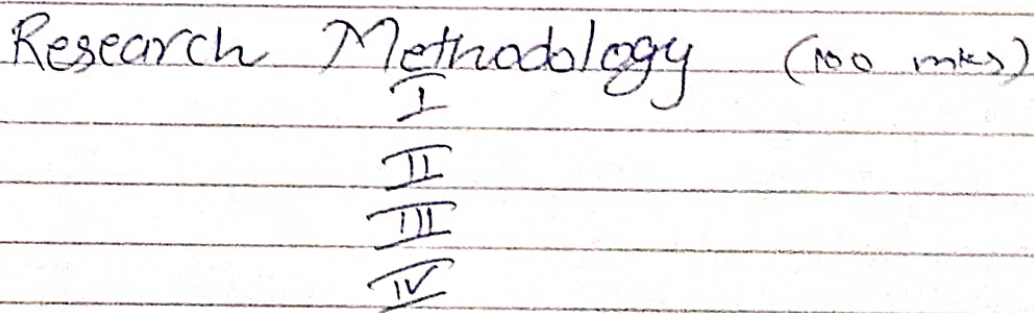
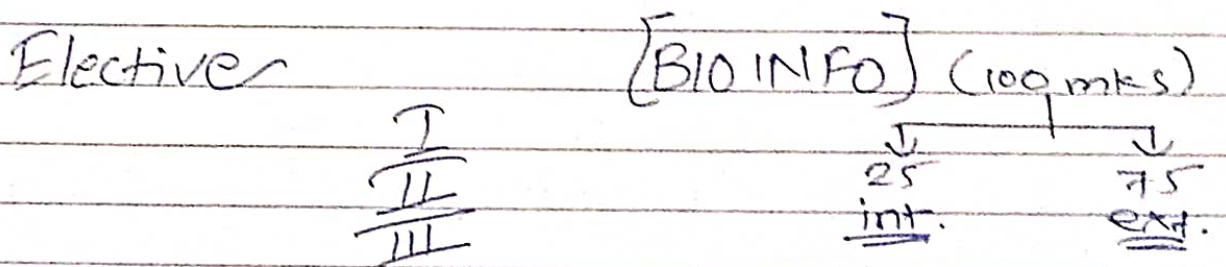
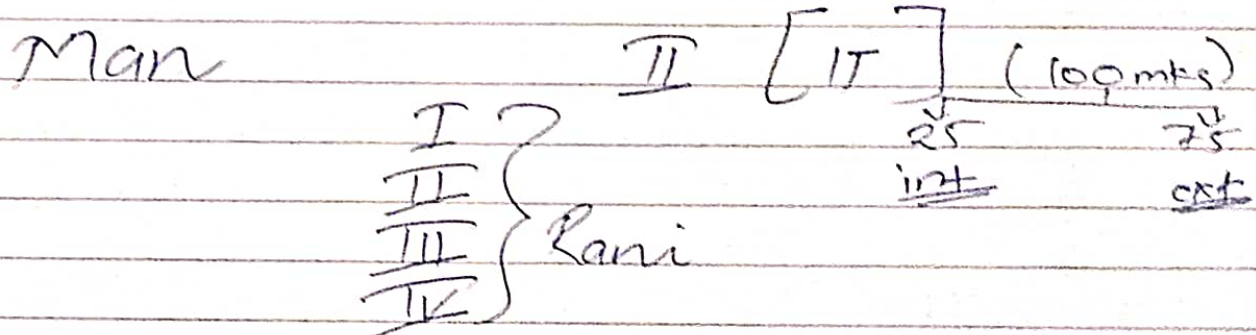
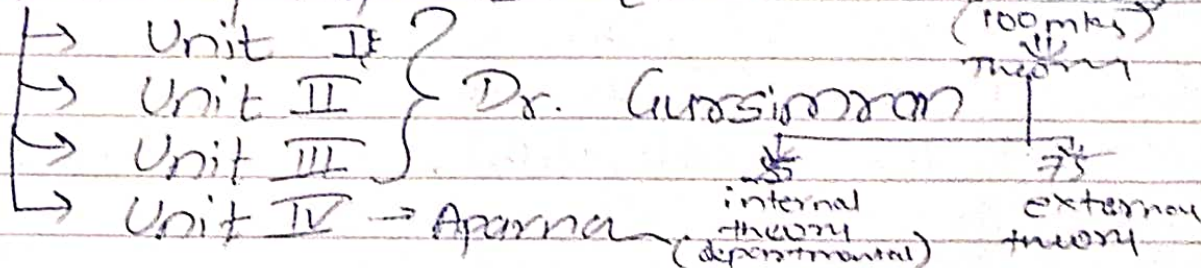
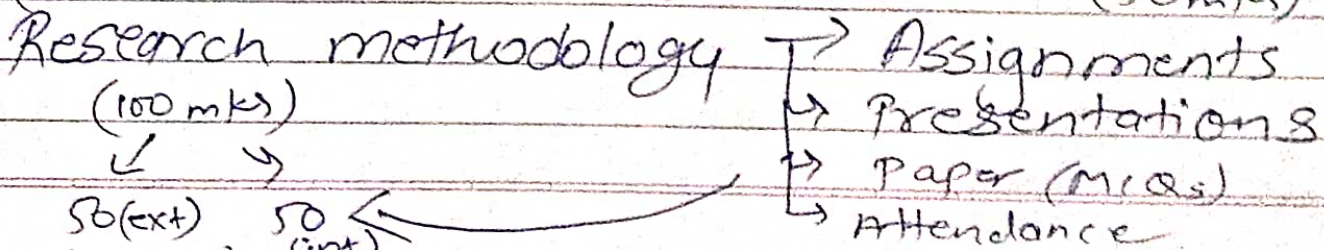
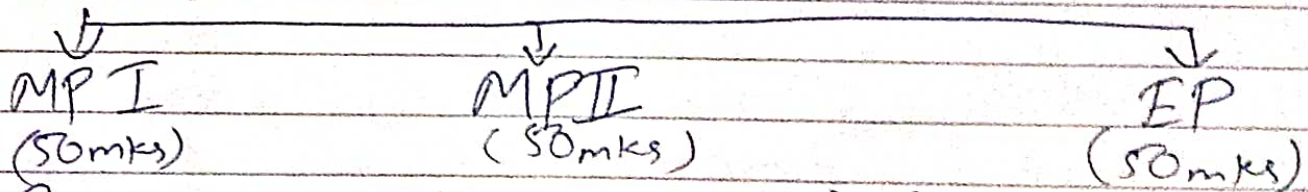


⇒ NEP

↳ Mandatory Paper I [BIO + BIOINFO] (100 mks)



⇒ Practicals



→ Paper pattern

- Q.1 U1 [a & b or c & d]
- Q.2 U2 [a & b or c & d]
- Q.3 U3 [a & b or c & d]
- Q.4 U4 [a & b or c & d]
- Q.5 U5 [U1(a), U2(b), U3(c), U4(d), U5(e)] only 5

