Etege Menen Girls' Boarding Secondary School

Biology Department

Grade 11

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Unit 4: Cell biology

4.1 Cell theory

- The major contributors of cell theory are.
- Cell size
- Surface area to volume ratio of a cell and its consequence

4.2 Types of cells

- Prokaryotic cells
- Eukaryotic cells
  - Endosymbiotic theory

4.3 Parts of the cell and their functions

4.3 Parts of the cell and their functions

- Cell membrane
  - Model of Plasma membrane
  - Movement of substance across the plasma membrane
- Mitochondria
- Ribosomes
- Endoplasmic reticulum
- Golgi apparatus
- Lysosomes
- Organelles found in plant cells
  - Cell wall
  - Vacuole
  - Chloroplast

Cell theory

How did the modern cell theory develop?

- The discovery of cell and their structure is linked to the development of microscopes
- Many biologists contributed to the development of cell theory.

The major contributors of cell theory are.

Robert Hooke (1665)- The first person who discovered cell

- The **first person** use the term **'cell'** after observing the structure of cork
- He use a compound microscope using a magnification of **30X.**
- He saw the walls of **dead cork cell**
- The word cell comes from Latin word **cellulae** meaning little rooms.

Anton van Leeuwenhoek

- **Anton van Leeuwenhoek (1974)**: the **first person to sea living cell**
- Observed moving unicellular organisms in a drop of water.
- He also responsible for achieving the magnification of microscope up to **300×.**
- He called **little moving animals** (protoctistans) **‘animalcules’** meaning ‘little animal.
- He was also the first person to sees **bacteria** called **‘tiny animalcules’.**

Rene Dutrochet;

- **Rene Dutrochet (1824):** all living things are made of cells
- He is the first person who concludes that **all organisms are made of cells.**
- He also responsible **for the discovery of**:
  - **Stomata** in epidermis of leaves
  - the **process of osmosis**
  - **chlorophyll** and its importance for photosynthesis
  - occurrence of **respiration** in animals and plants

Matthias Schleiden and Theodor Schwann

- **Determine the first clearly stated cell theory.** It states that:
  1) Cells are structural, physiological and organizational unit of living things
  2) The cell retains a dual existence as:
     - a distinct entity, and
     - a 'building block' in the formation of organisms
  3) Cells form by **free-cell formation** (spontaneous generation)-**not accepted**

Rudolf Virchow(1858)

- He was a German doctor determined that **"omnis cellula e cellula".** That means cell can only **arise from previously existing cell.**
- He completes the **first accepted version of cell theory:**
  - all organisms are made up of one or more cells
  - all cells **come from pre-existing cells**
  - Cell is the unit of **structure, physiology** and **organization** in living things
  - Cell retains a dual existence as a distinct entity and a building block in the construction of organisms

Today, the modified point of cell theory states that;

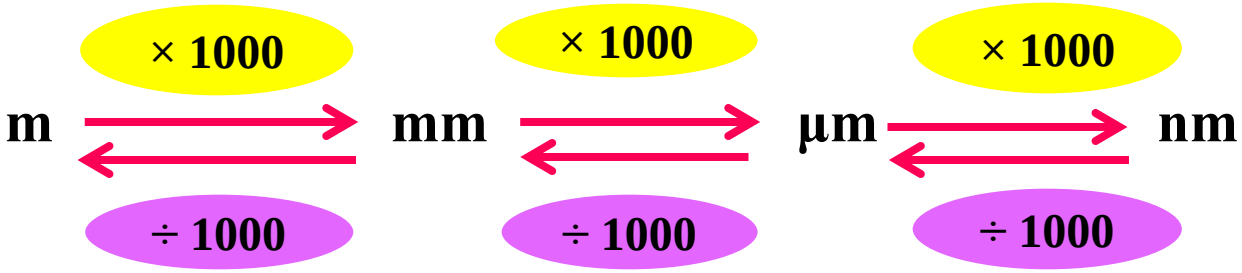
- All living things are made up of cells
- Cells are **structural and functional** unit of all living things
- All cells come **from pre-existing cells** by cell division
- Cells **contain hereditary information** which is passed from cell to cell during cell division
- All cells have basically the same chemical composition
- **Energy flow** occurs within cells

CELL SIZE

- **The size of cell depends on their type.**
- Some cell are **large and visible** by our naked eyes, while most cell are microscopic
  - For example, **chicken egg cell** is as big up to 5 cm length. While bacteria cell are only about 100nm length.
- The size of cell can be measured by using smaller units that are commonly used
  - **millimeters (mm)**
  - **micrometers (µm)**
  - **nanometers (nm)**
- **Micrometers (µm): the most appropriate** to measure the size of a cell.

The conversion of one unit into another

- We can convert the units from one to another as shown below:

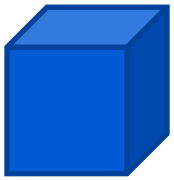


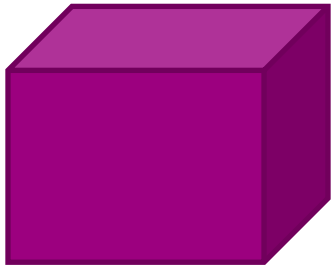
- **To convert a larger unit to the next smaller unit, multiply by 1000:**
  - For example, convert 3.5 mm to µm.
  - mm = 3.5 × 1000 = 3500 µm
- **To convert a smaller unit to the next larger unit, divide by 1000:**
  - For example, convert 87 nm to µm.
  - 87 ÷ 1000 = 0.087 µm

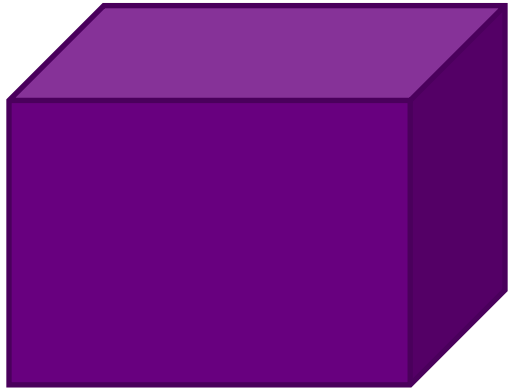
Surface area to volume ratio of a cell and its consequence

- Size of cell and its efficiency is determined by surface area to volume ratio.
- Think surface-area to- volume ratio in terms of ‘supply’ and ‘demand’.
- The **volume** of the cell **creates the ‘demand’** which is ‘**supplied’** through the **surface area** of the cell.
  - E.g. **Respiration:** the Volume of a cell creates the demand of oxygen for aerobic respiration to generate energy which is supplied through surface area of a cell.
- **Modification of a cells to increase their surface area to volume ratio.**
  - Folding surface of a cell
  - Finger like projection like intestinal villi and microvilli

Surface area to….

1au 

2au 

4au 

Cube A	Cube B	Cube C
➢ Area=1au×1au =1au^2	➢ Area= 2au×2au =4au^2	➢ Area=4au×4au = 16au^2
➢ Surface area (SA) =6×1au^2 =6 au^2	➢ SA= 6 ×4au^2 =24 au^2	➢ SA=6 ×16au^2 = 96au2
➢ Volume (V) =(1×1×1)au^3 =1au^3	➢ Volume(V)=(2×2×2)au^3 =8 au^3	➢ Volume(V)= (4×4×4)au^3 =64au^3
➢ SA/V=6 au^2/1au^3 =6:1	➢ SA/V=24 au^2 /8 au^3 =3:1	➢ SA/V=96au^2/64au^3 =1.5:1

Surface area to volume ratio….

