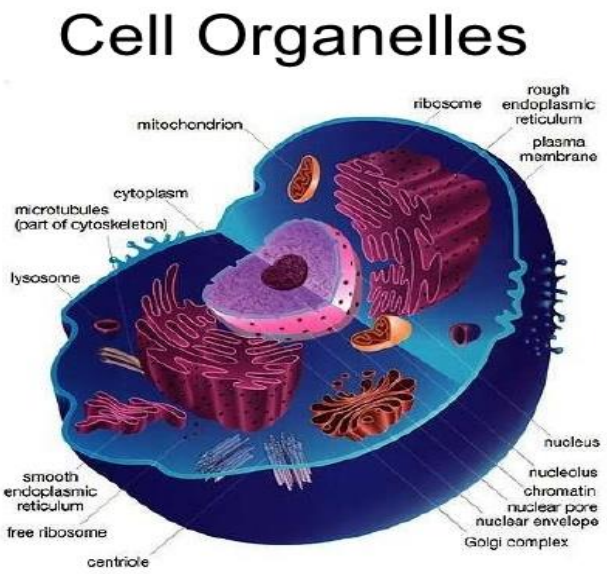
1.Cell membrane.

2. Nucleus

3.Cytoplasm

A. Cytosol

B. Cell Organelles



Cell membrane

Nucleus

Nucleolus

Cell wall

Cytoplasm

Cytoskeleton

Ribosomes

Endoplasmic Reticulum

Golgi apparatus

Mitochondria

Lysosomes

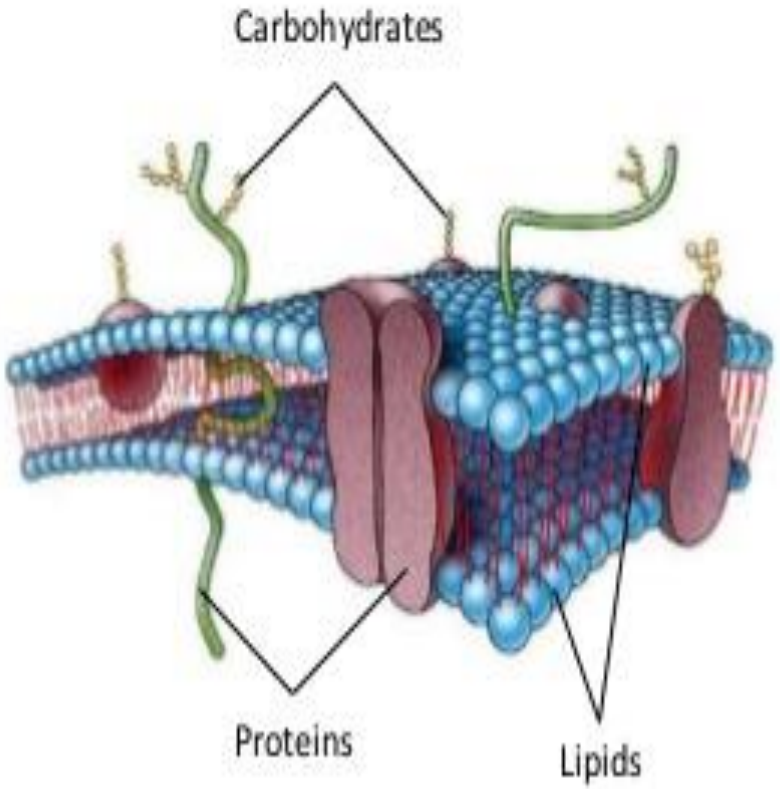
Peroxisomes

Cilia &Flagella

Centrioles

Vacuoles

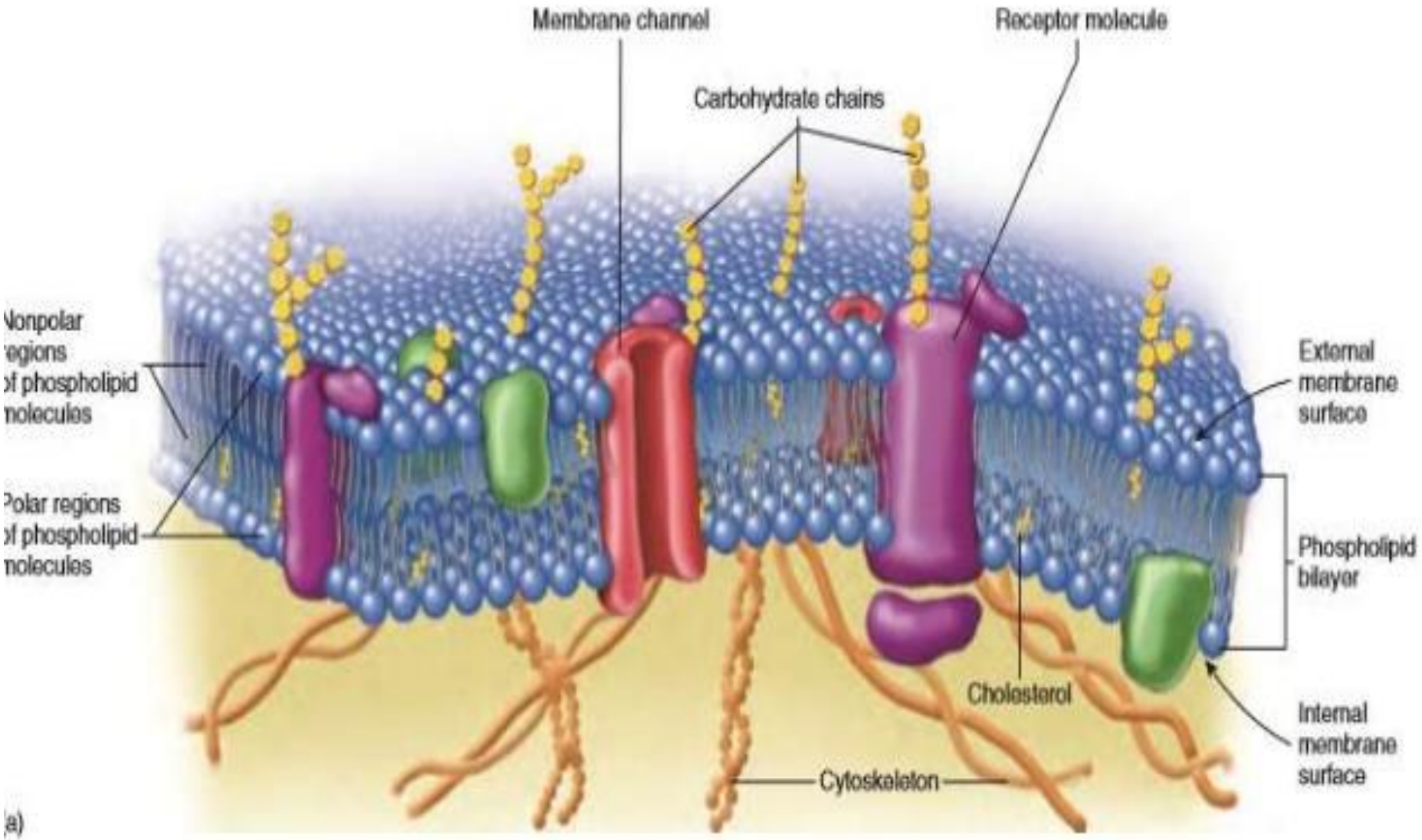
Plasma Membrane



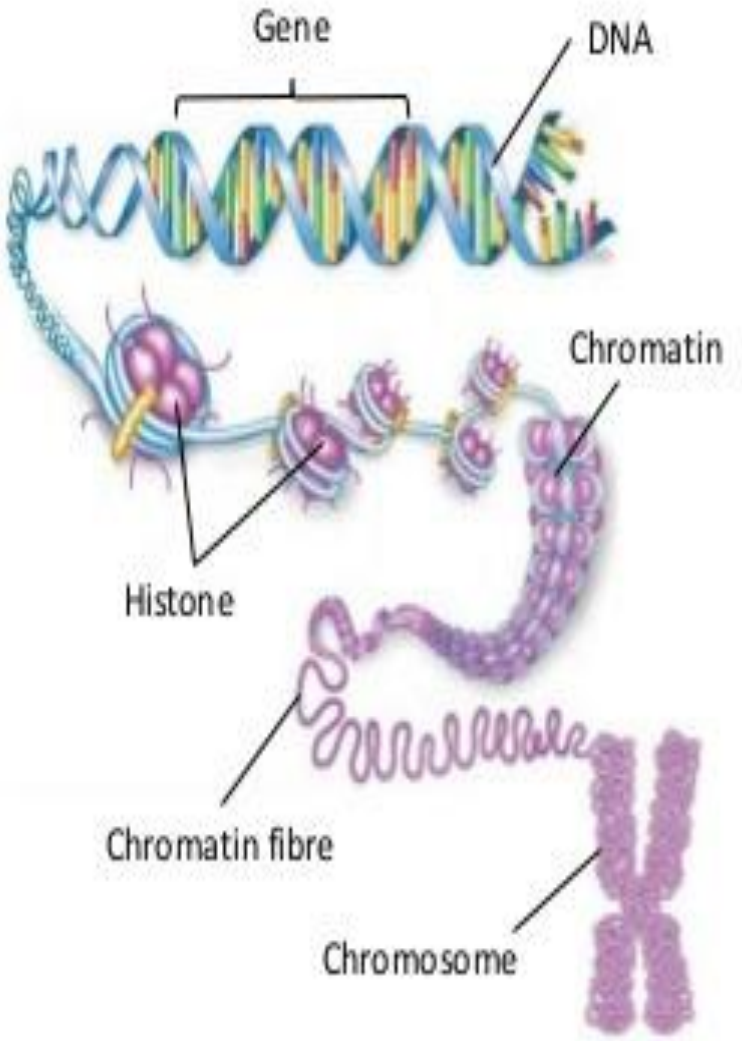
- Extremely delicate, thin , elastic, living and semi-permeable membrane
- Made up of two layers of lipid molecules in which protein molecules are floating
- Thickness varies from 75-110 A°
- Can be observed under an electron microscope only

Functions:

- Maintains shape & size of the cell
- Protects internal contents of the cell
- Regulates entry and exit of substances in and out of the cell
- Maintains homeostasis


Membrane channel
Receptor molecule
Carbohydrate chains
Nonpolar regions of phospholipid molecules
Polar regions of phospholipid molecules
External membrane surface
Phospholipid bilayer
Cholesterol
Internal membrane surface
Cytoskeleton
(a)

Nucleus

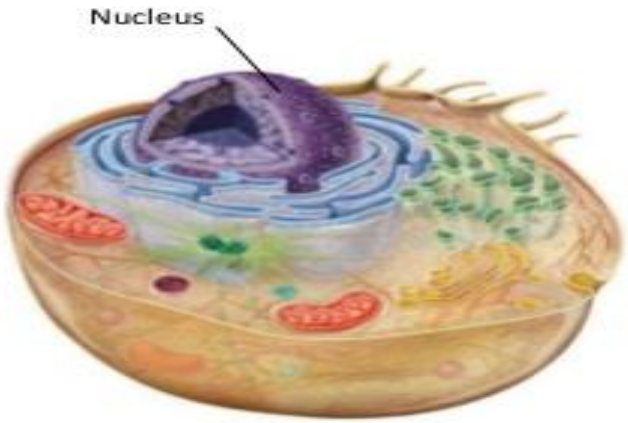


- Chromosomes contain stretches of DNA called genes
- Genes transfer the hereditary information from one generation to the next

Functions:

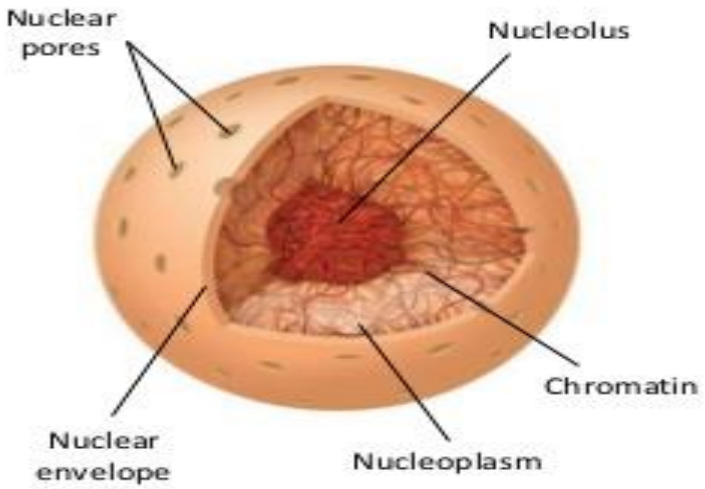
- Control all the cell activities like metabolism, protein synthesis, growth and cell division
- Nucleolus synthesizes ribonucleic acid (RNA) to constitute ribosomes
- Store hereditary information in genes

Nucleus



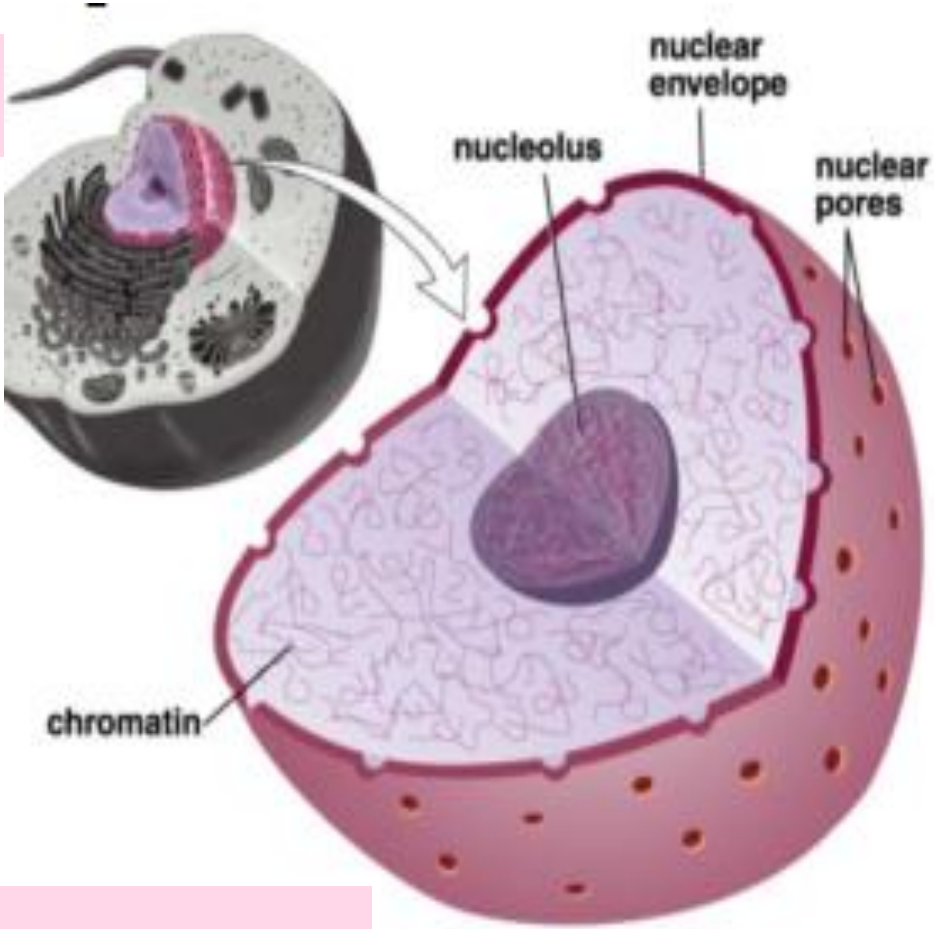
- Dense spherical body located near the centre of the cell
- Diameter varies from 10-25 µm
- Present in all the cells except red blood cells and sieve tube cells
- Well developed in plant and animal cells
- Undeveloped in bacteria and blue-green algae (cyanobacteria)
- Most of the cells are uninucleated (having only one nucleus)
- Few types of cells have more than one nucleus (skeletal muscle cells)

