UNIT 2

BIOLOGICAL CHEMISTRY

ORGANIC MOLECULES:

Molecules composed of a carbon skeleton

Monomers: single building units

Polymers: (macromolecules)

Very large molecules composed of many monomers put together.

Artificial polymers:

Plastics, nylon, Teflon, orlon, polypropylene,

FOUR MAIN GROUPS OF BIOLOGICAL ORGANIC COMPOUNDS

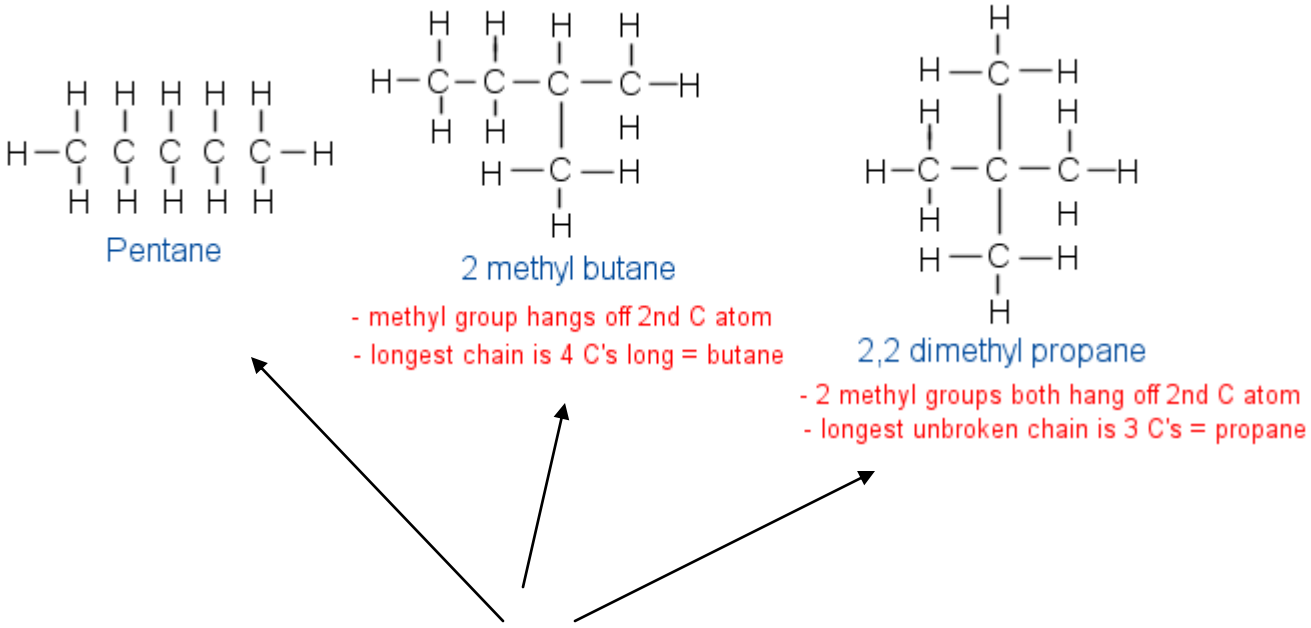
1. Proteins (amino acids) CHONS
2. Lipids (Fats, oils) CHO
3. Carbohydrates (sugar, starch, enzymes) CHO
4. Nucleic Acids (DNA, RNA) CHONP

CARBON SKELETONS AND ISOMERS

Isomer:

Compounds w/ the same molecular formula but different structural formulae

3 isomers of pentane C_5H_{12} (molecular formula)



STRUCTURAL FORMULA

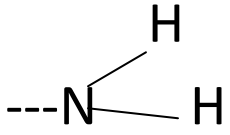
FUNCTIONAL GROUPS

Clusters of atoms that act in specific ways no matter what the rest of the molecule is like.

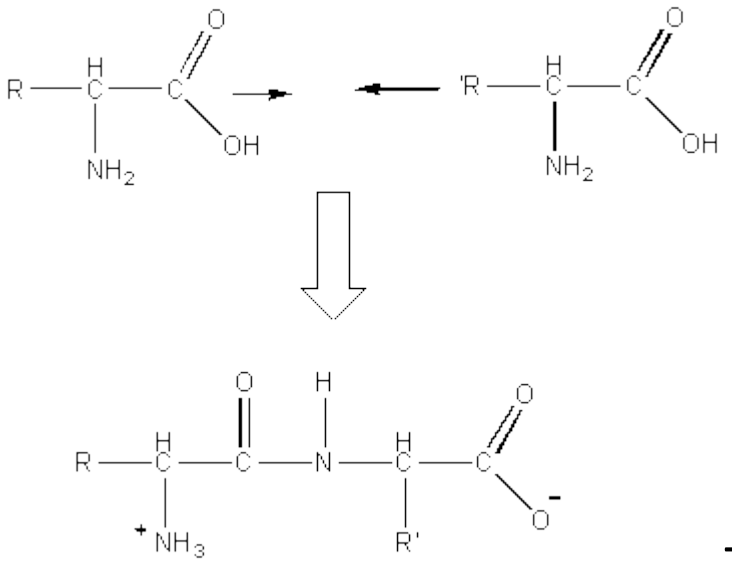
Carboxyl group R-COOH C--C(=O)OH

Found in amino acids and fatty acids

Amine group --NH_2



Amino Acid bond between carboxyl group and amine group



+ H_2O

Amino acids are the basic building block of proteins.

Other important functional Groups:

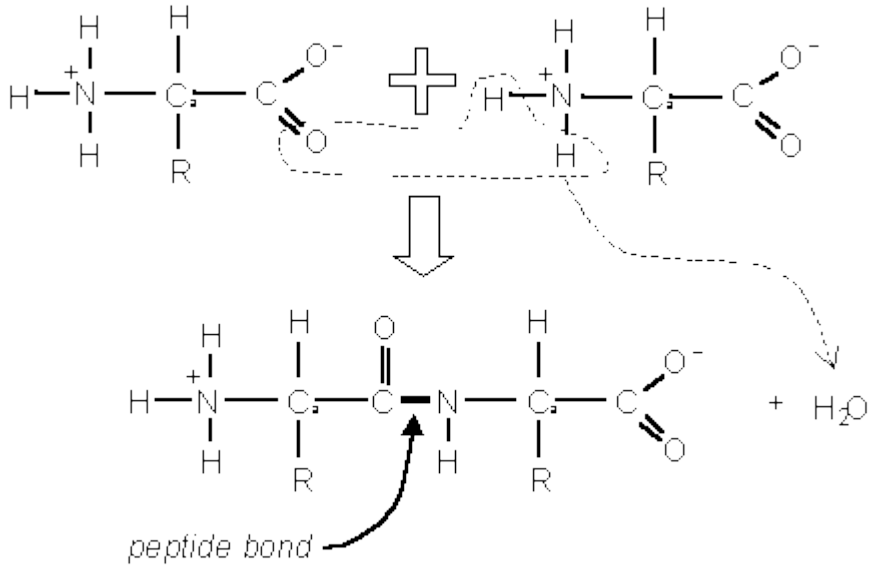
-OH alcohol

Condensation rxn : two molecules are joined… one loses H and the other –OH . This is how polymers are made

(HYDROLYSIS)

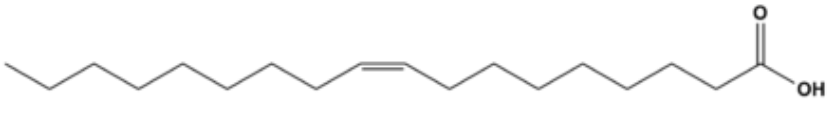
Monomer-H + HO—Monomer ←--→

Monomer---monomer + H_2O (CONDENSATION)

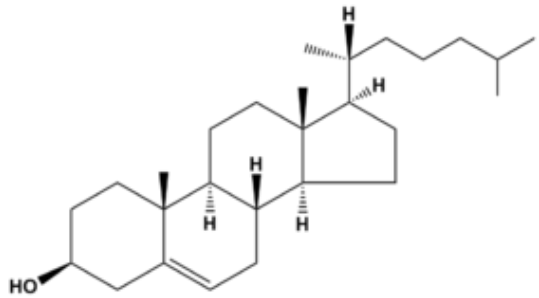


CONDENSATION REACTIONS ARE REVERSIBLE. WHEN THEY BREAK UP IT IS CALLED A **<u>HYDROLYSIS RXN</u>**.

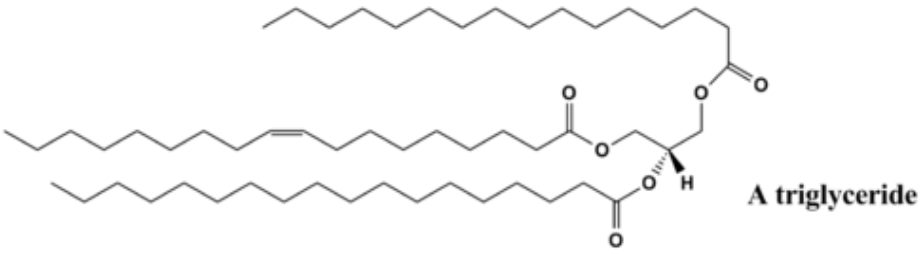
I. LIPIDS: (fats, fatty acids, oils , phospholipids, steroids)



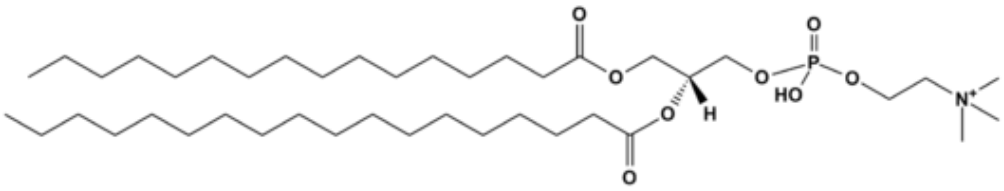
A free fatty acid



Cholesterol



A triglyceride



A phospholipid

Characteristics :

- Nonpolar
- Don't dissolve much in water

Elements: C,H,O

Uses: (3 main)

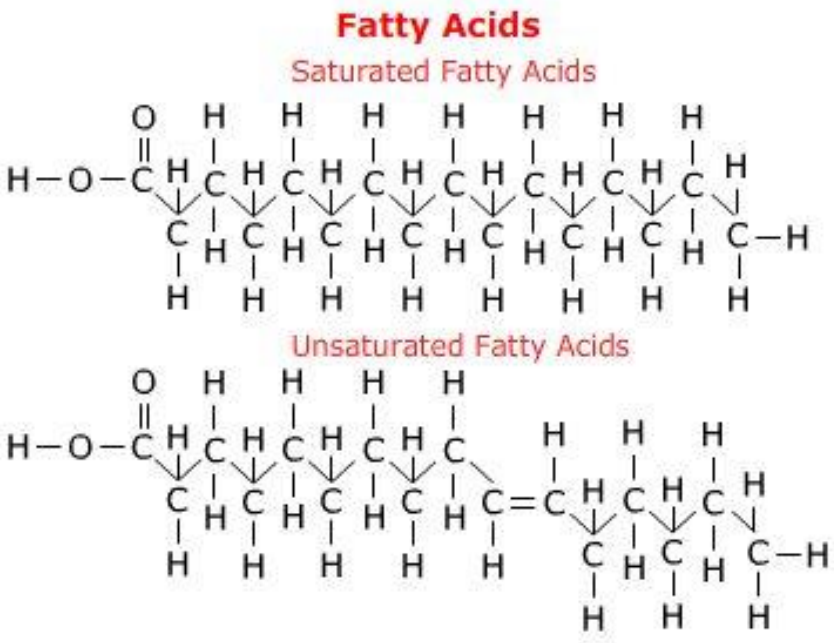
1. Waterproofing
2. Energy storage(contain more than twice as much as carbohydrates

   10g of fat vs 20g of sugar
3. Insulation :

A.Fatty Acids

These are the simplest Lipids

Def: A simple lipid molecule composed of a long hydrocarbon chain w/ a carboxyl group at one end .



