



भारतीय प्रौद्योगिकी संस्थान दिल्ली
INDIAN INSTITUTE OF TECHNOLOGY DELHI

SAAKAAR

Lecture – 08

BIOTECHNOLOGY

Chapter Name : Cell Biology

**Topic Name : Electrical Properties of Plasma
Membrane 02**

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Recap of previous lecture



1

Structure of Plasma membrane



Topics to be covered



1 Transport across Plasma Membrane





TRANSPORTERS



MEMBRANE ACTIVE TRANSPORT

only transporters
used

energy used

coupled transporters
(ATP not used)

- Indirect transport
- Secondary active transport

symporters

Antipporters

ATP driven pumps
(transporters)

- ATP used
- Direct transport
- Primary Active transport

P-type pumps

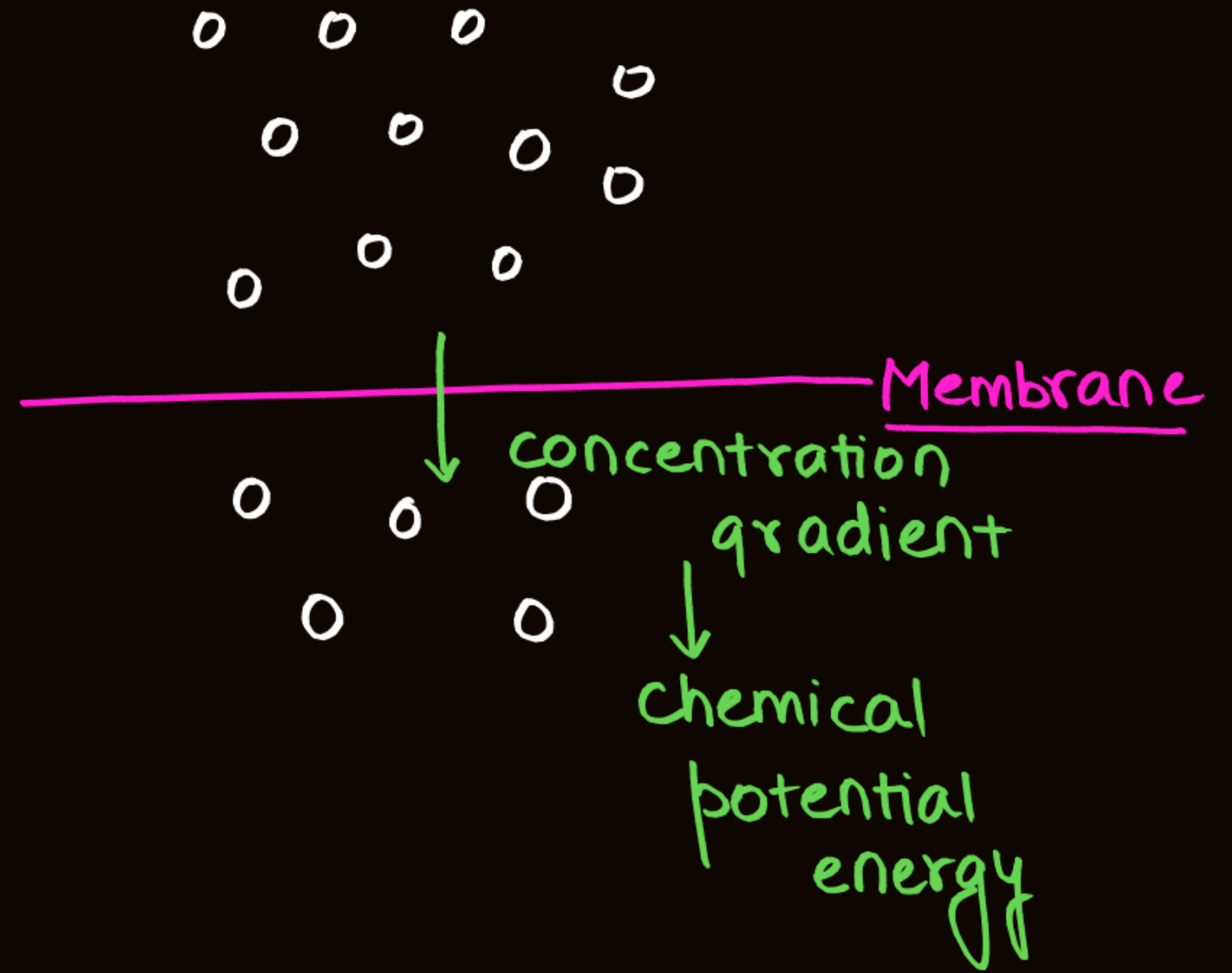
V-type pumps

ABC transporters

forms of energy:-

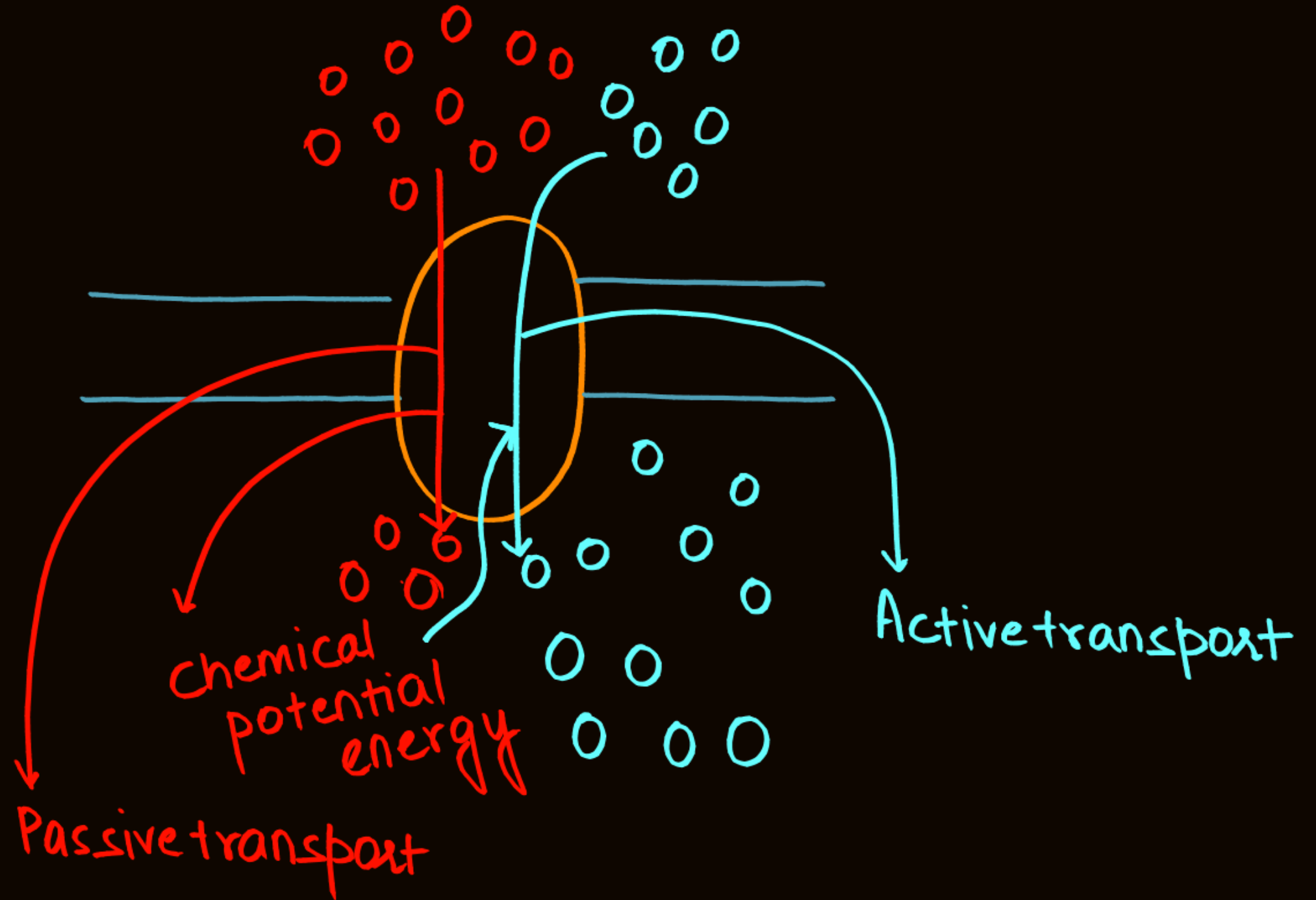
1) Potential energy
(stored energy) → stationary / static

2) Kinetic energy
(energy in moving object)