Nucleus



- Nucleus has a double layered covering called nuclear membrane
- Nuclear membrane has pores of diameter about 80-100 nm
- Colourless dense sap present inside the nucleus known as nucleoplasm
- Nucleoplasm contains round shaped nucleolus and network of chromatin fibres
- Fibres are composed of deoxyribonucleic acid (DNA) and protein histone
- These fibres condense to form chromosomes during cell division

Nucleolus



-An organelle in the nucleus

-A region that produces ribosomes which make proteins

Function: Takes RNA and makes ribosomes

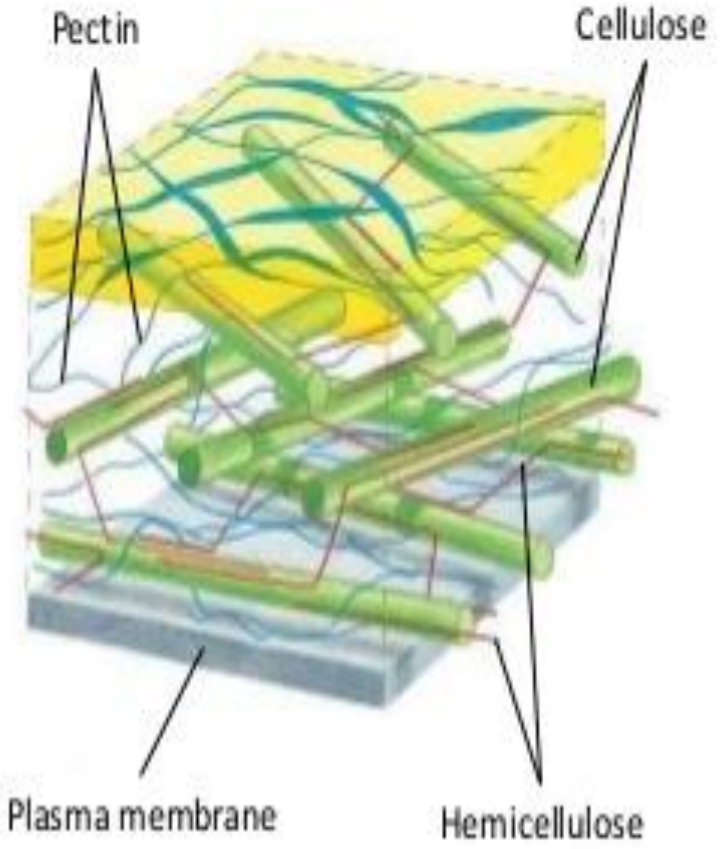
Structure: Dense region inside the nucleus

Nuclear Envelope

-Adouble membrane that surrouds the nucleus

- Has large pores so materials can pass back & forth between the nucleus & the rest of the cell

Cell wall



- Non-living and outermost covering of a cell (plants & bacteria)
- Can be tough, rigid and sometimes flexible
- Made up of cellulose, hemicellulose and pectin
- May be thin or thick, multilayered structure
- Thickness varies from 50-1000 A˚

Functions:

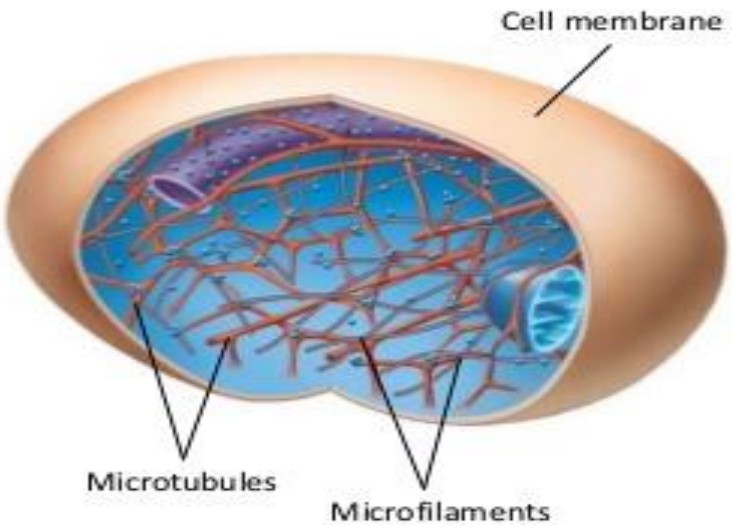
- Provides definite shape, strength & rigidity
- Prevents drying up(desiccation) of cells
- Helps in controlling cell expansion
- Protects cell from external pathogens

Cytoplasm /Cytosol

- Jelly-like material formed by 80 % of water
- Present between the plasma membrane and the nucleus
- Contains a clear liquid portion called cytosol and various particles
- Particles are proteins, carbohydrates, nucleic acids, lipids and inorganic ions
- Also contains many organelles with distinct structure and function
- Some of these organelles are visible only under an electron microscope
- Granular and dense in animal cells and thin

- Suspends the organelles.

Cytoskeleton

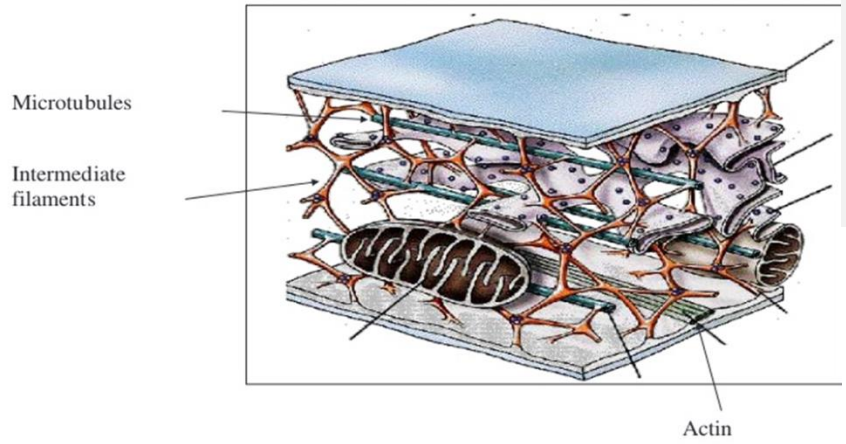


- Formed by microtubules and microfilaments
- Microtubules are hollow tubules made up of protein called tubulin
- Microfilaments are rod shaped thin filaments made up of protein called actin

Functions:

- Determine the shape of the cell
- Give structural strength to the cell
- Responsible for cellular movements

Cytoskeleton



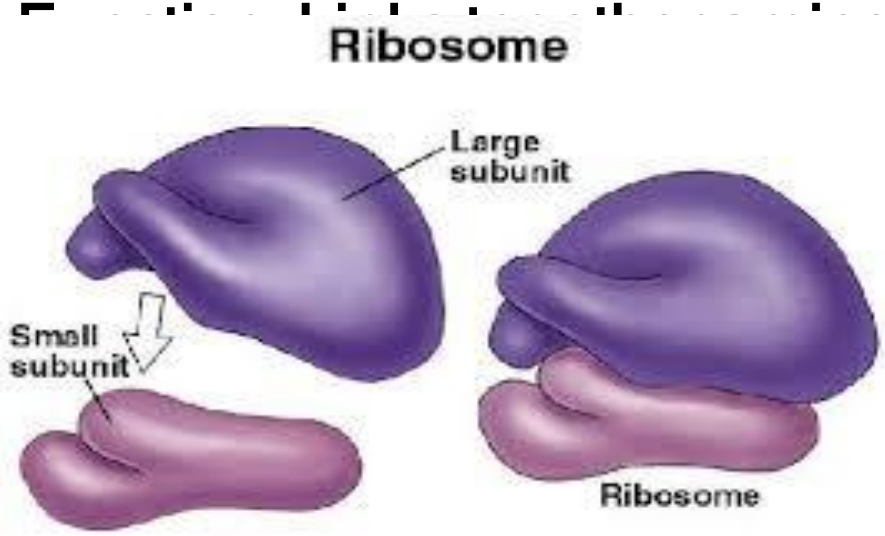
Structure: *A network of thin , fibrous elements made up of microtubules(hollow tubes) & microfilaments (threads made out of actin) & intermediate filaments.)*

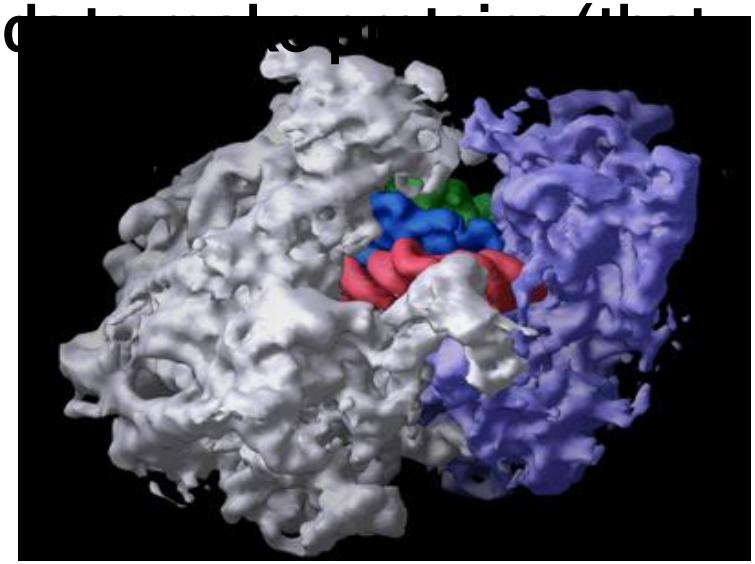
Function: *Act as a support system for organelle.*

Ribosomes

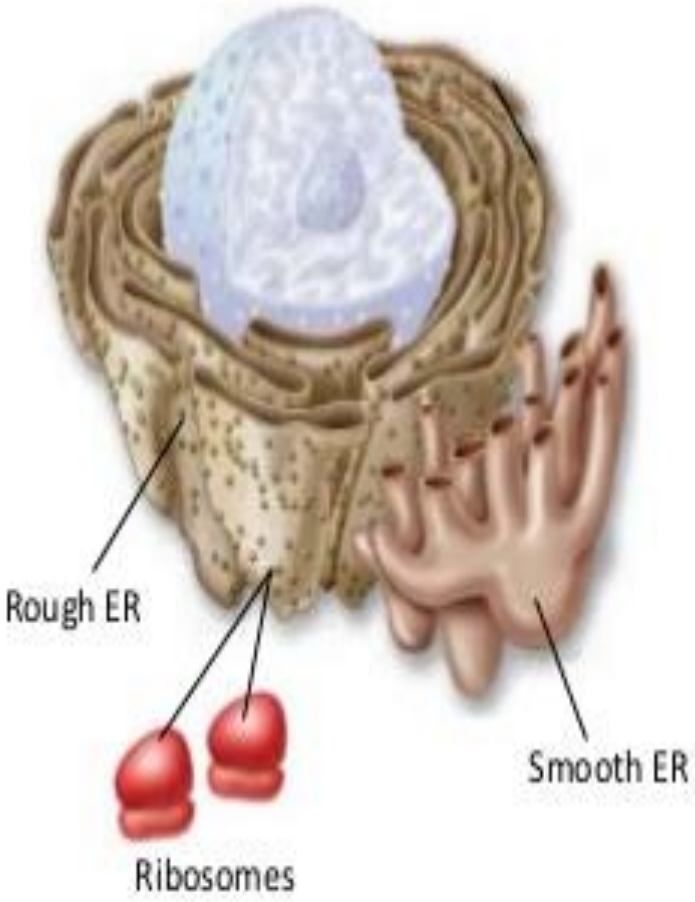
Although not bound by a membrane, they are considered organelles.

Structure: Tiny organelles made of proteins & RNA. Found on Rough ER





Endoplasmic Reticulum



- Network of tubular and vesicular structures which are interconnected with one another
- Some parts are connected to the nuclear membrane, while others are connected to the cell membrane
- Two types: smooth(lacks ribosomes) and rough(studded with ribosomes)

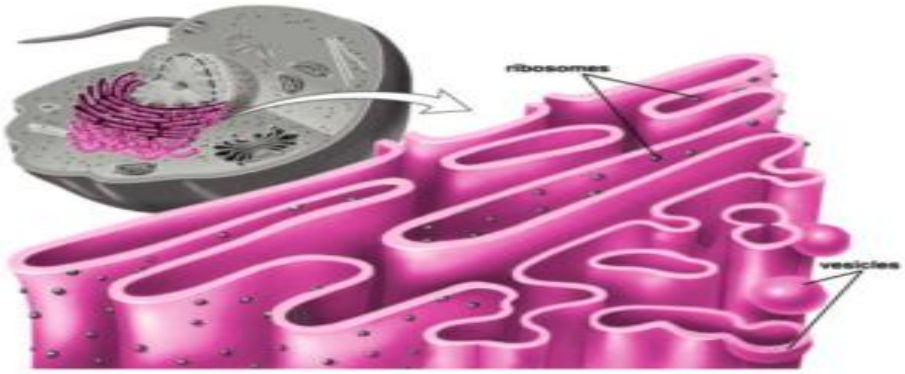
Functions:

- Gives internal support to the cytoplasm
- RER synthesize secretory proteins and membrane proteins
- SER synthesize lipids for cell membrane
- In liver cells SER detoxify drugs & poisons
- In muscle cells SER store calcium ions

Rough Endoplasmic Reticulum (RER)

Structure: Thin folded membranes that are connected together. HAS ribosomes

Function: Transpo[illegible]otein synthesis; makes more ER.

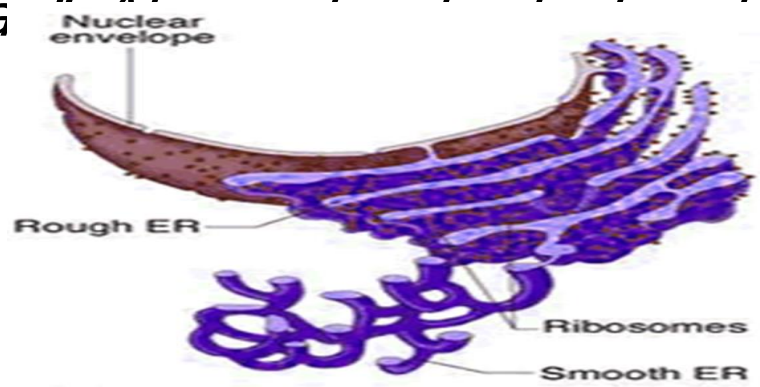


Smooth Endoplasmic Reticulum (SER)

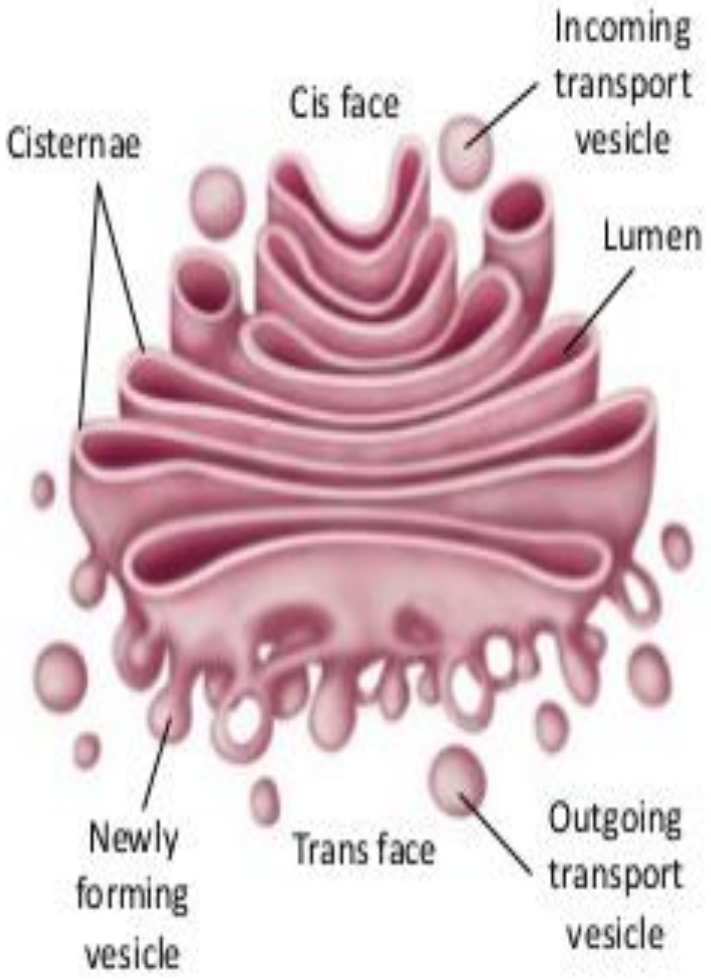
Structure: Thin folded membranes that are connected together. No ribosomes