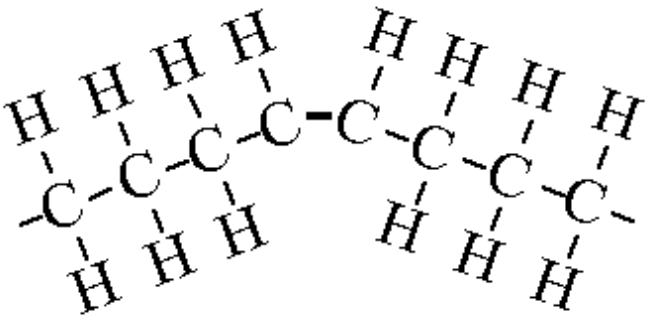
a. Saturated Fatty acids:

All single bonds . (holding as many H as they can)

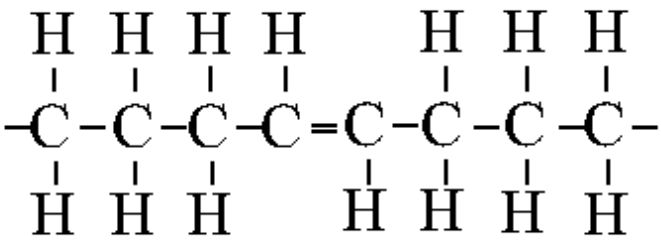
b. Unsaturated fatty acid:

Double and/or triple bonds between C atoms

Trans vs. Cis fats



Cis configuration - bent molecule



Trans configuration - straight molecule

Hydrophilic :

Water loving

Hydrophobic:

Water fearing

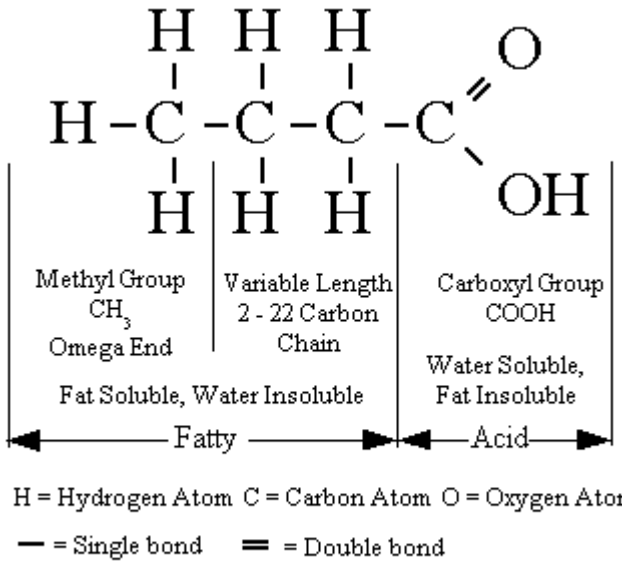
-The Carboxyl end of a fatty acid is polar and therefore Hydrophilic.

-The hydrocarbon chain end however is hydrophobic because it is non-polar.

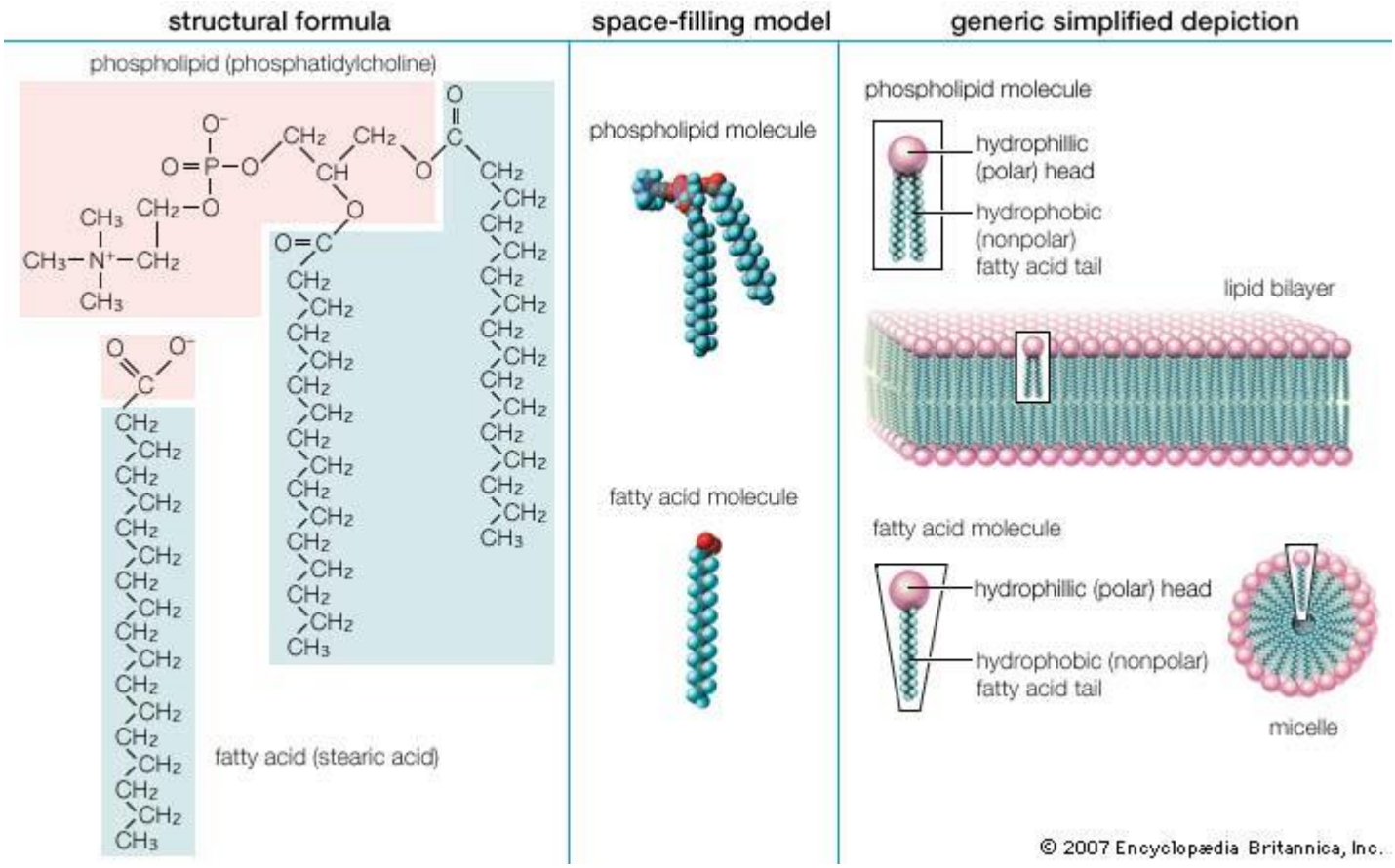
These characteristics make fatty acids an integral part of cell membranes.

Fatty acids found where?

1. Cell and organelle membranes
2. Glycolipids (Carbohydrate + lipid)
3. Lipoproteins (fat + protein) see book diagram



Structure of a saturated fatty acid, butyric acid in butter



B.FATS AND OILS: Pg 39 Fig 3-5

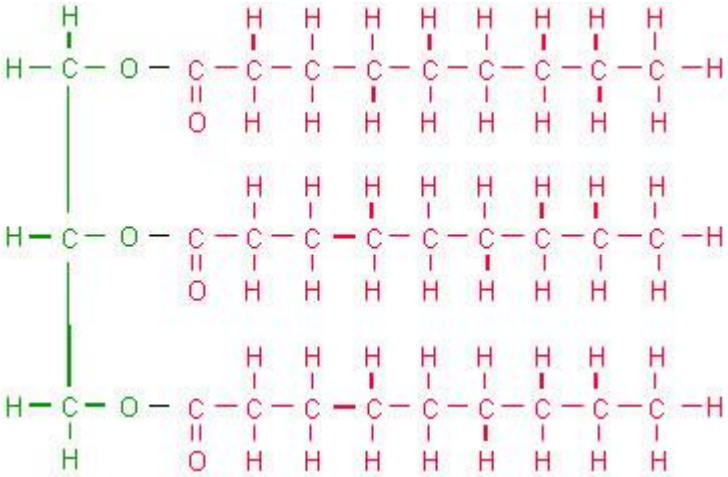
Function:

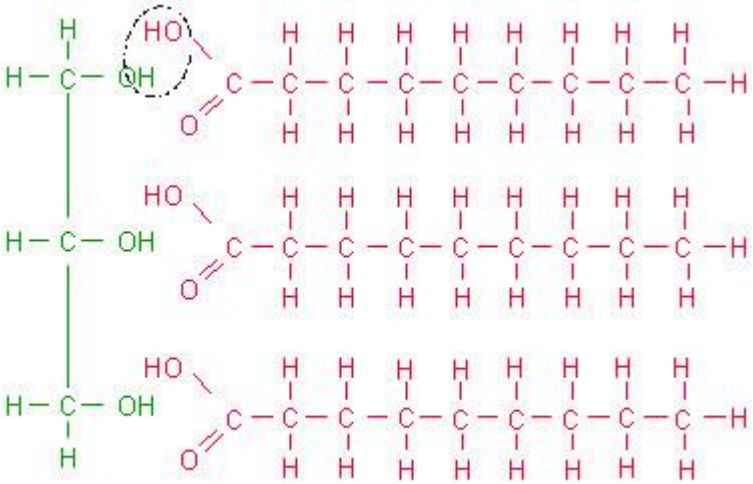
Store energy (energy reserve)

Formed by condensation rxn of 3 fatty acid molecules to the alcohol (glycerol) (triglycerides)

