Water

I. Properties of Water

A. Hydrogen bonding is responsible for other properties.
B. High surface tension.
C. Capillarity.
D. High specific heat and therefore:
    1. it's a good coolant
    2. it's a good antifreeze
E. High heat of fusion and vaporization
    1. If water didn't hydrogen bond it would boil at a much lower temperature and freeze at a much higher temperature.
F. Most dense at 4°C.
G. Universal solvent
H. Great lubricant

II. Buffers

A. Can the body withstand major shifts in pH?
B. The pH of human blood ranges between 7.35-7.45
C. There are several buffer systems including the sodium bicarbonate/carbonic acid systems, as well as the amino acids and proteins.
D. The Sodium bicarbonate-carbonic acid system

1. What happens when a strong acid enters the blood stream?

$$HCl + NaHCO_3 \rightleftharpoons NaCl + H_2CO_3$$

Strong acid — Sodium Bicarbonate (Weak Base) — Sodium chloride — Carbonic Acid (Weak Acid)

2. What happens when a strong base enters the blood stream?

$$NaOH + H_2CO_3 \rightleftharpoons NaHCO_3 + H_2O$$

Strong Base — Weak Acid — Weak Base — Water

Chemistry of Life

I. HONC Rule

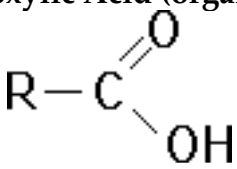
II. Hydrocarbons

A. Composed of hydrogen and carbon and form the backbone of most organic molecules.
B. Have a lot of stored energy.
C. Insoluble in water, Why?
D. Examples: CH_4 and C_3H_8

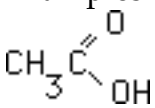
III. Alcohols (R-OH)

A. A hydroxyl group.
B. Soluble in water.
C. Also good fuels.
D. Examples: CH_3CH_2OH (Ethanol)

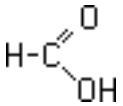
IV. Carboxylic Acid (organic acid)



A. many are aromatic
B. Water soluble
C. Sour
D. Examples:



Acetic Acid (Vinegar)

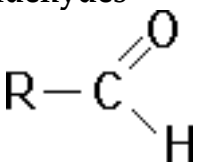


Formic Acid ("Piss Ants")

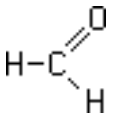
V. Amines (R- NH_2)

A. Soluble in water
B. Alkaline (a proton acceptor)
C. Example: NH3 ammonia

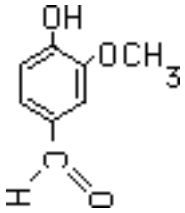
VI. Aldehydes



A. Small ones (4 carbons or less) are soluble in water
B. Aromatic aldehydes are used as artificial scents, see example.
C. Examples of aldehydes:

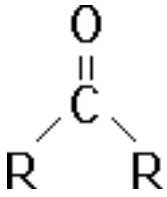


Formaldehyde

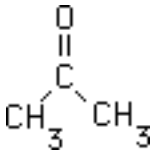


Vanillin

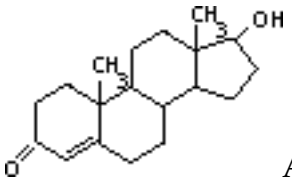
VII. Ketones



A. Also very aromatic.
B. Many steroids contain ketone groups.
C. Examples



Testosterone



Acetone

Foodstuffs

I. Carbohydrates (composed of C, H and O).

A. Functions

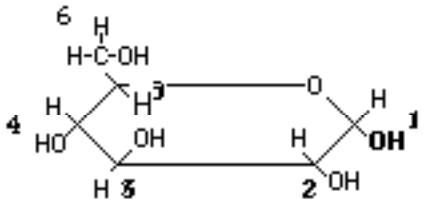
1. Fast energy (4 Kcals/ gram)
2. Roughage
3. Structural backbone of plant cell walls (wood).

