The Working Cell and its Dynamic Activities

سلول در حال کار
و
فعالیتهای پویای آن

CELL MEMBRANES

- Purpose
  - Isolate cell from outside environment
  - Regulate materials coming **in** and **out**
  - Communication with other cells

CELL MEMBRANES

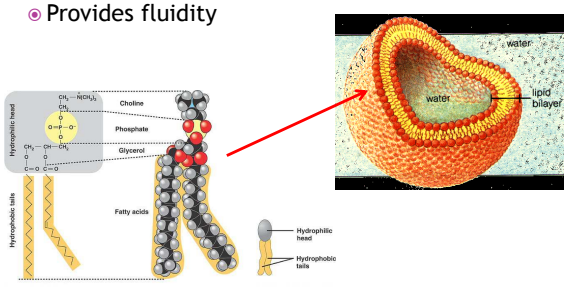
- Basically similar in all membranes
- Fluid mosaic model
  - Mixed composition
  - Lipids not fixed in place, can move

CELL MEMBRANES

- Components
  - Phospholipids
    - Hydrophilic head, hydrophobic tail
  - Glycolipids, glycoproteins
    - Cell signaling
  - Proteins
    - Working molecules
  - Sterols (Cholesterol)
    - Stabilize membrane
    - Increased cholesterol, decreased fluidity

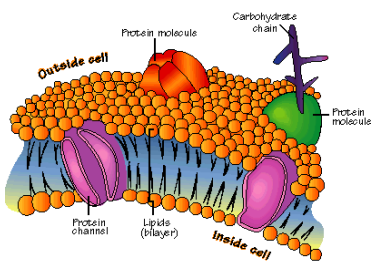
PHOSPHOLIPIDS

- Polar head, non-polar tail
- Majority of membrane
- Provides fluidity



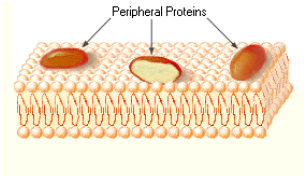
PROTEINS & GLYCOPROTEINS

- Glycoprotein = Carbohydrate + Protein
- Multiple functions within cell membranes



PROTEINS

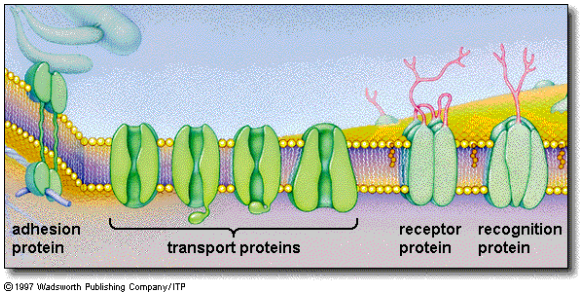
- Peripheral proteins
  - Only on surface, not integrated into membrane
  - Cell receptor sites
    - Cell signaling
  - Structural—cytoskeleton



PROTEINS

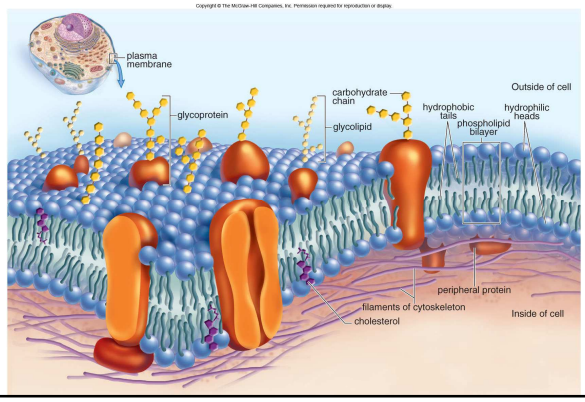
- Integral proteins
  - Embedded within the membrane
  - Channel Proteins—pore; ions, water, other soluble substances pass across
  - Transport/Carrier Proteins—carries specific molecules across surface
  - Adhesion Proteins—connect similar cells into tissues
  - Receptor Proteins—Docks for chemicals that signal cell activities
  - Recognition Proteins—ID self vs. non-self

