Movement Into and Out of Cells

Learning Outcomes

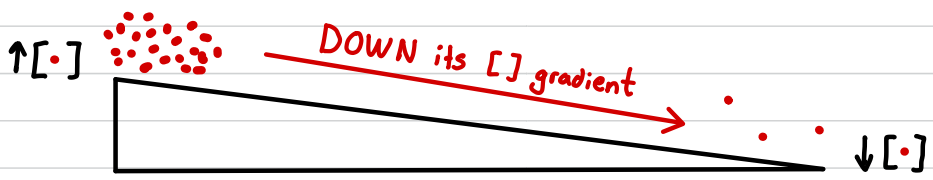
- *3.1.1* – **Describe** diffusion as the net movement of particles from a region of their higher concentration to a region of their lower concentration (i.e. down a concentration gradient), as a result of their random movement
- *3.1.2* – **State** that the energy for diffusion comes from the kinetic energy of random movement of molecules and ions
- *3.1.3* – **State** that some substances move into and out of cells by diffusion through the cell membrane
- *3.1.4* – **Describe** the importance of diffusion of gases and solutes in living organisms
- *3.2.2* – **State** that water diffuses through partially permeable membranes by osmosis
- *3.2.7* – **Describe** osmosis as the net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane
- *3.2.3* – **State** that water moves into and out of cells by osmosis through the cell membrane
- *3.3.1* – **Describe** active transport as the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration
- *3.3.3* – **State** that protein carriers move molecules or ions across a membrane during active transport

Passive Transport

Each cell requires nutrients for energy for life processes (such as growth) and through the course of metabolic reactions, wastes are generated which needs to be expelled. Anything that goes in or out of a cell passes through cell membrane

→ transport across membranes can be either: passive or active

Passive transport: movement of particles from an area of high concentration (↑[ ]) to low concentration (↓[ ]) without the use of cellular energy (such as ATP)



particles move 'down' concentration gradient

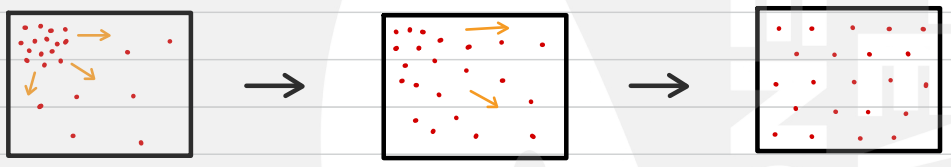
* if ATP is not needed - where does the energy for this come from?

→ Particles are always in motion → they have **kinetic energy**. The more energy (i.e. temperature), the faster they move

→ Despite random motion, particles tend to flow in a predictable manner:
hot to 'cold' / high to low, which increases disorder to the system (2nd law of thermodynamics)

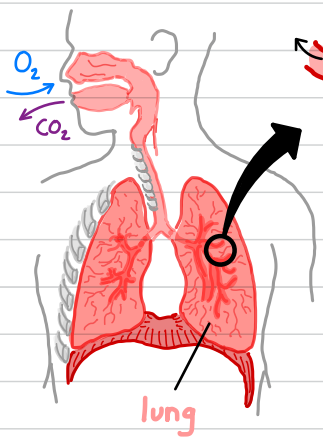
Simple diffusion: net movement of particles down a concentration gradient without the use of membrane proteins as a result of their random movement

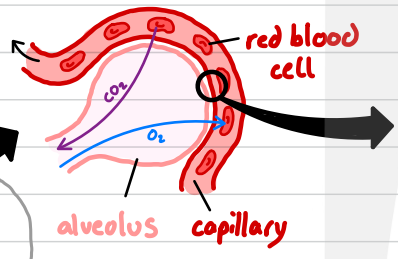
all particles are moving but the net movement will be from ↑[•] to ↓[•]