❖**The smaller cell size**

- **Large surface area to volume ratio**
- **High efficient to transport nutrient** into and outside the cell.
- The cell metabolically active is high

❖**The bigger cell size**

- **Smaller surface area to volume ratio**
- It will not allow sufficient nutrient to pass into the cell
- The rate of activity of the cell is relatively slow
- Cellular products distribute slowly

Review questions

Choose the correct answer

1) ***Of the following four cells whose surface area to volume ratio is given, which cell can more efficiently transport its need of material across the cell surface?***

A. 24:8 **B.** 54:27 **C.** 96:64 **D.** 150:125

2) ***Which of the following statement is in agreement with the modern cell theory?***

A. Cells form by free-cell formation
B. Cell arise by spontaneous generation
C. Cell come from preexisting cell
D. Cell come from nothing

3) ***Suppose we consider four hypothetical cell (designed A.B.C and D) having cube shape with their side measuring 2,4,5 and 6. which of these cell has less efficient to transport substance?***

A. Cell 'A' **B.** Cell 'B' **C.** Cell 'C' **D.** Cell 'D'

Answer 1.A, 2.C & 3.D

4.2Types of cells

1. Prokaryotic cells

- Prokaryotic cell is a type without true a nucleus.
- The **first type of cells** that evolved on the earth
- Prokaryotic cells are much **smaller and simpler** than eukaryotic cells
- **Lack distinct nucleus** and **membrane bounded organelle**
- Prokaryotic **plasma membrane adapted to generate energy**

Organisms that have prokaryotic cell

1. The archaebacteria

- The **oldest organisms** evolve on Earth.
- The first prokaryotes live in **extreme environmental condition** like
  - very hot environment **/thermophiles/**.
  - salty water **/Halophiles/** or
  - Large concentrations of gases like methane or sulphur dioxide **/Methanogens/.**

2. Eubacteria

- Unicellular and prokaryotic organism
- True bacteria
- Bacteria found everywhere like soil, water, living in and on organisms
- Inhabit our intestines, decay organisms, convert milk to yoghurt and so on.

3. Cyanobacteria/blue green algae/

- **Photosynthetic** prokaryotes
- **Have flattened sac** called **thylakoid** where photosynthesis is performed

Eukaryotic cell

- The word **eukaryotic** is derived from Greek
  - **eu** (**true**) and
  - **karyos** (**nuclear**),
  - So, eukaryotic cell **has a true distinct nucleus.**
- **Contain membrane bounded organelles** and evolved from prokaryotic endosymbiotic association.
- Organelles individual structures in a cell with a specific function
- **Organelles surrounded by membranes**

- **Nucleus,**
- **Mitochondria**
- **Endoplasmic reticulum**
- **Chloroplasts (if present),**
- **Lysosomes,**
- **Golgi apparatus**

Organisms that have Eukaryotic cell

- **Fungi** (multicellular, eukaryotic)
- **Protista** (eukaryotic, unicellular, and multicellular)
- **Plantae** (multicellular, eukaryotic)
- **Animalia** (multicellular, eukaryotic)

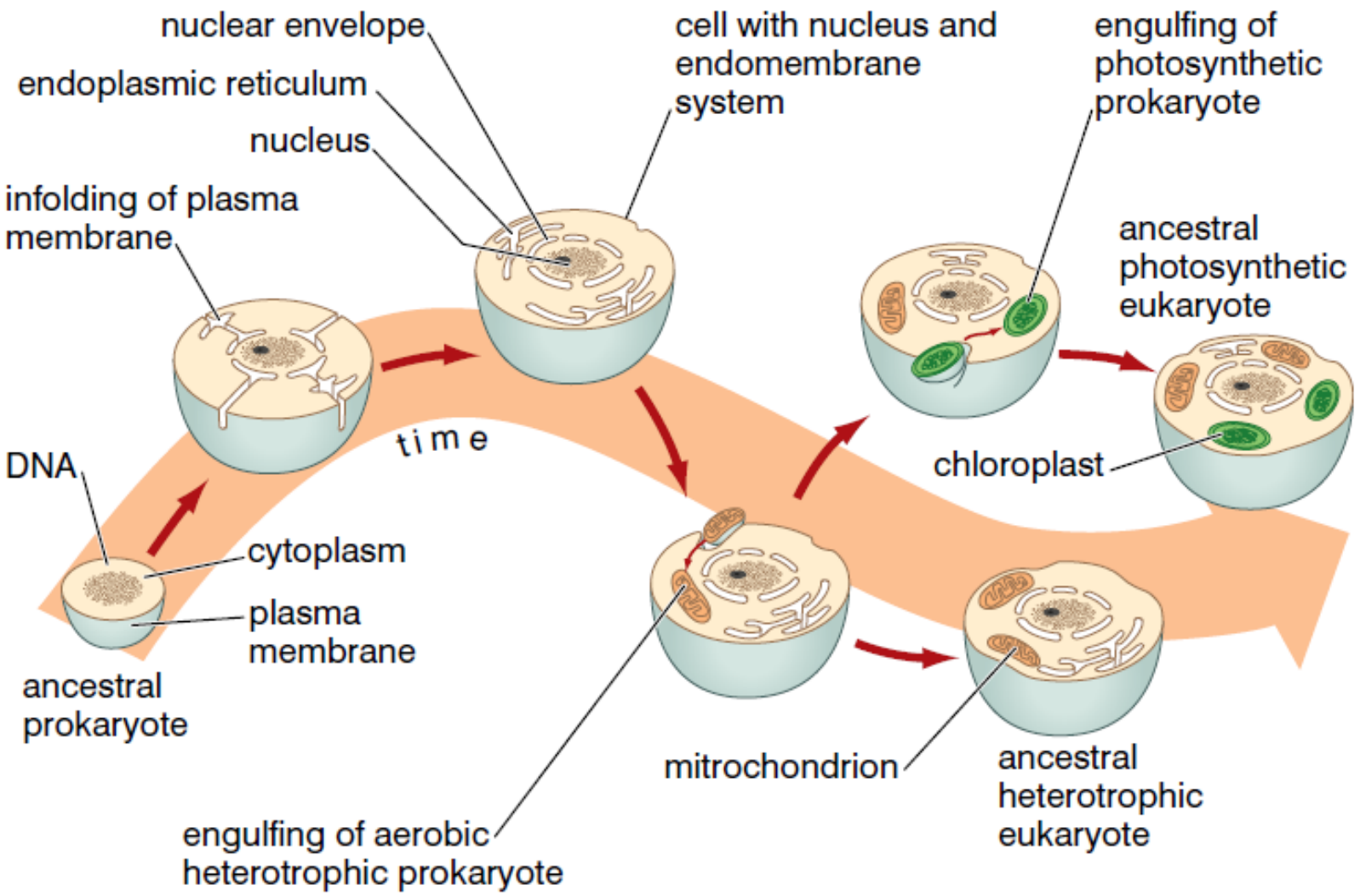
Endosymbiotic theory the origin of eukaryotic cells

- **Endosymbiosis** is the theory of **evolution of eukaryotic cell** arose from the symbiosis of different species of prokaryotic cell.
- According to this hypothesis, ***modern eukaryotic cells evolved from endosymbiotic association prokaryotic with large unicellular organisms.***
- The theory was proposed by **Lynn Margulis.**

Origin of eukaryotic cells

1) **Infolding plasma membrane** and would eventually evolve into the **endoplasmic reticulum (EPR**) of eukaryotic cells.
2) Engulfing of **aerobic heterotrophic prokaryote,** which later evolve into the **mitochondria** of eukaryotic cells.
   - Precursors of animal, fungal and protoctistans cells.
3) Engulfing of **photosynthetic prokaryote** evolve into **chloroplasts** develop into ancestral photosynthetic eukaryotic.
   - Precursors of plant cells.

Origin of eukaryotic cell



Feature	Prokaryotic cells	Eukaryotic cells
➢ **Size**	➢ 1–10 μm	➢ 10–100 μm
Nucleus	➢ Do not have distinct nucleus	➢ Have distinct nucleus
➢ **DNA**	➢ In a **continuous** loop ➢ Not **associated with protein** to form chromosomes	➢ Linear DNA ➢ **Associated with histone proteins** to form chromosomes
➢ **Ribosomes**	➢ Present, but smaller than in eukaryotic cells (**70S**)	➢ Present, but larger than in prokaryotic cells (**80S**)
➢ **Cell wall**	➢ Always present ➢ made from **peptidoglycan**	➢ Present in plant, algal and fungal cells ➢ **Cellulose** in plant cells
➢ **Cell membrane**	➢ In addition of controlling substance in and out of a cell, **specialized to generate energy**	➢ Control the movement of substance in and out of cell

1.The endosymbiotic hypothesis for the origin of eukaryotic cells provides an explanation for the origin of which of this cellular structure?