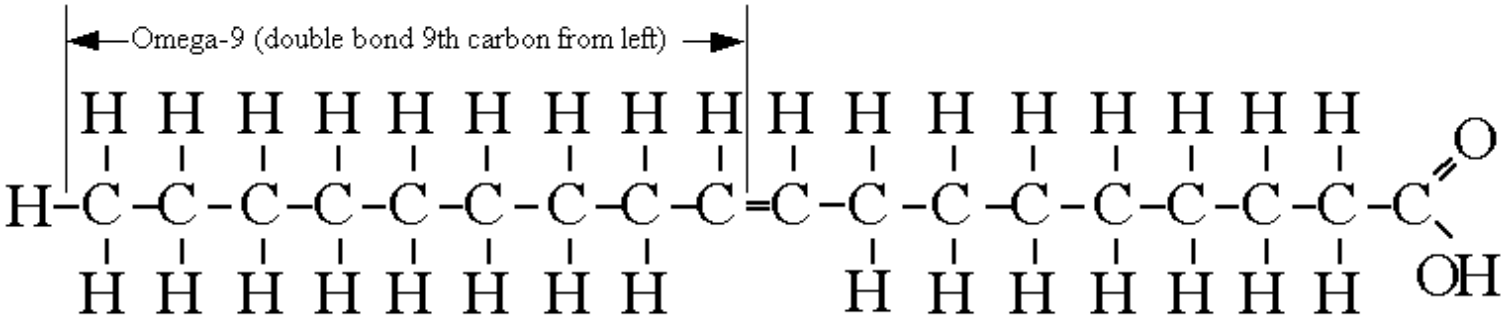
Fats: solid @ room temperature

Oils: liquids @ room temperature due to more unsaturated fatty acids.

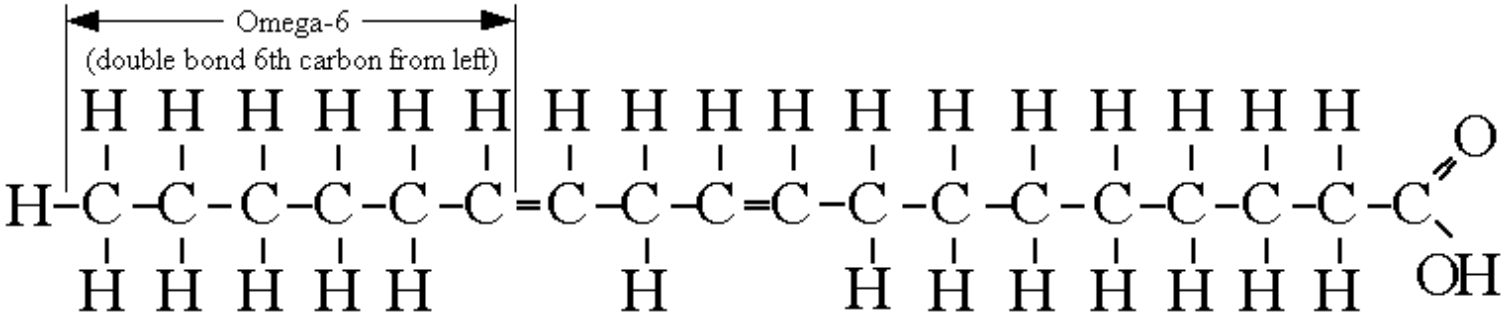




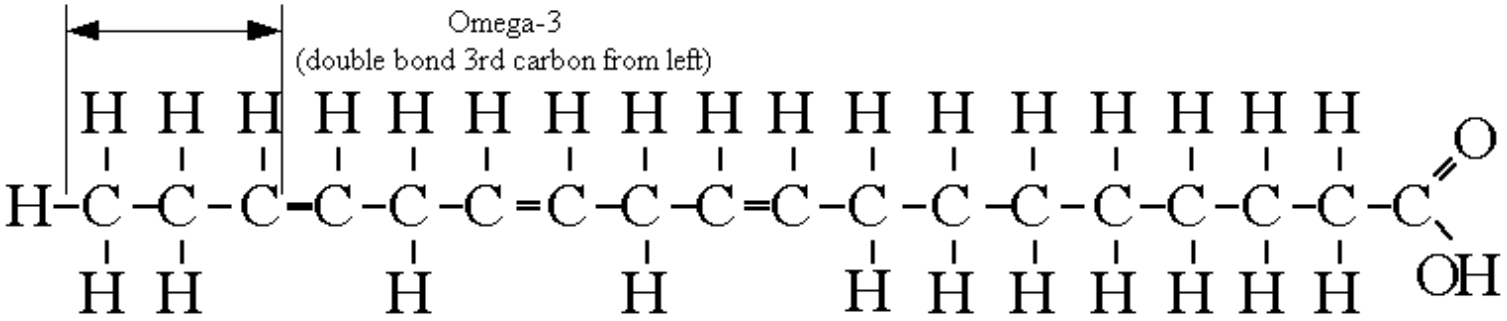
Glycerol Fatty Acids



Oleic Acid (OA), monounsaturated = single carbon double bond



Linoleic Acid (LA), polyunsaturated = more than one double bond
An essential fatty acid

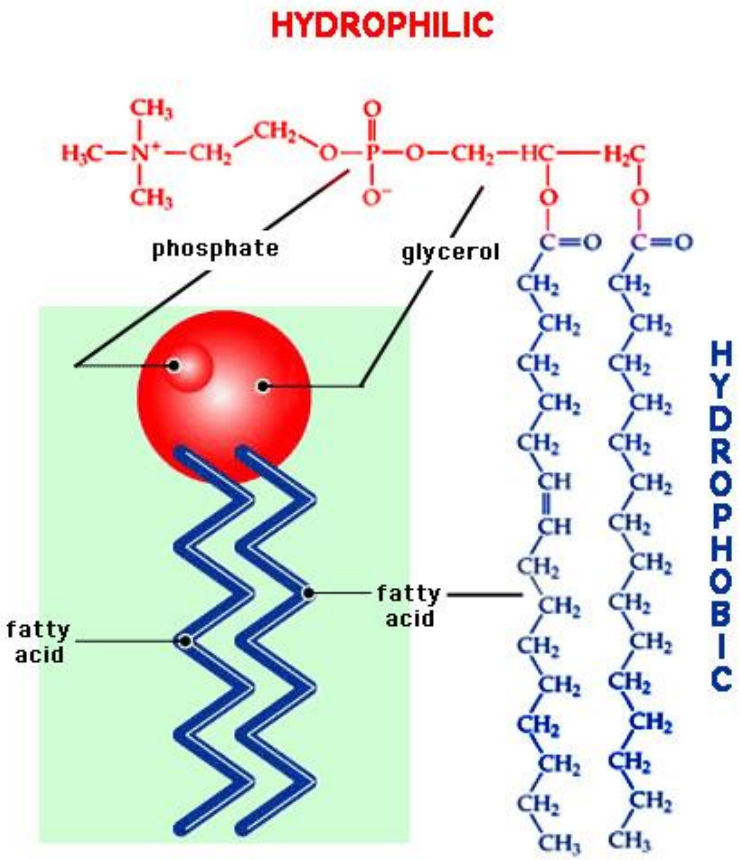


Alpha-linolenic Acid (LNA), polyunsaturated = more than one double bond
An essential fatty acid

H = Hydrogen Atom C = Carbon Atom O = Oxygen Atom

— = Single bond = = Double bond

C.Phospholipids Pg 39 Fig 3-6



Similar to fats except that one or more fatty acids are replaced by a phosphate group.

Function: pg 39

-structural molecules

- chief lipid component of biological membranes

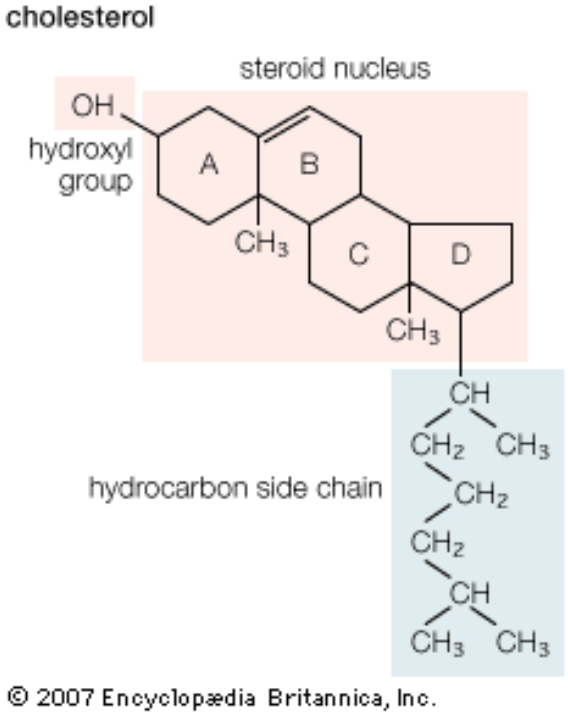
- polar – nonpolar

D. STEROIDS: (HAS A CYCLIC 4 CARBON RING)

Qualify as lipids because insoluble in water

-Cholesterol is the most abundant steroid

- important component of (**animal**) cell membranes
- involved in vitamin D production



-Hormones

Chemical messengers between different parts of the body.

