METABOLISM= all the chemical reactions in an organism

CATABOLIC PATHWAY (CATABOLISM)-

• release of energy by the breakdown of complex molecules to simpler compounds

EX: digestive enzymes break down food

ANABOLIC PATHWAY (ANABOLISM)

• consumes energy to build complicated molecules from simpler ones

EX: linking amino acids to form proteins

ORGANISMS TRANSFORM ENERGY

ENERGY- capacity to do work

KINETIC ENERGY- energy of moving objects

POTENTIAL ENERGY- energy stored as a result of position or structure

CHEMICAL ENERGY- form of potential energy stored in chemical bonds in molecules

THERMODYNAMICS- study of energy transformations that occur in matter

1st LAW OF THERMODYNAMICS = Conservation of energy

• energy of universe is constant; energy CAN BE transferred and transformed, but NEVER created or destroyed

2nd LAW OF THERMODYNAMICS

• every energy transfer or transformation increases the entropy (disorder or randomness) in universe

• Living systems **DO NOT VIOLATE** 2nd Law of Thermodynamics (open systems with constant input of matter & energy)

Equation that describes energy of system; $\Delta G = \Delta H - T\Delta S$

You don't need to be able to do G problems; just know that there is an equation;

Δ G = change in free energy

S = ENTROPY

G = FREE ENERGY of a system

(energy that is able to perform work when the temperature is uniform)

H = Total energy in system

T = Absolute temperature in °Kelvin

EXERGONIC REACTION- releases energy and occurs spontaneously

Energy of products is lower than energy of reactants (negative G)

ENDERGONIC REACTION- requires energy; absorbs free energy from system; not spontaneous

Energy of products is higher than energy of reactants (positive G)

SPONTANEOUS REACTION - can occur without outside help

- can be harnessed to do work (objects moving down their power gradient)

Growth, reproduction and maintenance of organization in living systems require

- constant input of free energy and matter

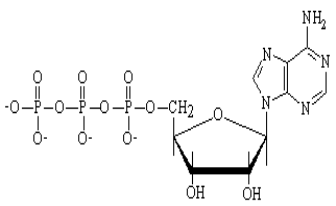
Loss of order/free energy = death

Cells manage their energy resources and do work by **ENERGY COUPLING**

(use energy from exergonic reactions to drive endergonic ones)

Energy input must exceed free energy lost to entropy

to maintain order & power cellular processes



Key role of ATP = **ENERGY COUPLING**

ADENOSINE TRIPHOSPHATE (ATP)

= primary source of energy in all living things
ADP (adenosine diphosphate) + P_i → ATP

-adding phosphate group stores energy

-removing it releases energy = - ΔG reaction

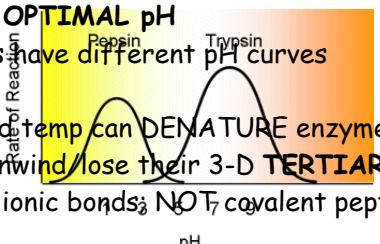
- hydrolysis of ATP provides energy for + ΔG reactions

ACTIVATION ENERGY = amount of energy required to get chemical reaction started
CATALYST- substance that changes the rate of a chemical reaction without being altered
ENZYMES = biological catalysts; most enzymes are **PROTEINS** (Ch 17 & 26: RNA enzymes = RIBOZYMES)
ENZYMES work by **LOWERING ACTIVATION ENERGY;** Don't change the FREE ENERGY of reaction
SUBSTRATE= Reactant enzyme acts on
ACTIVE SITE = region on enzyme that binds to substrate
Substrate held in active site by **WEAK** interactions (ie. hydrogen and ionic bonds)
SUBSTRATE(S) + enzyme → Enzyme-substrate complex → enzyme + PRODUCT(S)

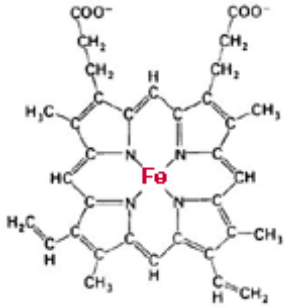
ENZYMES are **UNCHANGED & REUSABLE**
LOCK-AND-KEY MODEL: enzyme fits substrate like "lock and key"
-only specific substrate will fit
INDUCED FIT MODEL: once substrate binds to active site, enzyme changes shape slightly to bind the substrate more firmly placing a strain on the existing bonds in substrate lowering act energy

Enzymes have **OPTIMAL TEMPERATURE** for activity
Higher temperatures = more collisions among the molecules so increase rate of a reaction BUT. . .above a certain temperature, activity begins to decline because the enzyme begins to **DENATURE**
So . . . rate of chemical reaction increases with temperature up to optimum, then decreases.