A. Golgi bodies
B. Chromosomes
C. Nucleus
D. Mitochondria

2. Which one of the following eukaryotic cell organelles was a free living cell before eukaryotic cell is evolved?

A. Nucleus
B. Lysosomes
C. Ribosomes
D. Chloroplast

3. Cube A has a side measuring 1mm. Cube B has a side measuring 2mm. The surface-area- to-volume ratio of cube A when compared to cube B is:

A. two times bigger
B. two times smaller
C. half times smaller
D. half times bigger

ANSWER. 1D,2D & 3A

4.3. Part of the cell and their function

1. Cell membrane or **plasma membrane** or **cell surface membrane**

- isolates the cell from the environment
- controls the exchange of substances between cell and its cellular environment.

The major function Cell membrane

1. Cell membrane **isolates and protects a cell** from its surroundings.
2. It **control the exchange of substances** between the cell and cellular environment.
3. **It communicate with other cell** (**cell signaling**); allow the cell to cell recognition and identify;
   - Hormones
   - Immune system (in animals) and
   - Growth regulator substances, such as auxins (in plants).

☞A timeline of the development of our understanding of the structure of the plasma membrane

- **1665 Robert Hooke** discovers cells, but only sees dead cells and has **no idea of a cell membrane**
- **1895 Charles Overton** shows that **lipid nature of Membrane**.
- **1905 Langmuir** proposes a **lipid monolayer** as the basic membrane structure.
- **1925 E Gorter and G Grendel** suggested plasma membrane is a **phospholipid bilayer**.
- **1935 Davson and Danielli** suggests that **phospholipid bilayer sandwich** between **two protein layers**
- **1959 J D Robertson** proposes the **unit membrane model**
- **1972 S J Singer and G L Nicholson** propose the **fluid mosaic model** of membrane structure.
- **2000 Unwin and Henderson** propose **membrane protein structure**

Model of Plasma membrane

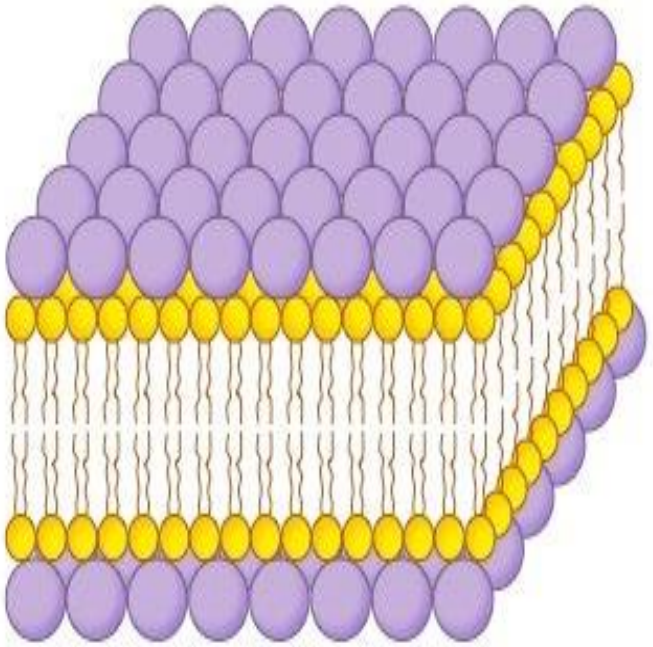
1. The Davson–Danielli model (sandwich model)

- The model suggests that **phospholipid bilayer sandwich** between **two layers protein.**
- This model was a **revised in 1954** which included **protein-lined pores.**
- **Limitation of Davson–Danielli model**
  - The model generalized as all membrane are identical. However, membrane with different function also have different chemical composition.
  - The model does not properly explain how molecule crosses the membrane.

Fluid mosaic model

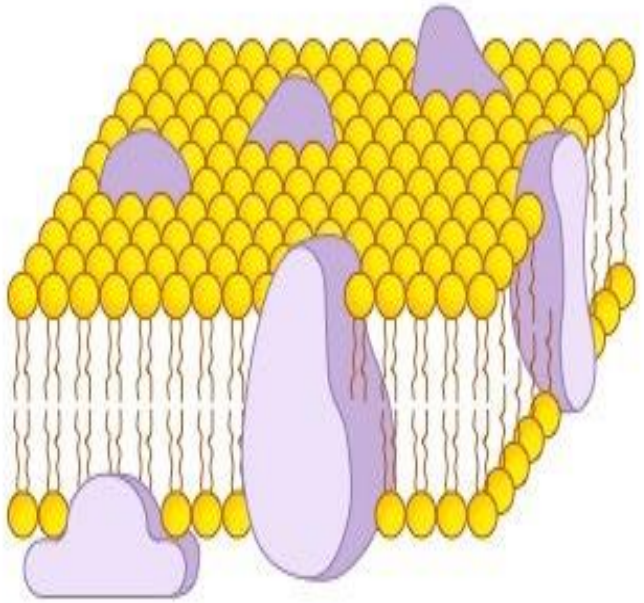
- Proposed by **Singer and Nicholson** in 1972
- It states that membrane is a **mosaic of protein** dispersed in a **fluid bilayer** of phospholipids
- It suggest that the **model** has both **fluidity** and **mosaic** properties.
- A mosaic is a pattern of appearance of protein and cholesterol within the membrane.
- The membrane is not static, but it is dynamic and constantly changing.
- Plasma membrane has **protein molecules scattered in the bilayer**.

Davson-Danielli Model (1935)



Proteins form distinct layers *(sandwich)*

Singer-Nicolson Model (1972)



Proteins embedded within bilayer *(fluid-mosaic)*

Fluid mosaic model of membrane consists the following components

1) **Phospholipid bilayer:** the main substance of the membrane
   - It has hydrophilic /water loving/ toward the outside and hydrophobic /water hating/ toward the inside.
2) **Integral proteins /intrinsic protein and trans-membrane protein/**
   - **Channel proteins:**
     - Have an ion pore that **allow the passage of ions** through them
     - There are different channel protein for different ions
   - **Carrier proteins**
     - move larger molecules through the membrane by facilitated diffusion or active transport
   - **Peripheral proteins (extrinsic proteins):**
     - **Protein that span in one of phospholipid bilayers** some of them **function as enzymes**, others **anchor integral proteins to the cytoskeleton**

Fluid mosaic model of membrane…

3) Carbohydrates

- It is the third major component of plasma membrane
- Always found on the exterior surface of a cell: these are
  - **Glycoproteins** are carbohydrate group attached to protein
  - **Glycolipids** are carbohydrate attached to lipid molecules
- **Serves as receptor sites** for hormones and drugs and allow cell to cell recognition.

4) Cholesterol

- A **steroid lipid** that **stiffen the membrane**
- **Regulate membrane fluidity**
- Reduces the fluidity of the membrane. **How?**

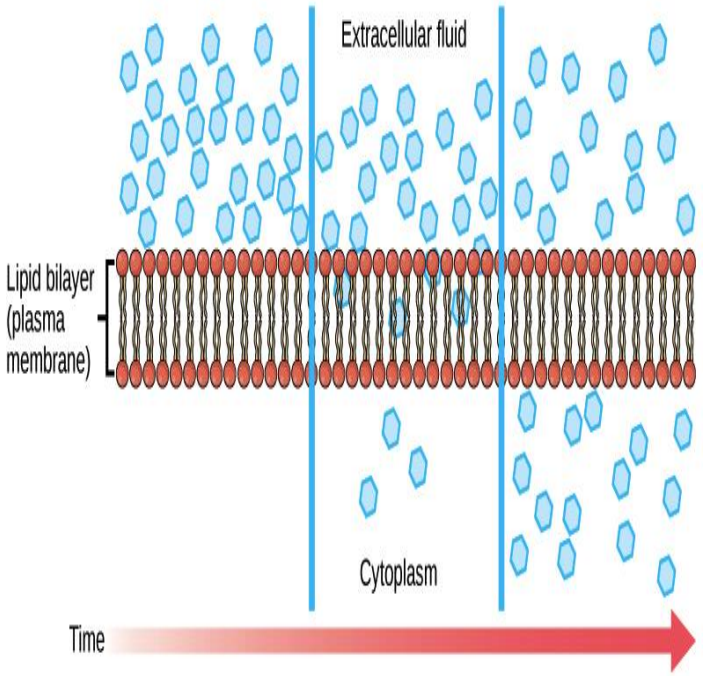
Movement of substance across the plasma membrane

- Plasma membrane allows selective substance in and out of cell **/selectively permeable/**
- There are two ways in which Substances can enter or leave a cell:

1) **Passive processes: simple diffusion, facilitative diffusion and Osmosis**
   - The movement of substance along /on/ concentration gradients;
   - Does not require extra energy from the cell's metabolism
2) **Active processes: endocytosis, exocytosis** and **active transport**
   - The movement of substance against concentration gradient
   - Require extra energy (ATP) from the cell's metabolism.

