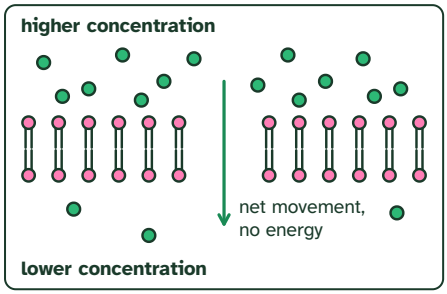
AP BIOLOGY | UNIT 2 | TOPICS 2.5, 2.6, 2.8 | REVISION ON TWO PAGES

# Across the *membrane*

What to know, what to draw and what to say. Nothing else.

**THE ONE IDEA**

**Down a gradient is free, with or without a protein. Against it needs a pump and energy. Large cargo travels in vesicles.**




**Net movement, not all movement.** At equal concentrations molecules still cross, as many each way.

2.5.A START HERE

## Downhill, *for free*

- Molecules move at random. Where one side is more crowded, more wander away from it than come back: a net movement from higher to lower concentration, **diffusion**. The difference is a **concentration gradient**.
- Moving down a gradient takes no energy from the cell: **passive transport**. It imports materials and exports wastes: oxygen in, carbon dioxide out of every cell that respires.
- A membrane can keep up a gradient only because it is **selectively permeable**.

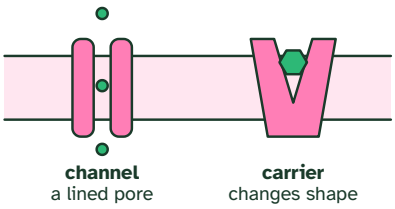
THREE QUESTIONS NAME ANY MECHANISM

| | | |
|---|---|---|
| **1** **Which way?** down the gradient or against it | **2** **A protein?** none, channel, carrier or pump | **3** **Energy?** none, or ATP |

2.6.A A DOOR THROUGH

## *Facilitated* diffusion

- Ions and large polar molecules cannot cross the hydrophobic core, but move down their gradients **through proteins**. Still passive: no energy.
- A **channel protein** is a tunnel with a hydrophilic lining, often gated. A **carrier protein** binds its molecule, such as glucose, and changes shape.
- Each is **specific**: a potassium channel passes $K^+$ but not $Na^+$.




2.6.A WATER IN SINGLE FILE

## *Aquaporins*

- **Aquaporins** are channel proteins for water: large quantities of water cross membranes through them.
- They are passive and specific: the pore blocks ions, even $H^+$. Water moves only down its own gradient, toward more solute.
- A cell sets its water permeability by its **number of aquaporins**: kidney cells add more when the body is short of water.

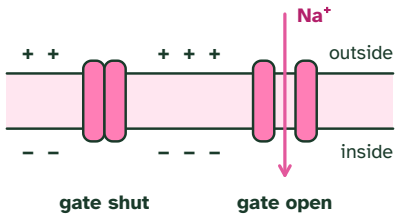
**Bilayer** a little
Water is polar but small: some slips between the phospholipids, slowly.

**Aquaporin** a lot
Single file through a narrow pore, billions of molecules a second.

2.6.A GATED CHANNELS

## Gates and *charge*

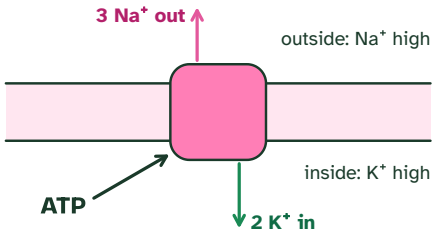
- $Na^+$ and $K^+$ cross only through channels, many of them gated. **Ligand-gated:** opens when a signal molecule binds. **Voltage-gated:** opens when the charge across the membrane changes.
- Moving ions separates charge. Most cells keep the inside negative: the **membrane potential**. The membrane is **polarized**.
- Open the $Na^+$ gates and $Na^+$ floods in: a neuron signals.




2.5.A

## Uphill, *for a price*

- **Active transport** moves a substance **against its gradient**, from low to high concentration. It always needs a pump protein and a direct input of energy, usually **ATP**.
- The **sodium-potassium pump** ($Na^+/K^+$ ATPase) moves **3 $Na^+$ out and 2 $K^+$ in** for each ATP. Pumps make and keep gradients, and help keep the inside negative.
- Root cells take in mineral ions from dilute soil water this way.




