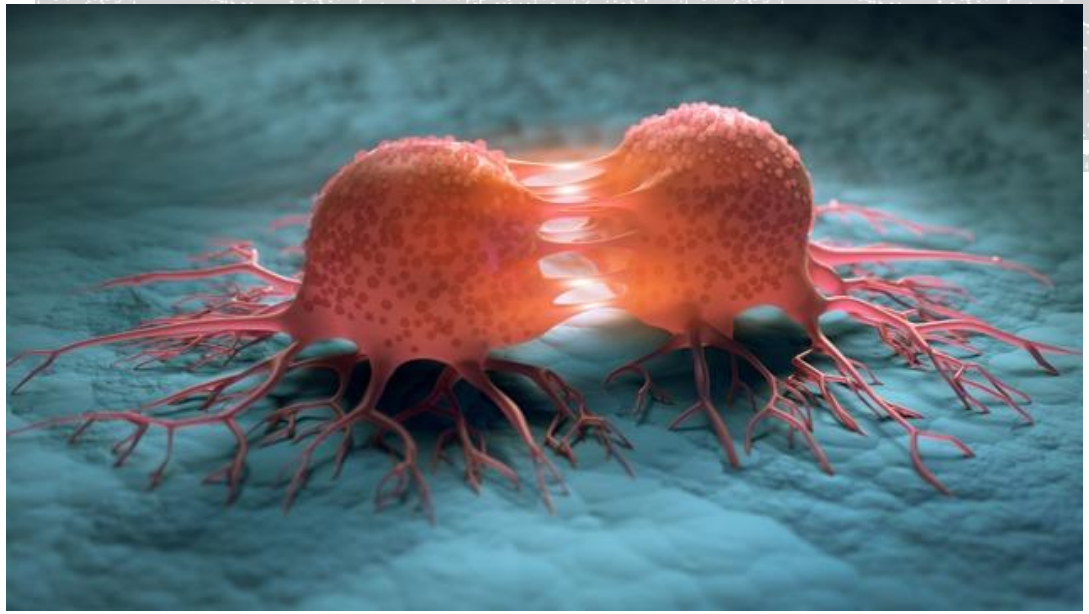
METABOLISM & CELL COMMUNICATION



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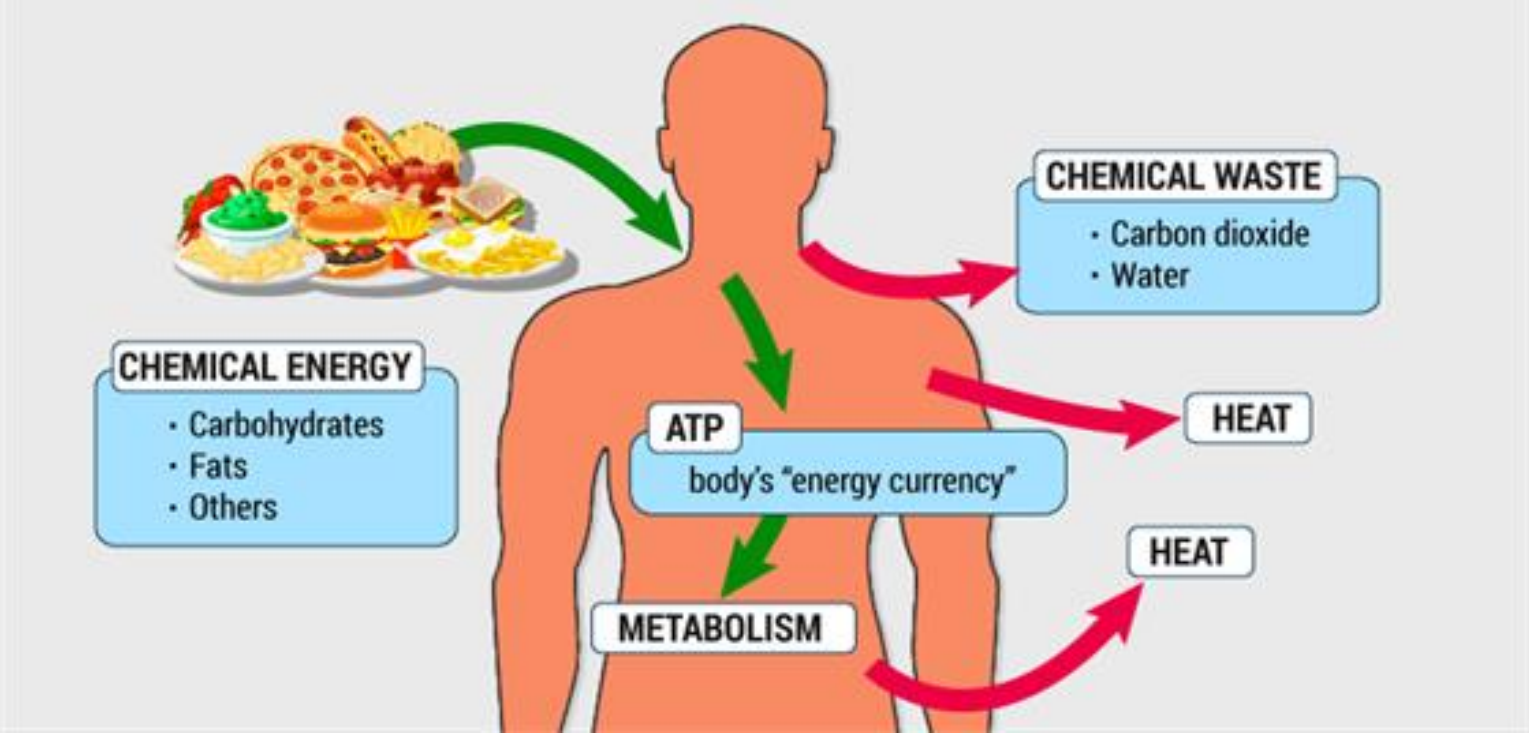
Dr. Manu Smriti Singh

Department of Biotechnology

Bennett University

METABOLISM



All the chemical processes that take place in the body in order to sustain life- allowing you to breathe, pump blood, keep your brain functioning and extract energy from your food.

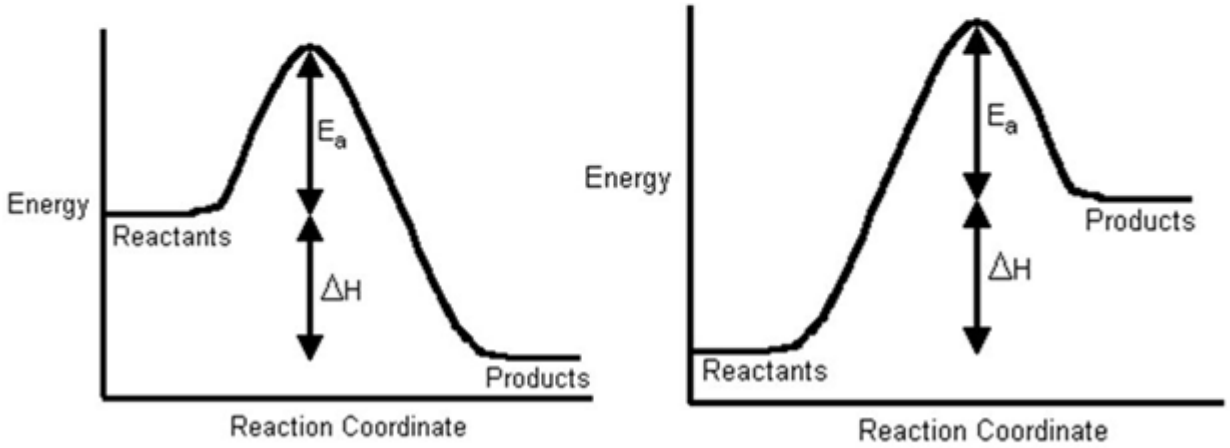
LIVING ORGANISMS AS THERMODYNAMIC SYSTEMS

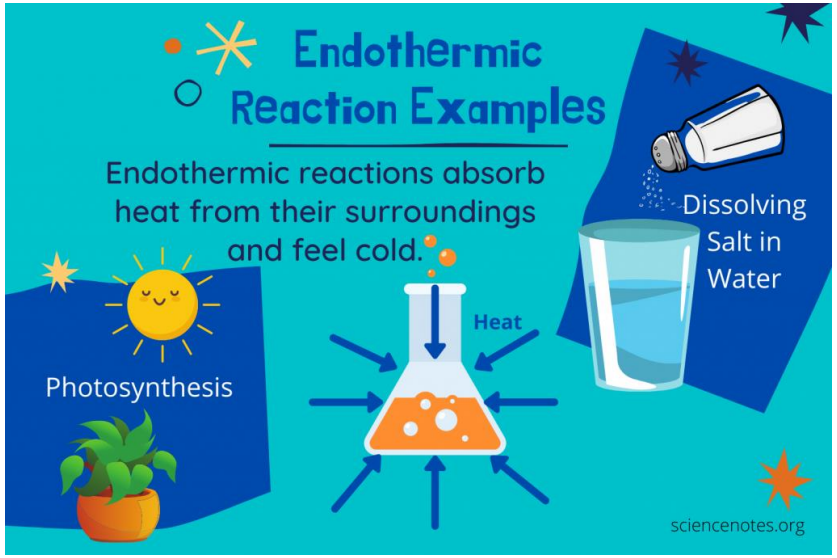
- The matter flowing into the living system contains a high energy potential.
- The matter flowing out of the system is at a low energy potential.
- The energy changes that occur between these two mass flow events are used to perform chemical and physical work processes.

- Enthalpy (ΔH)
- Entropy (ΔS)

What is Enthalpy?

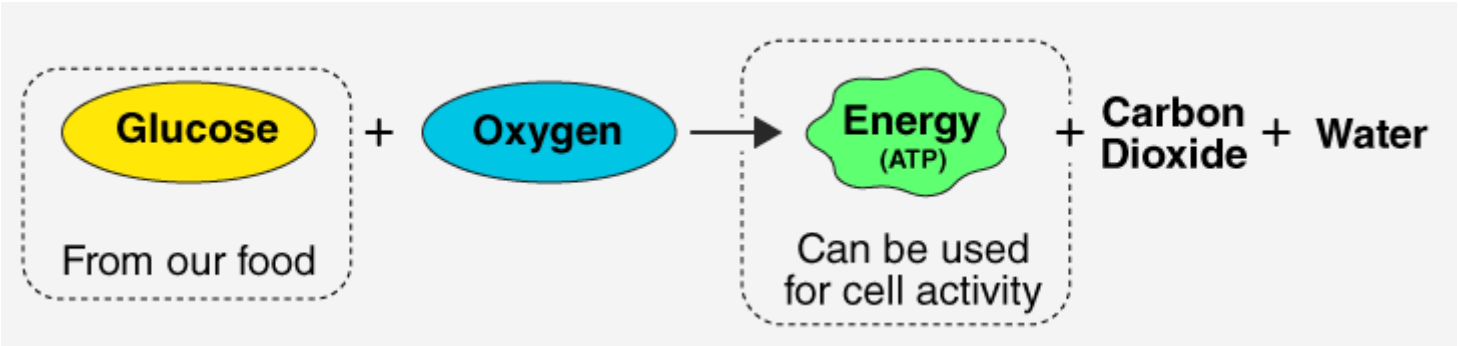
- ΔH, heat energy
- ENDOthermic: heat is taken in by the reactants
- EXOthermic: heat is released as a product





Exo (ΔH)= -ve (heat given out)
Endo (ΔH)= +ve (heat absorbed)