Cell Biology

observed / discovered \hookrightarrow study of living
Robert Hooke Structural & functional unit of life
in (1665) termed "cell"

\rightarrow 5 kingdom classification [R.H. Whittaker]
[Monera] [Protista] [Fungi] [Plantae] [Animalia]

\rightarrow 6 kingdom classification [Carl Woese]
[Archaeobacteria] [Eubacteria] [Protista] [Fungi] [Plantae] [Animalia]

\rightarrow ~~3 domains~~ [Archae] [Bacteria] [Eukarya] -
~~Eubacteria~~ ~~Archaeobacteria~~
3-domain classification [Carl Woese]

\rightarrow ~~measurement scale (km to angstrom A)~~

\rightarrow 2-kingdom classification [Carolus Linnaeus]
[Plantae] [Animalia]

* Cell Theory

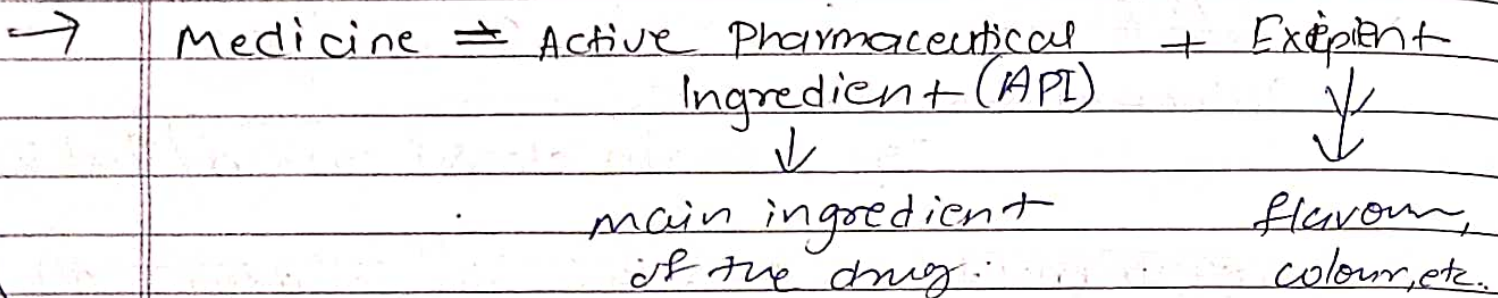
- Theodor Schwann & Matthias Schleiden
 \hookrightarrow all living things are made up of cells.
- Rudolf Virchow
 \hookrightarrow all cells comes from cells

* Principles of Cell Theory.

- All living things are made up of cells
- Smallest living unit of structure & function of all organisms is the cell.
- All cells arise from preexisting cells
 \hookrightarrow [discarded] \rightarrow Idea of spontaneous generation

⊗ Characteristics of cell

- contain highly organized molecular & biochemical systems and are used to store info.
- uses energy → ATP, NADPH, etc.
- capable of movement → ^{via} cilia, flagella, etc.
- can sense env. changes → skin, etc. cell wall, etc.
- can duplicate → transfer of genetic info to offspring
- capable of self-regulation.



- has surrounding membrane
- protoplasm → cell contents in thick fluid
 - ↳ acts as shock absorbers
- organelles → structure inside for cell function.

→ cell types } Prokaryotic
 } Eukaryotic

- Prokaryotic
- single cell with nuclear material but no nuclear membrane or membrane bound organelles.

- Eukaryotic
- cells with nuclear material within nuclear membrane & membrane bound organelles: (MOSTLY)

- Kilometer = 1×10^3 m
- Hectometer = 1×10^2 m
- Dekameter = 1×10^1 m
- meter = 1×10^0 m
- Decimeter = 1×10^{-1} m
- Centimeter = 1×10^{-2} m
- millimeter = 1×10^{-3} m
- (μ m) micrometer = 1×10^{-6} m
- (nm) nanometer = 1×10^{-9} m
- (\AA) Angstrom = 1×10^{-10} m
- (pm) Picometer = 1×10^{-12} m
- (fm) femtometer = 1×10^{-15} m

- E. coli is widely studied as it has faster reproductive rate / doubling time, i.e. 20 minutes.

→ Cell culture → (3-5 days at least)

- the process by which the cells are grown under controlled laboratory conditions.
- cell culture or tissue culture → Montrose Thomas Burrows, American pathologist

→ Contamination

- the presence of a constituent, impurity, organism or other undesirable element that spoils, corrupts, infects, makes unfit or makes ^{inferior} a material, physical body, natural env., workplace, etc.

→ Fermentation

- breaking down of sugar molecules into simpler compounds to produce substances that can be used ^{in making} as a source of chemical energy, under anaerobic conditions.

→ Optical density (O.D.)

- the ability of material to transmit the light through it.

→ Upstream

- the entire process from which initial steps/stage of cell isolation & cultivation to cell banking & culture expansion of cell

→ Downstream

- recovery & purification of ^{desired} products from sources such as animals, plants, tissues or fermentation broths, including the recycling of salvageable components & proper waste treatment & disposal until the final harvest

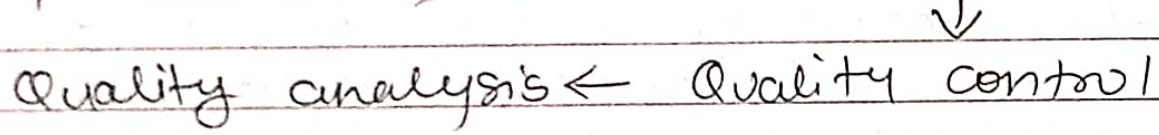
→ Molecular Biology

- branch of biology that studies the molecular basis of biological activities.

→ Recombinant DNA Technology

- altering of genetic material outside an organism to obtain enhanced & desired characteristics in living organisms or as their products

→ upstream → downstream → characterization



→ Surface of cell

protection, communication & movement.

→ Cytoplasm

machinery of cell

→ Nucleus

control center

⇒

Prokaryotic cells
 ↳ Bacteria & archaea

- first type of cell on Earth
- has ribosomes, DNA, plasma membrane, capsule, cell wall, basal bodies, flagella, etc.

⇒

Eukaryotic cells.

- Nucleus bound by membranes & cell-bound membranes.
- evolved prokaryotic cells.

⇒

Plant cell

- cell wall — protection & support
- Chloroplast — for photosynthesis.
- ~~sur~~ large central vacuole — for storage & increase surface area

⇒

cell wall

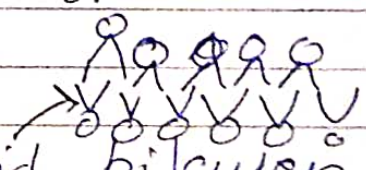
- ↳ Plants → cellulose
- ↳ fungi → chitin

- surrounded by cell membrane.

