Signal Transduction:
The cascade of processes by which an extracellular signal (typically a homone/neurotransmitter) interacts w/ a receptor at the cell surface, causing a change in the level of a 2nd messenger & the cell's and ultimately affects a change in the cell's f'n'ng.

Biology 2A03
Lecture 6

Signal transduction

→ Cell Communication
↳ via chem. messengers
↳ they bind to cell surface or inside cell

the info they want to relay are transmitted via sig. transdxn.

Osmosis

Water diffusion: although water is polar it has high permeability in membranes due to its small size

Flux can be increased by the ~~presence~~ presence of aquaporins = protein channe

H_2O concentration depends on the # of dissolved particles

Total [solute] in solution determines osmolarity (colligative properties).

1 mole of dissolved particles = 1 osmolar solution

e.g. 1M of glucose in solution = 1 osmole
but 1M of NaCl = 2 osmoles since it ionizes in sol'n to Na^+ & Cl^-

The higher the osmolarity of a solution the lower the H_2O conc

Osmosis in the direction of higher osmolarity (or lower H_2O conc)

colligative properties of solns that depend on the # of molcs in a given volume of solvent & not the properties of the molcs (size & mass) for ex.

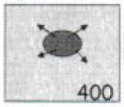
Osmolarity has to do w/ particles
↳ things that dissociate
i.e. NaCl produces 2 osmoles

Cells are very permeable to water and impermeable to many solutes

Isotonic: Extracellular fluid has the same # of osmoles of nonpenetrating solute

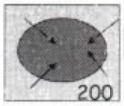
No change in cell volume

Hypertonic: Extracellular fluid has a greater # of osmoles of nonpenetrating solute



Cell shrinks

Hypotonic: Extracellular fluid has the lower # of osmoles of nonpenetrating solute



Cell swells

Fig 4-19

tenicity?

Compare to osmolarity

Relates the osmolarity of a solution relative to normal extracellular fluid without regard to penetrating or nonpenetrating nature of solutes

A solution can be isoosmotic at 300 mOsm but hypotonic due to penetrating solutes

having the same solute concentration & therefore the same water potential

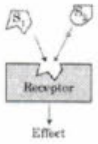
isoosmotic But hypotonic

: nonpenetrate
: penetrating

Signal Transduction Pathways detect intercellular messengers and convert them into a biologically meaningful response

4 features of signal transduction pathways:

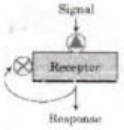
1) Specificity: The signal mol'c fits in its receptor while others do not.



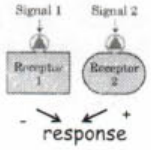
Can also have messenger bind to multiple receptors with different affinities

2) Amplification: 1 receptor binding can lead to 1000 000 products.

3) Desensitization / adaptation: Feedback shuts off receptor or removes it.



4) Integration: Outcome the result of integration of both receptor inputs



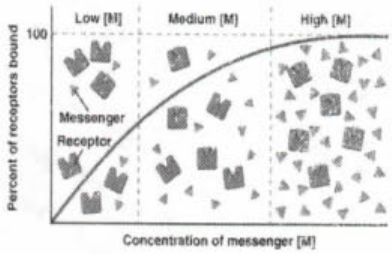
feedback: process in which part of the output system is returned to its input in order to regulate its further output.

Fig 5-9
Fig 5-10

Receptors

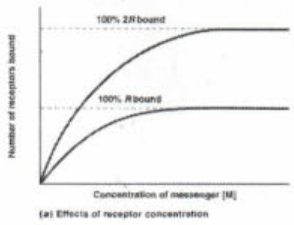
The magnitude of a cell's response depends on:

1) the messenger's concentration
2) the # of receptors present
3) affinity of receptor for messenger



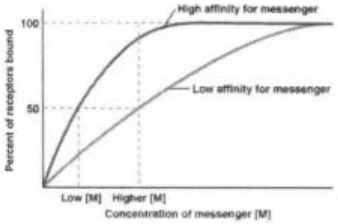
Show characteristics very similar to enzymes

Can become saturated with messenger



(a) Effects of receptor concentration

An increase in the # of receptors increases the % bound w/ messenger.



(b) Effects of receptor affinity

Change in affinity for messenger

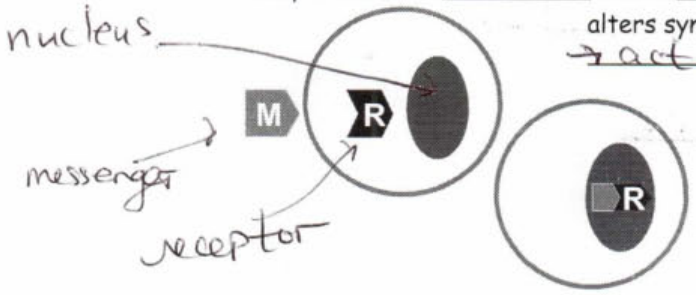
Can increase # of bound receptors at the same messenger concentration

Or...50% of the receptors are bound at a lower messenger conc.

Fig 5-10

lipo. msngrs are located IN cell membrane → can cross over plasma membrane and get into cell.

Receptors can be intracellular: bind to lipophillic messengers
alters synthesis of a specific protein
→ act as transcription factors



e.g. steroids = hormones.

