A. HOW PHOSPHOLIPIDS FORM A BILAYER AND PROVIDE FLUIDITY

Hydrophilic = polar

Glycerol and phosphate head

Attracted to water

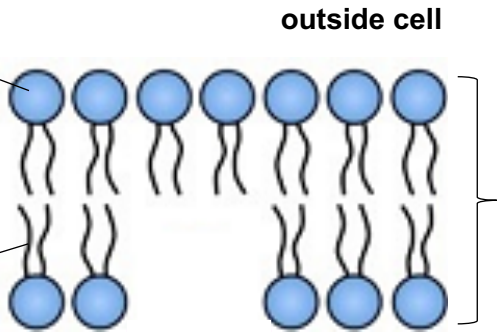
So: in contact with water on outside and inside of cell

Hydrophobic = non-polar

Fatty acid tail

Not attracted to water

So: within the membrane



Phospholipids are **amphipathic**. = They have both **hydrophilic and hydrophobic** parts

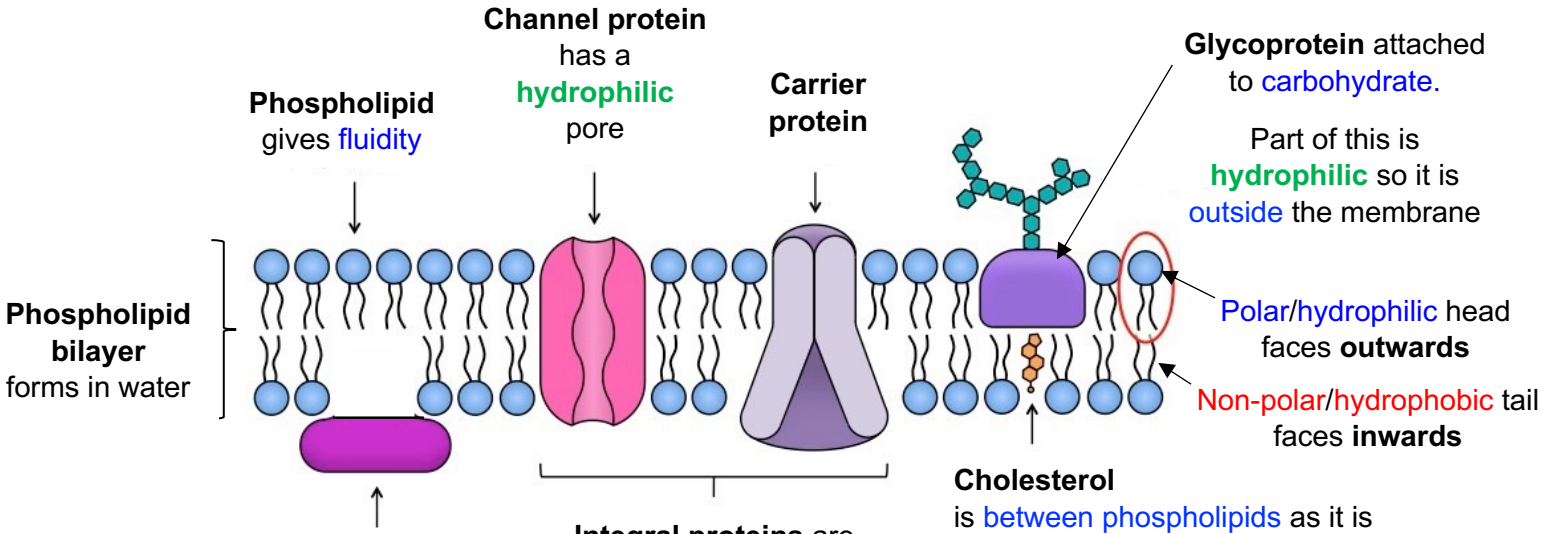
Double layer (bilayer) forms in water. It has:

Stability as **heads** on **outer edge** are **attracted to water** and **tails** in the **middle** are attracted to **each other**

Fluidity because **hydrophobic tails** are **attracted** to **each other**

Fluidity allows **membranes to change shape/vesicles to form** to allow **endocytosis / exocytosis / cell division**

B. FLUID MOSAIC MODEL OF PLASMA MEMBRANE STRUCTURE



- **Integral proteins** have:
  - **hydrophilic** amino acid regions on the **membrane surface**
  - **hydrophobic** amino acid regions in the **phospholipid bilayer**

C. FUNCTIONS OF MEMBRANE PROTEINS

- **receptors** (binding sites) for **hormones**
- **cell recognition** / cell-to-cell communication
- **channels** for **facilitated diffusion**
- **carrier proteins**/pumps for **active transport**
- **cell adhesion**
- immobilised **enzymes**
- **electron transport**/carriers

FLUID =

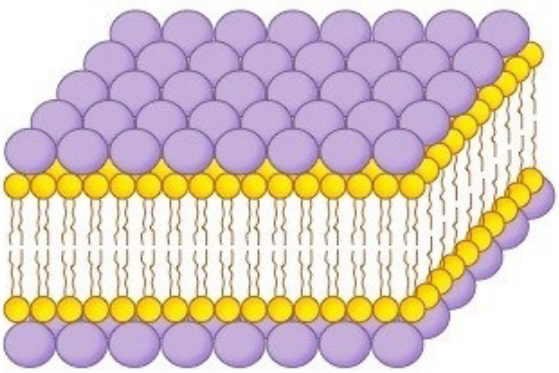
The phospholipids and proteins can move in the membrane