PROTEINS

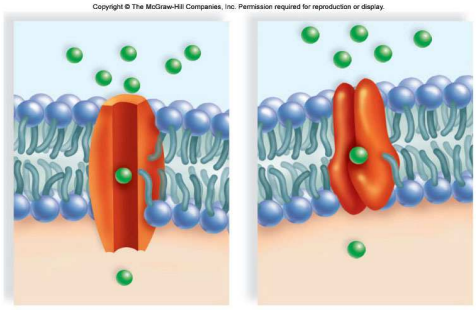


PROTEINS

Proteins in the Plasma Membrane have Numerous Functions

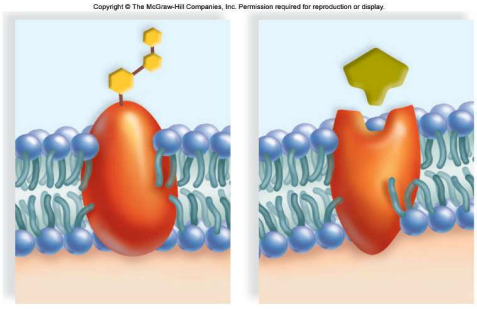


1. Channel Proteins have channels that let molecules move across the membrane
2. Carrier Proteins combine with a molecule to help it move across the membrane
Differentially permeable - only certain substances can pass through a specific carrier protein



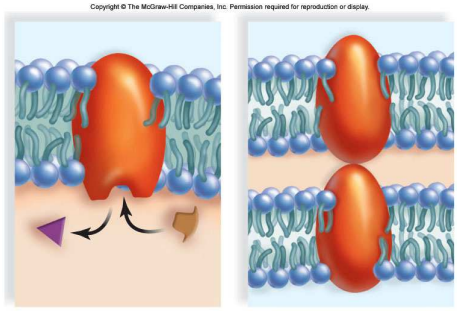
Channel protein Carrier protein

3. Recognition Proteins extend out across the outer surface of the cell and provide recognition patterns that the body's immune system uses to distinguish 'self' from another person's cells and from invading microorganisms.
4. Receptor proteins have a binding site for a specific molecule (e.g., a specific hormone)



Cell recognition protein Receptor protein

5. Enzymatic proteins carry out metabolic reactions
6. Junction proteins form various types of junctions between cells



Enzymatic protein | Junction proteins

MALFUNCTIONING PLASMA MEMBRANE PROTEINS CAN CAUSE HUMAN DISEASES

Diabetes Type 2 - insulin binds to receptor protein, but the number of carriers sent to the plasma is not enough

- Too much glucose in the blood, which spills over into the urine

MALFUNCTIONING PLASMA MEMBRANE PROTEINS CAN CAUSE HUMAN DISEASES

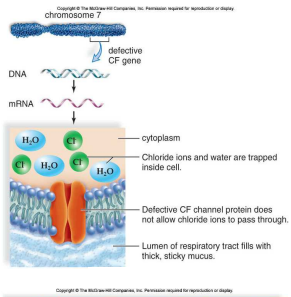
Color Blindness - Usually three types of photopigment proteins in plasma membrane within photoreceptor cells

- Some people lack of functional red or green photopigment

MALFUNCTIONING PLASMA MEMBRANE PROTEINS CAN CAUSE HUMAN DISEASES

Cystic Fibrosis (CF) - Usually, chloride ions pass easily through a plasma membrane channel protein

- When not regulated, a thick mucus appears in the lungs and pancreas damaging the lungs and contributing to an early death