Receptors can be located in the cytosol or in the nucleus

nuclear receptors → fat metabolism

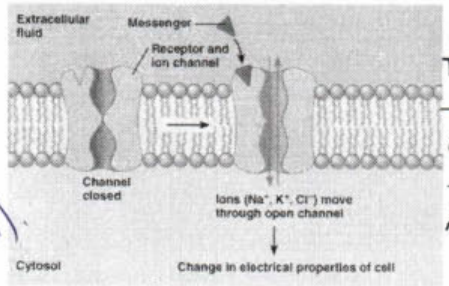
See Fig 5-11

→ bnd lipophobic messengers

Receptors can be membrane bound: 3 main types

1) Channel-linked: (e.g. bndng opens ion channel).

Channel-linked: transmembrane ion channels that are opened/closed in response to the bndng of a chem. msngr (i.e. a ligand).



(a) Changing the electrical properties of a cell through ligand-gated channels

called ligand-gated channels

This is an example of "fast" channel → just relies on bndng of messenger

Channel also acts as the receptor.

Allows channel to open quickly & briefly.

Fig 5-12

2) Enzyme-linked: Ligand-binding domain on extracellular surface and an enzyme active site on intracellular side.

Binding activates tyrosine kinase activity which phosphorylates a protein on tyrosine

Tyrosine kinase: an enzyme that can transfer a phosphate group from ATP to a tyrosine residue on a protein

i.e.) insulin receptor is an enzyme-linked receptor.

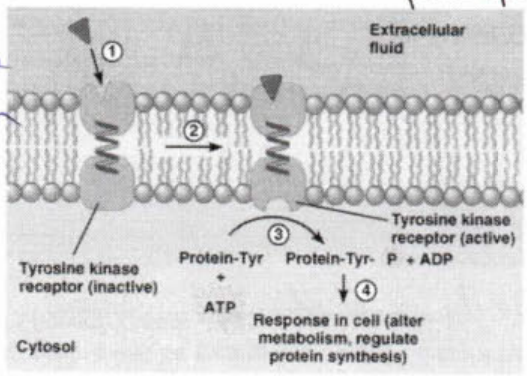


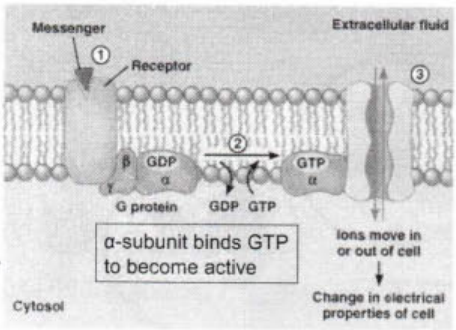
Fig 5-13

G-protein: class of proteins that are involved in second messenger cascades.

"guanine nucleotide-binding protein"

3) G-protein-linked: (activate membrane proteins called G-proteins and begin a signaling cascade.

G-proteins can be stimulatory (Gs) or inhibitory (Gi)



1. Regulates a protein channel

e.g. Can open or close a "slow" ion channel
- Channel does not act as receptor

2. Often activates an enzyme

e.g. adenylate cyclase to produce cAMP

Fig 5-14

Second messengers

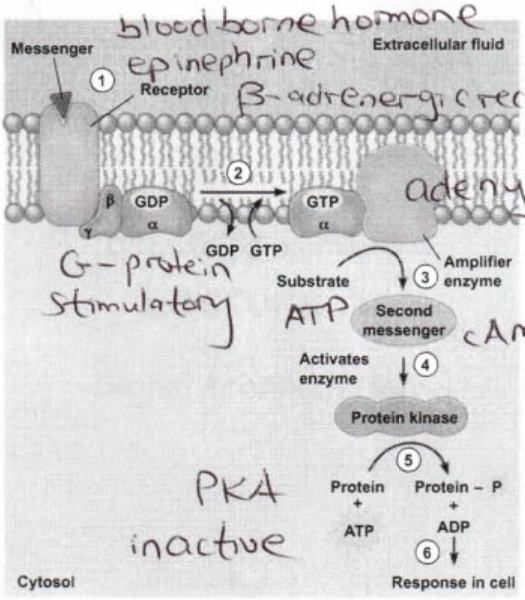
Intercellular chemical messenger which reaches the cell surface is called the first messenger

The intracellular messenger produced by the binding of the first messenger is called the second messenger

Act as chemical relays from the plasma membrane to the biochemical machinery inside the cell.

Important 2nd messengers are:
1) Ca^{2+}
2) cAMP
3) cGMP
4) DAG
5) Eicosanoids
6) IP3

Table 5-3
Fig 5-16
Fig 5-17
Fig 5-18



blood-borne hormone

epinephrine

β-adrenergic receptor

adenylate cyclase

G-protein stimulatory

cAMP

PKA inactive

PKA active

1x molecules

20x molecules.

10x molecules.

Response of the cell (e.g. glycogen breakdown in liver cells)

PKA active — 10x molecules

inactive Phosphorylase b Kinase → active Phosphorylase b Kinase (100x molecules)

Amplification of hormone signal

inactive Glycogen phosphoryase b → active Glycogen phosphoryase a (1000x molecules)

glycogen → Glucose 1-P (10,000x molecules)

Glycogen synthase (inactive)

PKA active

Adrenergic receptor can be desensitized by phosphorylation

a class of G-coupled receptors that are targets of catecholamines (norepi ; epi) for example.