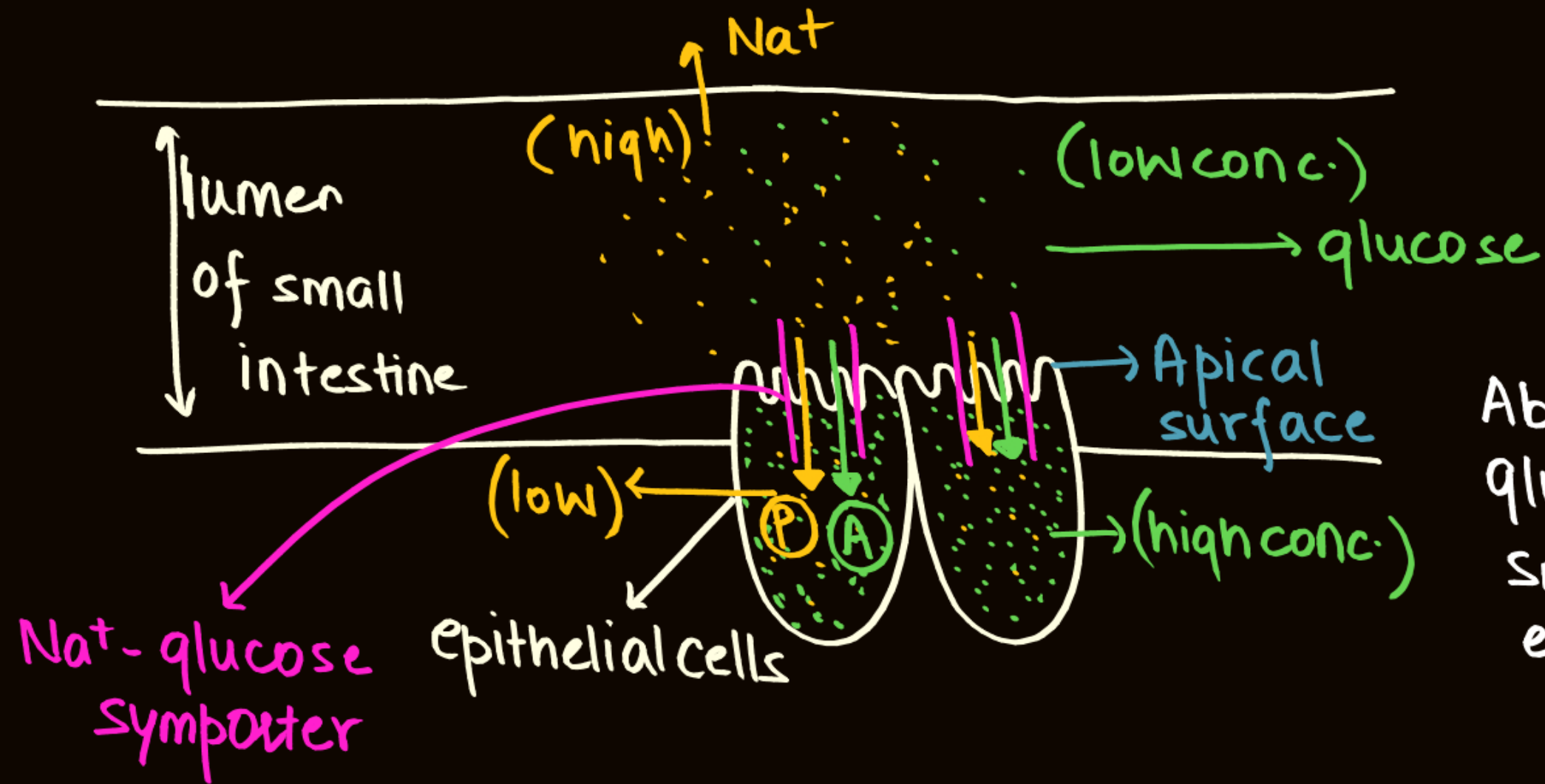


SYMPORTER:-

↓
coupled transporter
↓
transports both
molecules in same
direction



Symporter: Example -



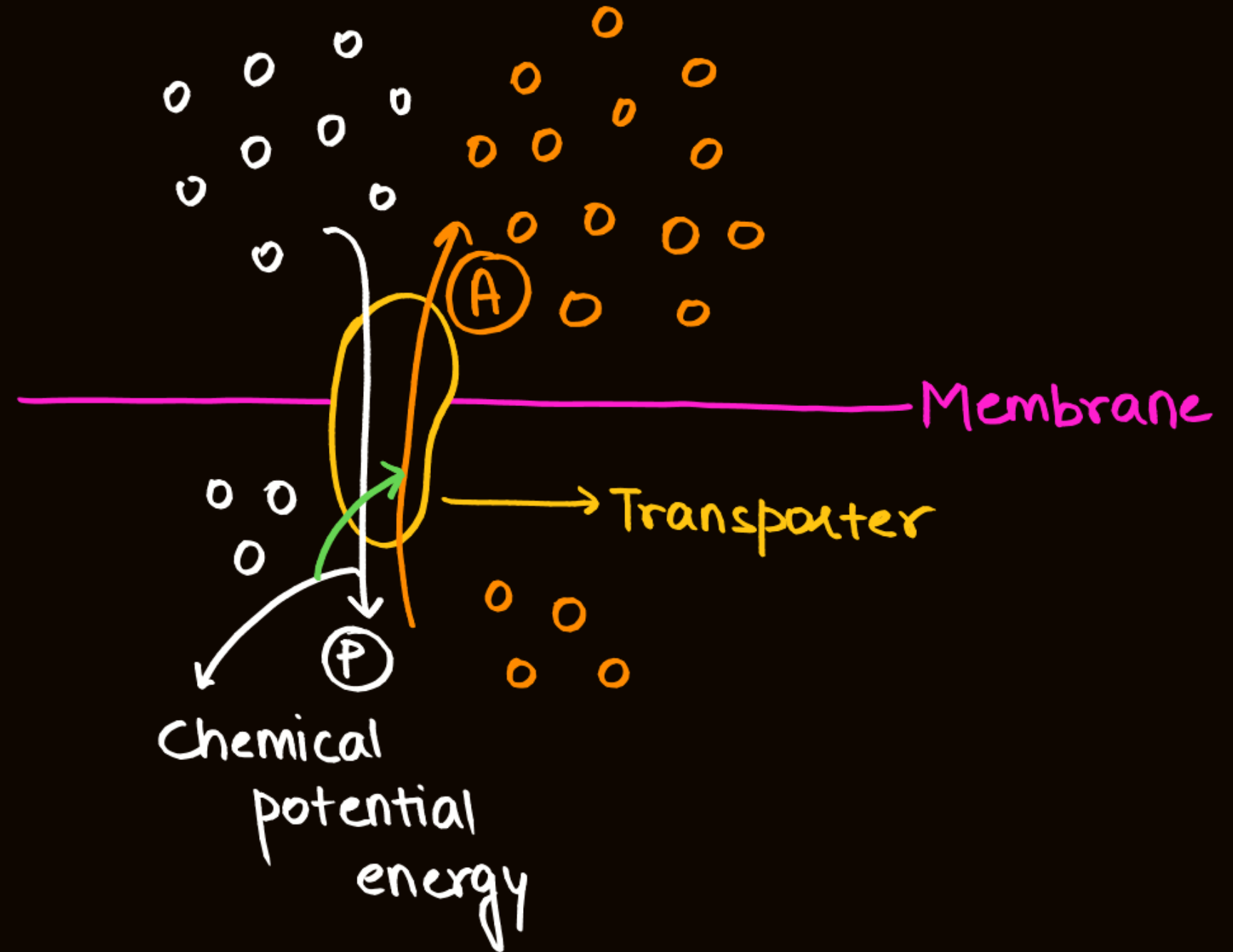
[Na⁺] is always high outside the cell as compared to inside of cell

Absorption → entry of glucose from lumen of small intestine into epithelial cells

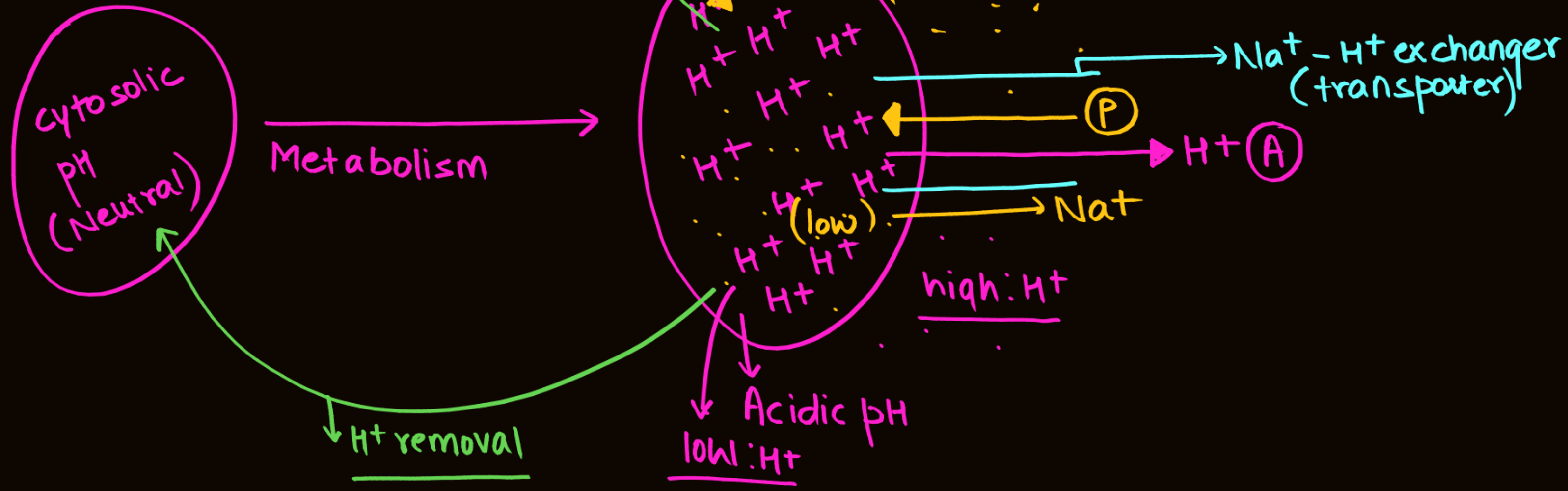
ANTIORTER:-

↓
coupled transporter

↓
molecules move in
opposite direction



ANTIORTER: EXAMPLE



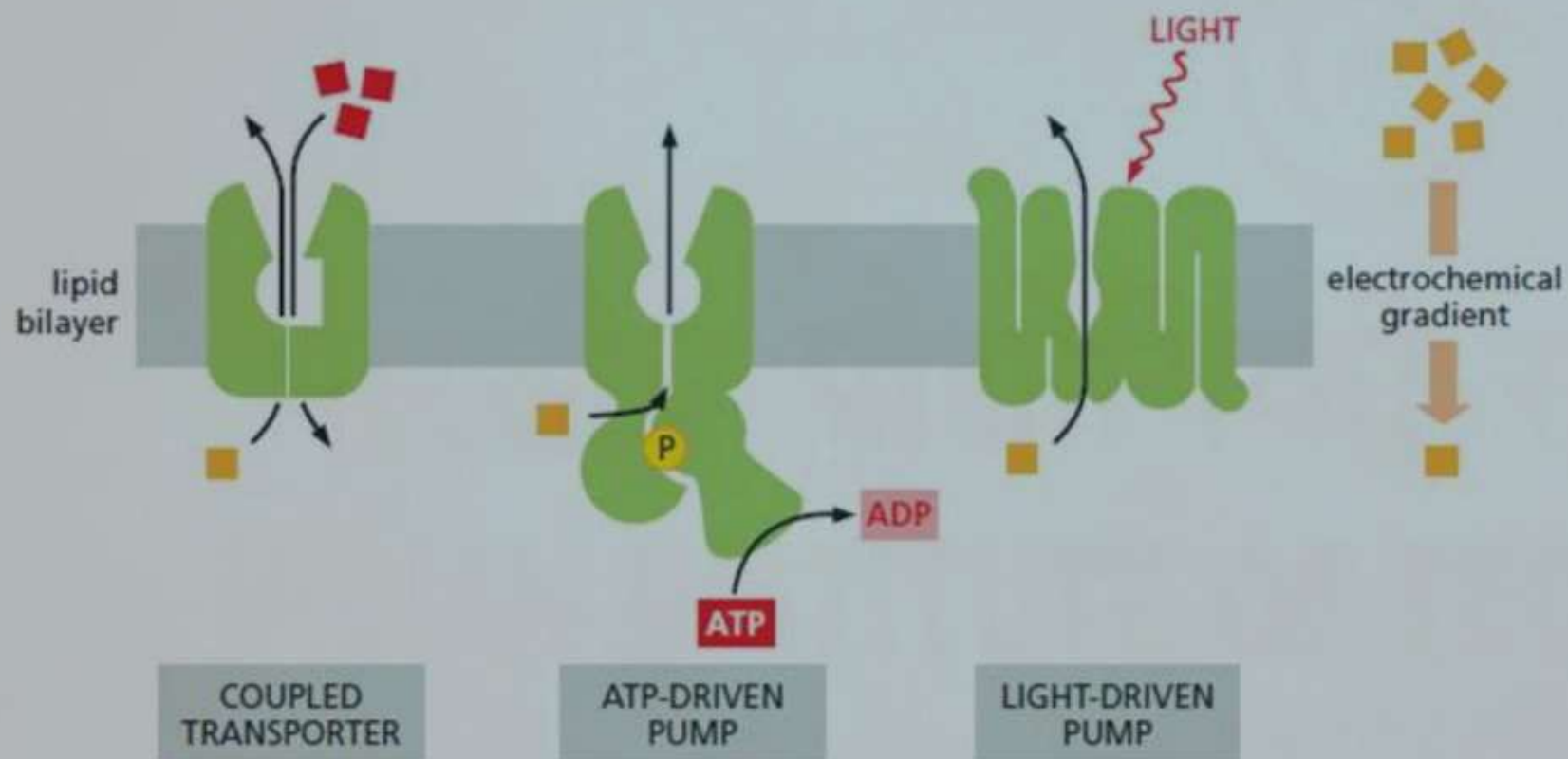


Figure 11–7 Three ways of driving active transport. The actively transported molecule is shown in *orange*, and the energy source is shown in *red*. Redox driven active transport is discussed in Chapter 14 (see Figures 14–18 and 14–19).

ATP Driven pumps

↓
ATP used and
transport occurs

P-type pumps

- P = phosphorylation (addition of phosphate)
- phosphate of ATP attaches to transporter during transport.

V-type pumps

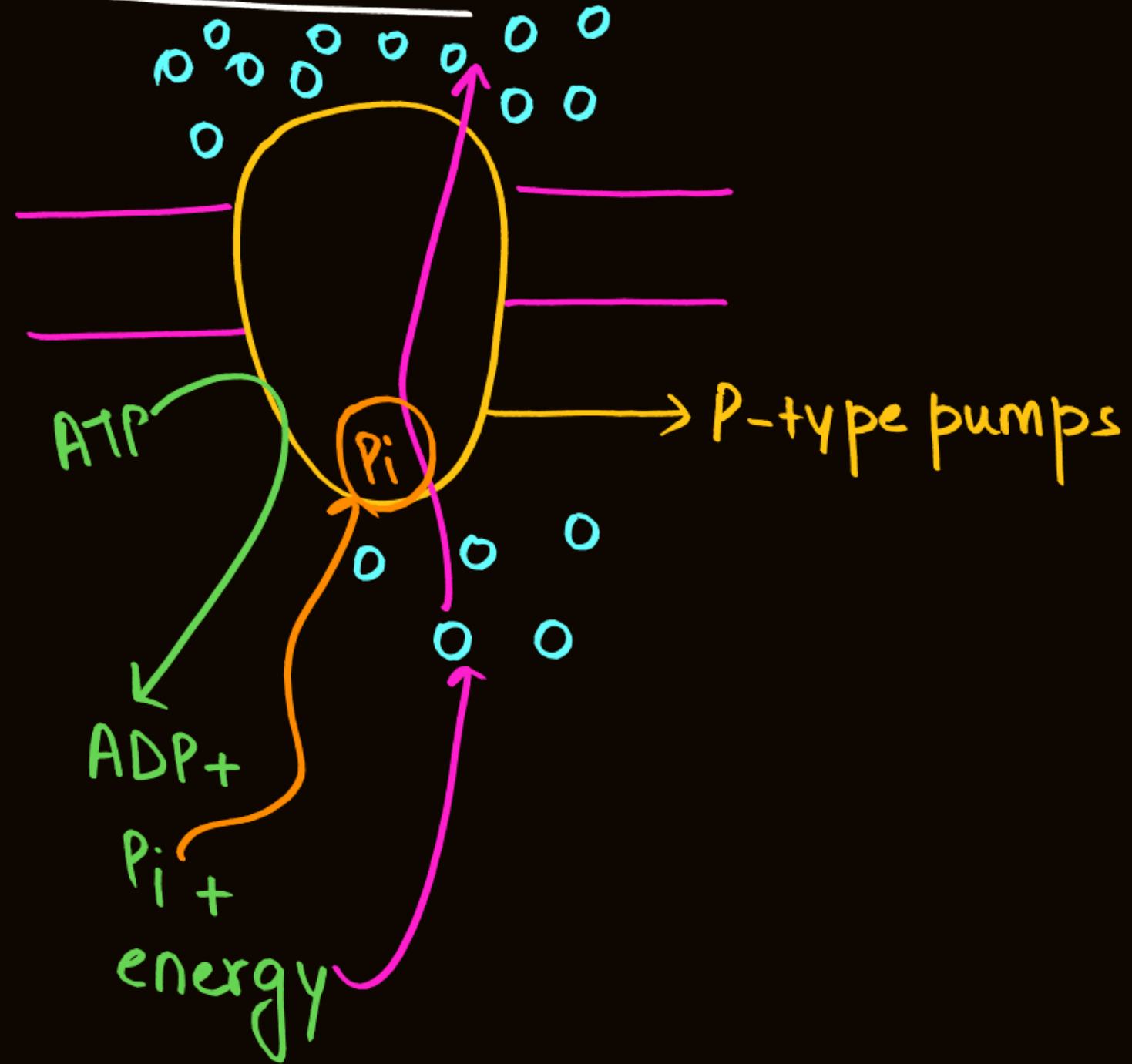
vacuole / organelle

- ATP driven pumps present on the membranes of organelles.

