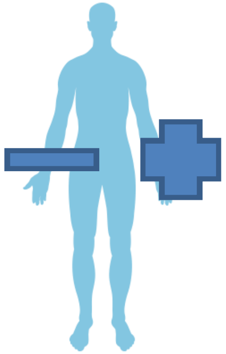
MEMBRANE DYNAMICS

How will body volume and concentration change?

- Ingestion of food and drinks
- IV infusions

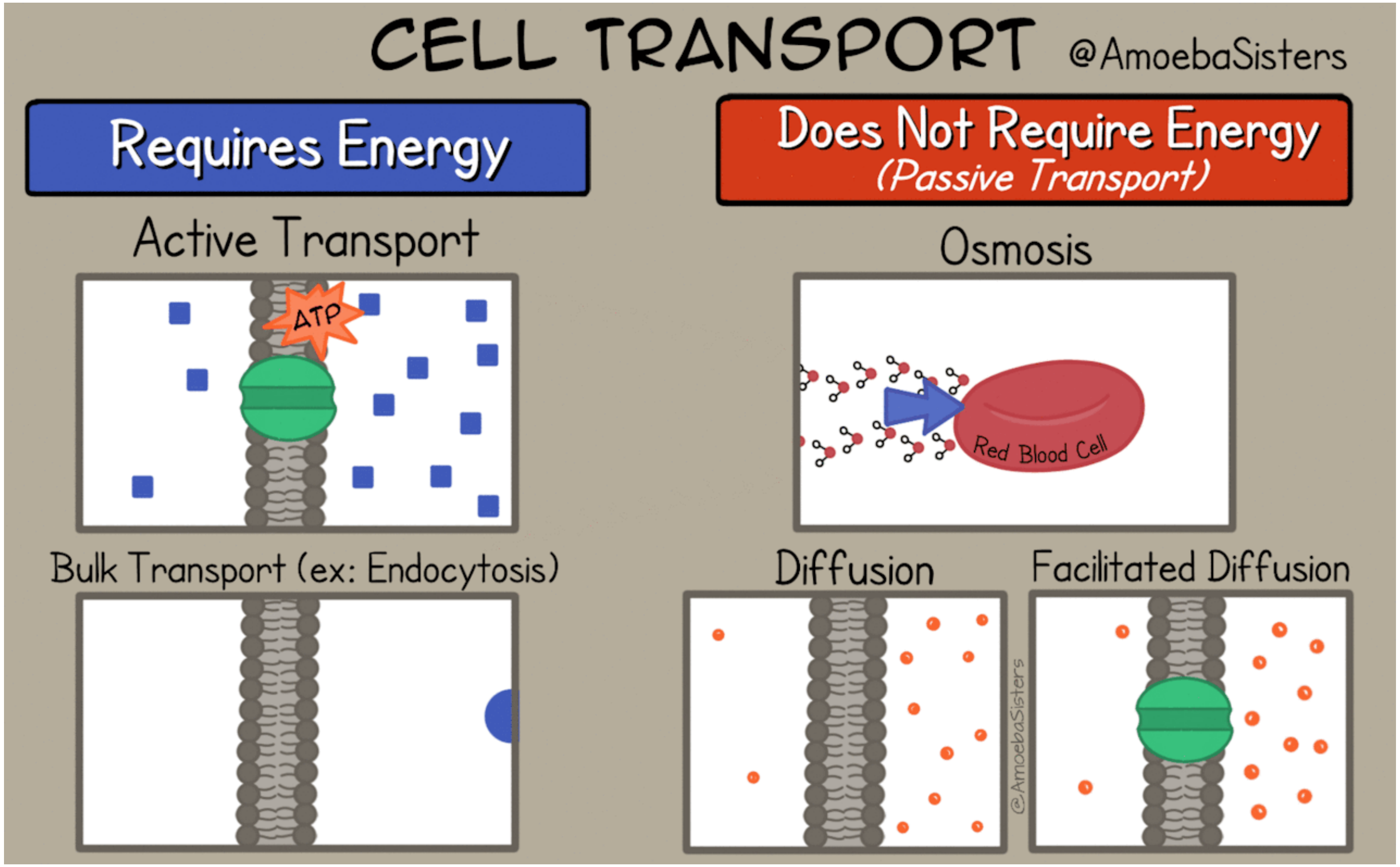
- Sweating
- Vomiting
- Diarrhea
- Blood Loss