B. Structure

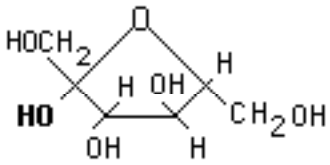
1. Carbohydrates are classified according to **size** (# of carbon atoms) and/or type of **functional groups** (aldehyde or ketone) or the complexity.
    a) Examples: pentose or hexose (**How many carbons**?) Or aldose or ketose (**what functional group**?)

C. Monosaccharides

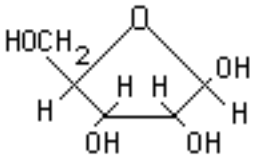
1. composed of a **single** sugar unit.



Glucose



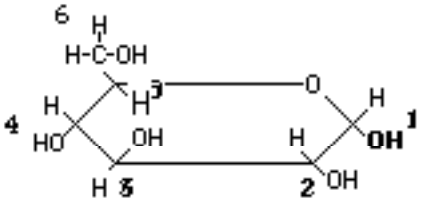
Fructose



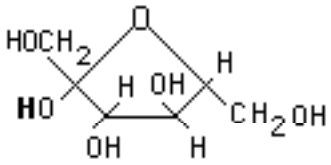
Ribose

D. Disaccharides

1. composed of **two** sugar units
2. How does a disaccharide form?

