Macromolecules

Chapter 5, Campbell

Macromolecules

- Composed of long chains of smaller molecules
- Macromolecules are formed through the process of *polymerization*.
- **Polymerization** = large compounds are built by joining smaller ones together
- Small units (*monomers*) form larger units (*polymers*)
- There are four groups of organic compounds found in living things…

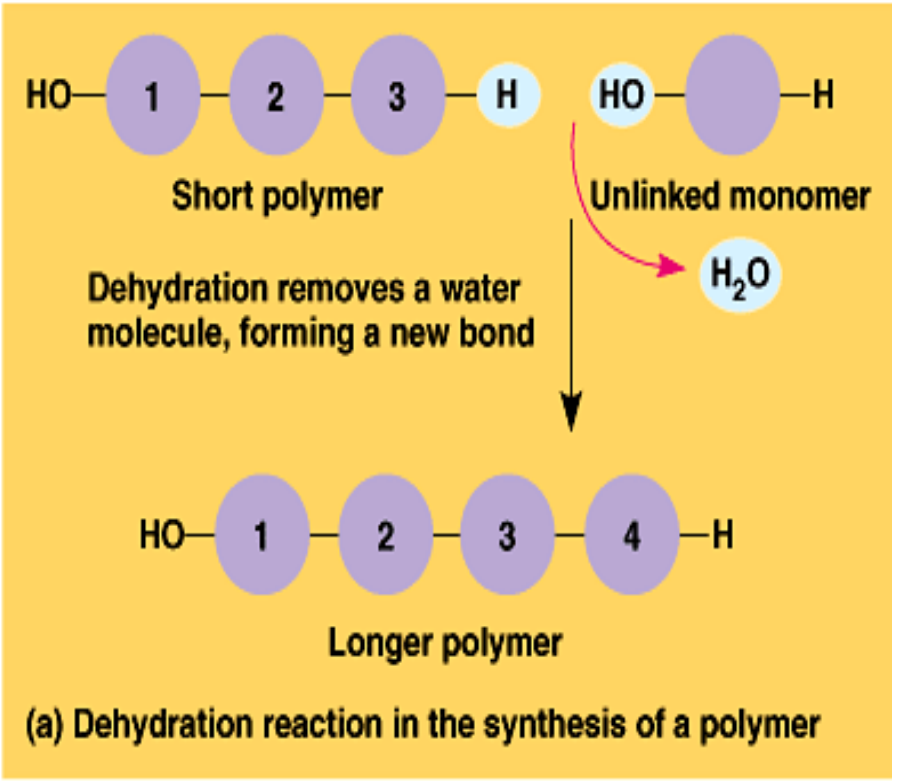
Macromolecules

- There are four groups of organic compounds found in living things:

1. Carbohydrates
2. Proteins
3. Nucleic Acids
4. Lipids

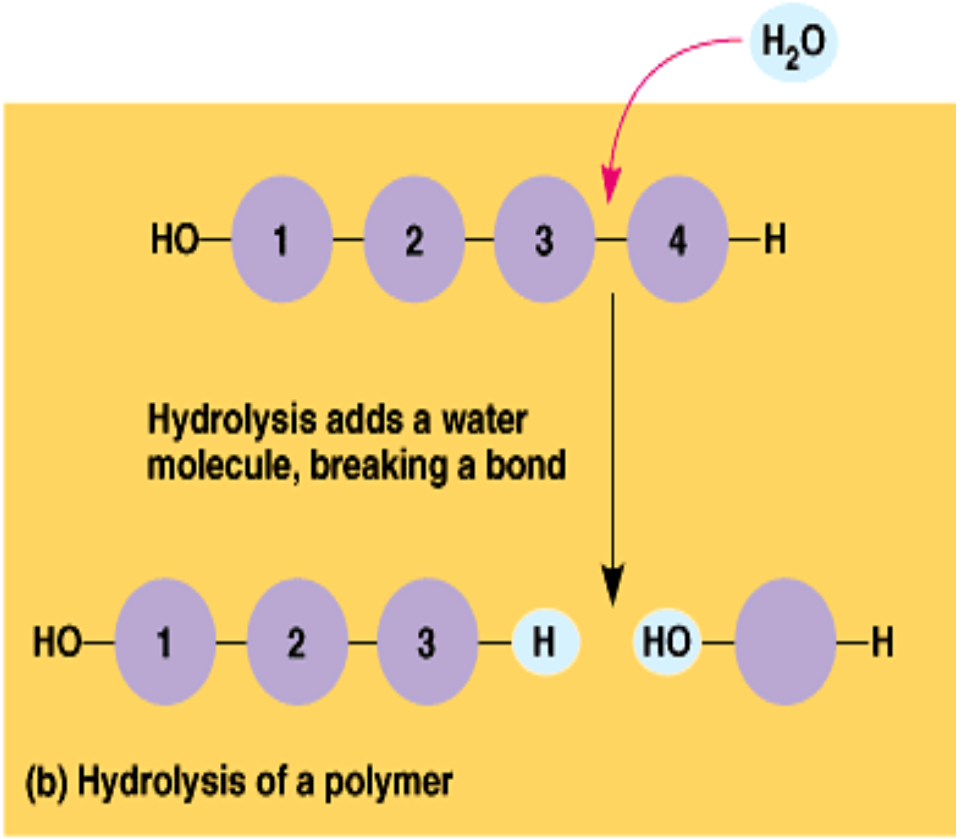
Dehydration Synthesis

- "AKA" condensation reaction
- *Dehydrate* = lose water
- *Synthesis* = to join or make
- Monomers are combined
- H_2O released