Cystic Fibrosis
is due to a defective CF gene and defective CF channel proteins

MEMBRANE PERMEABILITY

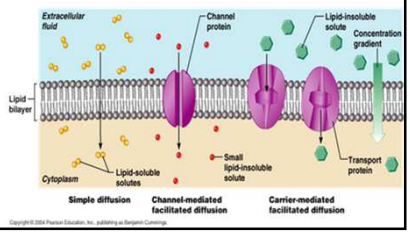
- Selectively permeable
  - Some things pass through, others don't
- Depends on…
  - Size
    - Smaller moves faster
  - Charge
  - Polarity
  - Temperature
    - Faster with higher temp
  - Concentration gradient
    - Concentration is higher on one side than the other
- Equilibrium
  - No movement across membrane
  - Same concentration on either side

MEMBRANE TRANSPORT

- Passive—no energy used
  - Diffusion—movement of molecules/compounds from high to low concentration
  - Osmosis—movement of WATER from high to low
  - Down concentration gradient
- Active—energy used
  - Movement against gradient
  - Usually requires carrier molecule

PASSIVE TRANSPORT

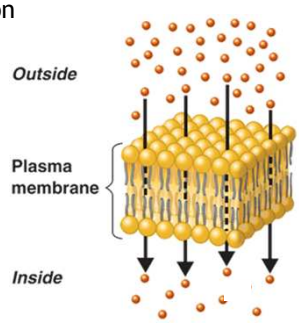
- **Diffusion**
  - Simple &
  - Facilitated
  - Movement of molecules
  - High to low
  - Lipid solubility



SIMPLE DIFFUSION: REQUIRES NO ENERGY

- **Simple Diffusion** - molecules move down concentration gradient until equilibrium is achieved and they are distributed equally
- Dissolved gases can diffuse readily through the phospholipid bilayer
  - How **oxygen** enters and **carbon dioxide** exits cells
  - How oxygen enters blood, and carbon dioxide leaves the blood from air sacs in the lungs

Simple Diffusion: Movement of a solute from an area of **high** concentration **to** an area of **low** concentration



(a) Simple diffusion through the lipid bilayer

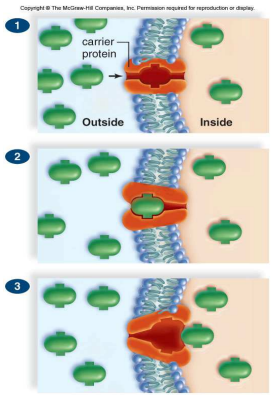
FACILITATED DIFFUSION REQUIRES A CARRIER PROTEIN BUT NO ENERGY

- **Facilitated Diffusion:** certain molecules cross membranes by combining with a carrier protein, but no energy

The carrier proteins are thought to be specific.

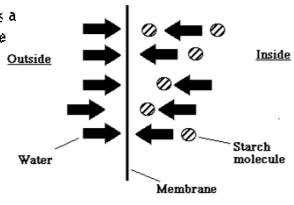
- Substance won't move across without protein "pore"

During facilitated diffusion, a carrier protein assists solute movement across the membrane



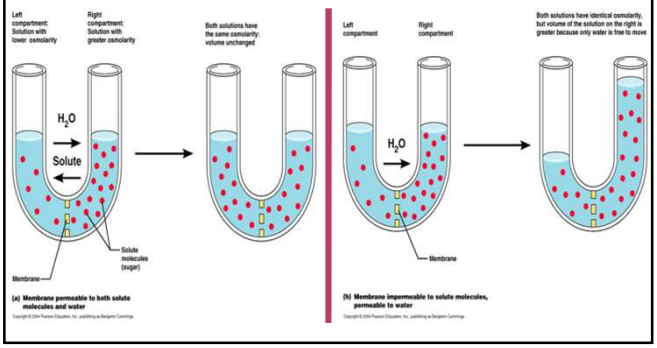
PASSIVE TRANSPORT

- **Osmosis :** diffusion of water across a differentially permeable membrane due to concentration differences
  - Movement of water
  - High to low
  - Semipermeable membrane
  - Based on solute



- **Solution** contains both a solute and a solvent. **Solvents** dissolve **solutes**