***Functi**[illegible]va[illegible]*

down



Golgi body

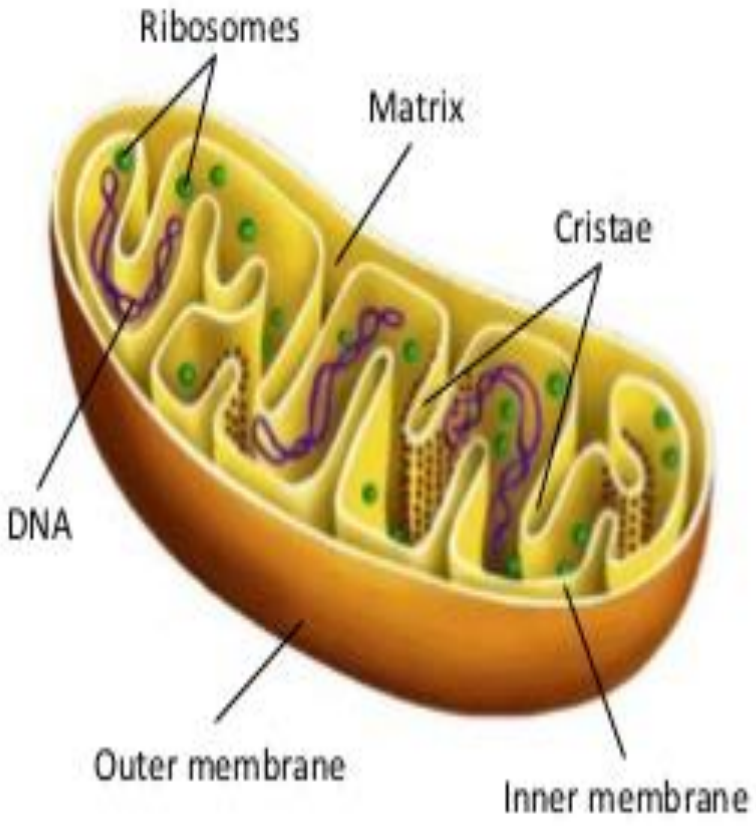


- Discovered by Camillo Golgi
- Formed by stacks of 5-8 membranous sacs
- Sacs are usually flattened and are called the cisternae
- Has two ends: cis face situated near the endoplasmic reticulum and trans face situated near the cell membrane

Functions:

- Modifies, sorts and packs materials synthesized in the cell
- Delivers synthesized materials to various targets inside the cell and outside the cell
- Produces vacuoles and secretory vesicles
- Forms plasma membrane and lysosomes

Mitochondria



- Small, rod shaped organelles bounded by two membranes - inner and outer
- Outer membrane is smooth and encloses the contents of mitochondria
- Inner membrane is folded in the form of shelf like inward projections called cristae
- Inner cavity is filled with matrix which contains many enzymes
- Contain their own DNA which are responsible for many enzymatic actions

Functions:

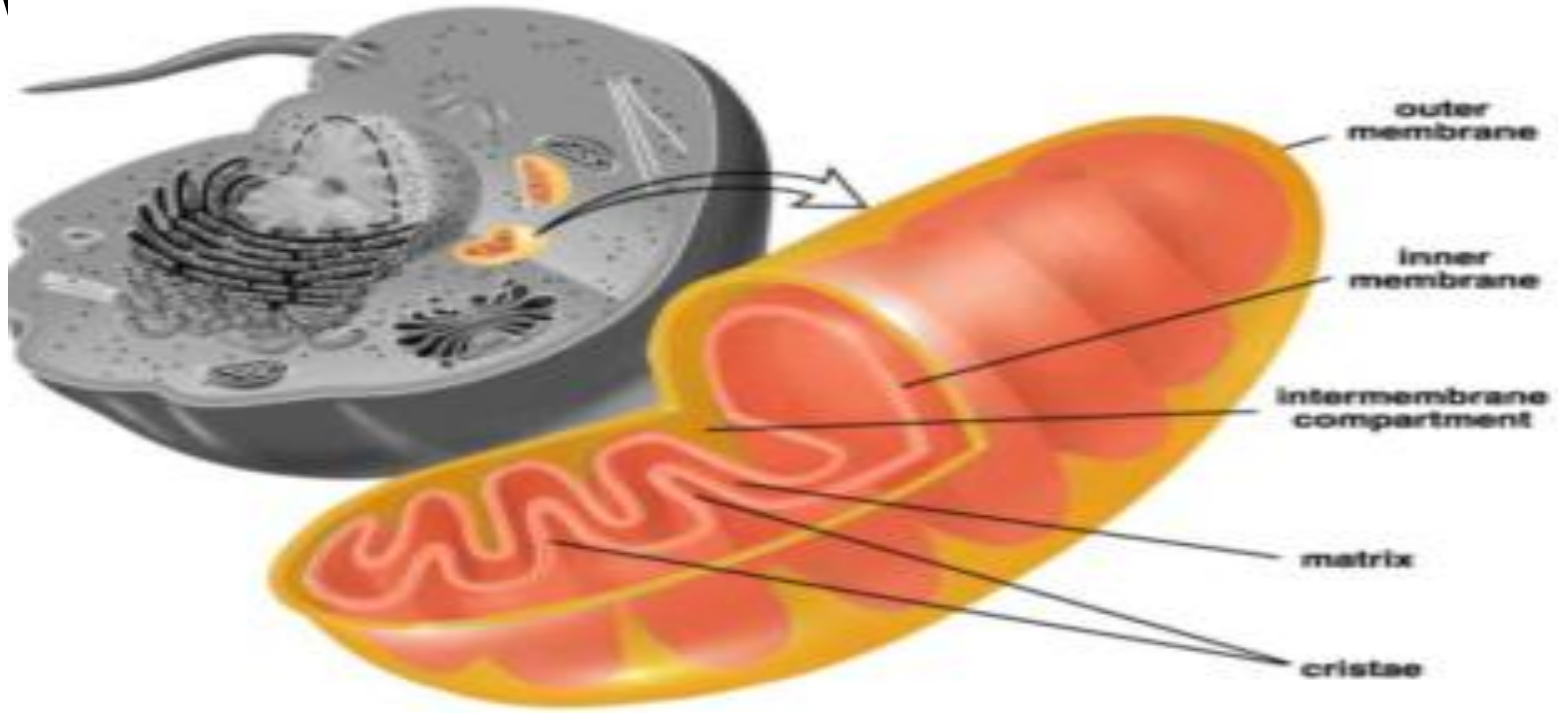
- Synthesize energy rich compound ATP
- ATP molecules provide energy for the vital activities of living cells

- Cellular respiration

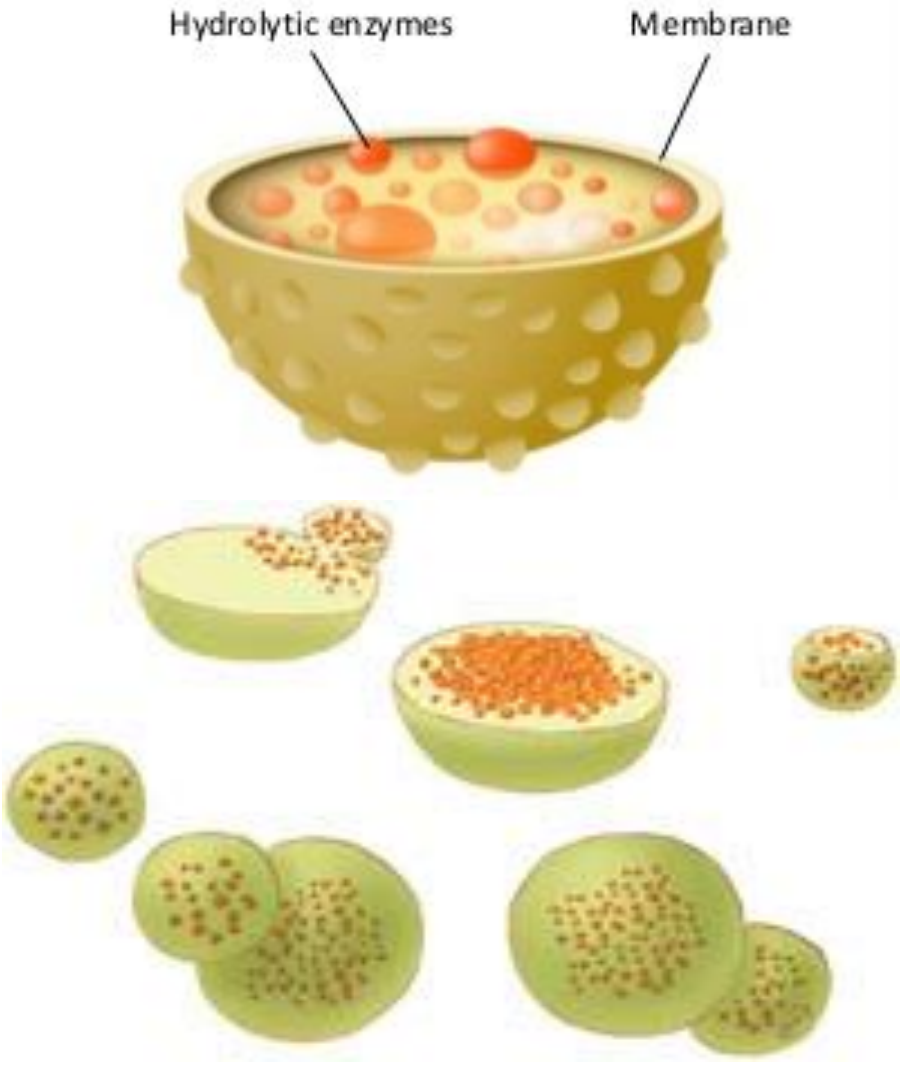
Mitochondria

Structure: Bean shaped; 2 membranes; has own DNA & ribosomes.

Function: Supplies <u>energy</u> to the cell:site of cellular respiration; 'pow[illegible]'



Lysosomes



- Small, spherical, single membrane sac
- Found throughout the cytoplasm
- Filled with hydrolytic enzymes
- Occur in most animal cells and in few type of plant cells

Functions:

- Help in digesting of large molecules
- Protect cell by destroying foreign invaders like bacteria and viruses
- Degradation of worn out organelles
- In dead cells perform autolysis

Structure: Contains enzymes; membrane bound

Function: Breaks down food, waste & damaged cell parts all within the cell.

Peroxisome

Structure: Contains enzymes; membrane bound

Function: Protects cell from toxins, especially H_2O_2.

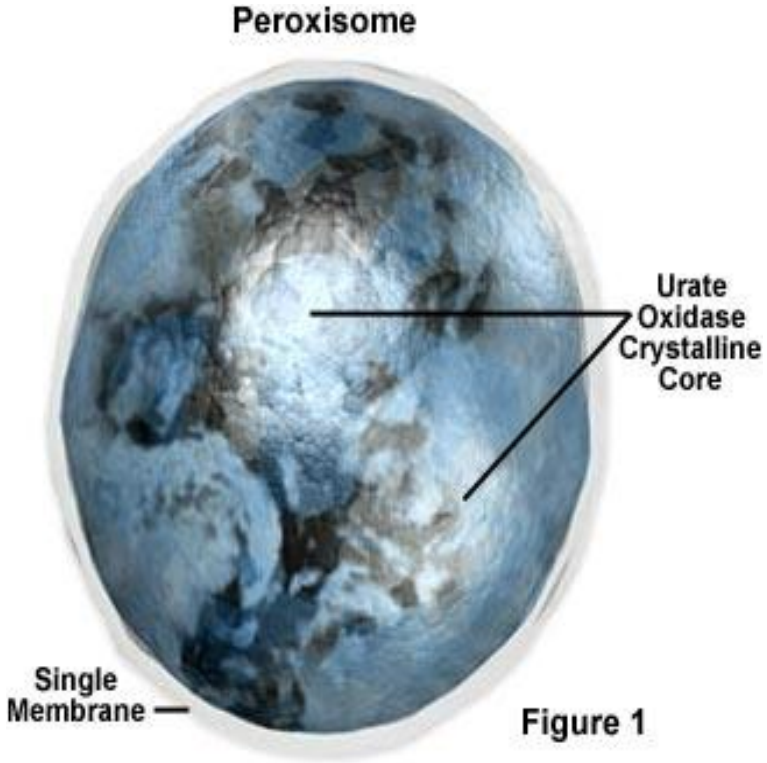
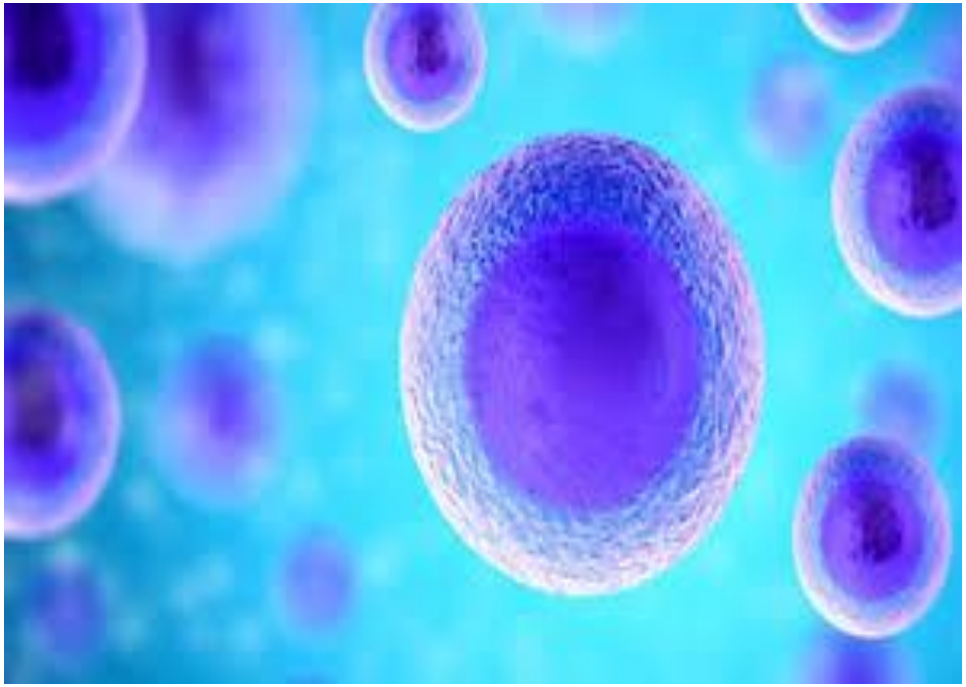


Figure 1



Flagella, Cilia & Microvilli

Structure:hair- like organelles that extend from the surface of cells.

- when they are present in large numbers on a cell,

they are called cilia(Plural)

*(single:cilium):*Tiny hair-like projections on cell exterior used for movement and gathering food.