Simple diffusion

- Is the **random movement** of molecules from a region of **higher** concentration to **lower concentration**.
- Movement of substance down a concentration gradient until equilibrium is reached
- Diffusion occur in **solid, liquid** or **gas** and across **plasma membrane** of cell.
- **Kinetic energy** of the molecule and **concentration gradient drives diffusion**



Substance cross phospholipid bilayer by simple diffusion must be;

- **Small non-polar molecules** which are lipid soluble such as;
  - ***fatty acid ,***
  - ***glycerol,***
  - ***steroid,***
  - ***Vitamin*** A,D,E and K
- **Non-charged molecule** such as, **water, oxygen and carbon dioxide**

The phospholipid bilayer is not permeable to;

- **Large polar molecule,** which are not soluble in lipid , such as
  - ***glucose,***
  - ***amino acids,***
  - ***nucleic acids and***
  - ***polysaccharides***
- **Ions (charged),** such as H^+, Na^-, HCO_3^-, K^+

Factor affecting rate of simple diffusion

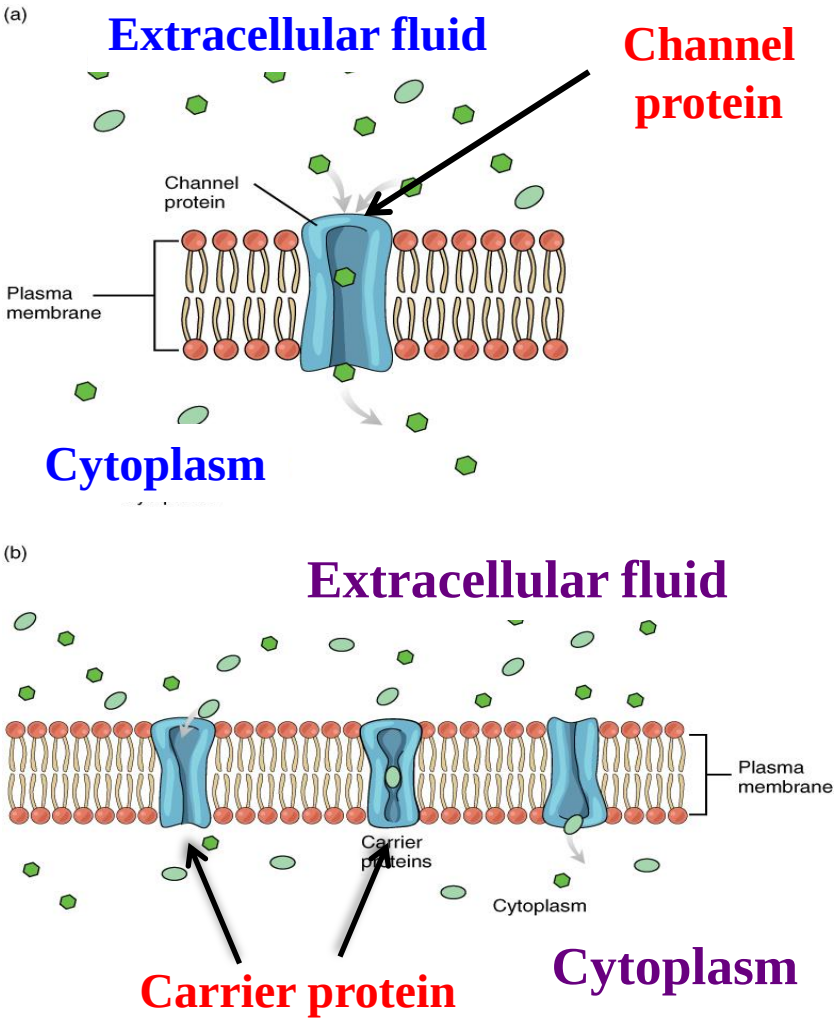
1) **Concentration gradient**; a bigger difference in concentration results in faster diffusion
2) **Thickness of the membrane**; as all plasma membranes are the same thickness, this is not really an issue when considering diffusion into and out of cells, but for other situations where particles must cross some kind of barrier, **a shorter distance/thinner membrane/ results in faster diffusion**
3) **Surface area of the membrane**; the larger surface area the faster the rate of diffusion.
4) **Temperature;** diffusion occurs faster at higher temperatures because the particles have more kinetic energy and so move faster.

Facilitated diffusion

- Facilitate diffusion is the movement of specific molecule /ions/across plasma membrane.
- Does not require expenditure of metabolic energy
- It is assisted by **either channel protein or carrier protein**
- The movement of substance down concentration gradient.

Factor affect rate of facilitative diffusion

1) **Thickness of a membrane**
2) **Concentration gradient**
3) **Numbers of carrier proteins (**or **channel proteins)**



The three essential characteristics of facilitate diffusion

- **Specific:** channel is designed for one molecule to transport/
- **Passive:** no need of ATP
- **Saturate:** maximum rate is reached when trans-membrane protein is saturated