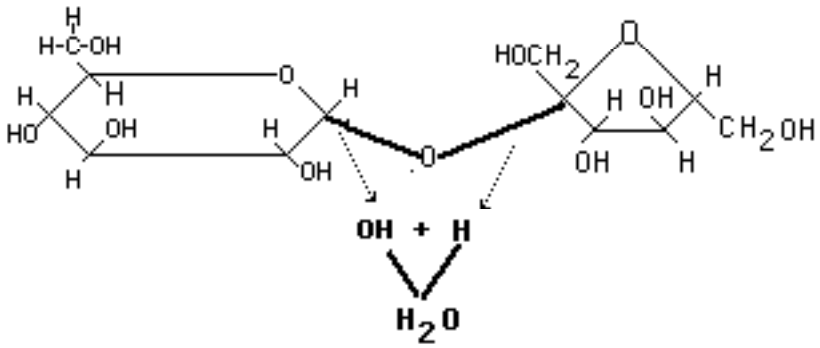


Glucose



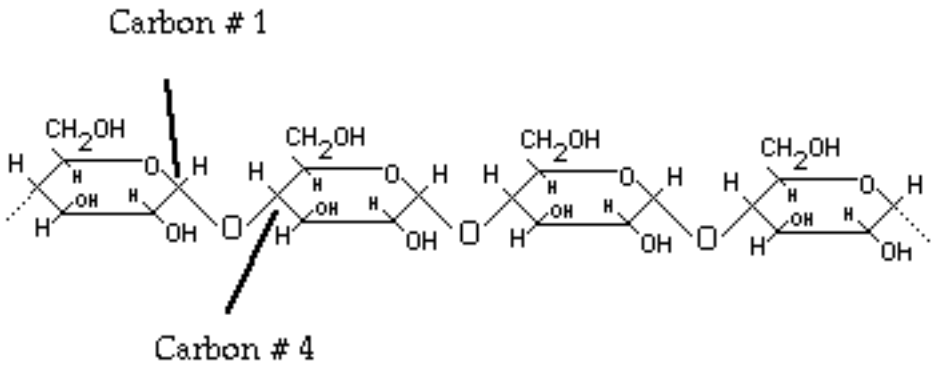
Fructose

Sucrose



E. Polysaccharides

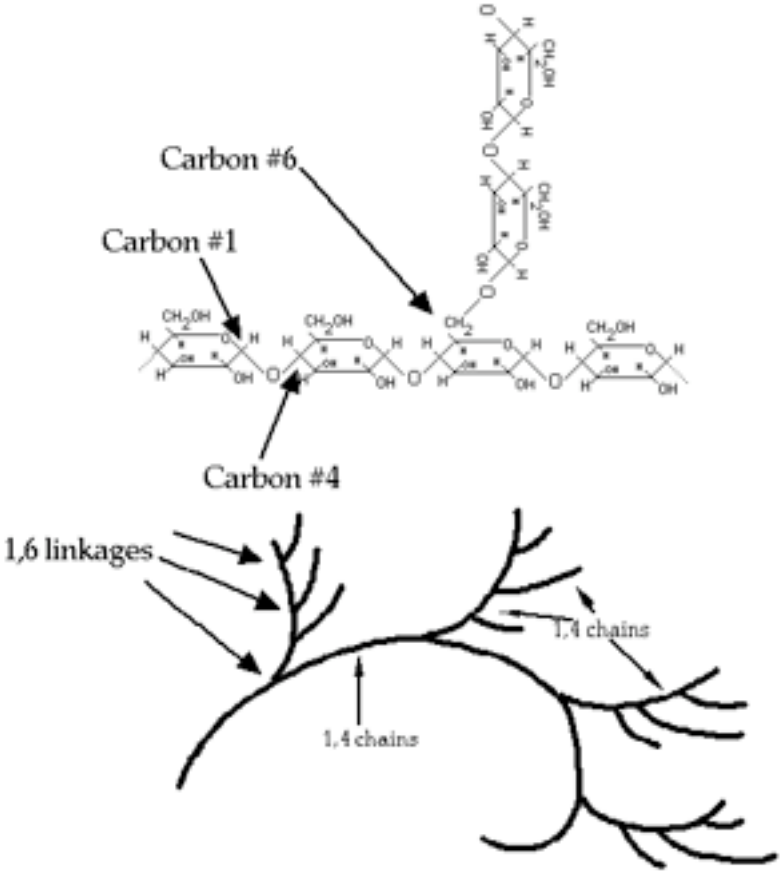
1. Types (all three are composed of chains of glucose)
2. **Starch**
   a) Storage form of glucose in plants.
   b) Digestible by man.
   c) Made of **amylose** and **amylopectin**
   d) Tend to form clusters or granules
   e) The bond between the two molecules is alpha **1,4 glycosidic** bond.



   f) The molecule forms a helix and can be 1,000 or more glucose units.

Amylose

   g) The amylopectin molecule can contain between 1,000 -6,000 glucose units with 1,6 linkages about every 30 glucose units.



3. Glycogen

a) Storage form of sugar in animals.

b) All **alpha** linkages

c) Structure looks like amylopectin, but more branching of glucose units.

d) Glycogen has **1,6 linkages every ten glucose** units (on the 1,4 chain)

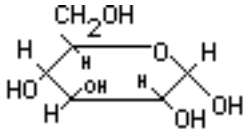
4. Cellulose

a) Structural carbohydrate, forms cell wall in plants.

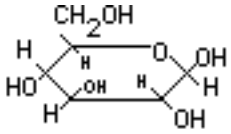
b) Not digestible by man.

c) What makes cellulose different from starch?

(1) Contain **beta** glycosidic bonds.

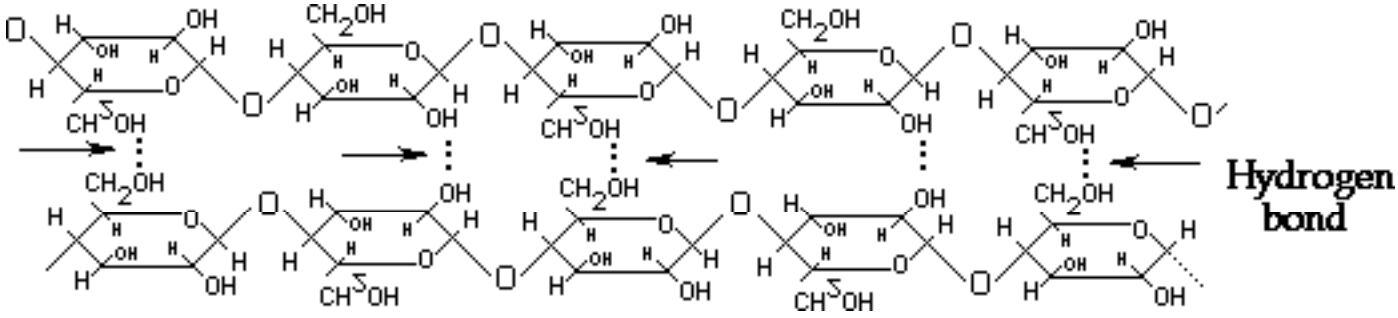


Alpha Glucose



Beta Glucose

(2) This allows for hydrogen bonding between the chains. The chains are attracted to each other, thus preventing enzymes from attacking the molecule.