MOSAIC =

The phospholipids and proteins are arranged in a random pattern that looks like a mosaic when viewed from above

D. DIFFERENT MODELS FOR MEMBRANE STRUCTURE

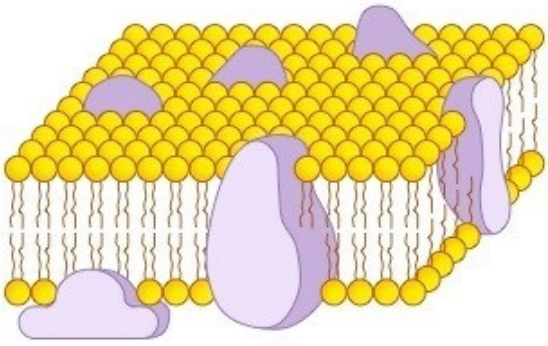
Davson-Danielli Model (1935)



Phospholipid bilayer in the **centre**
A **layer of protein** on **either side**

= 'Sandwich' model

Singer-Nicolson Model (1972)

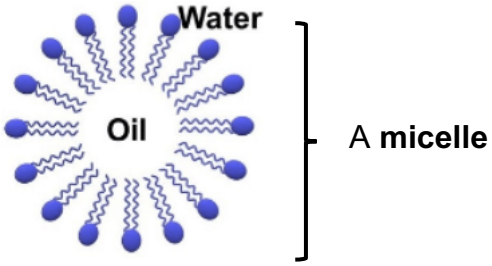


Proteins embedded/floating
in the **phospholipid bilayer**

= 'Fluid-mosaic' model

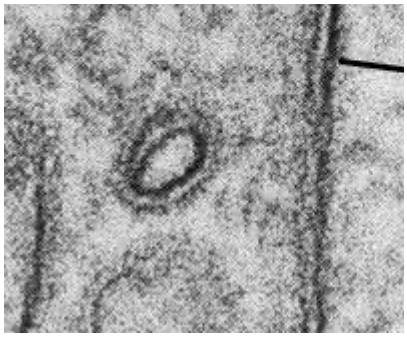
EARLY evidence for membrane structure

- Early evidence showed that membranes are **partially permeable** and **organic solvents penetrate** them **faster** than water
- This **suggested** that they have **hydrophobic** (**non-polar**) regions
- This was backed up by **chemical analysis**, which showed that membranes consist mainly of **lipids** and **proteins**.
- There was also knowledge that **phospholipids** will form a **monolayer** over water, with their **hydrophobic tails** out of the water and their **hydrophilic heads** in contact with the water.
- They also knew that **phospholipids** form **micelles** when shaken with water, with their **hydrophobic tails** facing **inwards** away from water:



SUPPORTING evidence for the Davson-Danielli model

Electron Microscopy



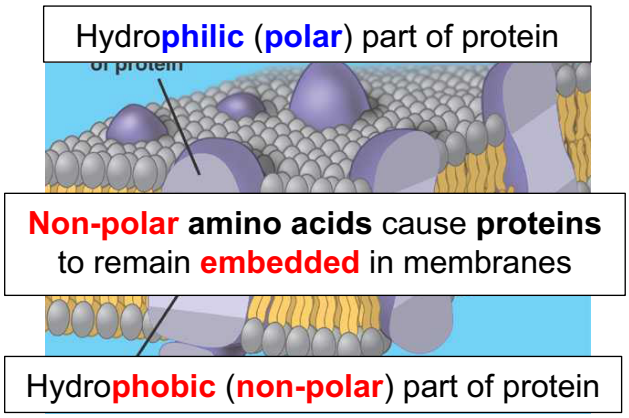
- **protein** usually appears **darker**
- the **plasma** membrane looks like **two dark** lines **separated** by a **lighter** band
- so: this **supported** the **Davson-Danielli** model

FALSIFYING evidence for the Davson-Danielli model

1. Freeze-fracture electron micrographs

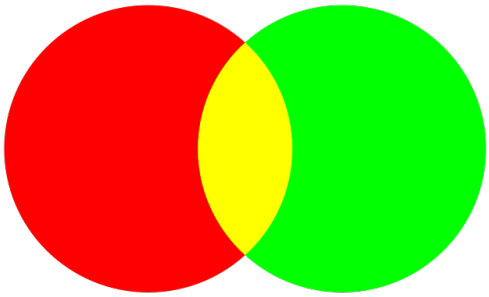
- showed that **proteins** were present in the **centre** of the **phospholipid bilayer**
- showed that **proteins** can **cross** the phospholipid bilayer **completely** or **partially project** out from it
- indicated the presence of **integral** and **peripheral proteins**

2. Analysis of membrane proteins



1. Membrane proteins were discovered to be **insoluble in water**, indicating **hydrophobic surfaces** and they **varied** in **size**
2. Such proteins would **not** be able to form a **uniform** and **continuous layer** around **the outer surface** of a membrane.
3. **Outer parts** of **protein** are **hydrophilic (polar)** so must be **outside** the **phospholipid bilayer**
4. **Central part** of protein is **hydrophobic** (**non-polar**) so must be **within** the **phospholipid bilayer**