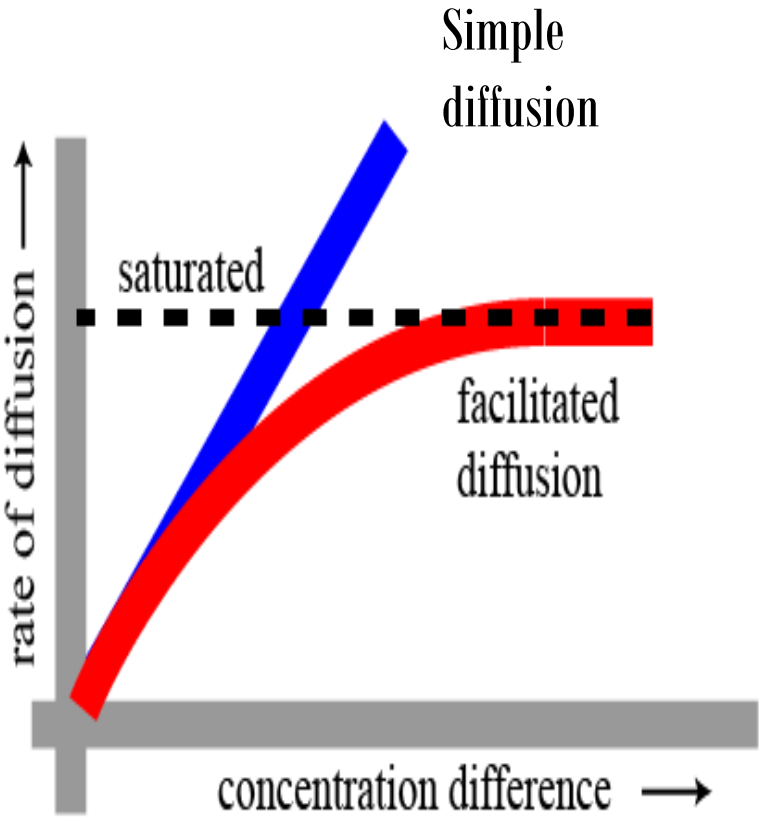
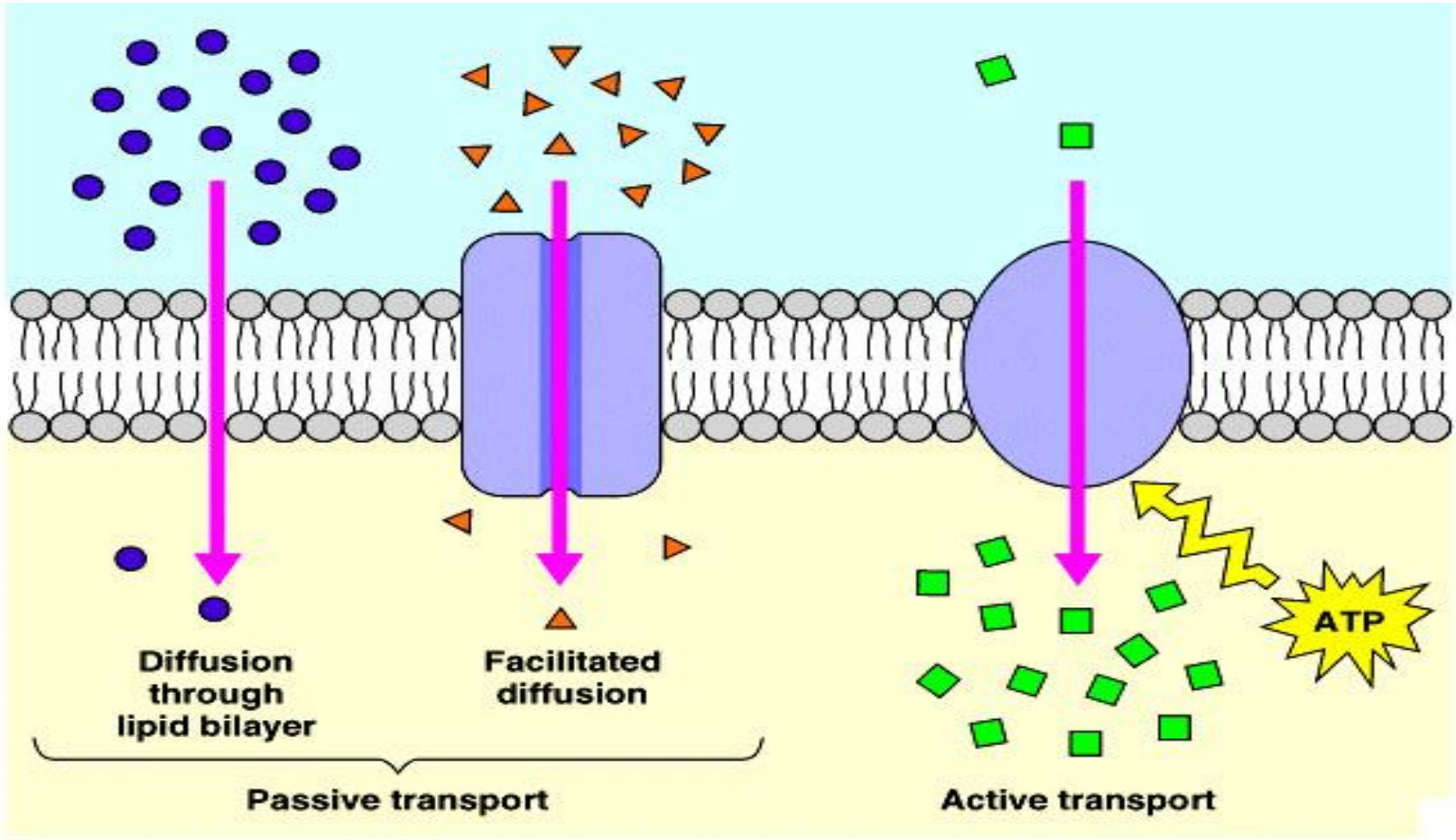


Figure: comparisons of passive and active transport



Osmosis /the diffusion of water/

- **Osmosis** is the **movement of water** from a system with a **high water potential** to a system with a **low water potential** across a partially permeable membrane.
- The symbol for water potential is Ψ (psi).
- It is measured in units of pressure called **pascal (pa).**
- Pure, liquid water has a higher water potential than any other system. It is defined as zero:
  - **Ψ (pure water) = 0 Pa**
- The other system (cell, Solution and suspension) have a negative vale of water potential.

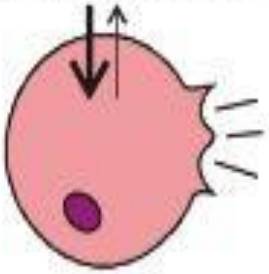
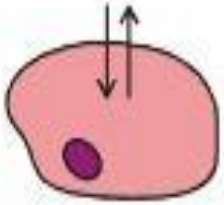
Osmosis…

- **Water potential (Ψ) of pure water = 0 Pa**
- All other systems (cells, solutions and suspensions) have a negative value water potential. This is because the solid particle reduce the number of free water molecule in the system and so the water potential is reduced and become negative. So we can define osmosis:
- ***Osmosis is the movement of water from a system with a high water potential (less negative) to one with a lower water potential (more negative), across a partially permeable membrane.***
- **Factor affecting osmosis:**
  - **surface area of the membrane**
  - **difference in water potential**
  - **distance the molecules must travel**

What happens to cells placed in solutions of different concentrations?

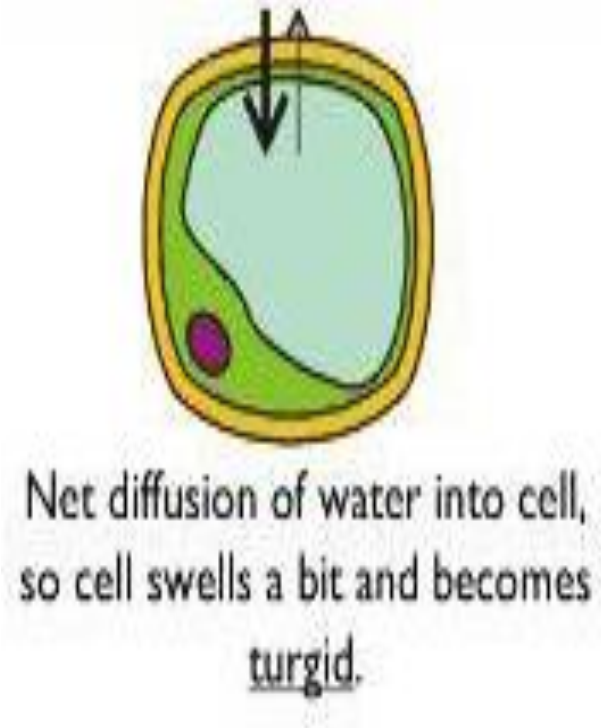
- The difference in water potential between cell and solution will determine whether water enters or leaves by osmosis.
- **There are three type of solution,** when comparing the water potential of a solution to that of a cell
  - **Isotonic solution** having the same water potential as the cell.
  - **Hypertonic solution** having lower water potential **(more negative)** than the cell.
  - **Hypotonic solution** having a higher water potential **(less negative)** than the cell.

What happens to cells placed in solutions of different concentrations?

	Surrounding solution hypotonic or high ψ (e.g. fresh water)	Surrounding solution isotonic or equal ψ	Surrounding solution hypertonic or low ψ (e.g. sea water)
Animal cell			
	Net diffusion of water into cell, so cell swells and bursts (lysis)	No net diffusion of water, so cell is normal size	Net diffusion of water out of cell, so cell shrinks and crenates.
Plant cell			
	Net diffusion of water into cell, so cell swells a bit and becomes turgid.	No net diffusion of water, so cell is normal size	Net diffusion of water out of cell, so cytoplasm shrinks from cell wall and cell plasmolyses.

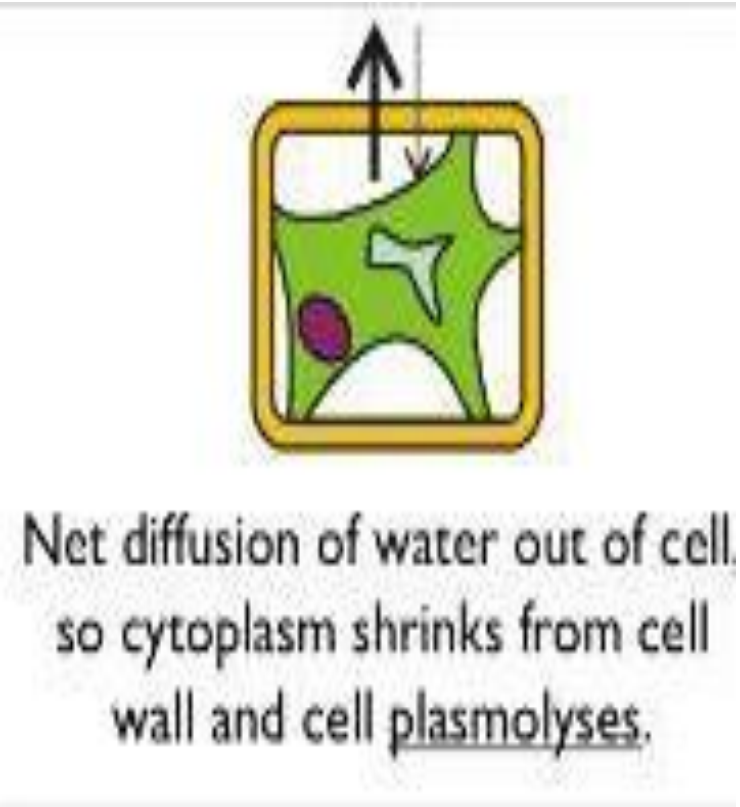
Hypotonic dilute or weak solution in plant