5. Chitin

a) A polysaccharide that contains nitrogen.

b) Found in the exoskeleton of arthropods and the cell wall of fungi.

II. Lipids

A. Functions

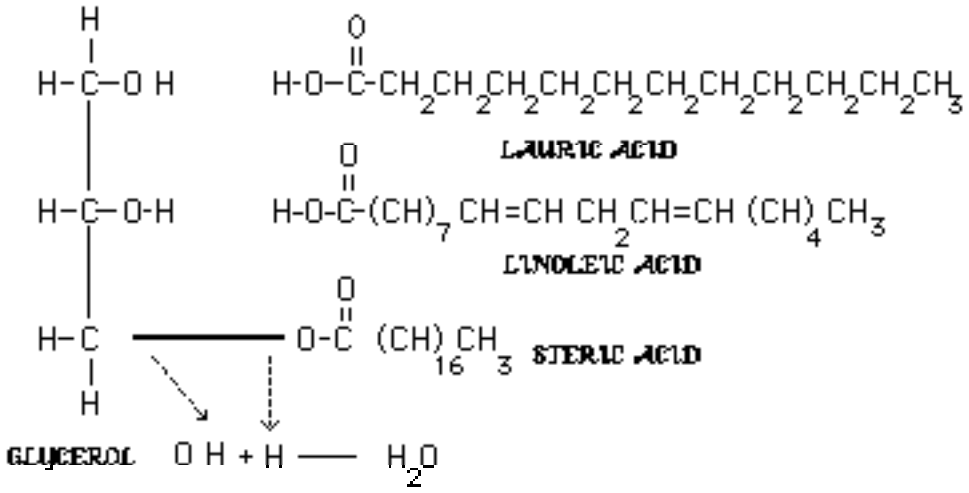
1. Padding and insulation (protection)
2. Long term storage of energy **(9 kcal/gram)**
3. Form backbone of some hormones.
4. Store fat soluble vitamins (A,D,E, and K)
5. Component of all cell membranes.

B. All lipids have a high hydrogen to carbon ratio with few oxygens.

1. What functional group would this be?
   What properties would you expect?
2. There are five common lipids: fats, oils, waxes, phospholipids, and steroids.

C. Fats

1. Fats are fatty acid esters of glycerol.
2. Saturated vs unsaturated fatty acids
   a) Saturated
      (1) no carbon to carbon double bonds
      (2) comes from animals
      (3) solid at room temp.
      (4) accumulate in arteriole walls
   b) Unsaturated
      (1) has carbon to carbon double bonds
      (2) come from plants
      (3) liquid at room temp
      (4) don't accumulate in arteries
3. Essential fatty acids: Linoleic and linolenic
4. Formation of a fat