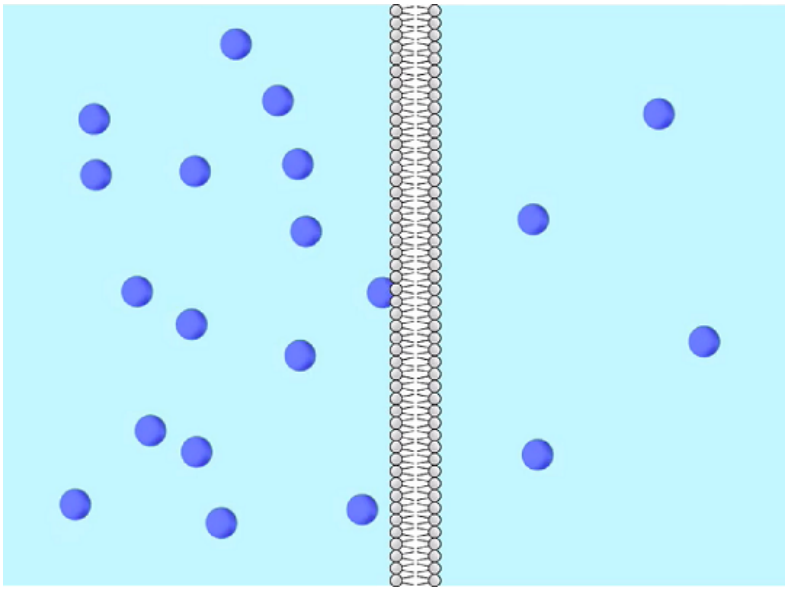
3. Fluorescent marker tagging of membrane proteins



- **membrane proteins** from **one cell** were tagged with a **red** fluorescent marker
- **membrane proteins** from **another** cell were tagged with a **green** fluorescent marker
- when the **two** cells were **fused**, the **colours** became **mixed** throughout the membrane of the fused cell
- this showed that the **membrane proteins** could **move** and did **not** form a **fixed** layer (as for the Davson-Danielli model)

E. DIFFUSION

The **passive** net movement of particles from a **higher** to **lower concentration**, due to the **random** movement of particles



The **difference in concentration** across the **membrane** is known as the **concentration gradient**

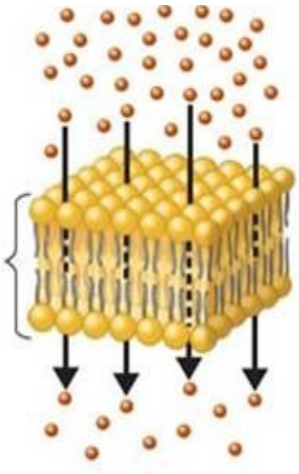
HIGH CONCENTRATION GRADIENT =
LARGE DIFFERENCE IN CONCENTRATION ACROSS THE MEMBRANE =
FAST DIFFUSION

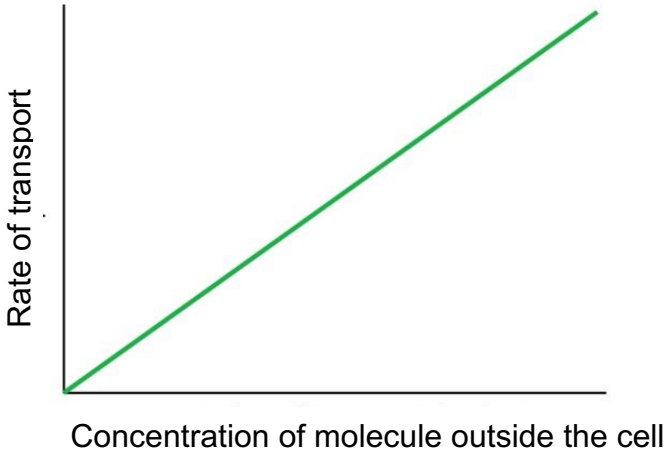
Diffusion is faster when the following are **increased**:

- Temperature
- Pressure
- Surface area
- Concentration gradient

Simple diffusion

Small, **non-polar (lipid soluble)** molecules such as **O_2** and **CO_2** move through the **phospholipid bilayer**

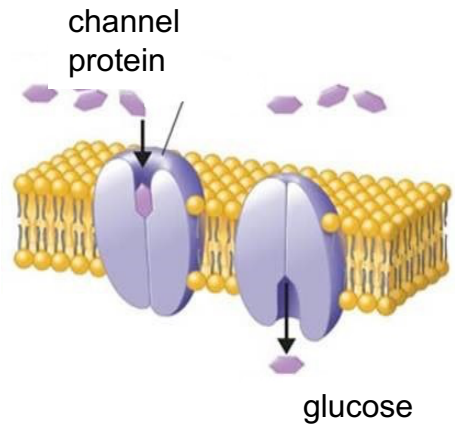




- Rate of transport is **proportional** to the **concentration of substance outside the cell**.
- The **higher the concentration gradient**, the **faster the diffusion**.