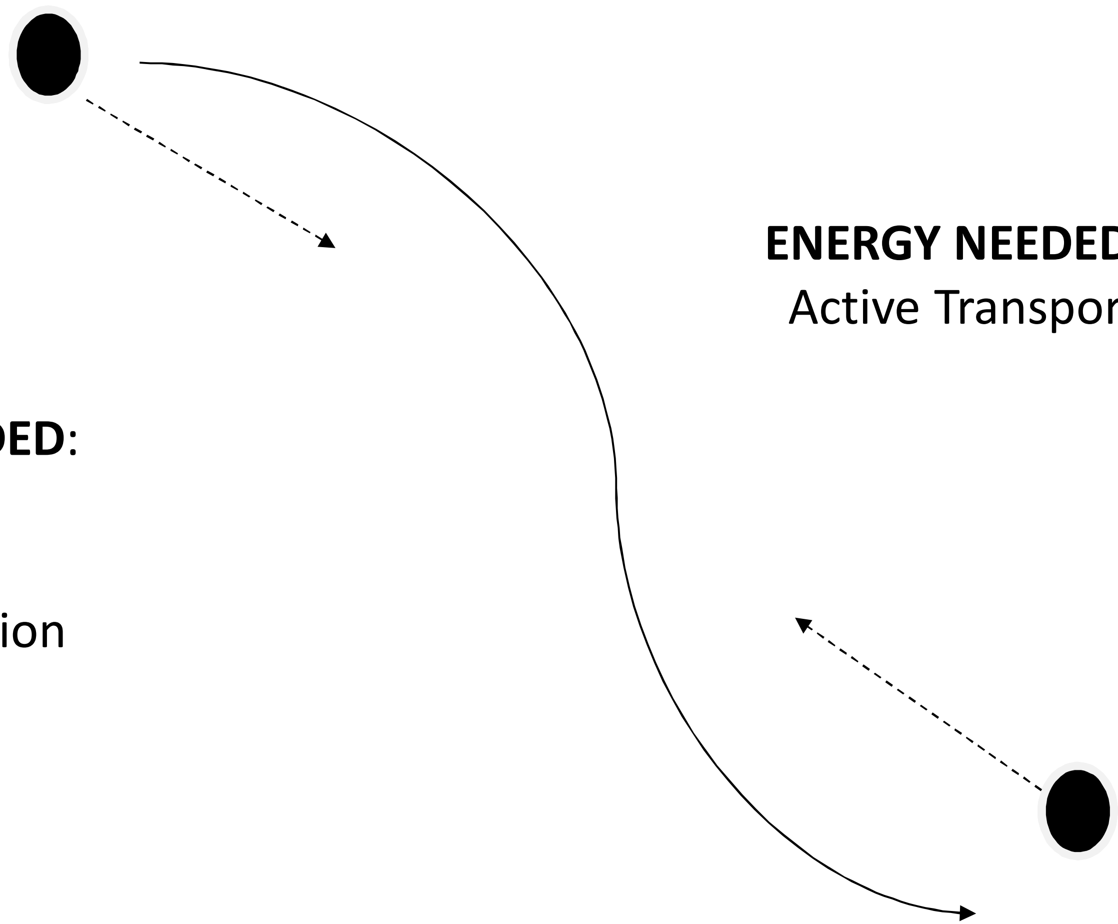


A few negative ions are found in ICF while their matching positive ions are in ECF. As a result inside of the cell is slightly negative relative to ECF.