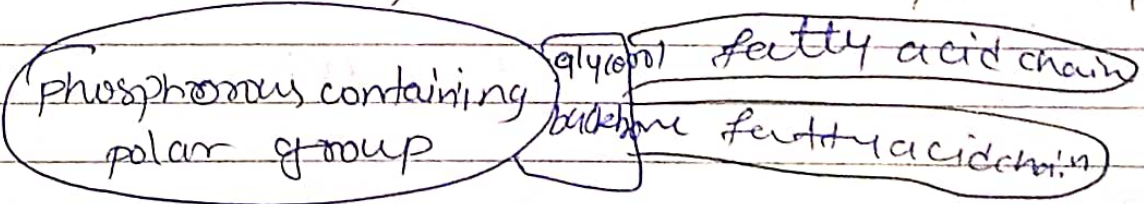
⇒

cell membrane

- made up of phospholipid bilayer
- contains abundant lipids.
- Polar/hydrophilic head → attracted to H_2O
- ^{pair of} nonpolar/hydrophobic tail → repelled by H_2O



Fluid Mosaic Model



↑
hydrophilic head

↑
hydrophobic tail

- has tunnel proteins, or gate to allow the exchange of materials.

→ organelles

→ Support

cell wall, cell membrane, cytoskeleton, microtubules.

→ controls material entering & leaving.
cell membrane, pores

→ Internal transport system
Endoplasmic reticulum

→ Powerhouse
Mitochondria

→ control center
nucleus, organelle DNA for mito & chloroplast.

→ production of key products.
ribo, ER, chloroplast.

→ Package
Golgi & ER

→ shipment (out of the cell)
Golgi, vesicles.

→ storage (liq. & solids)
Vacuoles, vesicles, plastids.

→ Recycling center.
lysosome, peroxisomes

→ light ^{ene} → ^{chem} energy
chloroplast

→ New cell factories
Nucleus, centrioles.

* Nucleus

- has nuclear envelope with nuclear pores
- Nuclear ~~mem~~ envelope
- membranous barrier that separates nuclear material & nucleoplasm from cytoplasm

→ Chromosome structure

- Nucleosomes

core of DNA wrapped around 8 histone proteins plus linker DNA.

- Solenoid

coiling of nucleosomes like ^(telephone) phone cord

→ condensed chromatin fibre

material of which chromosomes of organisms other than bacteria are made up of, ~~is~~ & consists of protein, RNA & DNA.

* Cell membrane

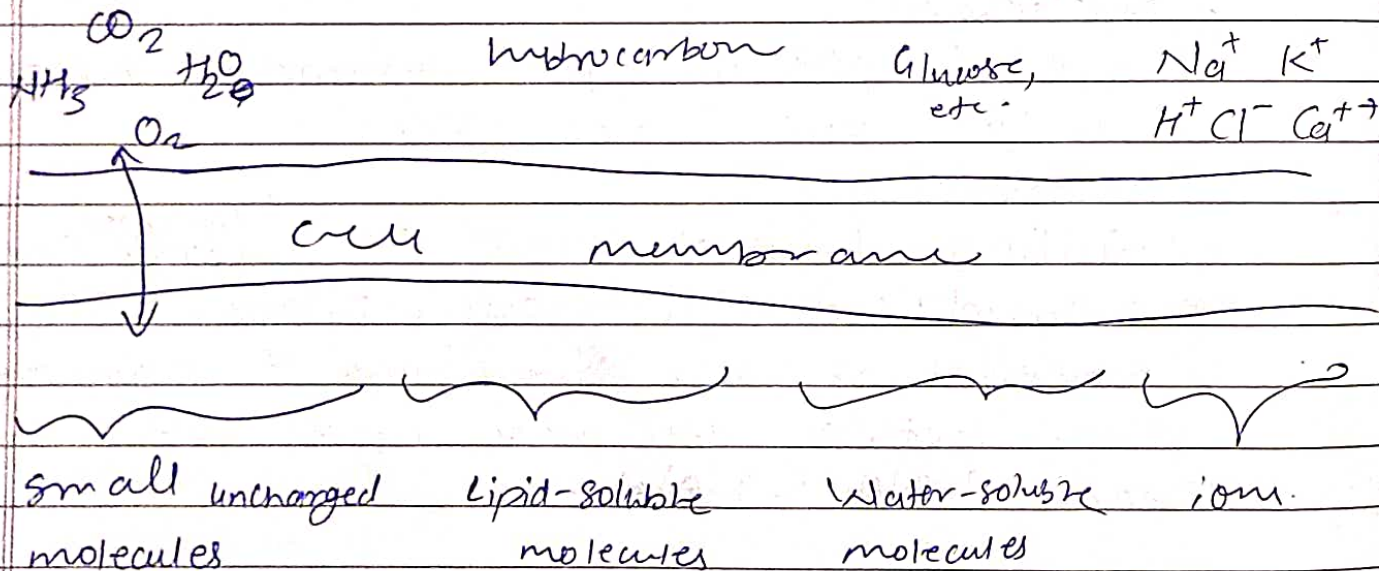
- made up of protein & phosphoprotein
- some proteins form tunnel protein.
- has imp function in receptors, transportation & structure.

- lipids embedded can laterally move about 2 $\mu\text{m}/\text{sec}$.
- saturated & unsaturated fatty acids.
 - ↳ rigid cell membrane
 - ↳ smooth cell membrane
- As temp drops, organisms transport more unsaturated fatty acids into the membranes.

⇒ Central Dogma

DNA $\xrightarrow{\text{Transcription}}$ mRNA $\xrightarrow{\text{Translation}}$ Protein

⇒



⇒

Active diffusion → movement of mols/ions from low conc. to high conc. via carrier proteins [ATP/NADPH reqd.]

⇒

Passive diffusion → movement of mols/ions from high conc. to low conc. through cell membrane.

[No external Energy needed.]

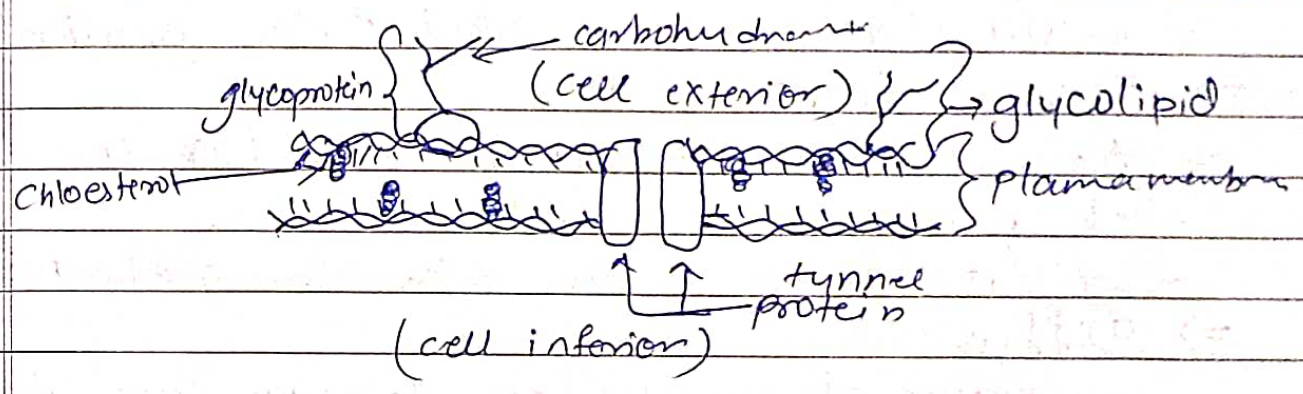
Membrane Proteins

channels

Receptors

↓
- moves mol's. in one direction

- Recognizes certain chemicals/molecules



⇒ Enzymes

- biochemical compounds produced by organism that acts as a catalyst in specific biochemical reactions, bringing down the requirement of activation energy & speeding up the reaction, without undergoing permanent conformational changes & gets recycled

⇒ Glycoprotein

- class of protein that have carbohydrate/glycan groups attached to polypeptide chain of protein by glycosidic (covalent) bond.

