CHAPTER 1.4

Membrane Transport

MEMBRANE TRANSPORT

Essential idea: Membranes control the composition of cells by active and passive transport.

UNDERSTANDINGS, APPLICATIONS, SKILLS

	Statement	Guidance
1.4.U1	Particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport.	
1.4.U2	The fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis.	
1.4.U3	Vesicles move materials within cells.	
1.4.A1	Structure and function of sodium–potassium pumps for active transport and potassium channels for facilitated diffusion in axons.	
1.4.A2	Tissues or organs to be used in medical procedures must be bathed in a solution with the same osmolarity as the cytoplasm to prevent osmosis.	
1.4.S1	Estimation of osmolarity in tissues by bathing samples in hypotonic and hypertonic solutions. (Practical 2)	Osmosis experiments are a useful opportunity to stress the need for accurate mass and volume measurements in scientific experiments.

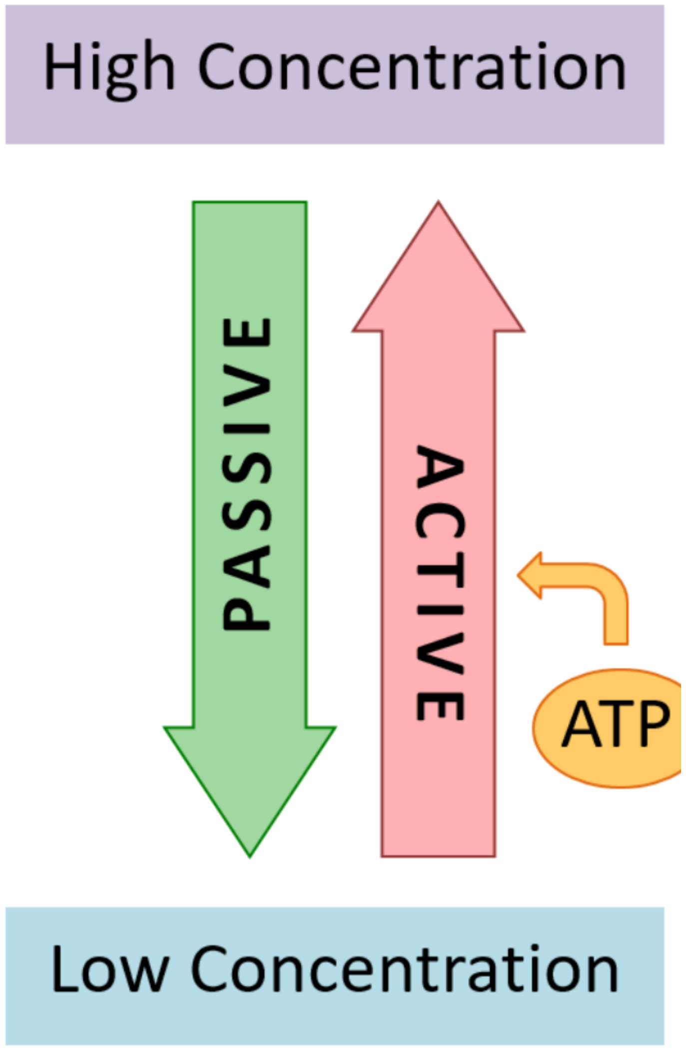
TYPES OF MEMBRANE TRANSPORT

Passive Transport:

- involves movement along a concentration gradient
- does NOT require energy in form of ATP

Active Transport:

- involves movement against a concentration gradient
- requires energy in form of ATP



PASSIVE TRANSPORT

Three main types of passive transport:

Simple Diffusion:

- small or lipophilic molecules can freely cross the plasma membrane

Facilitated Diffusion:

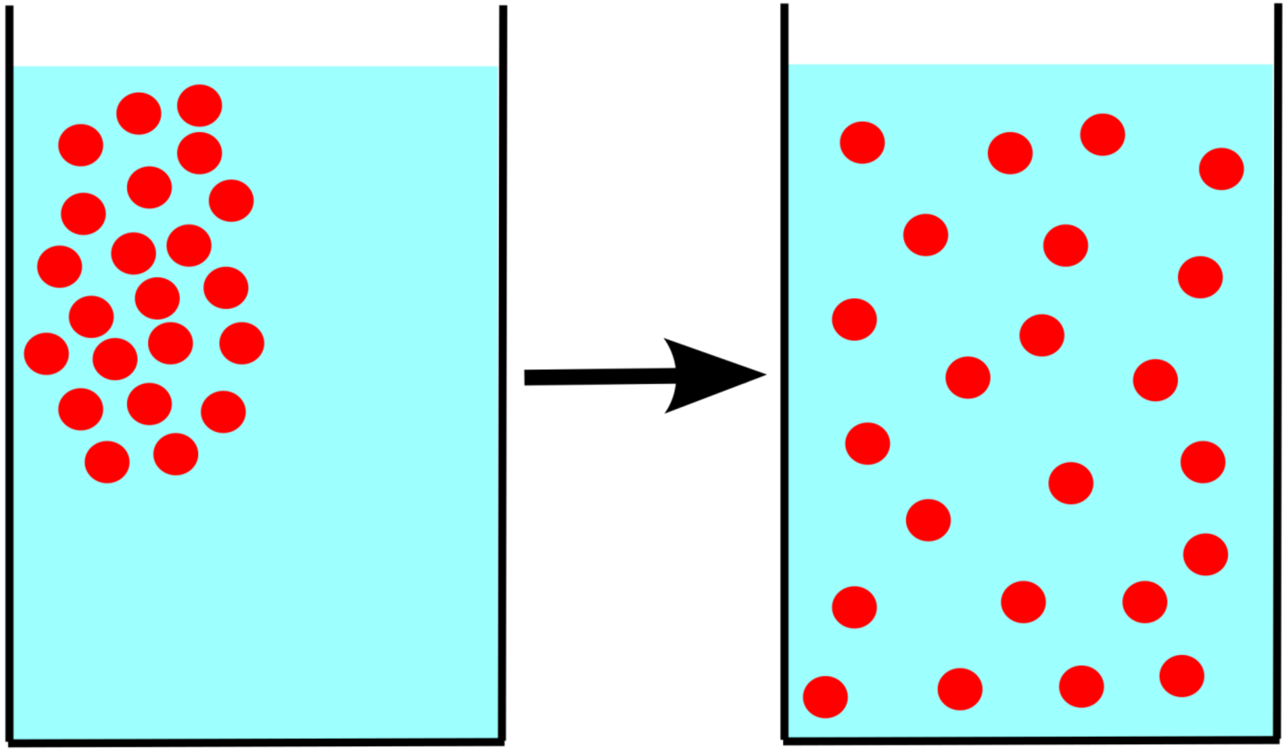
- large or charged molecules require transport via membrane proteins

Osmosis:

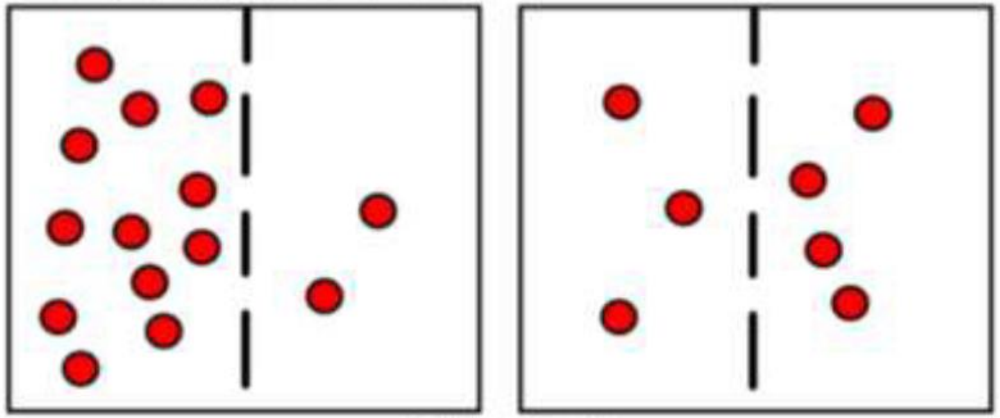
- Water movement → depending on relative solute concentration

SIMPLE DIFFUSION

The net movement of particles from a region of high concentration to a region of low concentration (along a concentration gradient) until equilibrium is reached.