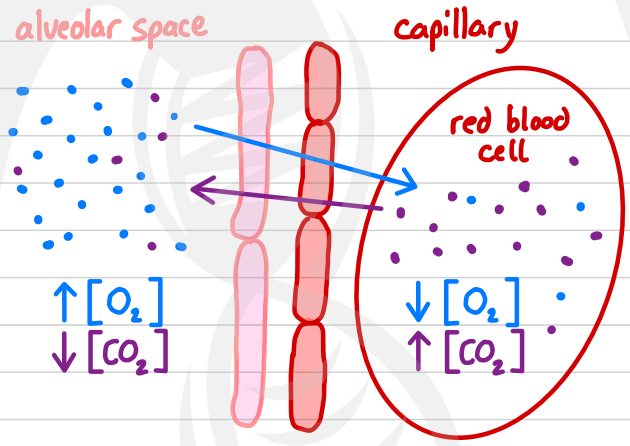
diffusion will stop once concentration gradient is equal across volume

Diffusion of gases





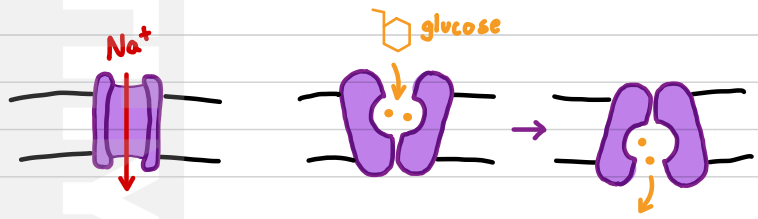
inside lungs are million of sphere-like alveolar cells surrounded by tiny blood vessels (capillaries)



both O_2 and CO_2 move down their concentration gradients, allowing gas exchange across cell membranes

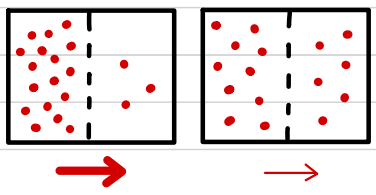
Diffusion of solutes

most diffusion occuring in living organisms occurs in fluids (cytoplasm, blood plasma, etc.)
∴ a lot of diffusion occurs as solutes
* cell membrane is **selectively permeable**, meaning some things can freely pass but not others



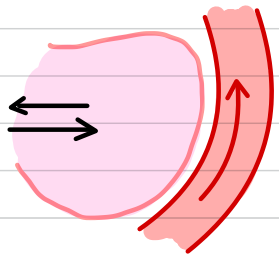
facilitated diffusion: proteins allow specific solutes (ions and polar molecules) to diffuse across membrane

Increasing rate of diffusion

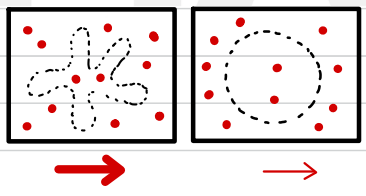


greater conc. gradient
↳ larger difference

ex:

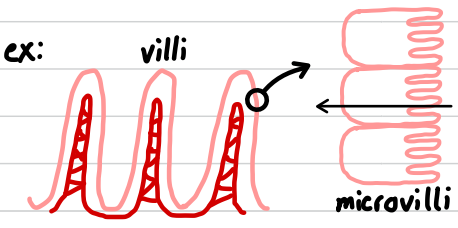


- breathing continually moves O_2 in and CO_2 out of lung
- blood circulation constantly moves red blood cells

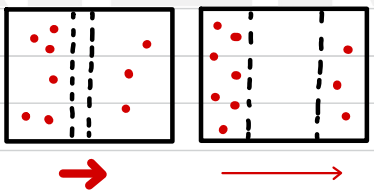


greater SA: vol of cell
↳ more area to diffuse through

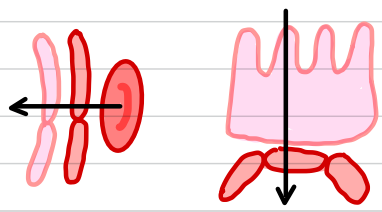
ex:



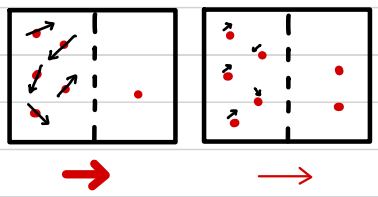
the small intestines have millions of folds which allow nutrients to be absorbed into the blood quickly