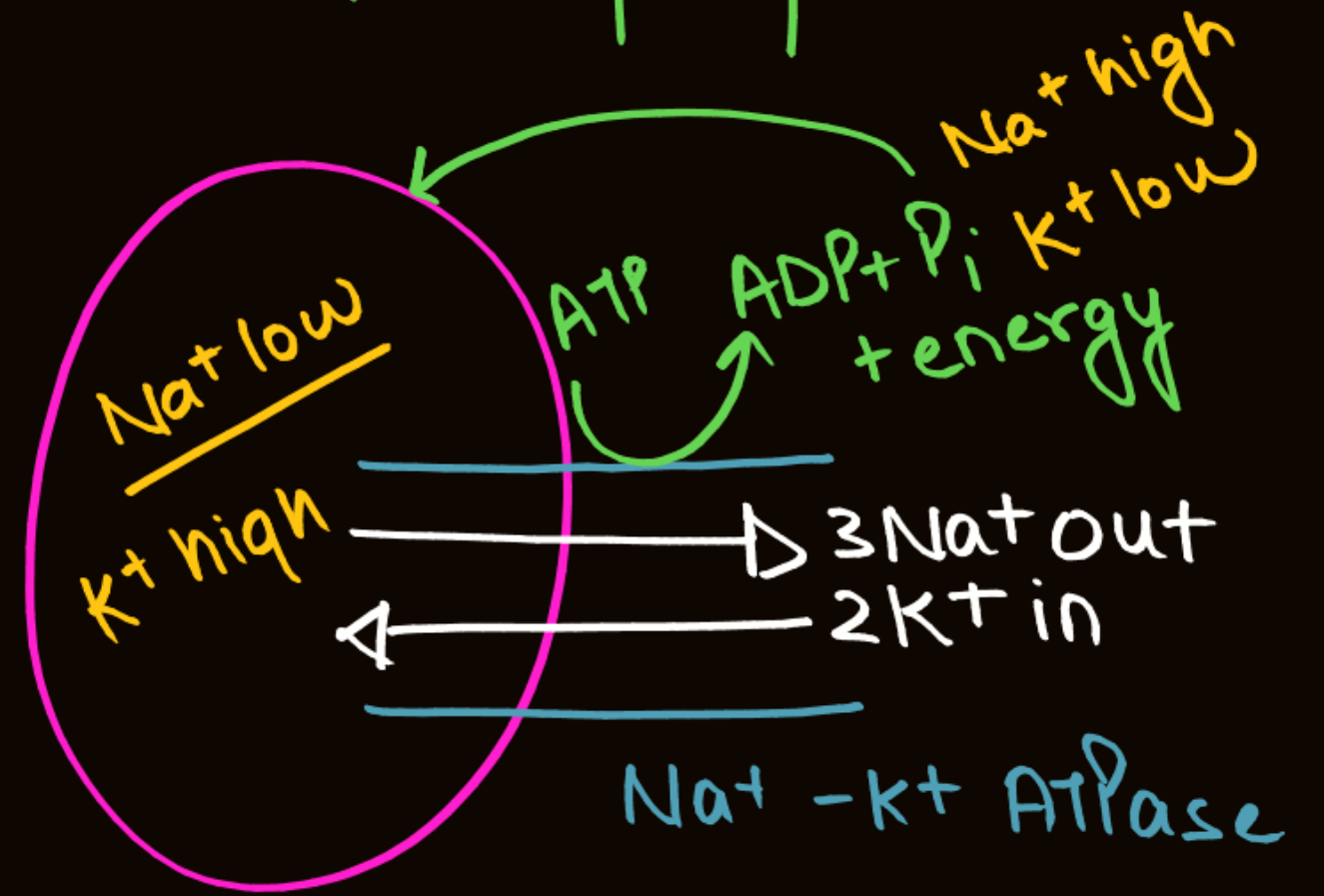
ABC transporters

- ATP Binding cassette (site / location)
- use 2 ATP for transport
- largest family (group) of ATP driven pumps