CONCENTRATION GRADIENT

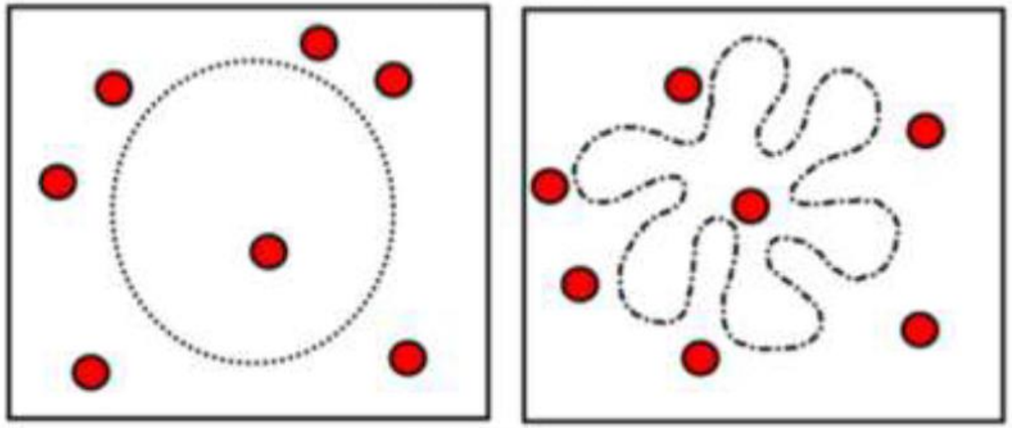


net movement

concentration gradient

rate of diffusion

SURFACE AREA

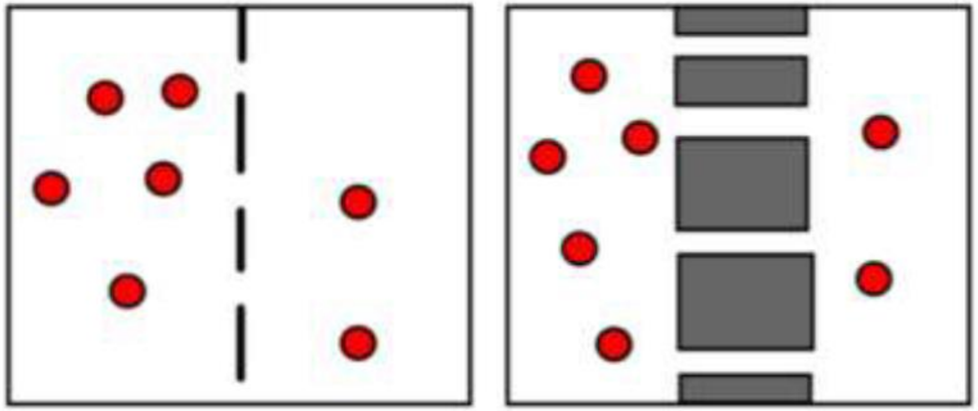


net movement

surface area

rate of diffusion

LENGTH OF DIFFUSION PATH



net movement

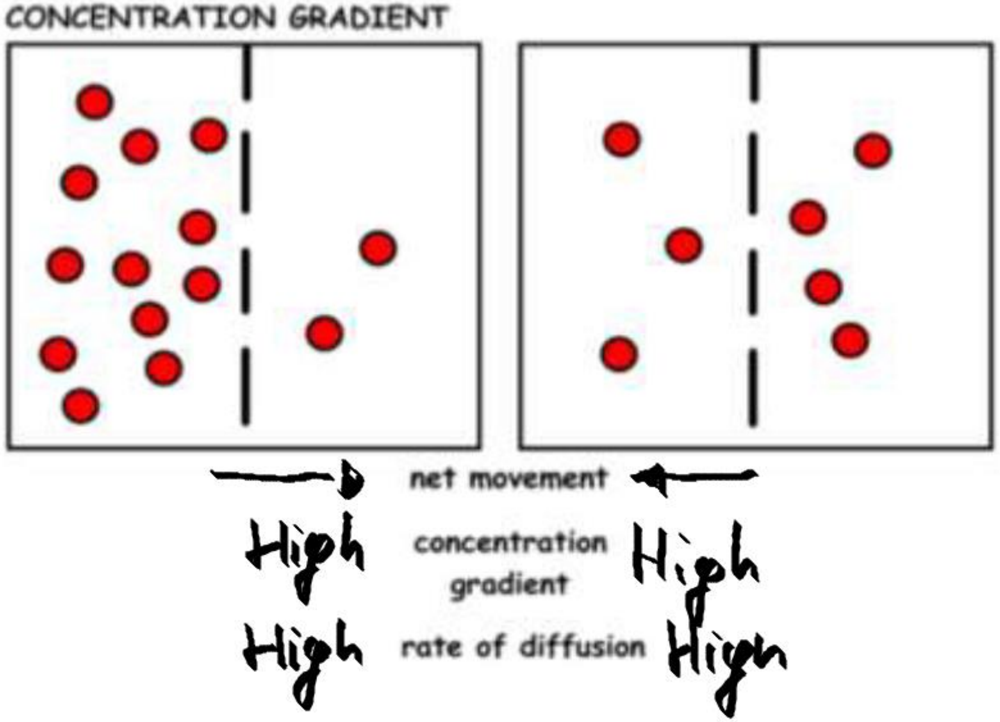
diffusion path

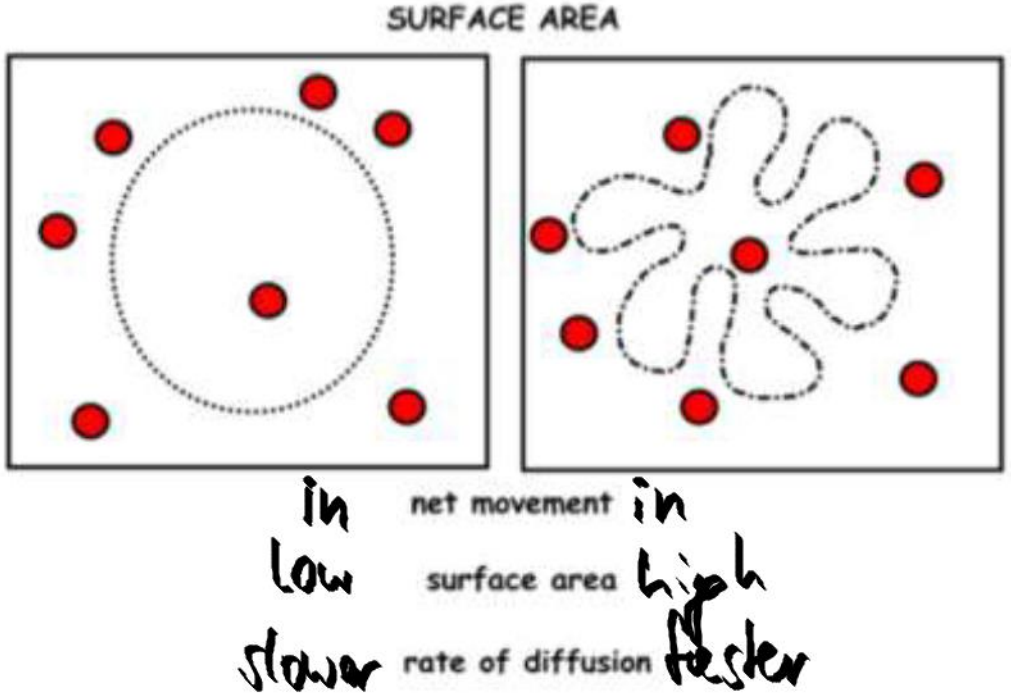
rate of diffusion

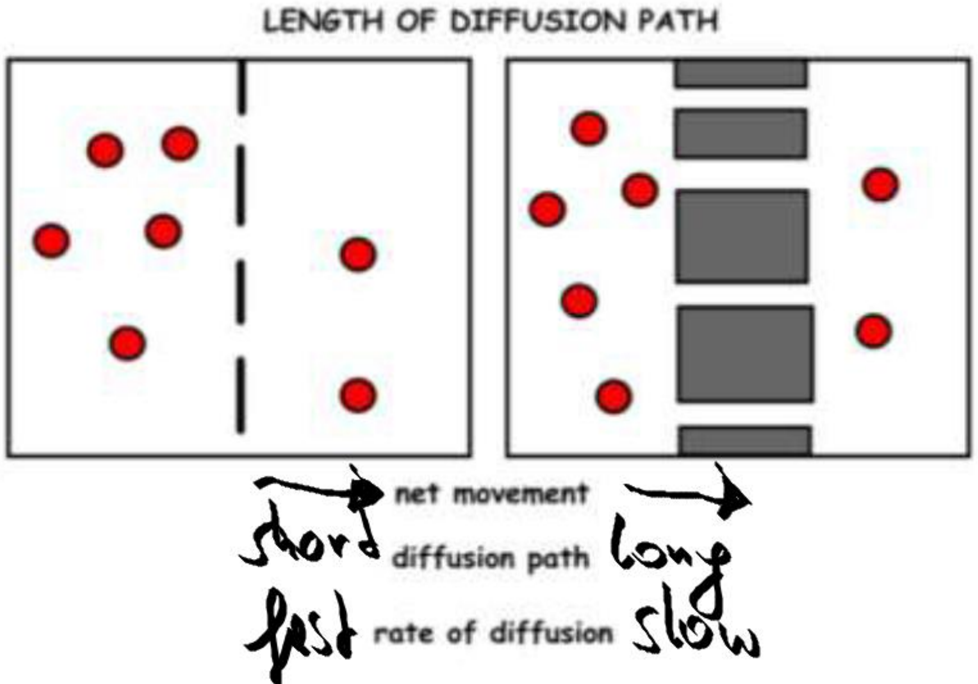
Which way are the molecules diffusing in each diagram?

