CELL

* Cell is the structural and functional unit of life
* It is the basic unit of biological activity
* The cells of biological systems are divided into two categories:

Prokaryotes – Pro (before) karyon (nucleus).
lack a well defined nucleus and possess relatively simple organisms.

Eukaryotes – membrane enclosed nucleus encapsulating their DNA.
Higher organisms like plants and animals.

differences

	Prokaryotes	Eukaryotes
Size	1–10 Mm	10–100 Mm
cell membrane	Rigid cell wall	Plasma Membrane
Cytoplasm	Viscous, No sub cellular organelles	sub cellular organelles present.
Nucleus.	Nuclear zone with DNA	well defined nucleus
Nucleolus.	×	✓
Mitochondria	×	✓
Golgi Complex	×	✓
Cytoskeleton.	×	✓
Cell division	Fission	Mitosis.

* Plasma membrane – limiting boundary of cell.

Sub Cellular Organelles.

Nucleus, ER, Golgi complex, mitochondria, lysosome, peroxisome.

- Functional role of organelles
  → Organelles have very specific functions.
  → Their specific enzyme activities serve as markers of the organelle during isolation – Marker Enzymes.

Organelle	M.E.
Mitochondria.	ATP Synthase.
Golgi complex.	Galactosyl transferase.
ER.	Glucose–6–Phosphatase.
lysosome.	Acid phosphatase

NUCLEUS

→ Most prominent.
→ spherical and central
→ absent in RBC.
Nucleus is a large membrane bound compartment.
Nucleus is surrounded by 2 membranes, nuclear envelope with outer membrane continuous with endoplasmic reticulum.

- Functions: DNA replication, repair of DNA, synthesis and processing of RNA.

ENDOPLASMIC RETICULUM.

* A network of intra connecting membranes that are continuous from the nuclear envelope to plasma membrane.

It has a role in protein synthesis and many sympathetic pathways.

- Functions:

SER → several metabolic processes, synthesis of lipids and steroids, drug metabolism.

Marker Enzyme → Glucose 6 phosphatase.

RER → ribosome protein synthesis.

GOLGI COMPLEX (Dictyosomes)

Golgi complex is a network of flattened smooth membrane sacs → cisternae.

M.E → Galactosyl Transferase.

→ Involved in secretion, modification and sorting of proteins.
→ Glycosylation of Proteins.
→ Major site of new membrane synthesis.
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MITOCHONDRIA.

* Spherical, oval or rod like bodies.
* Size → 0.2 – 0.8 µm.
* Absent in RBC, cornea, intestine, lense and centriole
* Bilayered
  OMM – smooth
  IMM – convolutes into folds (cristae)
* 2 compartments
  Inner membrane space & Matrix
  M.E → ATP Synthase.
* powerhouse of the cell – supply most of the cell's need for ATP
* IMM contains electron transport chain.
* Matrix – Enzymes of TCA cycle, Beta oxd^n of fatty acids etc.
* Extracellular DNA is found in the matrix of mitochondria.

- Functions:

→ Potion of ATP.
→ cellular respiration.
→ Oxd^n of carbohydrates and lipids.
→ Urea and heme synthesis.

- Clinical significance:
  - → Luft's disease – defective energy transduction.
  - → Mt. Myopathies – Oxphos diseases due to mutation in Mt. DNA

LYSOSOMES

- → Vesicular structure.
- → 0.4 Nm.
- → Surrounded by lipoprotein membrane.
- → Acidic pH (~5).
- → Contain a group of hydrolytic enzymes.

  M.E → Acid phosphatase.

- 'Garbage disposal system'.

lysosomes recycle materials by breaking down worn out parts of a cell into smaller units.

they deliver these materials ~~to~~ to the cytoplasm for use in constructing new proteins.

- → If the membrane of a lysosome breaks, the enzymes released may also destroy the cell itself giving lysosymes the name "suicide bags".
- → Cellular digestion.
- → hydrolysis of carbohydrates, proteins, lipids and nucleic acids.

- Clinical aspects:
  - → Lysosomal storage disorders
  - → Inclusion cell disease – a protein targeting defect. accumulation of undegraded molecules – inclusion bodies.
  - → gout – urate crystals are phagocytosed and cause physical damage of lysosomes releasing enzymes producing inflammation and arthritis.

