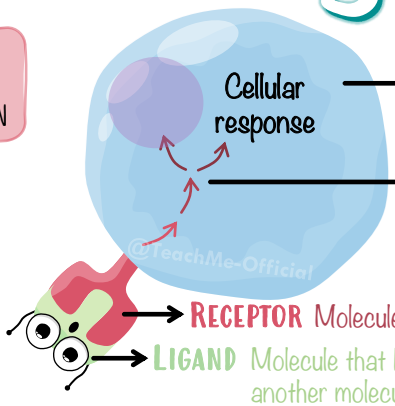
C2.1

Chemical Signaling (HL)

CELL SIGNALING = CELL COMMUNICATION



1. LIGANDS

- Hydrophilic (M/C) → Bind surface receptor.
- Hydrophobic → Bind intracellular receptors.

CALCIUM

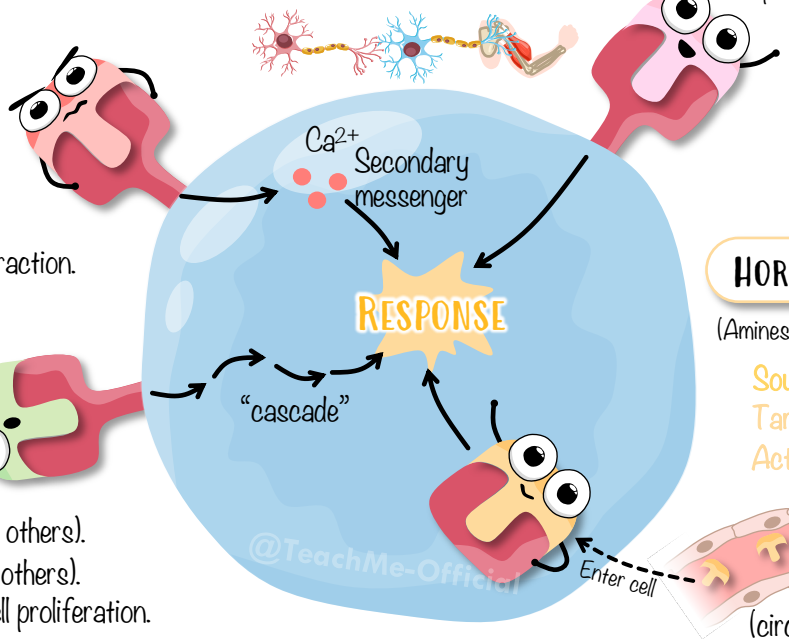
(Ion)

Source: Inside cell.
Target: Muscle proteins.
Action: Eg. Muscle contraction.

NEUROTRANSMITTERS

(Peptides, AA, nitrous oxide, amines)

Source: Released from neuron.
Target: Act on neighboring cells (Short distance).
Action: Synaptic transmission.

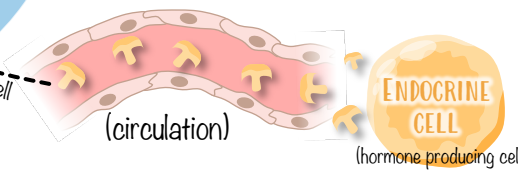


HORMONES

Hydrophobic -> bind intracellular receptors

(Amines, Proteins, Lipids [steroid]):

Source: Endocrine cells.
Target: Distant site (travels by blood).
Action: Various. See example.