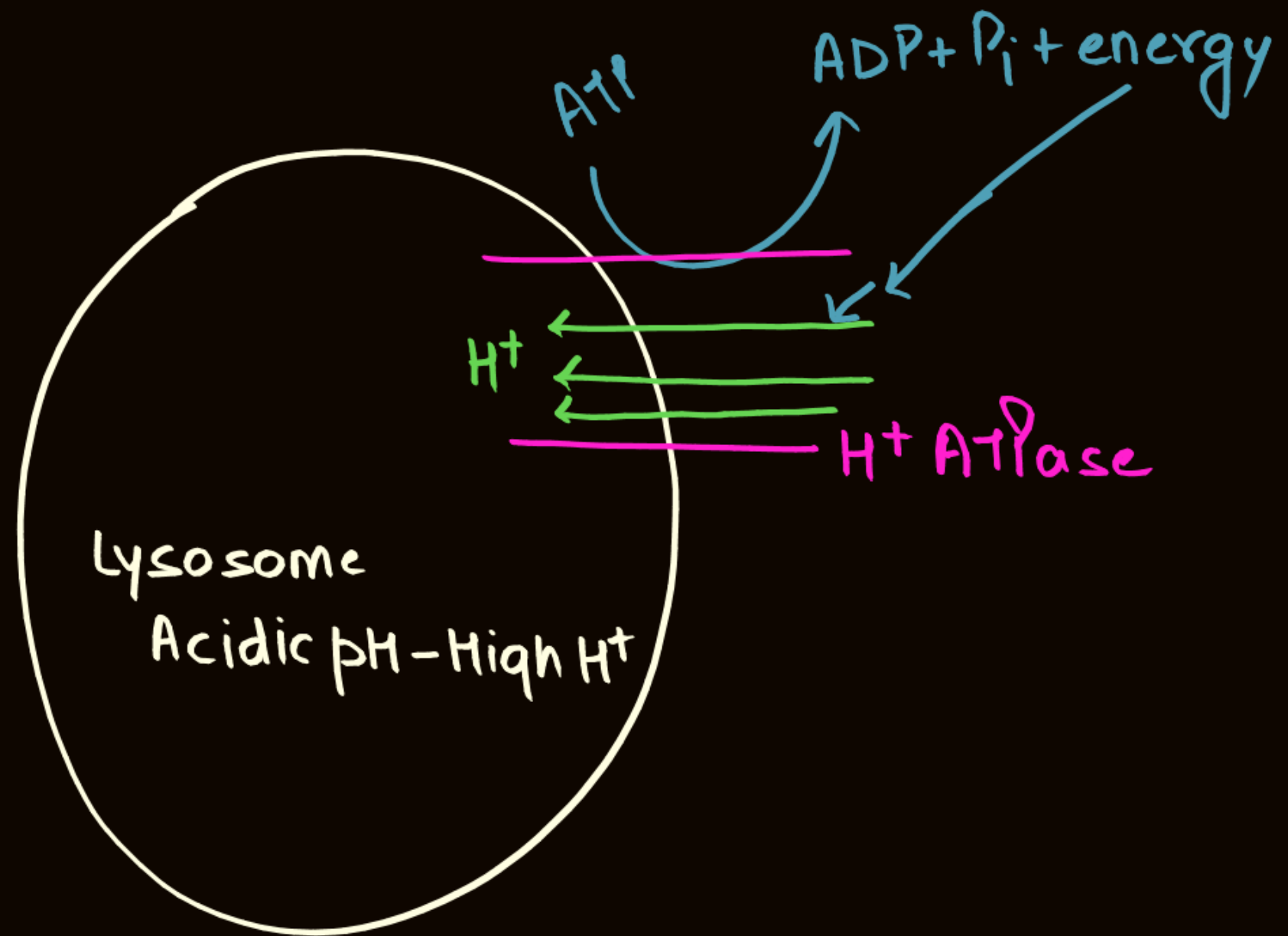
P-type pumps -



eg - Na⁺ - K⁺ ATPase pump

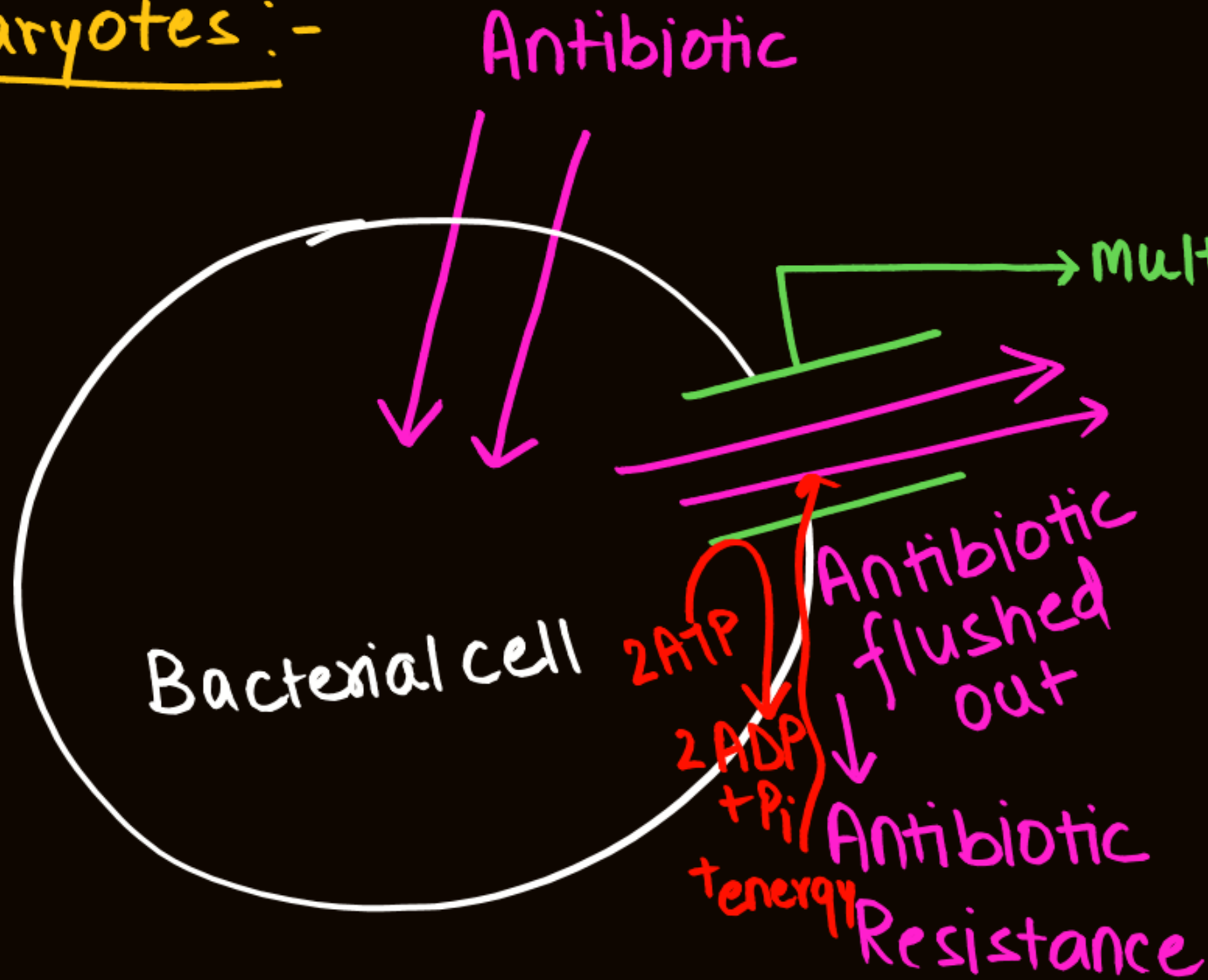


V-type pumps -



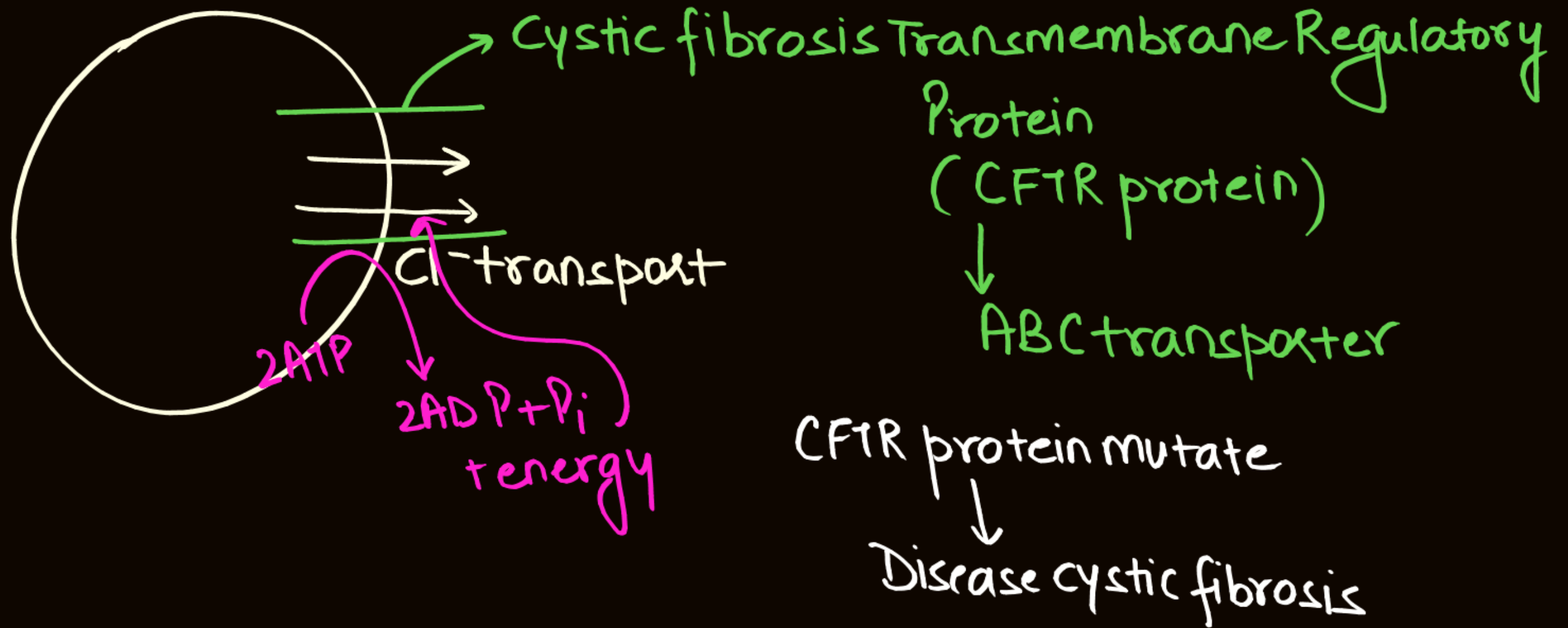
ABC Transporters

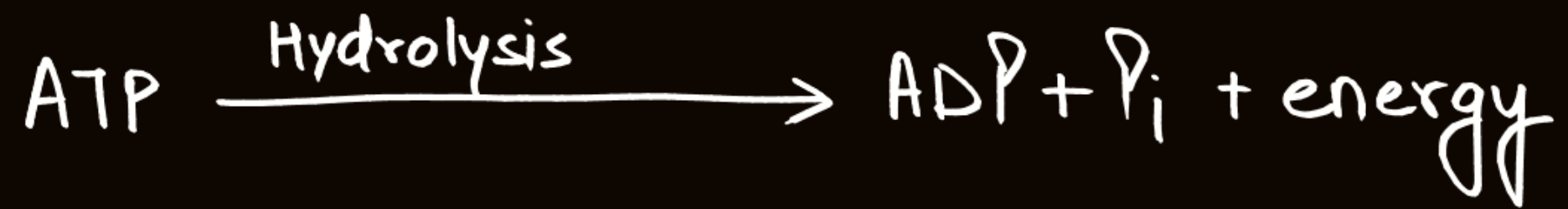
Prokaryotes:-



Multi Drug Resistant Protein (MDR protein) /
P-glycoprotein
↓
ABC transporter

Eukaryotes





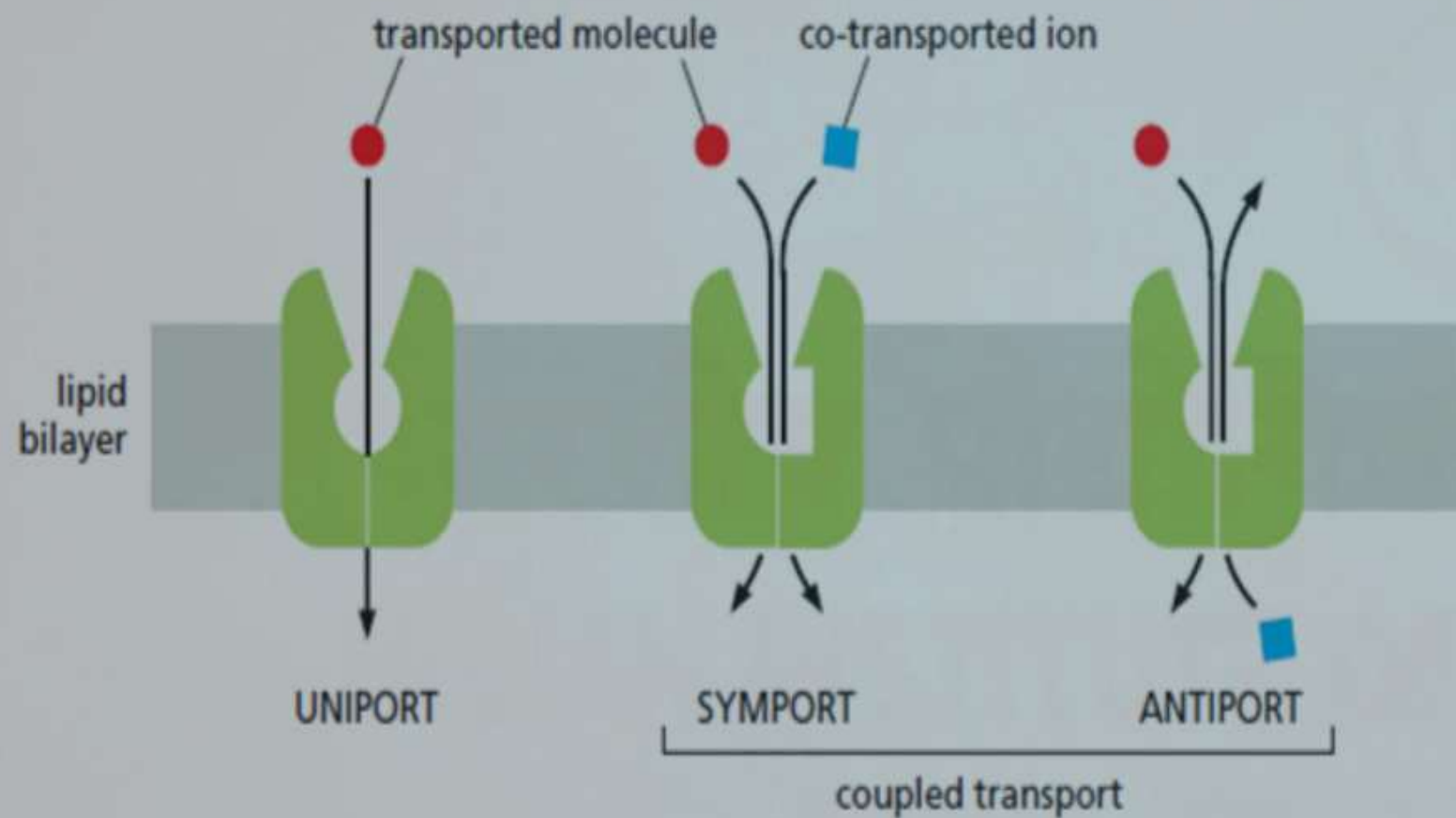


Figure 11-8 This schematic diagram shows transporters functioning as uniporters, symporters, and antiporters (**Movie 11.1**).

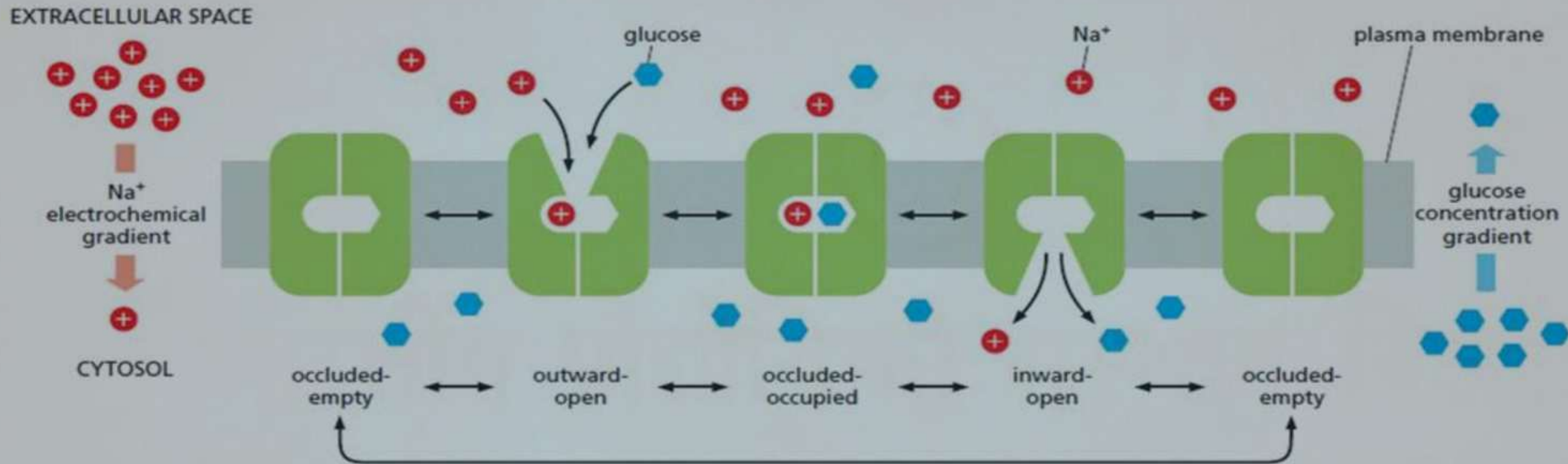


Figure 11–9 Mechanism of glucose transport fueled by a Na^+ gradient. As in the model shown in Figure 11–5, the transporter alternates between inward-open and outward-open states via an occluded intermediate state. Binding of Na^+ and glucose is cooperative—that is, the binding of either solute increases the protein’s affinity for the other. Since the Na^+ concentration is much higher in the extracellular space than in the cytosol, glucose is more likely to bind to the transporter in the outward-facing state. The transition to the occluded state occurs only when both Na^+ and glucose are bound; their precise interactions in the solute-binding sites slightly stabilize the occluded state and thereby make this transition energetically favorable. Stochastic fluctuations caused by thermal energy drive the transporter randomly into the inward-open or outward-open conformation. If it opens outwardly, nothing is achieved, and the process starts all over. However, whenever it opens inwardly, Na^+ dissociates quickly in the low- Na^+ -concentration environment of the cytosol. Glucose dissociation is likewise enhanced when Na^+ is lost, because of cooperativity in binding of the two solutes. The overall result is the net transport of both Na^+ and glucose into the cell. Because the occluded state is not formed when only one of the solutes is bound, the transporter switches conformation only when it is fully occupied or fully empty, thereby assuring strict coupling of the transport of Na^+ and glucose.