- The cell **gain water and swells** and becomes **turgid**
- The cells do not burst because the cell wall exerts wall pressure against turgor pressure
- **Role of turgidity in plants**
  - Supporting young, non-woody plant stems.
  - Mechanical support of young non woody tissue e.g. leaves



Hypertonic, concentrated, strong solution in plant

- The cell **loss water** by osmosis
- The vacuole **shrinks** and the cell **become flaccid**
- Finally cytoplasm pulls away from cell wall known as **plasmolysis**
- If the plant is not watered, the cells will be plasmolysed and become flaccid.



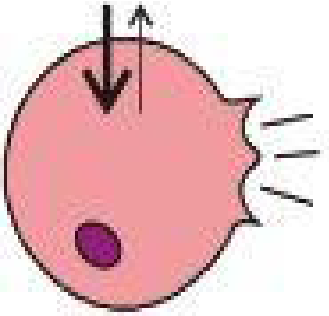
Osmosis in Animal cell

Hypotonic dilute or weak solution. E.g. fresh water

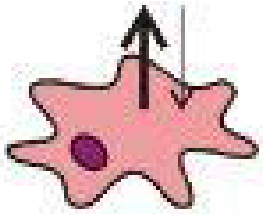
- The **cell gain water**
- The cell **swell** and eventually **burst /haemolysis/**

Hypertonic, concentrated, strong solution. E.g. sea water

- The cell **loss water** by osmosis
- The cell becomes **shrink** and **shrivel** a state known as **crenation**



Net diffusion of water into cell, so cell swells and bursts (lysis)



Net diffusion of water out of cell, so cell shrinks and crenates.

Active processes

a) Active transport

- Active transport is the move substance from an area of low concentration to an area of high concentration
- Substance move against concentration gradient
- **It requires**:
  - **Energy:** requires metabolic energy (ATP) from cellular respiration to drive the process
  - **Pump** (**transporter**): is the transmembrane protein used to actively transport substance across plasma membrane.
- **Important of active transport**
  - The cell can absorb ions and other substance from dilute solutions
  - Regulate the volume of cell by controlling osmotic potential
  - Maintain homeostasis

b) Endocytosis

- Endocytosis is the movement of a substance into a cell by **forming Vesicles.**
- Engulfing large particles into a cell via vesicle forming at the plasma membrane.
- **Require ATP** to move the membrane around the particles to form the vesicle.
- There are a number of ways endocytosis can happen
  1) **Phagocytosis**
  2) **Pinocytosis**
  3) **Receptor-mediated endocytosis**

Type of endocytosis

Phagocytosis /cell eating/

- Is the injection of materials from outside of a cell into its interior, forming cytoplasmic vesicle.
- Involves the creation of pseudopodia to enclose large particles or even whole organisms from outside the cell.

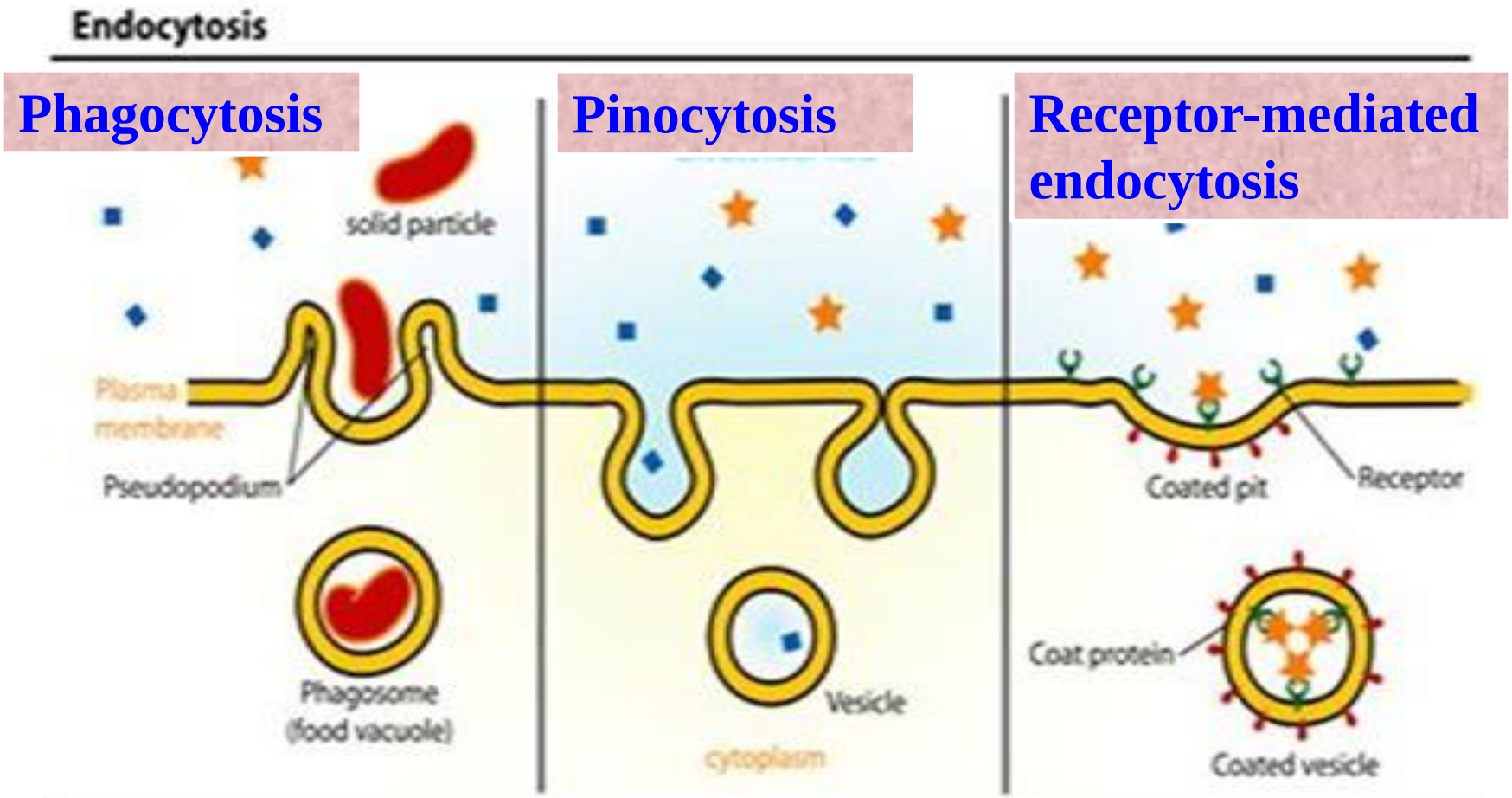
Pinocytosis /cell drinking/

- It is the injection of fluid into a cell by turning a portion of cell membrane inward to form internal vesicle
- Does not require the formation of large pseudopodia to engulf the particles.