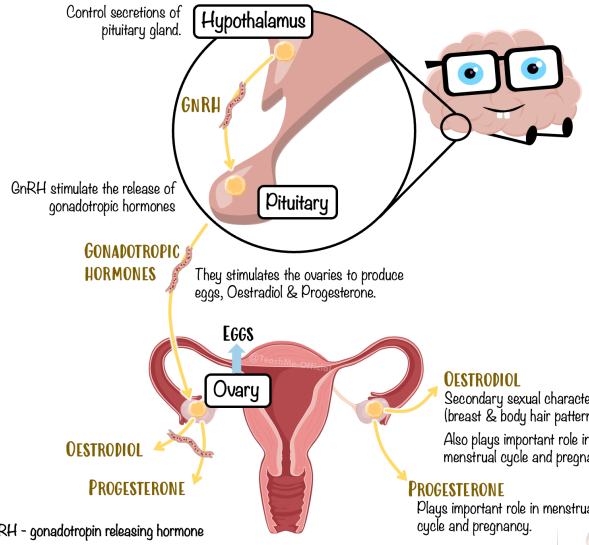
CYTOKINES

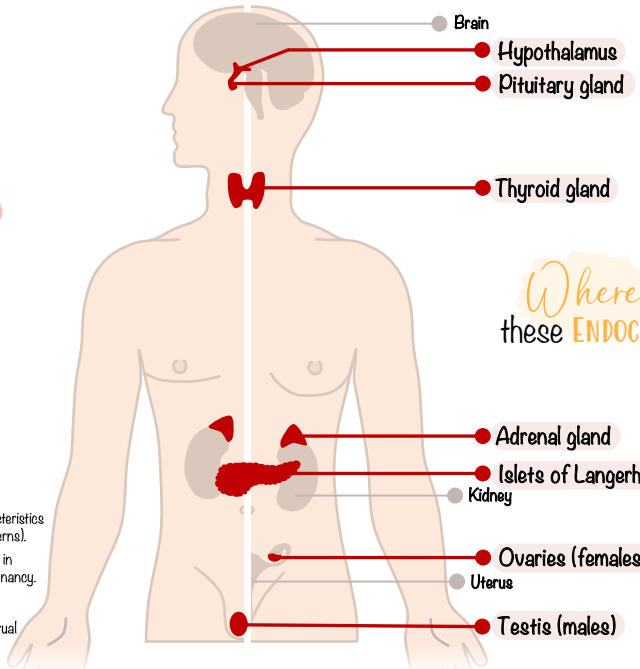
(Glycoproteins, 50 kinds)

Source: Immune cells (& others).
Target: Immune cells (& others).
Action: Inflammation. Cell proliferation.

Example of hormones in the **HYPOTHALAMUS-PITUITARY-OVARY** axis:

This content is learned in more detail in **D3.1!**





C2.1

Chemical Signaling (HL)

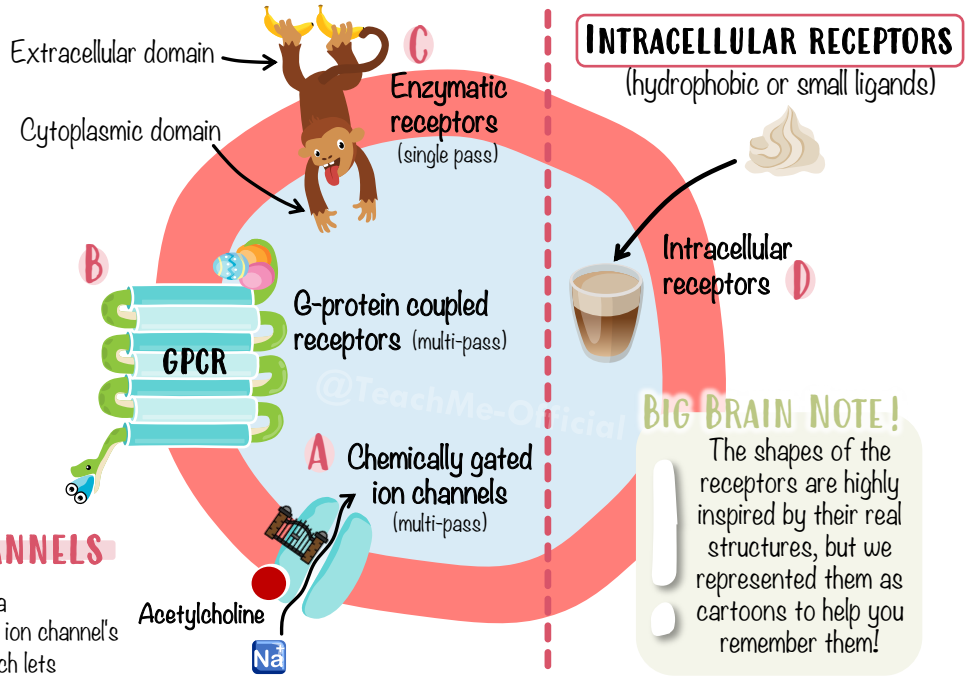
II. Receptors

Molecules (proteins) to which a ligand binds. Complementary binding cause the receptor shape change.