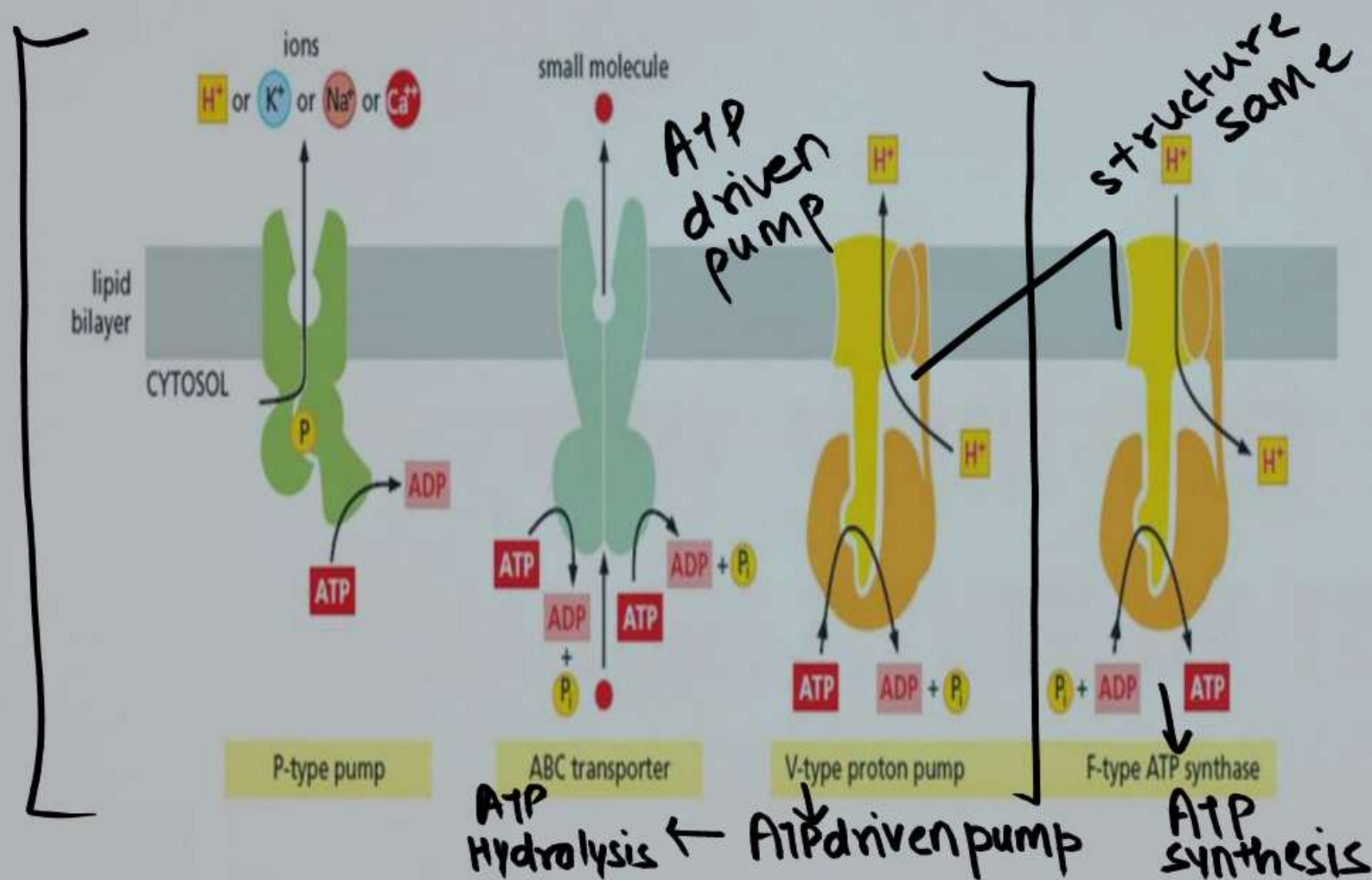


Figure 11-12 Three types of ATP-driven pumps. Like any enzyme, all ATP-driven pumps can work in either direction, depending on the electrochemical gradients of their solutes and the ATP/ADP ratio. When the ATP/ADP ratio is high, they hydrolyze ATP; when the ATP/ADP ratio is low, they can synthesize ATP. The F-type ATPase in mitochondria normally works in this “reverse” mode to make most of the cell’s ATP.

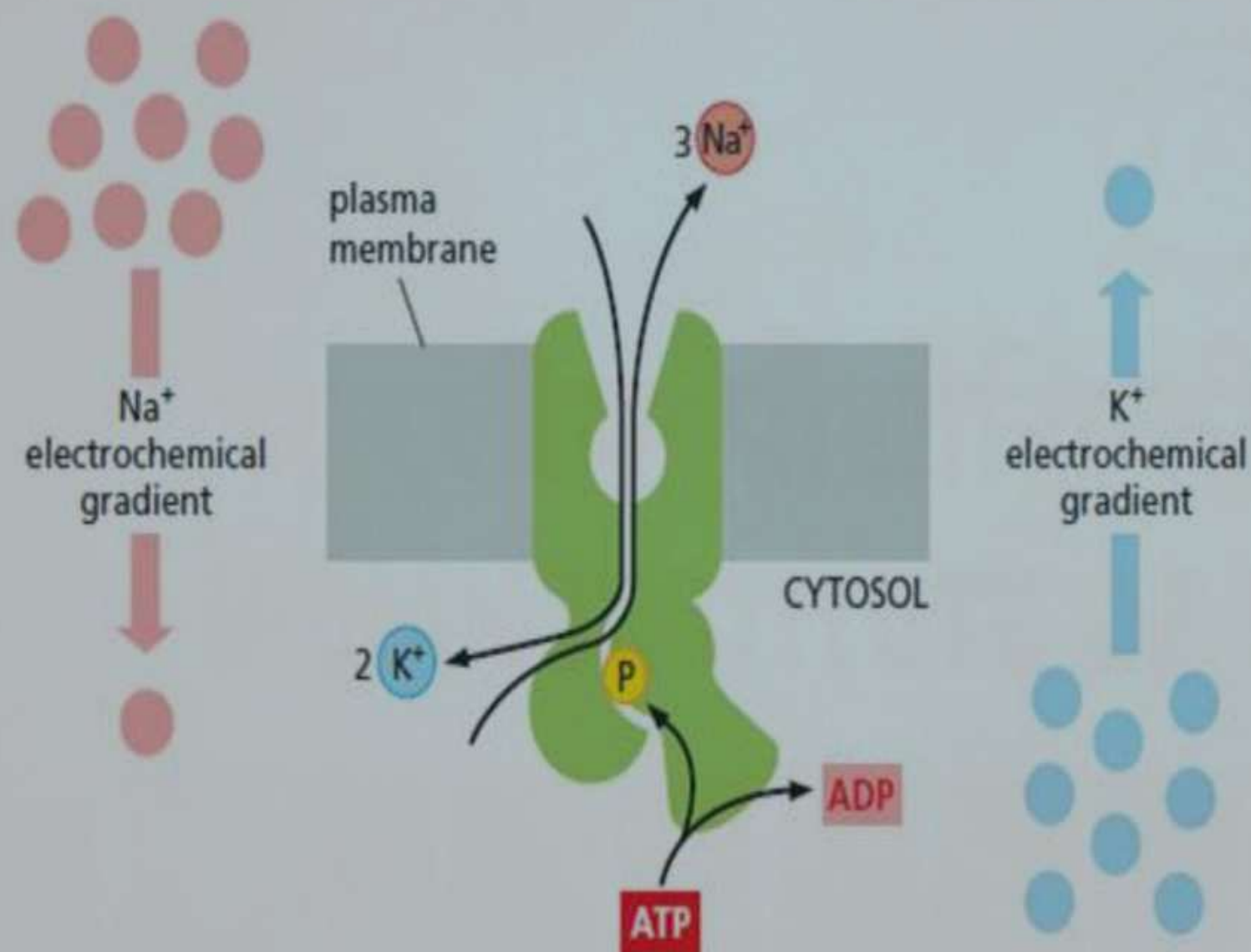
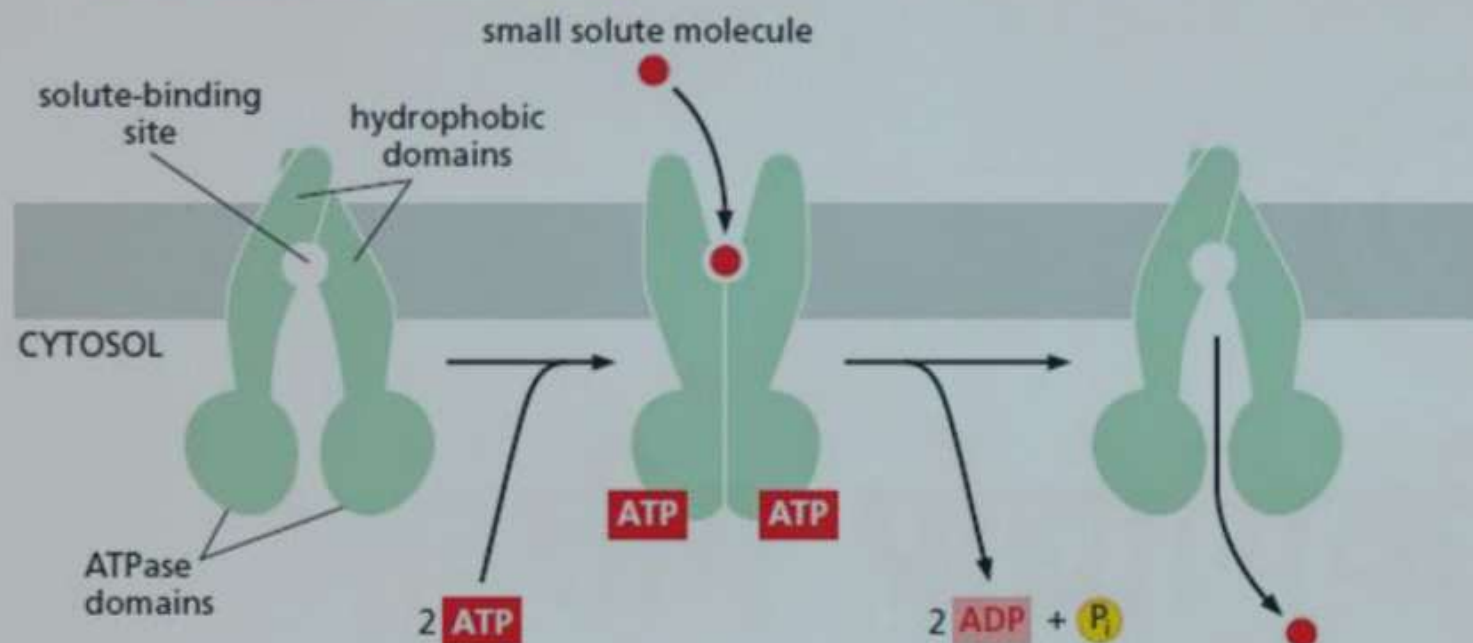


Figure 11-15 The function of the Na⁺-K⁺ pump. This P-type ATPase actively pumps Na⁺ out of and K⁺ into a cell against their electrochemical gradients. It is structurally closely related to the Ca²⁺ ATPase but differs in its selectivity for ions: for every molecule of ATP hydrolyzed by the pump, three Na⁺ are pumped out and two K⁺ are pumped in. As in the Ca²⁺ pump, an aspartate is phosphorylated and dephosphorylated during the pumping cycle (**Movie 11.4**).