⇒ Glycolipids

- class of ~~prot~~ lipids that have lipids/fats attached to the polypeptide chain of protein by glycosidic (covalent) bond.

⇒ tunnel ^{or channel} proteins / transmembrane protein

- type of integral membrane protein that spans the entirety of cell membrane & acts as a gateway to permit passage of specific compounds.

⇒ Cholesterol ^{waxy, fat-like}

- compound of sterol type found in body tissues

⇒ Carrier Proteins

- A membrane transport protein is in movement of ions & small molecules & macromolecules across cell membrane.

⇒ Active transportation

- transfer of mols/ions/compds. from low conc. to high
- ~~no~~ energy is required.
- mols/ions/compds. moves against the gradient.

⇒ Passive transportation

- transfer of mols/ions/compds. from high conc. to low
- No energy is required.
- mols/ions/compds. moves with the gradient.

⇒ Diffusion

- movement of particles from higher conc. to lower ~~without~~

⇒ Intrinsic & Extrinsic Protein

→ Intrinsic protein

- group of integral membrane proteins that are present in the cell membrane towards the inside (i.e. cytoplasm side) of the cell membrane
- also called integral or internal proteins
- hydrophobic
- Types → Type I (most of the protein is outside cytoplasm)
 Type II (most of the protein is inside cytoplasm)

→ Extrinsic protein

- group of the ~~per~~ peripheral ~~protein~~ membrane proteins that are present on ~~per~~ periphery or surface of the cell membrane.
- also called ~~per~~ peripheral or external proteins
- more hydrophilic & less hydrophobic

★ Movement across membrane.

⇒ Diffusion ⇒ (solid particles moves)
 - molecules moving from higher to lower concentration ~~via a membrane~~ via semipermeable membrane
 - $conc. = \frac{no. of mol.}{Vol.}$

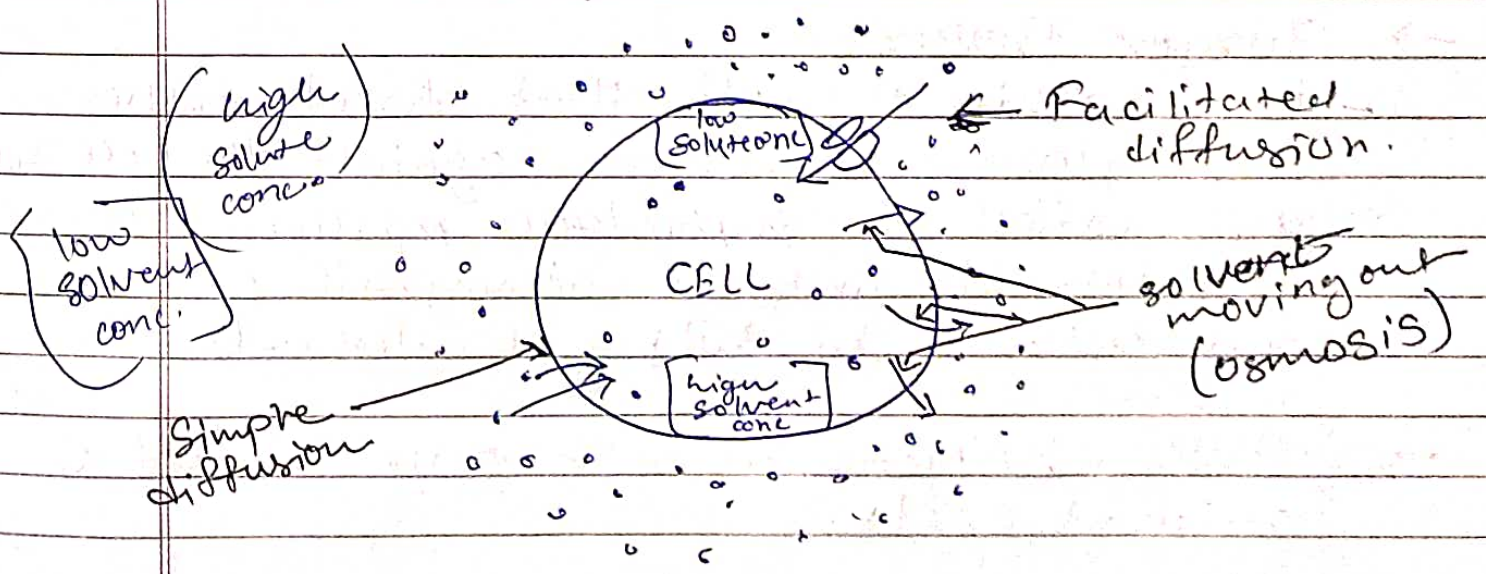
→ Simple Diffusion → Diffusion of particles across the semipermeable membrane without any transport proteins.

→ Facilitated Diffusion → Diffusion of particles across the semi-permeable membrane by the means of the transport proteins.

⇒ solvent molecules Osmosis ⇒ (Liquid moves) moving from higher to lower conc. via a selectively permeable membrane or semi-permeable

- movement of solvent molecules from region of lower solute concentration to the region of higher solute concentration ~~via~~ through a semipermeable membrane

⇒ ~~Facilitated Diffusion.~~



⇒

Osmosis

→ Hypertonic

- relatively high solute conc.

→ Hypotonic

- relatively low solute conc.

→ Isotonic

- both the solutions have same solute conc.

⇒

Plasmolysis

↳ due to increase in turgor pressure inside the cells.

- plant cell in concentrated salt solution shrinks. (hypertonic solution)
- plant cell in mannitol solution swells. (hypotonic solution)
- Nothing happens when plant cell is in distilled water (isotonic solution).