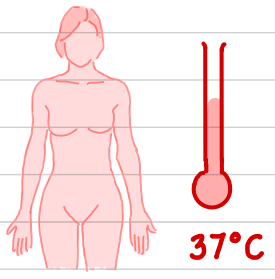
shorter diffusion distance
↳ less distance required to move



cell membranes are ~ 0.007μm so where exchange occurs, tissues are only 1 cell thick, making distance very short



higher temperature
↳ more kinetic energy



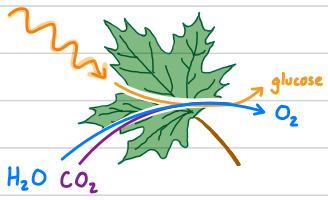
human body is warm, which allows diffusion to occur quickly

Passive Transport

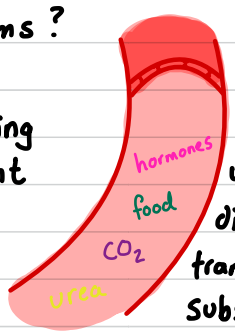
Water is a vital part of organisms - most cells contain 75% water and will die if this content falls too low

Why is so water important to living organisms?

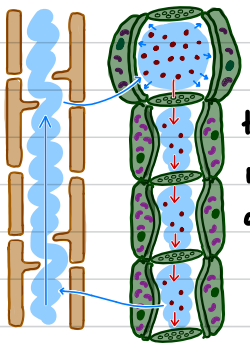
↳ key reactant in photosynthesis



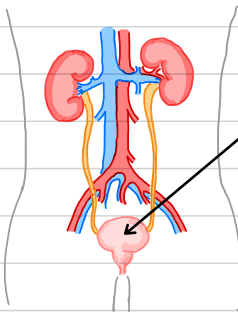
↳ amazing solvent



blood is mainly water which dissolve and transports substances



water transports minerals and sugars in plants



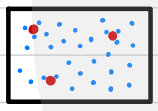
waste materials (like urea) are dissolved in water making them less toxic and can be stored

*when water dissolves into and out of cells through a membrane, it is called osmosis.

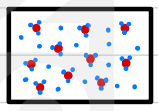
Osmosis: net movement of water molecules from a region of higher water potential (dilute solution) to a region of lower water potential (concentrated solution), through a partially permeable membrane

↳ **water potential** (Ψ): the free energy of water. A measure of how likely a solution will lose or gain water molecules

Solutes can attract water molecules, stopping them from moving freely

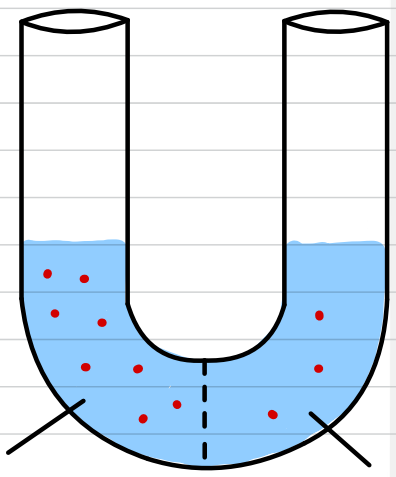


dilute, low [solute]
more free water, high Ψ

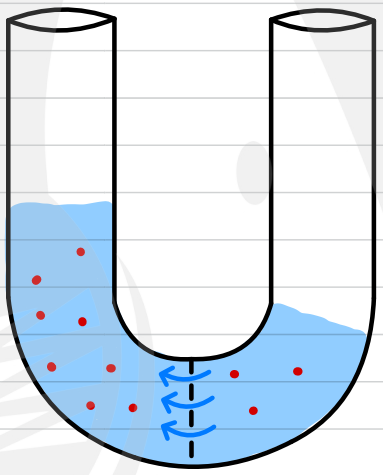


concentrated, high [solute]
more free water, low Ψ

This U-tube has a partially permeable membrane separating two sides (water can pass freely but not solutes)