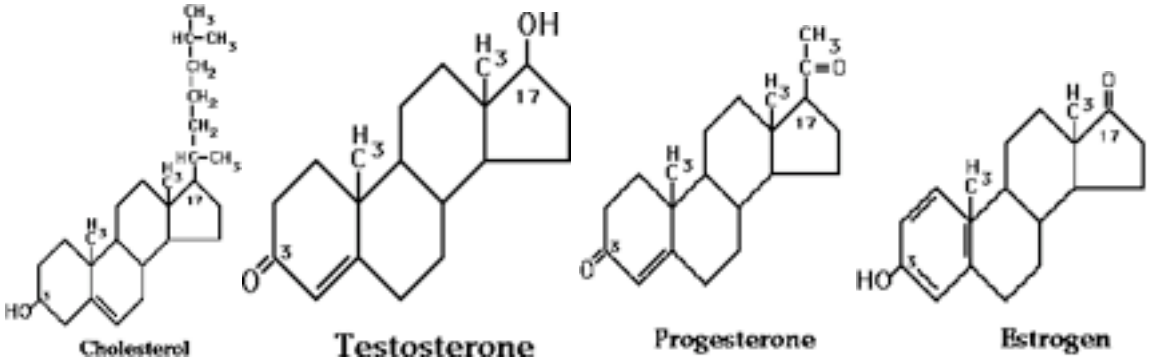
D. Waxes

1. Waxes are similar to fats but are composed of much larger fatty acids

E. Phospholipids

1. Water loving (hydrophilic) phosphate head and a water hating (hydrophobic) tails

F. Steroids



1. How do you know they are lipids?
   They have a high hydrogen to carbon ratio.
2. Sex hormones and the survival benefit of amenorrhea.

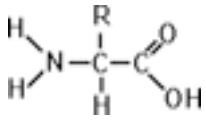
III. Proteins

A. Functions

1. Most every structure in an organism contains protein.
   a) 50% of the dry weight of most organisms.
   b) Except which organisms?
   (1) What makes up most of the dry weight of plants?
   c) Other common proteins collagen, silk, hair, nails, membranes.
2. All **enzymes** are composed of protein.
3. Other functions: hormones for regulation, movement proteins, poisons, and gas transport (hemoglobin).
4. **<u>Not good</u>** for fuel but can be used (4 kcal/gram)
   a) Why would proteins be a bad fuel source?

B. Structure of amino acids

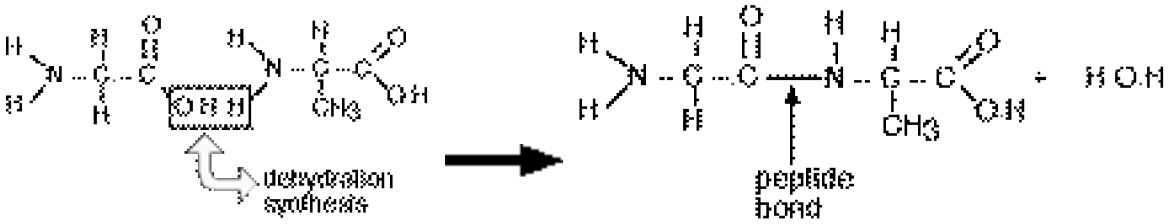
1. Long chains of amino acids held together by peptide bonds.
2. Amino Acid Structure



****change the "R" group and you get a different amino acid

   a) How would these respective R groups alter the properties of an amino acid and protein?
   b) Do any amino acid contain any unusual elements?
3. Essential amino acids.
   a) All meats contain all the essential AA's
   b) Vegetarians don't eat meat, they must be careful to eat the proper combination of vegetables and fruits to get the essential amino acids.

C. Formation of a peptide bond.



D. How have all of the macromolecules been assembled?

E. Monomer vs polymer

F. Structural properties and organization of proteins.

1. Primary (1°) structure (page. 60)

a) The sequence of amino acids in the protein

2. Secondary (2°) structure

a) Caused by hydrogen bonding between the amino groups and the acids groups along the protein chain.

b) Two possible patterns

(1) Alpha helix

(2) Beta sheath

3. Tertiary (3°) structure

a) Caused by interactions with water and other properties of the polypeptide side chains.

4. Quaternary (4°) structure

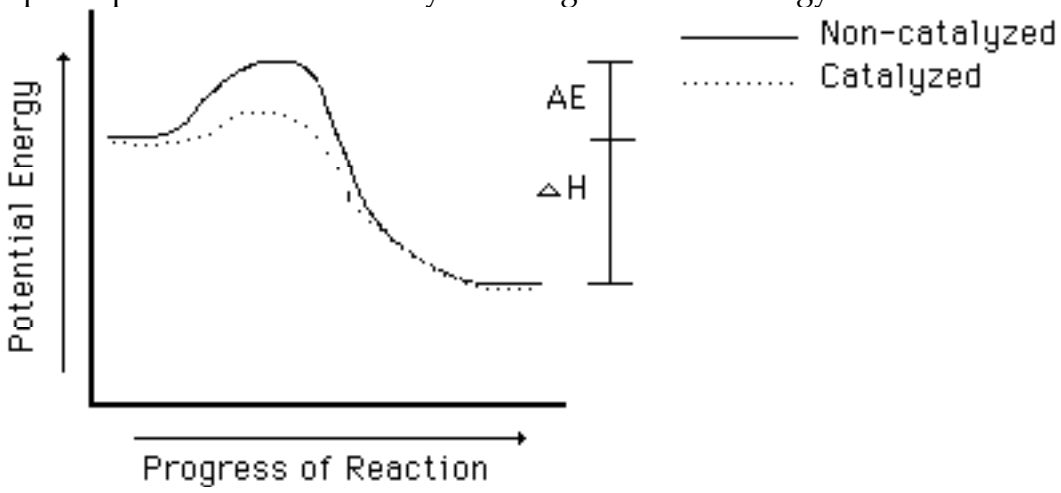
a) caused by interaction between various polypeptide chains