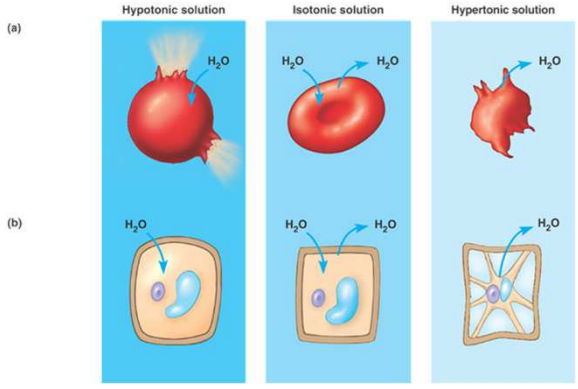
DIFFUSION VS. OSMOSIS



TONICITY نیروی ارتجاعی

- Relative concentration of solutes
- Across semi-permeable membrane
  - Water moves, not solute!!!
- Isotonic (*iso*, same as)
  - Same solute concentration in cell & solution
  - No movement
- Hypertonic (*hyper*, more than)
  - More solutes in solution than cell
  - Water moves out of cell
  - Cell will shrink
- Hypotonic (*hypo*, less than)
  - Less solutes in solution than cell
  - Water moves into cell
  - Cell will expand, may burst (lyse)

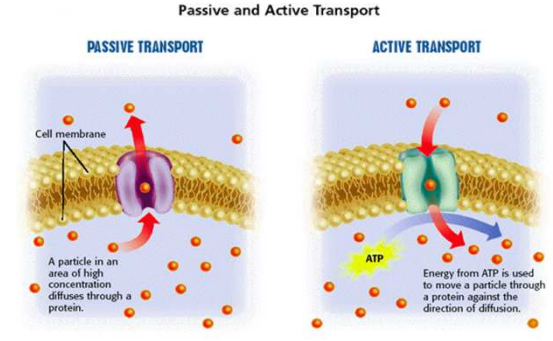
TONICITY



ACTIVE TRANSPORT

- Requires energy
  - **ATP**
- Against a gradient
- Requires a transport protein
  - Protein changes shape to move the solute

PASSIVE VS. ACTIVE



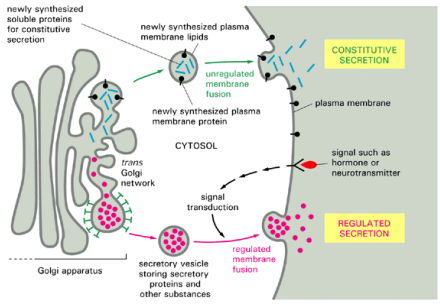
BULK TRANSPORT

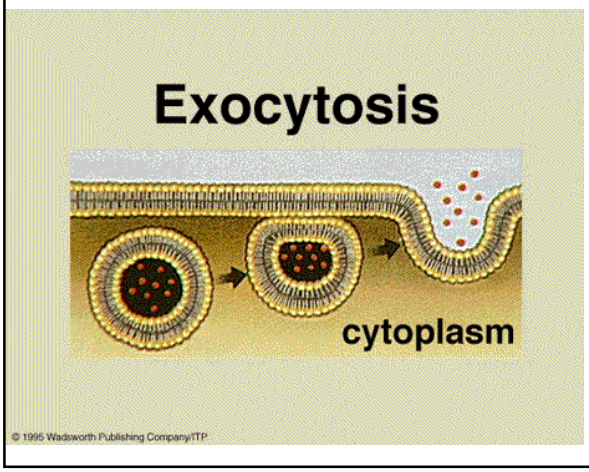
Occurs only in Eukaryotes, when fluid or particles are brought into a cell by vacuole formation.