Facilitated diffusion

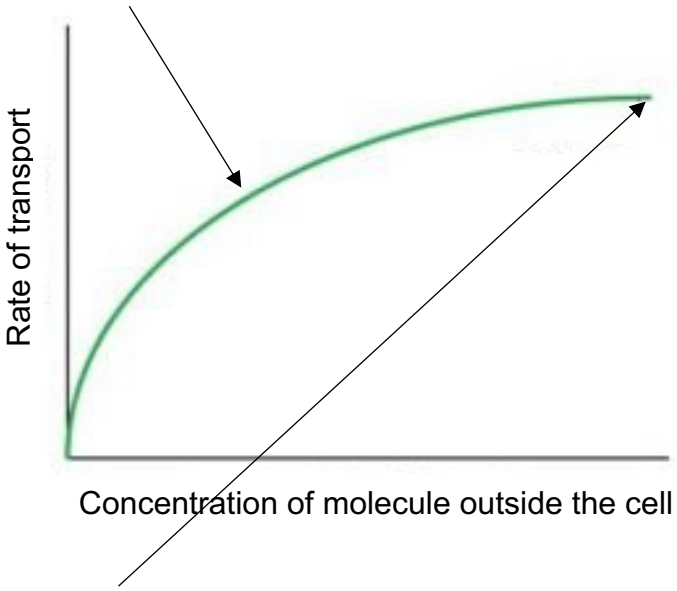
Polar (water soluble) molecules such as **glucose, amino acids** and **ions** move through water-filled **channel proteins**



Specific
Each protein **only transports one type** of molecule.

Only **one type** of molecule **fits** into its **complementary-shaped receptor** in the **protein**.

- Rate is **limited** by the **concentration of substance outside the cell**.

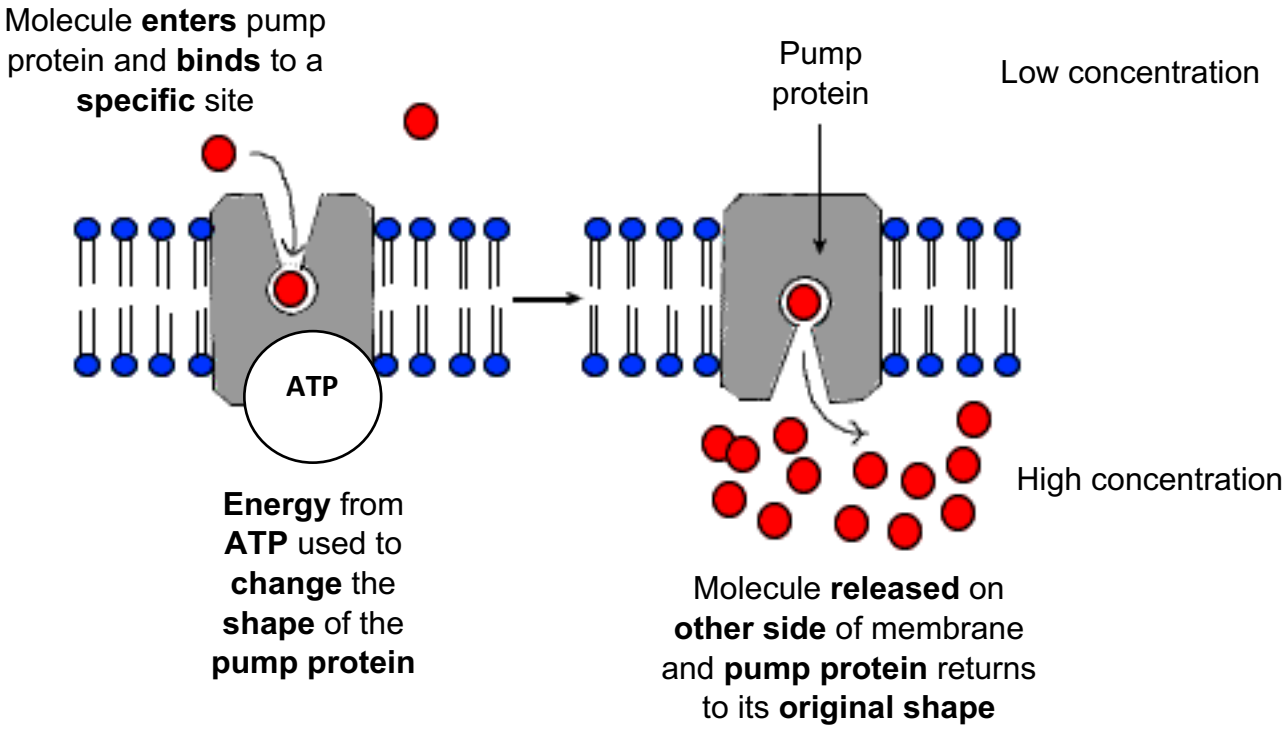


- Rate is **limited** by the **number** of **empty channel proteins** in the membrane.
- All **channel proteins** are **saturated** (full up) so they **cannot transport extra molecules** across the membrane.

Comparing and contrasting SIMPLE DIFFUSION and FACILITATED DIFFUSION

	SIMPLE DIFFUSION	FACILITATED DIFFUSION
Energy/ATP needed	**No – both are passive**	
Direction of movement	**Down concentration gradient**	
Molecules pass directly through phospholipids	**Yes**	**No**
Involves channel proteins	**No**	**Yes**
Specific	**No**	**Yes**
Molecule binds to carriers	**No**	**Yes**
Speed	**Slower**	**Faster**
Examples	**O_2 / CO_2**	**Sugars / amino acids**