(A) A BACTERIAL ABC TRANSPORTER



(B) A EUKARYOTIC ABC TRANSPORTER

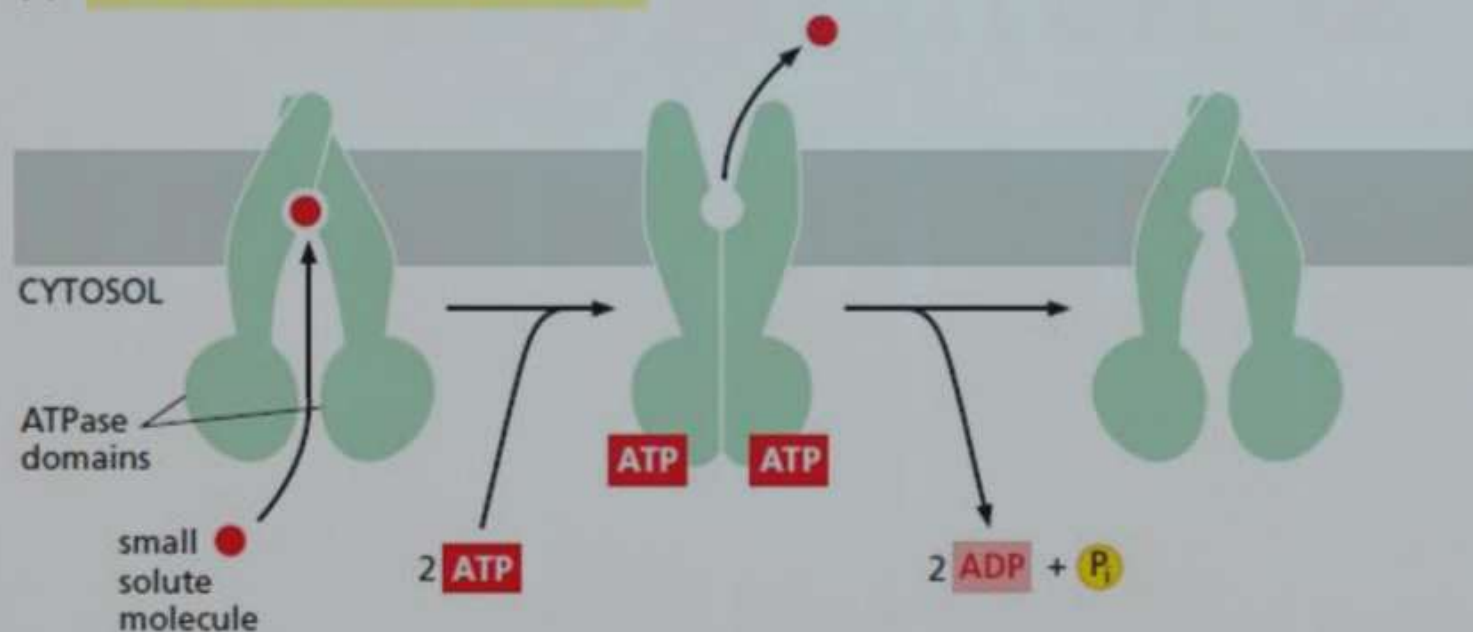


Figure 11–16 Small-molecule transport by typical ABC transporters. ABC transporters consist of multiple domains. Typically, two hydrophobic domains, each built of six membrane-spanning α helices, together form the translocation pathway and provide substrate specificity. Two ATPase domains protrude into the cytosol. In some cases, the two halves of the transporter are formed by a single polypeptide, whereas in other cases they are formed by two or more separate polypeptides that assemble into a similar structure. Without ATP bound, the transporter exposes a substrate-binding site on one side of the membrane. ATP binding induces a conformational change that exposes the substrate-binding site on the opposite side; ATP hydrolysis followed by ADP dissociation returns the transporter to its original conformation. Most individual ABC transporters are unidirectional. (A) Both importing and exporting ABC transporters are found in bacteria; an ABC importer is shown in this cartoon. The crystal structure of a bacterial ABC transporter is shown in Figure 3–76. (B) In eukaryotes, most ABC transporters export substances—either from the cytosol to the extracellular space or from the cytosol to a membrane-bound intracellular compartment such as the endoplasmic reticulum—or from the mitochondrial matrix to the cytosol.

QUESTION : IIT JAM



#Q.

Q.16	Which one of the following statements is correct about solute transport across membranes?
(A)	Passive transporters decrease the activation energy and does not facilitate the transport of polar compounds
(B)	The direction in which a charged solute tends to move spontaneously across a membrane does not depend on the electrical gradient across the membrane
(C)	All ABC transporters do not have nucleotide binding domain
(D)	P-type ATPases get reversibly phosphorylated as a part of transport cycle



CHANNELS



PROPERTIES:-

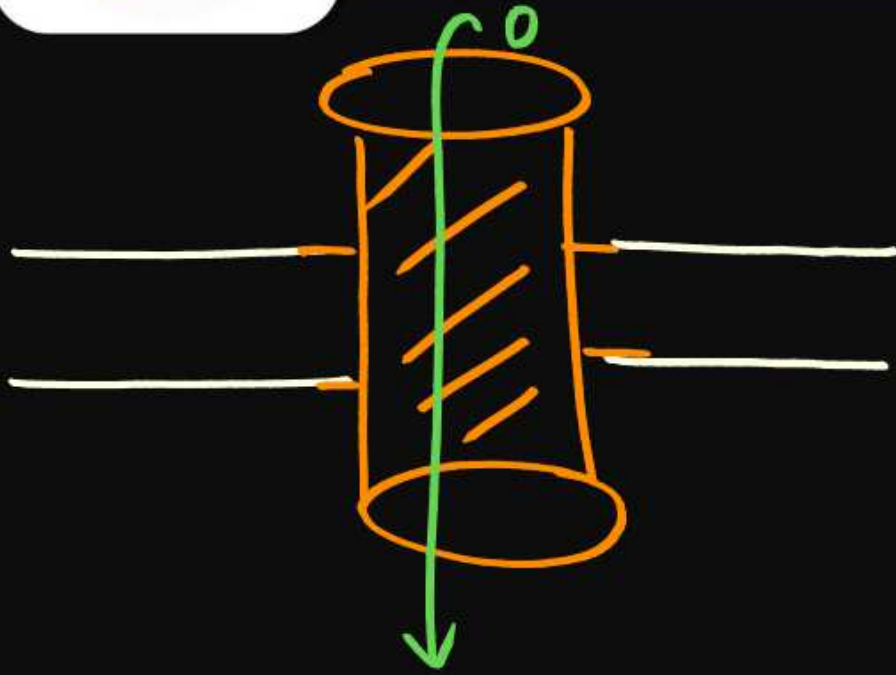
1) Gated:- channel open and close according to transport conditions of cell

Exception

→ some channels always open → leaky channels
↓
maximum leaky channels → K^+
some for → Na^+

2) specificity:- channels are specific for molecule they transport.

3) Selectivity filter:- During ion transport by channel, hydration shell is removed.



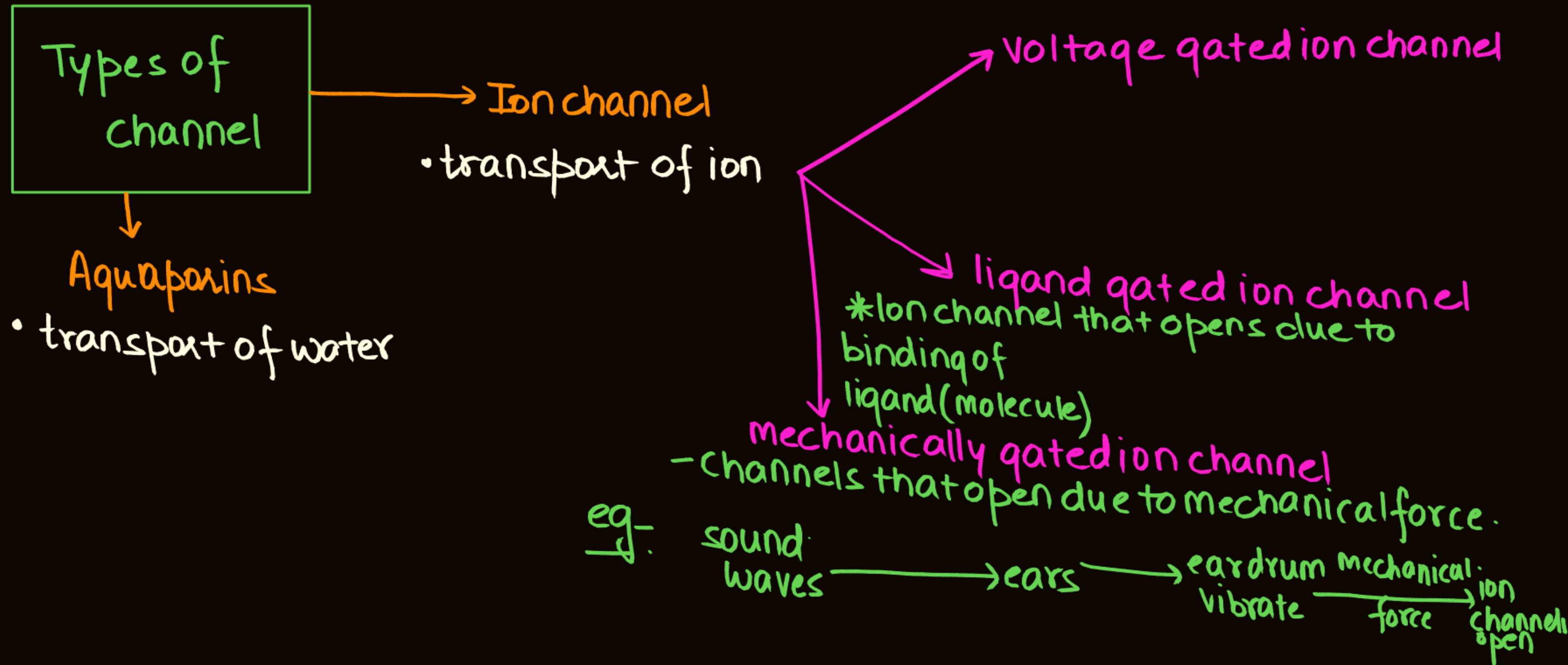
4) Saturation:-

All channels occupied $\longrightarrow$ more molecules added $\longrightarrow$ but no increase in transport rate (speed)

5) All or none rule:-

Threshold $\longrightarrow$ channel $\longrightarrow$ all work done (All)

Threshold absent $\longrightarrow$ No work by channel (None)