electrical disequilibrium

TRANSPORT PROCESSES



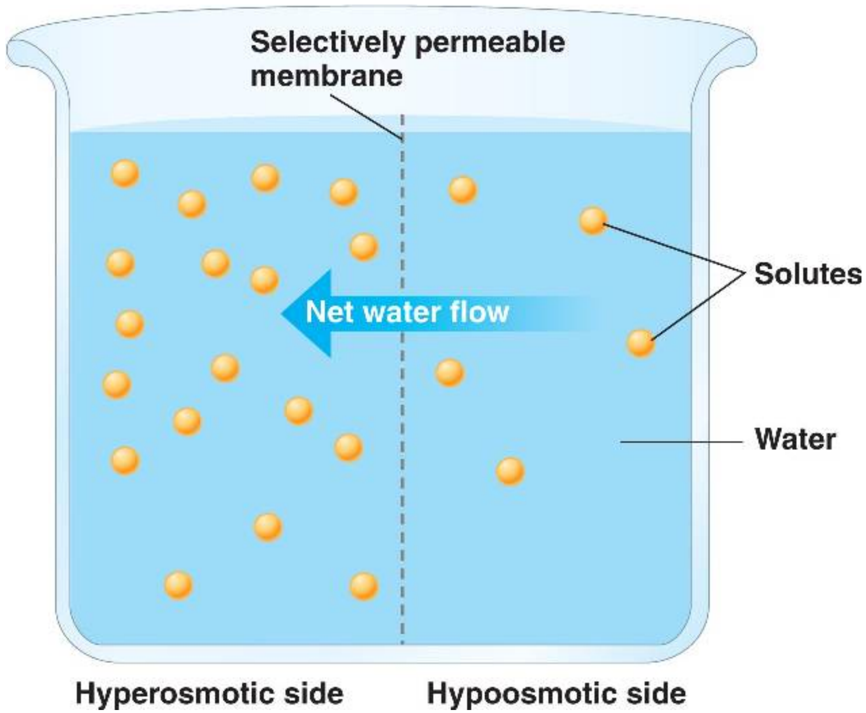


ENERGY NEEDED:
Active Transport

NO ENERGY NEEDED:
Diffusion
Osmosis
Facilitated Diffusion

OSMOSIS

Water Movement across membrane



Red blood cells in isotonic, hypotonic, & hypertonic solutions

Isotonic Solutions: contain the **same concentration** of solute as another solution (e.g. the cell's cytoplasm). When a cell is placed in an isotonic solution, the water diffuses **into and out** of the cell at the same rate. The fluid that surrounds the body cells is isotonic.

Hypotonic Solutions: contain a **low concentration** of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypotonic solution, the water diffuses **into** the cell, causing the cell to **swell** and possibly **explode**.

Hypertonic Solutions: contain a **high concentration** of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypertonic solution, the water diffuses **out** of the cell, causing the cell to **shrivel**.

DIFFUSION

Movement of molecules from an area of higher concentration of the molecules to an area of lower concentration of the molecules.

Fick's law of diffusion

Diffusion of an uncharged solute across a membrane is proportional to,
the concentration gradient of the solute,
the membrane surface area and
the membrane permeability to the solute

Membrane permeability depends on

- The molecule's lipid solubility
- The molecule's size
- The lipid composition of the membrane

Molecules that diffuse through cell membranes

1. Oxygen – Non-polar so diffuses very quickly.

1. Carbon dioxide – Non-polar, very small so diffuses quickly.

2. Water – Polar but also very small so diffuses quickly.

MEMBRANE TRANSPORTERS

Channel proteins

more rapid, for small ions and water

Carrier proteins

slower, for larger molecules

Facilitated Diffusion

- Passive transport:
  - ATP not needed.
  - Involves transport of substance through cell membrane down concentration gradient

Active Transport

- Protein-Carrier mediated transport
- Molecules moves against their concentration gradient
- Involves net transport (uphill), i.e. against electrochemical gradient (from lower to higher conc).
- Requires metabolic energy (ATP). Creates a state of disequilibrium

I. Primary Active Transport

- Energy is supplied directly from hydrolysis of ATP.
- Molecule or ion binds to "recognition site" on one side of carrier protein.
- Binding stimulates phosphorylation (breakdown of ATP) of carrier protein.
- Carrier protein undergoes conformational change.
- Some of these carriers transport only one molecule or ion for another.

The sodium-potassium pump, Na+/K+-ATPase

Present in most cell membranes.

Energy dependent transport, because both ions are moved against their conc gradient.

Secondary Active Transport

- If the other molecule or ion is moved in the <u>same direction</u> as Na^+ (into the cell), the coupled transport is called either: '**cotransport**' or '**symport**'.

- If the other molecule or ion is moved in the <u>opposite direction</u> as Na^+ (out of the cell), the process is called either: '**countertransport**' or '**antiport**'.

b. Counter transport (Antiport)

- Na^+ is moving to the interior causing other substance to move out.

- e.g.

  - Ca^{2+}– Na^+ exchange

    … (present in many cell membranes)

  - Na^+– H^+ exchange in the kidney

  - Cl^-– HCO_3^- exchange across RBCs.

VESICULAR TRANSPORT

Movement of macromolecules across cell membrane:

1. Endocytosis
– Phagocytosis
– Receptor mediated endocytosis
– Pinocytosis

2. Exocytosis

Food is moved **into the cell** by **Endocytosis**

Wastes are moved **out of the cell** by **Exocytosis**

- Phagocytosis is the type of endocytosis where an entire cell is engulfed.
- Pinocytosis is when the external fluid is engulfed.
- Receptor-mediated endocytosis occurs when the material to be transported binds to certain specific molecules in the membrane.

EXOCYTOSIS

Opposite of endocytosis
Cells export large lipophobic molecules as synthesized in cell, waste of cell.