5. What determines the secondary, tertiary and quaternary structures?

Enzymes

IV. Properties of enzymes

A. Speedup chemical reactions by lowering activation energy.

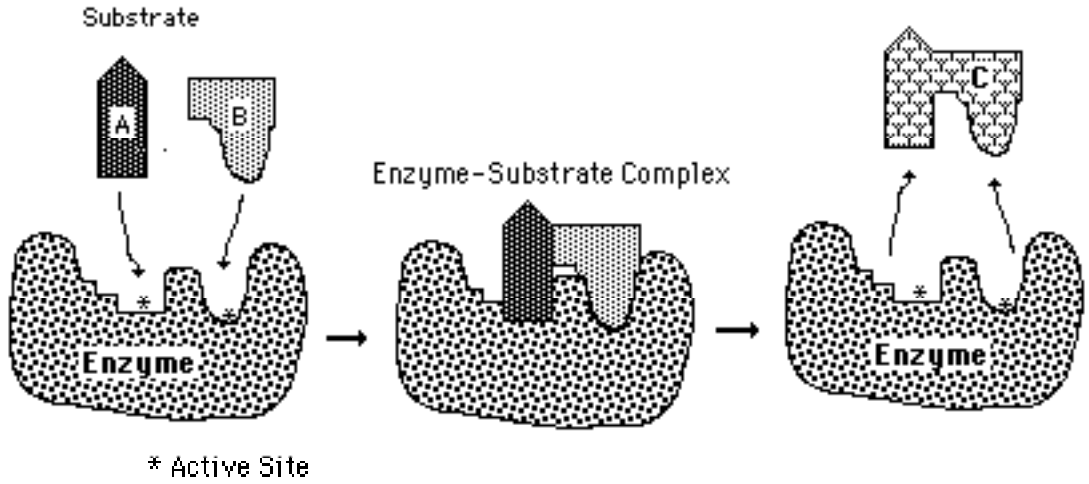


1. Temperature effects compared with enzymatic effects
2. Why can't we speed up the chemical reactions of human body by using heat?

B. Made of protein

1. therefore their production is under the control of DNA

C. Specific for their substrate



D. Remain unchanged after reaction, do not become part of the products **(lock and key model)**

E. Can be reused over and over again (millions of times/sec)

V. How do enzymes work?

A. They increase the local concentration of reactants.

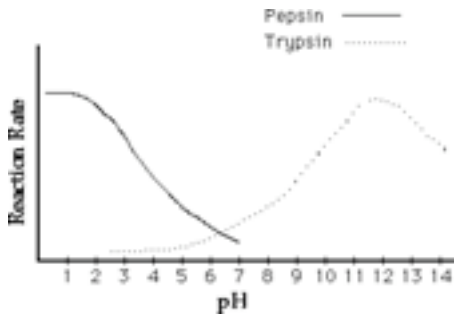
B. Bring reactants into the proper orientation (see induced-fit model).

C. Enzymes allow for acid-base catalysis by providing OH^- and H^+ ions from amino acids side chains in solutions that are low in these species.

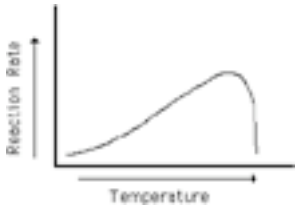
D. Slightly distort (strain) the substrate molecules moving them closer to the activation energy (transition peak).