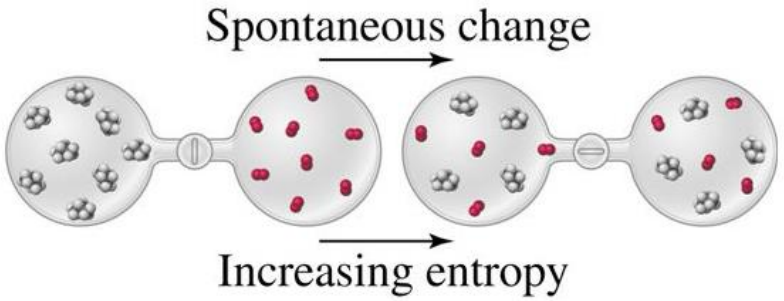
Exothermic Reaction



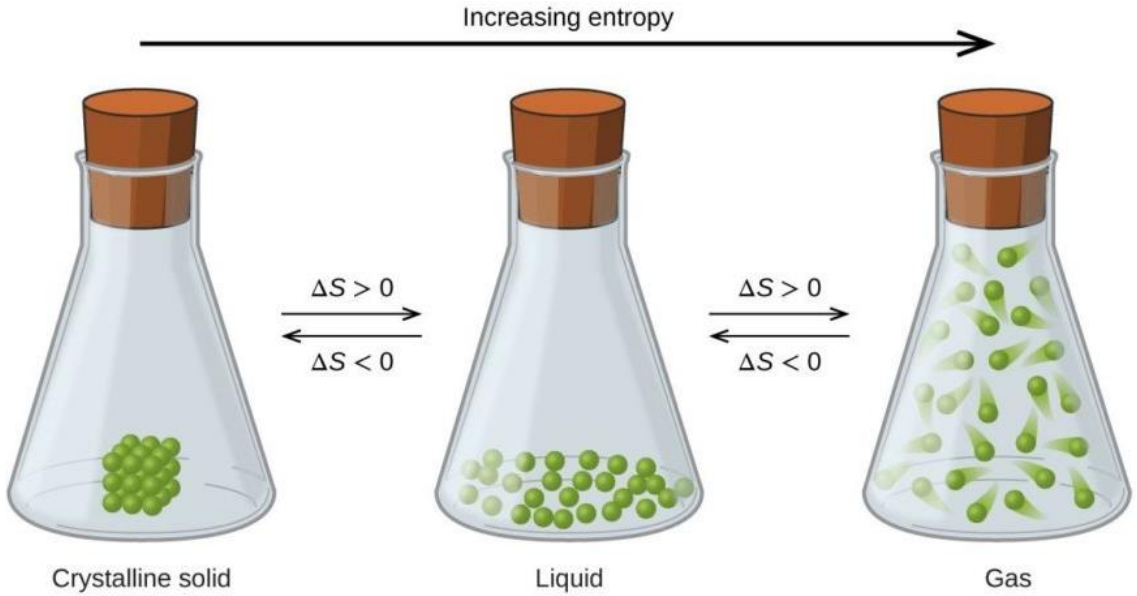
ENTROPY

Consider mixing two gases: this occurs spontaneously, and the gases form a homogeneous mixture.

There is essentially no enthalpy change involved, so why is the process spontaneous?

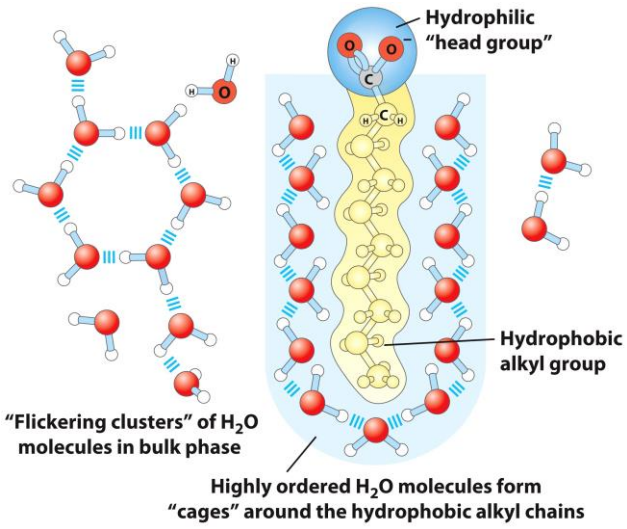


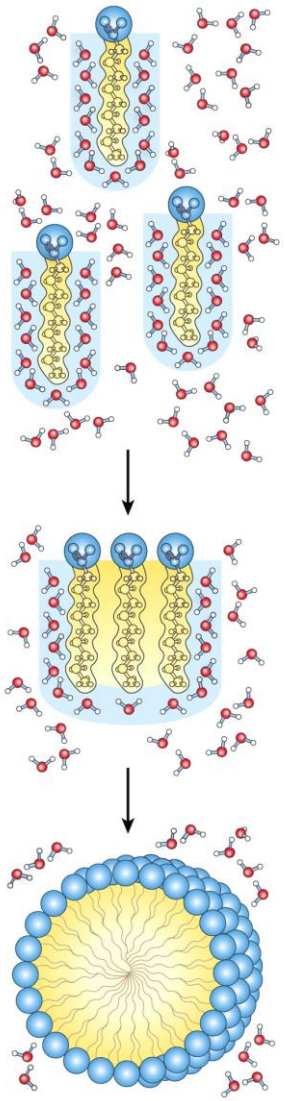
The driving force is a thermodynamic quantity called entropy, a mathematical concept that is difficult to portray visually



HYDROPHOBIC EFFECT

Suspension of a hydrophobic substance in water is thermodynamically unfavorable due to the decreased entropy of water molecules in the cage-like shell.





Dispersion of lipids in H_2O

Each lipid molecule forces surrounding H_2O molecules to become highly ordered.

Clusters of lipid molecules

Only lipid portions at the edge of the cluster force the ordering of water. Fewer H_2O molecules are ordered, and entropy is increased.

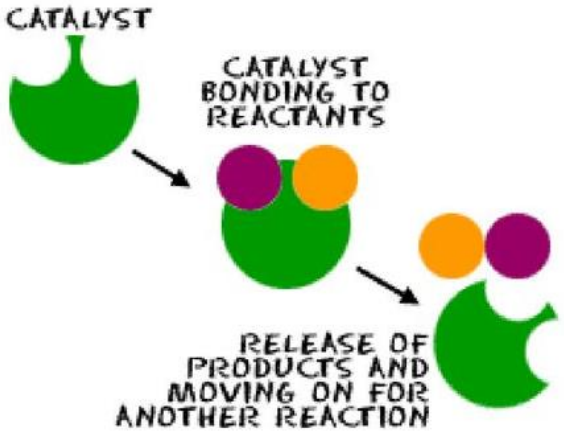
Micelles

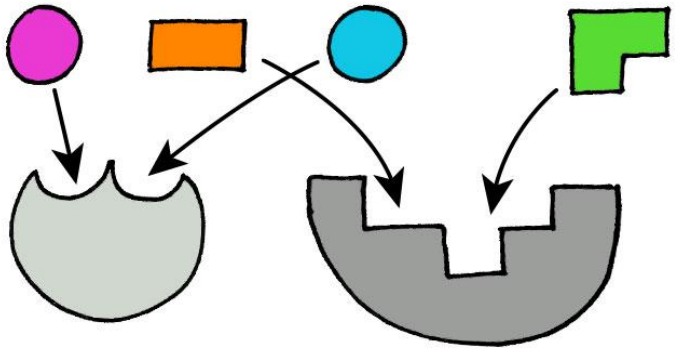
All hydrophobic groups are sequestered from water; ordered shell of H_2O molecules is minimized, and entropy is further increased.

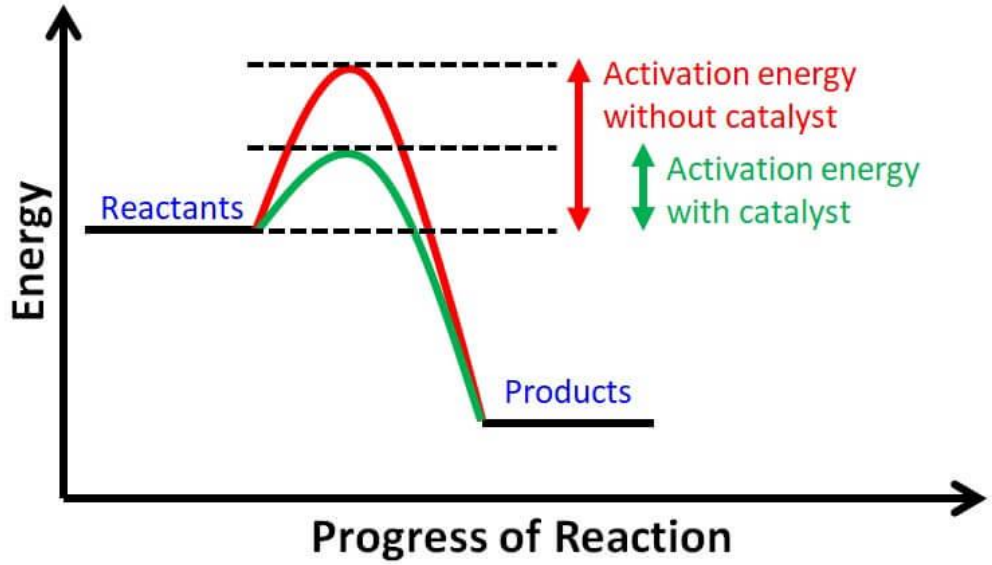
- The hydrophobic effect, and the term hydrophobic interactions, refers to the entropy-driven aggregation of nonpolar molecules in aqueous solution that occurs to minimize the ordering of water molecules with which they are in contact. This is not an attractive force, but rather a thermodynamically driven process.
- The hydrophobic effect drives the formation of membranes and contributes to the folding of proteins and the formation of double helical DNA.

What is a catalyst?

- A compound that **speeds up the rate of a chemical reaction,** but is not used up in the reaction.
- Can be used over and over





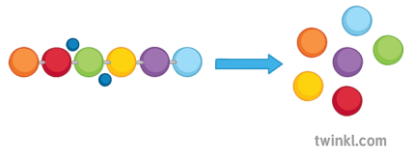


A. Without a catalyst. Note the higher activation energy required for the process to start. Reaction would take longer to form and products would gradually form.

B. With the help of a catalyst, the activation energy required for the reaction goes down significantly. This means the process would go faster and yield more of the products.

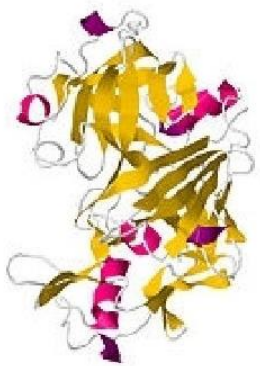
Examples of Classification of Enzymes

- **Oxidoreductoases**
  - oxidases - oxidize ,reductases – reduce
- **Transferases**
  - transaminases – transfer amino groups
  - kinases – transfer phosphate groups
- **Hydrolases**
  - proteases - hydrolyze peptide bonds
  - lipases – hydrolyze lipid ester bonds
- **Lyases**
  - carboxylases – add CO_2
  - hydrolases – add H_2O



Enzyme	Reactant	Product
Pepsin	Protein	Short polypeptides
Rennin	Soluble casein (milk protein)	Insoluble casein (curdled milk)

Rennin (Chymosin)