How does each factor affect the rate of diffusion?

How does nature maximise the rate of diffusion?







Which way are the molecules diffusing in each diagram?

How does each factor affect the rate of diffusion?

How does nature maximise the rate of diffusion?

SIMPLE DIFFUSION

IB Companion page 36-37

Data based questions.

FACILITATED DIFFUSION

Certain substances cannot freely cross a plasma membrane (e.g. ions).

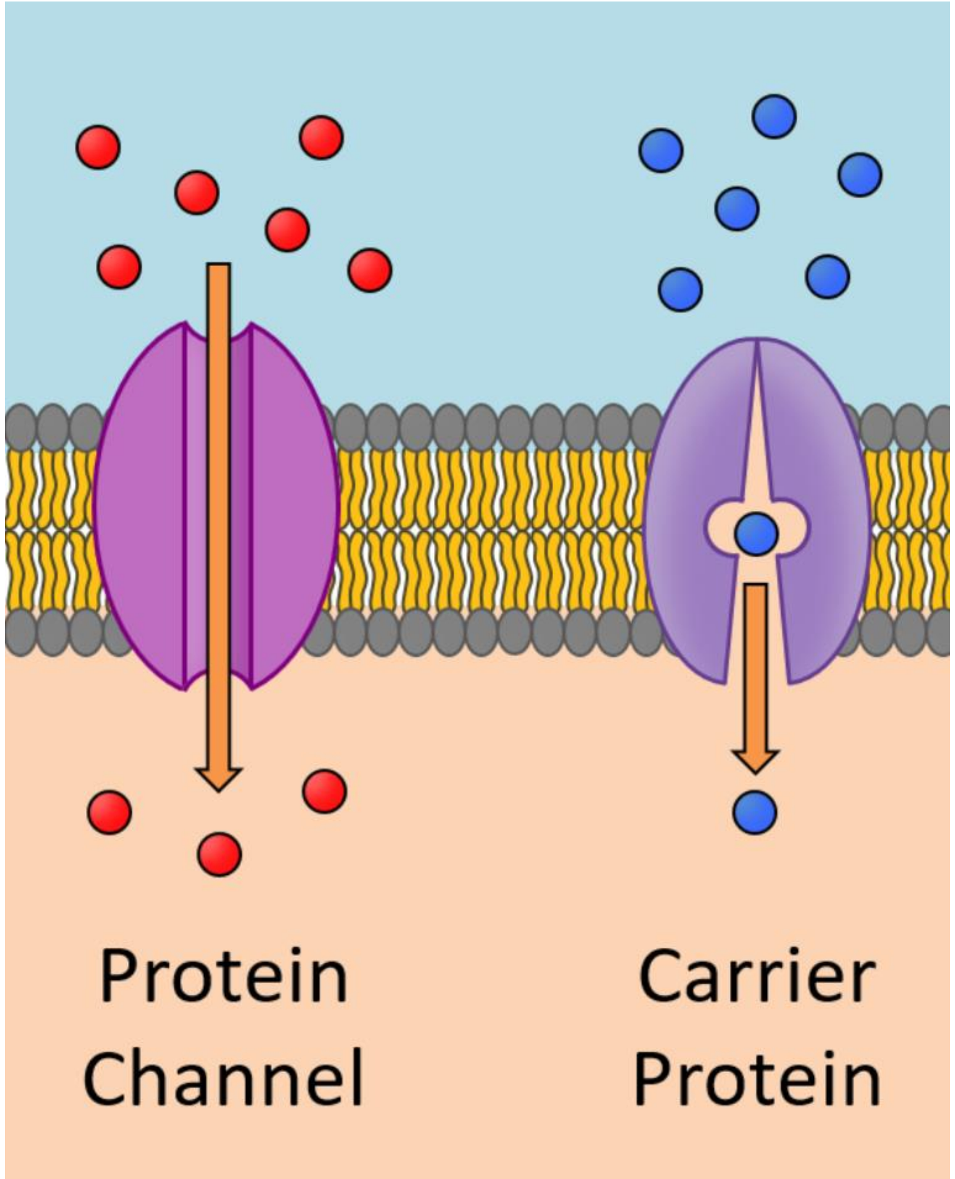
Membrane proteins facilitate their transport.

Protein channles:

hydrophilic pores → allow passage of ions

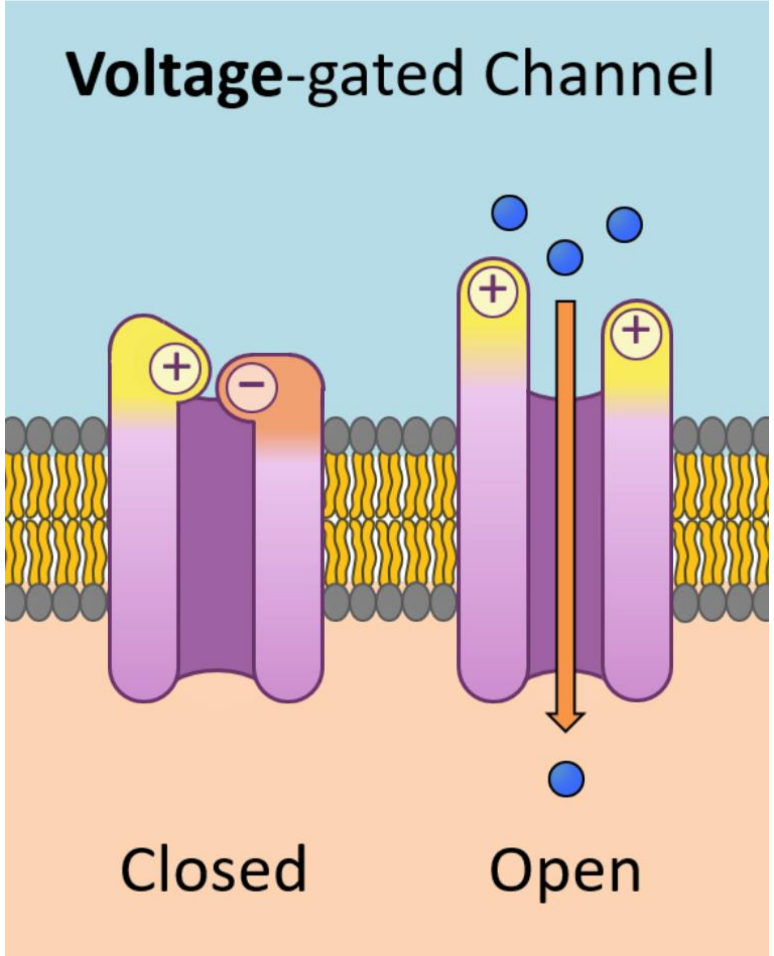
Carrier proteins:

conformational change → translocation

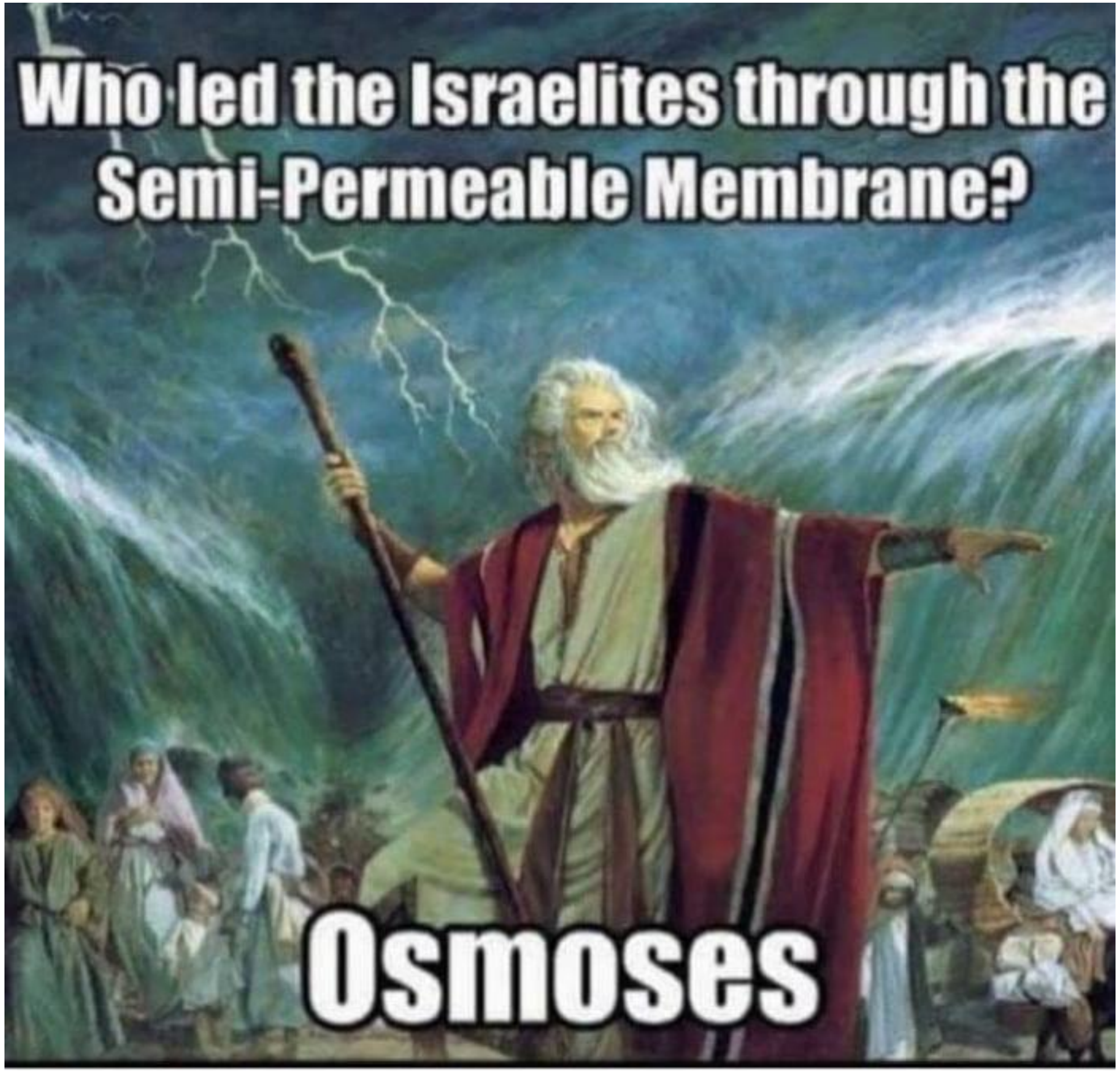


FACILITATED DIFFUSION EXAMPLE: POTASSIUM CHANNEL

- Integral protein + hydrophilic inner pore
- Inner pore selectivity filter → no other ions can pass
- Channels can have an open or closed conformation
- Example → polarity based (voltage-gated channel)

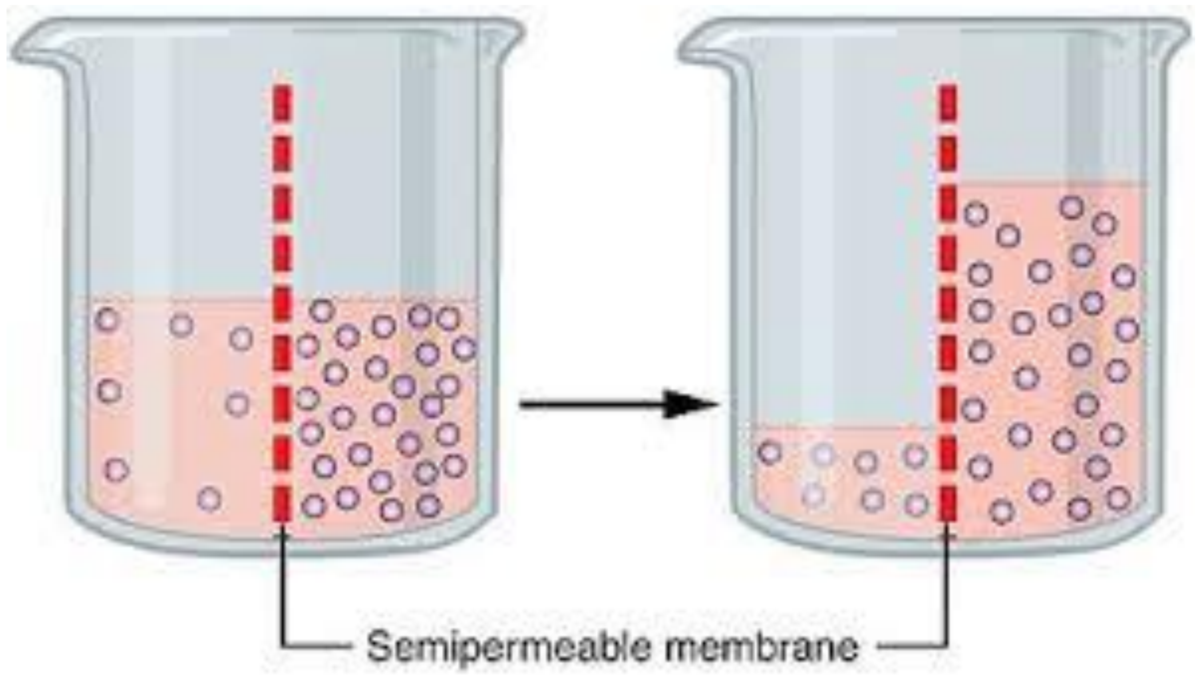


OSMOSIS


Who led the Israelites through the Semi-Permeable Membrane?
Osmoses

OSMOSIS

The net movement of free water molecules across a semi-permeable membrane from a region of low solute concentration to a region of high solute concentration.



OSMOLARITY

- is a measure of solute concentration

- solutions can be classified as:

<u>Hypertonic:</u>

→ higher relative solute concentration

→ hypertonic solutions gain water via osmosis

<u>Hypotonic:</u>

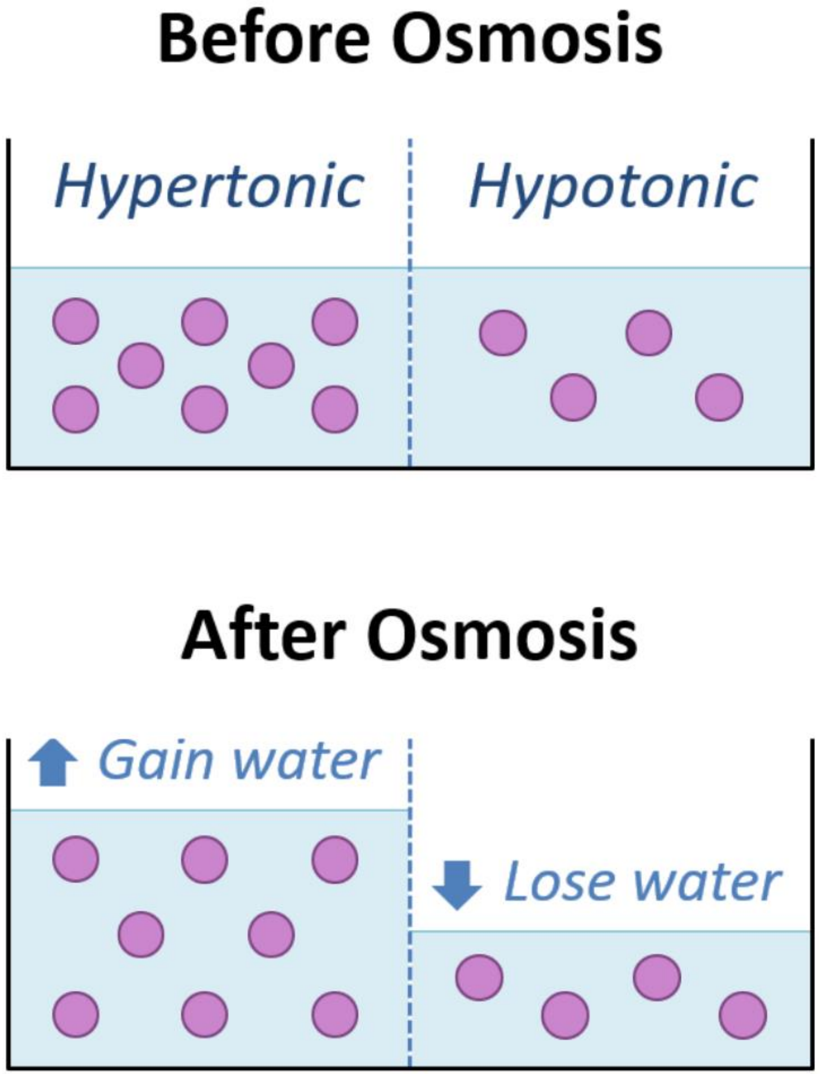
→ lower relative solute concentration

→ hypotonic solutions lose water via osmosis

<u>Isotonic:</u>

→ same relative solute concentration

→ no overall net water movement



stern.de

Mordverdacht: Wenn ein Gewürz zu Gift wird

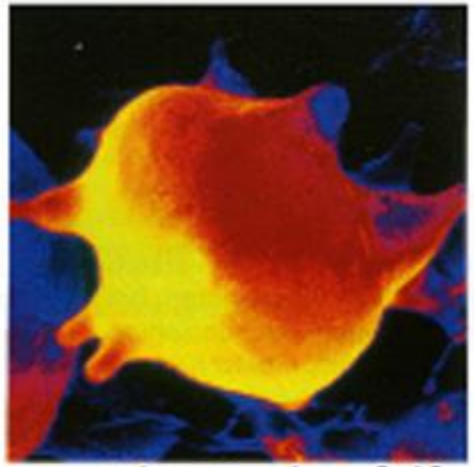
Eine 23-Jährige Frau wird verdächtigt, die Tochter ihres Lebensgefährten mit einer Überdosis Kochsalz ermordet zu haben. Sie bestreitet alle Vorwürfe und gibt dem Kind die Schuld.

Zwei Esslöffel Salz als Mittel zum Mord an einem Kind: Um diesen wohl beispiellosen Vorwurf geht es vom 13. Juli an in einem Prozess vor dem Landgericht Frankenthal in Rheinland-Pfalz. Angeklagt ist eine 23 Jahre alte Frau aus Ludwigshafen. Sie soll im März 2004 die vierjährige Tochter ihres Lebensgefährten ermordet haben - mit Kochsalz, das in einen Fertigpudding eingerührt war. Die Frau hat die Vorwürfe, für die es keine Zeugen gibt, bestritten. "Dabei wird sie auch in der Hauptverhandlung bleiben", sagt ihr Anwalt Bernd Rudolph.

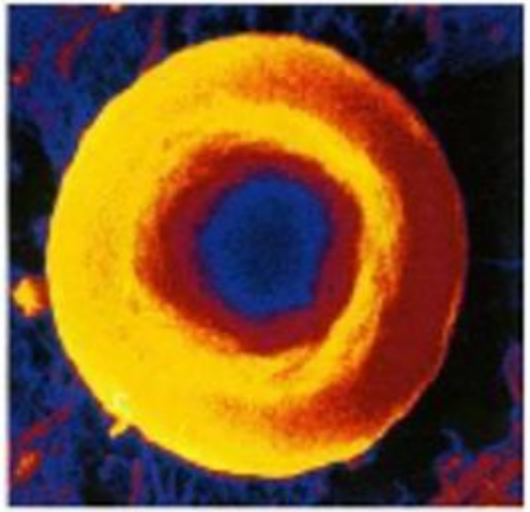
Kochsalz im Puddingbecher

Nach Darstellung der Anklage aß die Vierjährige am 25. März 2004 in der Küche der elterlichen Wohnung einen 0,2-Liter-Becher Pudding, dem 30 bis 40 Gramm Salz zugesetzt waren. Danach bekam sie Durchfall und musste sich übergeben. Einige Stunden später wurde das Kind in eine Klinik gebracht, wo es am 27. März starb. Die Vergiftung hatte zu einem Hirn- und Lungenödem geführt, Todesursache war letztlich ein Herz- und Kreislauf-Stillstand. Misstrauisch gewordene Angehörige setzten bei der Polizei eine Untersuchung in Gang. Dazu wurde zunächst eine Blutuntersuchung der Vierjährigen vorgenommen.

[...]



Erythrozyt in Stechapfelform – vorgefunden beim getöteten Mädchen (Körpergewicht: 16kg)



normaler Erythrozyt einer Vergleichsperson

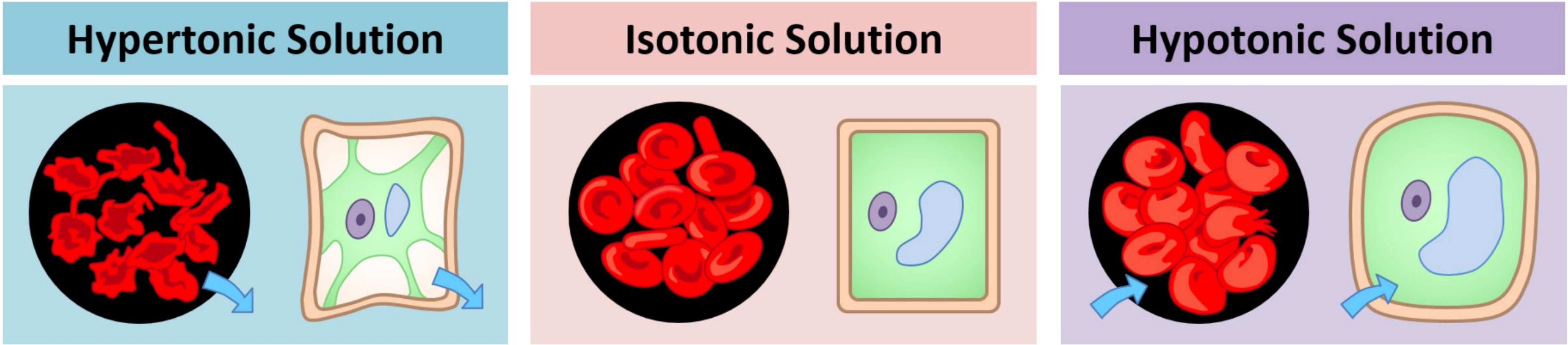
0,5 – 1 g of salt → per kg body weight = deadly

OSMOTIC POTENTIAL

Animal cells must be bathed in isotonic solutions → to maintain cell viability

Hypertonic solutions → shrivelling,

hypotonic solutions → lysis (breaking down of cell membrane)



ACTIVE TRANSPORT

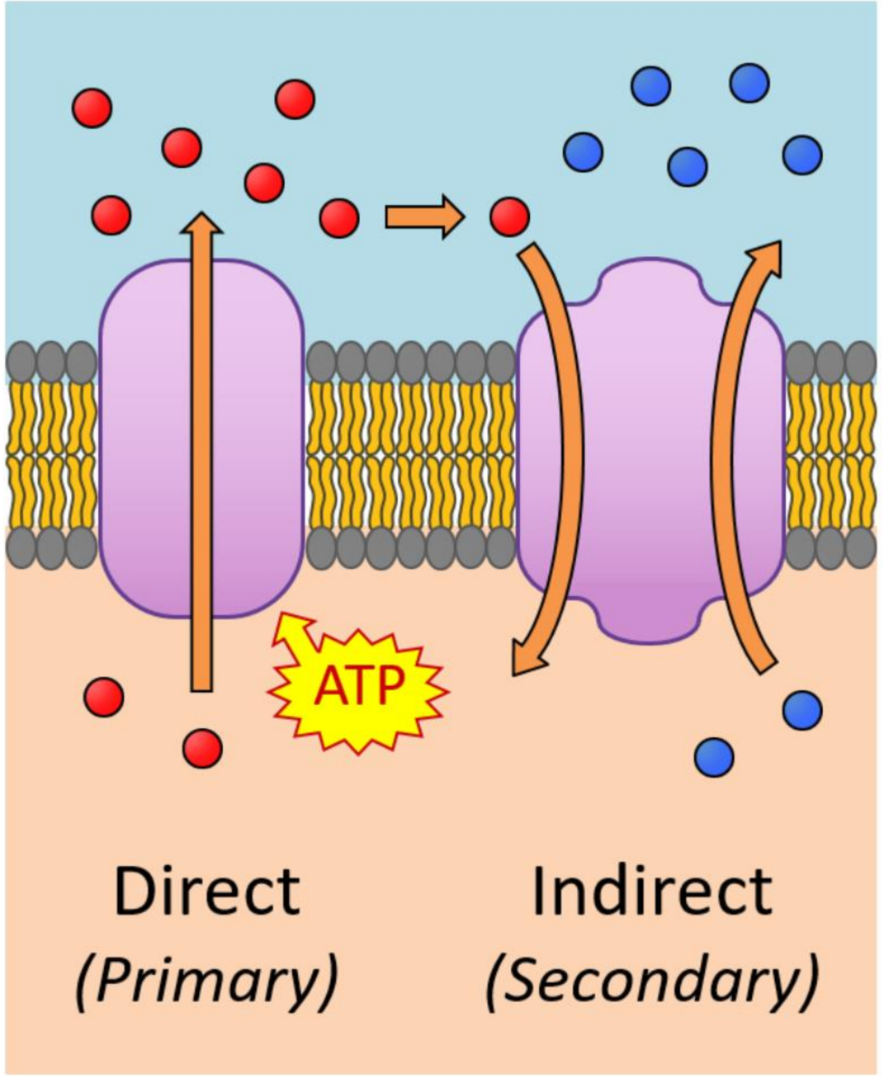
uses energy to transport molecules AGAINST concentration gradient (low → high)