Transmembrane receptors

(hydrophilic ligands)

- Receptors possess both **hydrophobic** and **hydrophilic** domains (due to amino acid properties).
  - portion of a proteins polypeptide chain that folds independently from the rest.
- Allows proteins to interact with molecules both outside & inside the cell



Intracellular receptors

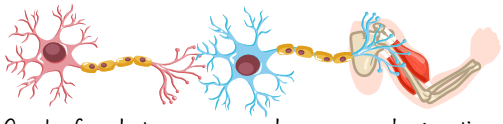
(hydrophobic or small ligands)

Big Brain Note!

The shapes of the receptors are highly inspired by their real structures, but we represented them as cartoons to help you remember them!

A. Chemically gated ion channels

- A specific ligand (chemical messenger) such as a **neurotransmitter** (acetylcholine) binds to the ion channel's receptor site causing the **channel** to **open** which lets specific ions (e.g., Na^+, K^+, Cl^-) flow across the membrane.
- The change in ion concentration inside the cell leads to a change in membrane potential, triggering a **cellular response** like muscle contraction or nerve impulse propagation. The ion channel closes when the ligand detaches (reversible).

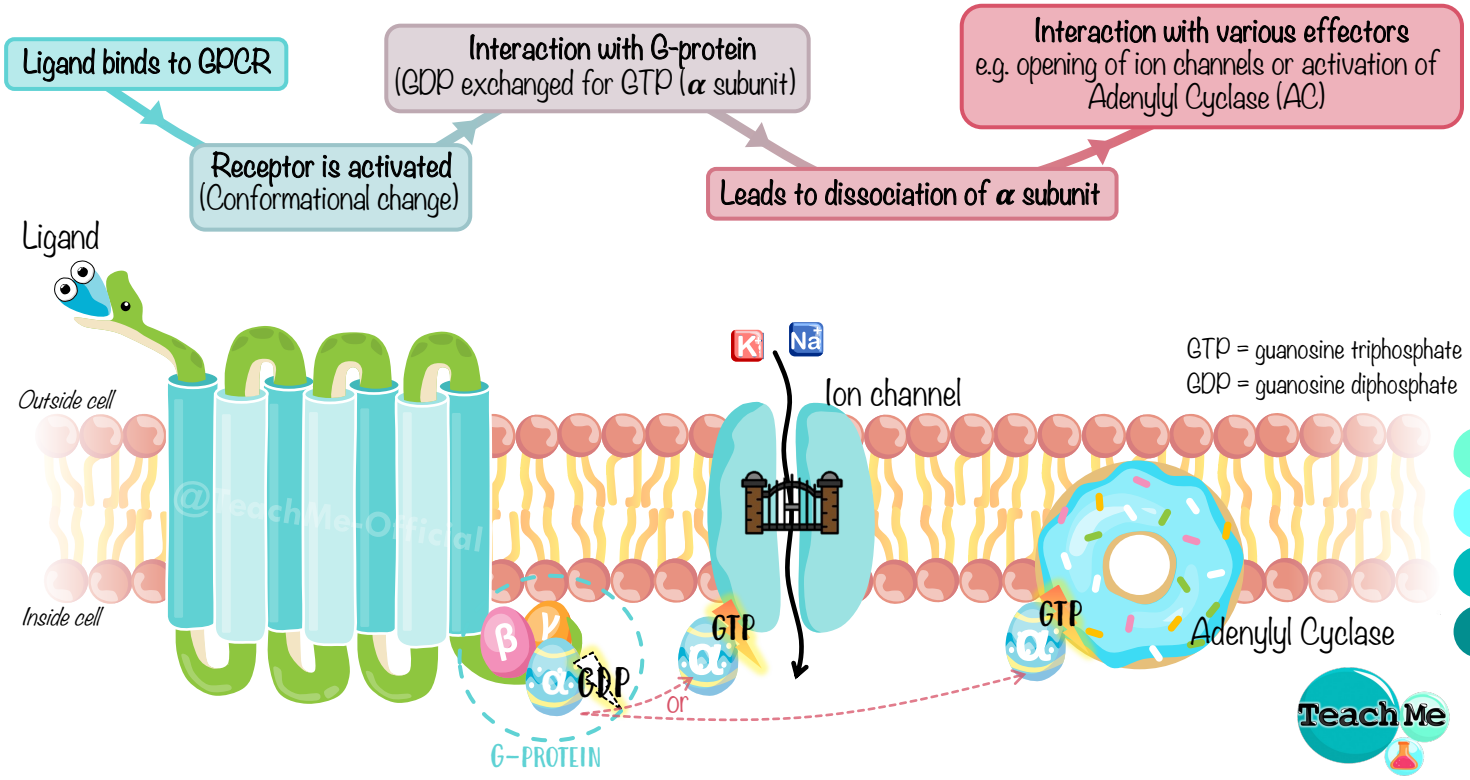


Can be found at synapses and neuromuscular junctions

More detail on the receptors from page 2 to 4 B C D

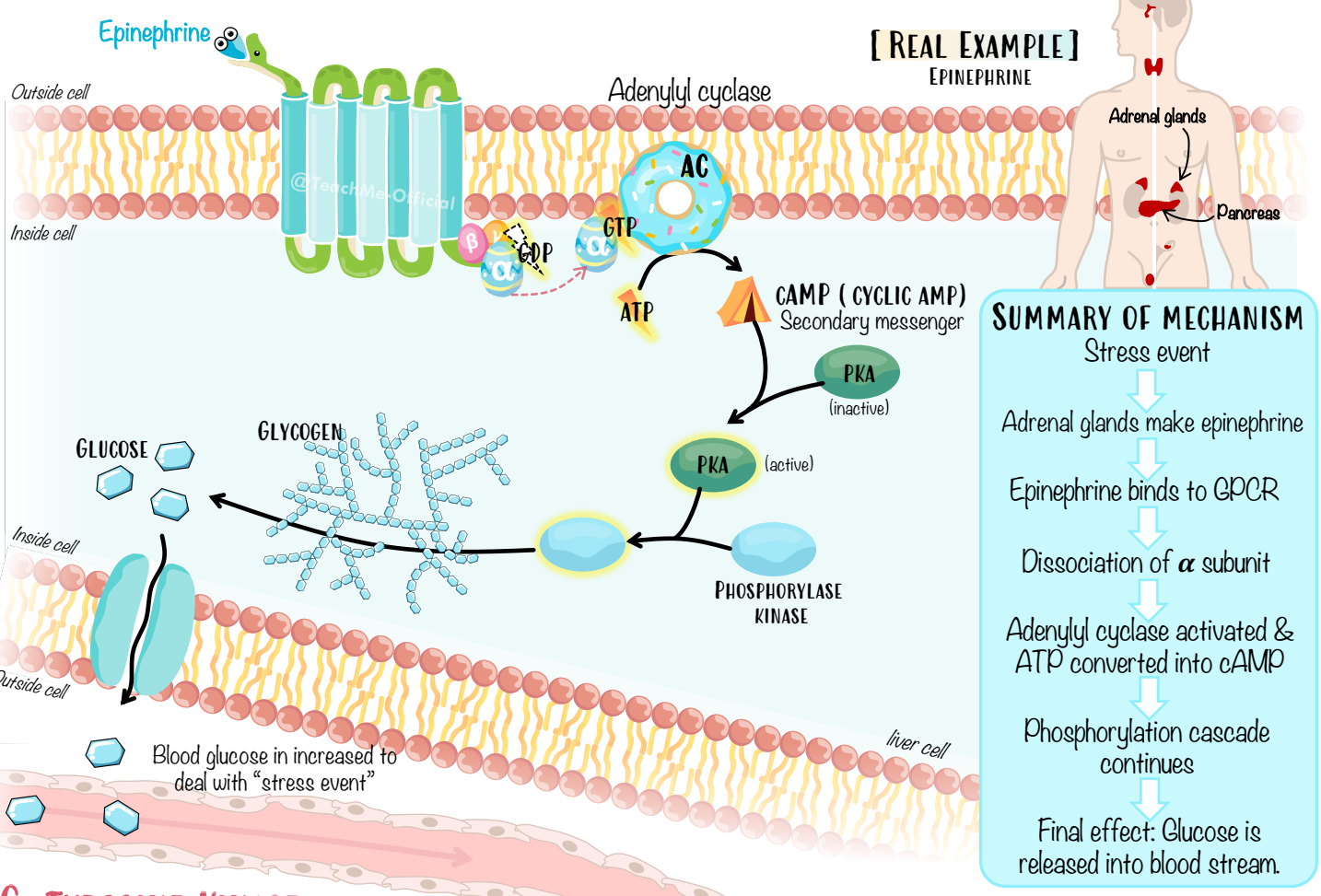
B. G-protein coupled receptors (GPCR)

Mechanism: Acts **indirectly** on enzymes or ion channels with the the aid of a protein called G protein. Protein passes membrane 7 times.