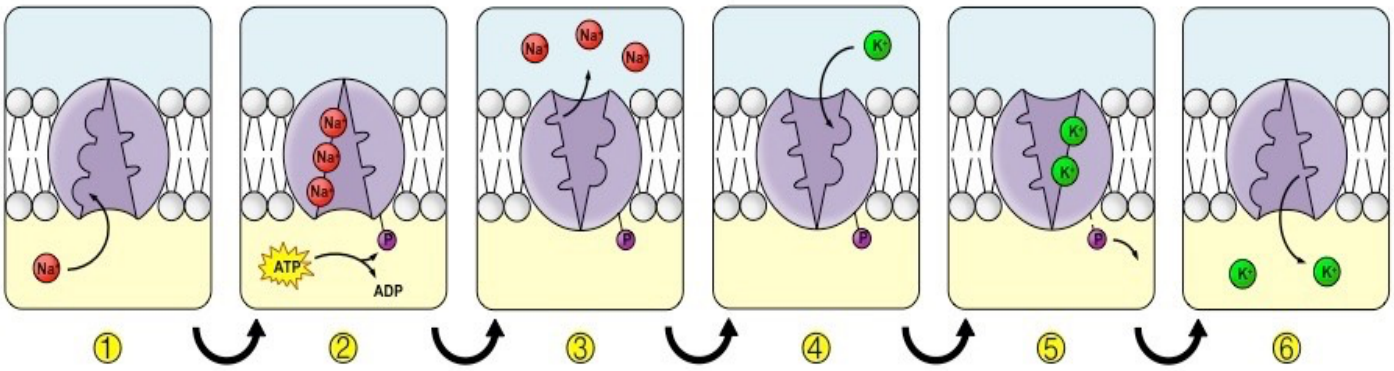
F. ACTIVE TRANSPORT



- The **rate** of **active transport** is **increased** if the **oxygen concentration** is **increased**
- More **oxygen** = more **respiration** = more **energy/ATP** = more **active transport**
- The **rate** of **active transport** is **inhibited** by any chemical that **inhibits respiration**
  e.g. cyanide

Example Of Active Transport: The SODIUM-POTASSIUM PUMP

- This is involved in **transmission** of **electrical** impulses by **nerve cells**. You will
- You will learn about it in more detail in a **later topic**.



1. **3 sodium ions** bind to sites **inside** the sodium-potassium pump
2. A **phosphate group** is **transferred** to the **pump** via the **hydrolysis** (breakdown) of **ATP**
3. The **pump** undergoes a **shape change**, **transporting sodium ions** across the membrane
4. The **shape change** exposes **2 potassium binding sites** of the pump
5. The **phosphate group** is **released** which **causes** the pump to **return** to its **original shape**
6. This **transports** the **potassium ions** across the membrane, completing the ion exchange

Comparing and contrasting FACILITATED DIFFUSION and ACTIVE TRANSPORT

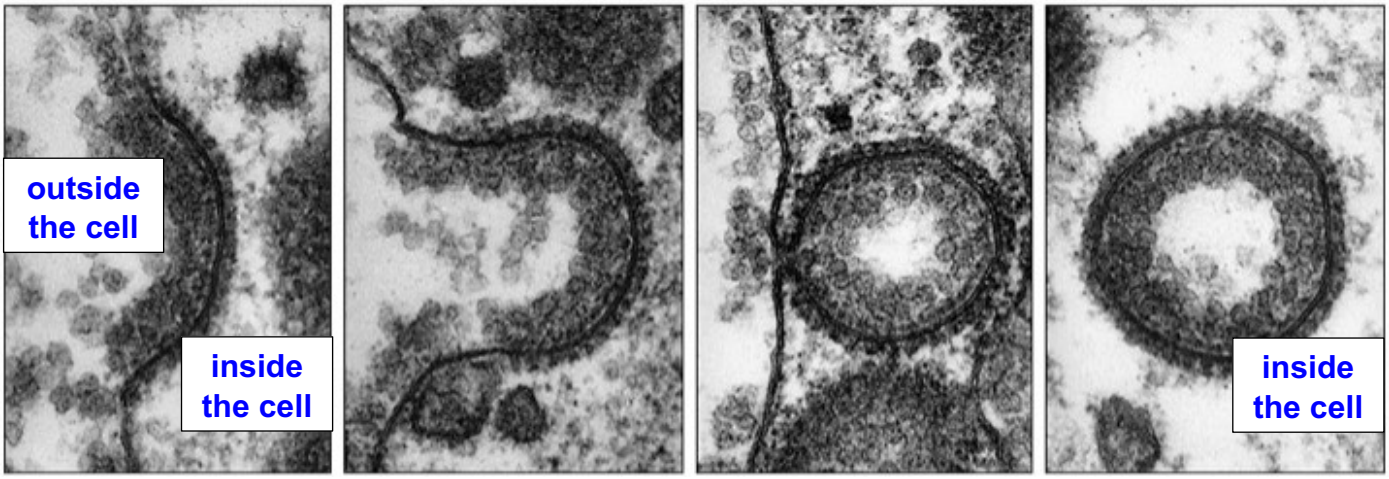
	FACILITATED DIFFUSION	ACTIVE TRANSPORT
Uses	**Channel protein**	**Pump protein**
Direction	**Down concentration gradient / high → low concentration**	**Against/up concentration gradient / low → high concentration**
Energy/ATP needed	**No**	**Yes**
Increasing the oxygen concentration increases the rate of transport	**No**	**Yes**
Specific	**Yes**	

G. ENDOCYTOSIS & EXOCYTOSIS

- For **BOTH**: **membrane changes shape** and **energy/ATP is needed** to **form vesicles**.