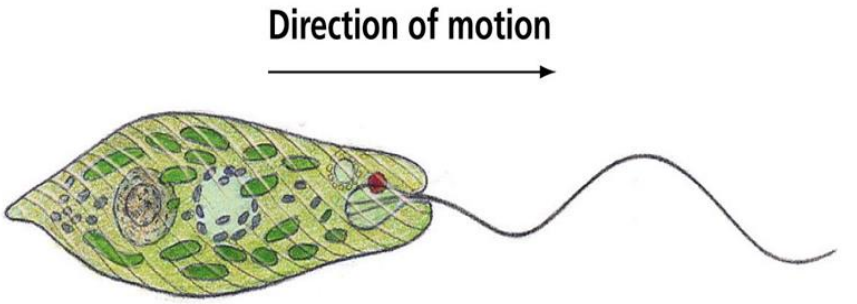
-when they are occuring only one per cell, they are called flagella(Pl.) (single:flagellum)

Microvilli(single :Microvillus) : speialized extentions of the cell membrane that are supported by microfilaments.

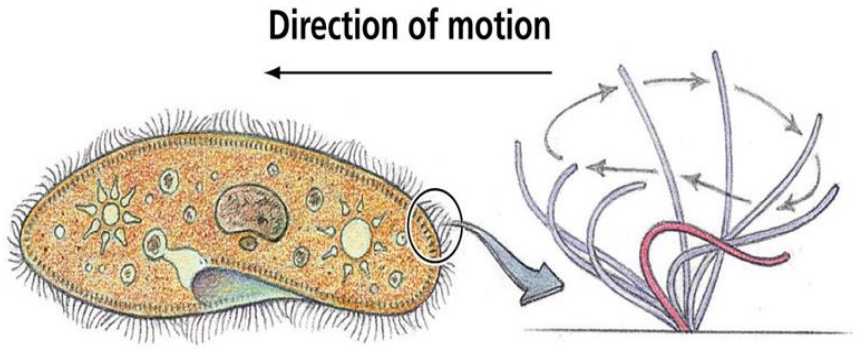
Abundant on the surface of cells in which absorption is an important functions.

Function : cell motility.

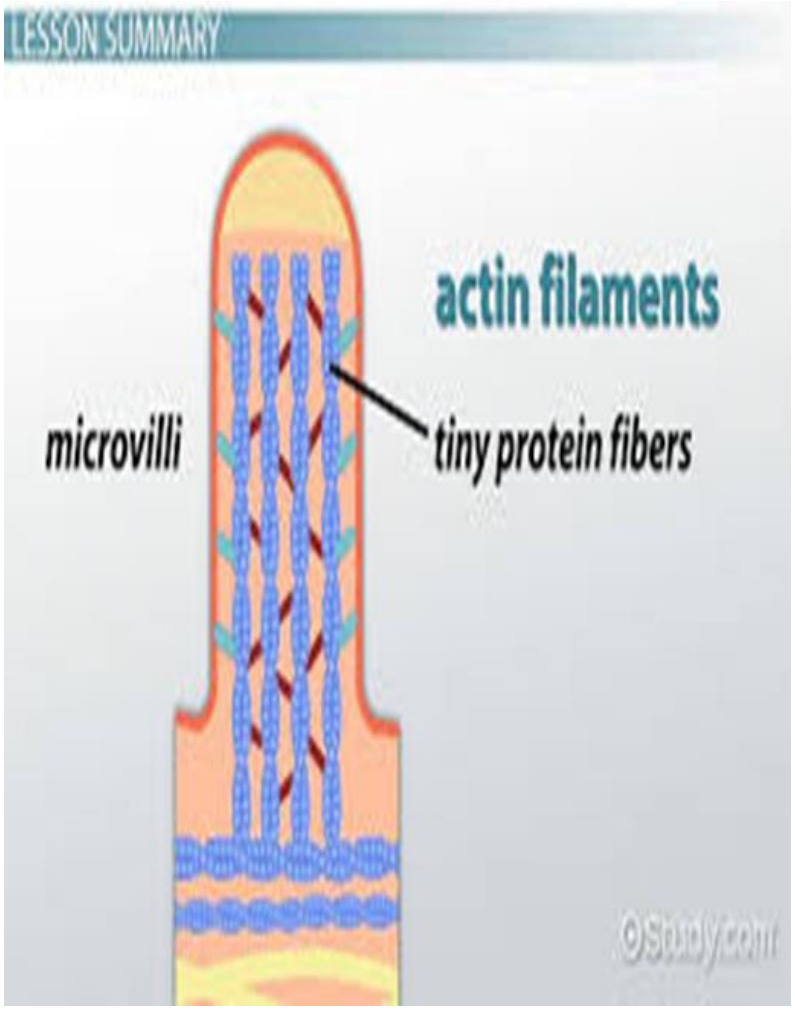
Flagella, Cilia & Microvilli



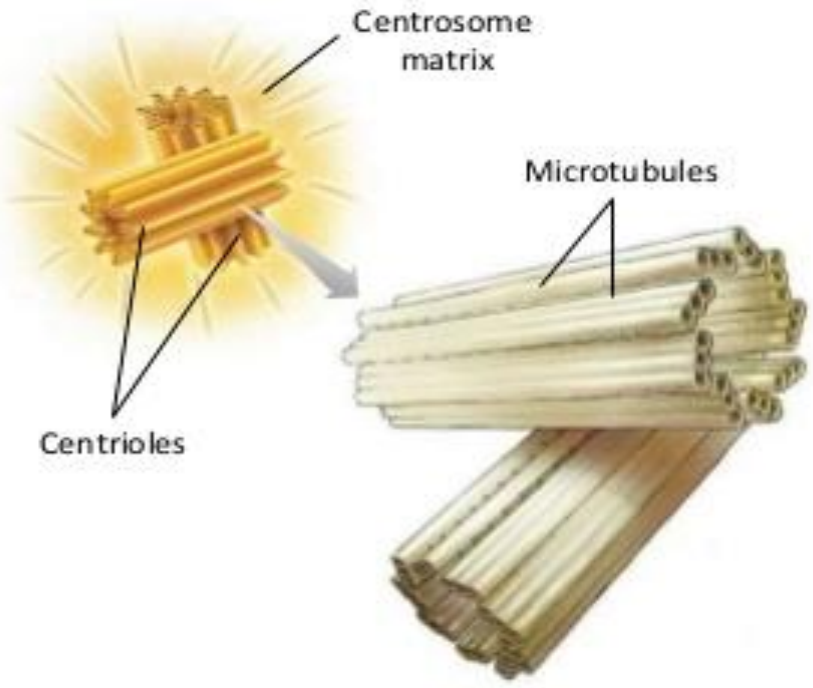
(a) Flagella



(b) Cilia



Centrosome



- Centrosome is the membrane bound organelle present near the nucleus
- Consists of two structures called centrioles
- Centrioles are hollow, cylindrical structures made of microtubules
- Centrioles are arranged at right angles to each other

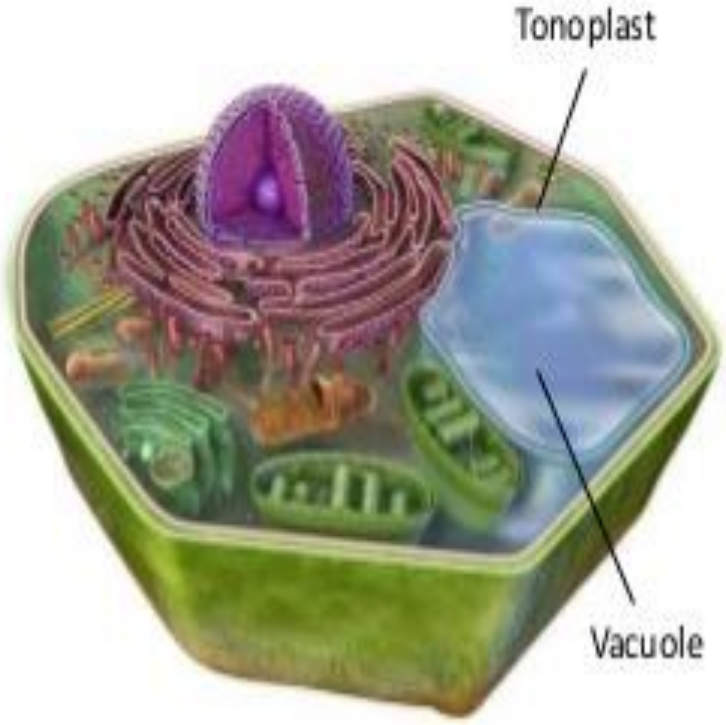
Functions:

- Form spindle fibres which help in the movement of chromosomes during cell division
- Help in the formation of cilia and flagella

Centrosome: *is a specialized zone of cytoplasm close to the nucleus which microtubule formation occurs. It contains 2 – centrioles which are normally oriented perpendicular to each other.*

Centrioles : *Is small , cylindrical organelle composed of*

Vacuoles



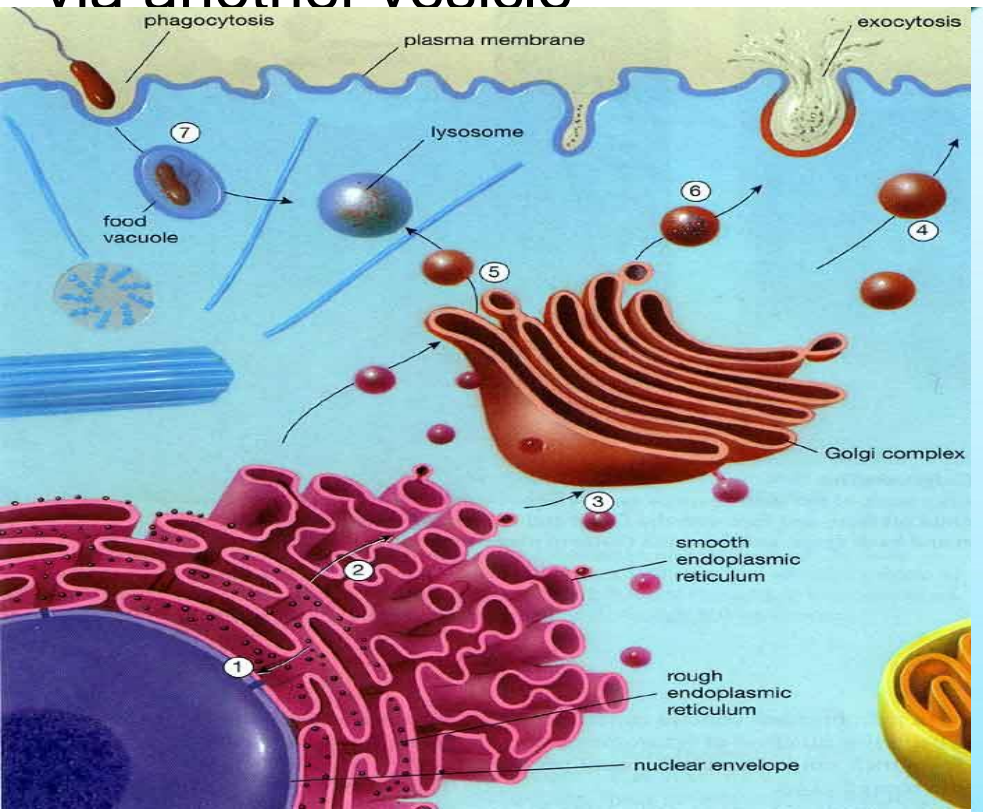
- Single membrane sac filled with liquid or sap (water, sugar and ions)
- In animal cells, vacuoles are temporary, small in size and few in number
- In plant cells, vacuoles are large and more in number
- May be contractile or non-contractile

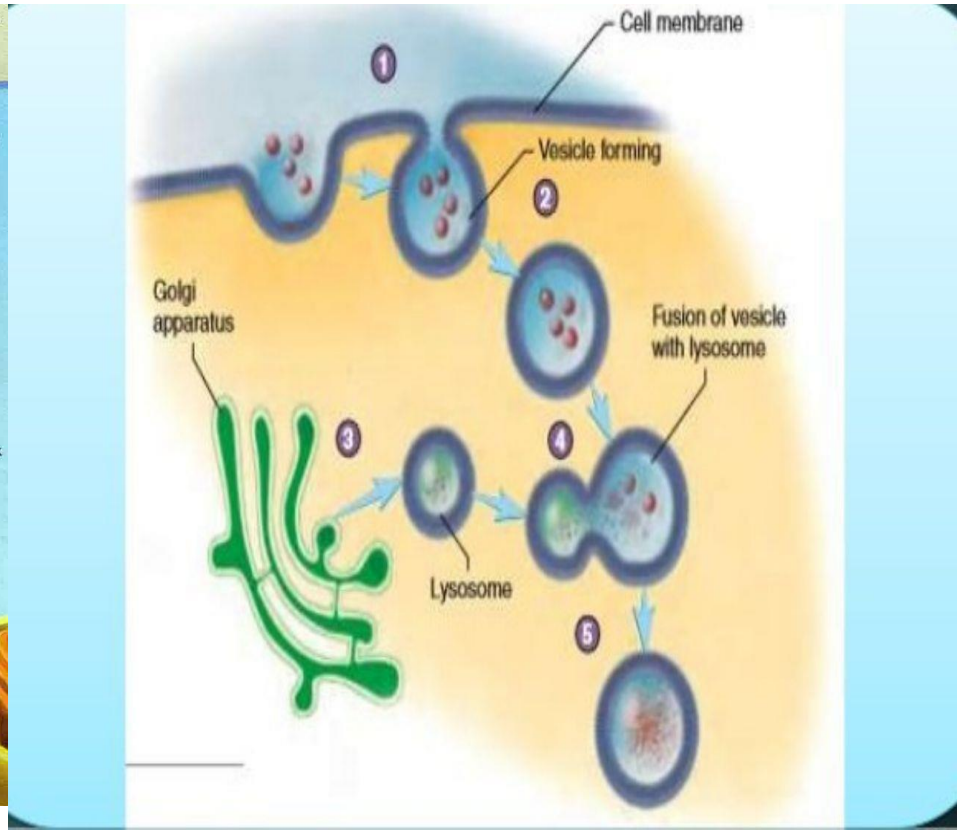
Functions:

- Store various substances including waste products
- Maintain osmotic pressure of the cell
- Store food particles in amoeba cells
- Provide turgidity and rigidity to plant cells

Vesicle

Vesicles *are small spheroidal packages that bud off of the RER and the Golgi apparatus.*
They carry proteins produced by ribosomes on the RER to the Golgi apparatus, where they are prepared for export from the cell via another vesicle



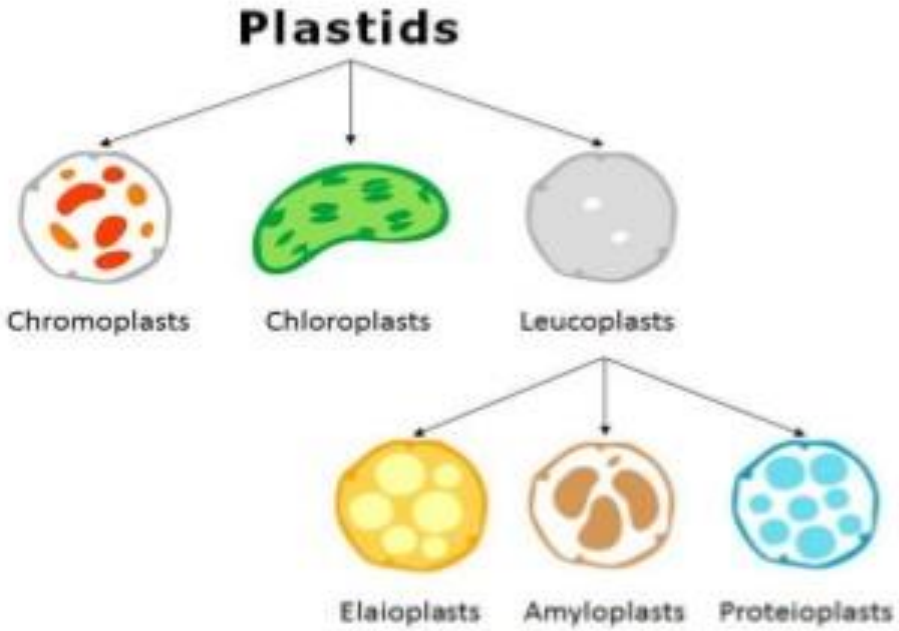


Plastids

Plastids are double membrane-bound organelles found inside plants and some algae.