Enzymes have own **OPTIMAL pH**
Different enzymes have different pH curves



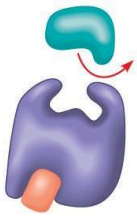
Extremes in pH and temp can DENATURE enzymes
-causing them to unwind/lose their 3-D **TERTIARY** structure
-breaks hydrogen, ionic bonds; NOT covalent peptide bonds



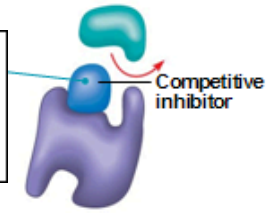
Many enzymes require helpers:
NON PROTEIN helper
= COFACTOR
Ex: METAL IONS
(zinc, iron, and copper)

ORGANIC helpers = **COENZYMES**
Ex: vitamins
-part of NAD+, NADP, $FADH_2$,
Coenzyme A molecules

Hemoglobin



COMPETITIVE INHIBITORS
- reversible
- compete with substrate for active site

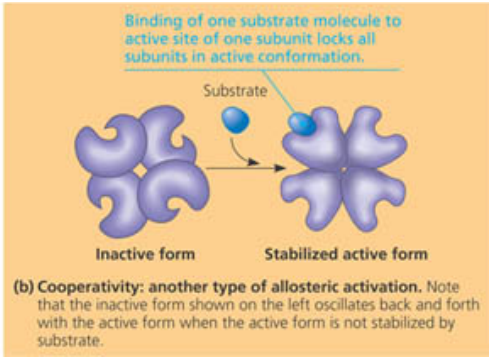


NONCOMPETITIVE INHIBITORS
- bind another spot on enzyme
- cause shape change making active site nonfunctional

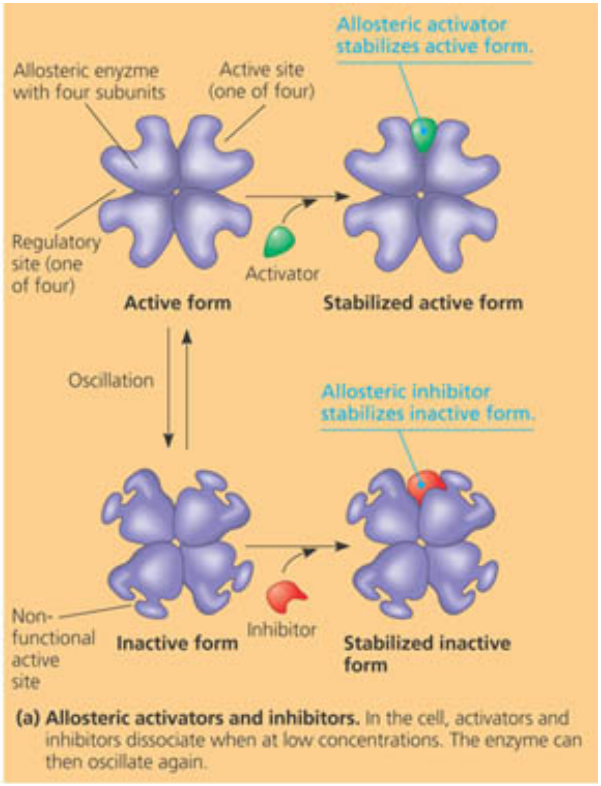
ENZYME REGULATION:

REGULATORS bind to **ALLOSTERIC** site
- binding site on enzyme (not active site)
- binding changes shape of enzyme
- **ACTIVATORS** can stimulate

INHIBITORS inhibit enzyme activity

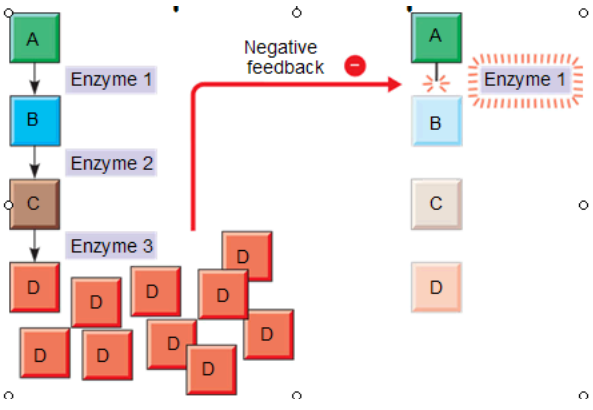


(b) **Cooperativity: another type of allosteric activation.** Note that the inactive form shown on the left oscillates back and forth with the active form when the active form is not stabilized by substrate.



(a) **Allosteric activators and inhibitors.** In the cell, activators and inhibitors dissociate when at low concentrations. The enzyme can then oscillate again.

NEGATIVE FEEDBACK (FEEDBACK INHIBITION)
- switches off pathway when product is plentiful
- common in many enzyme reactions;
- saves energy; don't make it if you don't need it



POSITIVE FEEDBACK – speeds up pathway
- Less common

EX: Chemicals released by platelets that accumulate at injury site, attract MORE platelets to the site.