PEROXISOMES

- → diverse group of organelles found in eukaryotic cell.
- → Peroxisomes are named so because they play unique role in Hydrogen Peroxide metabolism.
- → contain enzymes that use molecular oxygen to remove hydrogen atoms from specific substrates.

$$RH_2 + O_2 \longrightarrow R + H_2O_2$$

- → Hydrogen peroxide is used up or detoxified.
- → Catalases in peroxisome convert this hydrogen peroxide to water.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

Peroxisome has got an important role in lipid metabolism.

- Metabolism of free Oxygen radicals.
- Synthesis of cholesterol and other lipids.

- Bile acid formation.
- catabolism of purines, prostaglandins.
- Alcohol detoxification in liver.
- Metabolism of estradiol.

Clinical significance:

- Peroxisomes indirectly linked to human conditions such as obesity, heart disease, diabetes and certain cancers.
- Peroxisomal biogenic disorders
  The Zellweger Syndrome.
  Refsum's disease.
  Hyperoxaluria etc.

Cytosol

→ Organelle free sap.
→ No specific structure
→ Rich in proteins.
→ support synthesis of proteins on ribosome which are free or bound to endoplasmic reticulum by supplying the cofactors and energy.
→ Contains enzymes of glycolysis, fatty acid synthesis etc.

Structure of Membranes

Trilaminar appearance.
Width → 50 - 80 A°
Dynamic structure
Amphipathic.

→ The membranes are asymmetrical
→ irregular distribution of proteins.
→ The carbohydrates are located on the external surface only.
→ Specific enzymes are located exclusively on the outside (ectoenzyme) and inside of the membrane.
→ Composed of lipids, proteins and carbohydrates.

lipids - Phospholipids glycosphingolipids and cholesterol.

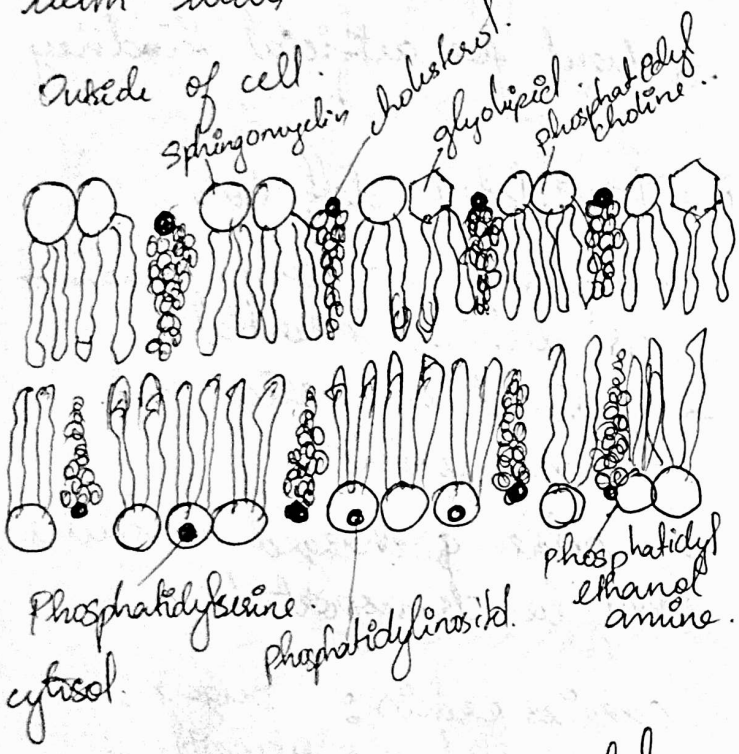
proteins - peripheral proteins & integral membrane proteins

carbohydrates - glycoproteins & glycolipids.

Structure

→ Dawson and Danielli (1935) Lipid Bilayer.
→ Nicolson and Singer (1972) Fluid Mosaic Model.

- The phospholipids are arranged in bilayer with the polar head groups oriented towards the outside and hydrophilic tails towards between the bilayer.
- The proteins are either on the surface or span the lipid bilayer.
- The hydropholic lipids and proteins are arranged to minimise their interaction with water.