They are responsible for activities related to making and storing food.

They often contain different types of pigments that can change the colour of the cell.



Function: Storage sacs in plant cells only .

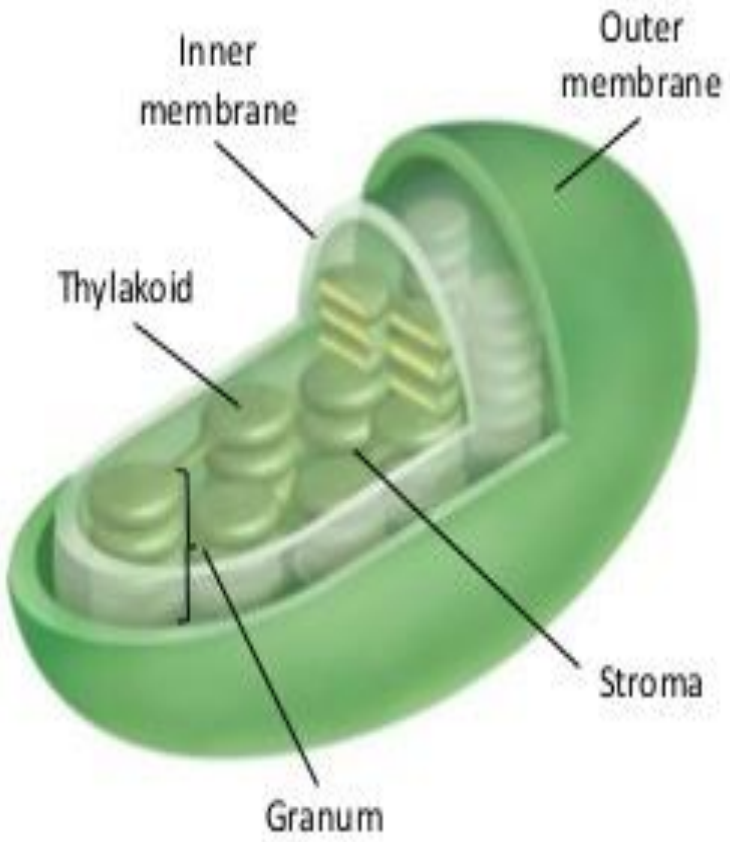
There are 3 different type of plastids:

1-Leucoplast - stores starch in roots & stems

2-Chromoplast - stores the orange/yellow pigment

3.Chloroplast- stores the green pigment/ site of photosynthesis

Chloroplasts



- Double membrane-bound organelles found mainly in plant cells
- Usually spherical or discoidal in shape
- Shows two distinct regions-grana and stroma
- Grana are stacks of thylakoids (membrane-bound, flattened discs)
- Thylakoids contain chlorophyll molecules which are responsible for photosynthesis
- Stroma is a colourless dense fluid

Functions:

- Convert light energy into chemical energy in the form of food
- Provide green colour to leaves, stems and vegetables

Chromoplasts

Chromoplasts are plastids that produce and store pigments

They are responsible for different colours found in leaves, fruits, flowers and vegetables.

Carrot

Pigment: Carotene

Mango

Pigment: Xanthophyll

Tomato

Pigment: Lycopene

Leucoplasts

Leucoplasts are colourless plastids that store foods.

They are found in storage organs such as fruits, tubers and seeds.

Potato tubers

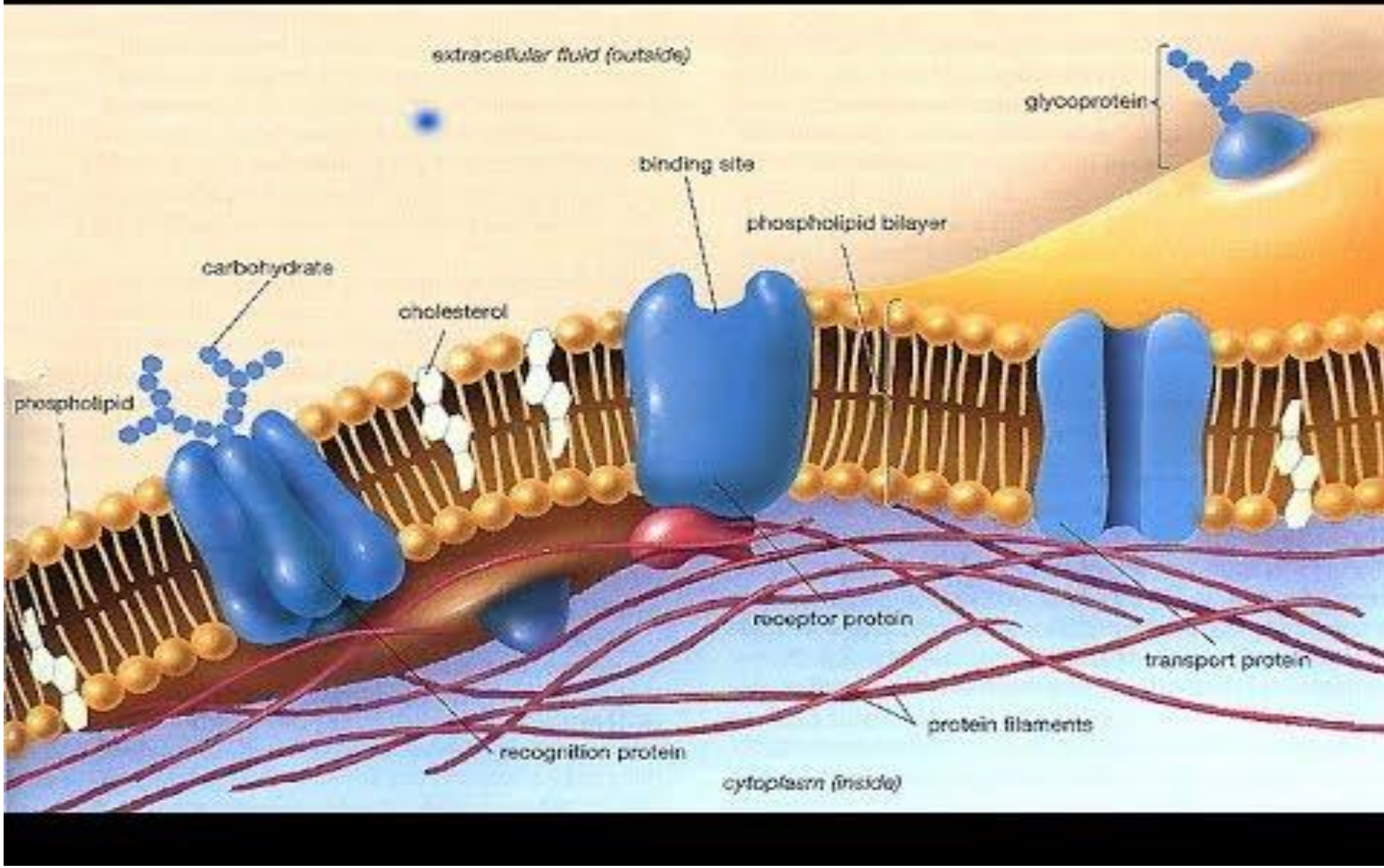
Food: Starch

Maize grains

Food: Protein

Castor seeds

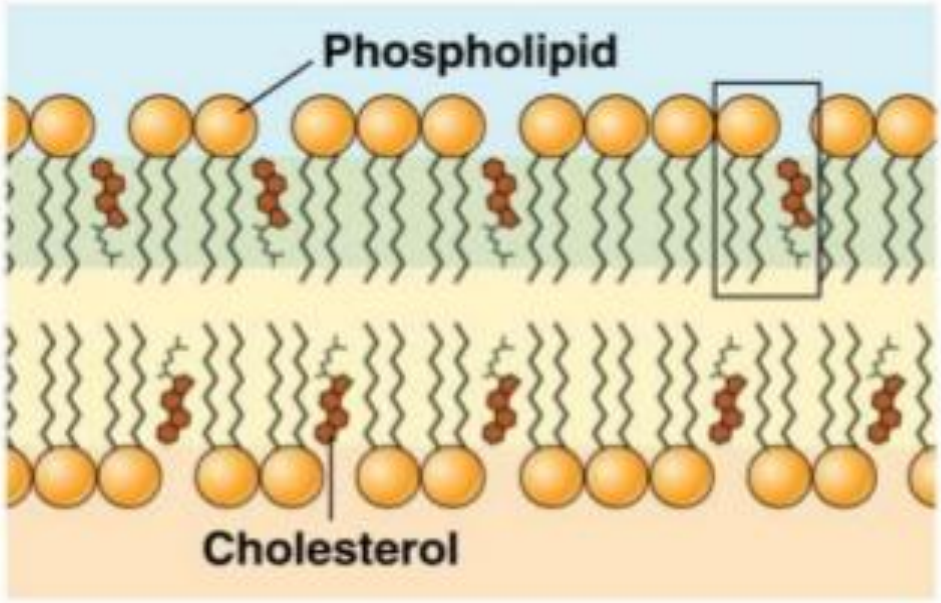
Food: Oil



1972- S.J. Singer and G. Nicolson propose membrane is a "mosaic" of proteins and phospholipids that are constantly moving and changing

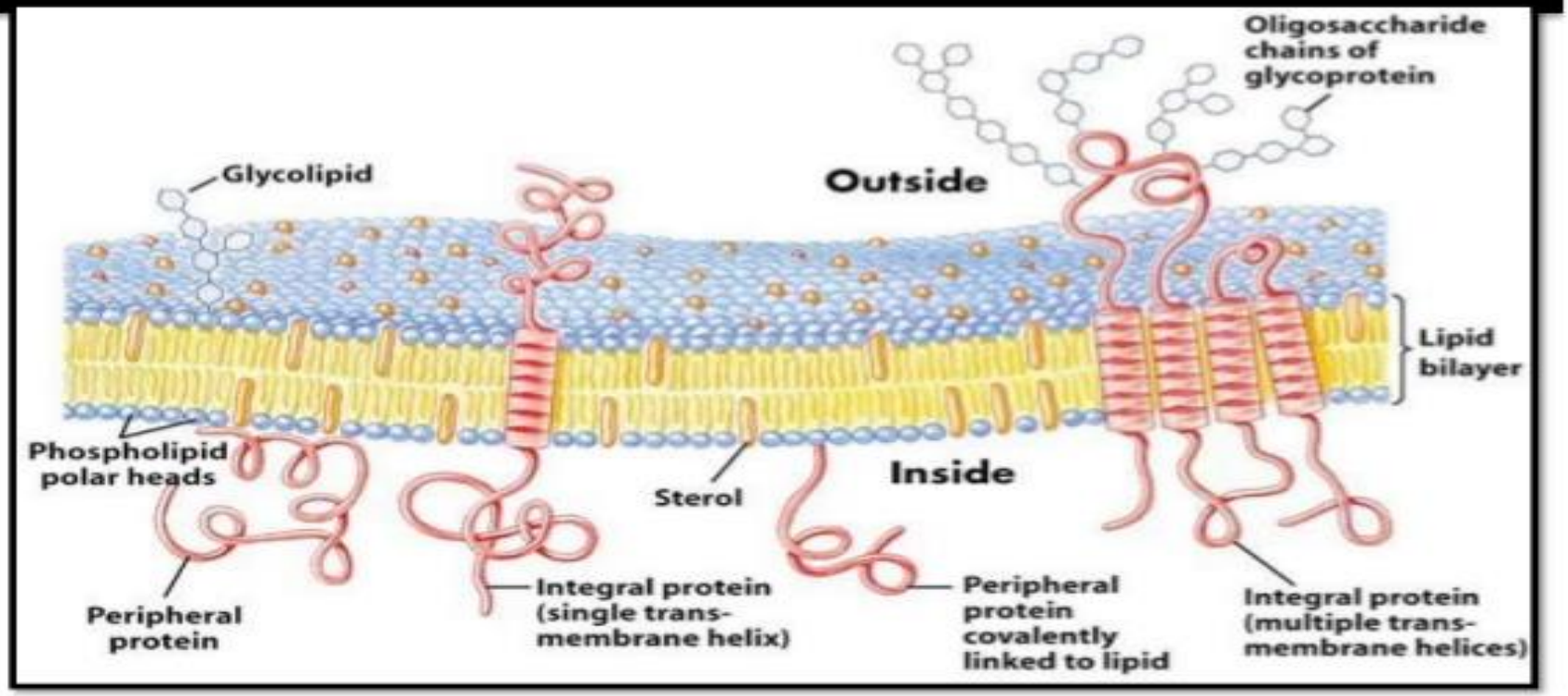
Other Components of the Membrane

- Cholesterol is also found in the plasma membrane, where it helps to stabilize the phospholipids by preventing their fatty acid tails from sticking together.



(a) Cholesterol in plasma membrane

Membrane Structure



Nelson & Cox, *Lehninger Principles of Biochemistry, 4th ed., Fig. 11-3*

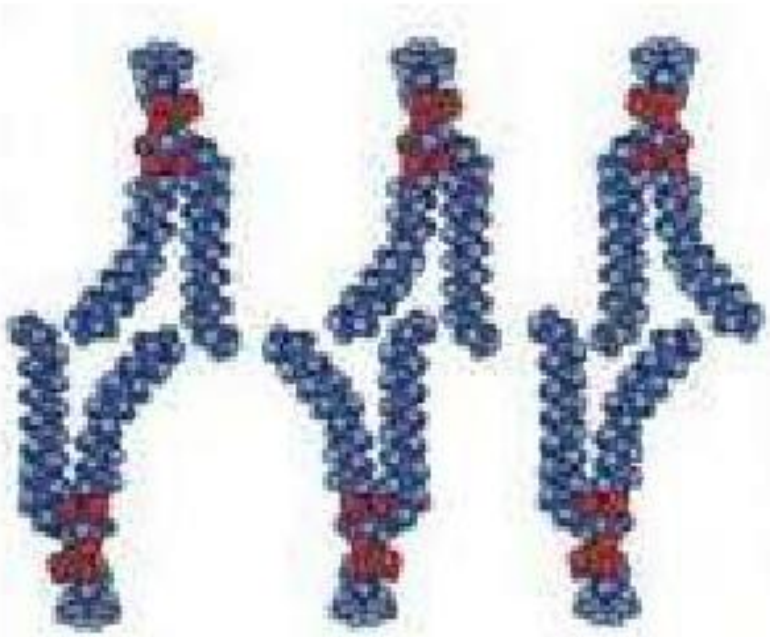
Functions of plasma membrane :

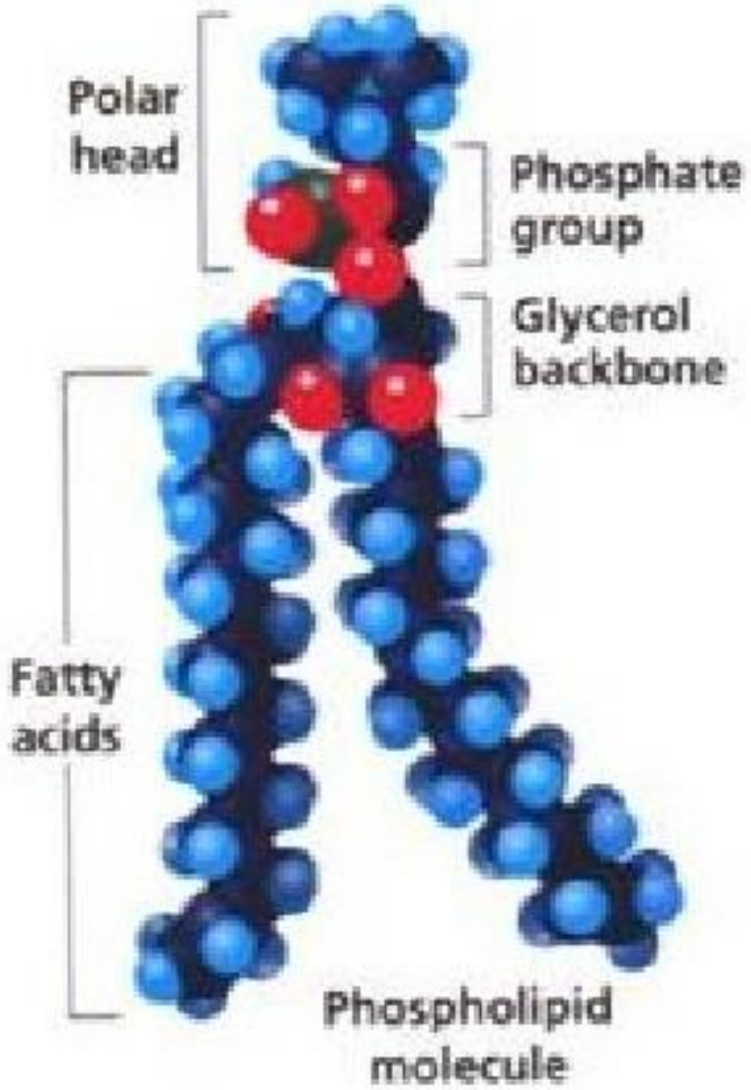
1. Barrier 2. slectivity 3. molecular recognition.