→

Plasmolysis

Protoplast → ^{cell}cyto + membrane

- contraction of protoplast of plant cell as a result of water loss from the cell

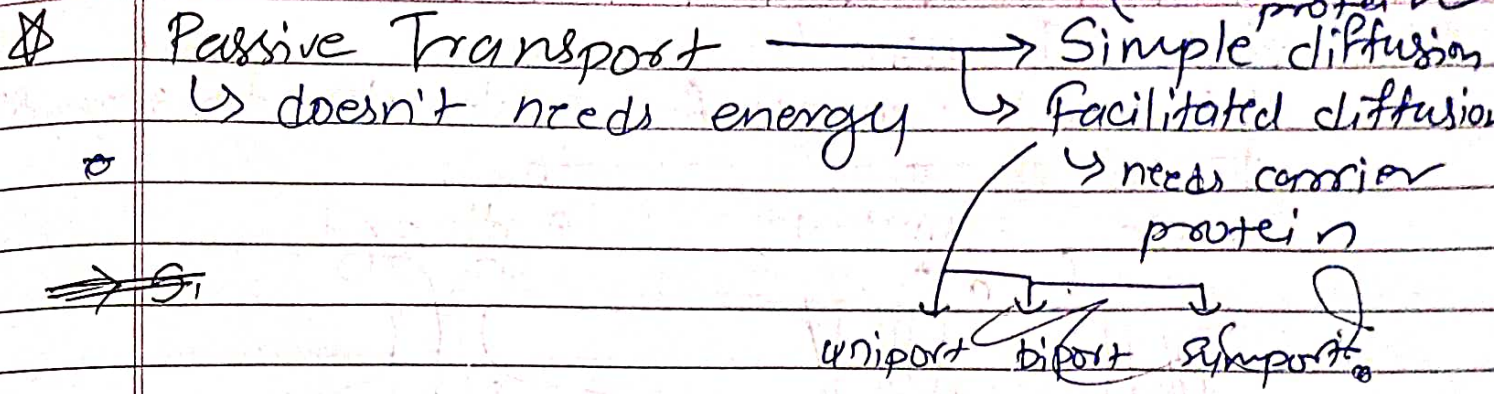
→

Turgor Pressure

- force within the cell that forcefully pushes the plasma membrane against the cell wall
- also called as hydrostatic pressure, which in excess of ambient atmospheric pressure can build up in living, walled cells.

-

These happens in both plant as well as animal cells.



⇒ ~~Simple Diffusion~~

⇒ ~~Facilitated Diffusion~~

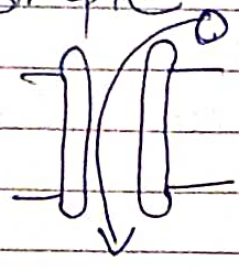
	UNIORT	SYMPORT	ANTIORT
→ <u>Types</u>			
<u>destination</u>	transports single substrate species across the membrane	transport 2 diff substrate species in same direction across the membrane	transports 2 diff substrate species in different/opposite directions across the membrane
<u>no. of molecules</u>	one	two	two
<u>directions of transport</u>	one	one	both
<u>proteins involved</u>	carrier protein	co-transporters	co-transporters.
<u>driving force</u>	ATP	Electrochemical gradient	Electrochemical gradient.
<u>Examples</u>	channel proteins	Na ⁺ /glucose symporter	Na ⁺ /H ⁺ antiporter

*

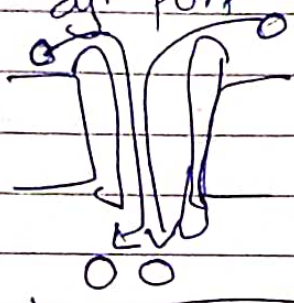
Active Transport

↳ needs energy for molecule transportation

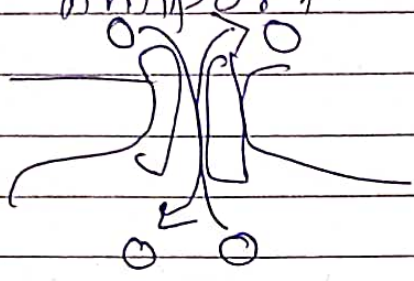
simple



Symport



Antiport



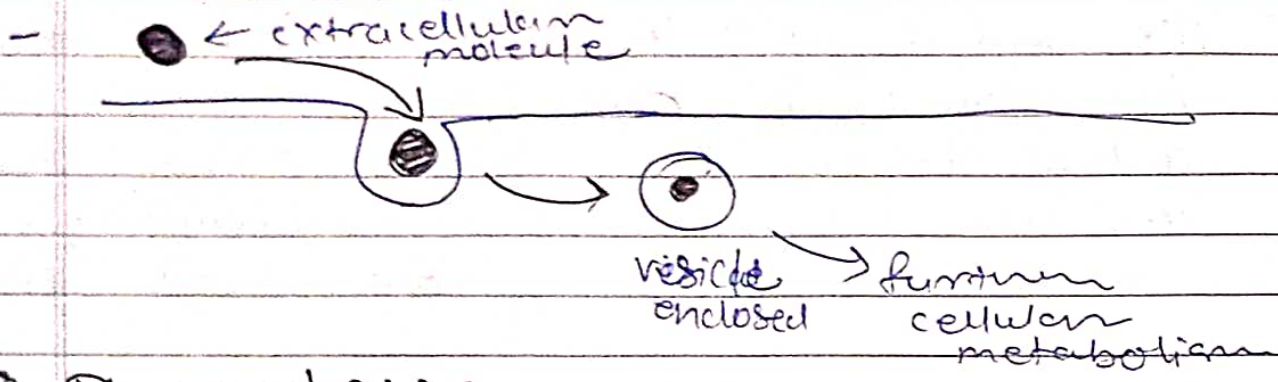
coupled transport

* Differentiation: Active & Passive transport

Property	Active	Passive
Def ⁿ	Movement of ^{solute} molecules from region of low conc. to high conc. via a semi-permeable membrane against conc. gradient	Movement of ^{solute} molecules from region of high conc. to low conc. via a semi-permeable membrane along the conc. gradient
Energy Requirement	Requires energy in form of ATP	Doesn't require energy
Molecule movement	Against the conc. gradient i.e. from low conc. to high	Along the conc. gradient i.e. from high conc. to low.
Membrane requirement	Semi permeable membrane is necessary.	Can occur even without a semi permeable membrane
Selectivity	Highly selective process	Comparatively, less selective process
rate of process	A rapid process	A slow process
Carrier proteins	carrier proteins are involved	No carrier proteins are involved.
Direction	Unidirectional	Bidirectional
Influenced by	Affected by ① metabolic inhibitors. ② temperature ③ presence of carrier proteins ④ presence of energy [ATP] ⑤	Affected by ① size size of the molecule ② selectivity of membrane ③ concentration gradient ④ change of molecule ⑤

* Endocytosis.

↳ molecules are taken inside by pinching off the cell membrane along with the molecules.