Hydrolysis

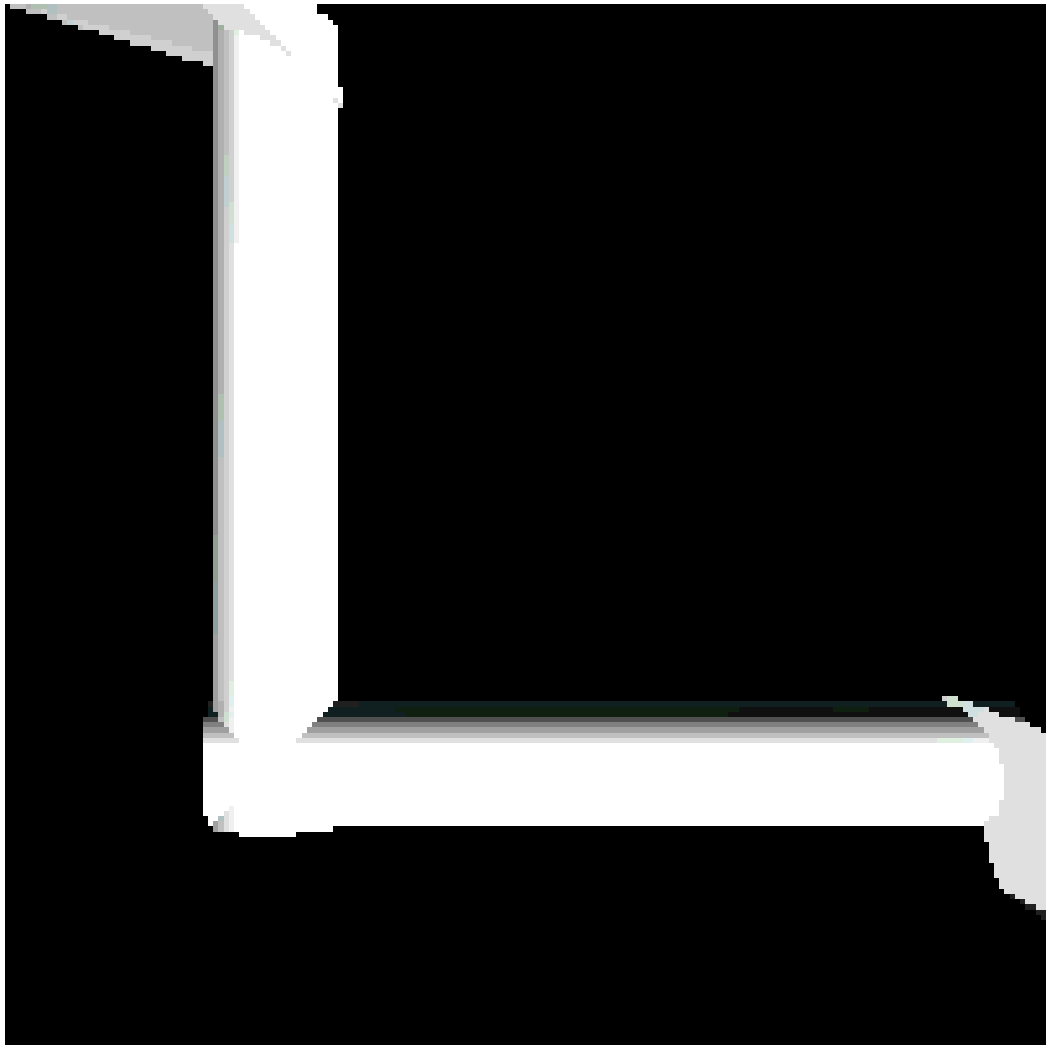
- Form of digestion
- *Hydrate* = to water
- *ysis* = process of
- With the breaking of bonds, water molecules are added to each smaller molecule



1. Carbohydrates

- "AKA" sugars or carbs
- Chemical compounds that contain carbon, hydrogen, and oxygen.
- The three elements exist in a *1:2:1* ratio
  Empirical vs molecular formula
- Organisms use carbohydrates as a primary source of fuel (energy).
- Plants use carbohydrates for structural support.

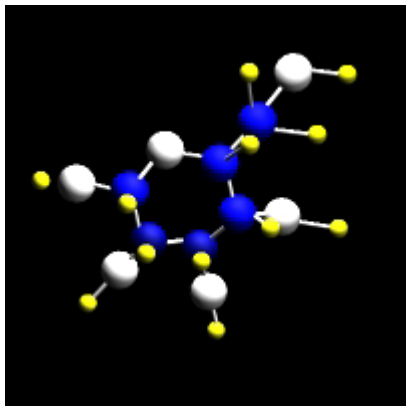
1. Carbohydrates



Monosaccharide

- **Monosaccharide** = simple sugars
- Small in size & easily diffuse into and out of the cell
- There are three monosaccharides;

1. *Glucose*
2. *Fructose*
3. *Galactose*



- Products of the following chemical reactions:
  - Photosynthesis
  - Digestion
  - Conversion of fats & proteins
- Organism uses:
  - Fuel for respiration
  - Building larger sugars
- Monosaccharides link together forming two – sugar

Disaccharide

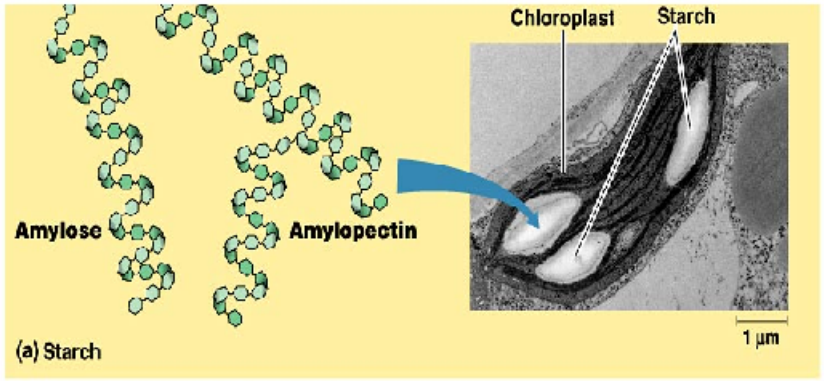
- **Disaccharide** = a sugar made from the combination of two monosaccharides
- Disaccharides are water-soluble, but cannot diffuse into or out of the cell
- There are three disaccharides in your home:

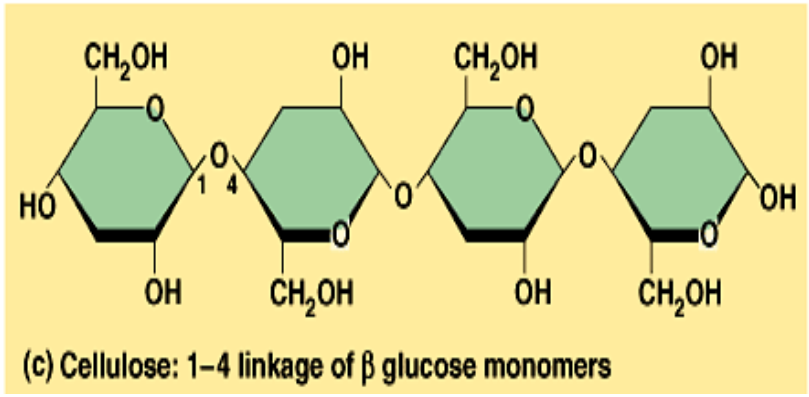
1. **Sucrose** = Glucose + Fructose (table sugar)
2. **Lactose** = Glucose + Galactose (milk sugar)
3. **Maltose** = Glucose + Glucose (cereal)

Polysaccharide

- **Polysaccharides** = “giant” sugar made from the combination of 3 or more monosaccharides
- “AKA” starches
- Large insoluble molecules that cannot diffuse into or out of a cell
- Used for long – term energy storage or structural support purposes
- Major bio – starches include
  - Glycogen
  - Amylose
  - Cellulose

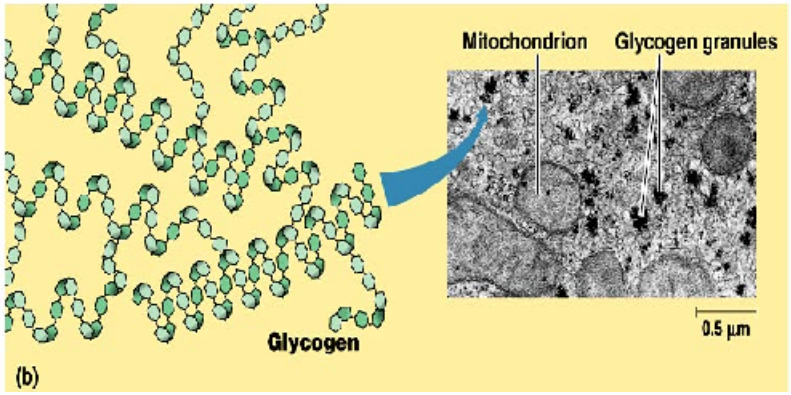
Plant Starch





- Amylose = surplus glucose storage in chloroplasts
- Cellulose = structural glucose that forms the cell wall in plant cells

Animal Starch



- **Glycogen** = storage starch for an organisms supply of glucose
- Glygogen is highly branched, many strands
- Animals store glycogen a one – day supply of glycogen in the liver and muscles
- **Chitin** = starch that forms the exoskeleton of arthropods and insects
- Chitin also forms the cell walls of various fungi

2. Proteins

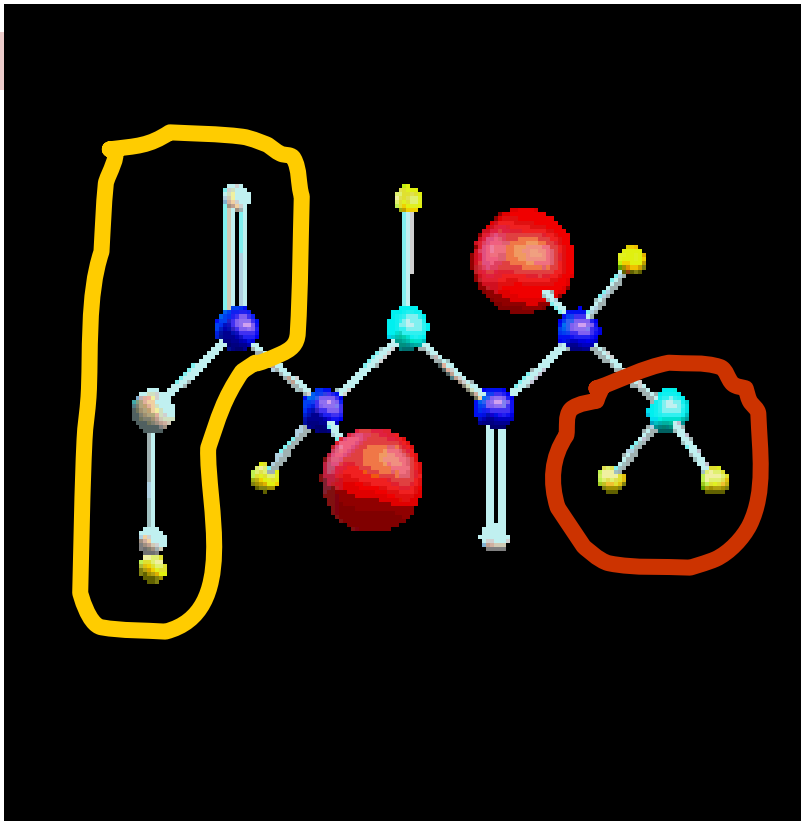
- Organic polymers that contain carbon, hydrogen, oxygen and nitrogen
- Formed from the bonding of monomer building blocks called ***amino acids***
- Used in the protective skin and muscle tissue of animals
- Also used as enzyme catalysts in both plants and animals