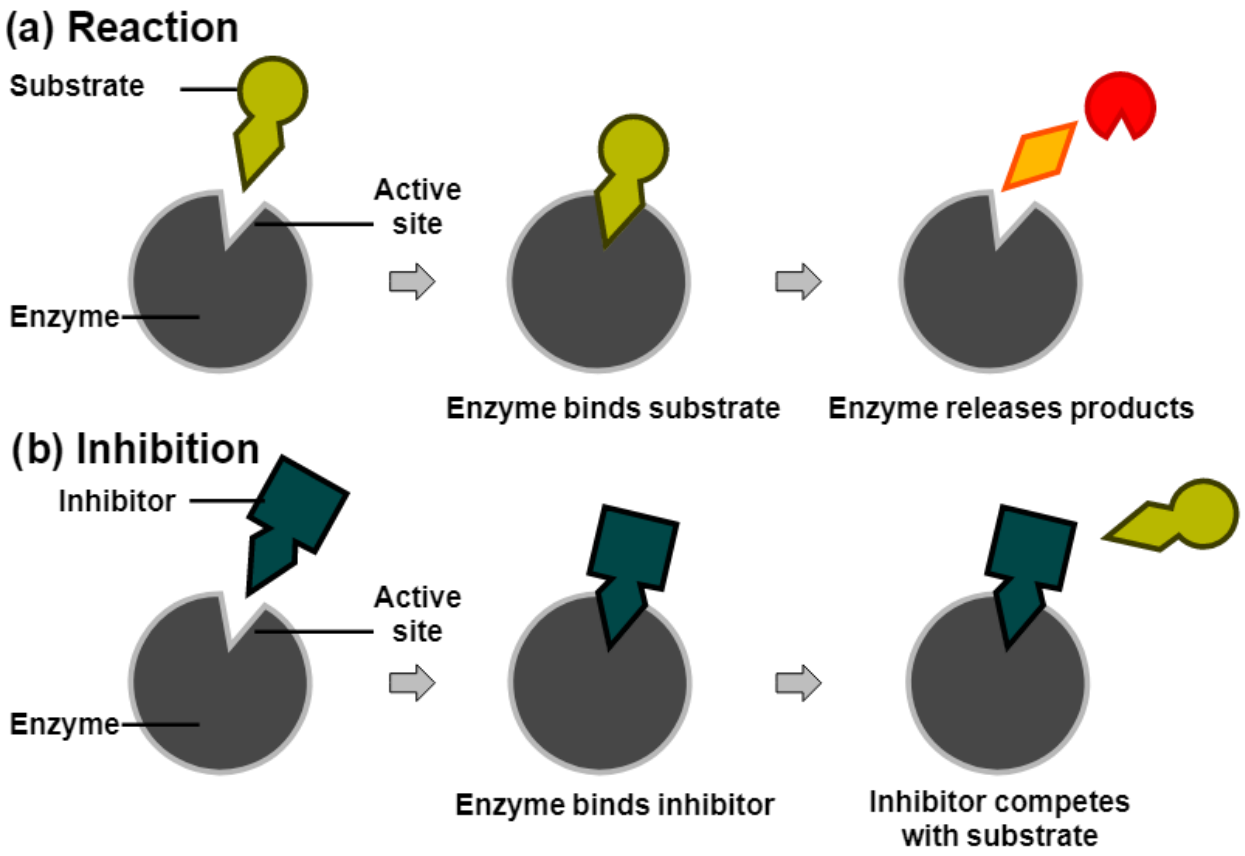
1. The main proteolytic enzyme found in rennet.
2. It is produced by Infants in the lining of the stomach.
3. It curdles milk, allowing a longer residence in the bowels and better absorption.

Enzyme Locations

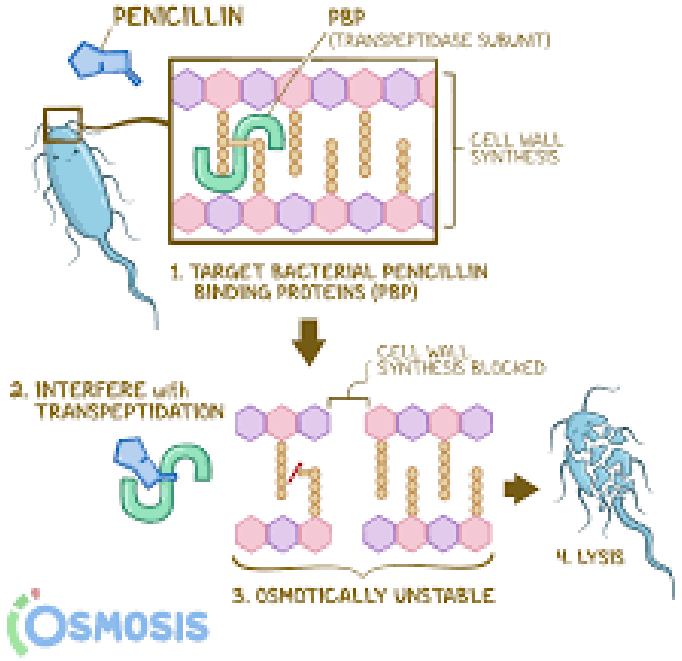
- Summary of enzymes involved with digestion, what reaction they catalyse and where they are produced: -

Enzyme	Reaction Catalysed	Location Produced
Amylase	Starch ➔ Sugars	Salivary glands; pancreas; small intestines
Protease	Proteins ➔ Amino Acids	Stomach; pancreas; small intestines
Lipase	Lipids ➔ Fatty Acids + Glycerol	Pancreas; small intestines

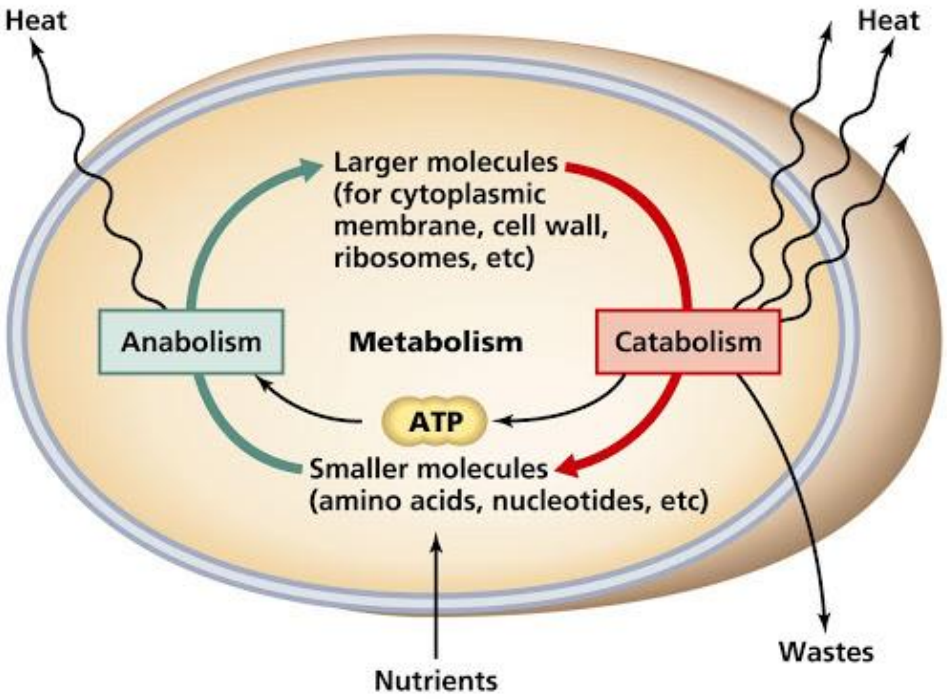
ENZYME INHIBITORS



- Penicillins inhibit a bacterial enzyme called the transpeptidase enzyme which is involved in the synthesis of the bacterial cell wall
- The β-lactam ring is involved in the mechanism of inhibition
- Penicillin becomes covalently linked to the enzyme's active site leading to irreversible inhibition



METABOLITES



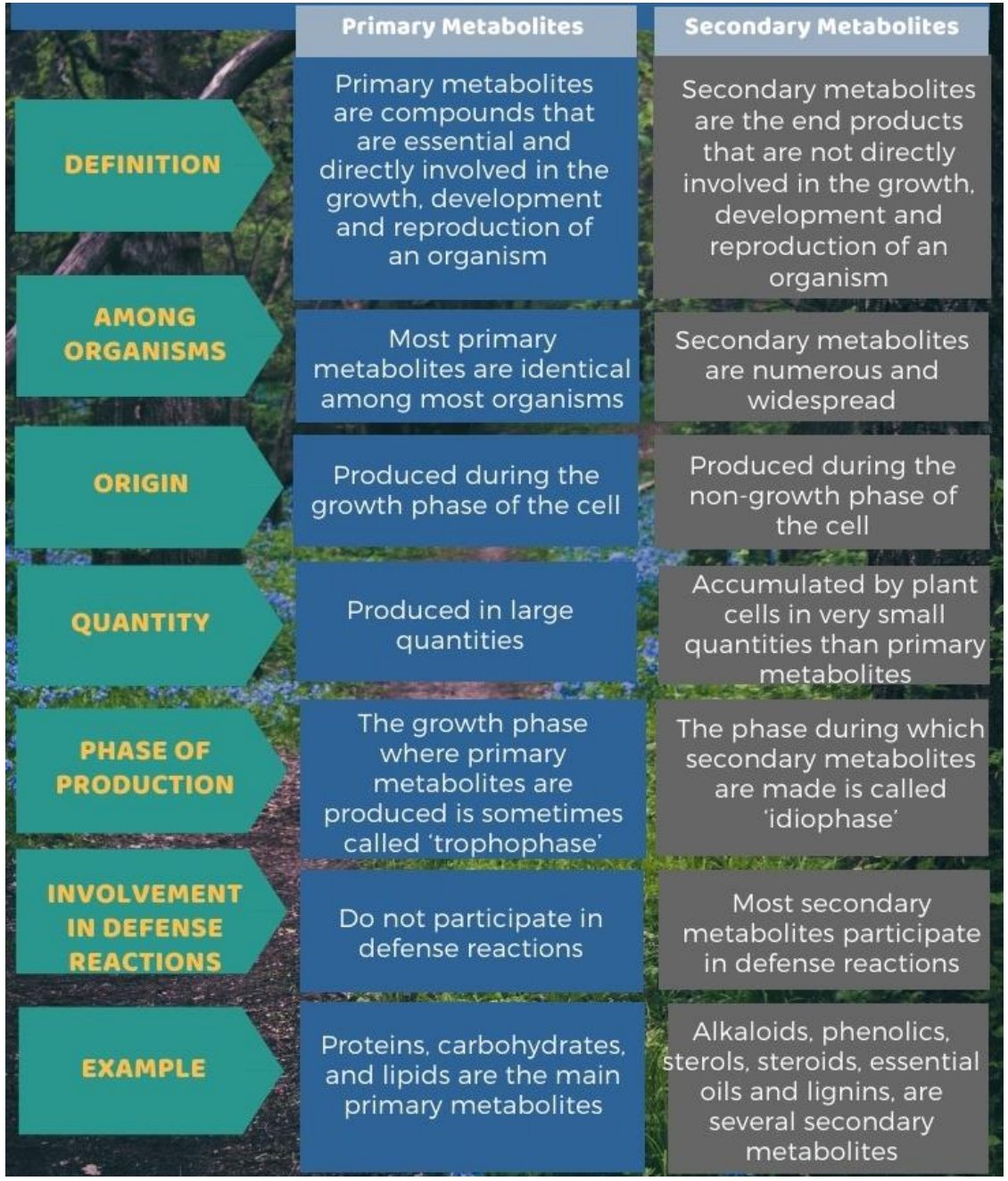
The reactants, intermediates and products of metabolic pathways are referred to as metabolites

Primary Metabolites:
Enzymes, Vitamins, Lactic Acid, Proteins, Lipids, Carbohydrates

Secondary Metabolites:
Steroids, Essentials Oils, Pigments, Antibiotics, Flavonoids, Gums/ Latex/ Tannins

SECONDARY METABOLITES

- Also called specialized metabolites, toxins or natural products, are organic compounds produced by bacteria, fungi, or plants which are not directly involved in the normal growth, development, or reproduction of the organism.
- Mediate ecological interactions, which may produce a selective advantage for the organism by increasing its survivability or fecundity.
- Specific within a phylogenetic group.
- Secondary metabolites often play an important role in plant defense against herbivory and infections.
- Humans use secondary metabolites as medicines, flavorings, pigments, and recreational drugs