C2.1

Chemical Signaling (HL)



Summary of Mechanism

Stress event

↓

Adrenal glands make epinephrine

↓

Epinephrine binds to GPCR

↓

Dissociation of α subunit

↓

Adenylyl cyclase activated & ATP converted into cAMP

↓

Phosphorylation cascade continues

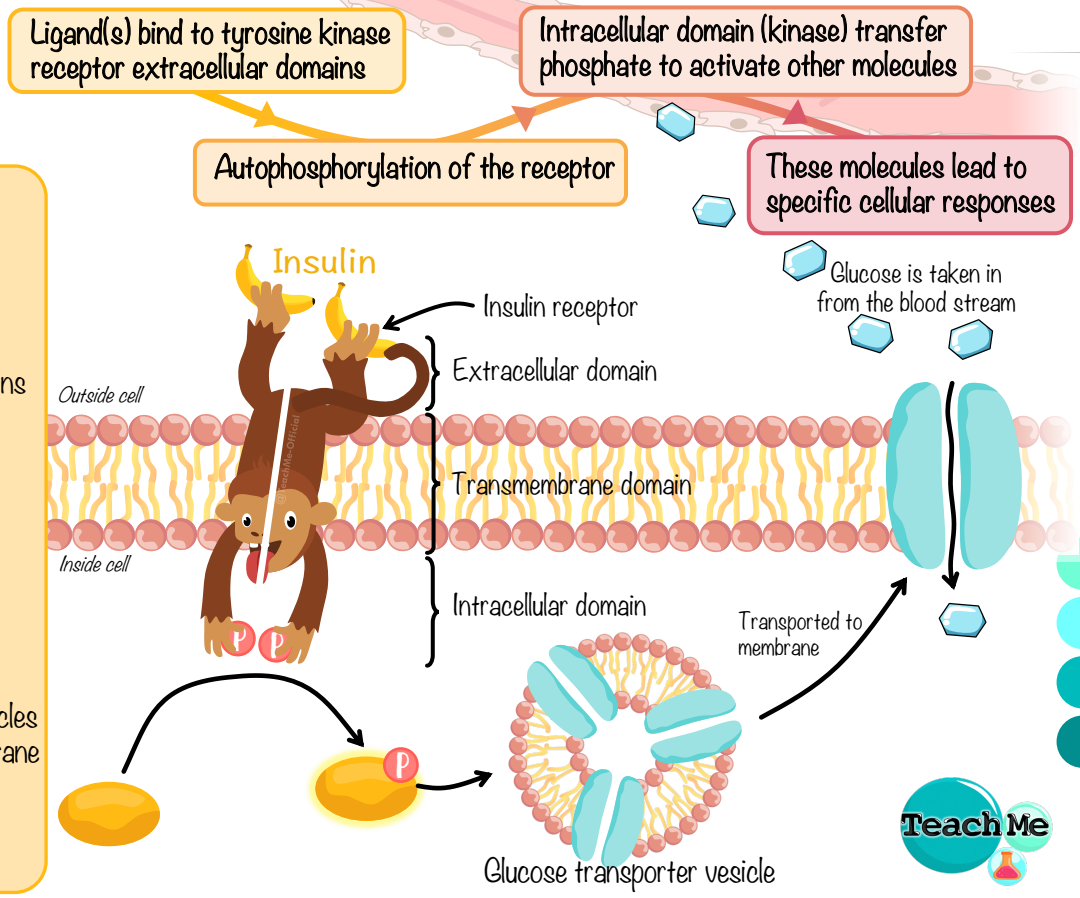
↓

Final effect: Glucose is released into blood stream.

C. Tyrosine Kinase

Mechanism: an enzyme that can phosphorylate other molecules.

[Real Example]
Insulin



Summary of Mechanism

Body has excess glucose

↓

Pancreas makes insulin

↓

2 Insulin binds extracellular domains

↓

Phosphate groups added to receptor (autophosphorylation).

↓

Intracellular domain (kinase) transfer phosphate group from ATP to another substance.