Receptor-mediated endocytosis

- Very selective process
- Receptors on the plasma membrane bind to the desired molecule and forming cytoplasmic vesicles

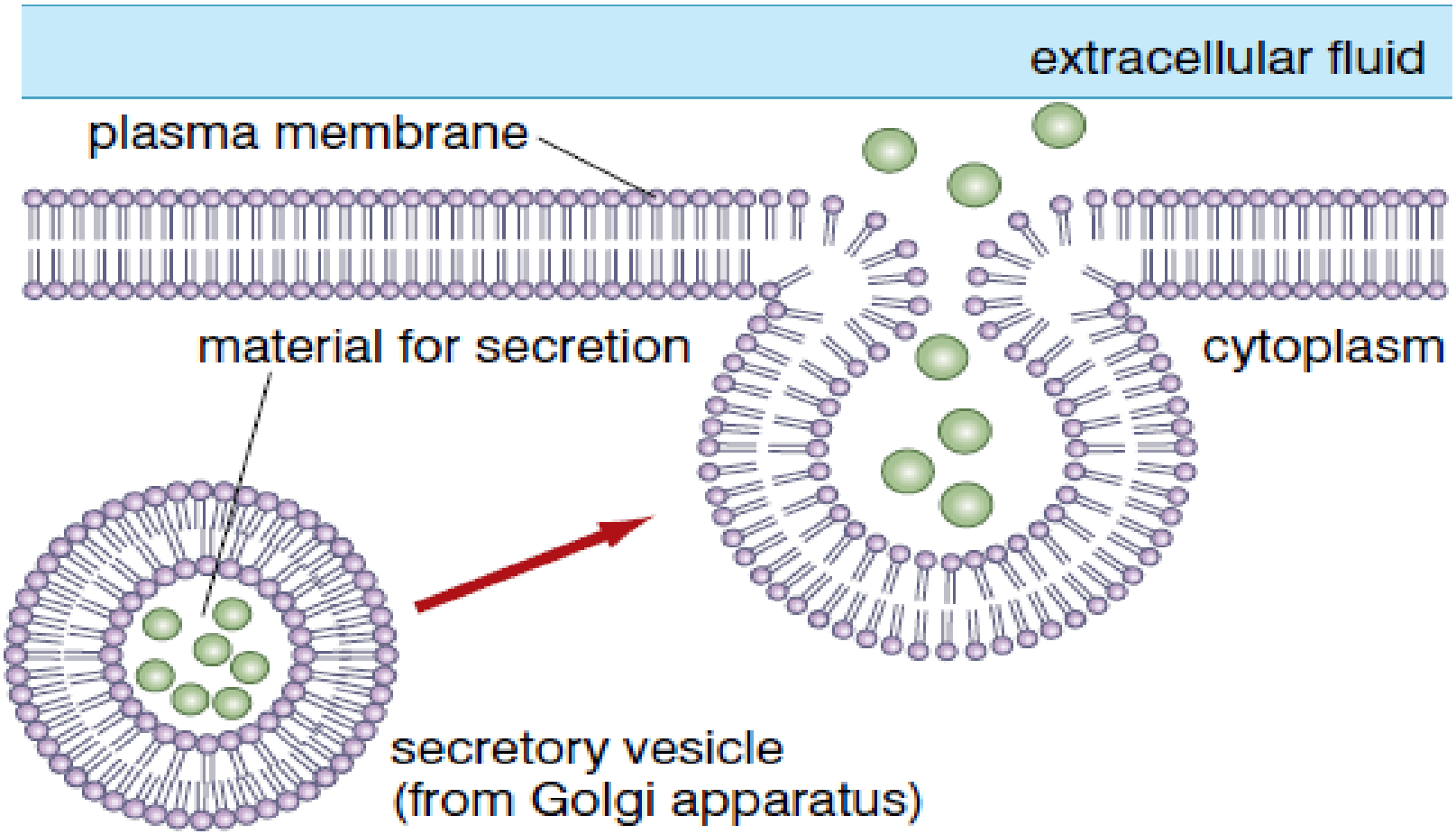
Type of endocytosis



C. Exocytosis

- The process by which substances are moved from inside to outside of the cell by forming a vesicles on the plasma membrane of a cell.
- Important to release macromolecules, such as;
  1) enzymes
  2) hormones
  3) Protein
  4) Polysaccharides
  5) neurotransmitter
- Used input of metabolic energy (ATP)

2. Exocytosis….



Cellular structure and their function

1. The nucleus

- The nucleus typically occupies about 10% of the volume of a cell.
- **It has several components:**

Nuclear envelope

- Surrounds the nucleus.
- double membrane with several pores
- selectively permeable
- control the movement of material in and out of nucleus

Nucleolus.

- A round a dark body within the nucleus
- It is not membrane-bound.
- Important in synthesise of ribosomes and RNA.

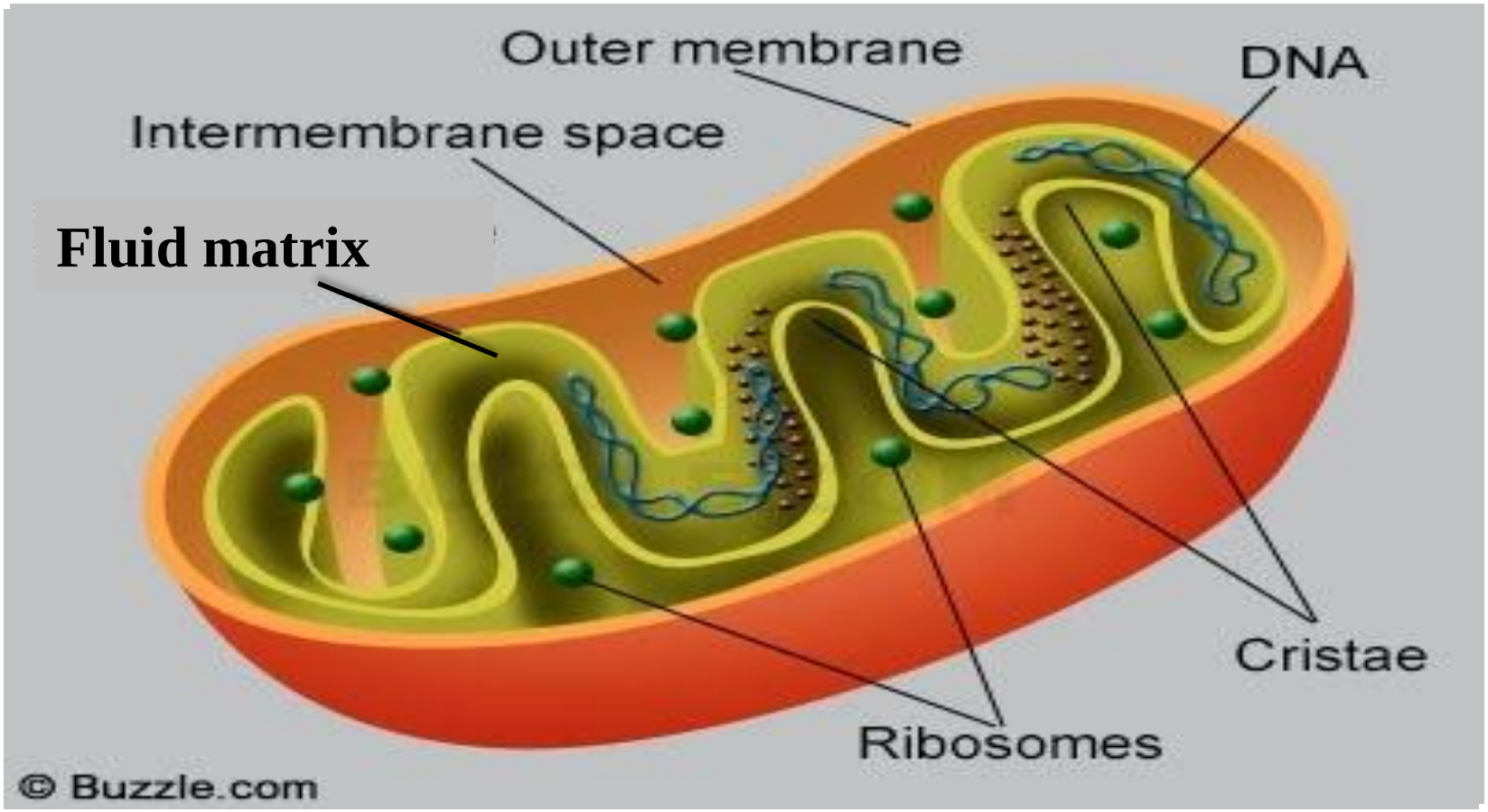
Chromatin

- Made up of DNA and proteins histones.
- When cells divide, the chromatin condenses into recognisable structures called **chromosomes.**

2. Mitochondria

- Is organelle **responsible for aerobic cellular respiration**.
- **It consists two membranes.**
  1) Smooth outer membrane
  2) Folded inner membrane **/cristae/**
     - Cristae is the site of ATP synthesis
- **Cristae separate mitochondria into two parts**
  - **Fluid matrix**: some of the reactions of aerobic respiration take place
  - **Intermembrane space** lying between membrane
- Mitochondria have their **own DNA** and **ribosome.**
- **Cell with** heavy **energy demands**, such as muscle cell and epithelial cell have **more mitochondria** than other cell.