METABOLITES IN USE

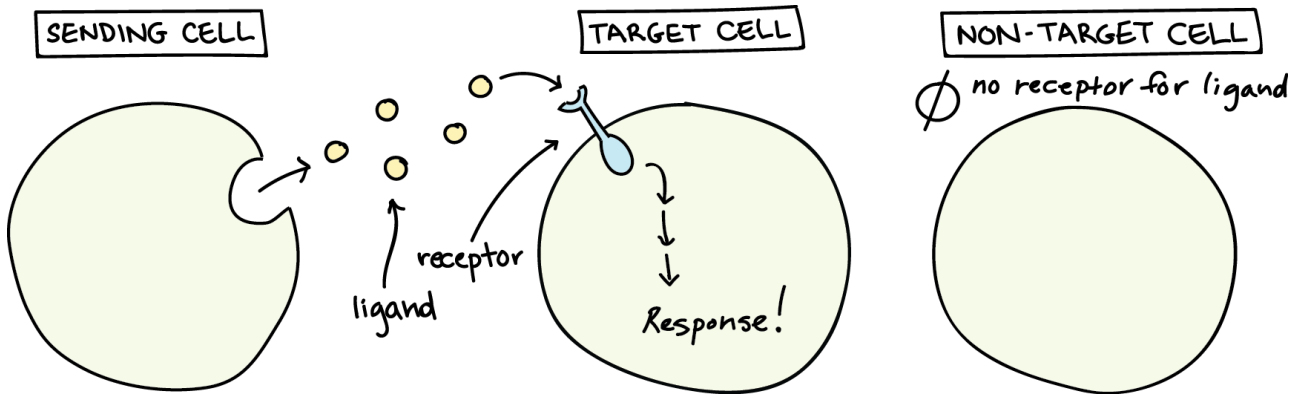
Secondary Metabolites:

Plant-Taxol/ Quinine/ Tannin/ Caffeine/ Nicotine
Bacteria- Botulin
Fungi- Penicillin

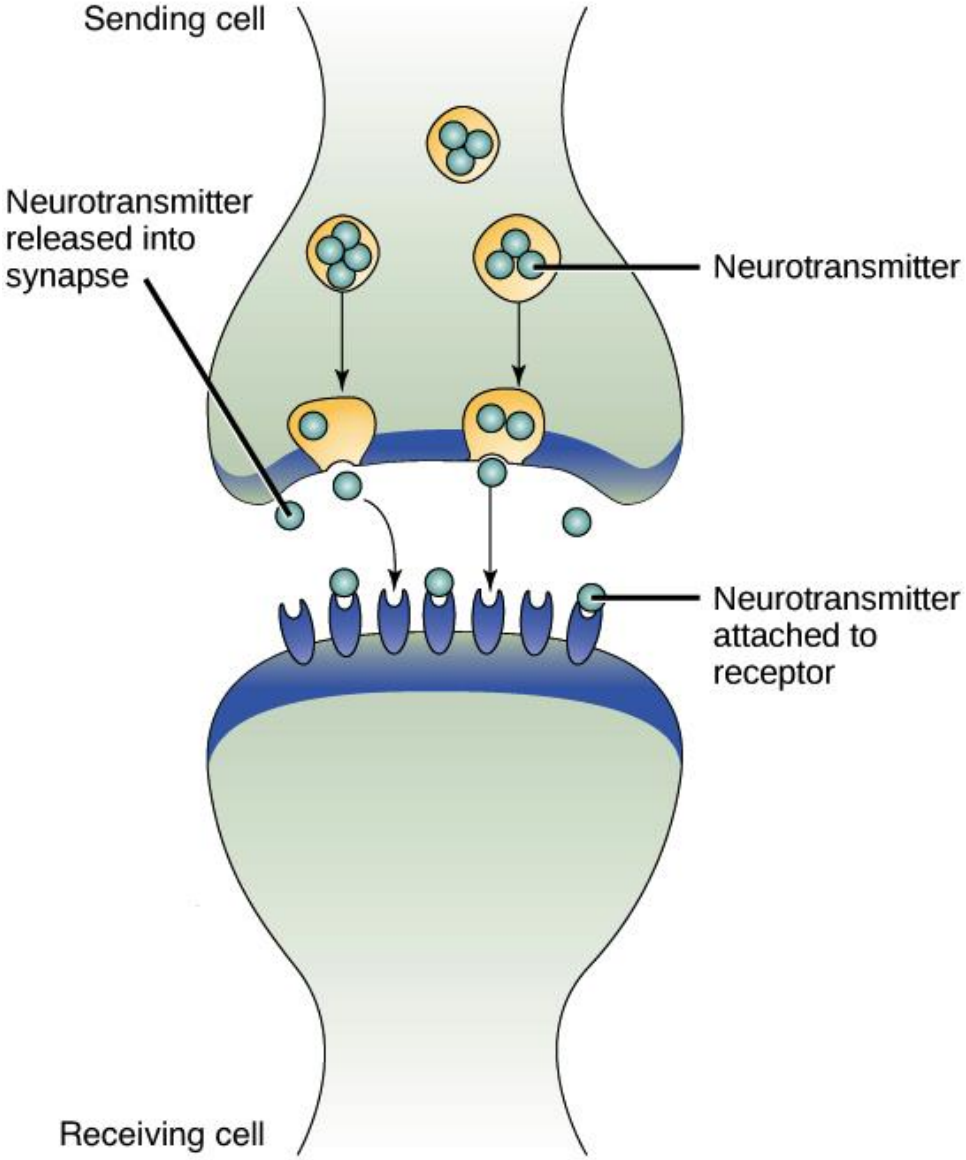
CELLS TALK IN CODES

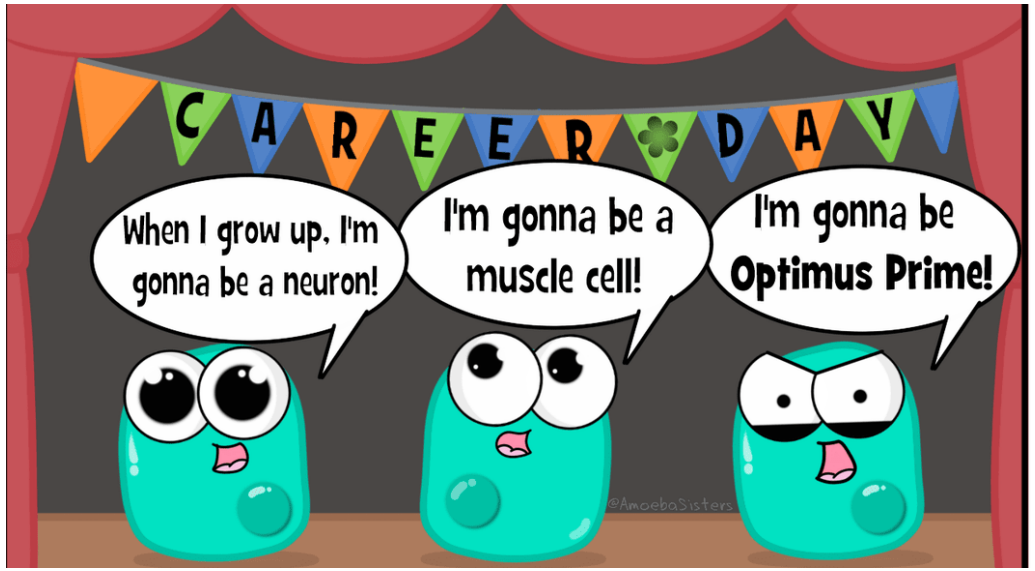
Some UNIVERSAL PRINCIPLES of cell communication are now well known
- **cells may use many different signal molecules including gas (NO)**
- **but only a few mechanisms have survived throughout evolution.**

In multi-cell organisms cell-to-cell contact is critical.
- **cell membranes contain specific protein-receptors, which bind & transmit extra-cellular signal molecules converting signals into specific cellular responses.**



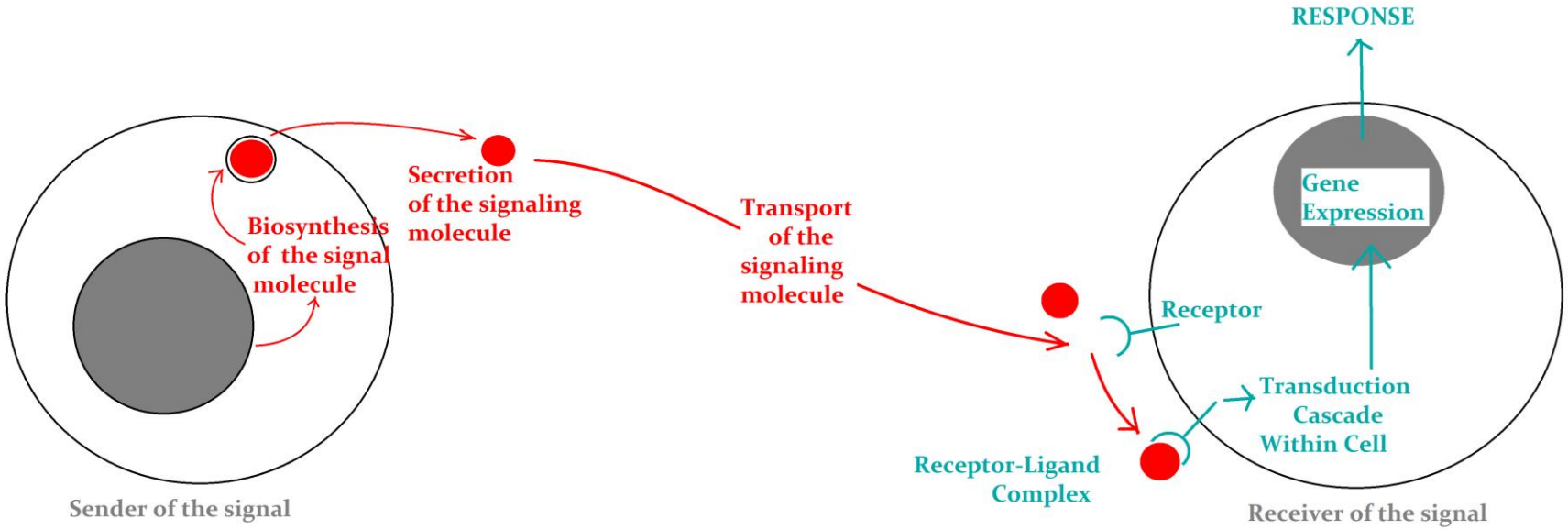
Specificity!


Sending cell
Neurotransmitter released into synapse
Neurotransmitter
Neurotransmitter attached to receptor
Receiving cell


CAREER DAY
When I grow up, I'm gonna be a neuron!
I'm gonna be a muscle cell!
I'm gonna be Optimus Prime!
@AmoebaSisters

WHY DO CELLS SIGNAL?