Endocytosis (e.g. food, pathogens) – moves substances into the cell

- e.g. **phagocytes** engulfing **pathogens**



Plasma membrane engulfs molecules

Fluidity of the **membrane** allows this

Membrane is **pulled inwards**

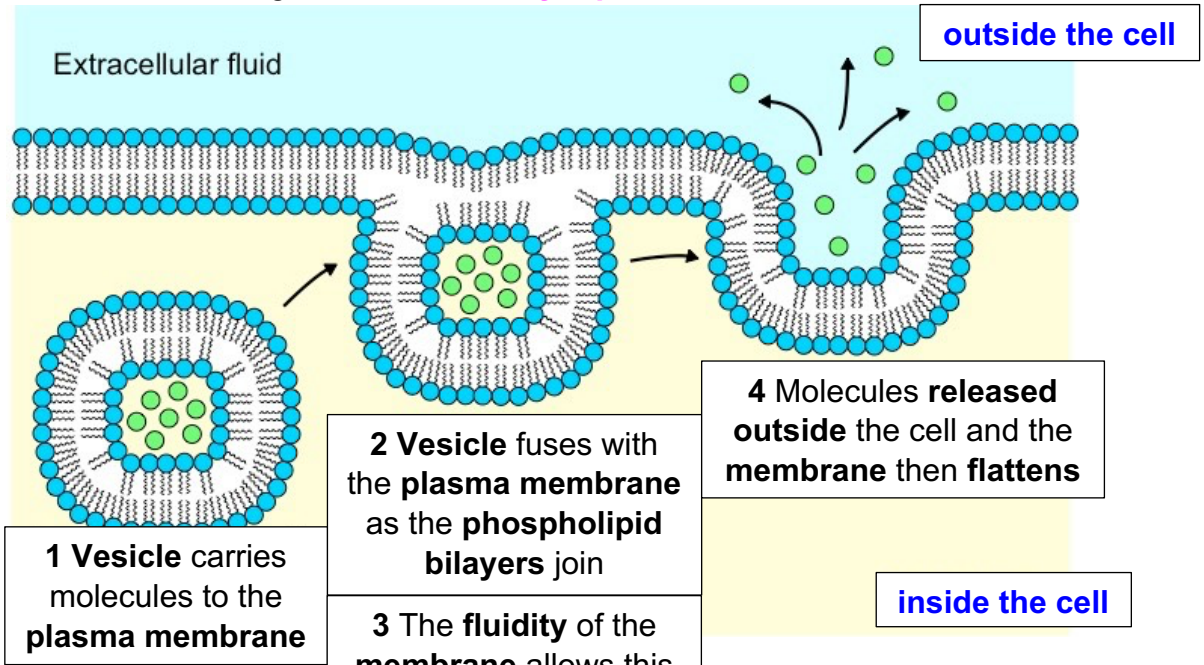
Membrane **pinches off** to **form** a **vesicle**

The **inside** of the **plasma membrane** becomes the **outside** of the **vesicle**

Vesicle **breaks away** from the **plasma membrane** and **moves** into the **cytoplasm**

Exocytosis (e.g. digestive enzymes, hormones) – secretes substances out of the cell

- e.g. **neurotransmitters** being **released** into a **synapse**



1 Vesicle carries molecules to the **plasma membrane**

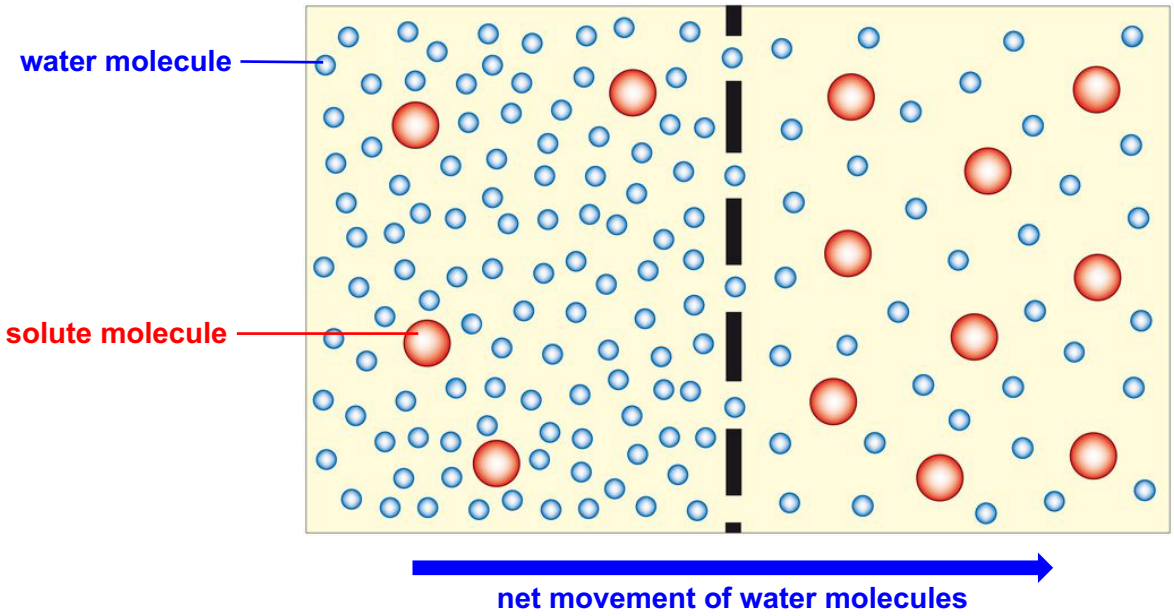
2 Vesicle fuses with the **plasma membrane** as the **phospholipid bilayers** join

3 The **fluidity** of the **membrane** allows this

4 Molecules **released outside** the cell and the **membrane** then **flattens**

OSMOSIS

- A **solute** (sugar/salt) dissolves in a **solvent** (water) to form a **solution**.
- A **dilute** solution contains a **high** concentration of **water** molecules and a **low** concentration of **solute** molecules.
- In living organisms, the solvent is **water**, which **enters** and **leaves** cells through the **partially permeable membrane**.