1. **Endocytosis**
   - Creating vesicle to move things into cell
   - "endo" means "inside"…moving it inside a cell
2. **Exocytosis**
   - Moving things out of cell by merging vesicle into membrane
   - "exo" means "outside"…moving it outside a cell

BULK TRANSPORT

- Exocytosis
  - Moving things out of cell by merging vesicle into membrane
  - Vescicles
  - Golgi bodies

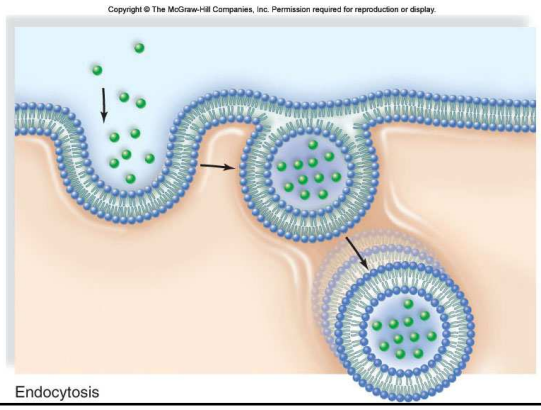




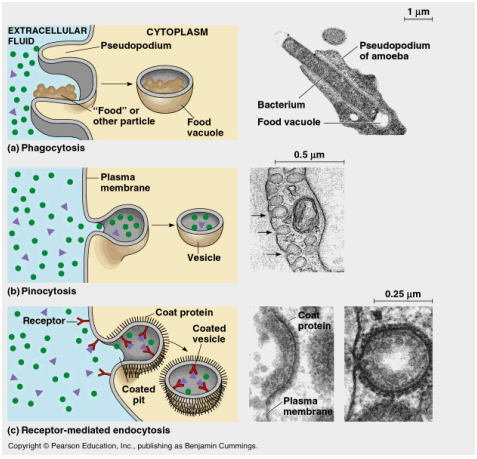
ENDOCYTOSIS

- Receptor-mediated
  - Receptor proteins on cell surface
  - Substance binds to specific receptors
  - Binding triggers pinching-in of membrane
  - Vesicle forms
- Phagocytosis—"cell eating"
  - Engulf food particle (large material)
- Pinocytosis—"cell drinking"
  - Engulf dissolved particles (very small), fluid

BULK TRANSPORT INTO THE CELL IS BY
ENDOCYTOSIS



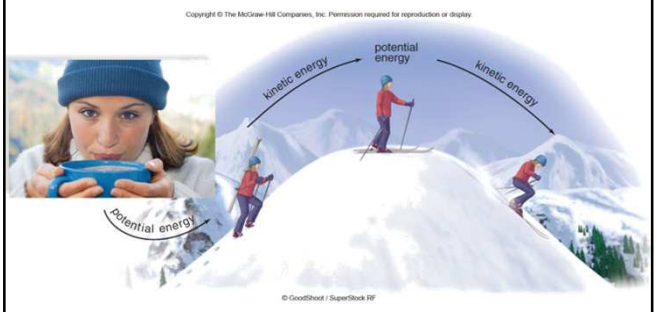
Endocytosis



ENERGY MAKES THINGS HAPPEN

- **Energy** - the capacity to do work
  - **Chemical Energy** present in organic molecules and is the direct source of energy for living things
  - **Potential Energy** is stored energy in resting object
  - **Kinetic Energy** is energy in action or motion
- **Calorie** - the amount of energy to raise the temperature of 1 g of water by 1° Celsius

POTENTIAL ENERGY VERSUS KINETIC ENERGY



THERMODYNAMICS (TWO LAWS OF ENERGY USE)

- 1st Law of Thermodynamics: Energy cannot be created or destroyed
  - Converted from one form to another
- 2nd Law of Thermodynamics: Energy flows from organized to disorganized forms (*Energy cannot be changed from one form to another without a loss of usable energy*)
  - Concentrated energy tends to disperse spontaneously
  - Moves from useable to non-useable energy
  - Chemical bonds resist this direction of energy flow
    - **Entropy** - disorder increases because it is difficult to use heat to perform more work

THERMODYNAMICS

- Entropy: Measure of randomness or disorder in a system
  - Organized energy = useable = less entropy
  - Disorganized = not useable = more entropy
- Living things must maintain ongoing replacement of lost energy