4.Export of wasts & cell products. 5. Import of nutrients.

6. Change in response to its environment

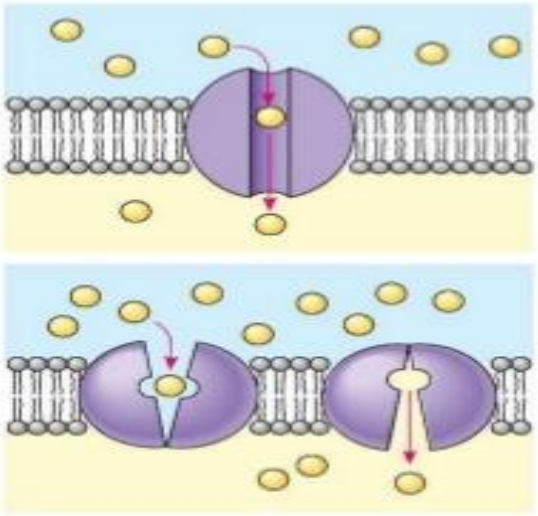
Phospholipid Molecule

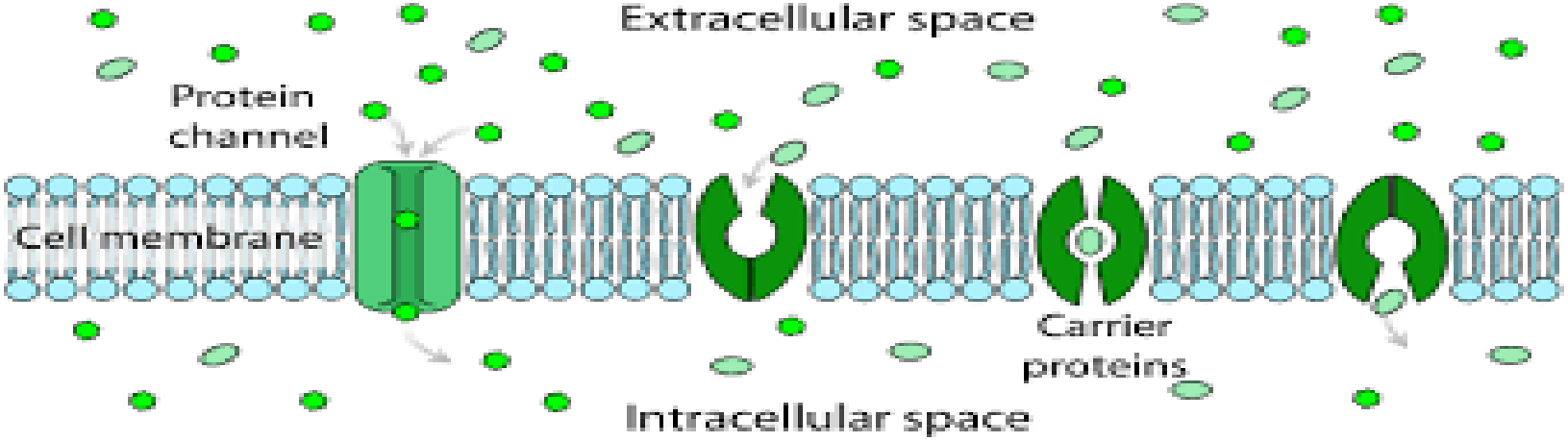




Types of Transport Proteins

- Channel proteins are embedded in the cell membrane & have a pore for materials to cross
- Carrier proteins can change shape to move material from one side of the membrane to the other





Classes of membrane proteins

- **Integral** proteins (includes lipid-linked): need detergents to remove
- **Peripheral** proteins: removed by salt, pH changes
- **Amphitropic** proteins: sometimes attached, sometimes not

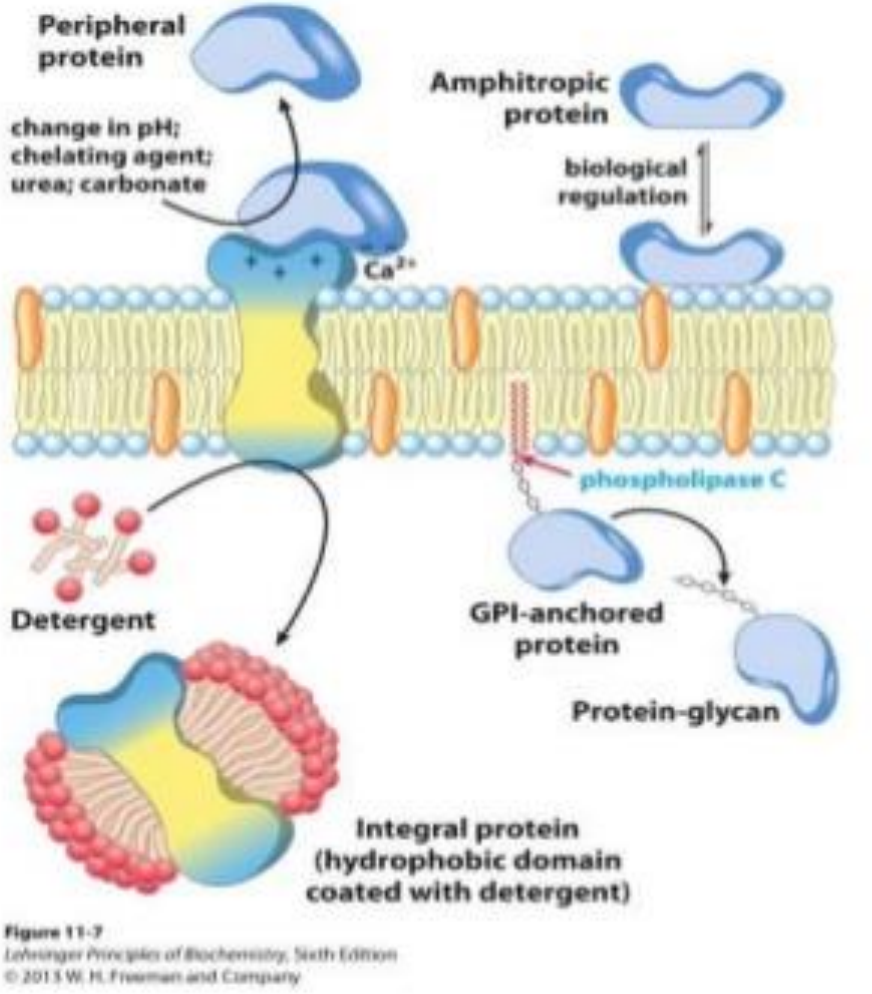
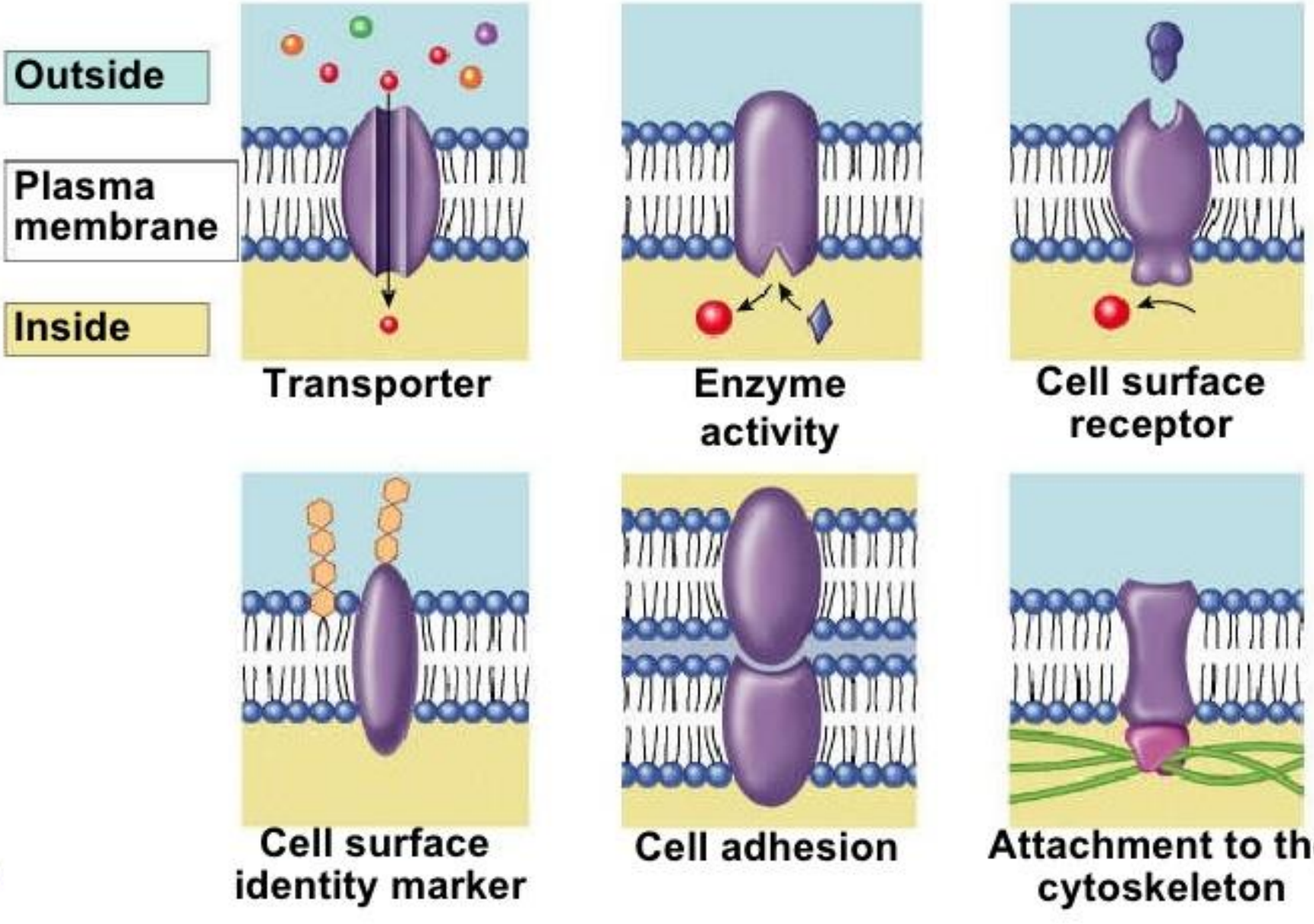


Figure 11-7
Lehninger Principles of Biochemistry, Sixth Edition
© 2013 W. H. Freeman and Company

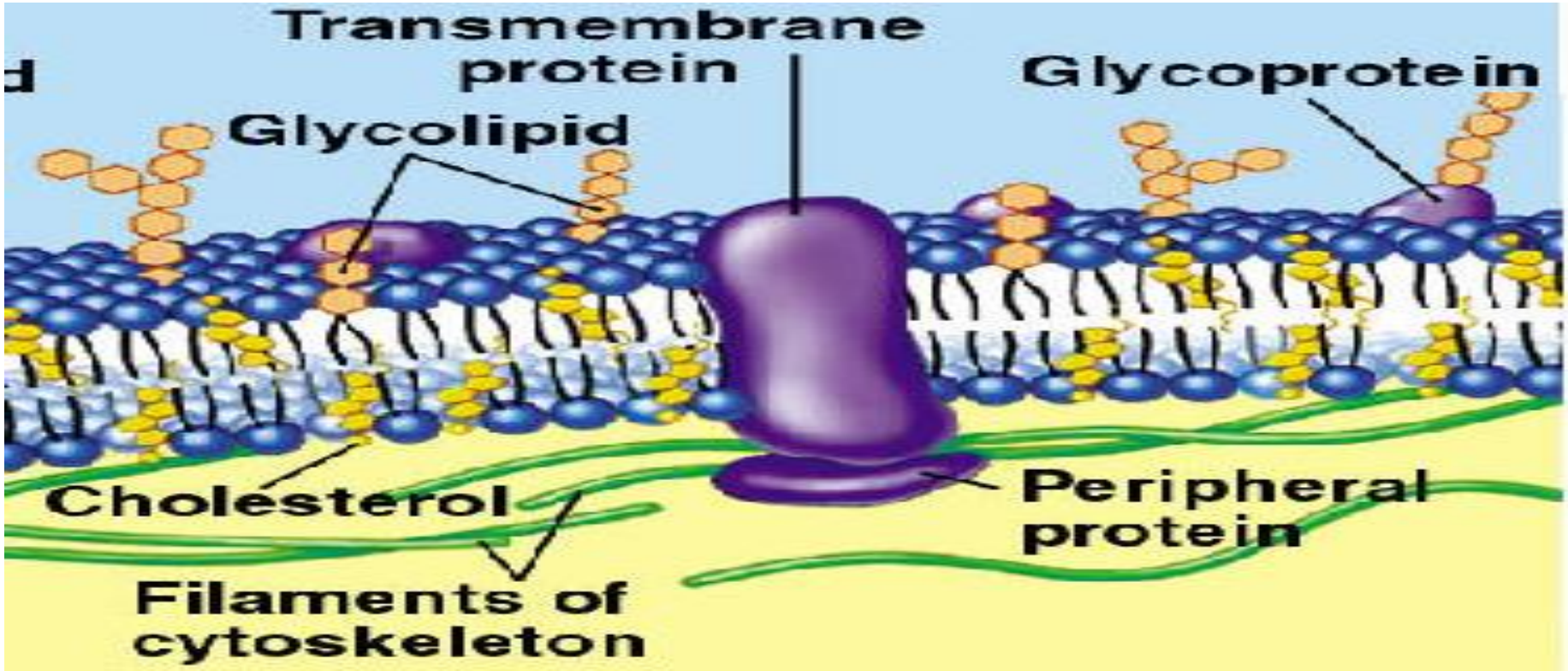
Many Functions of Membrane Proteins



Membrane Carbohydrates

-Attached to proteins (glycoproteins) or lipids (glycolipids)

-Play a key role in cell-cell recognition ability of a cell to distinguish neighboring cells from another important in organ &tissue development basis for rejection of foreign cells by immune system.