Amino Acids

- Building blocks for proteins
- Small molecules that can easily diffuse into and out of the cell
- Integral to the formation and copying of DNA
- 20 different amino acids are divided into two categories

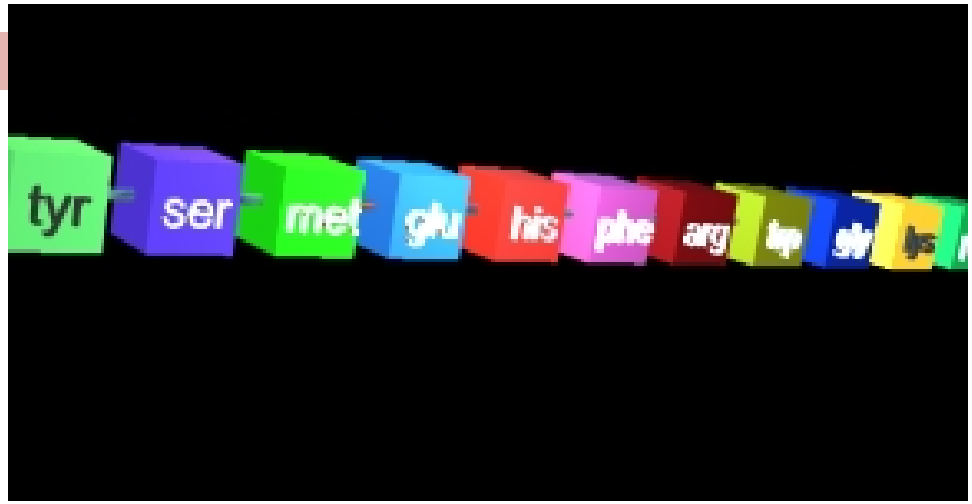
1. Essential = must be ingested (9)
2. Non-Essential = can be produced in the body

Structure of Amino Acids



- Amino acids are built like a sandwich
- One slice of bread must be an amine group
- The other slice must be a carboxyl group
- In this image the large red structures represent the R group of the Amino acid. The R group represents an organic variable.
- This organic molecule is different in each of the 20 amino acids and determines their behavior.

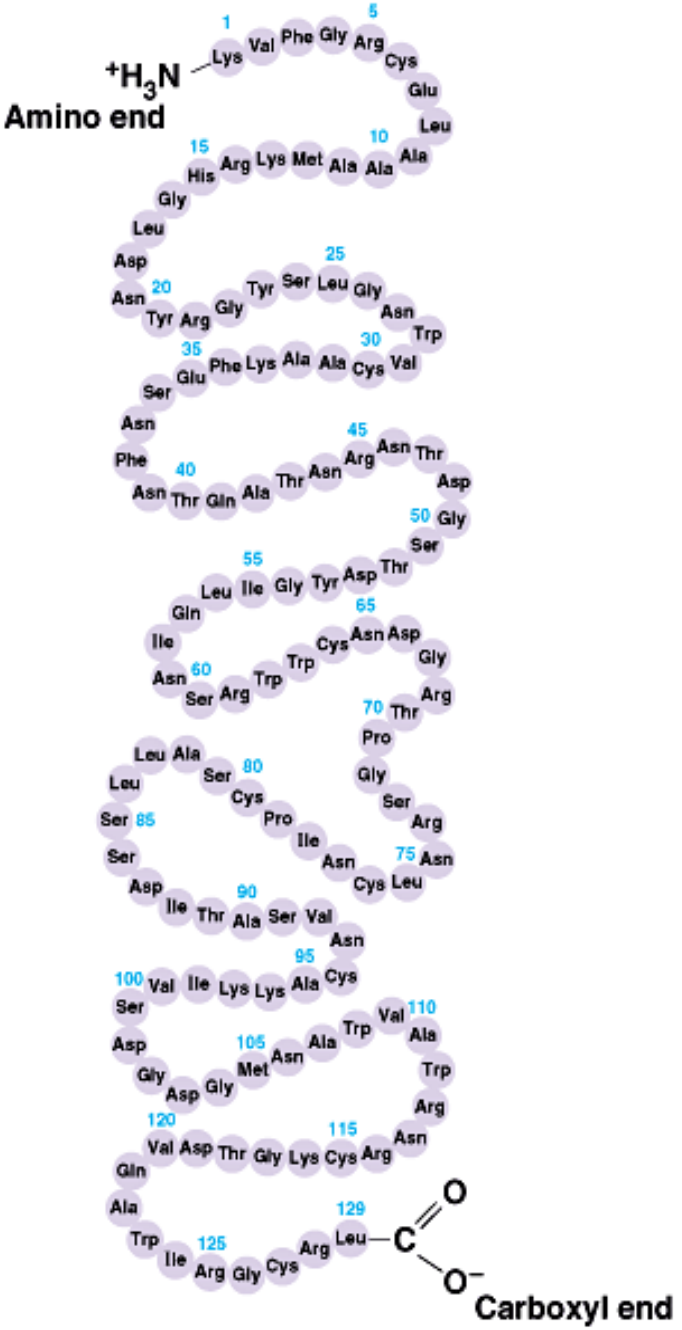
Peptides



- During the dehydration synthesis of two monomers, a *peptide bond* forms
- **Peptide bond** is a covalent bond that links amino acids together to create proteins.
- **Polypeptide** = bonding together of numerous amino acids
- Proteins are composed of polypeptides in various bond structures