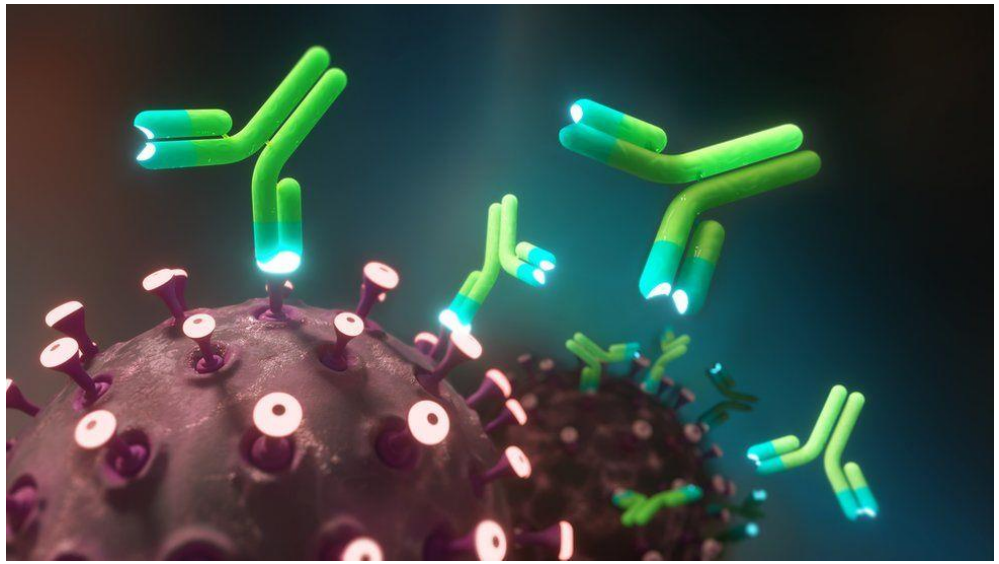
- Regulate gene expression- (Vitamin D, Thyroid)
- Warn of possible infection
- Regulate metabolism
- Allow enzyme secretion in stomach
- Relay messages to-and-from brain-to-body and vice versa
- Fight or flight reaction



RECEPTORS

- 0.01% of the total mass of protein in a cell
- Search through:

1. Gene analysis
2. Monoclonal antibodies



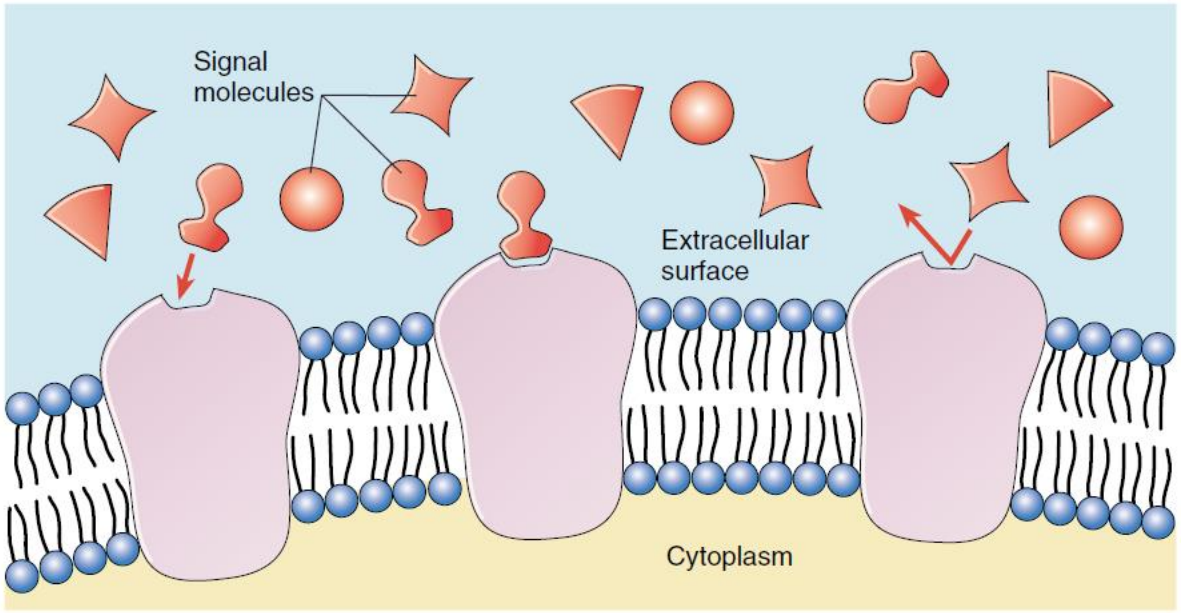


FIGURE 7.2
Cell surface receptors recognize only specific molecules. Signal molecules will bind only to those cells displaying receptor proteins with a shape into which they can fit snugly.

RECEPTORS

- 0.01% of the total mass of protein in a cell
- Search through:

1. Gene analysis
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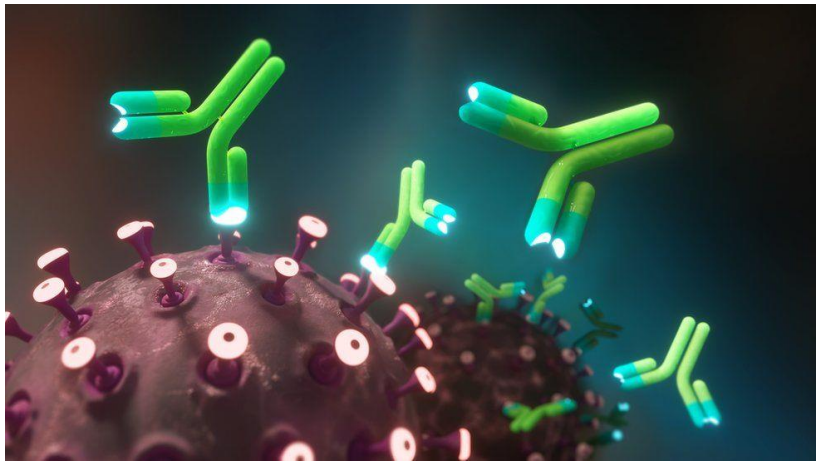
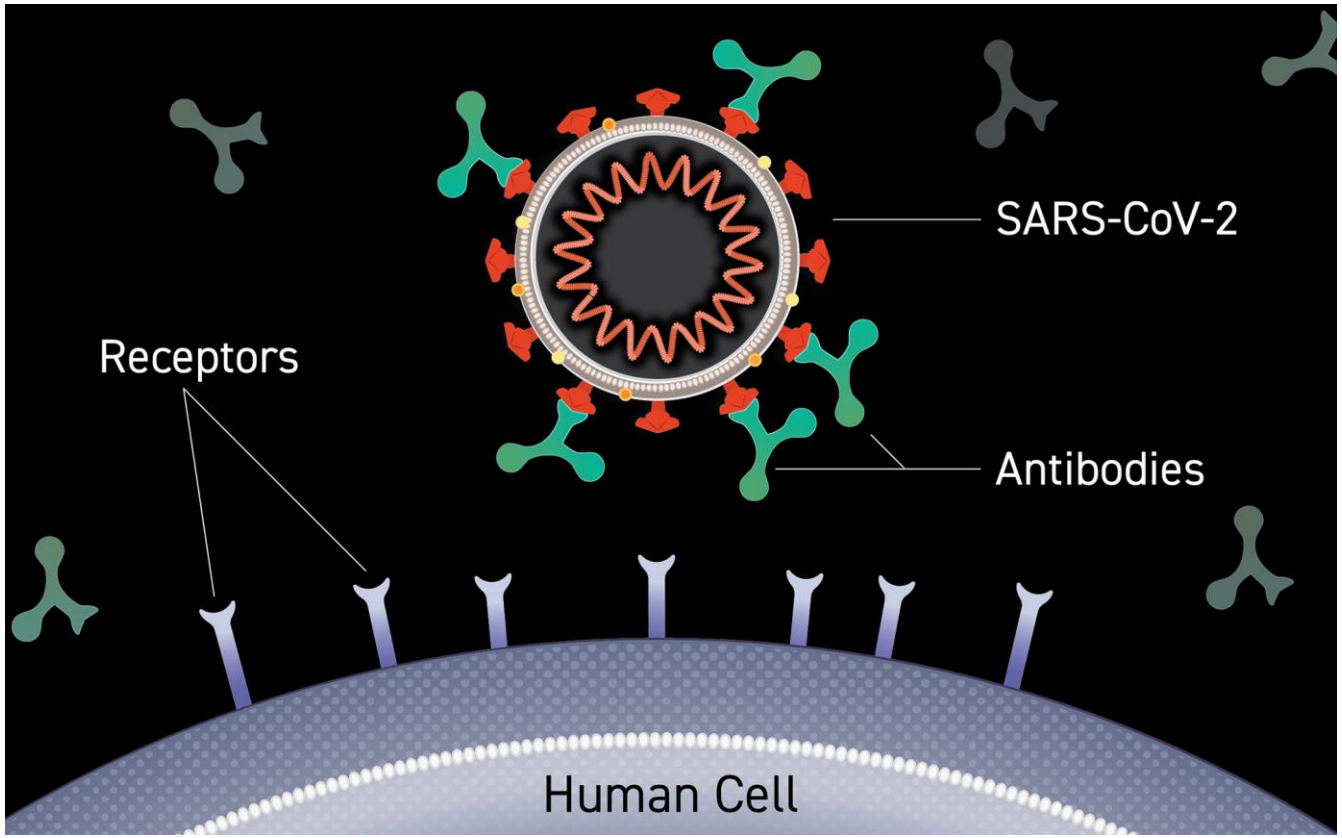
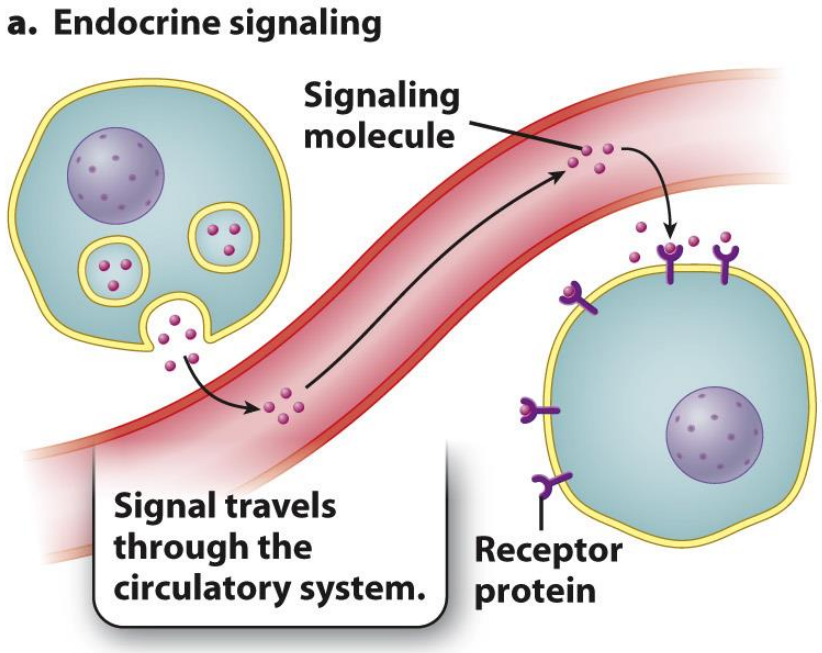
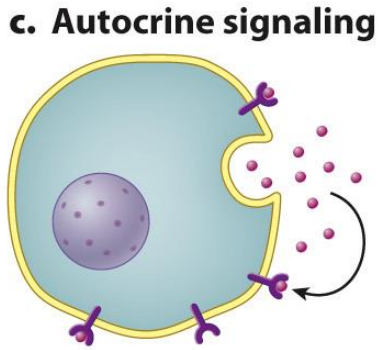