Produced in (adrenal and pituitary glands)

Ex. Cortisone and produced in adrenal

sex hormones in sex organs

II. CARBOHYDRATES:

Sugars, Starches, and related compounds

FUNCTION:

1. Energy + energy storage
2. Some structural : cellulose in plant

Glucose cell walls ,

Chitin – insect, crustacean, arachnids

Exo-skeletons

A. Monosaccharides:

(Means one sugar)

- These are simple sugars
- Glucose, Fructose (know structure of glucose)
- These are monomers of larger carbohydrates

Note: two monosaccharides are called a di-saccharide

Two sugars Sucrose = 2 glucose molecules

B. Polysaccharides:

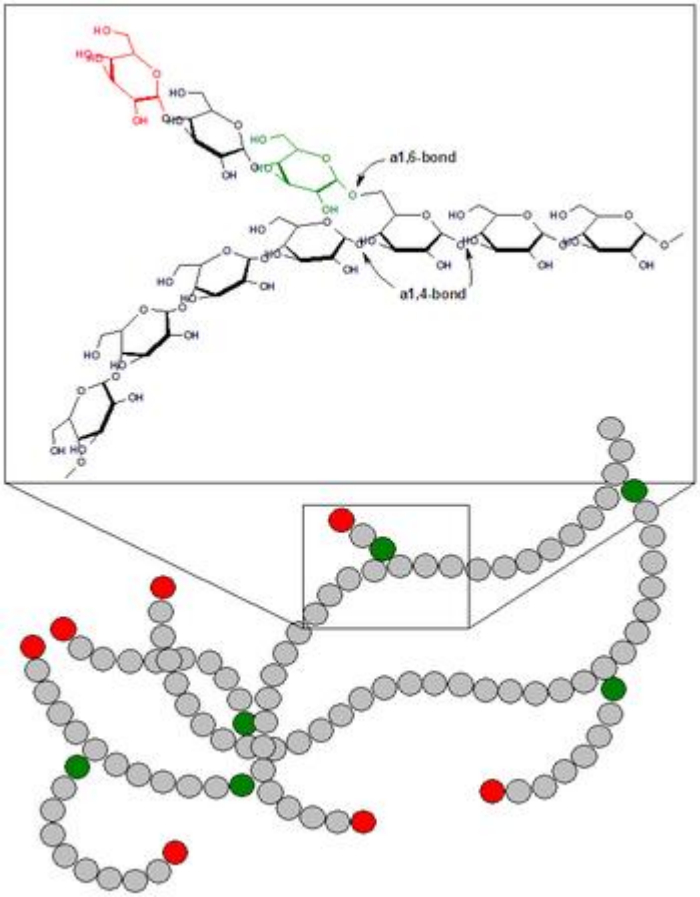
- Polymer of monosaccharides

Three important forms of polysaccharides

1. Glycogen : animal
2. Starch : Plants
3. Cellulose: Plant cell walls

A. Glycogen :

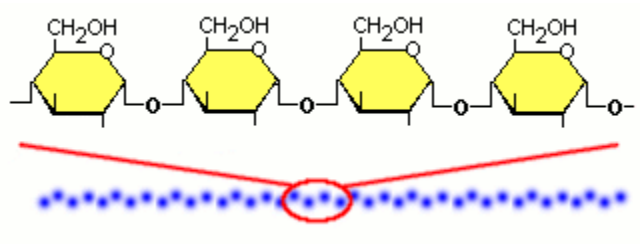
- This is the major Animal storage molecule
- Liver + muscles remove glucose in the blood and assemble it into glycogen to be later broken back down into glucose for energy.



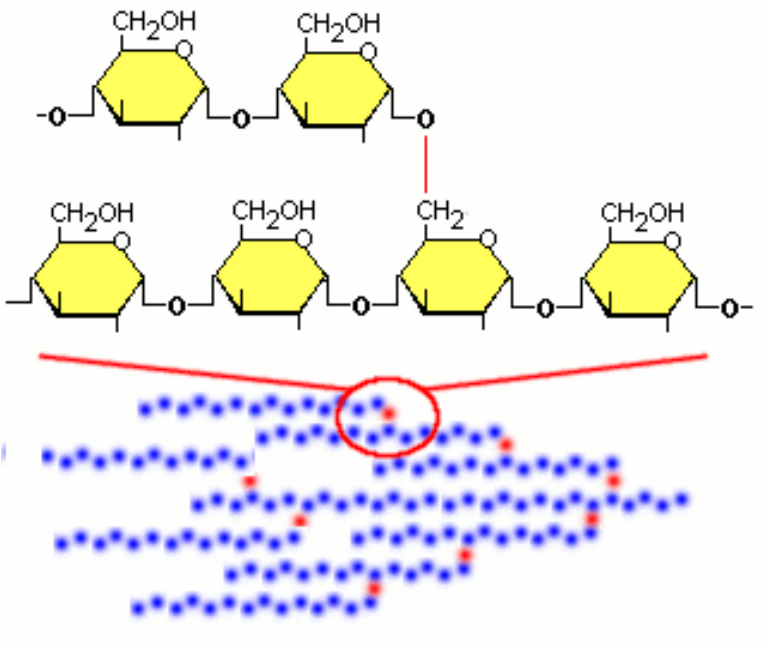
B. Starch: Pg 42

- This is the energy storage molecule in Plants
- Starch is made up of 2 kinds of glucose
  - 1. Amylose
  - 2. Amylopectin

Amylose consists of a linear, helical chains of roughly 500 to 20,000 alpha-D-glucose monomers linked together through alpha (1-4) glycosidic bonds.

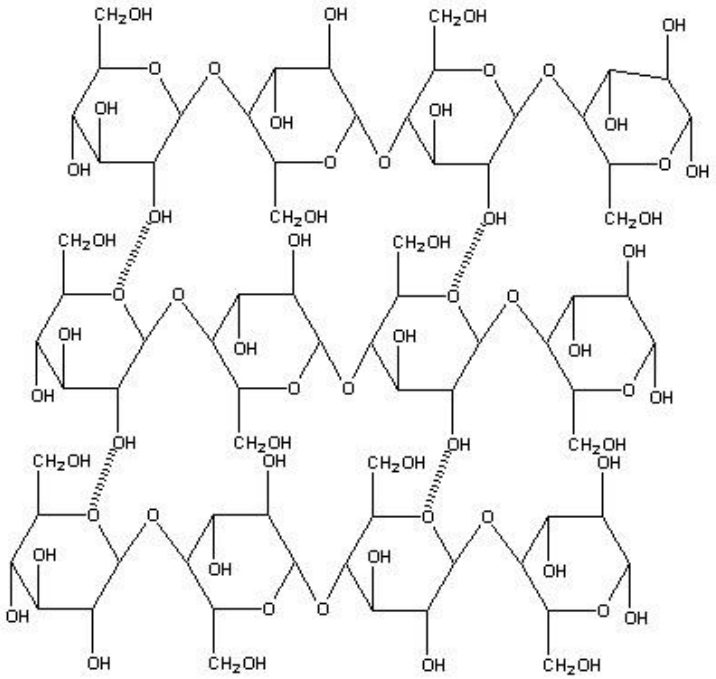


Amylopectin molecules are huge, branched polymers of glucose, each containing between one and two million residues. In contract to amylose, amylopectin is branched. It contains numerous amylose-like chains of up to 30 glucose residues linked through alpha (1-4) bonds, connected to one another through alpha (1-6) branch points.



C. Cellulose

- Most abundant organic material on earth
- Made of long straight chains of glucose
- Cell walls of plants.



Chitin :

i. Structural polysaccharide in arthropod exoskeletons and fungus cell walls

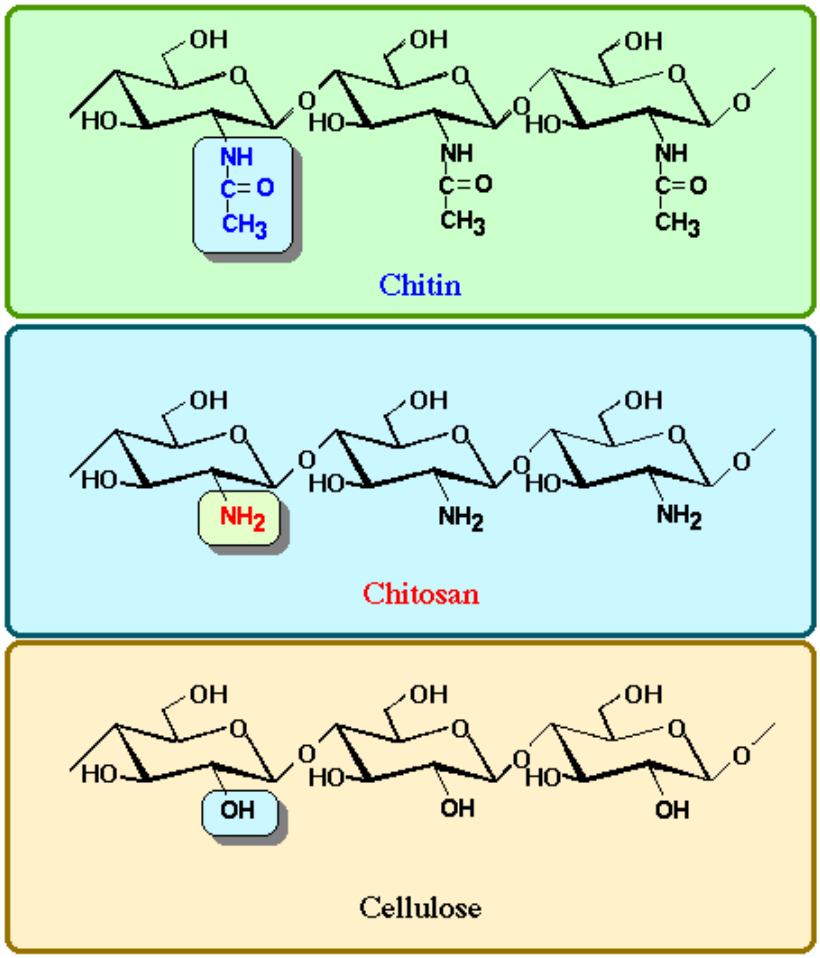


Fig. 3. Structure of Chitin, Chitosan and Cellulose

III. NUCLEIC ACIDS

- These include the largest biological molecules
- Contain CHONP
- There are two kinds of nucleic acids
- DNA, RNA, ATP, ADP, AMP

A. Deoxyribonucleic acid

1. Contains organisms genetic material
   - Information for making proteins
   - How to make other nucleic acids

B. Ribonucleic acid

1. Directs the building of proteins

Both DNA and RNA are named after the sugar they contain.