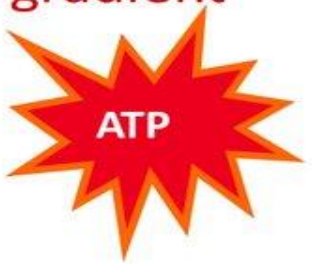


Cellular transport

Getting through cell membrane

- Passive Transport
  - Simple diffusion
    - diffusion of nonpolar, hydrophobic molecules
      - lipids
      - high → low concentration gradient
  - Facilitated transport
    - diffusion of polar, hydrophilic molecules
    - through a protein channel
      - high → low concentration gradient
- Active transport
  - diffusion *against* concentration gradient
    - low → high
  - uses a protein pump
  - requires ATP

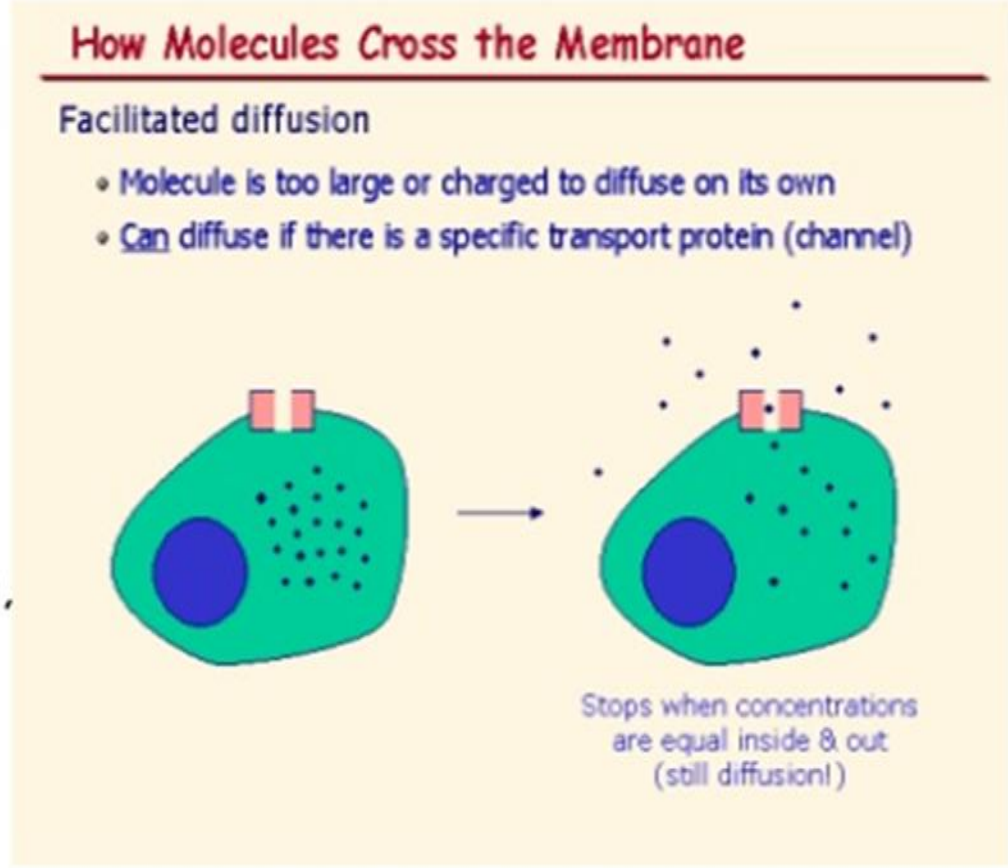
-Osmosis (diffusion of water)from high to low →



Facilitated diffusion

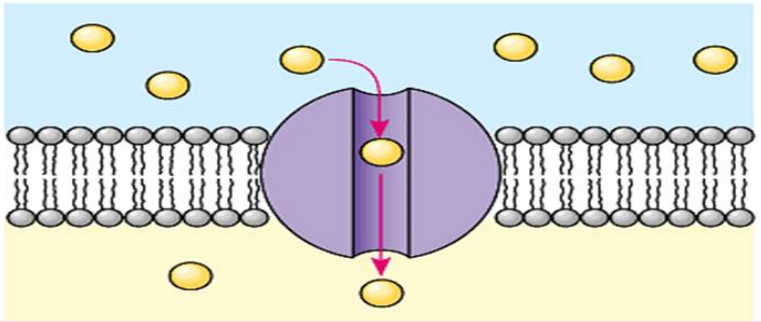
Facilitated diffusion

- Large polar molecules such as glucose and amino acids, cannot diffuse across the phospholipid bilayer. Also ions such as Na^+ or Cl^- cannot pass.
- These molecules pass through protein channels instead. Diffusion through these channels is called FACILITATED DIFFUSION.
- Movement of molecules is still PASSIVE just like ordinary diffusion, the only difference is, the molecules go through a protein channel instead of passing between the phospholipids.

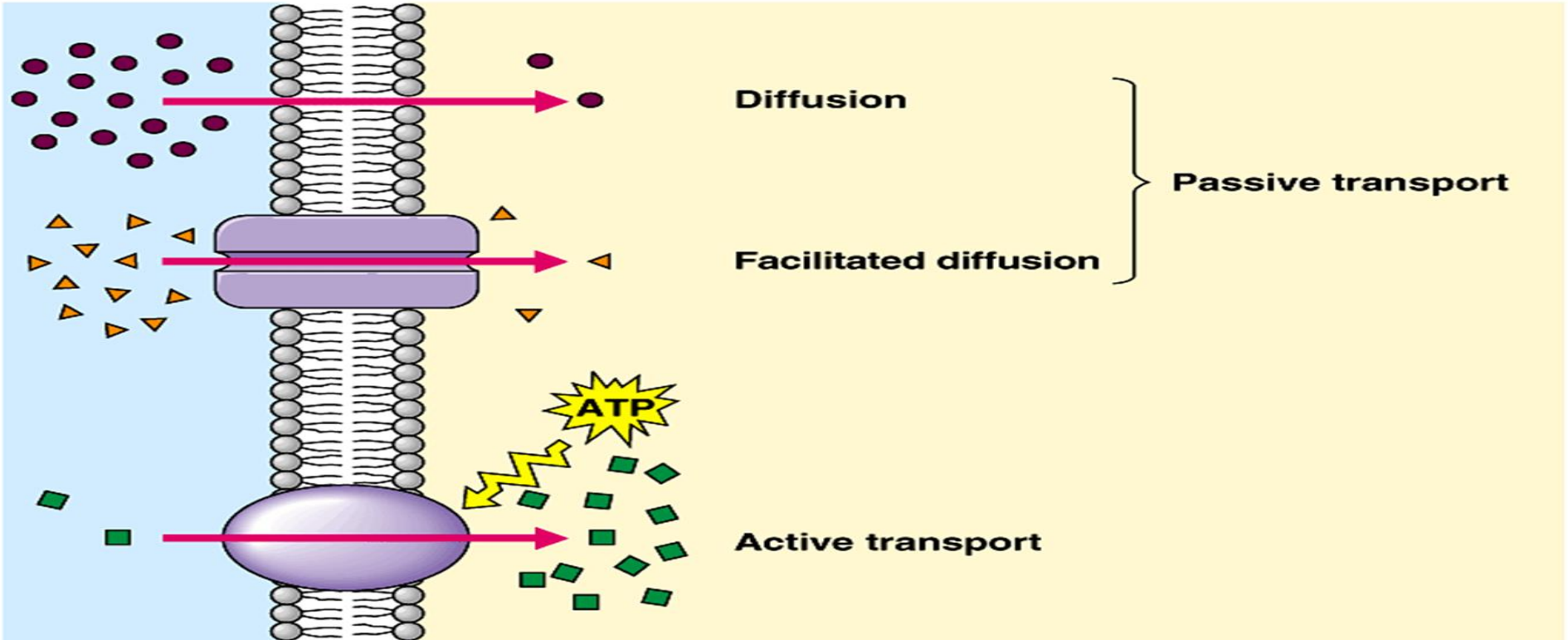


Cellular transport

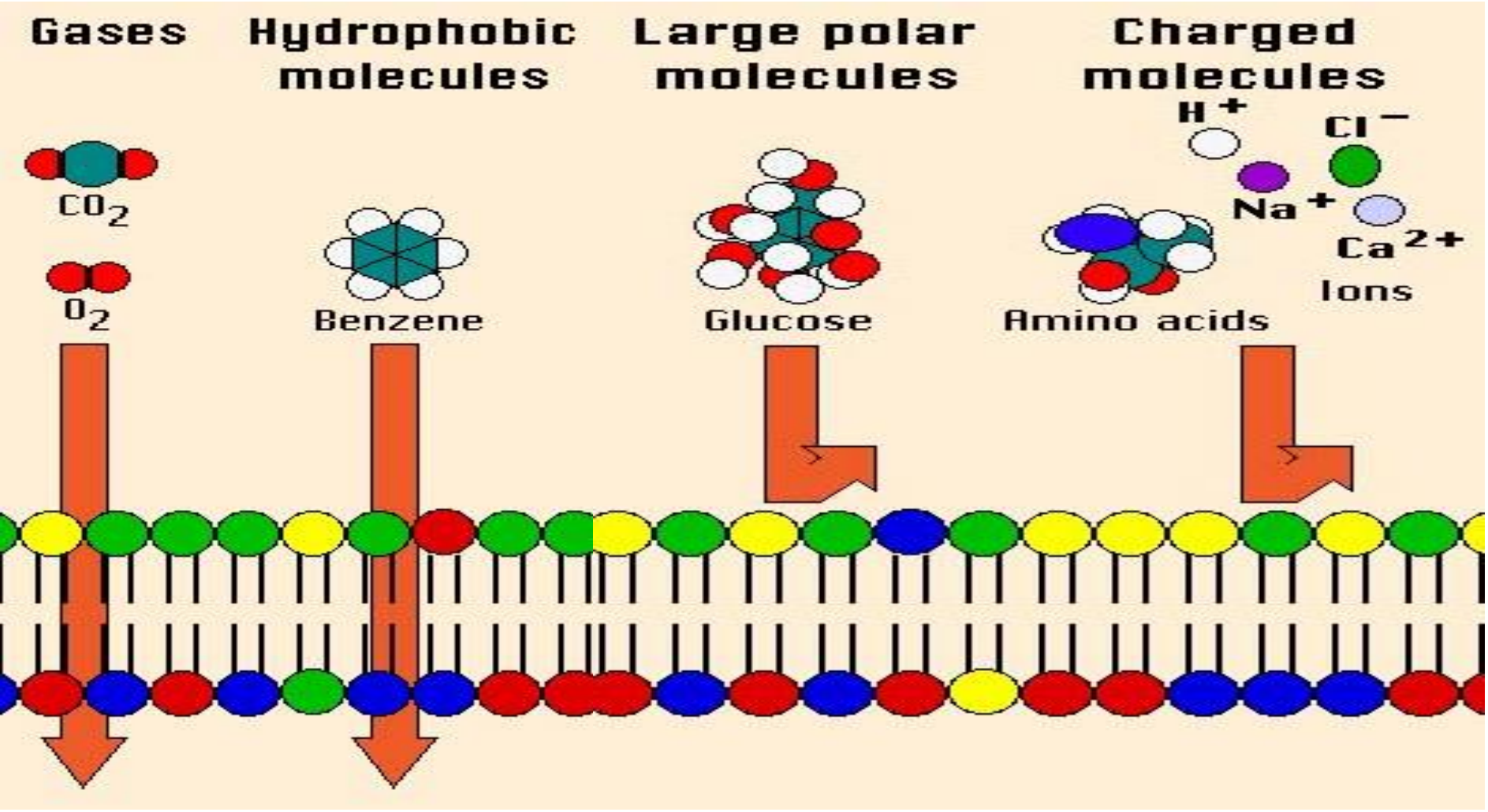
Move from HIGH to LOW concentration with aid of membrane transport proteins.
-passive transport. -no energy



Transport summary

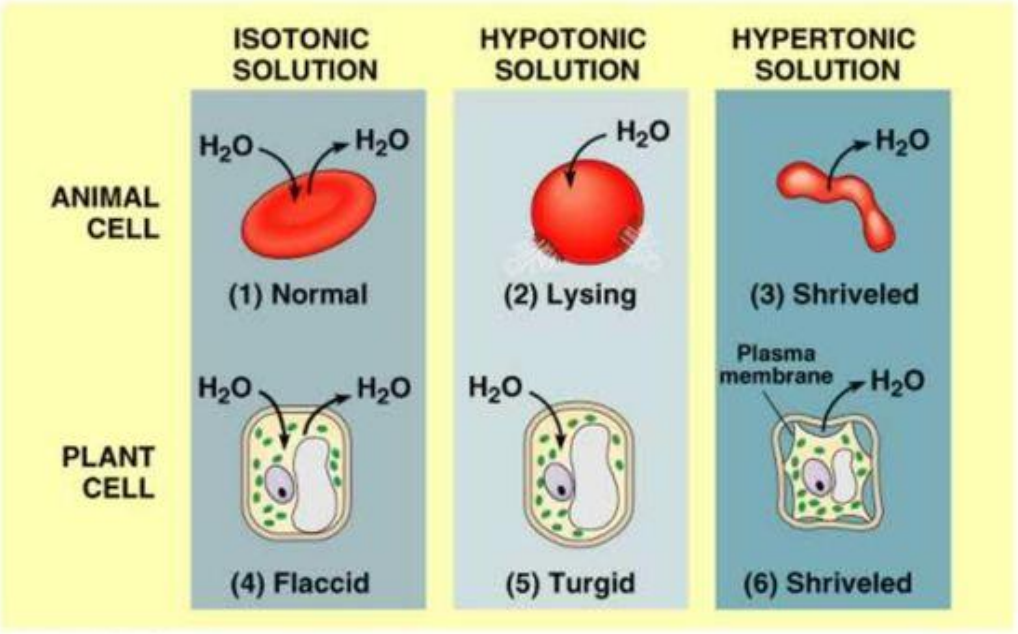


PHOBIC TAILS in center determine what can pass through

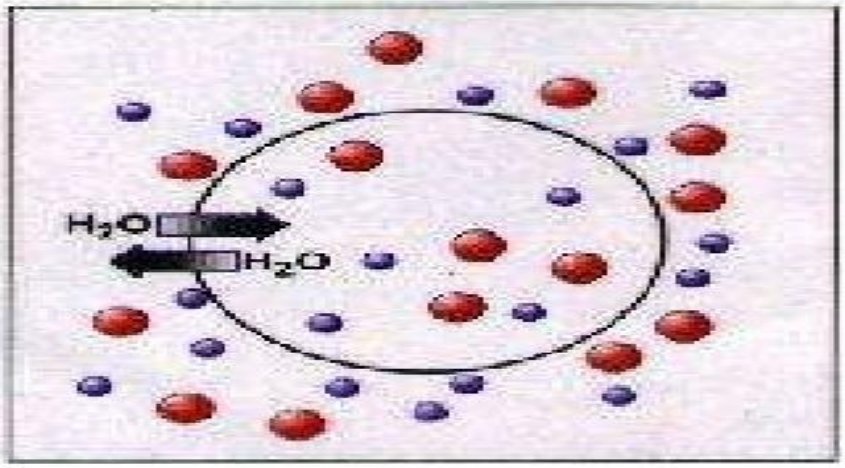


Tonicity

Tonicity: the concentration of solutes (dissolved substances) in a solution on either side of the membrane

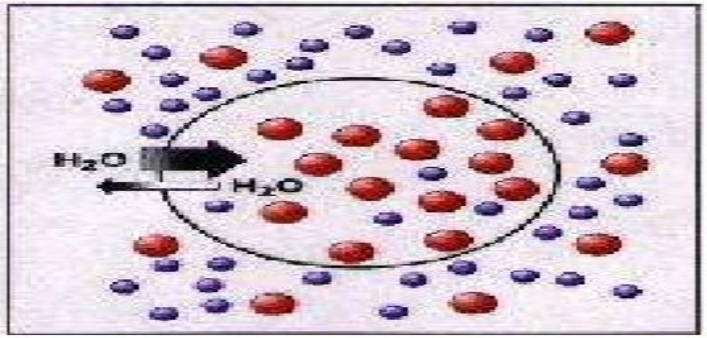


Isotonic Solution



- A solution in which the concentration of dissolved substances is the **same as** the concentration inside the cell
- Although water molecules move into and out of the cell, there is no net movement.
- No osmosis occurs.