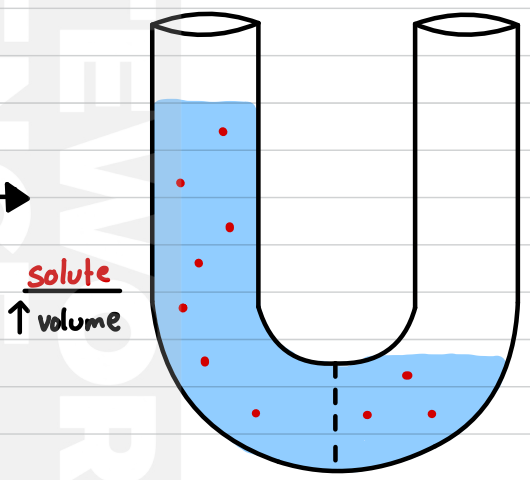


more solutes / volume
∴ more concentrated
∴ less water potential



less solutes / volume
∴ more dilute
∴ higher water potential

water moves to more concentrated side as Ψ is lower

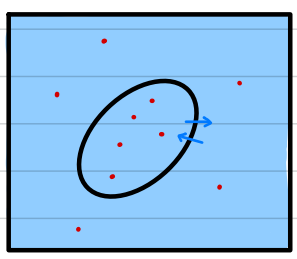


osmosis will stop (like diffusion), when there is no longer a conc. gradient both sides have same solute concentration

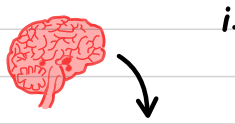
Osmosis in cells

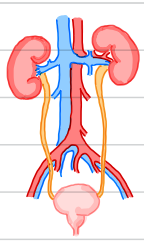
a cell's cytoplasm has minerals and ions dissolved inside. This concentration is called its osmolarity

Ideally, a cell's osmolarity will be ~ equal to its surroundings so there will be no net movement of water and its shape is maintained.



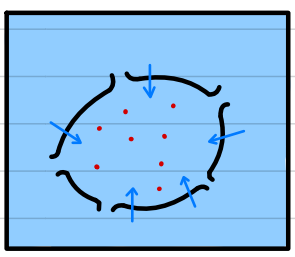
[solute] in cell = [solute] outside
isotonic solution



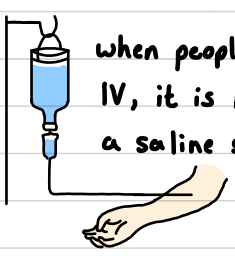


receptors monitor blood osmolarity and the brain signals kidneys to either remove or conserve water effectively maintaining constant osmolarity

If the solution outside the cell is less concentrated, water will flow in and cause cell to grow, maybe even lyse (burst)

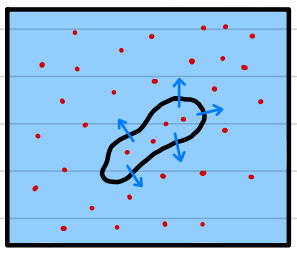


[solute] in cell > [solute] outside
hypotonic solution

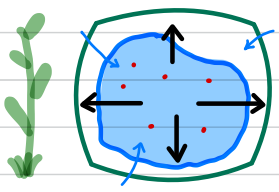


when people are rehydrated via IV, it is not pure water but a saline solution close to that of the blood, otherwise the patient's cells could lyse and die

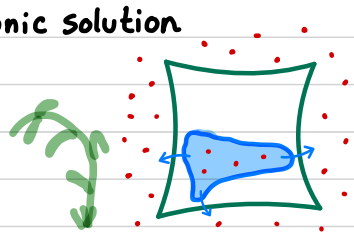
If the solution outside the cell is more concentrated, water will flow out and cause cell to shrink, maybe shrivel