1. Ribose: Ribonucleic acid
2. Deoxyribose: Deoxyribonucleic acid

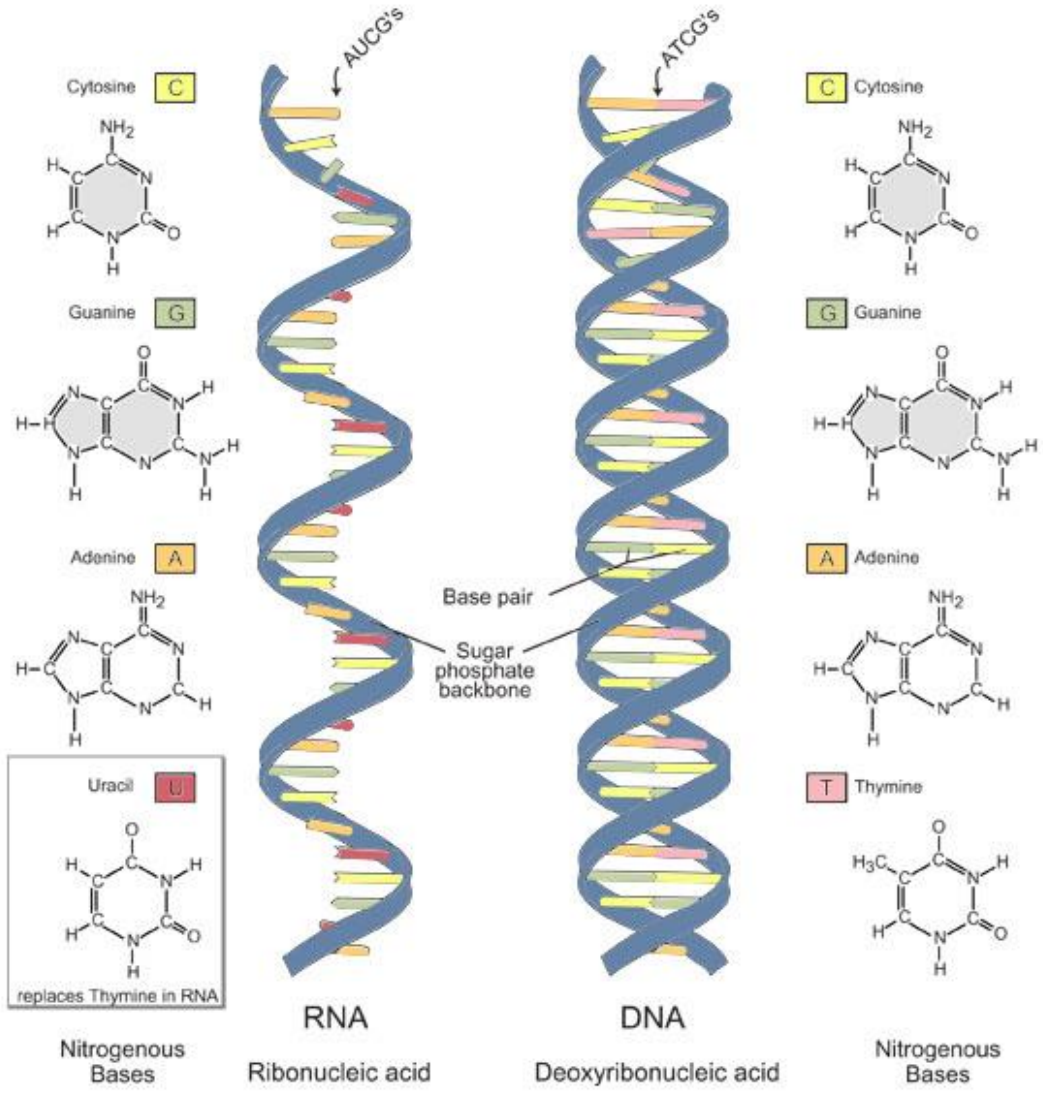


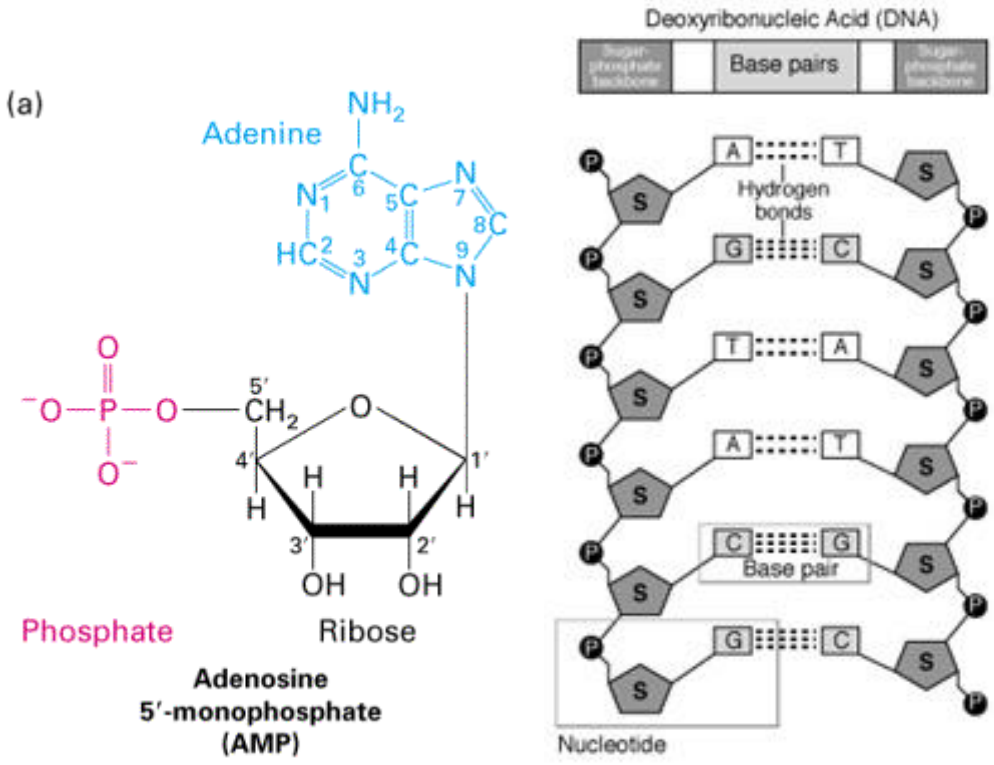
Image adapted from: National Human Genome Research Institute. Talking Glossary of Genetic Terms. Available at: www.genome.gov/Pages/Hyperion//DIR/VIP/Glossary/Illustration/rna.shtml.

DNA is double stranded while RNA is single stranded

Nucleotide: Monomer of nucleic acids

Contains:

1. Sugar (5 carbon)
2. 1-3 phosphate groups (PO_4^{-3})
3. Nitrogenous base



BASES FOUND IN DNA

1. Adenine
2. Guanine
3. Cytosine
4. **Thymine**

BASES FOUND IN RNA

1. Adenine
2. Guanine
3. Cytosine
4. **Uracil**

4.PROTEINS

-Proteins make up more than 50% dry weight of animals and bacteria.

-(Hair, fingernails are made of fibrous protein: collagen)Collagen is the most abundant protein by mass in animals.

-Hemoglobin is an oxygen carrying protein

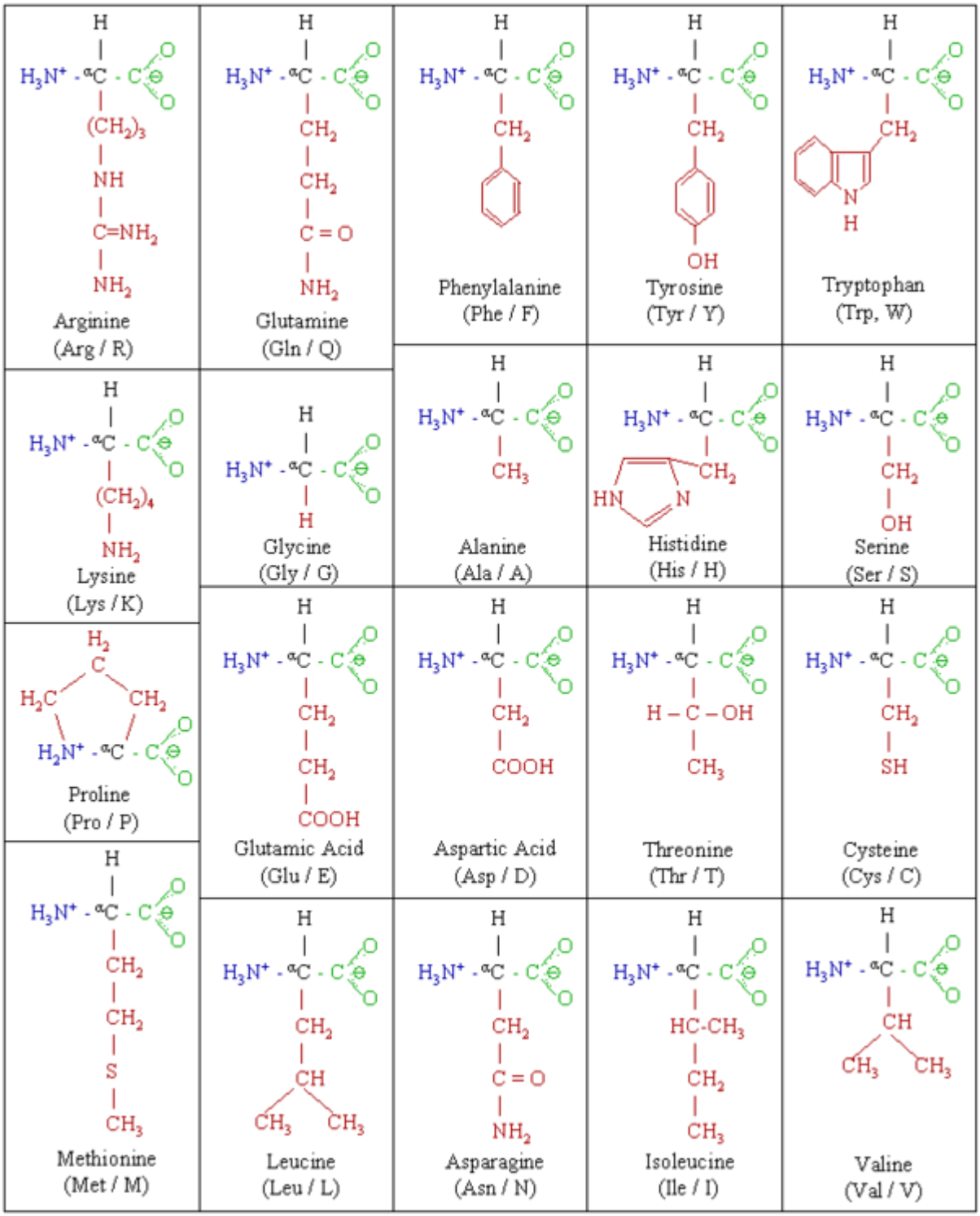
- The most numerous class of proteins are the enzymes. (end in –ase)

Enzymes: speed up chemical reactions

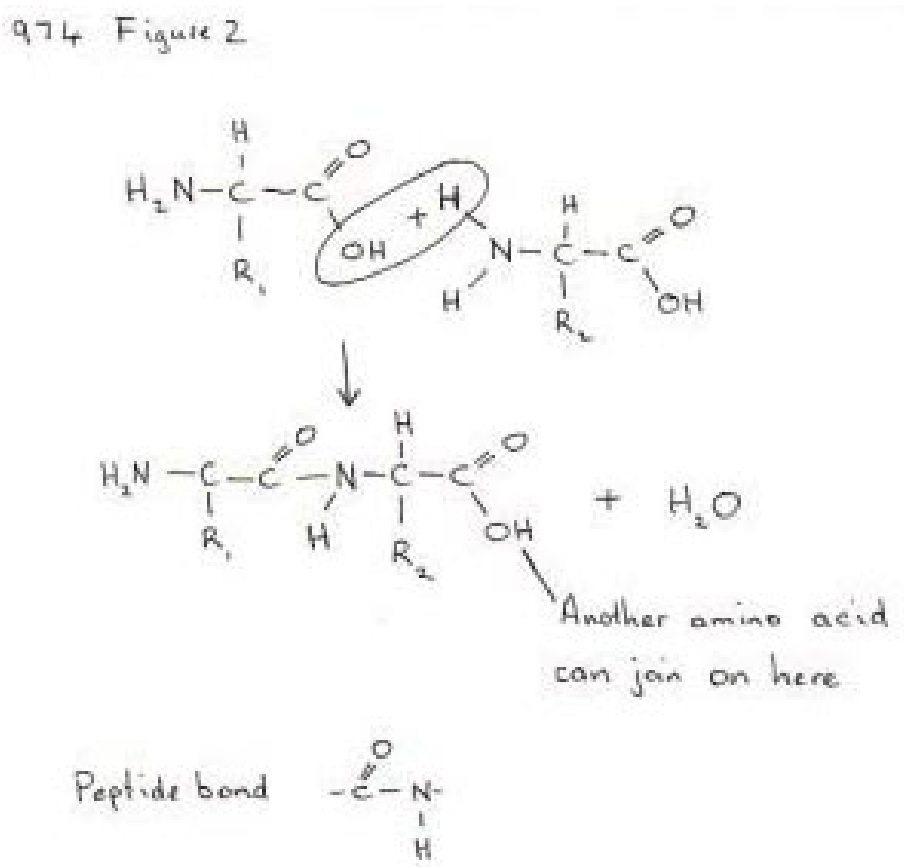
Monomer of Proteins:

Amino acid : 20 common amino acids

The 20 amino acids encoded by the genetic code are:



Amino acids are attached by Covalent bonds called Peptide bonds : formed during the condensation rxn.