EPITHELIAL TRANSPORT

Molecules entering and leaving the body must cross a layer of epithelial cells that are connected by junctions.

Transcytosis across the capillary endothelium

Endocytosis
↓
vesicular transport
↓
Exocytosis

- Moves large proteins intact
- Examples:

– Absorption of maternal
antibodies from breast milk

– Movement of proteins across capillary endothelium

Water is in osmotic equilibrium (free movement across membranes)
Ions and most solutes are in chemical disequilibrium (e.g., Na-K ATPase Pump)

Electrical disequilibrium between ECF and ICF

Equilibrium potential;

is the membrane potential that exactly opposes a given concentration gradient.

CELLULAR COMMUNICATION

75 trillion cells need to communicate each other
Chemical are the molecules secreted by cells inte ECF. Ligands bind to proteins to initiate a response.
Electrical are the changes in a cell's membrane potential.
Target cells which respond to signals.

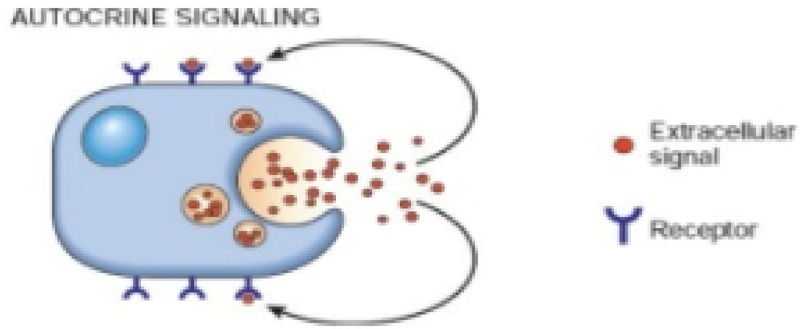
Consists of protein channels linking the cytosols of adjacent cells. Specific proteins from two membrane join and from small channels linking two cells. The small diameter of these channels limits what can pass to small molecules such as Na, K and excludes the exchange of large proteins.
Simplest cell-cell junction. They allow direct and rapid cell-cell communivation.

Cylindrical proteins called **connexins** create a narrow passageway through their centers. These channels are able to open and close, regulating the movement of small molecules and ions. They allow both chemical and electrical signals to pass rapidly from one cell too other.

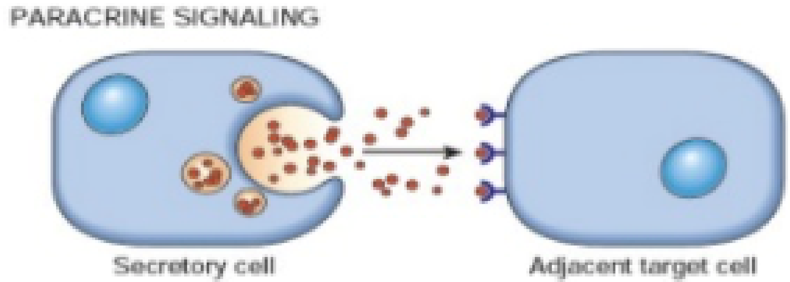
Cell Adhesion Molecules (CAMs)

Membrane spanning proteins responsible for cell junctions and cell adhesion

Autocrine:
Cells have receptors for their own secreted factors (liver regeneration)



Paracrine:
cells respond to secretion of nearby cells (healing wounds)



An electrical signal travels along the nerve cell until it reachs the very end of the cell where it is translated into a chemical signal secreted by the neuron. Chemicals secreted by neurons are called neurocrine molecules.

Hormones are chemical signals secreted into the blood, distributed all over the body by circulation. They can come in contact with most of the cells with receptor for the hormone.