→ the fluid mosaic model shows free lateral movement
No flip-flop movement
* → fluidity of membrane is proportional to concentration of cholesterol and fatty acid.

Membrane Proteins

(1) Peripheral membrane proteins
→ exists on surface of membrane
→ do not interact directly with the phospholipids.
→ they are weakly bound to the hydrophilic region of integral protein

(2) Integral membrane proteins.
→ commonest
→ Interact extensively with the phospholipids.
→ Embedded or span the entire distance of membrane
→ Attached by hydropholic bonds or van der Waal's forces.

Functions of Plasma Membrane

* Protective sheath
* Selective transport of ions and molecules (selective permability)
* Recognition of various stimuli
* Contains receptors for biomolecules like hormones, neurotransmitters etc.
* ~~Contains receptors~~ Maintenance of shape of cell.
* Cell motility

Membrane Transport

* Selectively permeable.
* transport mechanisms are classified into Passive and active.

(1) Passive
→ Simple diffusion
→ Facilitated diffusion
- carriers
- channels.

(2) Active transport

(i) Simple diffusion:
Solute particles move from higher to lower concentration.
→ driven by conc: gradient.
→ does not require energy.
→ factors affecting ~~sol~~ are solubility, size & shape of the solute, temperature & surface area of the membrane.

eg: Respiratory exchange of gasses is by diffusion.

- Transport small molecules, hydrophobic molecules, small polar but uncharged molecules.

Depends on physical properties of substance.
→ Osmosis
→ Dialysis

Osmosis
→ diffusion of water from dilute to conc: solution when separated by semi permeable membrane.
→ hydrostatic pressure which exactly balances osmotic influx of water from pure water to conc. solution is the osmotic pressure of that sol^n.
→ Colloid osmotic pressure exerted mainly by plasma protein retain blood volume.

Dialysis
→ Membranes made of cellophane, cellulose nitrate or cellulose acetate are freely permeable to water and small molecules but impermeable to large particles
→ Electrodialysis:
Semi permeability and migration of electrolyte ions in electric field are utilized for separating colloid particles from electrolyte
→ used for artificial kidney.

(ii) Facilitated diffusion
→ depends on conc. gradient or electrical potential
→ mediated by carrier and channel protein
→ polar & charged molecules can be transported

carrier protein: Sugar, amino acid, nucleoside, glucose transporters etc.

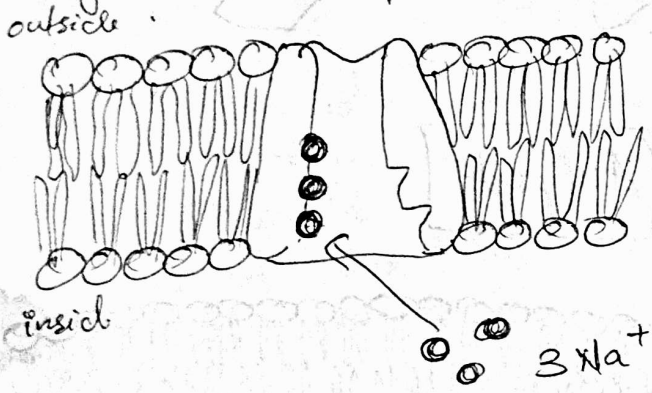
channel protein: aquaporin (water channels) ion channels.

Ion channels: → these are specialised protein molecule that span the membrane.
→ fundamental role in transmission of electric impulses.
→ allow passage of molecules in accordance with conc: gradient

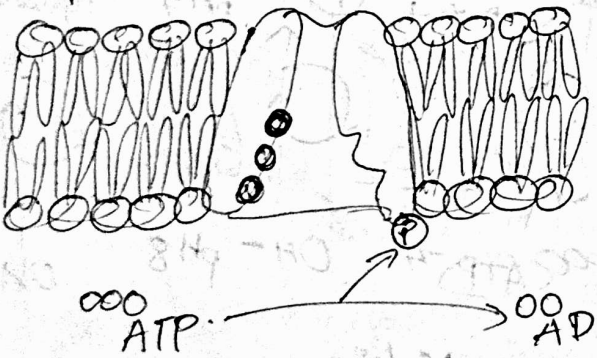
→ highly ion selective.
→ regulated by gates (ligand-gated, Voltage-gated)