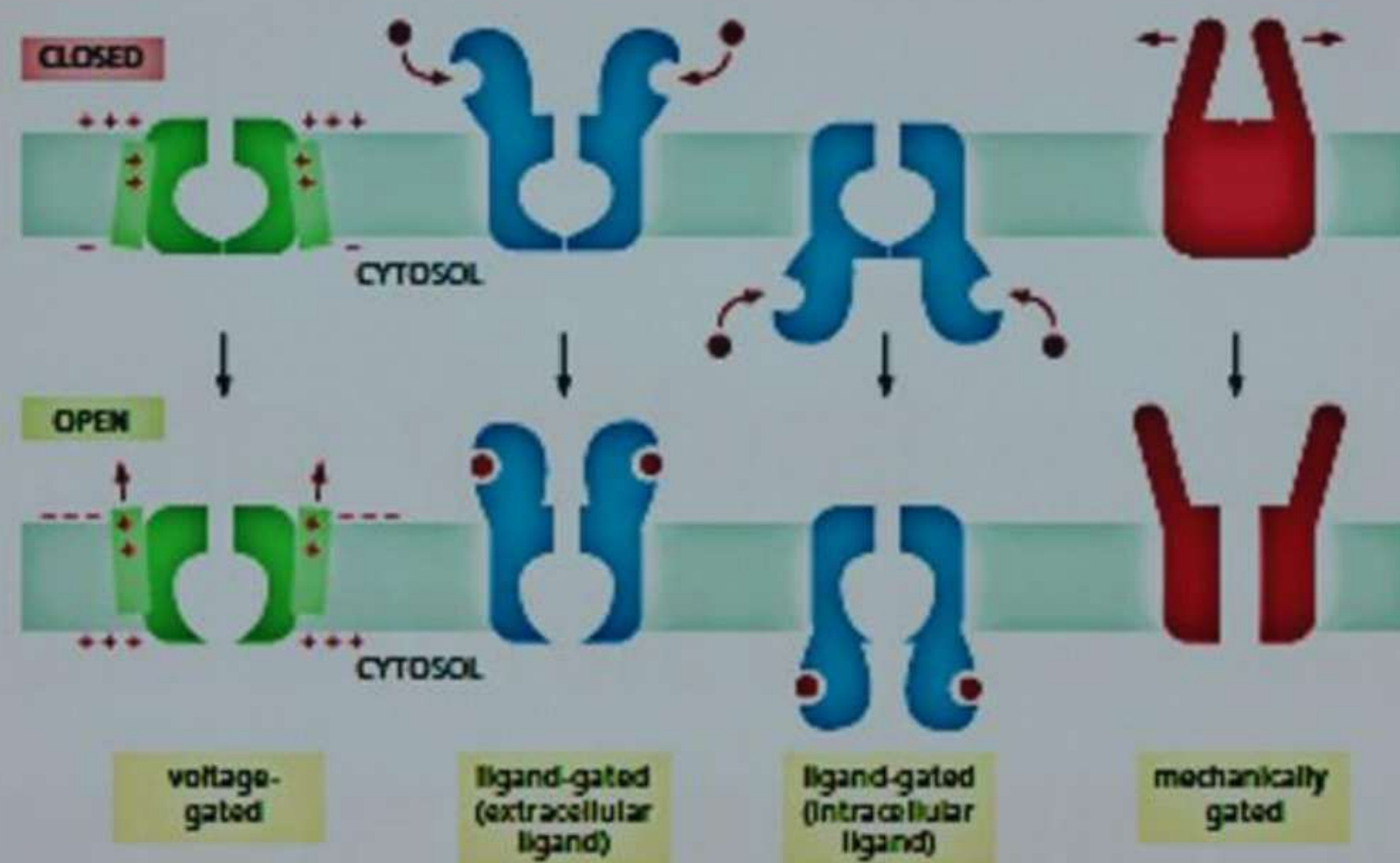
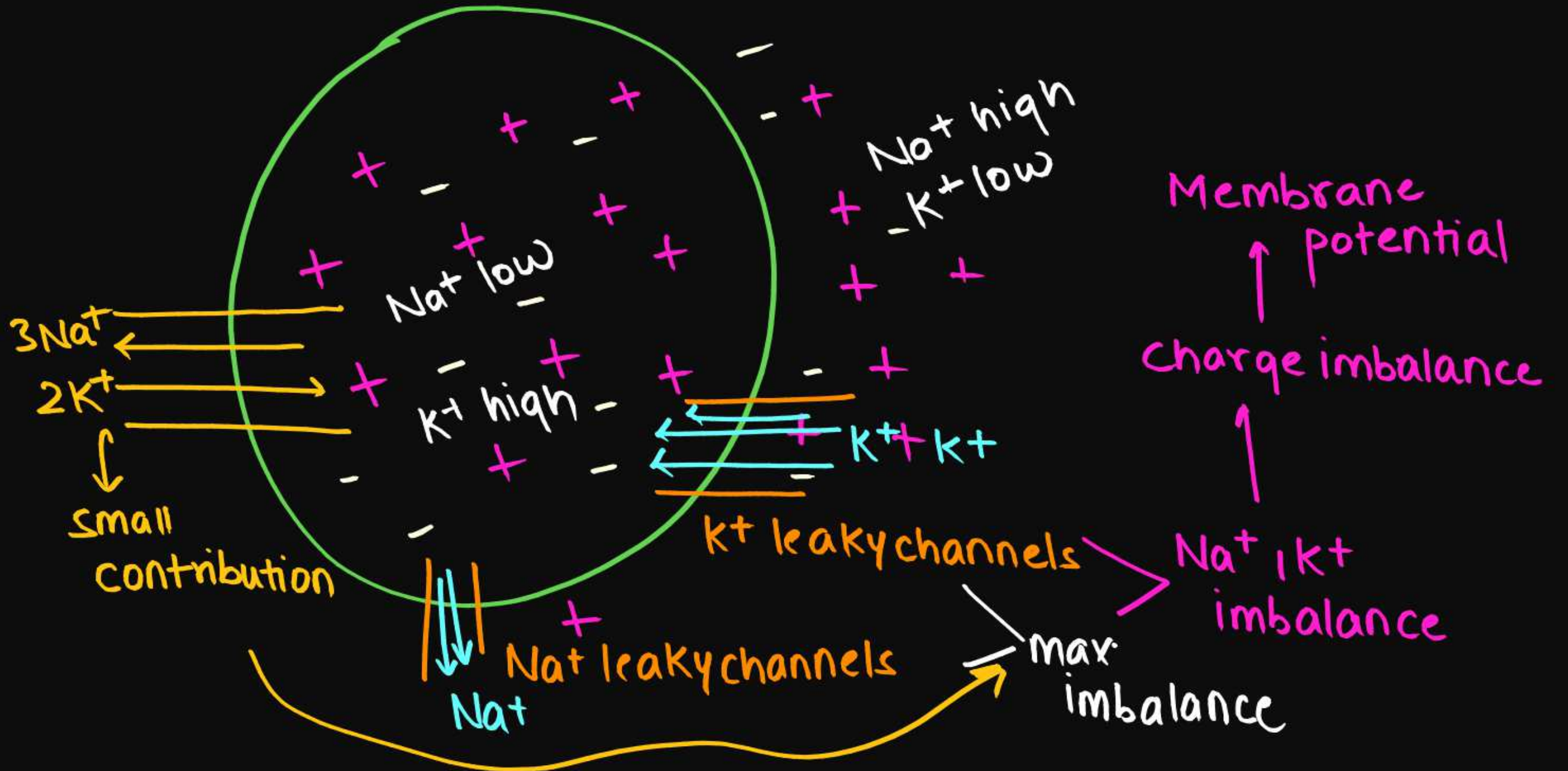
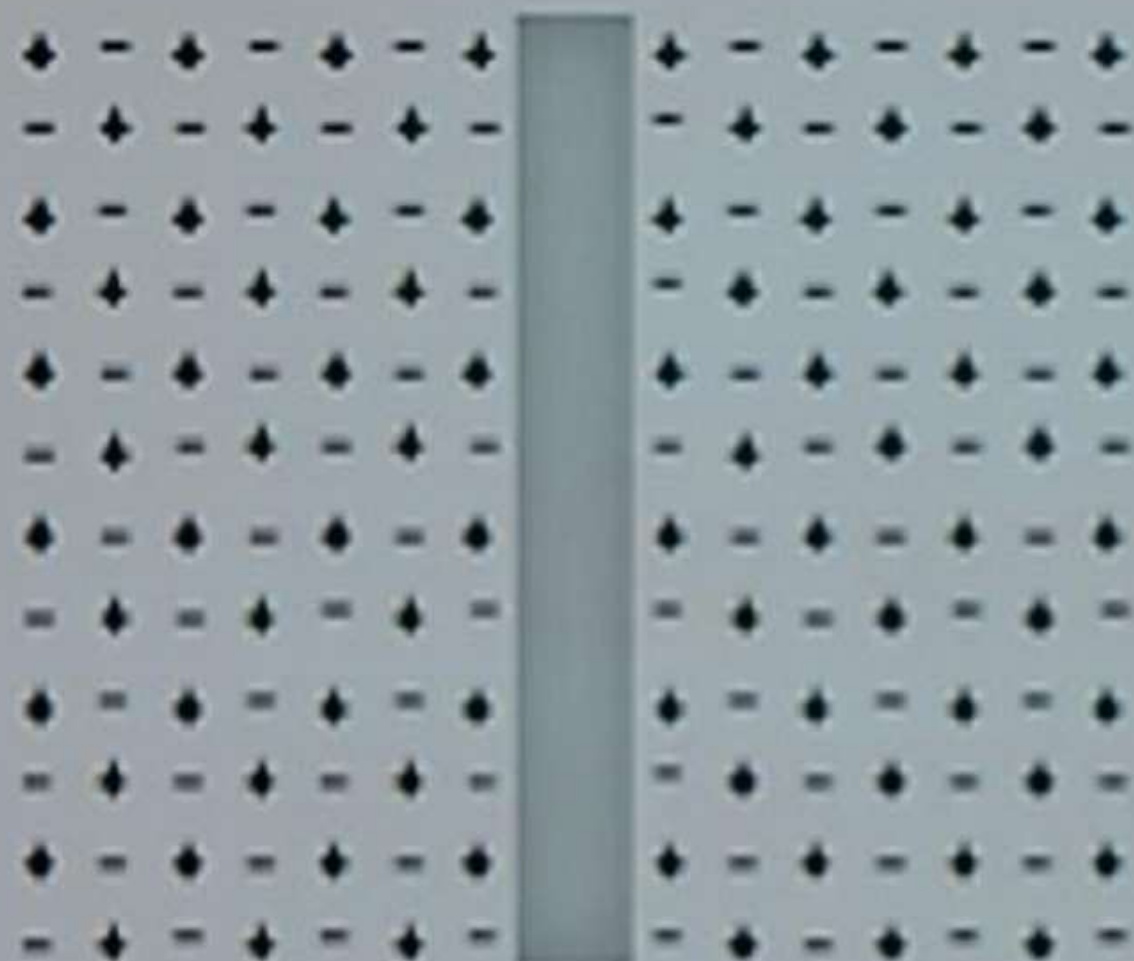


Figure 11-22 The gating of ion channels. This schematic drawing shows several kinds of stimuli that open ion channels. Mechanically gated channels often have cytoplasmic extensions (not shown) that link the channel to the cytoskeleton.

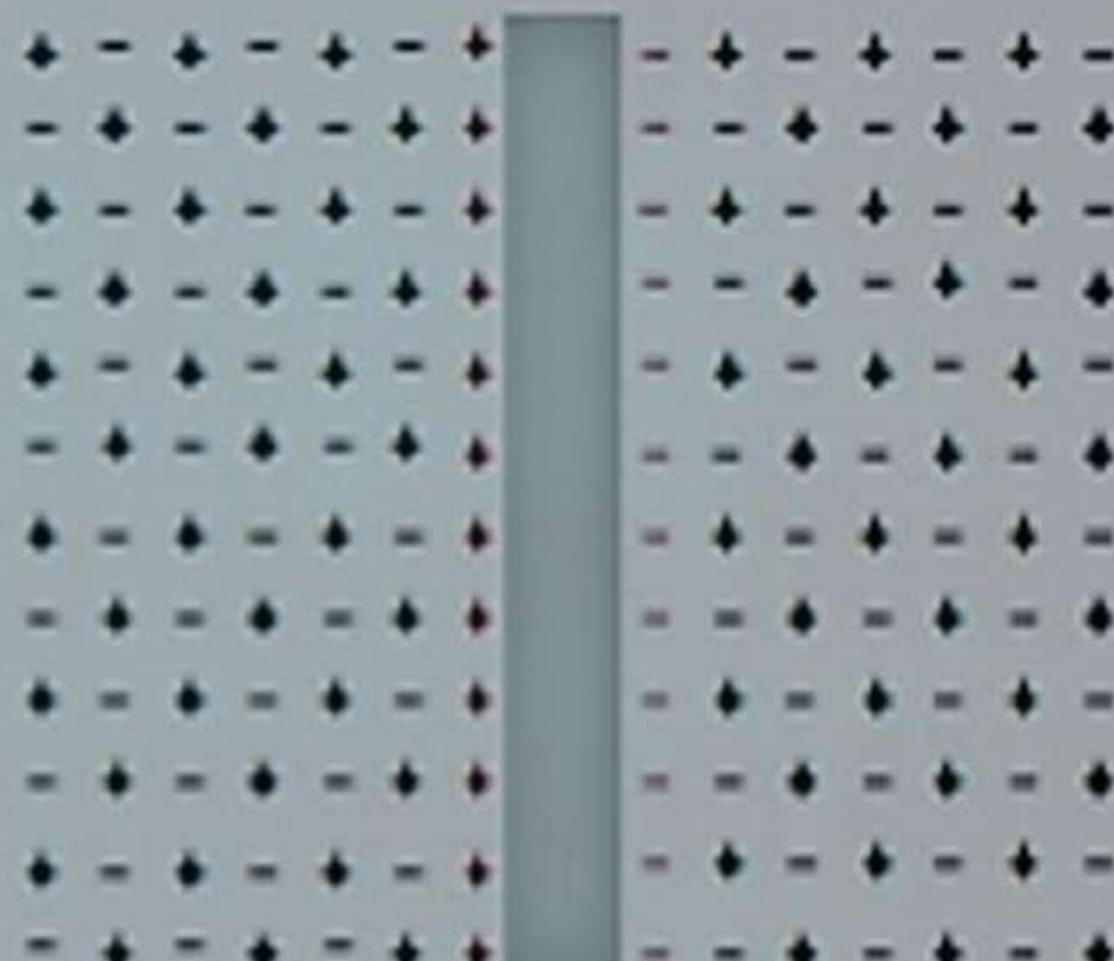


MEMBRANE POTENTIAL





exact balance of charges on each side of the membrane; membrane potential = 0

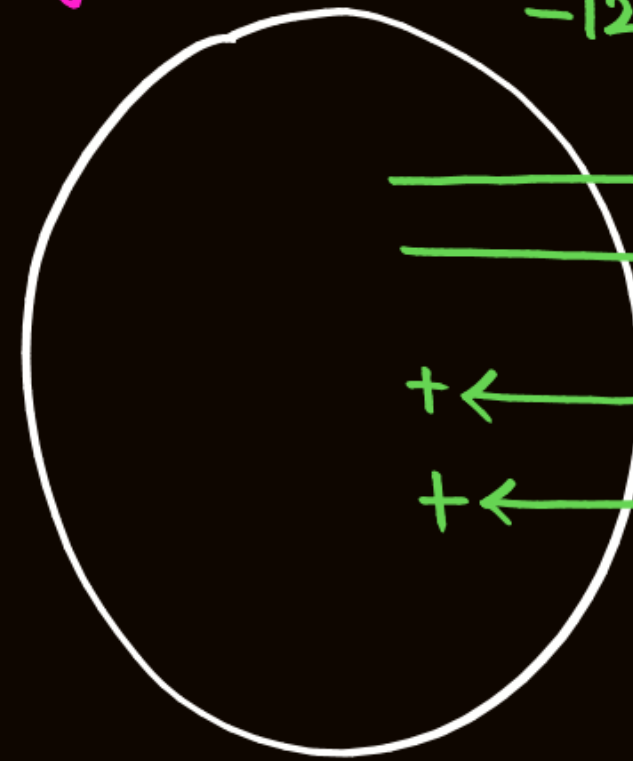


a few of the positive ions (red) cross the membrane from right to left, leaving their negative counterions (red) behind; this sets up a nonzero membrane potential