[solute] in cell < [solute] outside
hypertonic solution



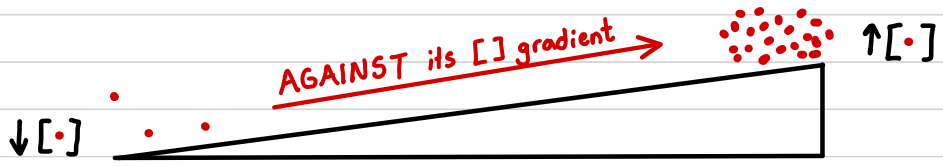
given pure water, vacuole will grow and push on walls



in salt water, vacuole loses water causing wilting

Active Transport

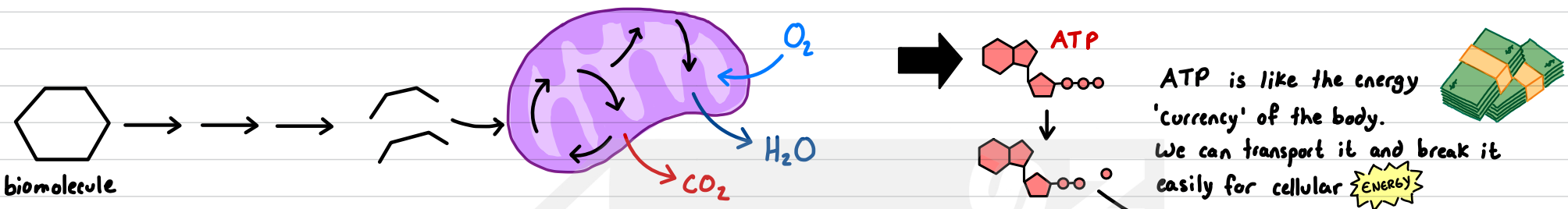
Active transport: movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration (i.e. against a concentration gradient), using energy from respiration



particles move 'up' concentration gradient

* as particles are moving against the natural tendency to move down gradient, additional ENERGY is needed

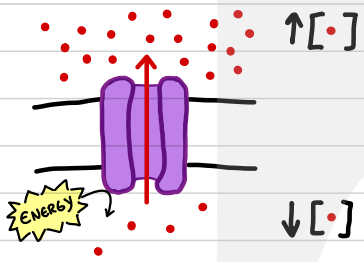
→ **cellular respiration** is a metabolic pathway (series of chemical reactions) where biomolecules (like glucose) are broken down incrementally in order to release energy in a controlled manner and store it in **ATP** molecules



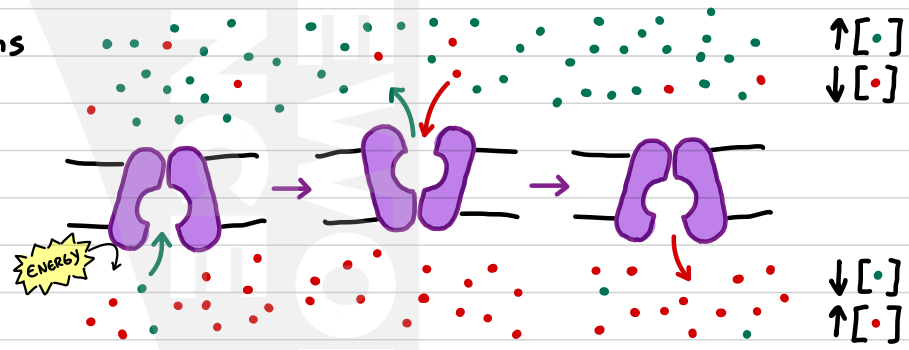
Active transport often utilizes **carrier proteins**, also called 'pumps' as they help move substances against gradients

→ **Primary active transport**. direct use of energy (ATP) in order to move particles against their concentration gradient

