What determines whether a substance can pass through a membrane or not?

- Chemical properties of the molecule attempting to cross the membrane
Movement of molecules

- What substances can cross by themselves?
  - Small, polar molecules (H$_2$O)
  - Small non-polar molecules (N$_2$, O$_2$, CO$_2$)
Movement of molecules

- What types of molecules need assistance?
  - Ions (Na\(^+\), H\(^+\), K\(^+\)…)
  - Large polar molecules (Glucose)
Movement of molecules

- How does the membrane provide the assistance?

- Membrane proteins act as the transporters
  - Channel and carrier proteins- like secret passageways!

- Cells can even transport mass amounts of water when needed
  - Aquaporins- water transporting proteins
- **Channel proteins**

- **Aquaporins**
More membranes

- We know what membranes are now, so let's talk about how they do their most important function

**Maintain homeostasis**

- Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
Homeostasis?

- What is it?
- Basically it’s the idea that living things can maintain a constant internal environment even when the external environment changes
- Living things respond to change
- Things that are regulated by homeostasis:
  - Temperature
  - pH
  - Solutes: sugar, etc
  - Hormones
  - And more!
Why is homeostasis important?

- Discuss and write
Membranes, homeostasis and growth

- Membranes are critical for homeostasis and growth because membranes transport needed substances (H\textsubscript{2}O, O\textsubscript{2}, Na\textsuperscript{+}, glucose etc) in and out of the cell

- Types of transport
  - Passive transport
  - Active transport
  - Bulk transport
How does this affect my cells?

- Many of your cells live in an aquatic environment
- Between each cell and the next cell is space which is filled with fluid
  - Interstitial fluid
    - Site of nutrient and waste exchange
Passive transport

- Passive transport
  - Does not use metabolic energy
  - (What form is metabolic energy found in?)

- Molecules naturally move from areas of high concentration to areas of low concentration

Vocab
- Concentration gradient
- Diffusion
Diffusion
Concentration gradients
Molecules of dye

Membrane (cross section)

WATER

(a) Diffusion of one solute

(b) Diffusion of two solutes

Equilibrium
Passive Transport – Facilitated Diffusion

- Used for removing wastes and importing resources
- Proteins can assist the movement of polar molecules and charged molecules across the membrane
  - Facilitated diffusion
  - Channel and carrier proteins
    - Gated

![Diagram of facilitated diffusion](a)

![Diagram of facilitated diffusion](b)
Osmosis: the diffusion of water

- When water is passively diffusing, we call it osmosis.
- What makes water move?
  - The concentration gradient
  - Free water

[Diagram of water molecules with arrows indicating diffusion and concentration gradient.]
Osmosis

Lower concentration of solute (sugar) → Selectively → Higher concentration of sugar → Same concentration of sugar
Tonicity

- The tonicity of the solution affects the movement of water molecules
- Vocab review
  - Solute
  - Solvent
  - Solution

- Real life application
  - External environments
  - Interstitial fluid
Hypertonic

- Hypertonic solutions have a higher concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell.

**net water movement out of cells**
Hypotonic

- Hypotonic solutions have a lower concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell.
Isotonic

- Isotonic solutions have an equal concentration of solutes outside of the cell compared to the concentration of solutes inside of the cell.

**equal movement of water into and out of cells**
How does this affect living cells?

- Your cells are in an aquatic environment
- Concentration gradients need to be maintained
Different story for cells with walls

- Plants, fungi, prokaryotes and some protists
- Hypotonic is good = turgid
- Hypertonic is bad = flaccid and plasmolysis
Active transport

- Requires the use of free energy
- ATP is used by membrane proteins to move molecules/ions across the membrane
- Moves from areas of low concentration to areas of high concentration
- Against the concentration gradient
How does active transport work?

- Phosphorylation
- Physical change of the protein
Active transport example

- The Sodium-Potassium pump
  - Exchanges sodium (Na\(^+\)) for potassium (K\(^+\))

- Maintains the concentration gradient
  - Cytoplasm: High K\(^+\) / low Na\(^+\)
  - Outside the cell: High Na\(^+\) / low K\(^+\)
  - Pumps against steep gradient. Three Na\(^+\) out and two K\(^+\) in

- Important in nerve cells
1. Binding of cytoplasmic Na\(^+\) to the protein stimulates phosphorylation by ATP.

2. Phosphorylation causes the protein to change its conformation.

3. The conformational change expels Na\(^+\) to the outside, and extracellular K\(^+\) binds.

4. K\(^+\) binding triggers release of a phosphate group.

5. Loss of phosphate restores original conformation.

6. K\(^+\) is released and Na\(^+\) sites are receptive again; the cycle repeats.

EXTRACELLULAR FLUID
Why do we need active transport?

- Maintains concentration gradients and prevents the arrival of the equilibrium state

- Maintains membrane potential
  - What is that?
Membrane Potential

- Potential energy that is “stored” across a membrane

- The physical movement of ions is kinetic energy.

- If they are held outside the cell and waiting to diffuse, its potential energy
Membrane Potential

- Measured in voltage
  - Opposite charges are separated
  - Cytoplasm is negative
  - Outside the cell is positive
    - Favors the rush of + ions into the cell

- Electrochemical gradient
  - Concentration and the attraction of charges

- Sodium-potassium pump maintains the electrochemical gradient by increasing the + charge on the outside of the cell
Proton Pumps

- Active transport that removes proteins from the cell
- Establishes gradient
  - Potential energy that can later be used for work
Cotransport

- Active transport coupled with passive transport
  - Molecule triggers passive transport
  - Gatorade
Transport Review

Diffusion

Facilitated diffusion

Passive transport

Active transport

ATP
Bulk transport

- Exocytosis and endocytosis
- Vesicles are used to move large molecules in or out of a cell
  - Macromolecules

- What is a vesicle?
Exocytosis

- Vesicles fuse with plasma membrane
- EX: Insulin from the pancreas, Neuron and neurotransmitters, Plant cell walls
Endocytosis

- New vesicles are formed from the plasma membrane capturing macromolecules and particles
  - Phagocytosis
  - Pinocytosis
  - Receptor-mediated endocytosis
Receptor mediated endocytosis

1. Ligand binds to membrane receptor.
2. Receptor-ligand migrates to clathrin-coated pit.
3. Endocytosis
4. Vesicle loses clathrin coat.
5. Receptors and ligands separate.
6. Ligands go to lysosomes or Golgi for processing.
7. Transport vesicle with receptors moves to the cell membrane.
8. Transport vesicle and cell membrane fuse (membrane recycling).
9. Exocytosis