Dipeptide :

2 amino acids

Polypeptide:

Long string

100-300 amino acids

Protein:

Def: a functional unit composed of one or more polypeptide chains.

PROTEIN STRUCTURE

Proteins are long unbranched chains of Amino acids

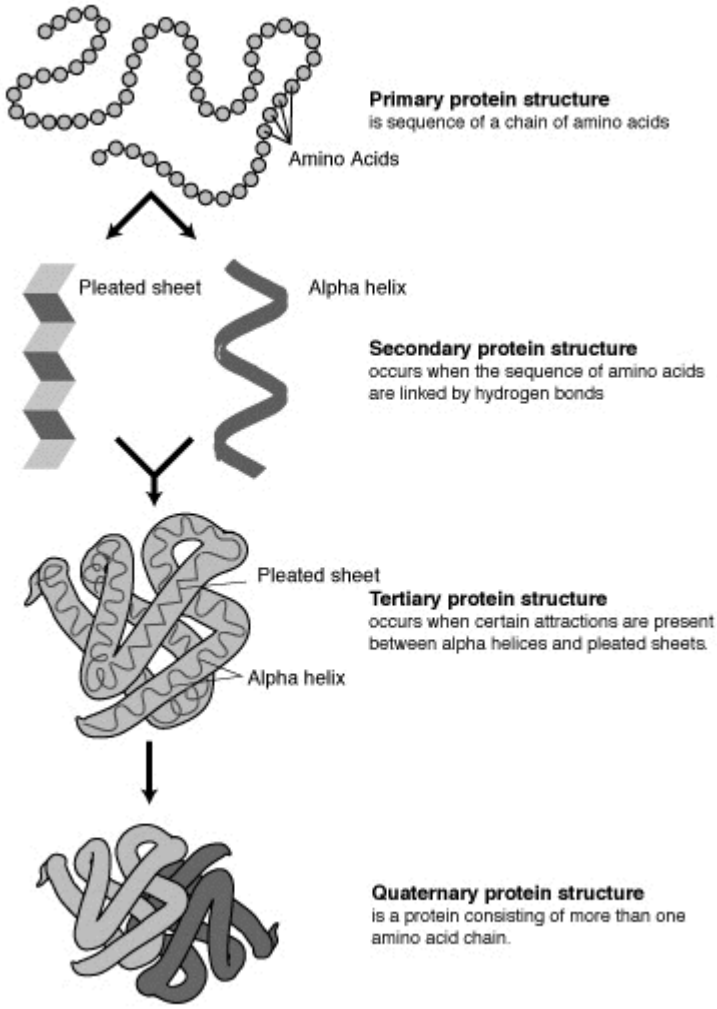
There are four levels of protein structure

1.primary structure

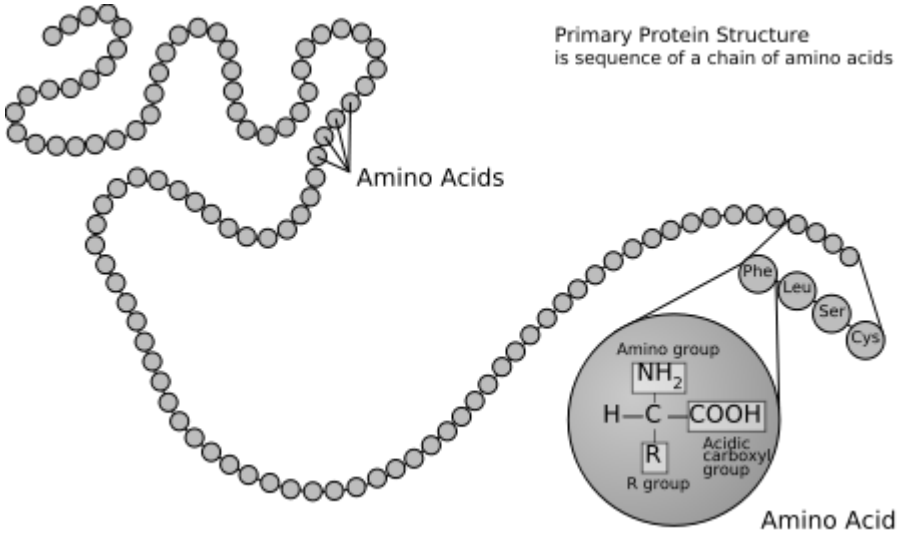
2.secondary structure

3.tertiary structure

4. quaternary structure

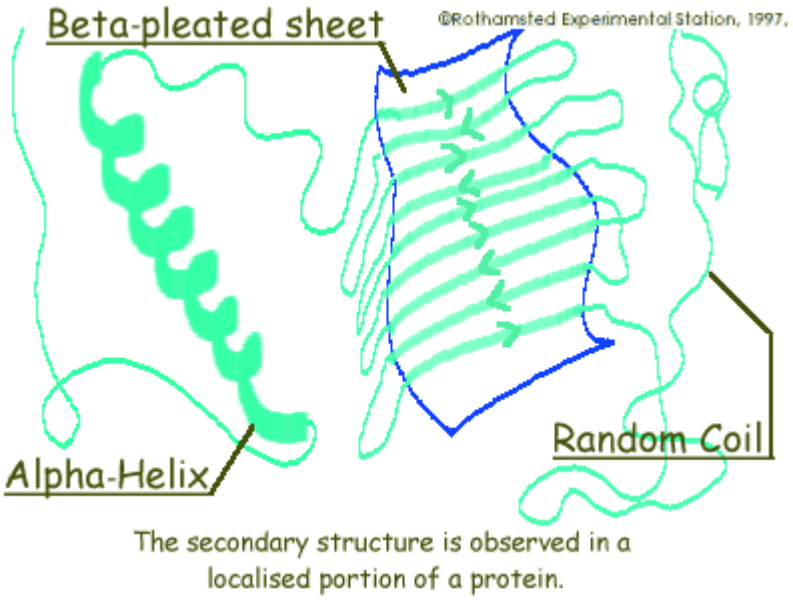


1.Primary Structure: is the sequence of amino acids in the polypeptide chain (help by peptide bonds)



2.Secondary structure: (hydrogen bonding)

Is the localized structure caused by hydrogen bonding across a polypeptide chain.