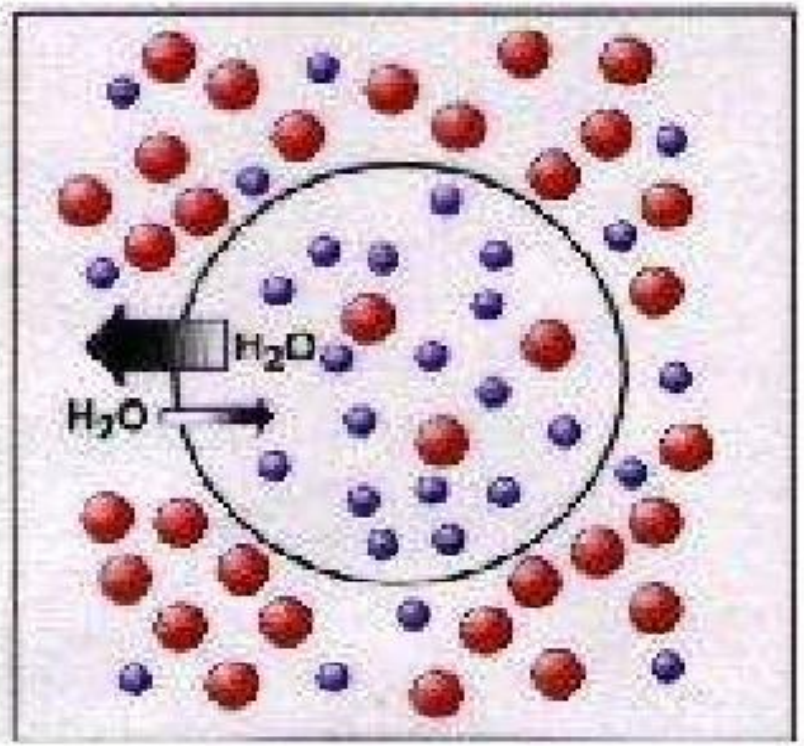
Hypotonic Solution



- A solution in which the concentration of dissolved substances is **lower than** the concentration inside the cell.
- Osmosis will cause water to move into the cell.
- The cell swells and its internal pressure increases.
- Pressure that exists in a cell is called turgor pressure.

Hypertonic Solution

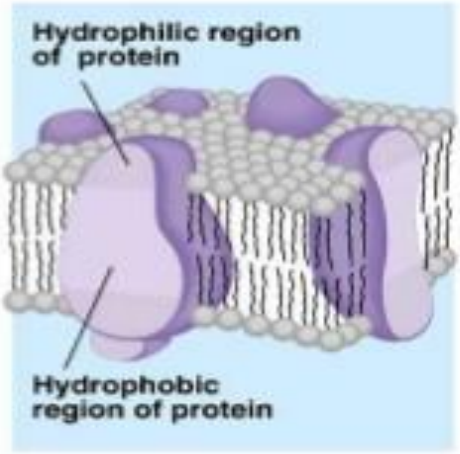
- A solution in which the concentration of dissolved substances is **higher than** the concentration inside the cell.
- Osmosis will cause water to leave the cell.

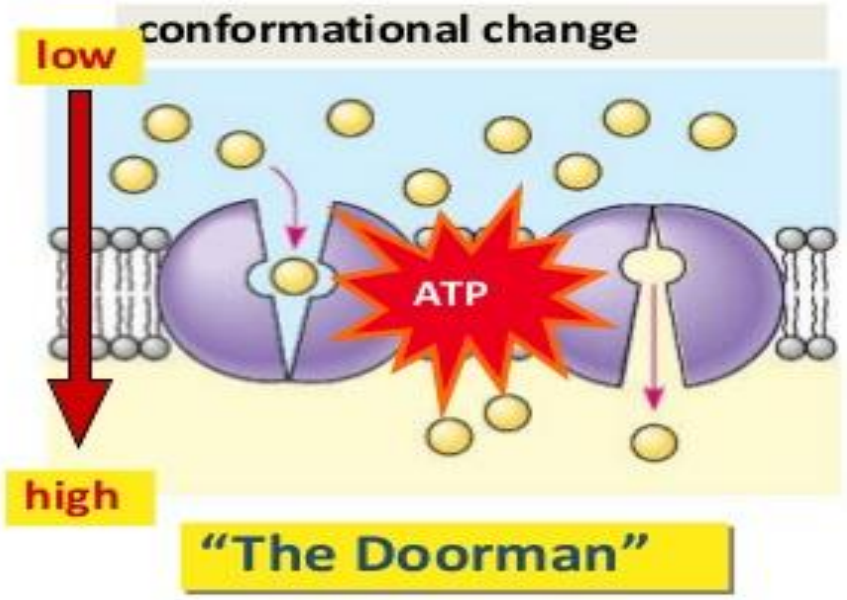


Active transport

Active Transport

- Cells may need to move molecules *against* concentration gradient
  - shape change transports solute from one side of membrane to other
  - protein "pump"
  - "costs" energy = ATP

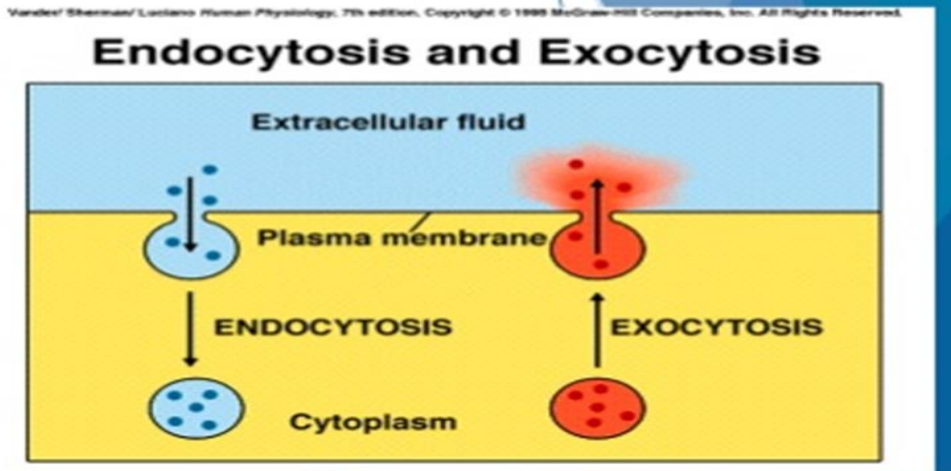




Transport of large amounts

Active Transport: Endocytosis and Exocytosis

- Transportation of large molecules into and out of the cell
- A small piece of the plasma membrane pinches off and becomes a carrier called a vesicle
- The vesicle merges with the plasma membrane and either opens outside the cell (exocytosis) or inside the cell (endocytosis)



Endocytosis: movement into the cell.

** Phagocytosis- "Cell eating" - solid particles*

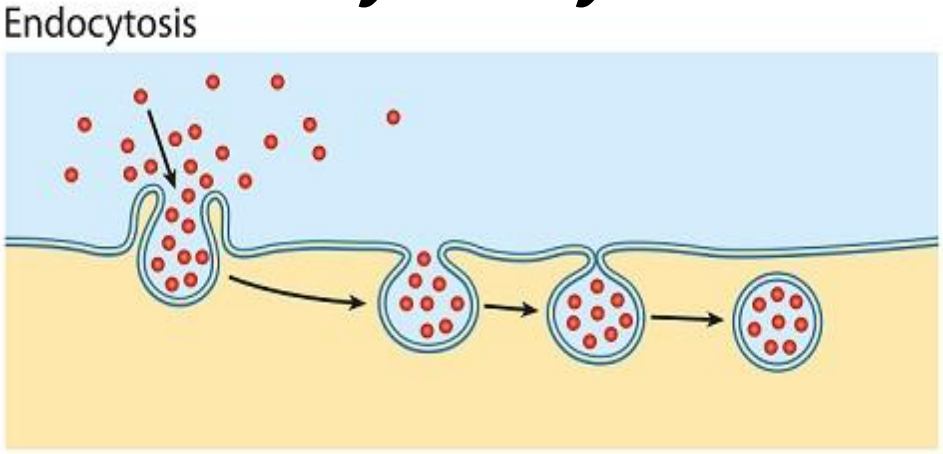
** Pinocytosis- "Cell drinking" - particles dissolved in water.*

**Exocytosis: movement out of the cell into the cell.*

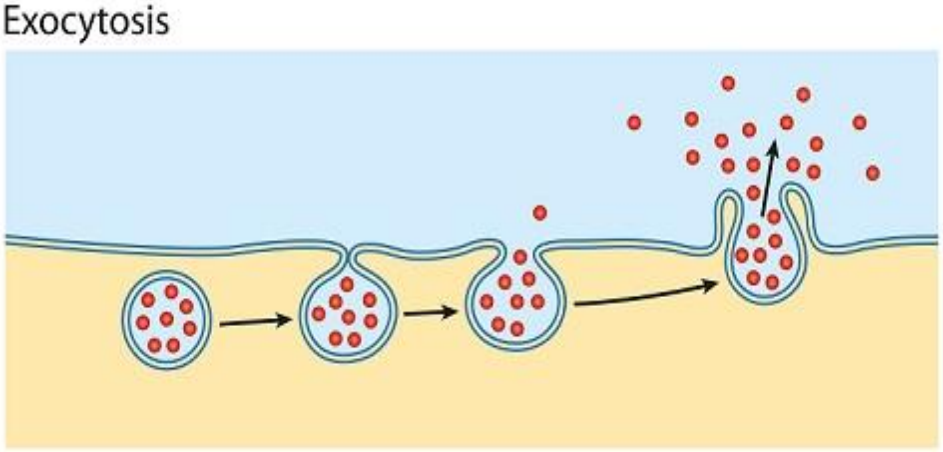
Transport of large amounts

The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis

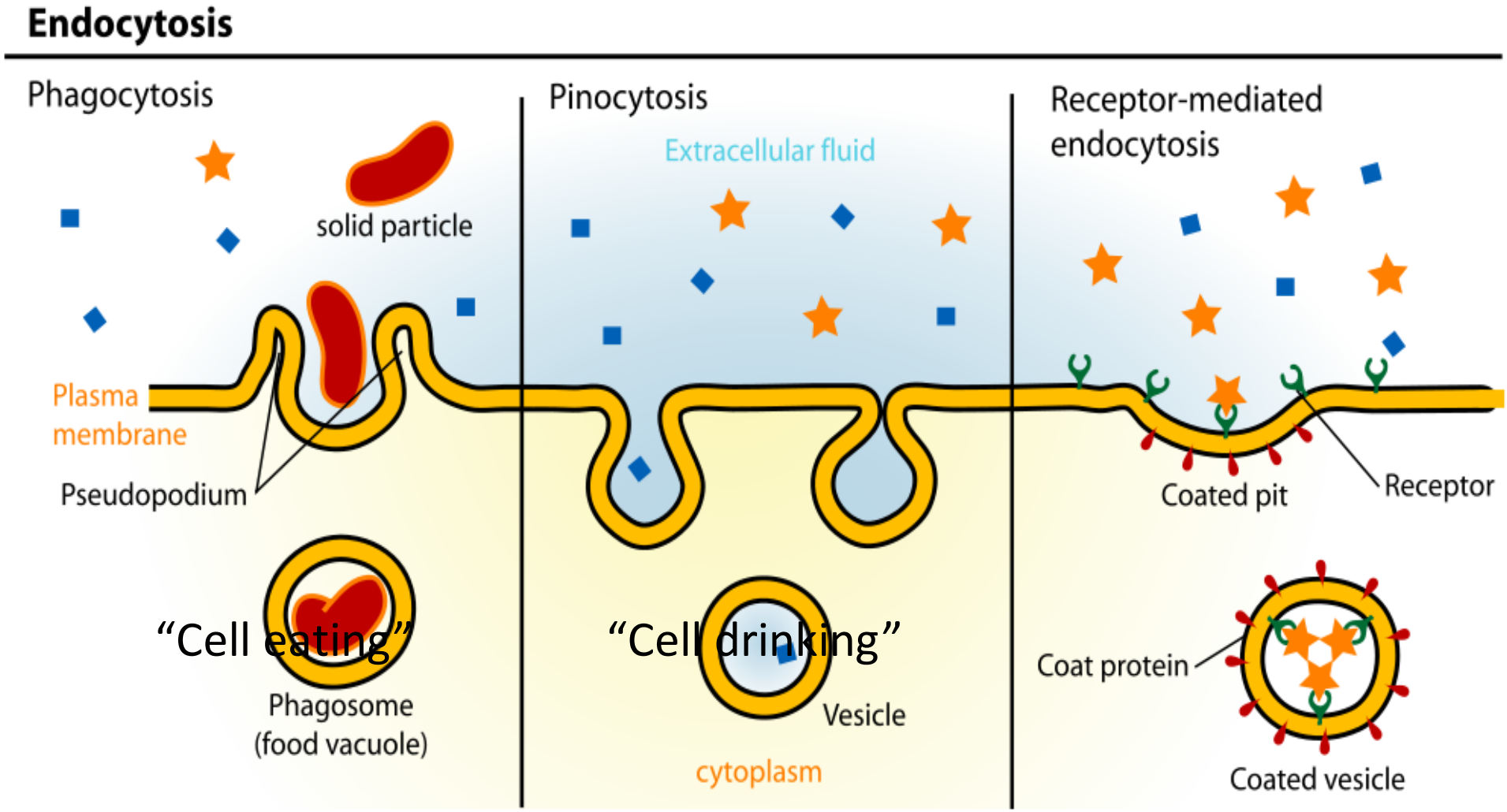
**Endocytosis: The taking in of external substances by an inward pouching of the plasma membrane, forming a vesicle.*



**Exocytosis: The release of substances from a cell (secretion) when a*

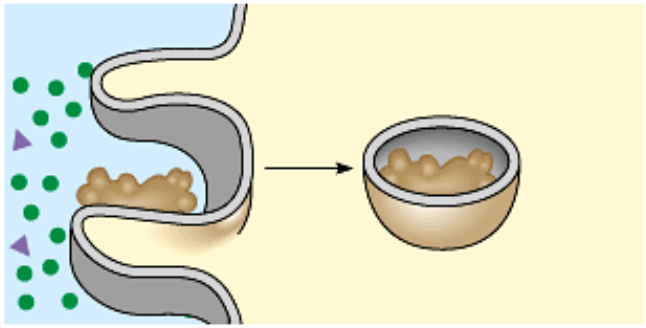


The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis.



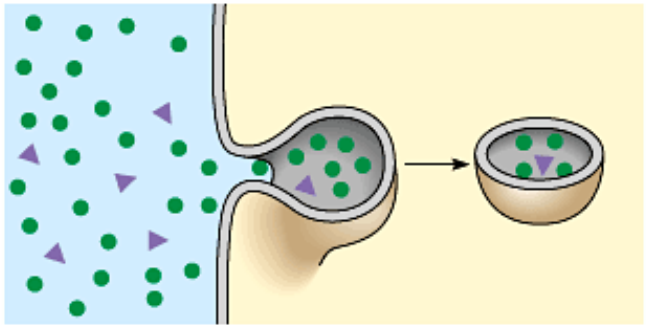
Endocytosis

phagocytosis



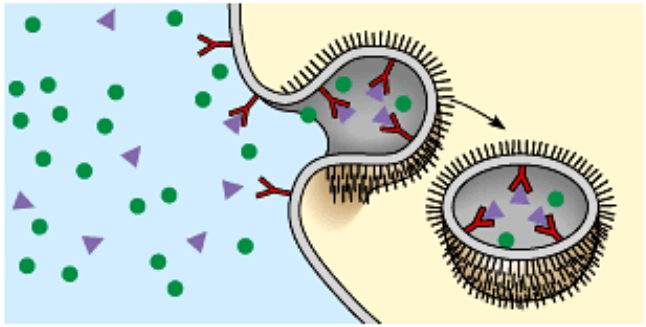
"Cell eating" large molecules; whole cells

pinocytosis



"Cell drinking" Fluids; Small molecules

receptor-mediated endocytosis



triggered by ligand signal

transport of large amounts