Parts of Mitochondria



3. Ribosomes

- Ribosome are **protein synthesizing organelle** in the cell
- They are **made** from **RNA** and **protein**
- Ribosome are **manufactured** in the **nucleolus** of the nucleus
- Found in both prokaryotic and eukaryotic cell
- Ribosome is not **surrounded by membrane**
- **It can be found;**
  - **Free in the cytoplasm**
  - **Bound to the endoplasmic reticulum**, forming rough endoplasmic reticulum.

Endoplasmic reticulum /ER/

- ER is a **membrane bounded organelle**
- The **ER connects** the plasma membrane with the nuclear membrane
- **Act as a system of canal** to transport material from plasma membrane to nucleus
- There are two types of endoplasmic reticulum:

Rough ER

- Has ribosomes on its surface
- Responsible for the **manufacture and transport of proteins.**

Smooth ER

- Have no ribosomes on its surface.
- It is concerned with the
  - **synthesis of lipids**
  - carbohydrate metabolism and detoxification

Golgi apparatus (or Golgi body)

- The Golgi apparatus consists of flattened membrane bound sacs called **cisternae**
- It receive protein and lipid made in endoplasmic reticulum and modify, sort, packaging them.
- For example protein may be converted into glycoproteins and lipid into glycolipids
- It acts as ‘a cellular post officer’ that labels and then distributes molecules.
- **Importance**
  - **Modify, sort and packaging molecules**
  - **Produce lysosomes**

Lysosomes

- Lysosomes are a single membrane bounded sac **found in animals** /absent in plant/**.**
- Produce in Golgi apparatus
- **Contain digestive enzymes** that break down cellular waste and debris
- **Abundant in phagocytic white blood cells** to digest foreign cells that have been engulfed

Function of Lysosome

1) **Hetrophagy**: digestion of extracellular material taken by endocytosis
2) **Autophagy:** digestion of unwanted structure within the cell,
3) **Autolysis:** self digestion of a cell. E.g. distraction of much larger uterus after birth,
4) **Release enzyme outside the cell**. E.g. sperm cell have a special lysosome called acrosome to penetrate the membrane of egg cell

Organelles found in plant cells

Cell wall

- Cell wall is a tough, rigid layer that surround the plant cell.
- It is the nonliving part of the cell which located outside cell membrane
- Made up of a complex polysaccharide called **cellulose**
- The cell wall is completely permeable
- Helps to **protect and support of plant cell**

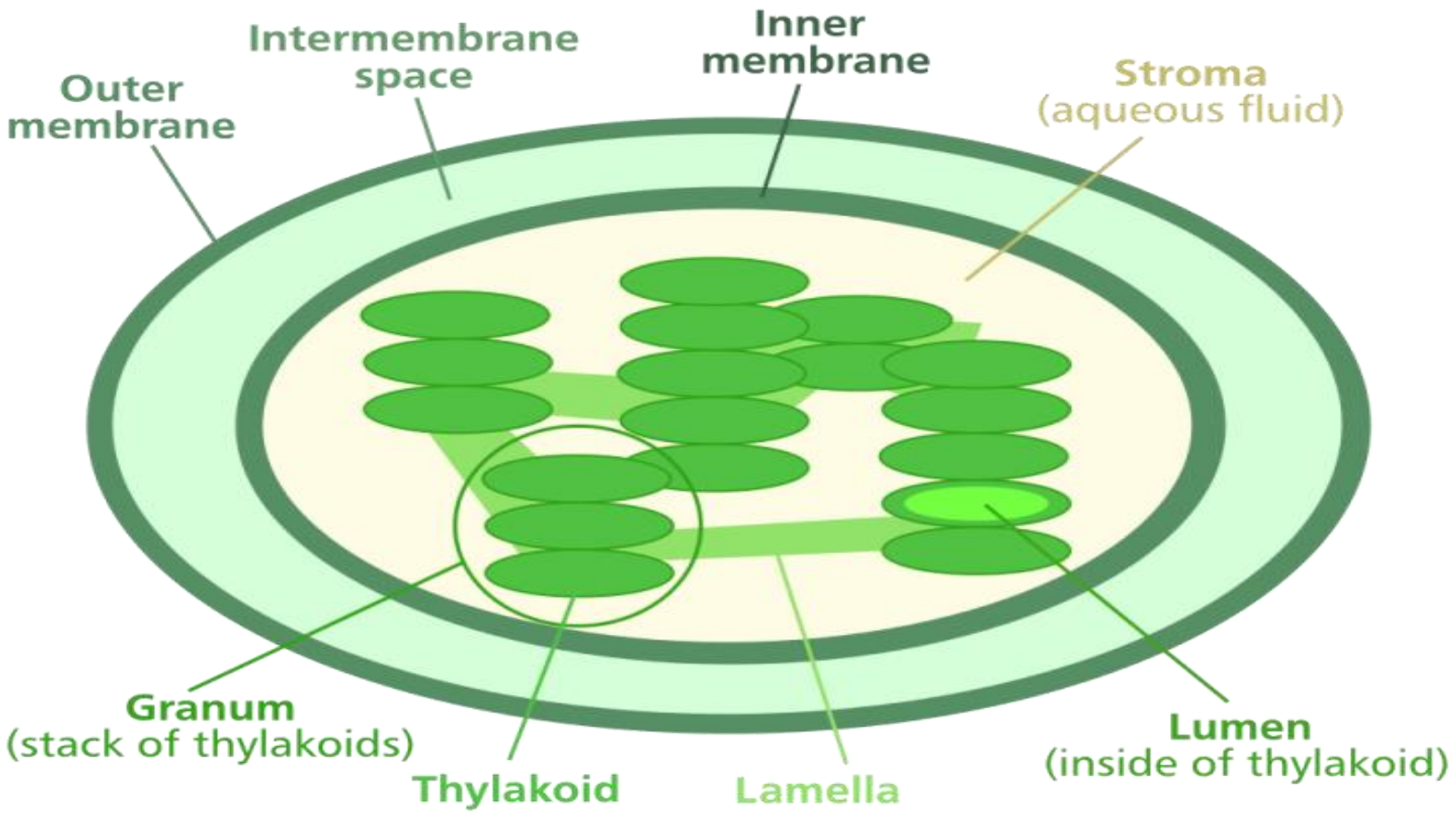
Vacuole

- Vacuole is a membrane enclosed fluid filled sac found in plant cell. A fluid filled sac called **cell sap.**
- When the vacuole is full of water it exerts hydrostatic pressure against the cell wall and the cell become turgid
- If the vacuole loses water by osmosis, the pressure reduces and turgor is lost. Consequently, the cell become flaccid
- There four, Vacuole is **important in developing turgidity of a plant cell.**

Chloroplast

- Chloroplast are the site of photosynthesis
- It is **surrounded by double membrane** like mitochondria
- Unlike mitochondria the inner membrane is not folded
  1) The smooth outer membrane
  2) The smooth inner membrane.
     - **Inside inner membrane**
       - ✓ **Grana** (stack of thylakoids) where the **light dependent reactions occur,** and
       - ✓ A fluid **stroma**; where the **light-independent reactions** occur.
- Chloroplast like mitochondria contain their own DNA

Chloroplast



Cell fractionation

- Cell fractionation separates the components of a cell by ultracentrifugation,
- **The technique is carried out as follows:**

1. **Cell sample is stored in a suspension** that is:
   - **Buffered:** the neutral pH prevents damage to the structure of proteins, including enzymes
   - **Isotonic** (of equal water potential):this prevents osmotic effect
   - **Cool** : this reduces the activity of enzymes
2. **Homogenization** the act of something homogeneous or uniform in composition
3. **Ultracentrifugation**: separating organelle by high speed in centrifuge

Cell fractionation organelle order

1) Nuclei
2) Chloroplast
3) Mitochondria
4) Lysosome
5) Peroxisomes
6) Fragment plasma membrane
7) Fragment of endoplasmic reticulum
8) Ribosomes