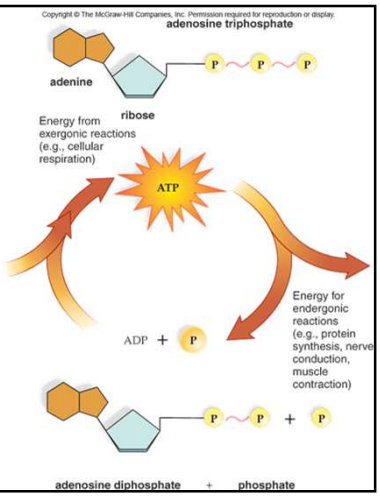
ENERGY

Reactions either release or store energy

- **Exergonic R.**— "outward energy"
  - Burning
  - Cellular respiration
- **Endergonic R.**— "inward energy"
  - Photosynthesis

ATP

- Energy source for cells
- Created by photosynthesis or in mitochondria

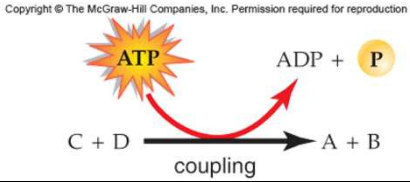


ATP BREAKDOWN IS COUPLED TO ENERGY-REQUIRING REACTIONS

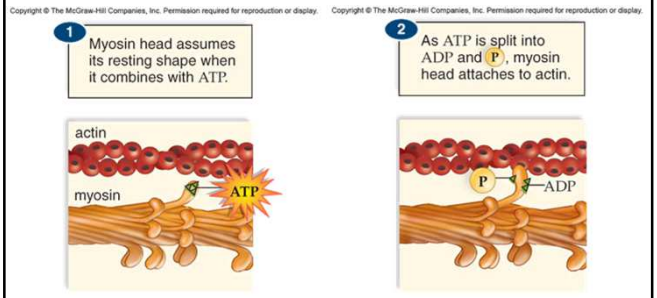
- Breaking down ATP releases energy
  - Energy stored in phosphorus bond
- This powers cell functions
  - E.g. Active transport proteins

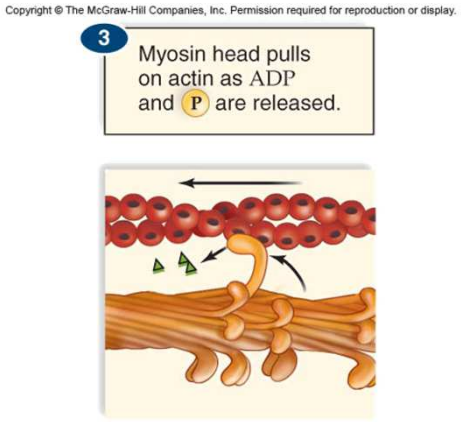
Coupled reactions occur in the same place, at the same time

- energy-releasing (exergonic) reaction drives an energy-requiring (endergonic) reaction



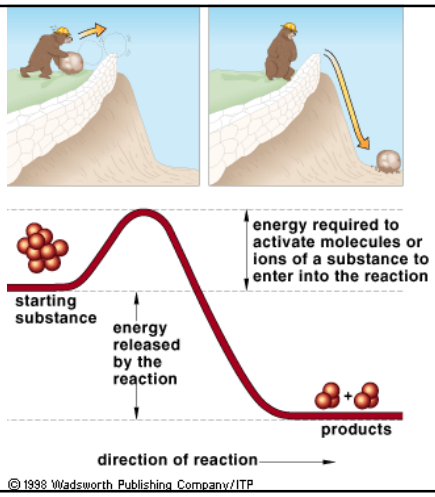
ATP BREAKDOWN COUPLED TO MUSCLE CONTRACTION





CHEMICAL REACTIONS

- Activation Energy—minimum energy that can get a reaction to run on it's own.
  - Cells control energy input into reactions, therefore controlling timing & speed of reactions.