VI. Factors effecting enzyme function

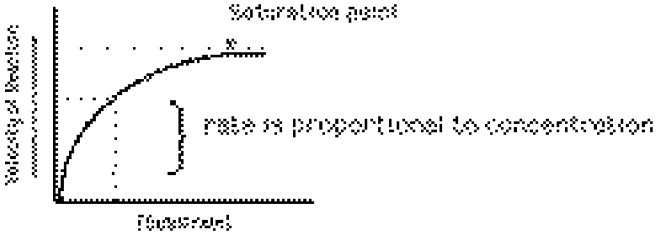
A. pH



B. Temperature



C. Concentration



D. Inhibition

1. **Irreversible inhibition**- the enzyme is denatured or destroyed.

2. **Reversible Inhibition**
   a) **Competitive -**The inhibitor and substrate compete for the same binding site on the enzyme.
   b) **Noncompetitive Inhibition -** The inhibitor binds to a point other than binding site but does not bind permanently.
   c) **Allosteric interactions**

VII. Co-enzymes

A. Nonprotein organic molecules.
B. Usually function as intermediate carriers of electrons, specific atoms, or functional groups.
C. Usually loosely bound to an enzyme but if it is tightly bound then it is referred to as Prosthetic group.
D. The heme group in cytochrome C is covalently bonded to its peptide chain.
E. Usually contain a B vitamin

VIII. Co-factors

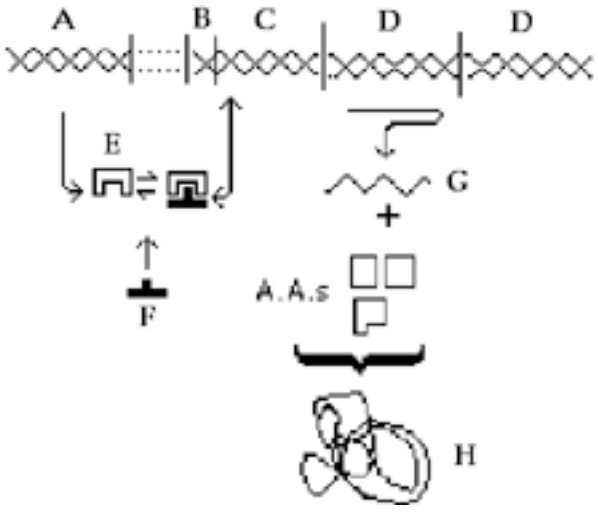
A. Inorganic ions
   1. What is the cofactor in chlorophyll?
B. Many times found at the active site and assist in binding substrate to enzyme.
C. Also helps maintain the tertiary structure of some proteins.

IX. How enzymes control cell function

A. If the cell is a factory what are the enzymes?
B. In a factory, what two factors determine how much product is produced?
   - # **of machines and how fast the machines work.**

C. The Operon Theory (Enzyme production)

1. All enzymes are made of protein.
2. DNA controls the production of all proteins by coding for RNA, therefore, DNA controls the production of all enzymes.
3. Central Dogma: DNA-----> RNA ---- >Protein
4. In 1961, Jacob and Monod proposed the operon theory to explain how cells control the production of proteins



D. The components of the operon

A**. Regulatory Gene -** codes for the repressor protein.
B**. Promoter Site** - attachment site for RNA polymerase.
C**. Operator gene** - attachment site for repressor protein.
D**. Structural genes** - code for proteins (enzymes).
E**. Repressor protein** - different for each pathway and custom fit to the regulatory metabolite.
F. **Regulatory metabolite** - either a product or reactant depending on the pathway. **Not**, a protein.
G. **Messenger RNA**
H. **The protein (enzyme)**

E. Two types of operons

1. Repressible
   a) The product is the regulatory metabolite. **Why?**
   b) The repressor protein only binds to the operator gene in the **presence** of the regulatory metabolite (product).
2. Inducible
   a) The reactant is the regulatory metabolite. **Why?**
   b) The repressor protein only binds to the operator gene in the **absence** of the regulatory metabolite (reactant).