Active Transport

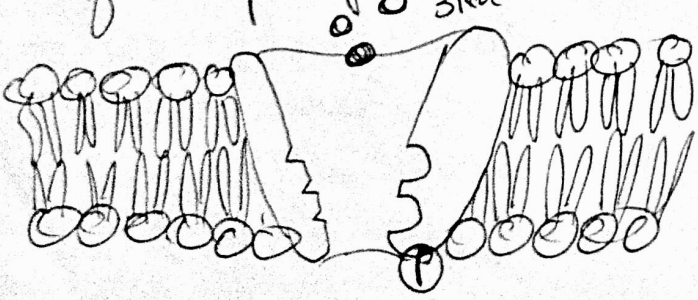
→ Energy is necessary
→ Usually against conc gradient.
→ Unidirectional
→ Requires specialized integral proteins called transporters
eg: Na^+ - K^+ pump.



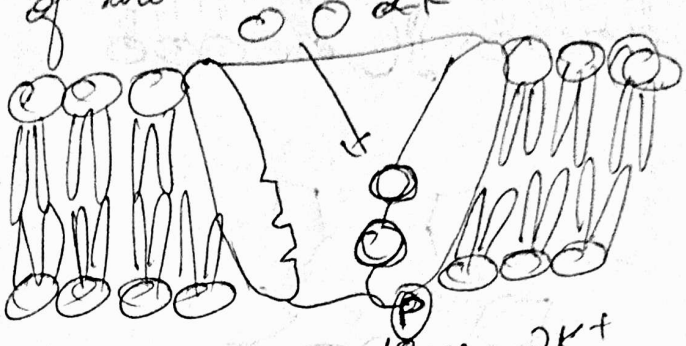
3 Na^+ bind to site exposed inside the cell.



The binding of Na^+ stimulates ATP-dependent phosphorylation of the pump.



Phosphorylation exposes the Na^+ binding site to the cell surface and lowers their binding affinity so that Na^+ is released on the outside of the cell.



At the same time, $2K^+$ binds to high-affinity sites exposed on the cell surface.

→ Active transport driven by ion gradient
→ It requires energy.
eg: Active transport of glucose.

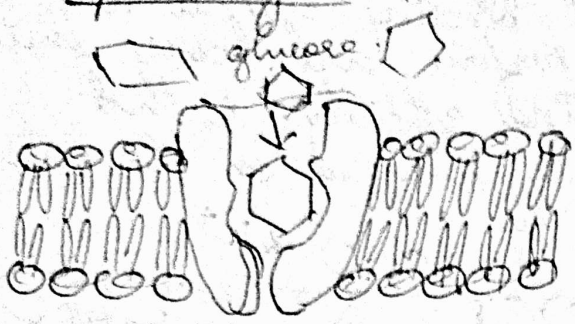
Ionophores

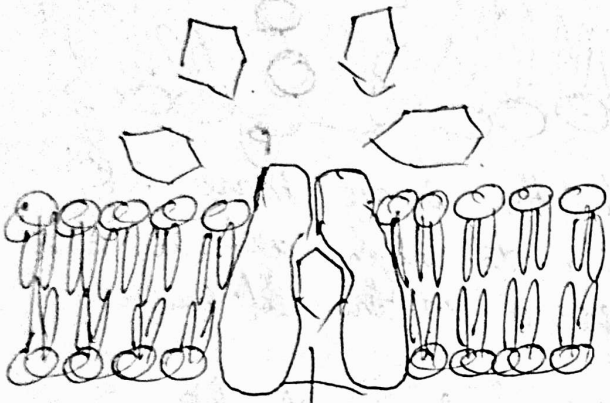
→ Increase the permeability of biological membranes to certain ions

Transport Systems

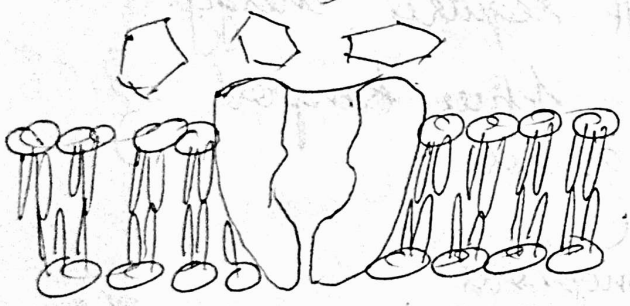
* Uniport system: single molecule through a membrane.
* Cotransport system:
→ symport system - simultaneous transport of 2 different molecules in the same direction
→ antiport → simultaneous transport of 2 diff. molecules in opp direction.