* Phagocytosis

- cellular projects of engulfing the particles for various metabolic/catabolic processes (majorly for degradation)

* Lysosomes

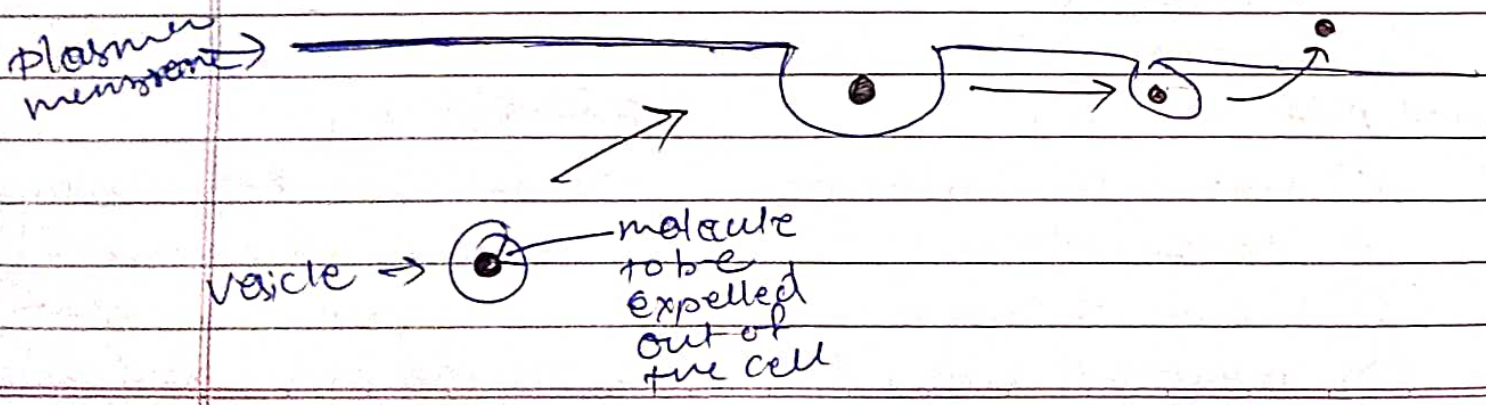
- membrane-bound/enclosed cell organelles containing various digestive enzymes capable of degrading almost all biological polymers & compounds like proteins, nucleic acid, carbohydrates, lipids, etc.

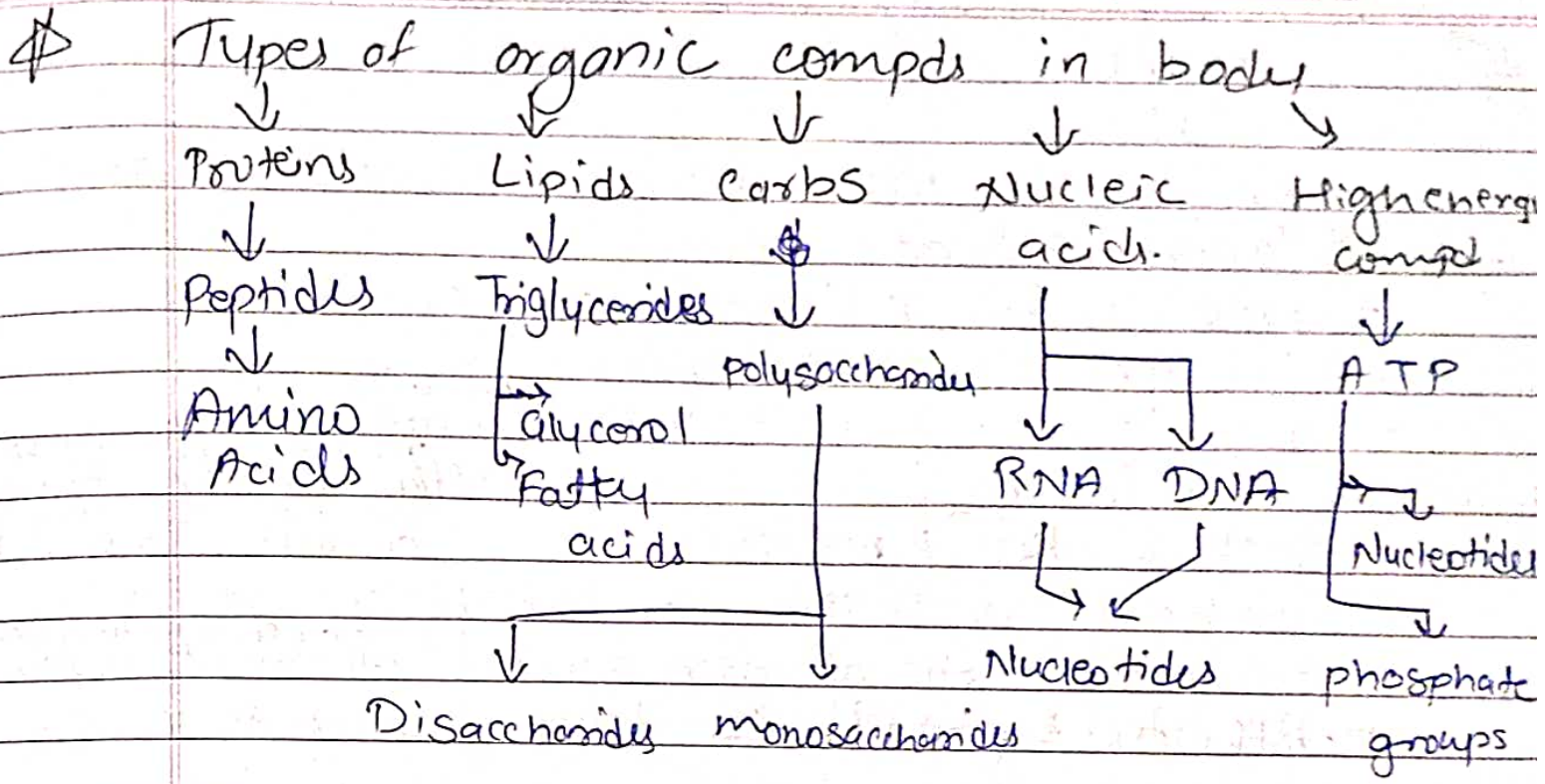
* Exocytosis

↳ molecules are moved outside of the cell by merging the vacuoles with the containing molecules with the cell membrane.