CELLS TALK IN CODES

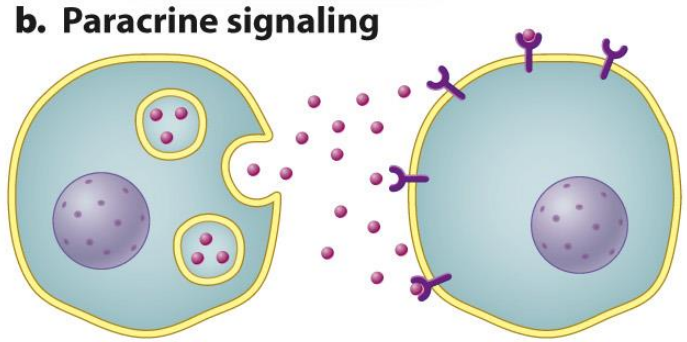
Hormones

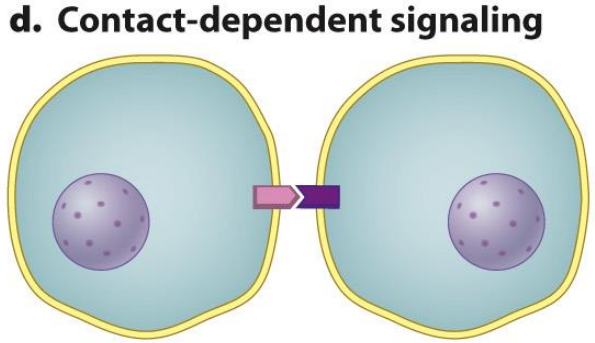




Cancer

Growth factors/
Neurotransmitters

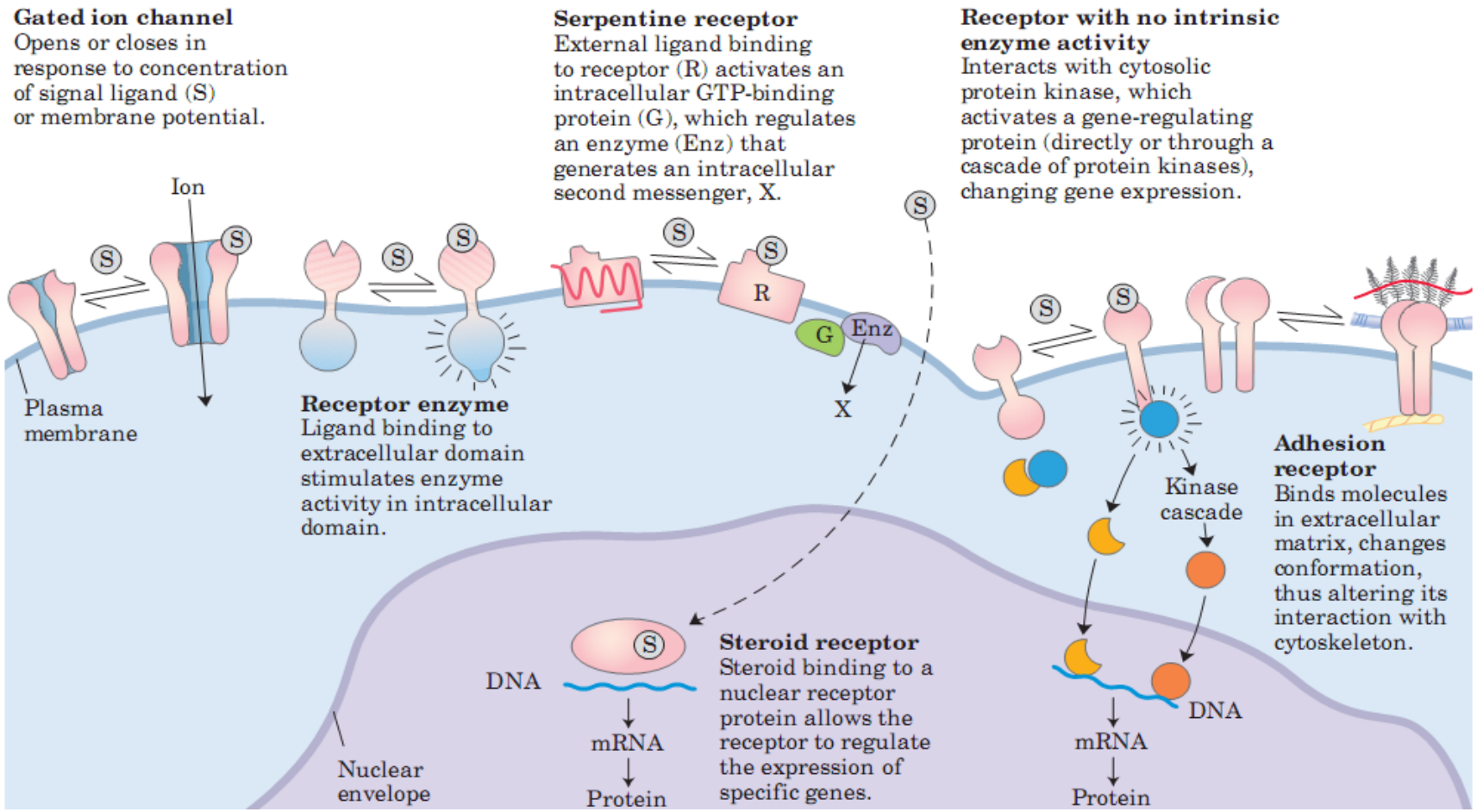


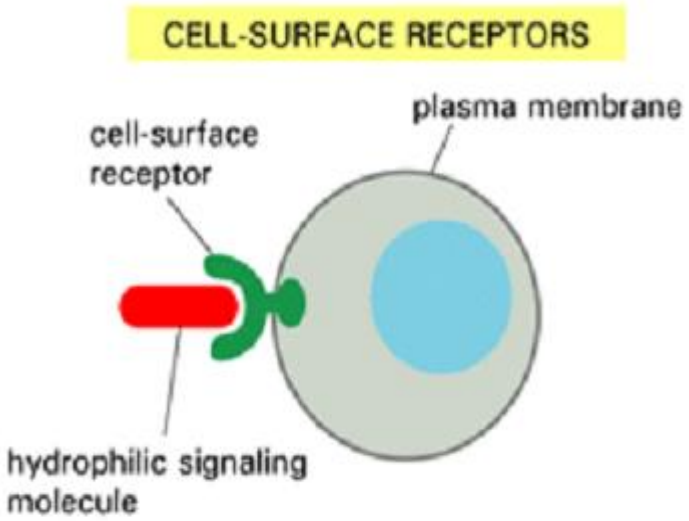


Immune cells
(T-cell)

CELL SIGNALLING

Receptors= Connect inside world with the outside world





Extra cellular Hormone

a) Hydrophilic- Glucagon, Insulin, Epinephrine and Norepinephrine

b) Lipophilic-

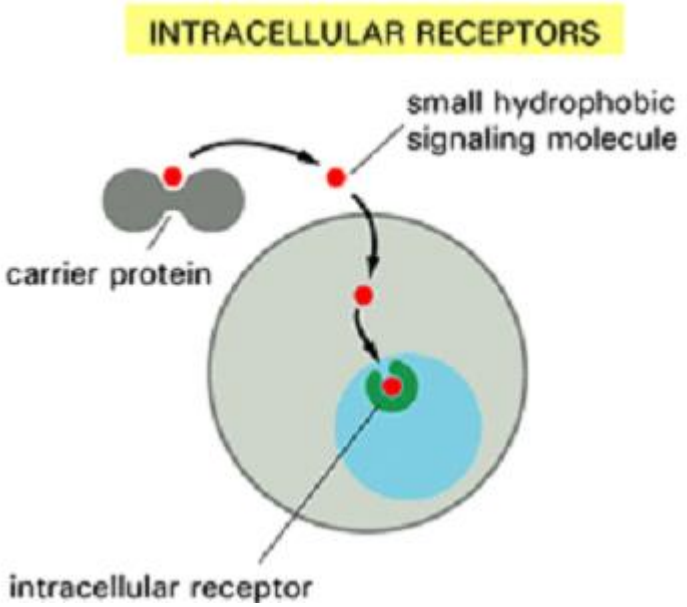
1) Membrane Receptor-Prostaglandins

2) Nuclear Receptor- sex hormones, thyroxine, Vitamin D, Retinoic Acid

Intra cellular Hormone

a) Proteinaceous- Kinase, Phosphatase, GTPase switch protein (ras, rab)

b) Non-proteinaceous (sec. messenger)- cAMP, IP3, DAG, Ca2+, Phosphoinoside



RECEPTOR COMPLEX

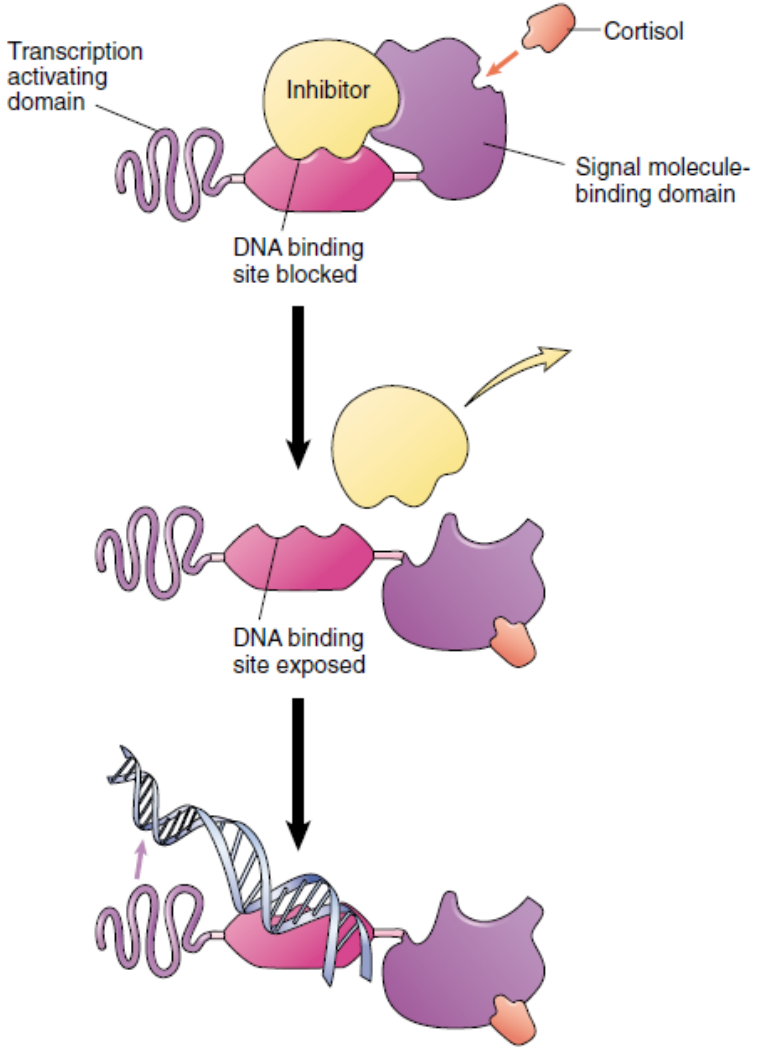
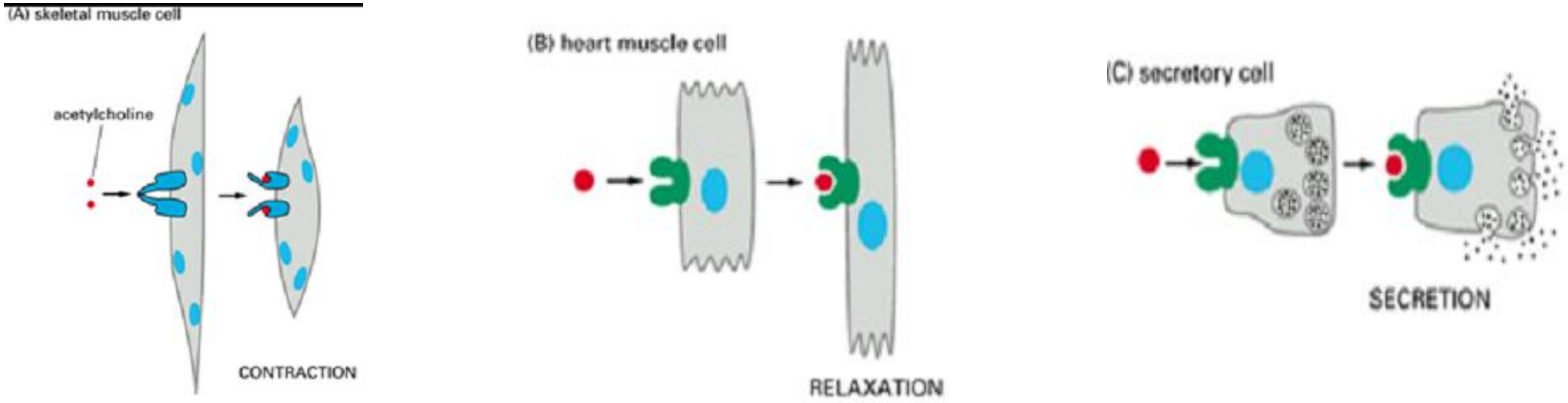