Direct Active Transport (Primary):

- ATP hydrolysis → transport

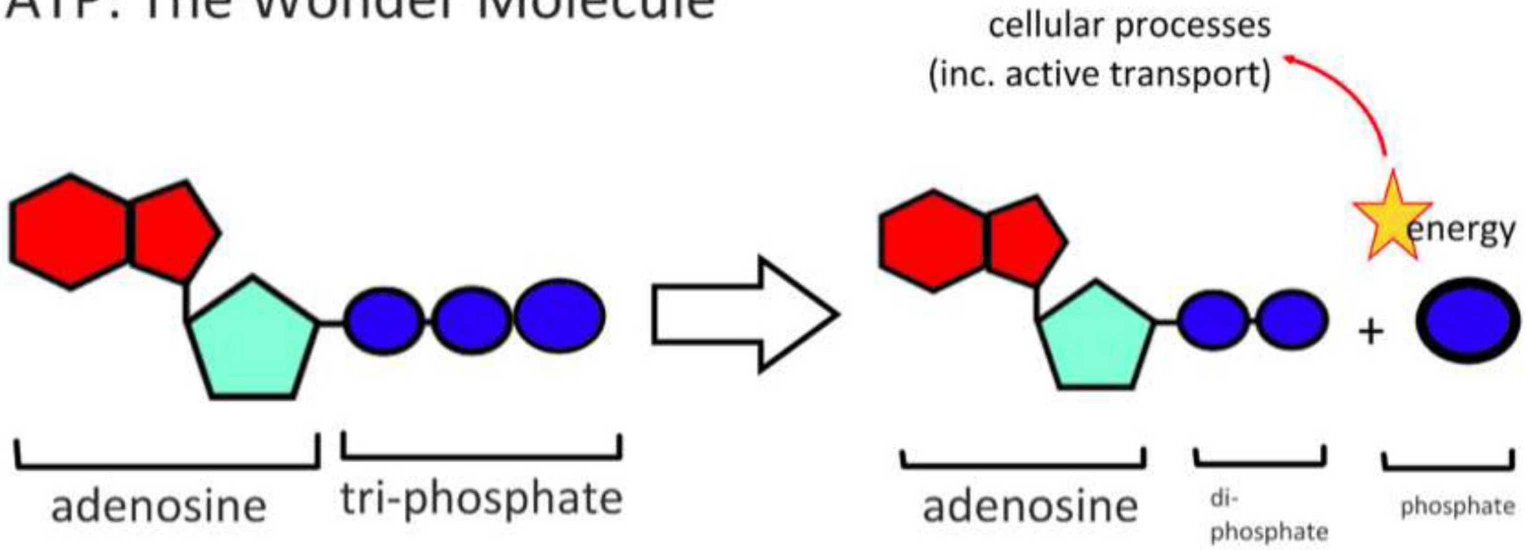
Indirect Active Transport (Secondary):

- transport coupled to another molecule moving along an electrochemical gradient (=cotransport)



ATP HYDROLYSIS

ATP: The Wonder Molecule



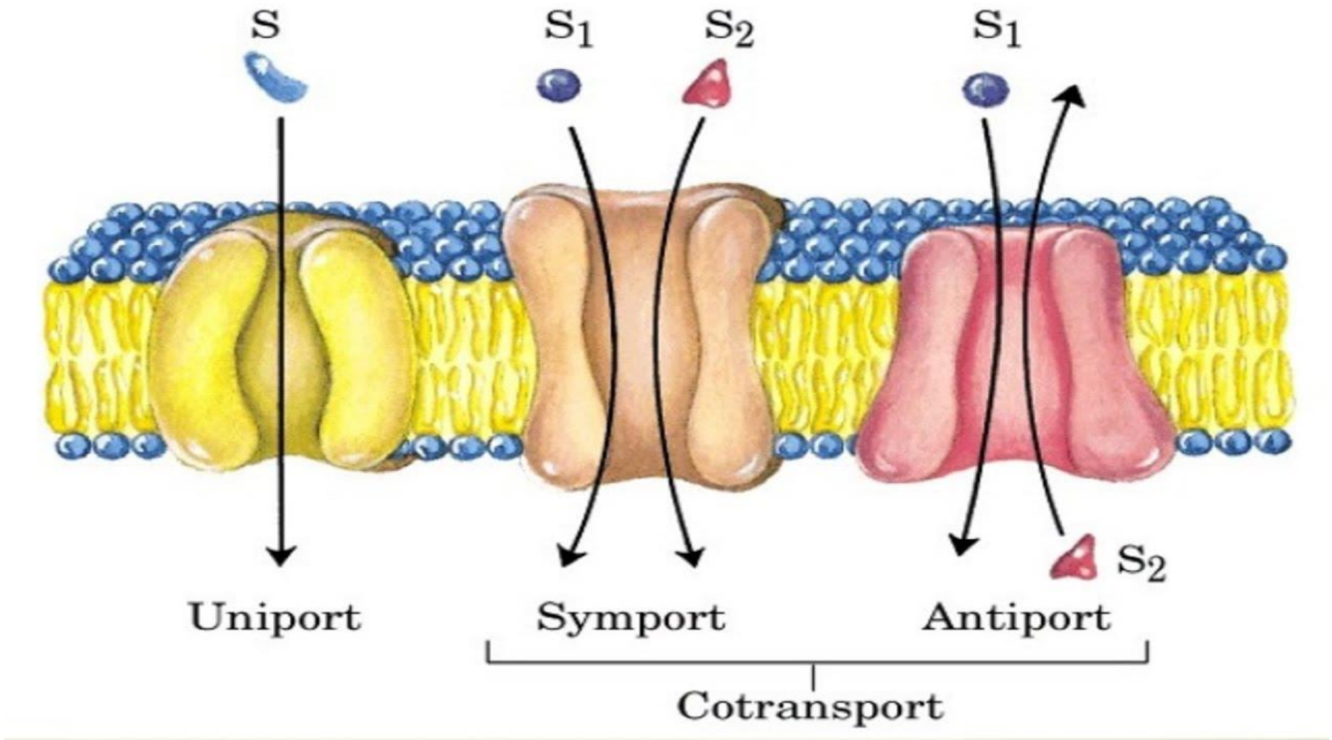
Hydrolysis of the bond releases one phosphate and a lot of energy.

use water split

Respiration in the cells recombines ADP with a phosphate ion, to be used for further cellular processes.

ACTIVE TRANSPORT

Active Transport uses energy from the hydrolysis of ATP to pump molecules against the concentration gradient.



ACTIVE TRANSPORT

Data-based questions: Phosphate absorption in barley roots (p.39)

SODIUM-POTASSIUM PUMP

Na+ :

Na+ :

Na+ :

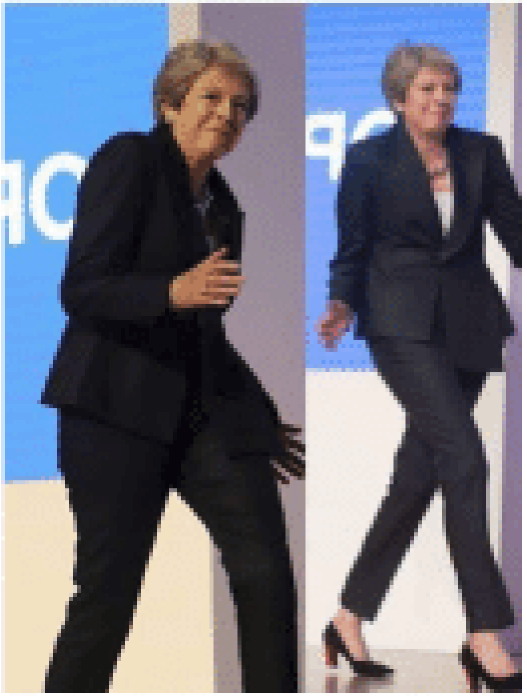
K+ :

K+ :

Sodium-Potassium Pump: * exists *

Na^+:

K^+:



active transport time

SODIUM-POTASSIUM PUMP

1) Three sodium ions bind to protein pump

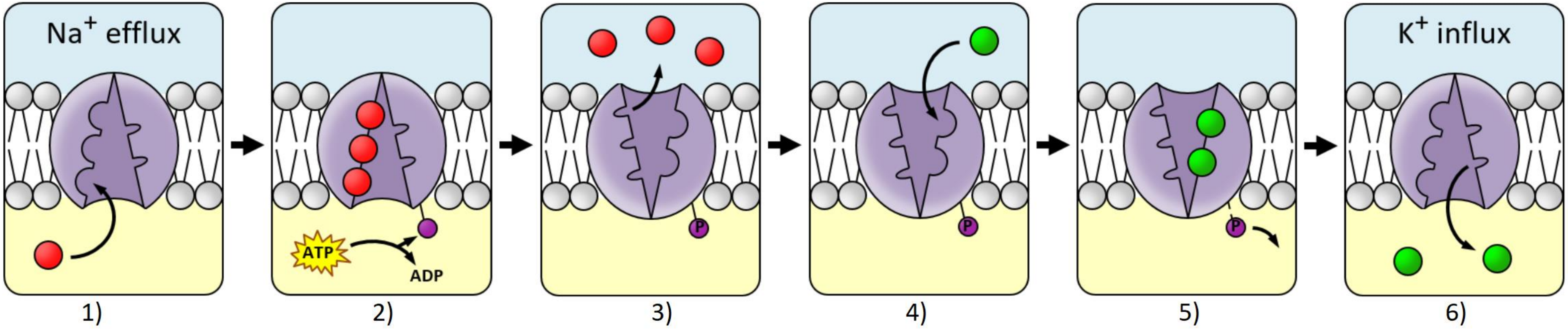
2) ATP transfers a phosphate group to the pump (hydrolysis) → changes conformation

3) Interior of pump opens to outside → sodium ions are released

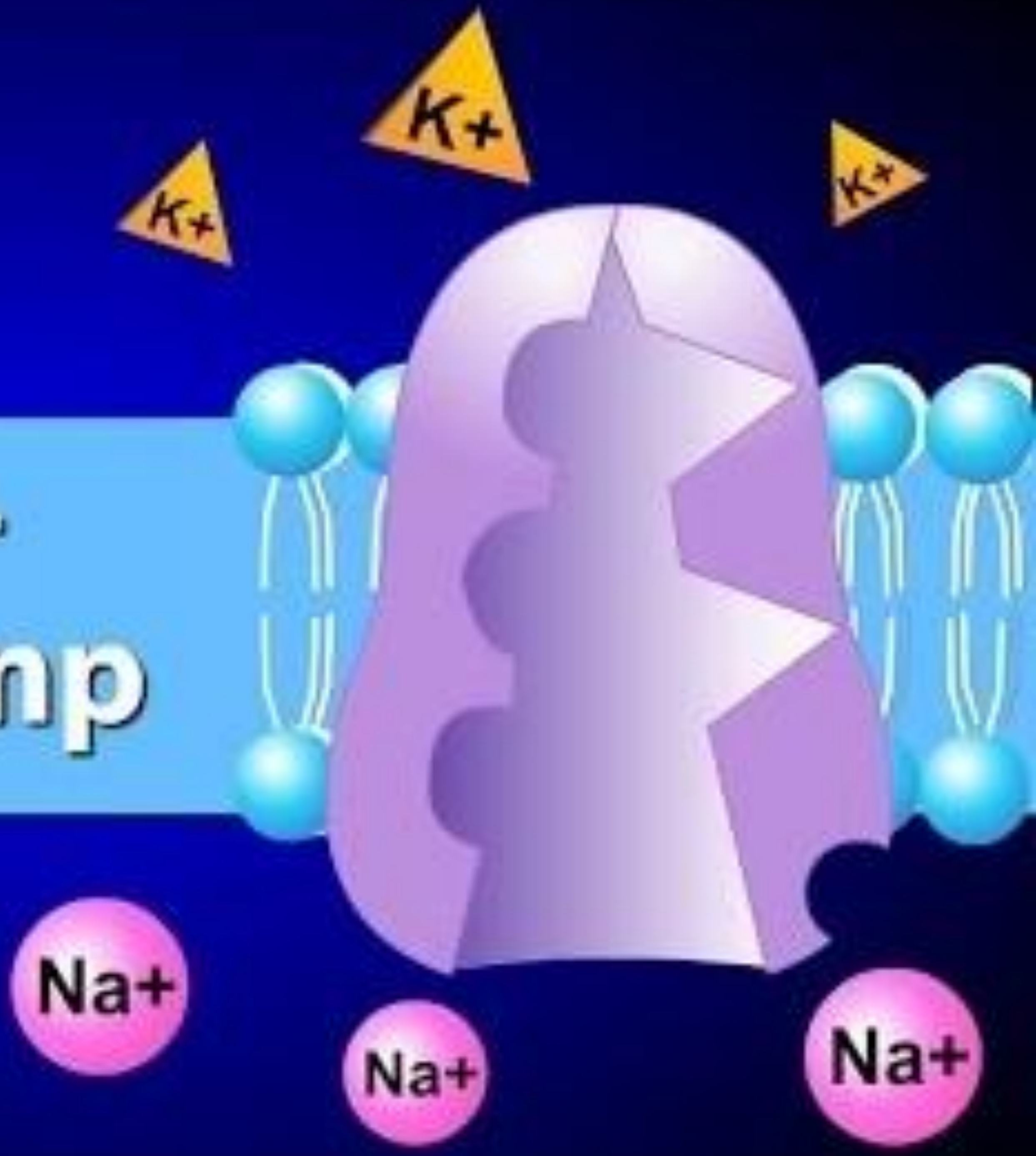
4) Two potassium ions from outside attach to potassium pump

5) Binding of potassium → releases phosphate group

6) release of phosphate → changes conformation and potassium ions are released



The Sodium-Potassium Pump



VESICLES

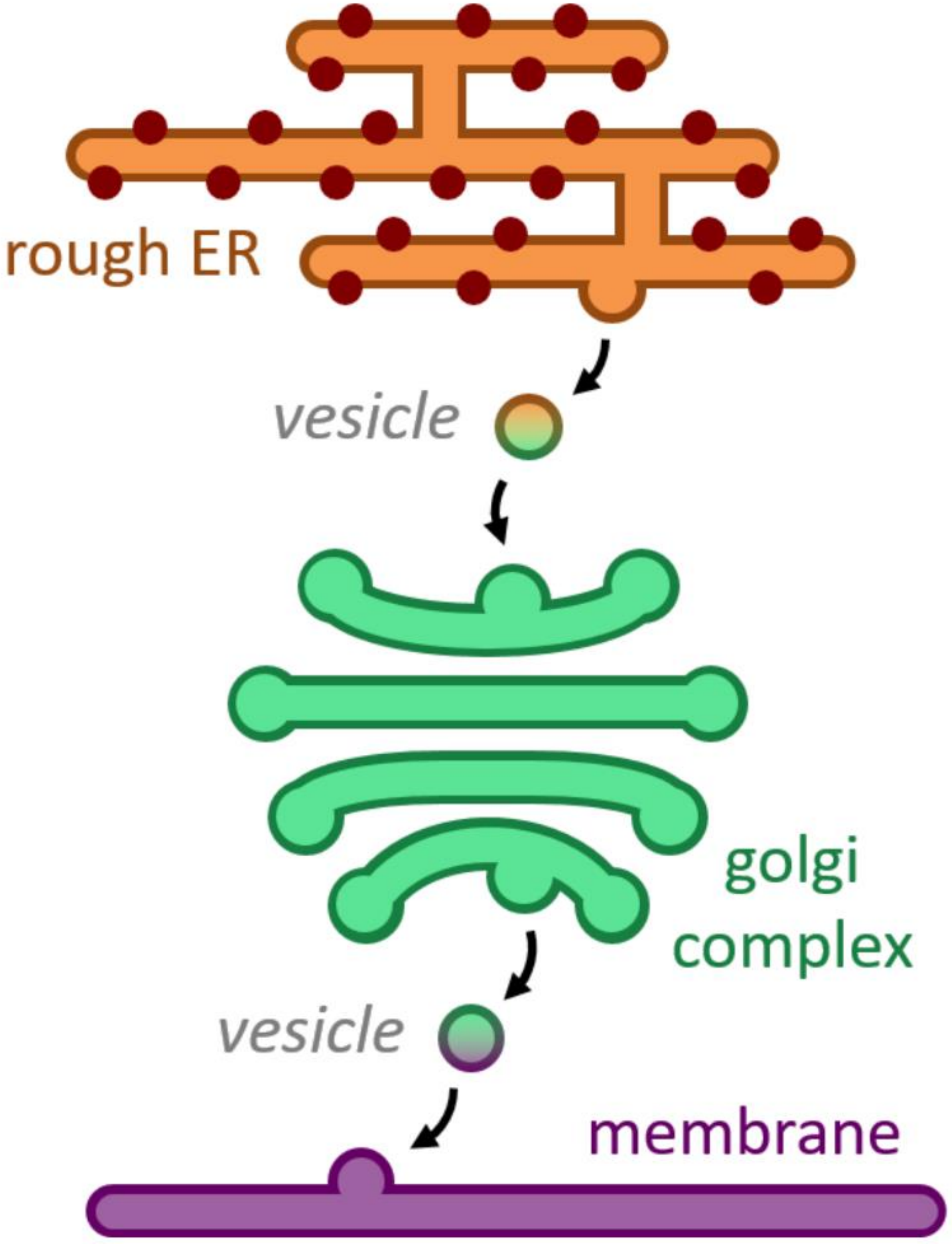
Molecules destined for secretion → transported by vesicles