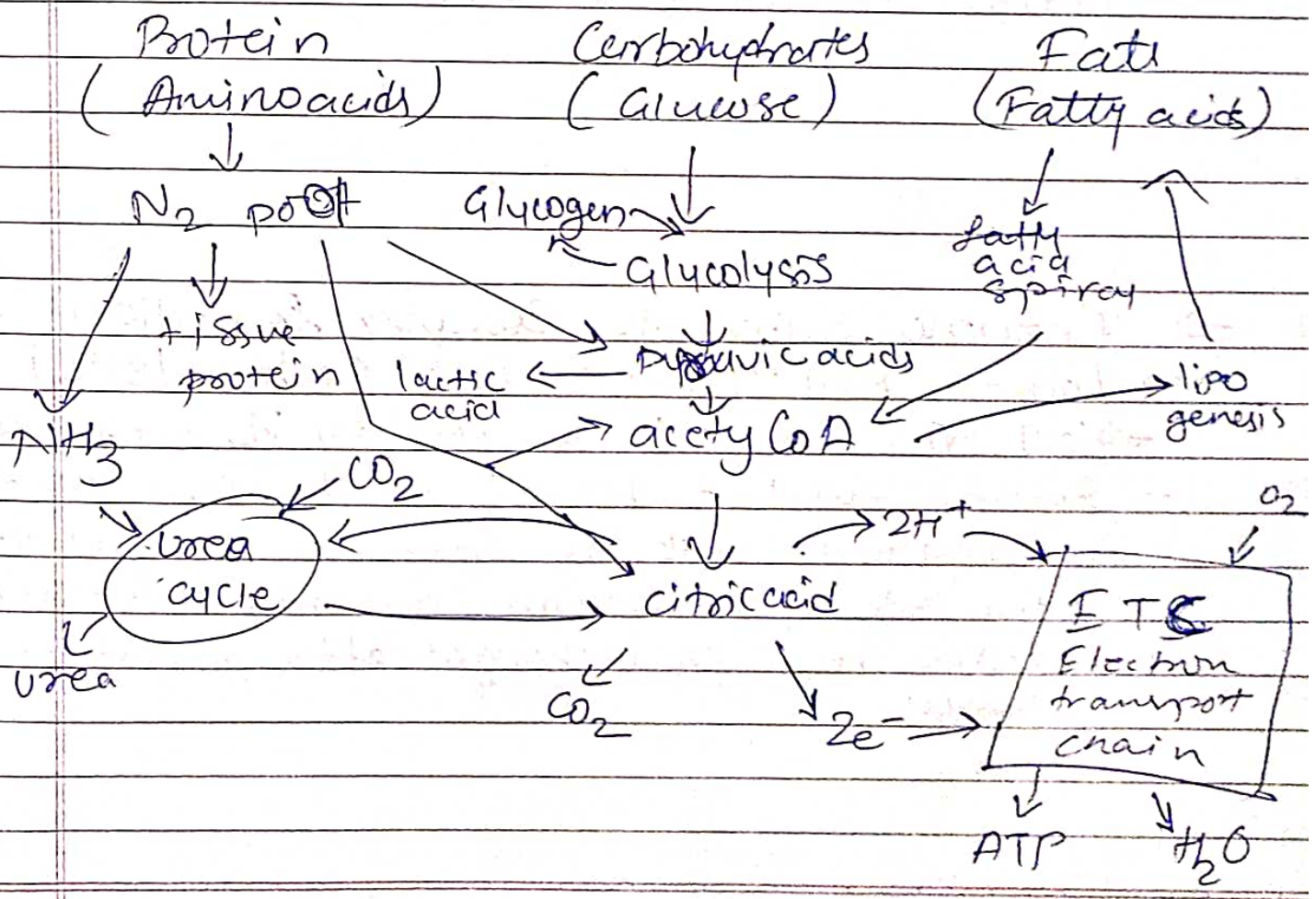
* Pinocytosis (part of Endocytosis)

- uptake of extracellular fluids or dissolved solutes by the cells. Pino (to drink); cyto (cell).





* Chemical interactions



* Enzymes

- catalyst
- proteins → may have non-protein parts.
- lowers activation energy
- NOT conformational changes
- Enzyme-substrate complex
- Inhibition → competitive (inhibitor binds to active site)
- mixed (can bind to both active & non-active site) → non-competitive (inhibitor binds to protein site & bring conformation changes to active site)
- lock & key hypothesis
- can have anabolism or catabolism reactions
- active site - Site at which substrate attaches to protein (complementary to each other)
- Affected by → pH, ~~temp~~ temp & substrate conc.

→ Enzymatic mechanisms

- brings reacting molecules in close proximity.
- decreases the ~~sub~~ reaction activation energy

⇒ Enzyme-Substrate Complex formation.

→ Lock-&-Key Theory ⇒ Emil Fischer (1898)

- lock can only be operated by its specific key
- Specific substrate having specific structure that is complementary to the specific structure of the active site of the enzyme can interact & bind to enzyme
- Enzyme remains unchanged after product is released.

(1966)

- Induced Fit Model Theory → Daniel Koshland
- The shape/structure of the active sites of enzyme is not rigid but is flexible
 - The structure of the active site is not ~~complemen~~ complementary to the structure of substrate, initially. But, as the substrate approaches the enzyme, it brings about ^{minor} structural change at the active site to ^{bind &} interact with the enzyme thus forming the enzyme-substrate complex.

⇒ Endocytosis & Exocytosis

- Endo & Exo-cytosis is used by all the cell to ~~move~~ ^{transport} the molecules inside & outside of the cell, respectively, which cannot pass through the membrane passively.
- Endocytosis is the process of actively transporting molecules into the cell by engulfing it with its membrane.
- Exocytosis provides an opposite function & pushes the molecules out of the cell.
- The amount of the molecules entering the cell by endocytosis is equal to the amount of molecules exiting the cell via, exocytosis.
- These two processes combined ensures that there's a balance of nutrient & waste for regular cell life & function.



→ Endocytosis is used for

- ① receptor signalling
- ② nutrient uptake
- ③ membrane remodelling
- ④ pathogen entry
- ⑤ neurotransmission
- ⑥ modulating cell signalling responses

- In developing tissues, it has been found that the endocytosis aids in cell migration
- Toxins, pathogens & foreign debris have also found to exploit the different endocytotic endocytic pathways in order to gain entry into the cell.
- Particles will recruit clathrins [proteins that are necessary for vesicle shape & formation] or will initiate the initial steps of pathway in order to begin the process ~~of~~ to enter the cell.
- Endocytosis pathway can be subdivided into 4 categories:
 - ① receptor-mediated endocytosis or clathrin-mediated endocytosis
 - ② caveolae
 - ③ pinocytosis
 - ④ phagocytosis

→ Receptor/Clathrin-mediated endocytosis

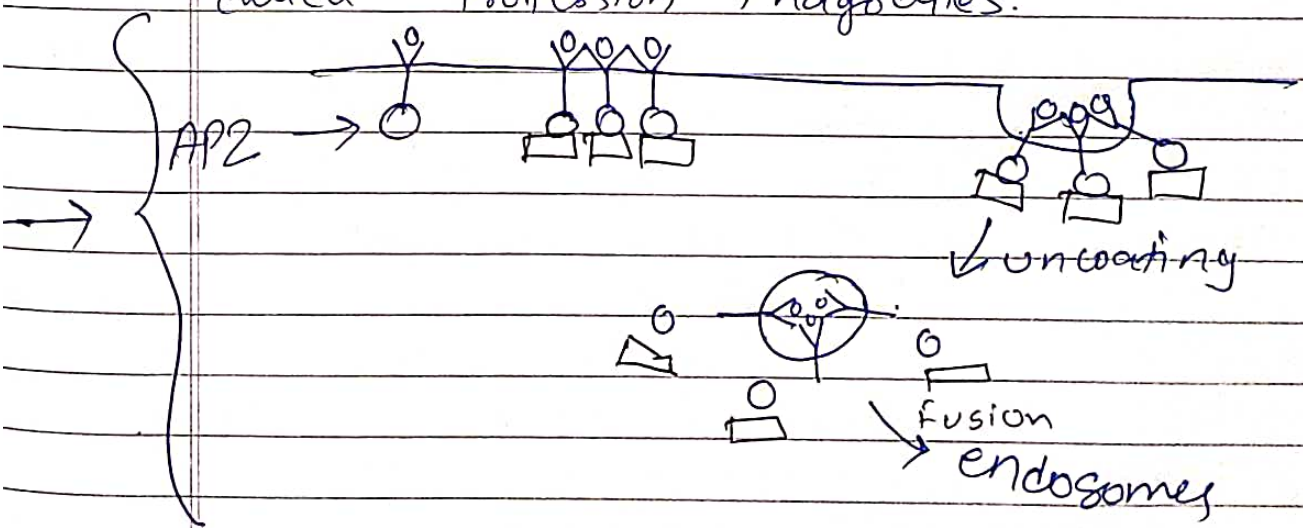
- process by which cell absorbs metabolites, hormones, proteins or viruses by inward budding of plasma membrane (invagination)
- forms vesicles containing absorbed substances & is strictly mediated by receptors on cell surface
- only receptor-specific molecules can enter cell.