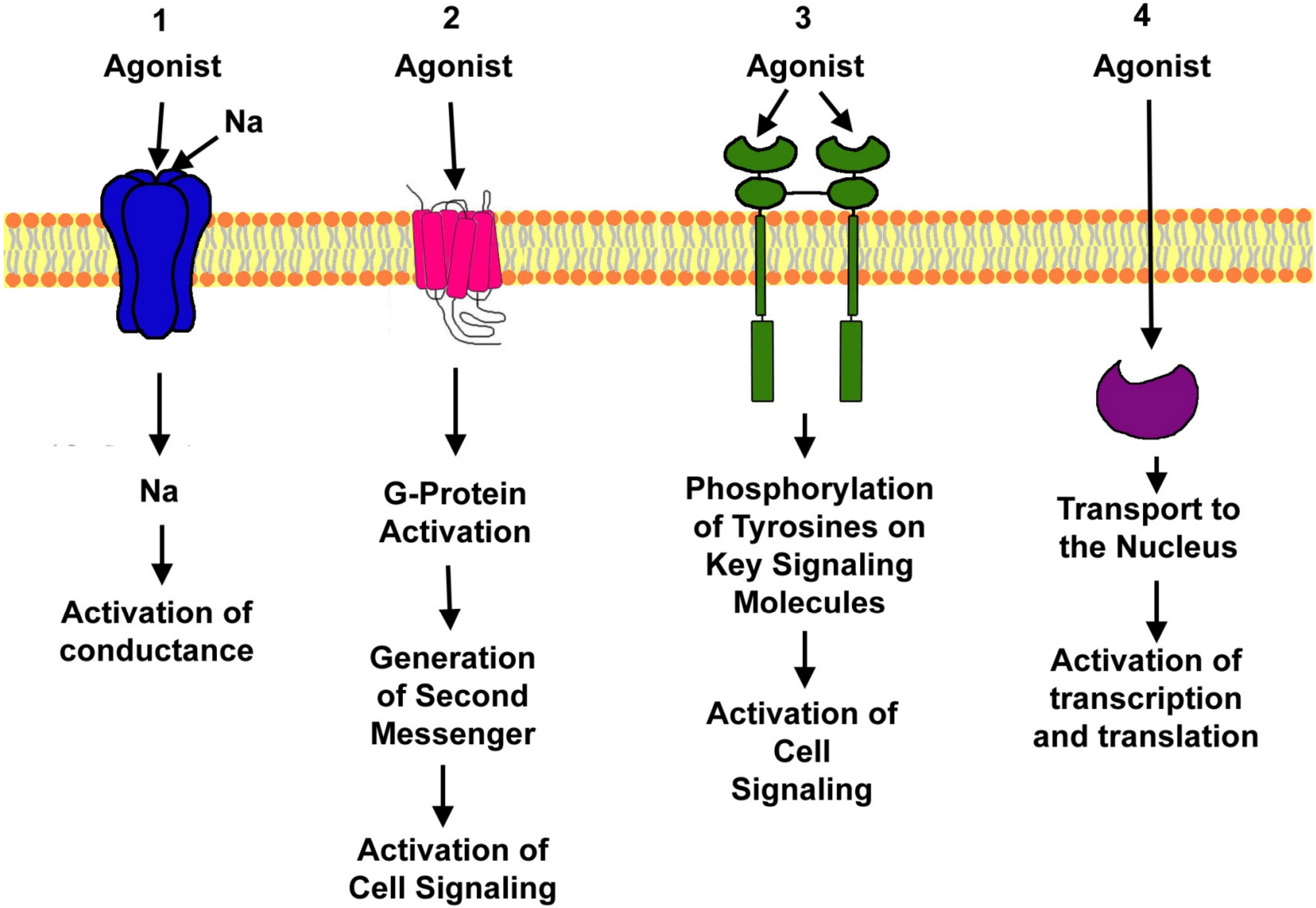
Neurotransmitter rapid-onset
Neuromodulator acts more slowly
Neurohormone diffuses into the blood

THREE RECEPTOR LOCATIONS

- Membrane
- Cytosolic
- Nuclear

Lipophilic ligands:
enters cell and/or nucleus
Often activates gene
Slower response
Lipophobic ligands:
can't enter cell
Membrane receptor

Fast response


1
Agonist
Na
Na
Activation of conductance
2
Agonist
G-Protein Activation
Generation of Second Messenger
Activation of Cell Signaling
3
Agonist
Phosphorylation of Tyrosines on Key Signaling Molecules
Activation of Cell Signaling
4
Agonist
Transport to the Nucleus
Activation of transcription and translation

Specifity

The ability of a receptor to bind only one molecule or only a group of related molecules. The ability of a receptor to bind a certain ligand is called specifity.

Affinity is the strength of association between ligand and receptor

If a receptor has **high affinity** for the ligand, the receptor is more likely to bind to that ligand than a ligand with lower affinity..

Competition

A transporter may move several members of a related group of substrates but those substrates compete with each other for binding sites on the transporter.

Saturation

At saturation, the carriers are working at their maximum rate, and a further increase in substrate concentration has no effect.

A cell may have different receptors with different physiological outputs to adapt

A cell may have different receptors present in its membrane. Therefore, it is able to respond to a range of varying molecules and regulate its physiological outputs to adapt.

Upregulation	the target cell inserts more receptors into its membrane
Downregulation	a decrease in receptor number