- ribosomes synthesize secretory proteins

- budding of ER creates vesicle

- vesicle transports protein to GA

- vesicle transports protein from GA to plasma membrane

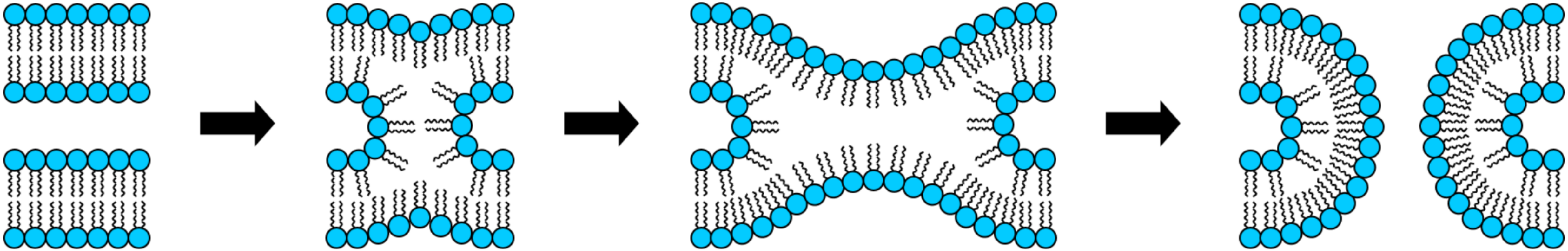


BULK TRANSPORT (CYTOSIS)

Only works because of the membrane‘s fluidity

Hydrophobic interactions between fatty acid tails hold membrane together

- interactions can easily be broken and reformed (requires ATP hydrolysis)
- seperation or fusion → easy way to transport a lot of molecules



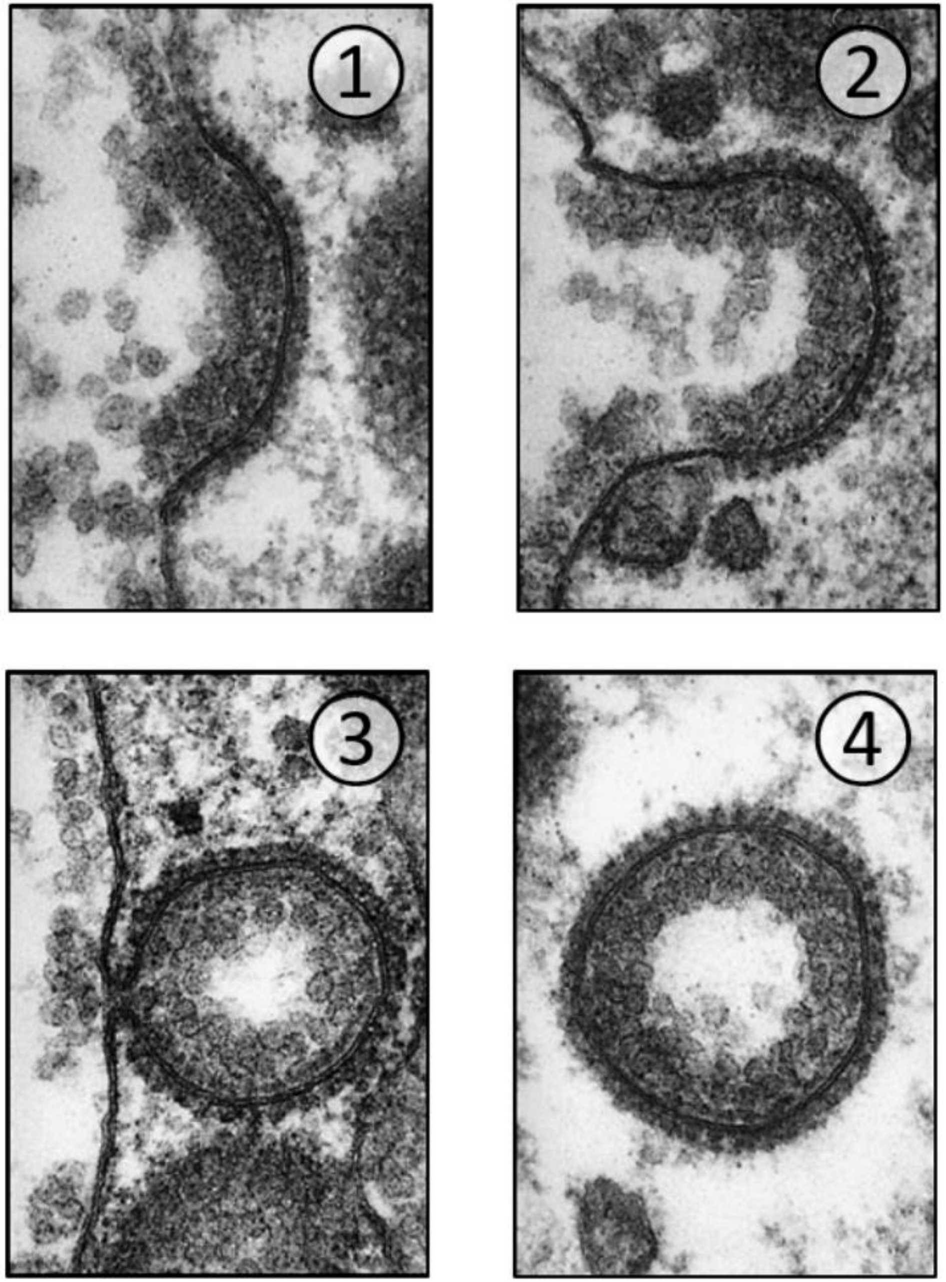
ENDOCYTOSIS

Process by which substances enter the cell → without passing across the plasma membrane

Substance becomes internalised within a vesicle

Phagocytosis → solid substances

Pinocytosis → liquids/solutions

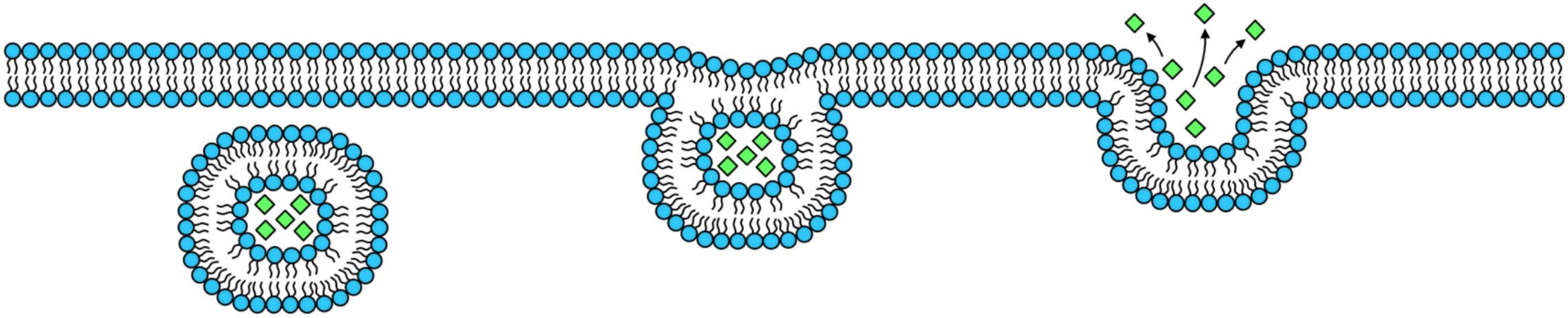


EXOCYTOSIS

- Exocytosis involves materials exiting cell → without crossing plasma membrane
- Materials packaged and stored within GA prior to secretion

Material can be immediately released after synthesis (constituive secretion)

Material release can be delayed until a signal (neurotransmitter) is received (regulatory secretion).



CHECKOUT

You should be able to:

- compare passive and active transport
- describe different types of passive transport
- outline how osmolarity affects cells/tissues
- describe the process of active transport
- identify organelles required for vesicle transport
- describe th eprocess of cytosis
- contrast endocytosis and exocytosis