↓

Triggers glucose transporter vesicles (glut-4) to move to the cell membrane

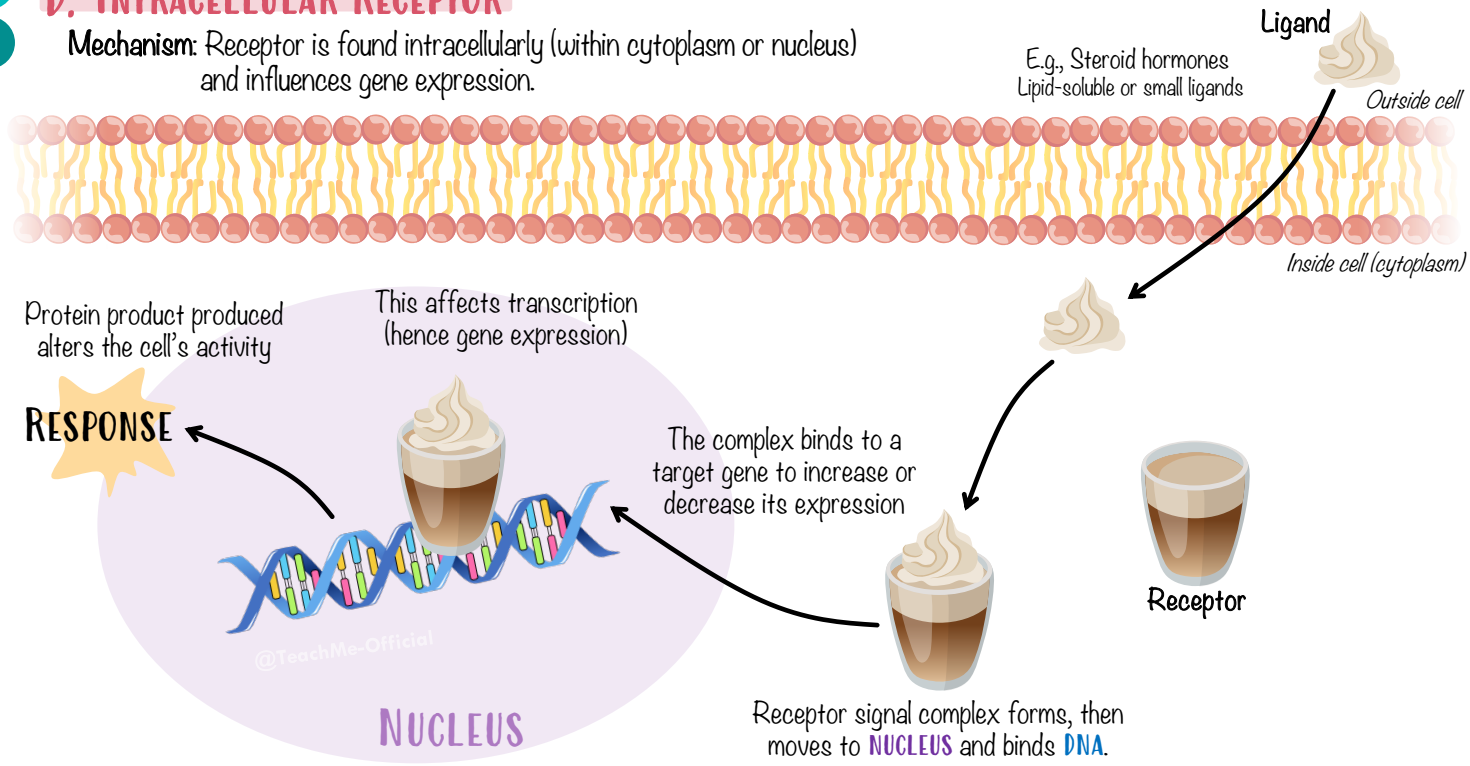
↓

Increase glucose uptake into cell and out of the blood stream.

Chemical Signaling (HL)

D. Intracellular Receptor

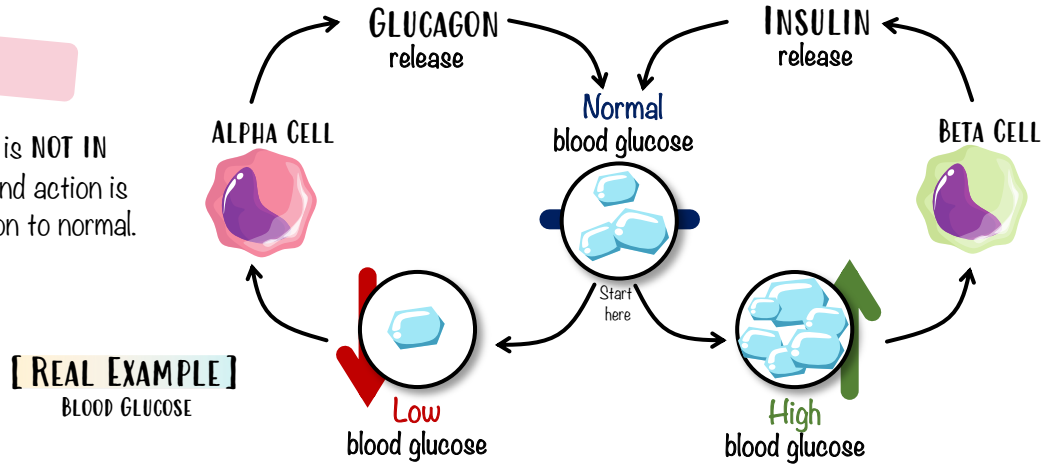
Mechanism: Receptor is found intracellularly (within cytoplasm or nucleus) and influences gene expression.