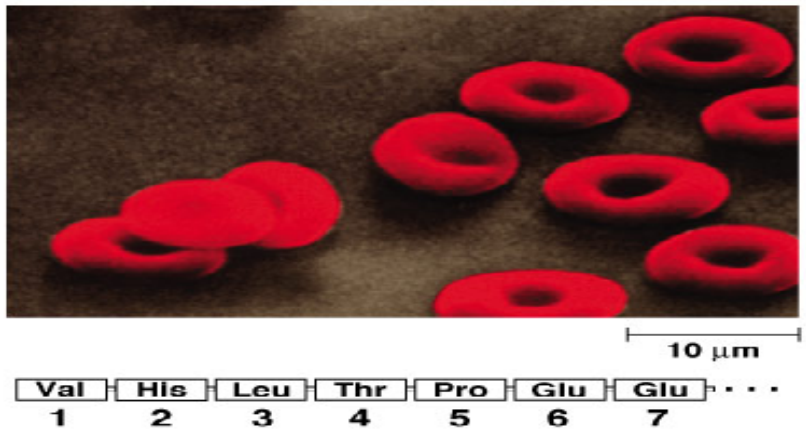
Primary Structure

- Unique sequence of amino acids
- Single polypeptide chain of amino acids
- Mistakes in sequence and structure will result in a failure to complete function
- Primary structure is determined through genetic inheritance

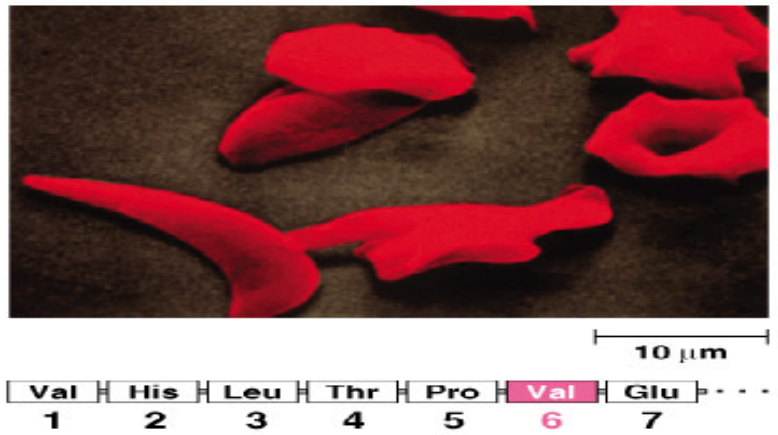


Primary Structure & Function

- A mistake in the reading sequence of amino acids in a polypeptide results in the change in shape of the human RBC
- Sickle cell anemia



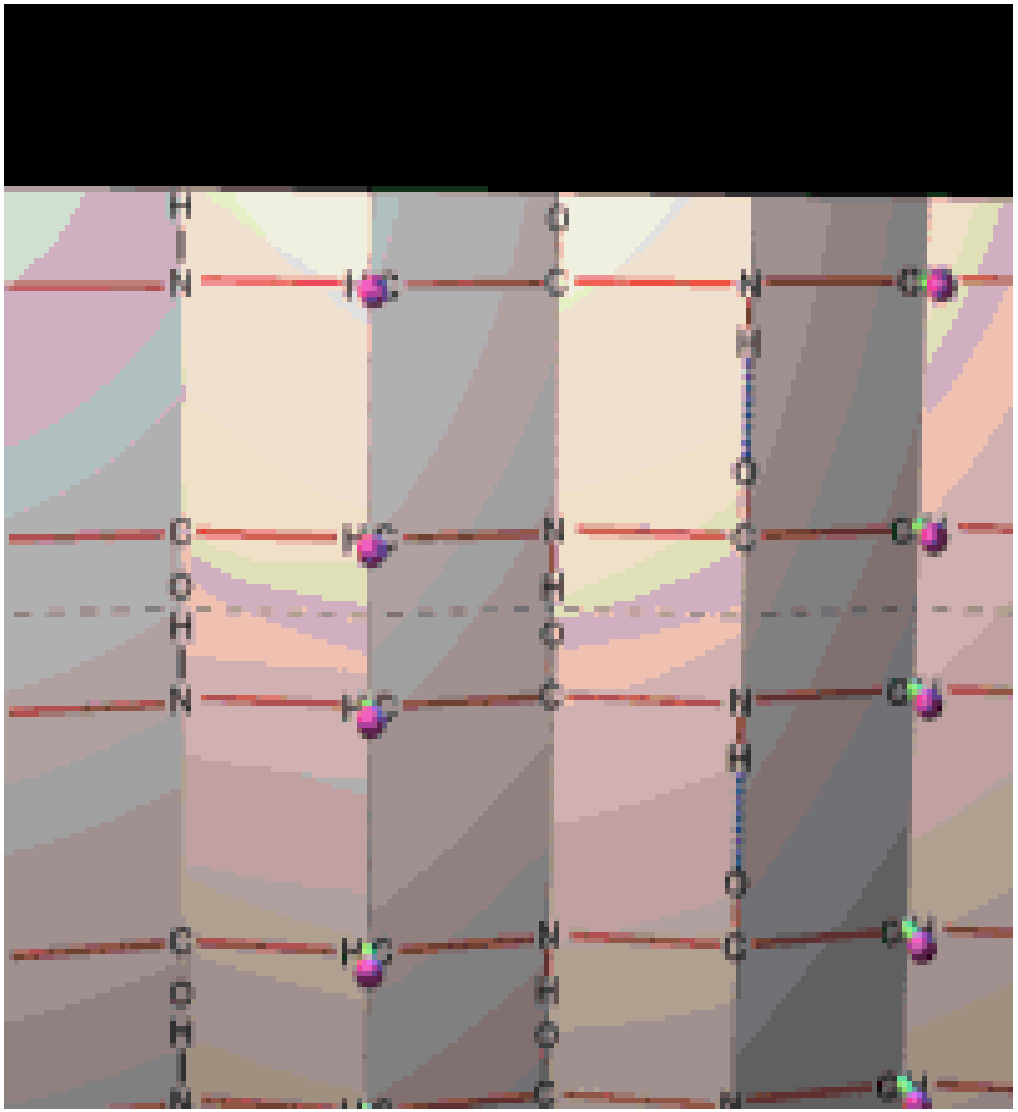
(a) Normal red blood cells and the primary structure of normal hemoglobin