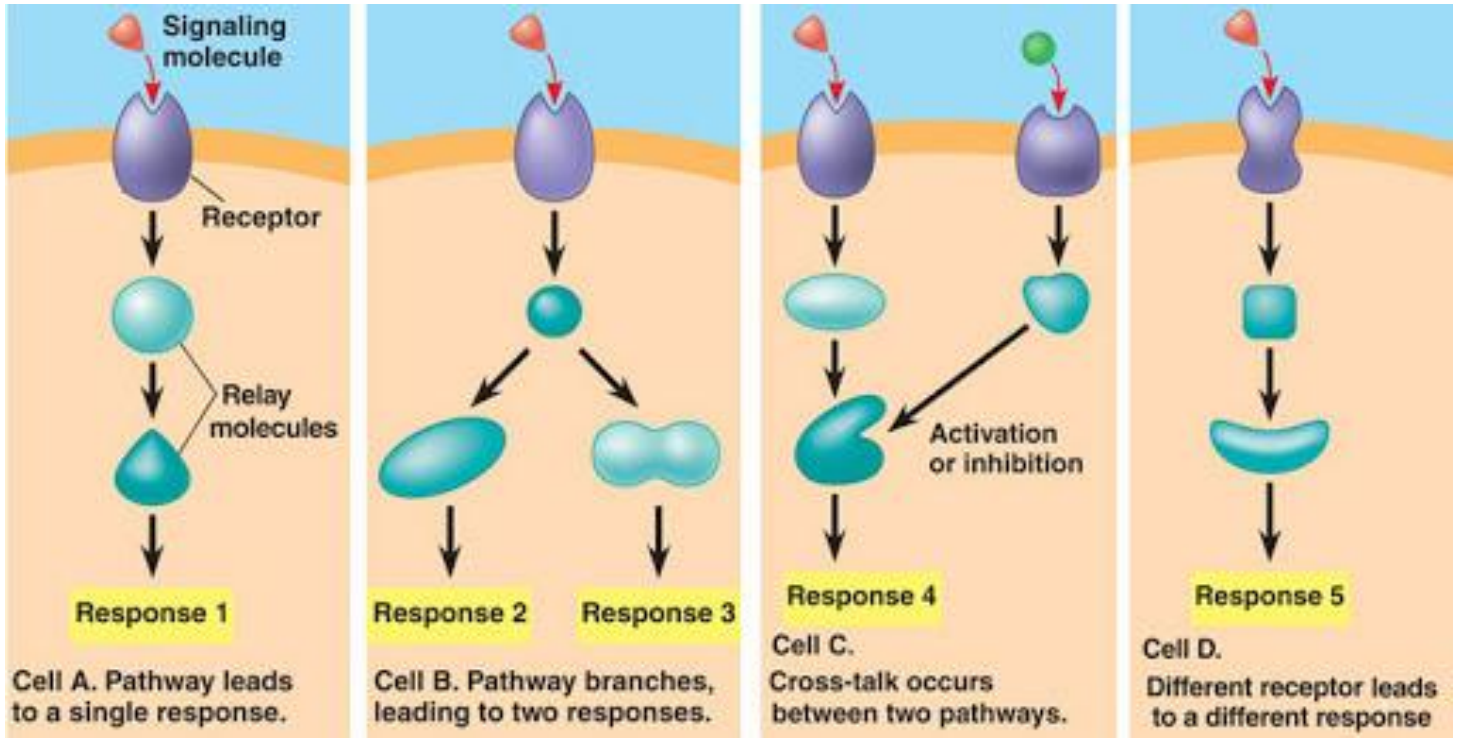
FIGURE 7.5
How intracellular receptors regulate gene transcription. In this model, the binding of the steroid hormone cortisol to a DNA regulatory protein causes it to alter its shape. The inhibitor is released, exposing the DNA binding site of the regulatory protein. The DNA binds to the site, positioning a specific nucleotide sequence over the transcription activating domain of the receptor and initiating transcription.

ACETYLCHOLINE AS THE SIGNALING MOLECULE

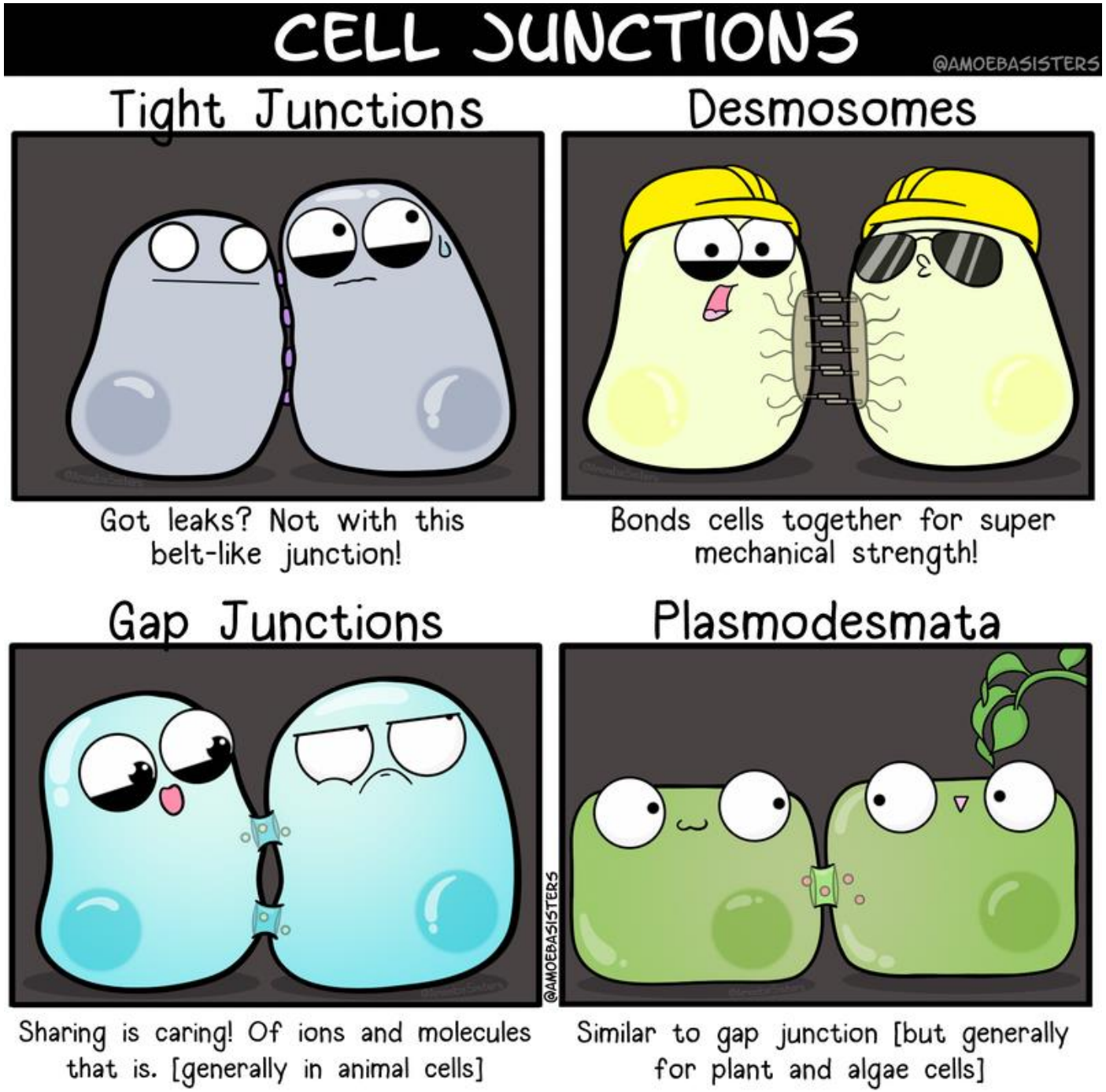


One Ligand can bind to multiple recptor types and bring about different biological response