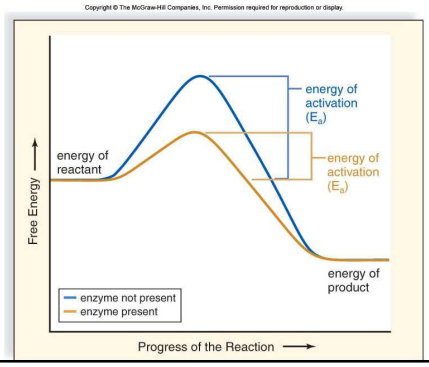
ENZYMES

- Biological catalysts
  - Speed up chemical reactions
  - Don't start reactions on their own
- Reusable
- Can catalyze in forward & reverse
- Very specific in relation to substrates

- **Enzymes** lower **energy of activation** (E_a)

ENZYMES

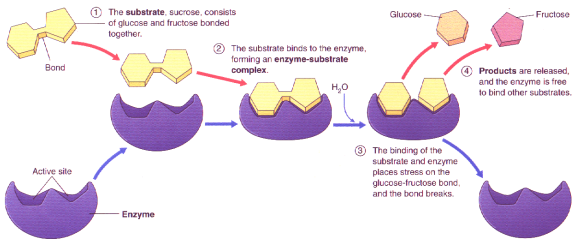
- Lowers activation energy
  - Makes reactions faster & easier



The energy of activation (Ea) is lower when an enzyme is involved

ENZYMES

- Substrate attaches to enzyme's active site

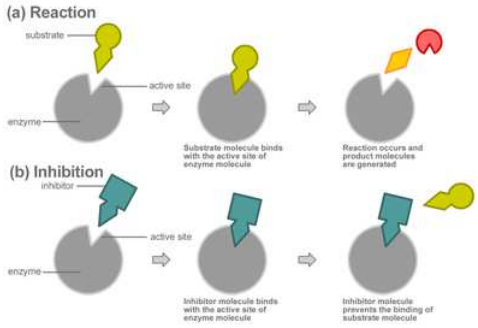


ENZYMES CAN BE INHIBITED BOTH COMPETITIVELY AND NONCOMPETITIVELY

- Enzyme inhibition occurs when a molecule (the inhibitor) binds to an enzyme and decreases its activity
- **Competitive inhibition** - inhibitor and the substrate compete for the same active site
- **Noncompetitive inhibition** - inhibitor binds to the enzyme at a location other than the active site

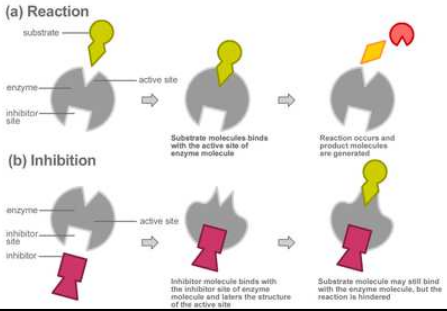
CONTROLS OVER ENZYMES

- Competitive Inhibition
  - inhibitor and the substrate compete for the same active site (or binds to site first or more strongly than enzyme)