(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

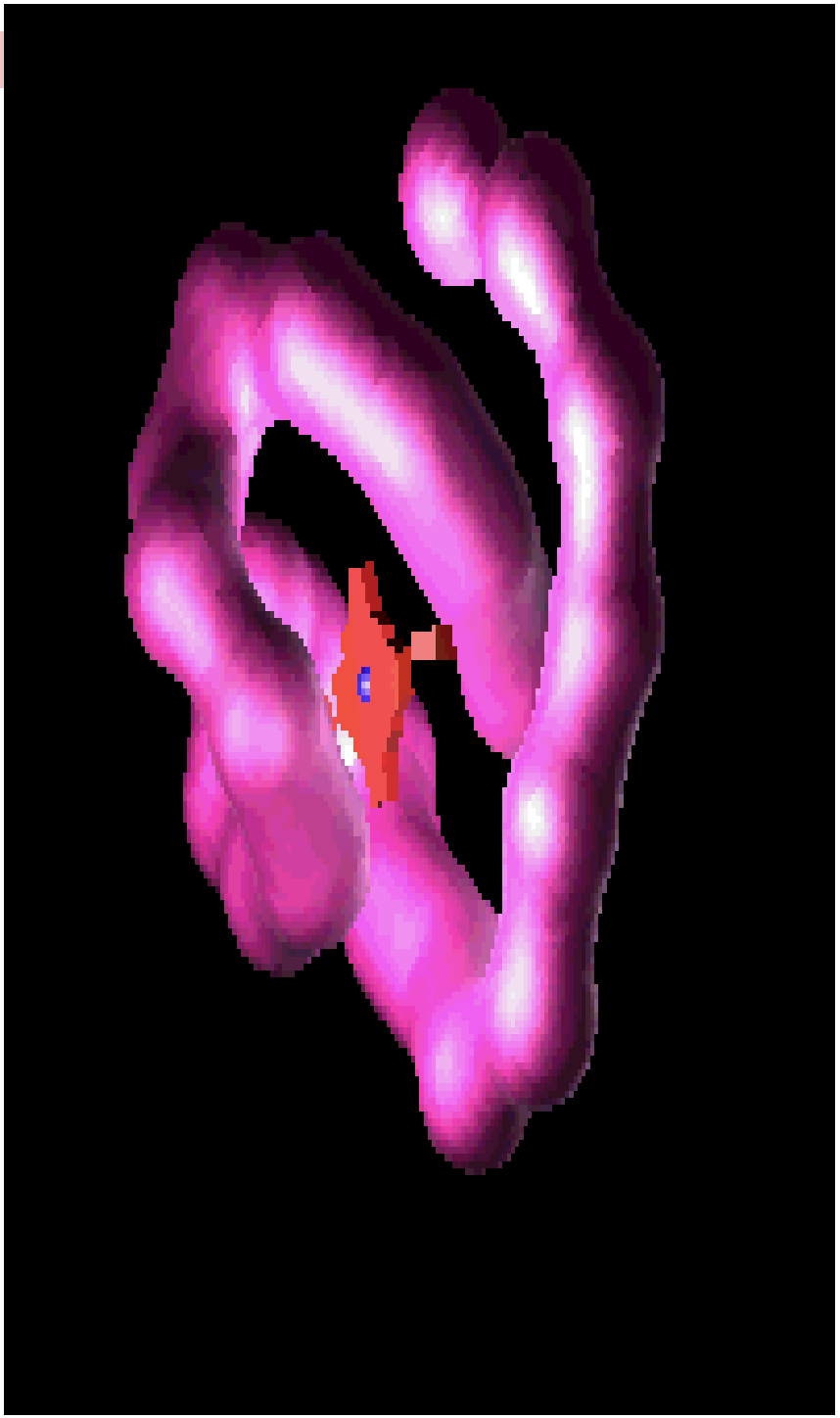
Secondary Structure

- Results from hydrogen bond inserted between peptide bonds at regular intervals along the amino acid sequence
- This alternation of bonding forms a coil or helix shape or a pleated sheet (folded paper)