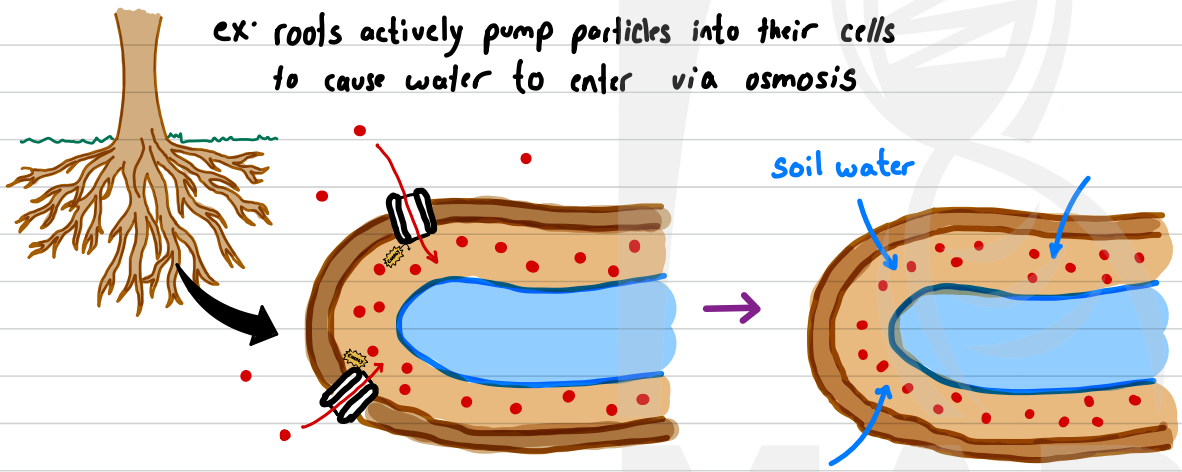
Some carrier proteins on membranes pump a single substance against its concentration gradient



Some carrier proteins pump multiple substances against their concentration gradient



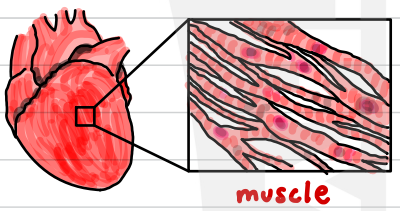
ex: roots actively pump particles into their cells to cause water to enter via osmosis

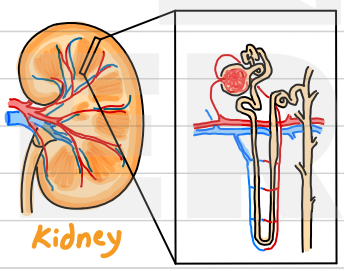


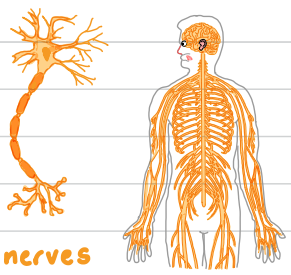
root hair cell actively pumps ions (•) into cell → creates ↑ [gradient]

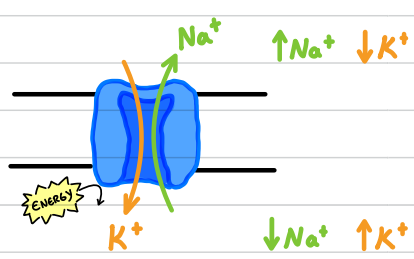
↑ water potential outside cell than inside → water moves in

ex: The sodium-potassium pump is very important for the function of many cells and tissues