**STEP 1**
**Bind**
Three $Na^+$ bind inside.

**STEP 2**
**Phosphate on**
A phosphate from ATP changes the pump's shape.

**STEP 3**
**Swap**
$Na^+$ leaves outside; two $K^+$ bind.

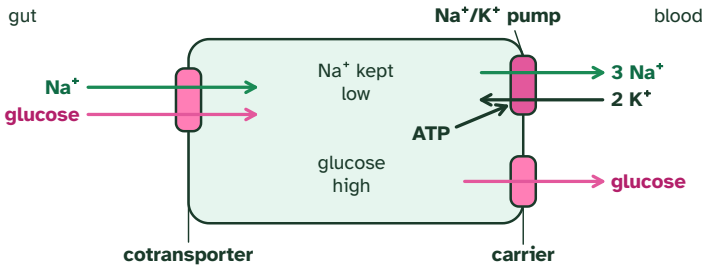
**STEP 4**
**Phosphate off**
The pump resets; $K^+$ leaves inside.

# Cotransport, *bulk transport* and naming the mechanism

2.8.A

## *Cotransport:* riding a gradient

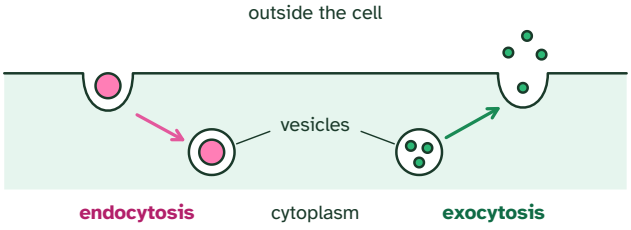
- A gradient made by a pump is **stored energy**. A **cotransporter** lets an ion flow down its gradient and uses that flow to carry another substance **against its own gradient**.
- **In the gut lining:** the pump keeps $Na^+$ low inside the cell. On the gut side $Na^+$ flows in and glucose comes with it. Glucose then leaves on the blood side by facilitated diffusion.
- It is still active transport: the ATP is spent by the pump, **one step removed**. Stop the pump and the glucose stops too.




2.5.B

## Moving it *in bulk*

- Proteins, polysaccharides and whole cells are too large for any channel or pump. Cells move them wrapped in membrane. **Both ways need energy**.
- **Endocytosis**: the plasma membrane folds in around material and pinches off as a vesicle. Taking in a large particle, such as a bacterium, is **phagocytosis**.
- **Exocytosis**: a vesicle fuses with the plasma membrane and releases its contents outside: insulin, neurotransmitters, mucus.




2.8.A PLACE ANY EXAMPLE

## Four ways *across a membrane*

| MECHANISM | DIRECTION | PROTEIN | ENERGY | FOR EXAMPLE |
|---|---|---|---|---|
| **Simple diffusion** | Down the gradient | None | **None** | $O_2$, $CO_2$, a little water |
| **Facilitated diffusion** | Down the gradient | Channel or carrier | **None** | Water by aquaporins, ions, glucose |
| **Active transport** | **Against the gradient** | Pump | **ATP, or another gradient** | $Na^+$ out and $K^+$ in |
| **Endocytosis, exocytosis** | In or out, in bulk | None crossing: vesicles | **ATP** | A bacterium in, insulin out |

An ion also feels the charge across the membrane: a positive ion can be drawn into a negative cell.

WATCH OUT

## Five mistakes that *cost points*

- ✕ **Diffusion does not stop at equal concentrations.** Molecules still cross both ways; only the net movement ends.
- ✕ **Facilitated diffusion is not active transport.** A protein helps, but movement is down the gradient and uses no ATP.
- ✕ **Aquaporins do not pump water.** Water passes through them only down its own gradient.
- ✕ **ATP does not push the ions.** Its phosphate changes the pump's shape, and the shape change moves them.
- ✕ **Nothing in endocytosis crosses the membrane.** The cargo stays inside a vesicle, apart from the cytoplasm.

COVER THE SHEET

## Can you *answer these?*

1. Describe diffusion in terms of net movement.
2. Explain why $Na^+$ needs a channel but $O_2$ does not.
3. Describe how a carrier differs from a channel.
4. Explain how a cell changes its permeability to water.
5. Explain what makes a membrane polarized.
6. Describe one cycle of the sodium-potassium pump.
7. Identify how insulin leaves a cell. Justify your answer.
8. Predict the effect on glucose uptake in the gut if the $Na^+/K^+$ pump stops.

IN THE EXAM

**Name the mechanism, then justify it** with direction, protein and energy: "active transport, because the ion moves against its gradient, which needs a pump and ATP".

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.