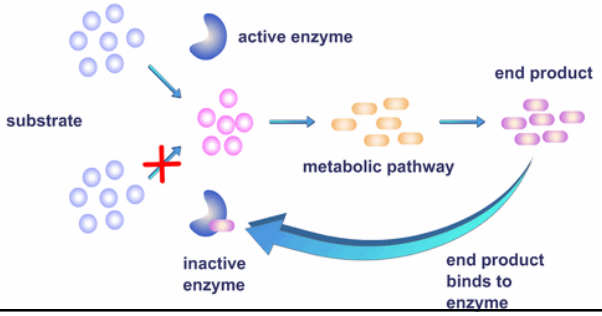
CONTROLS OVER ENZYMES

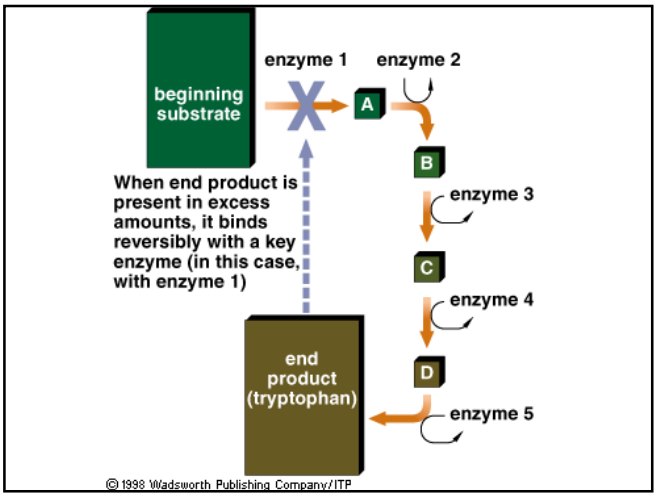
- Noncompetitive inhibition
  - inhibitor binds to the enzyme at a location other than the active site (or Binds to a different area of the substrate)
  - Changes enzyme bonding area



CONTROLS OVER ENZYMES

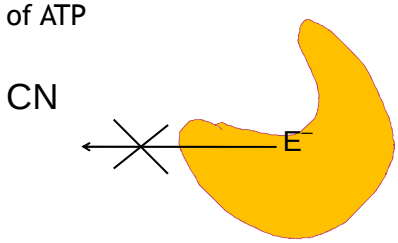
- Feedback inhibition
  - Product of reaction binds to enzyme
  - Shuts down reaction





ENZYME INHIBITORS CAN BE FATAL

Cyanide can be fatal because it binds to a mitochondrial enzyme necessary for the production of ATP



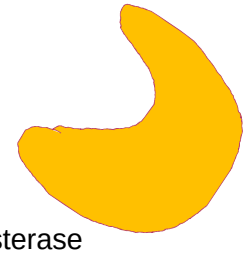
Cytochrome c oxidase

ENZYME INHIBITORS CAN BE FATAL

Sarin is a chemical that inhibits an enzyme at neuromuscular junctions, where nerves stimulate muscles

Neurotransmitter

Sarin



Cholinesterase

ENZYME INHIBITORS CAN BE FATAL

Warfarin can be fatal because it binds to an enzyme that is necessary for blood clotting.

Inhibits enzyme responsible for modifying Vitamin K for use in blood clotting.

Anticoagulant drug (Coumadin) and also serves as a rat poison.

Statins Block Cholesterol Synthesis in the Liver

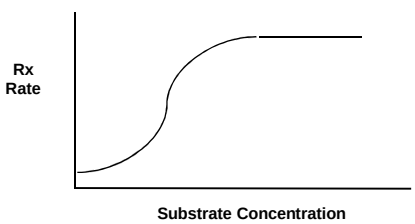
HMG-CoA

Cholesterol

ENZYME SPEED IS AFFECTED BY ENVIRONMENTAL CONDITIONS

1. Substrate Concentration

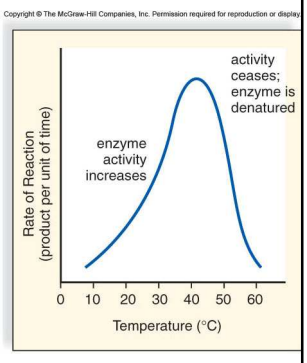
- More substrate means more chance encounters between substrate molecules and the enzyme



ENZYME SPEED IS AFFECTED BY ENVIRONMENTAL CONDITIONS

2. Temperature

- Warmer temperatures cause more effective encounters between enzyme and substrate



ENZYME SPEED IS AFFECTED BY ENVIRONMENTAL CONDITIONS

3. **pH**
   - A change in pH can change the enzyme's shape and disrupt normal interactions
4. **Cofactors**
   - The presence of molecules like coenzymes or vitamins allow enzymes to be active

ENZYME SPEED IS AFFECTED BY ENVIRONMENTAL CONDITIONS

5. **Inhibitors**
   - Compounds that interfere with enzyme activity