Types of Membrane potential

↓
Action potential
• change in membrane potential

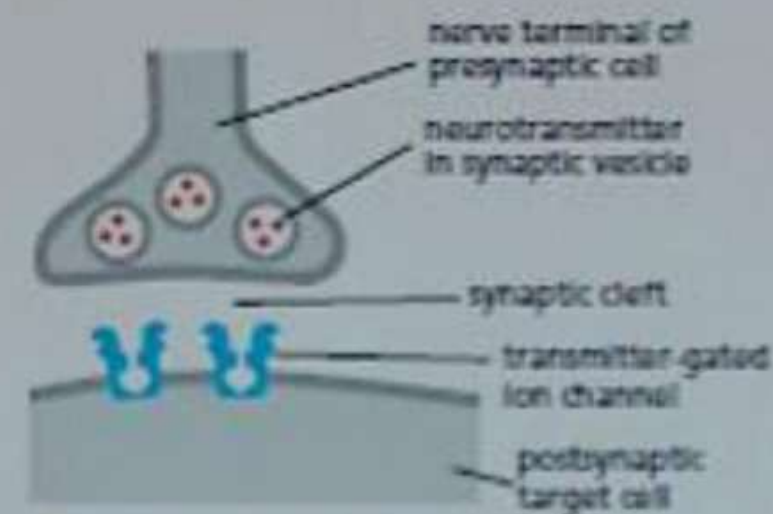
→ Resting membrane Potential



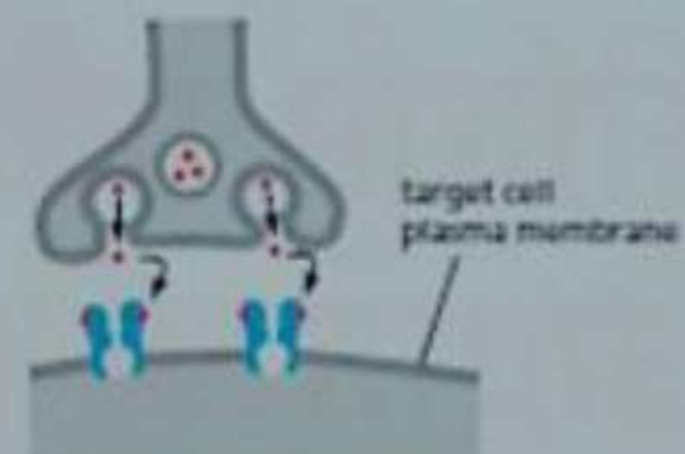
↓
-120mV — +120mV (depending on cell)

no change in
charges (membrane potential)

↓
Resting Membrane Potential



RESTING CHEMICAL SYNAPSE



ACTIVE CHEMICAL SYNAPSE

(A)

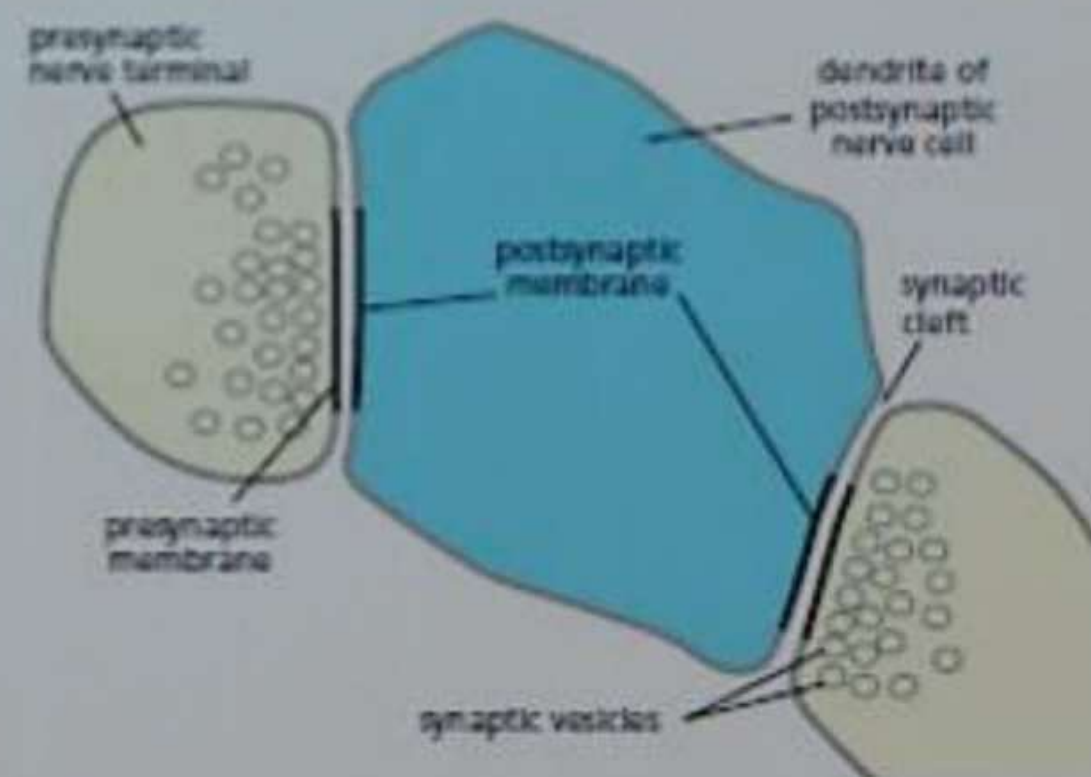
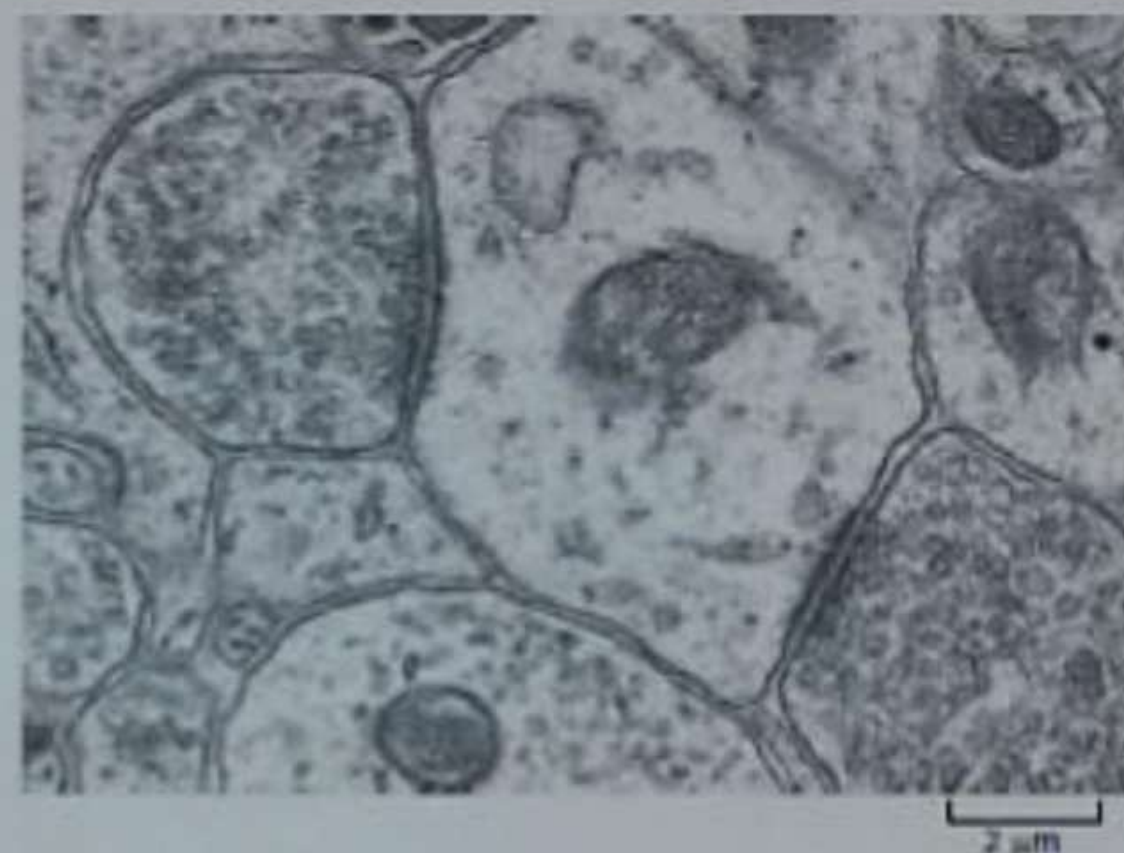


Figure 11-36 A chemical synapse. (A) When an action potential reaches the nerve terminal in a presynaptic cell, it stimulates the terminal to release its neurotransmitter. The neurotransmitter molecules are contained in synaptic vesicles and are released to the cell exterior when the vesicles fuse with the plasma membrane of the nerve terminal. The released neurotransmitter binds to and opens the transmitter-gated ion channels concentrated in the plasma membrane of the postsynaptic target cell at the synapse. The resulting ion flows alter the membrane potential of the postsynaptic membrane, thereby transmitting a signal from the excited nerve (B) (Movie 11.12). (B) A thin-section electron micrograph of two nerve terminal synapses on a dendrite of a postsynaptic cell. (B, courtesy of Cedric Raine.)

QUESTION : SAMPLE QUESTION



#Q.

Q1. The resting membrane potential (V_m) of a typical mammalian neuron is closest to the equilibrium potential of K^+ (E_K) rather than Na^+ (E_{Na}). This is primarily because:

- A) The concentration gradient for K^+ is steeper than that for Na^+ .
- B) The membrane has a much higher permeability to K^+ than to Na^+ at rest.
- C) The Na^+ / K^+ ATPase pumps out more Na^+ than it brings in K^+ .
- D) Na^+ channels are completely absent in the resting state.

QUESTION : SAMPLE QUESTION



#Q. During the rising phase (depolarization) of an action potential, the rapid reversal of membrane potential is driven by a:

- A) Negative feedback loop involving voltage-gated K^+ channels.
- B) Positive feedback loop involving voltage-gated Na^+ channels (Hodgkin cycle).
- C) Active transport of Ca^{2+} ions into the cytoplasm.
- D) Sudden closure of leak K^+ channels.

QUESTION : SAMPLE QUESTION



- #Q. The Na^+ / K^+ ATPase is electrogenic. This means that for every cycle of operation, it directly contributes to the negativity of the cell interior by:
- A) Pumping Na^+ out and K^+ in.
 - B) Pumping Na^+ out and K^+ in.
 - C) Exchanging Ca^{2+} for Na^+ .
 - D) Hydrolyzing 2 molecules of ATP to pump out 1 anion.

#Q.

- 16.** In electrophysiology, membranes are thought to be capacitors. The reason why they are considered to be so is because
- (a) they harbor ion channels
 - (b) they harbor voltage-gated channels
 - (c) there is an electric potential gradient across the membrane
 - (d) they are made up of lipids

#Q.

106. The order of glucose, urea, H_2O , CO_2 and steroid hormones according to their ability to diffuse through the lipid bilayer, beginning with the one that crosses the bilayer most readily is
- (a) CO_2 , steroid hormone, H_2O , urea, glucose
 - (b) CO_2 , H_2O , urea, glucose, steroid hormone
 - (c) H_2O , CO_2 , glucose, urea, steroid hormone
 - (d) steroid hormone, CO_2 , H_2O , urea, glucose

#Q.

146. Transport of molecules against concentration gradient is called
- (a) osmosis
 - (b) active transport
 - (c) diffusion
 - (d) passive transport

#Q.

Q.43 The main role of carbohydrates in the cell membrane is

molecular recognition

modulating membrane fluidity

locomotion

adhesion

#Q.

Which of the following statement/s is true for cell membrane?

(A).It is composed mainly of lipids.

(B).Its fluid nature is important for cell growth, endocytosis, cell division etc.

(C).Fluid mosaic model of its structure was given by Griffith

(D).Its one of the important function is transport of molecules across it.

Choose the **correct** answer from the options given below:

1. (A), (B) and (D) only.
2. (A), and (D) only.
3. (A), (B), (C) and (D).
4. (B), (C) and (D) only.

#Q.

The portion of transmembrane proteins that cross the lipid bilayer are usually

1. α -helices
2. β -sheet
3. turns
4. loops



Summary



1. ELECTRICAL PROPERTY OF PLASMA MEMBRANE

VAISHALI VERMA MA'AM PW

PW IIT JAM & CSIR NET

SCAN ME



@VAISHALI_VER
MA_MAAM_PW



JOIN MY OFFICIAL TELEGRAM CHANNEL



Thank
You