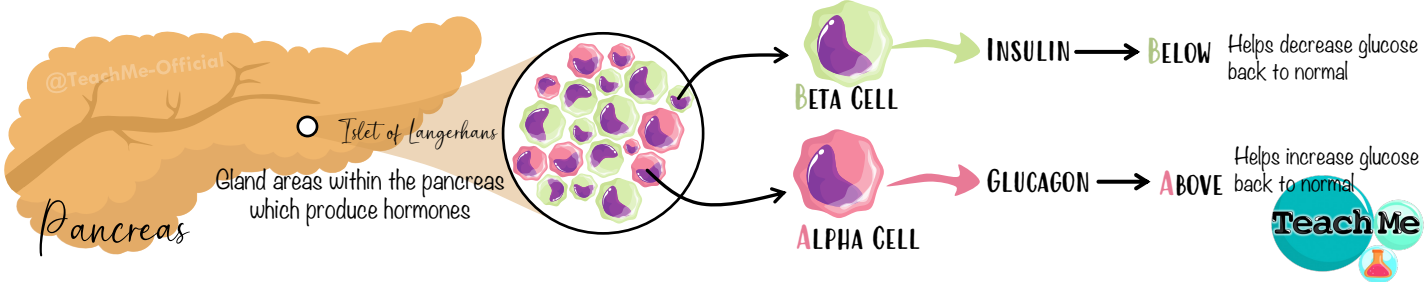
Chemical signaling plays a crucial role in maintaining **HOMEOSTASIS** by regulating both **NEGATIVE** and **POSITIVE FEEDBACK** mechanisms, ensuring that the body's physiological processes remain balanced.

Negative Feedback

Occurs when the condition is **NOT IN NORMAL RANGE** anymore and action is taken to return the condition to normal.