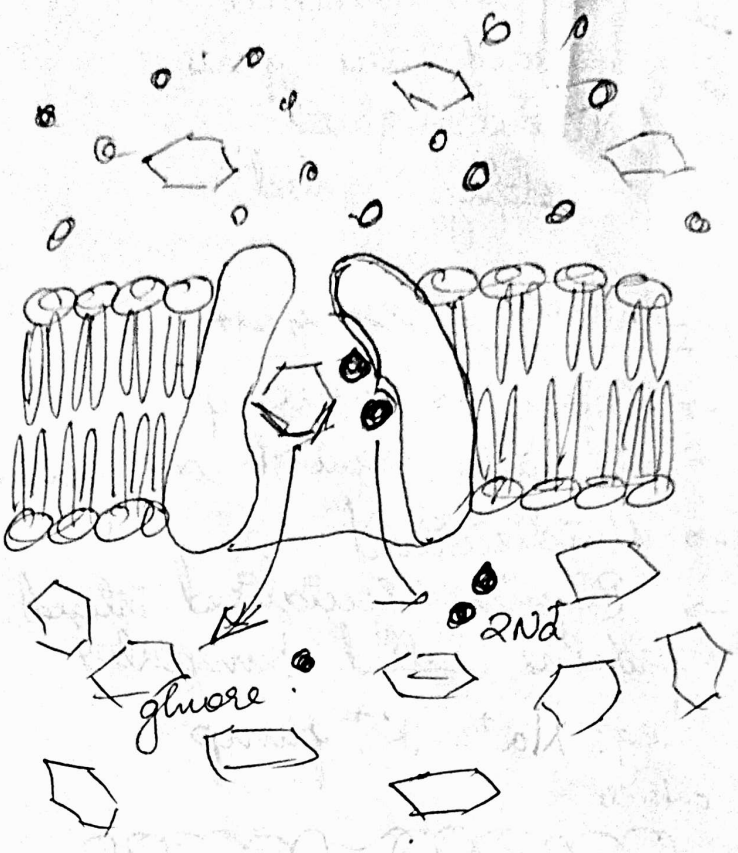
Uniport system



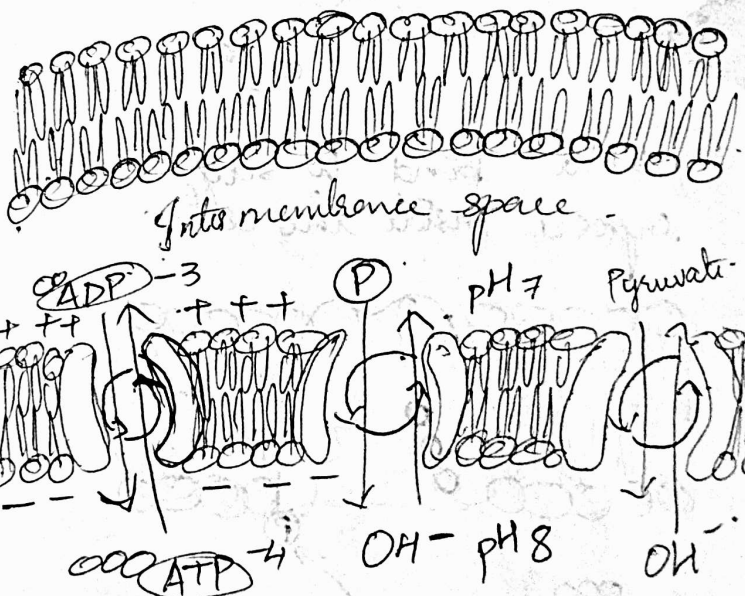


inside the cell





Antiport



Symport