GCSE Definition

The **passive movement** of **water molecules**

from a **higher concentration** to a **lower concentration**

across a **partially permeable membrane**

IB Definition

The **passive movement** of **water molecules**

from a **lower solute concentration** to a **higher solute concentration**

across a **partially permeable membrane**

- Obviously, **high water concentration** = **low solute concentration**, and vice versa.
- However, IB wants you to **explain osmosis** in terms of **solute concentration**.

Vocabulary

Think of me for
HYPOTONIC
('HIPPO'TONIC!)
= lots of water

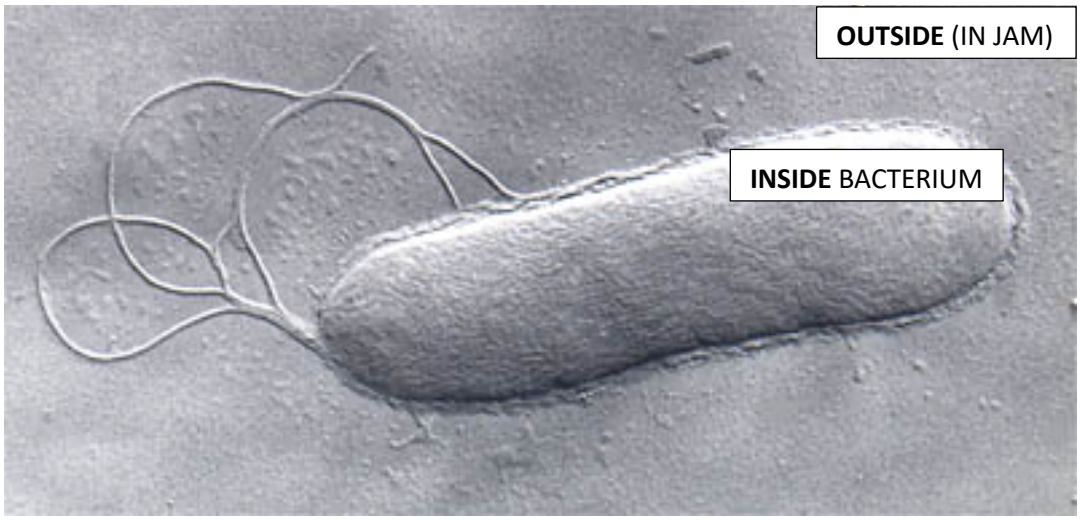
OSMOLARITY is a measure of the **solute concentration** of a **solution**

Pure water has an **osmolarity** of **zero**.

The **greater** the **solute concentration**, the **higher** the **osmolarity**.

- **HYPO**TONIC = **low solute** concentration = **loses** water
- **HYPER**TONIC = **high solute** concentration = **gains** water
- **ISO**TONIC = **same solute** concentration = **no net flow** of water

Jam has a high concentration of sugar. Explain why bacteria cannot survive in jam. [3 marks]



high**er** solute concentration in **jam** (outside)

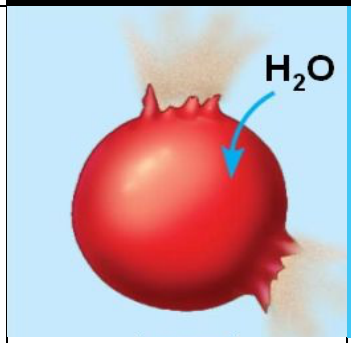
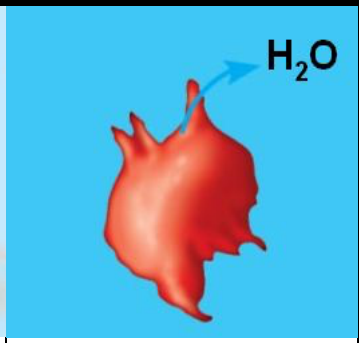
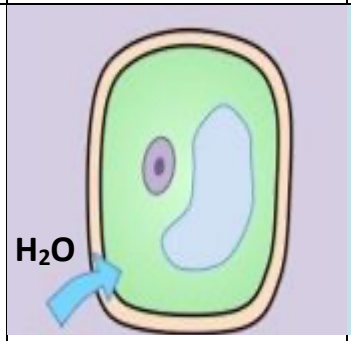
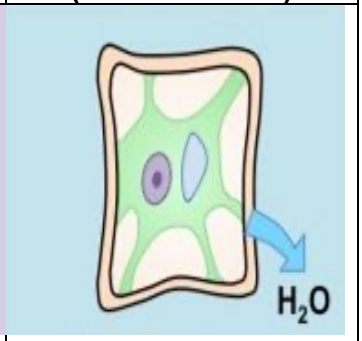
↓