Secondary Structure of a Protein or Polypeptide

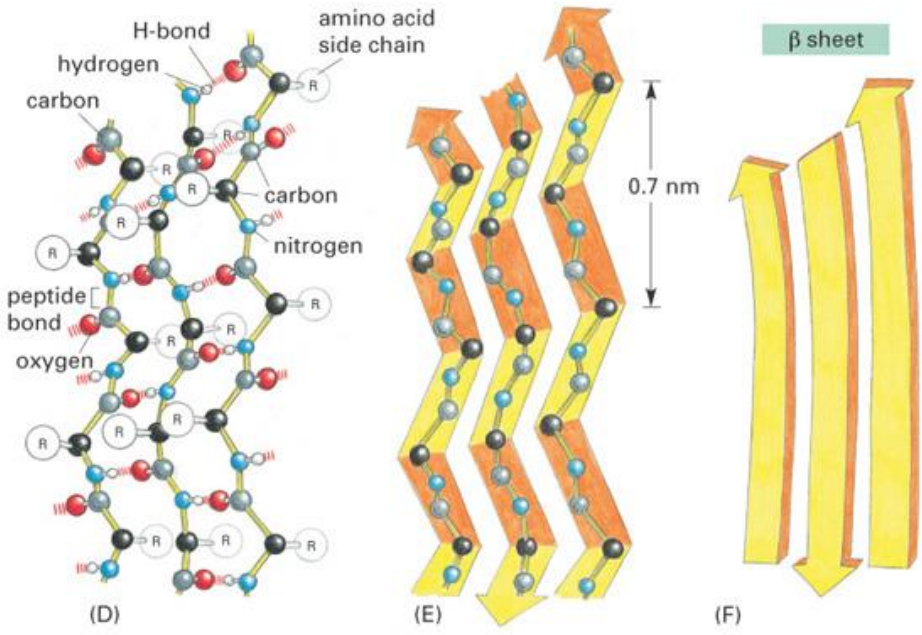


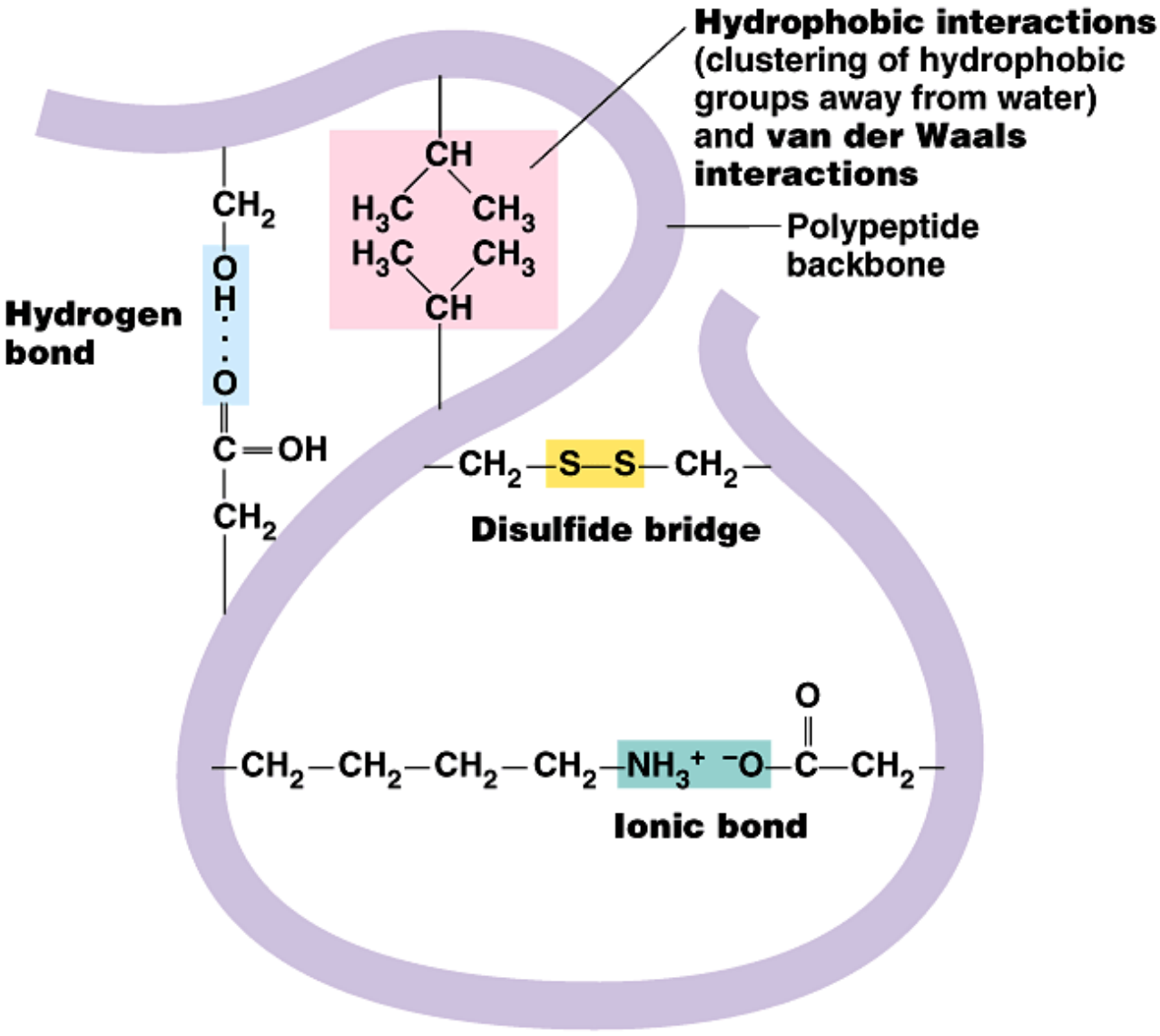
Figure 4-10 part 2 of 2 Essential Cell Biology, 2/e. (© 2004 Garland Science)

3.Tertiary Structure of a protein

4 Interactions effects these

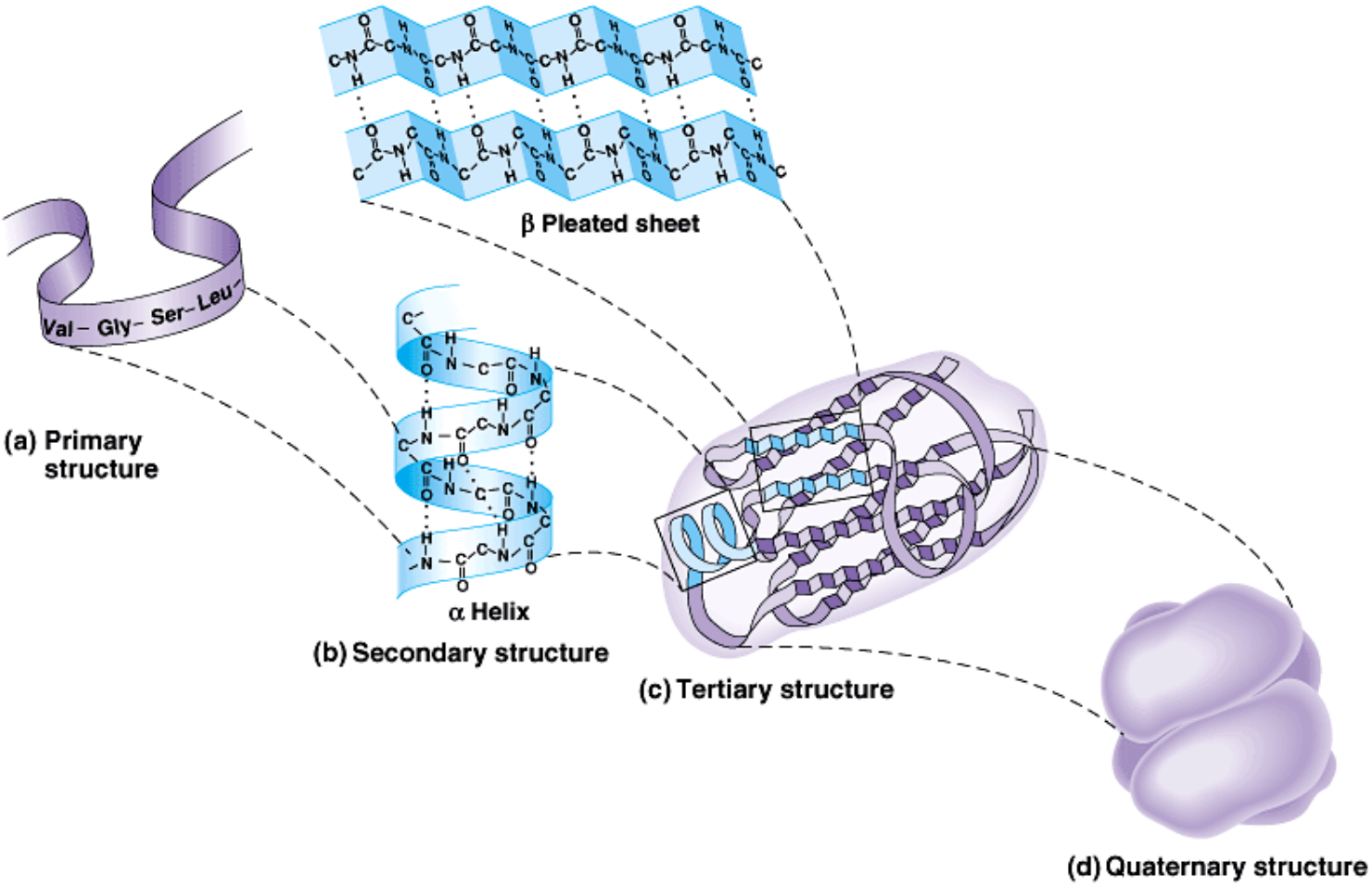
1. Ionic bonds
2. Hydrogen bonds
3. Disulfide bonds
4. Hydrophobic interactions

Nonpolar sections are pushed together by Water

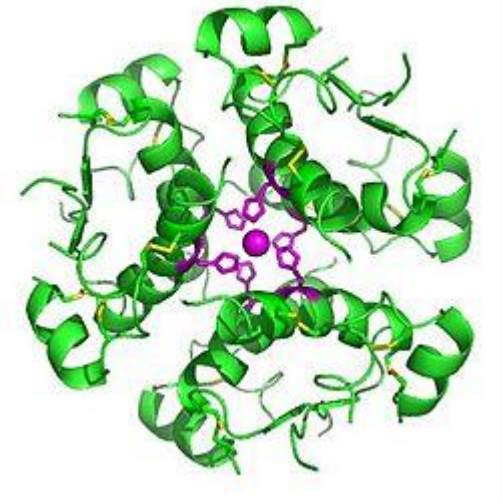


4.Quaternary structure: defined by the way the polypeptides fit together(fig 3-19 pg 47)

When polypeptides lose their shape their function and structure are destroyed and they are said to be **<u>Denatured : (</u>**caused by heat or chemicals)



Insulin



ENZYMES:

All enzymes are proteins

1. Proteins act as biological catalysts.. that is they speed up chem. Rxns. (lower activation energy)

- Substrates:

  The reactants in an enzyme-catalyzed rxn are called substrates

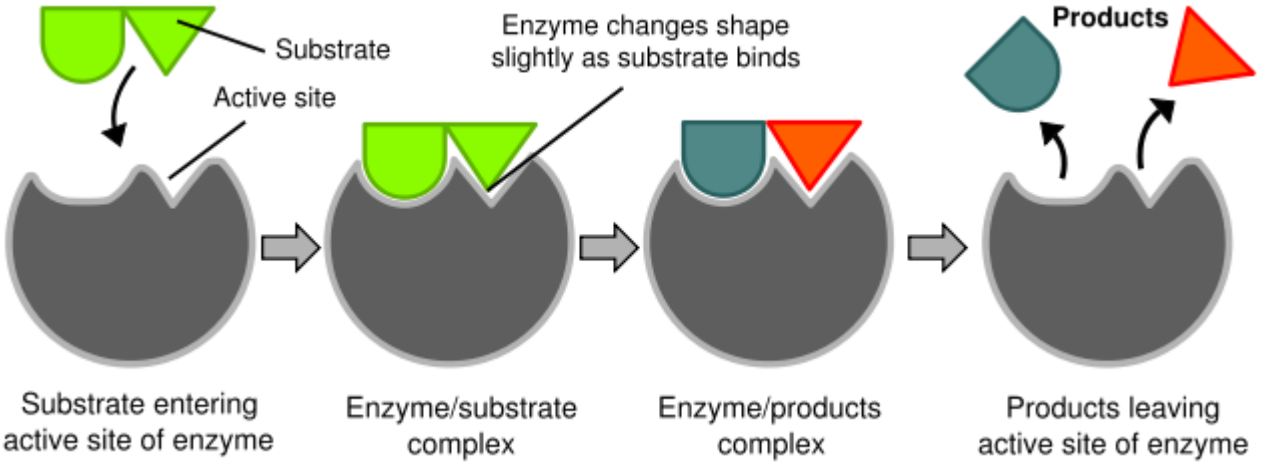
- Enzymes are named according to their substrates and the rxns they catalyze.

  Ex. RNA polymerase , Sucrase, Lipase

-Over 2000 known enzymes

-Some carry out condensation + hydrolysis rxns

Enzymes combine w/ very specific substrate in what is known as lock and key fit



-Enzyme combines w/ substrate and holds it in the correct angel for the rxn to occur. When rxn over the substrate is released and the enzyme can be reused. (note: enzymes are reuseable)

-The substrate binds a a site called the **ACTIVE SITE**
A small groove formed as the protein folds. It recognizes the substrate by its primary structure of amino acids.

-Specific point to point connection.
-**The active site is not rigid but flexible**
- The size , shape, and electrical charge of the aminoacids R groups are what help identify and fit the substrate at the site.

-The *active site flexes slightly upon connection* known as "induced fit model". (more accepted than lock and key)

Co-factors: Inorganic ions that bind to the enzyme to help catalyze the reaction

Co-enzymes: Organic molecules (not proteins)

-generally are bound at the active site and the enzymatic rxn will not work w/o it.

Coenzymes are found in small con. Because they are reusable. (vitamins, nucleotides, NAD)

NOTE: coenzymes and cofactors are needed in some active sites for enzymes and substrates to bind.