Tertiary Structure

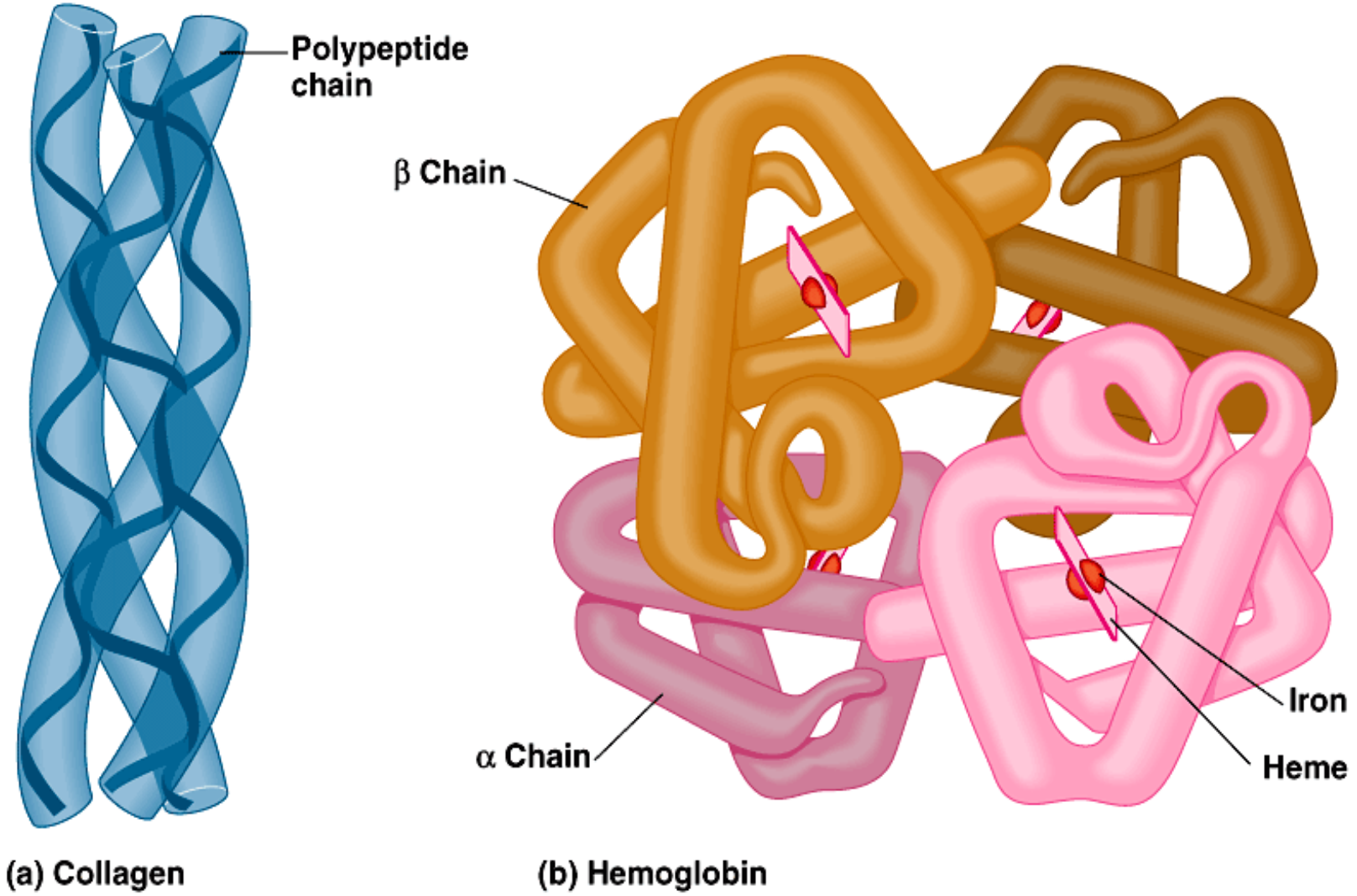
- Determined by interactions among functional groups of amino acids along the peptide bond chain
- Functional group interactions produce hydrophobic regions and van der Waals interactions



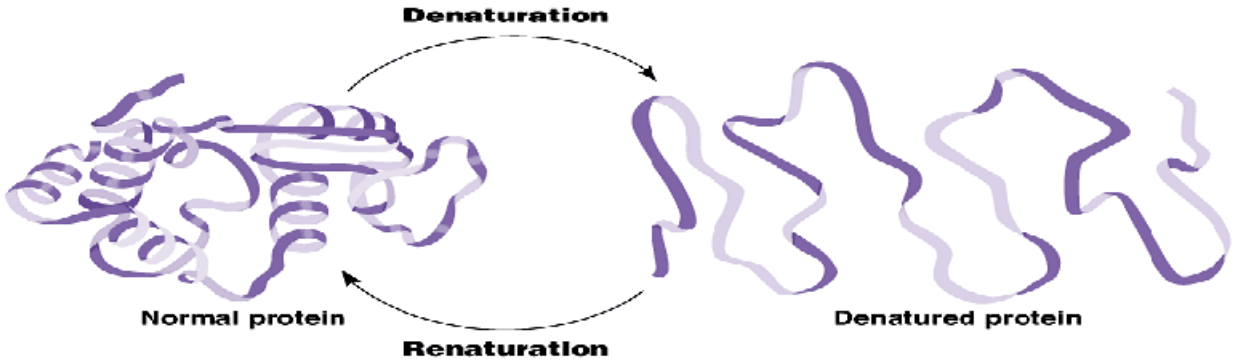
Quaternary Structure

- Results from the bonding or combination of two or more polypeptide chains
- Amino acids form a super coil of bond between the various chains
- Structure of these proteins similar to braided rope and is very strong