[REAL EXAMPLE]
BLOOD GLUCOSE

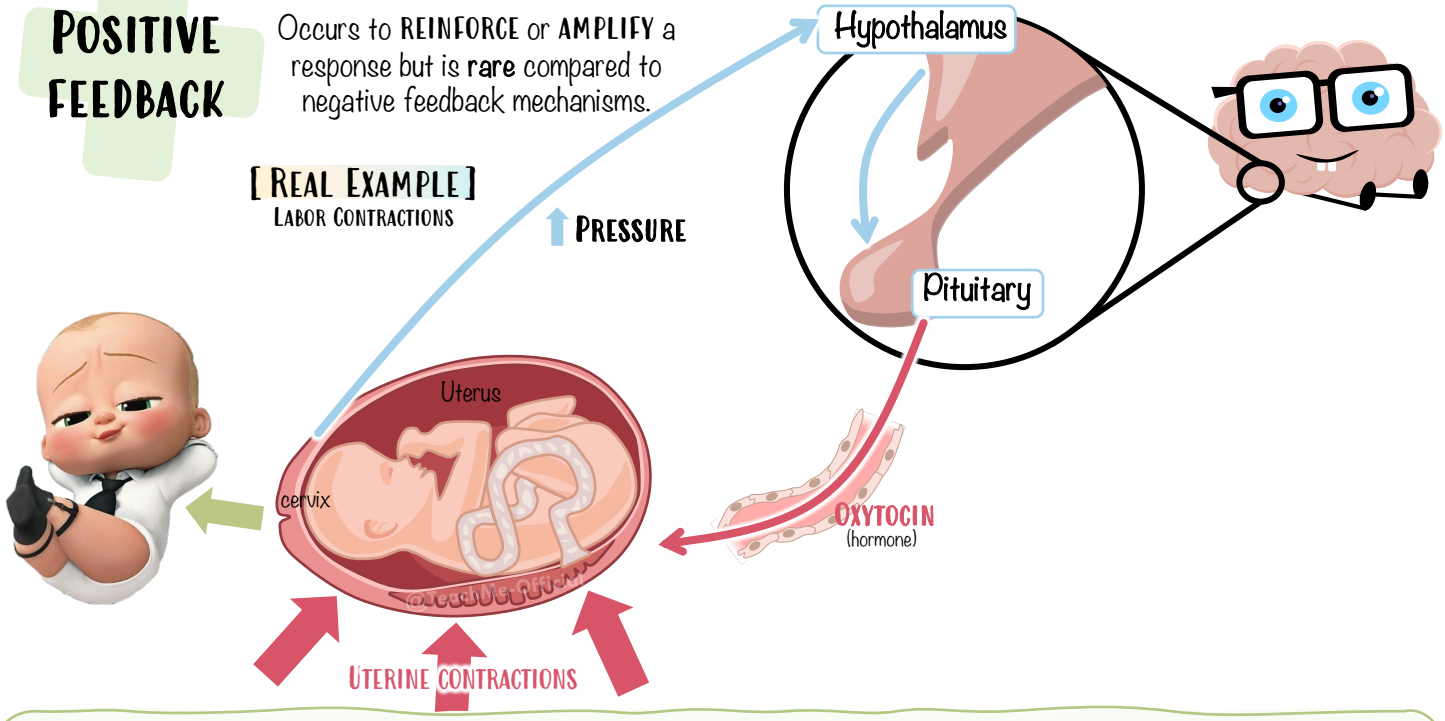


Chemical Signaling (HL)

POSITIVE FEEDBACK

Occurs to **REINFORCE** or **AMPLIFY** a response but is **rare** compared to negative feedback mechanisms.

[REAL EXAMPLE]
LABOR CONTRACTIONS

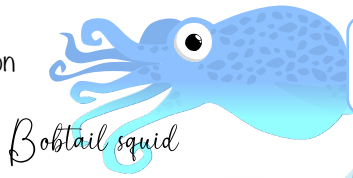


Labor begins when the baby's head pushes against the cervix, creating **PRESSURE**. This pressure signal is sent to the HYPOTHALAMUS in the brain which in turn prompts the PITUITARY GLAND to release OXYTOCIN into the bloodstream. OXYTOCIN travels through the blood to the uterus, causing the muscles of the uterus to contract more forcefully. These contractions push the baby further into the birth canal, increasing the **PRESSURE** on the cervix which lead to stronger signals being sent to the hypothalamus, leading to even more OXYTOCIN release. This cycle of increasing contractions continues until the baby is born, at which point the POSITIVE FEEDBACK loop is interrupted.

QUORUM SENSING

Mechanism by which bacteria can alter group behavior depending on population density. Examples are bioluminescence, virulence...

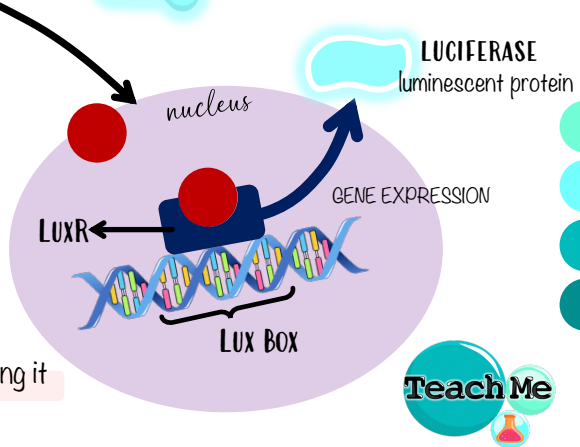
Bioluminescence: refers to the production of light by an organism



Bacteria is consumed by the squid and provides a safe environment for it to proliferate and grow

Mutualism (symbiotic relationship) between the squid and the bacteria

Protects squid against predators as they get perceived as sunlight



- During the reproductive cycle of the *V. fischeri* bacteria, they produce **AUTOINDUCER MOLECULES**.
- As the number of these bacteria increases, the concentration of autoinducer molecules increases in the surroundings.
- When the number of autoinducer molecules reach a threshold level, the move into the bacteria and bind to an intracellular receptor: **LUXR**.
- The bounded receptor then bonds to a DNA binding site called a **LUX BOX**, activating it and thus causing the production of a luminescent protein: **LUCIFERASE**.

notes