FACTORS EFFECTING ENZYME ACTIVITY:

1. Concentration of substrate present

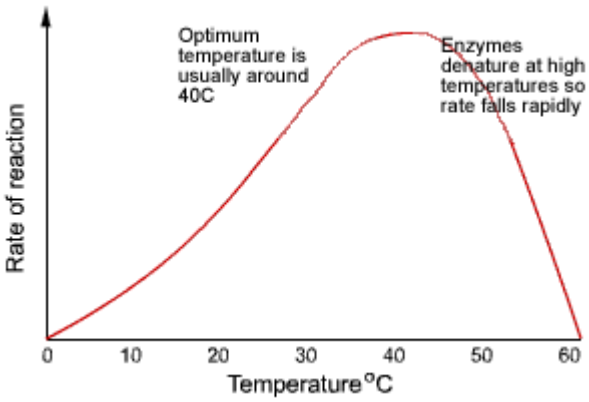
2. Inhibitors:

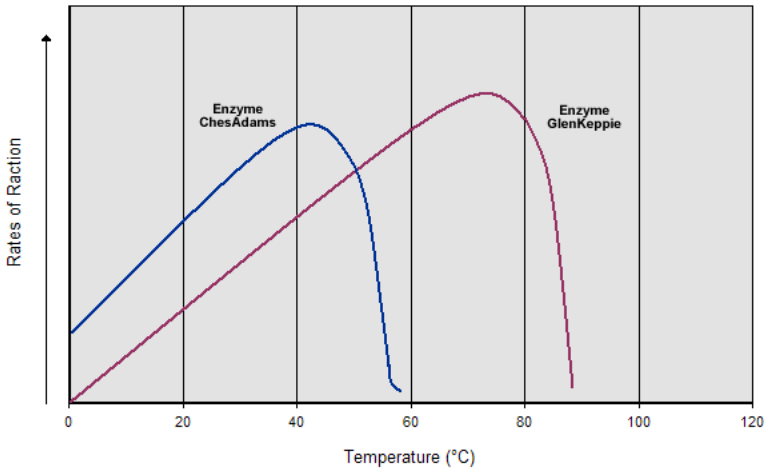
   Decrease an enzymes rxn rate.

   a. Some bind to active site (competition)
   b. Some disrupt enzymes 3 dimens. Structure and destroy its function.

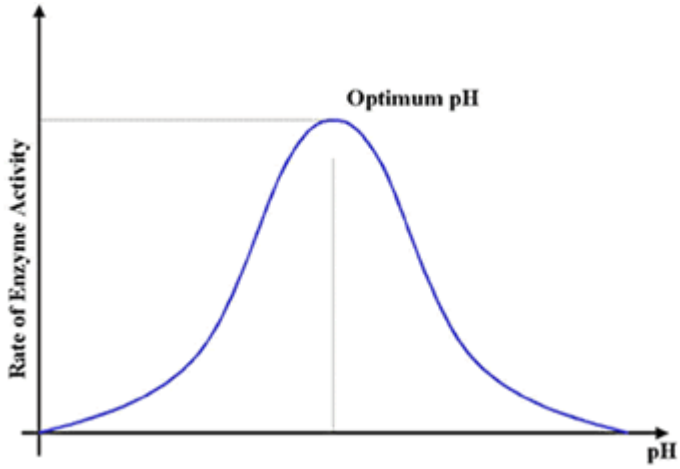
3. Temperature: (denatures the protein if too high)

Generally temperatures above 60^{o} denature enzymes.





4. <u>pH:</u> pH acids change the shape of the enzymes 3 dimensional structure because H^{+} ion changes overall charge of the molecule and disrupts ionic and hydrogen bonding interactions. (optimum pH for living systems?)



<u>Pg 51 ALLOSTERIC ENZYMES (ALLOSTERIC INTERACTIONS)</u>

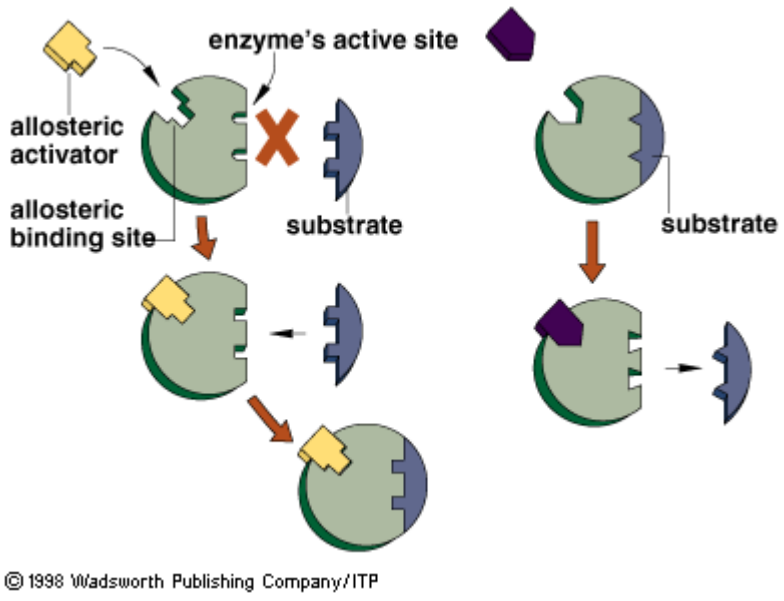
Allosteric Enzymes:

Enzymes that can exist in two or more different shapes

-Allosteric enzymes have

1. Active site
2. Regulatory site

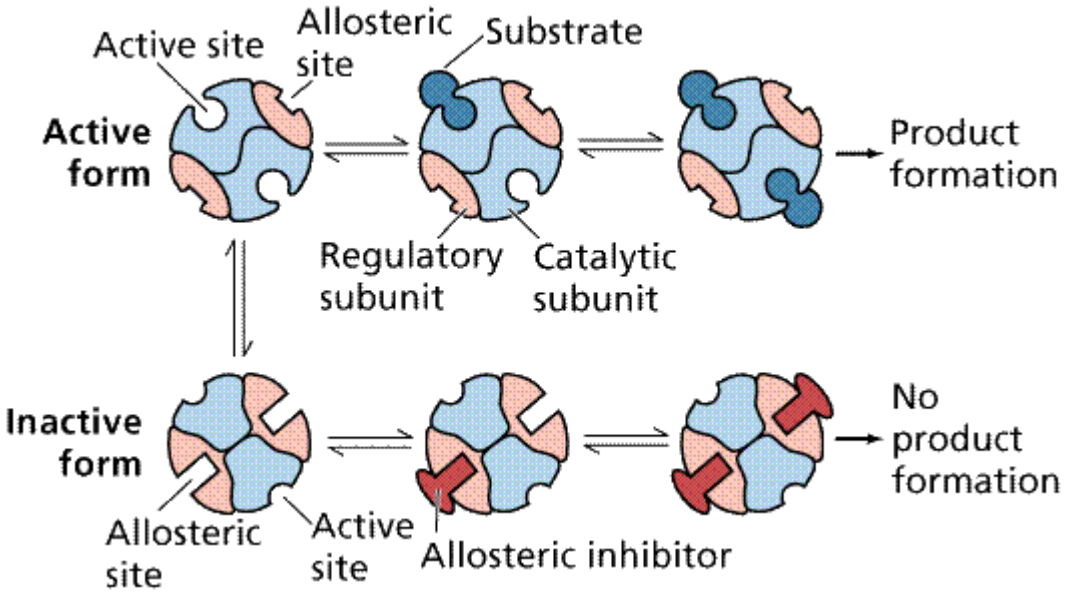
When molecules bind to the regulatory site, it alters the enzymes shape and therefore its activity.



ALLOSTERIC INHIBITORS:

Molecules that when bound to the regulatory site cause a change in the active site so it doesn't function anymore.

Stimulatory molecules: when attached to the R.S. correct the shape of the active site and let the rxn occur.



Allosteric feedback loop: (negative feedback loop)

Often the beginning enzyme is allosteric and the final substrate product is the inhibitor for the regulatory site on the allosteric enzyme.

Enzyme 1 ---→ product 1C------→ Product 2C--→ Product 3c----

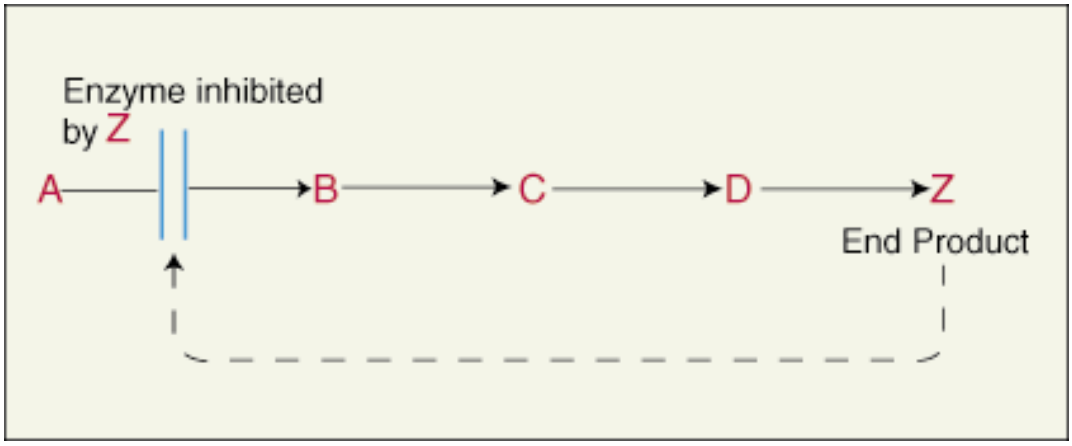
Enzyme 2 Enzyme 3

Allosteric inhibitor

→ Product 4c------→ Product 5C ---→ Product 6C (glucose)

Enzyme 4 Enzyme 5

Glucose becomes the allosteric inhibitor for enzyme 1



SIMPLE PROTEINS: on hydrolysis include only amino acids:

1. Albumins - soluble in water (distilled), most enzymes

2. Globulins - soluble in dilute aqueous solutions;

3. Protamines - not based upon solubility; small MW proteins with 80% Arginine & no Cysteine

4. Histones - unique/structural: complexed w DNA, high # basic aa's - 90% Arg, Lys, or His

5.Collagen = high Glycine, Proline, & no Cysteine when boiled makes gelatin

Keratins - proteins of skin & hair high basic aa's (Arg, His, Lys), but w Cys

Complex Proteins:

on hydrolysis yield amino acids + other molecules

lipoproteins *- (+ lipids)*

blood, membrane, & transport proteins

glycoproteins ***-*** *(+ carbohydrates)*

antibodies, cell surface proteins

nucleoproteins ***-*** *(+ nucleic acids)*

ribosomes & organelles