water moves from **low → high** solute concentration

↓

so **water leaves** bacterium by **osmosis**

Plant cells and animal cells

	HYPOTONIC LOW SOLUTE CONCENTRATION	HYPERTONIC HIGH SOLUTE CONCENTRATION
ANIMAL CELL	 **LYSIS (BURSTS)**	 **CRENATED (SHRIVELLED)**
PLANT CELL	 **TURGID**	 **PLASMOLYSED**
High**er** solute concentration	**inside** cell	**outside** cell
Water moves by **osmosis** from	**low → high solute** concentration	**low → high solute** concentration
Direction	**into** the cell	**out** of the cell
Pressure in cell	**in**creases	**de**creases
Volume of cell	**in**creases	**de**ceases
Plasma membrane	**pushes against** the cell wall (plant)	**comes away** from the cell wall (plant)
Cell becomes	**lysed** (animal) **turgid** (plant)	**crenated** (animal) **plasmolysed** (plant)

- Plant cells become **flaccid** before they are finally **plasmolysed** – it is a gradual process.

- Plant **stems** are **supported** due to **osmosis**:

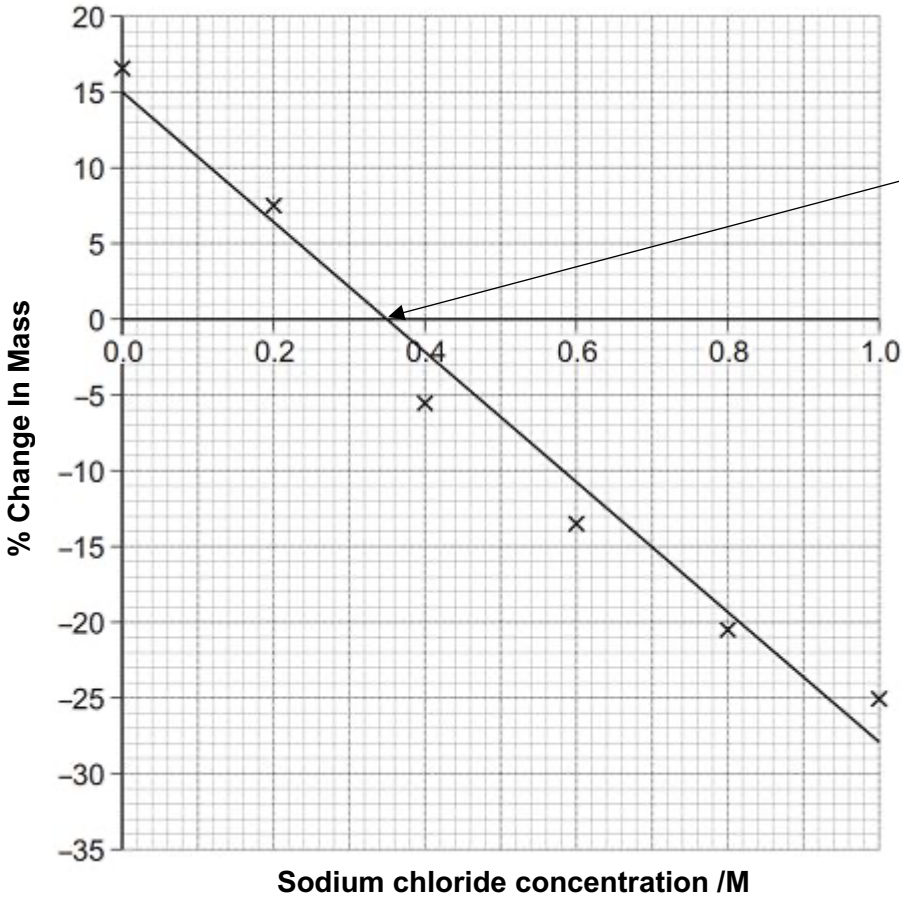
  - **Lower solute concentration** outside the cells (when watered)
  - (So) water **enters** plant cells (in stem) by **osmosis**
  - **Water pressure** inside plant cells **increases** and **pushes** on the **inelastic cell wall**
  - **Turgor pressure** inside plant cells **increases** and they become **turgid**
  - This gives plants the **stiffness** in their stem

Donor organs for transplants are kept in an isotonic solution during transport. Explain why. [4]

- isotonic solution has **same solute concentration**
- as **cells/organs**
- (so) **no net movement of water** by **osmosis**
- **into/out** of **cells**
- (so) cells do **not lyse/burst/swell/shrink**

Estimating the osmolarity of potato cylinders

- Place potato cylinders in solutions of **different concentrations** of **solute** e.g. sodium chloride.
- **Incubate** for a fixed time and then calculate their **% change in mass**.



- The potato cylinders had **no change in mass** when the solute concentration was **0.35M**.
- This means that the **0.35M solution** was **isotonic** to **inside** the **potato cells**.
- So, the **solute concentration** of the **potato cells** was **0.35**.

ENSURING ACCURACY

- The **initial** and **final masses** of each potato cylinder should be measured using the **same electronic balance** that is **accurate** to **0.01g**.

- The **volume of water** used for **making solutions** should be measured using a **volumetric flask**.

- **Before** weighing each potato cylinder, use **blotting paper** to **remove** any **excess water** on each potato cylinder. This is because **water has mass** and each potato cylinder may contain **different amounts** of **water**.

- Calculate the **percentage** change in mass, rather than just the change in mass.
  This allows a **fairer comparison** as the potato cylinders may have slightly **different initial masses**.