- Caveolae → non-clathrin coated ^{plasma} ~~protein~~ membrane buds on some cell surface
- consists of cholesterol binding protein, caveolin with bilayer enriched with cholesterol & glycolipids.
 - small (50nm diameter), flask-shaped pits in membrane resembling cave-like structure.
 - constitute upto 1/3rd of plasma membrane & abundantly found in smooth muscle, pneumocytes.

- Pinocytosis (liquid & takeup)
- uptake of extracellular fluids & dissolved solutes, such as fat droplets, vitamins & antigens.
 - cellular drinking (also known as)

- Phagocytosis (solid / pathogenic takeup)
- plasma membrane engulfs large particles ($\geq 0.5 \mu m$) giving rise to internal compartment, phagosome.
 - A cell that performs phagocytosis → phagocyte.
 - a mechanism of innate immune defence & one of the first processes responding to infection & is one of the initiating branches of an adaptive immune response.
 - Some cells perform phagocytosis extensively & are called "Professional Phagocytes".



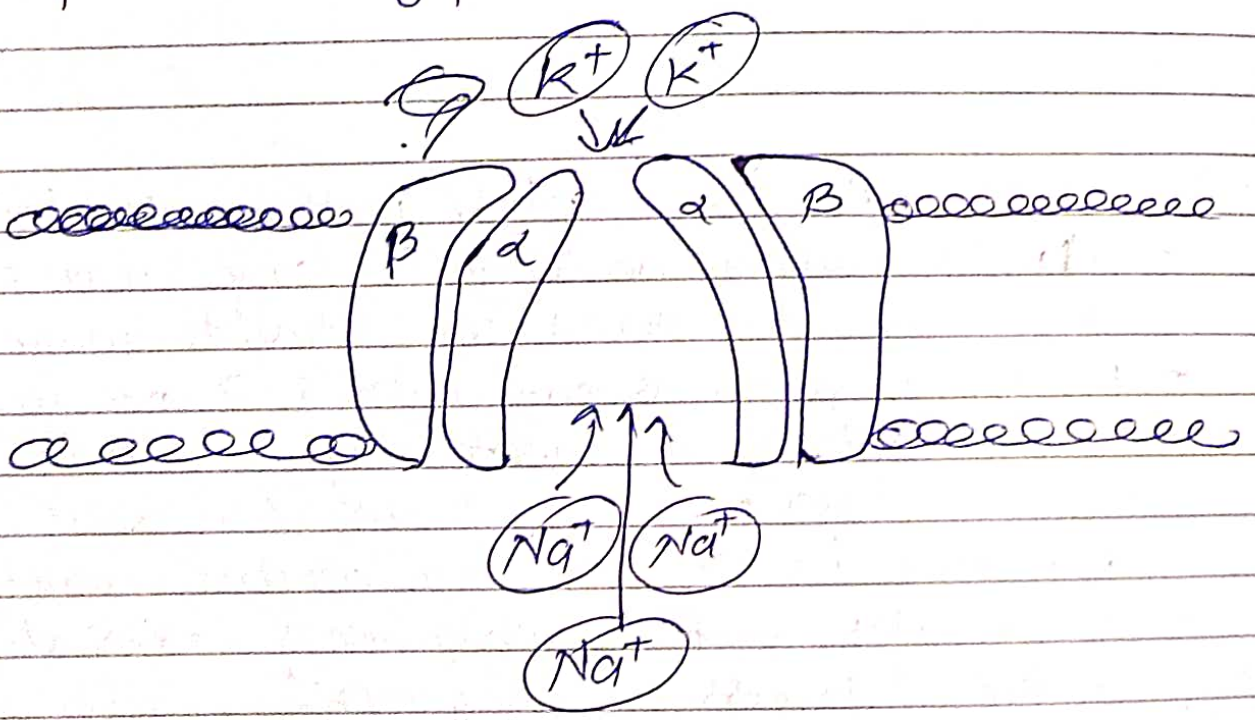
Na-K Pump

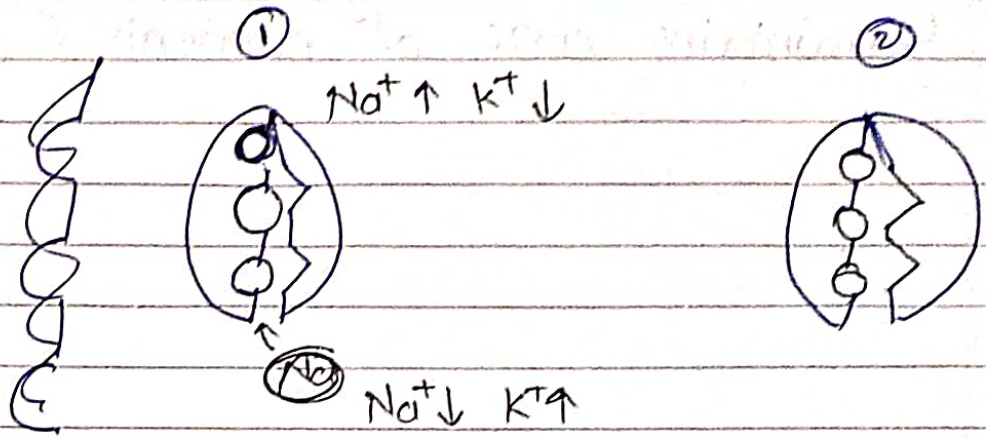
- Discovery \rightarrow in \downarrow by

Nobel prize

- ① depicts charge of the membrane
- ② movement of the ions & water
- ③ primitive discovery in biochemistry related to membrane

- movement of Na^+ & K^+ ions across the cell membrane is an active transport mechanism that requires ATP hydrolysis to provide energy to the transport of ions.





⇒ Functions

- transports ions in & out of the cell
- maintenance of cell's resting potential during & after stimulation.
- stabilizing or maintaining cell membrane potential by regulating the concentration of sodium & potassium ions within the cell
- Na^+ export activates many 2° active transporters (transport proteins in membrane), which are responsible for transportation of amino acids, glucose, & other essential nutrients.

- maintains osmolality, which regulates cell volume
- ↳ maintains conc. of nutrients & chemicals

⇒ How it can be used for drug administration?

DATE

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