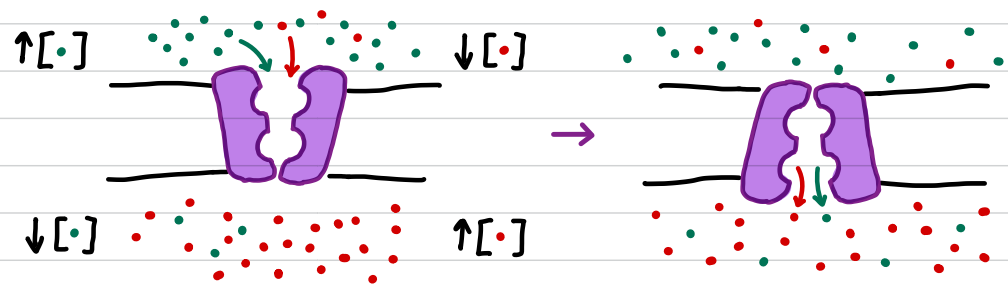






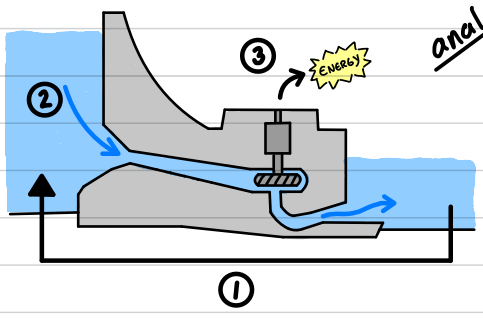
→ **Secondary active transport:** indirect use of energy in order to move particles against their concentration gradient

* particles move against their gradient using stored energy in the form of a gradient of another particle



• moved against its concentration gradient using • gradient

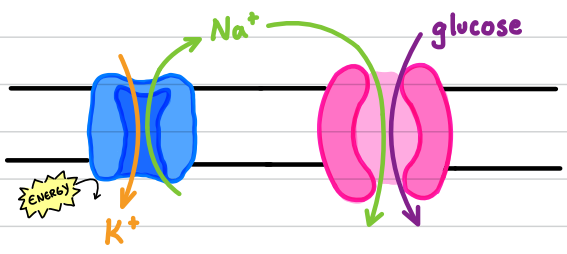
analogy



hydroelectric dam

1- water pumped to create high concentration gradient
2- water moves down gradient
3- water spins turbine and generator to generate energy

ex: sodium-glucose co-transporters in intestines



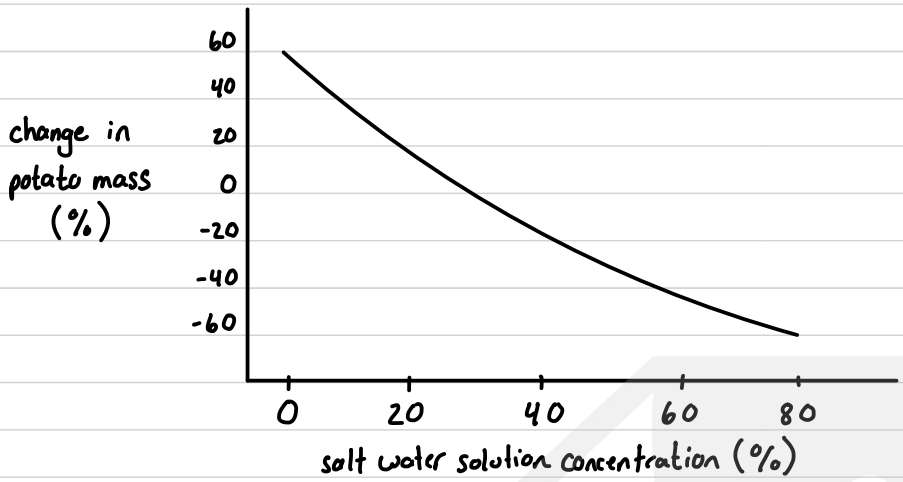
1- Na^+ pumped actively creating a gradient
2- glucose moves against its gradient using energy from Na^+ gradient

Assessment Tasks

Answer the following questions:

1. Contrast passive and active transport - at least 3 differences

2. an investigation into osmosis was conducted using potato slices. Slices of equal size were submerged into saltwater of various concentrations (0%, 20%, 40%, 60%, 80%) for 10 minutes. The mass for all slices were taken before and after submersion and the change in mass was plotted in graph below



a) Use this data to deduce the concentration of salt within the potato slice. Explain your deduction.

b) what % salt concentration is hypertonic relative to the potato? Explain.

c) what % salt concentration is hypotonic relative to the potato? Explain.

3. When organs are taken from donors and moved to a surgery, they are stored in a particular solution to prevent osmosis. Deduce the type of solution (in terms of concentration) that should be used.

4. The central role of the respiratory system is to exchange gases. Explain this importance in the context of cellular respiration

5. Compare and contrast osmosis and diffusion (2 similarities, 2 differences)