PERMUTATION-COMBINATIONS



Group I

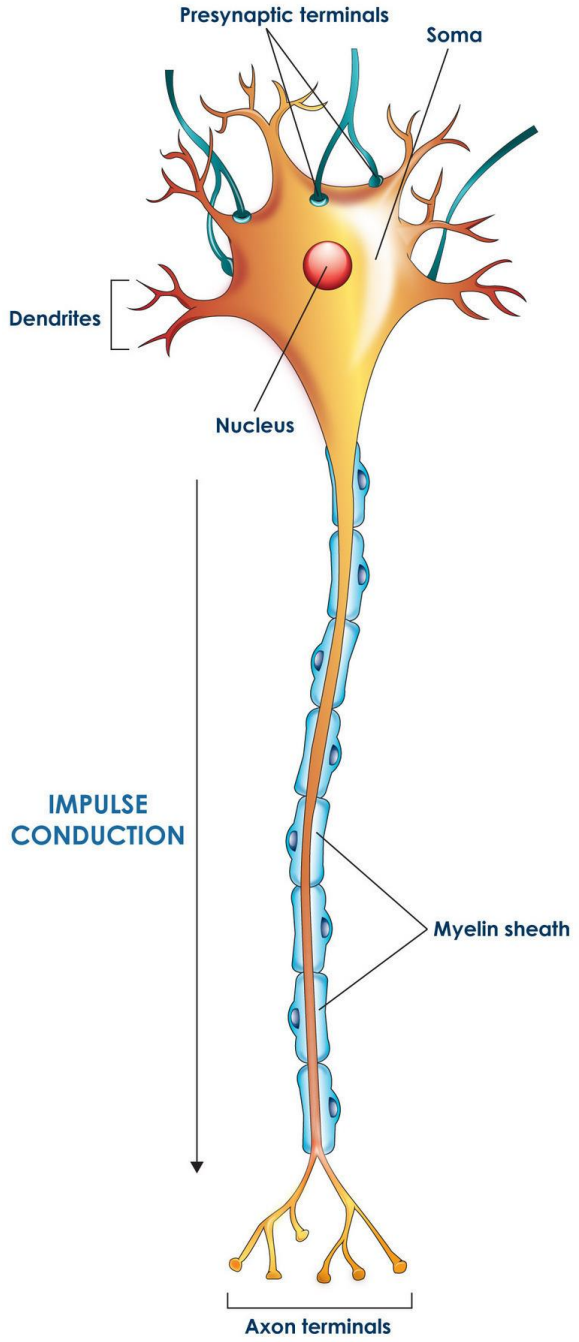


TIGHT JUNCTION
VERSUS
GAP JUNCTION

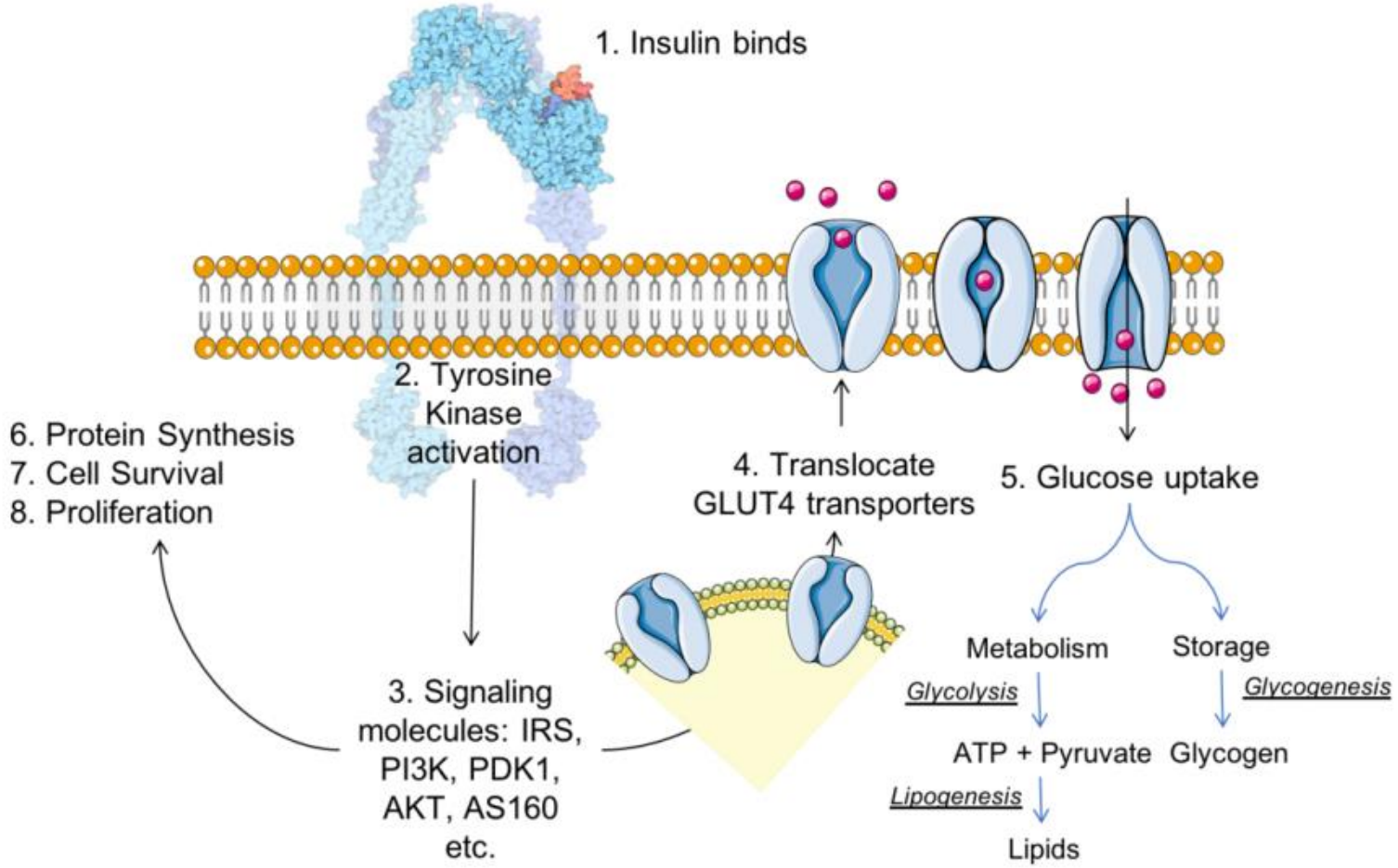
TIGHT JUNCTION	GAP JUNCTION
A specialized connection of two adjacent animal cell membranes, such that, space usually lying between them is absent	A linkage of two adjacent cells consisting of a system of channels extending across a gap from one cell to the other, allowing the passage
Also known as occluding junctions and zonulae occludentes	Also known as nexus and macula communicans
Occur in the epithelia of vertebrates	Occur in all types of tissues, except in fully-developed skeletal muscles and mobile cells types
Contain plasma membranes, which are very tightly pressed against each other due to bound proteins	Consist of cytoplasmic channels from one to the other cytoplasm, surrounding with membrane proteins
Contain proteins called claudins	Contain proteins called connexins
Regulate the movement of water and solutes between epithelial layers	Allows the direct chemical communication between adjacent cytoplasm
Prevent the leakage of extracellular fluid across the epithelial cell layer	Allow the movement of ions, sugars, amino acids, and other small molecules between cells

COMMUNICATION LOSS LEADS TO:

Multiple Sclerosis
Myelin sheath that protects nerve cells disappears
Brain and spinal cord
Signal do not pass

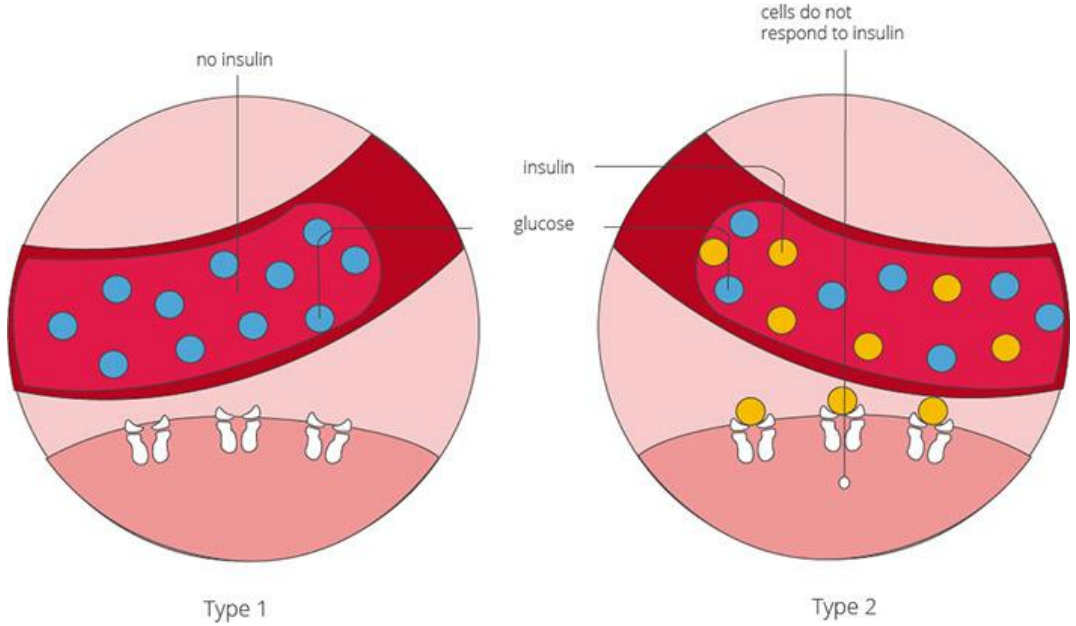


INSULIN SIGNALLING PATHWAY:



COMMUNICATION LOSS LEADS TO:

Diabetes
Target cell receptor not responding to Insulin signal
Diabetes 1- insulin signal is unable to be produced
Diabetes 2- cells have lost the ability to respond to the signals, resulting in abnormally high and dangerous sugar levels in the blood



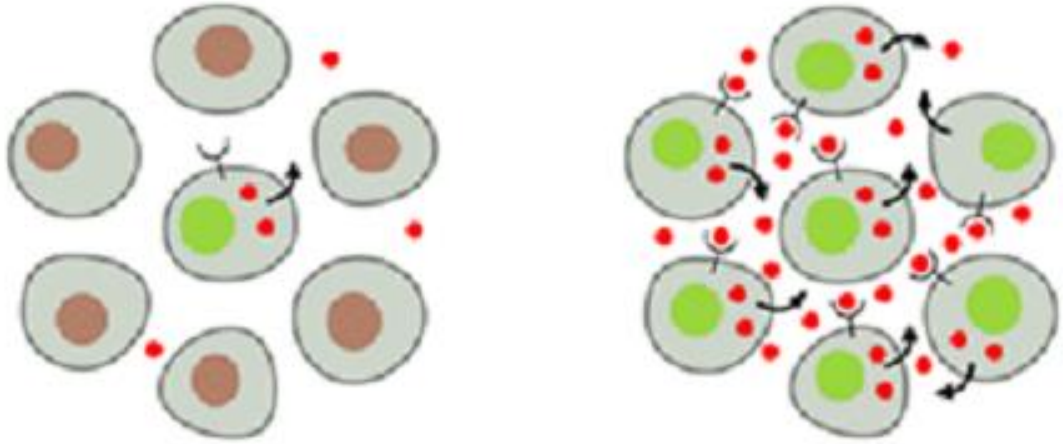
COMMUNICATION LOSS LEADS TO:

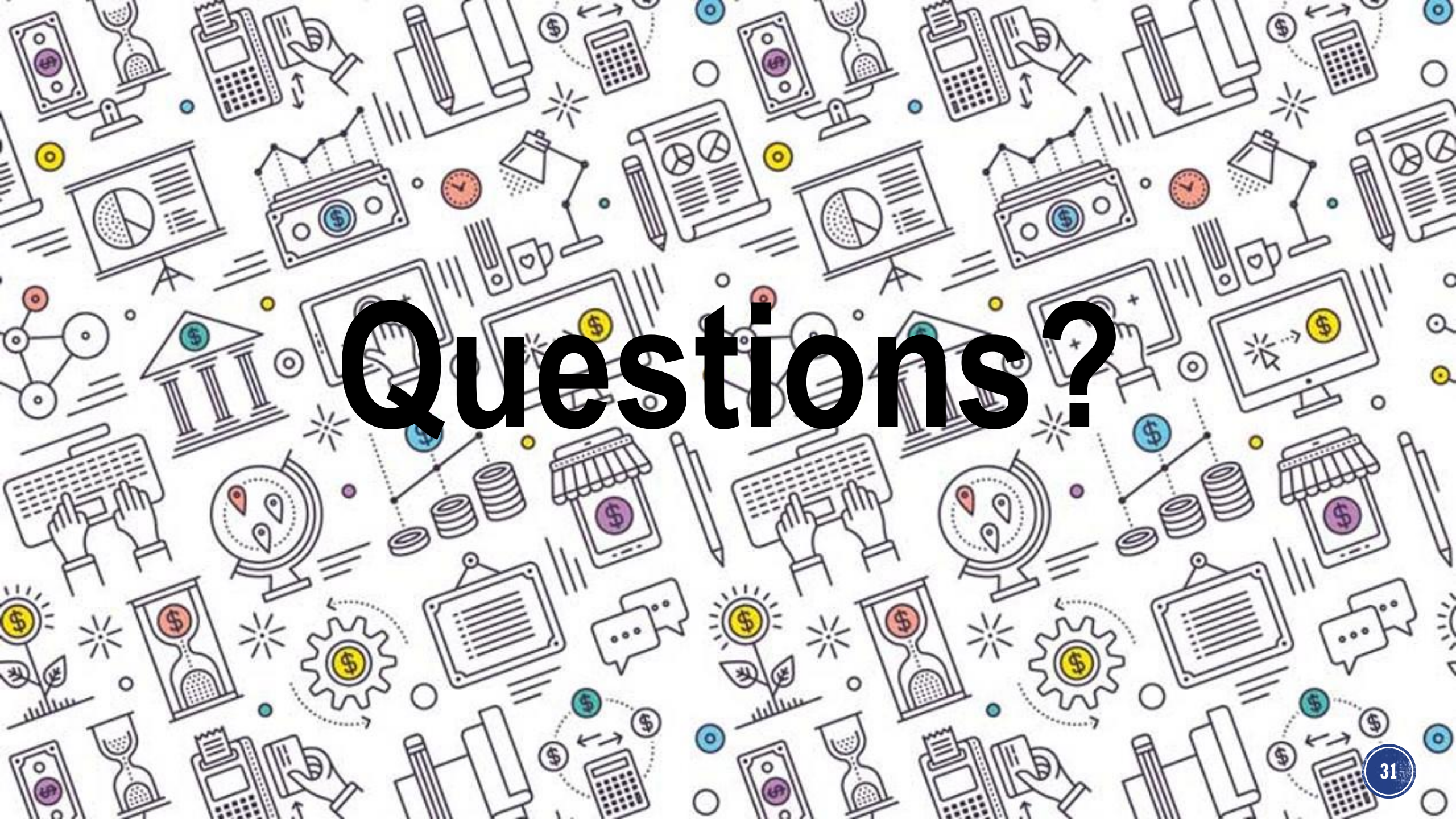
Brain Stroke

- Abnormally high amount of glutamate secreted by dying brain cells
- Kills healthy brain cells (excitotoxicity)
- Extensive brain damage

COMMUNICATION LOSS LEADS TO:

Cancer
Breakdown of multiple signaling pathways
Uncontrolled proliferation of cells- cancer




Questions?