Quaternary Structure



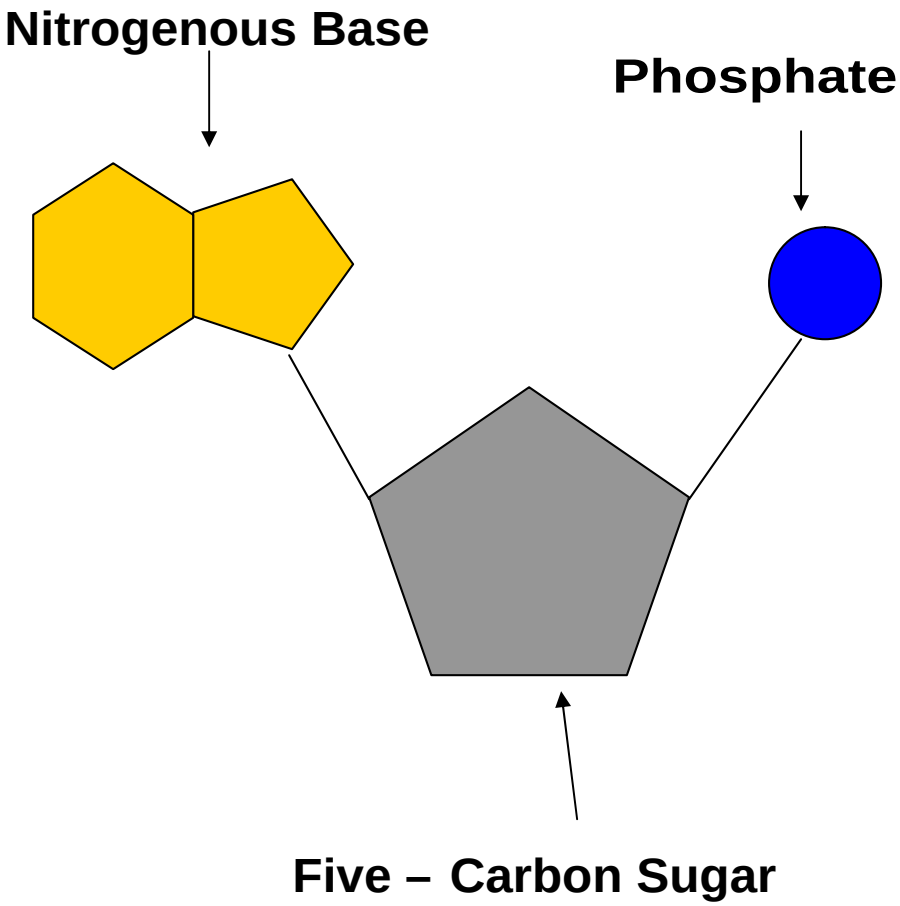
Denaturing



- Any change in shape, structure, & function of a protein
- The protein is now biologically inactive
- The protein is said to be “denatured”
- Causes of Denaturing:
  - Alteration of pH
  - Changes in solute concentration
  - Changes in environmental conditions
  - Temperature changes
- Some proteins may renature, other cannot

3. Nucleic Acids

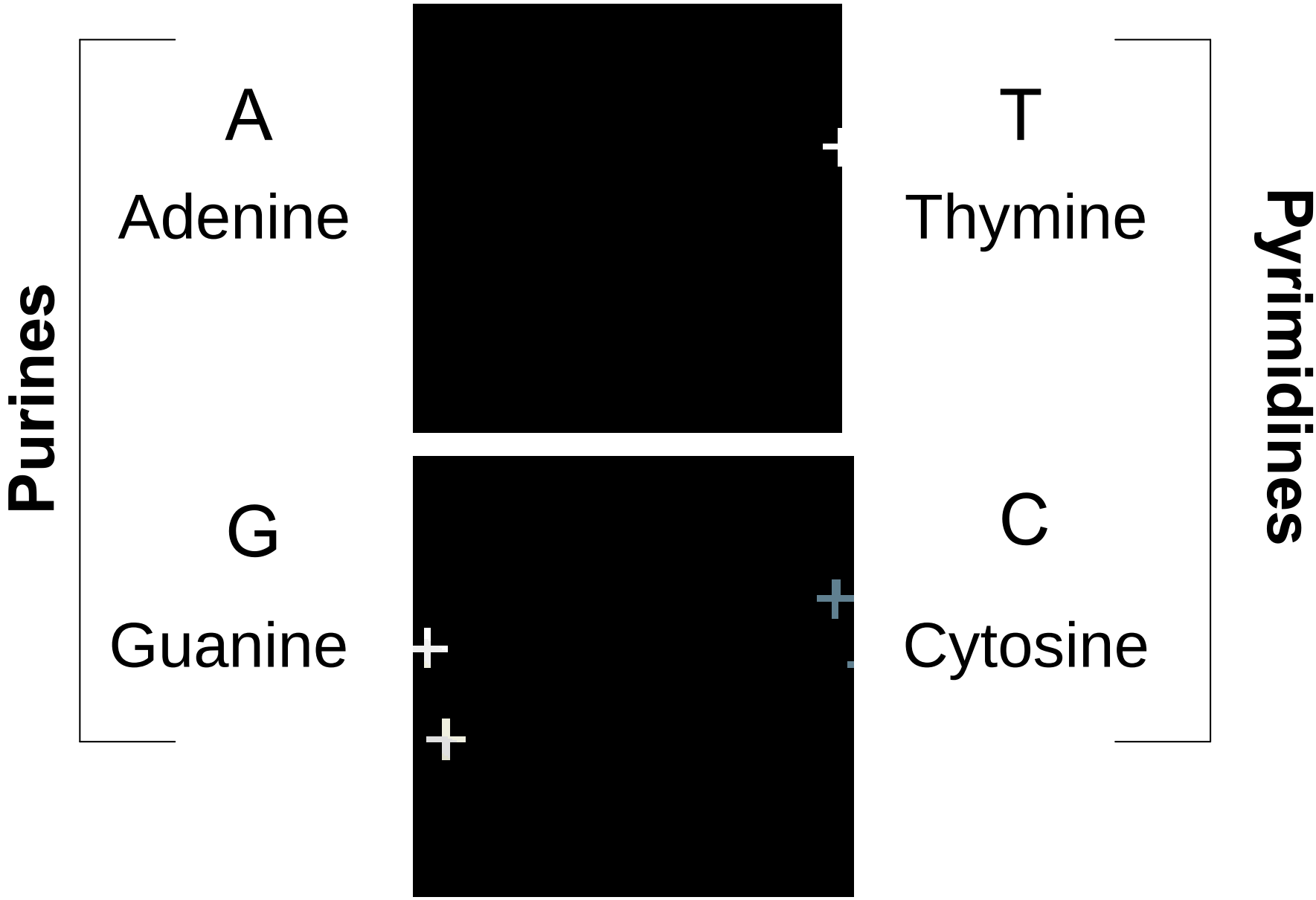
- Macromolecule monomer containing H, O, N, C, and P
- **<u>Nucleotides</u>** = 5-carbon sugar combined with a phosphate group and nitrogenous base
- Nucleic acids store and transmit genetic info
  1. Ribonucleic Acid (RNA)
  2. Deoxyribonucleic Acid (DNA)



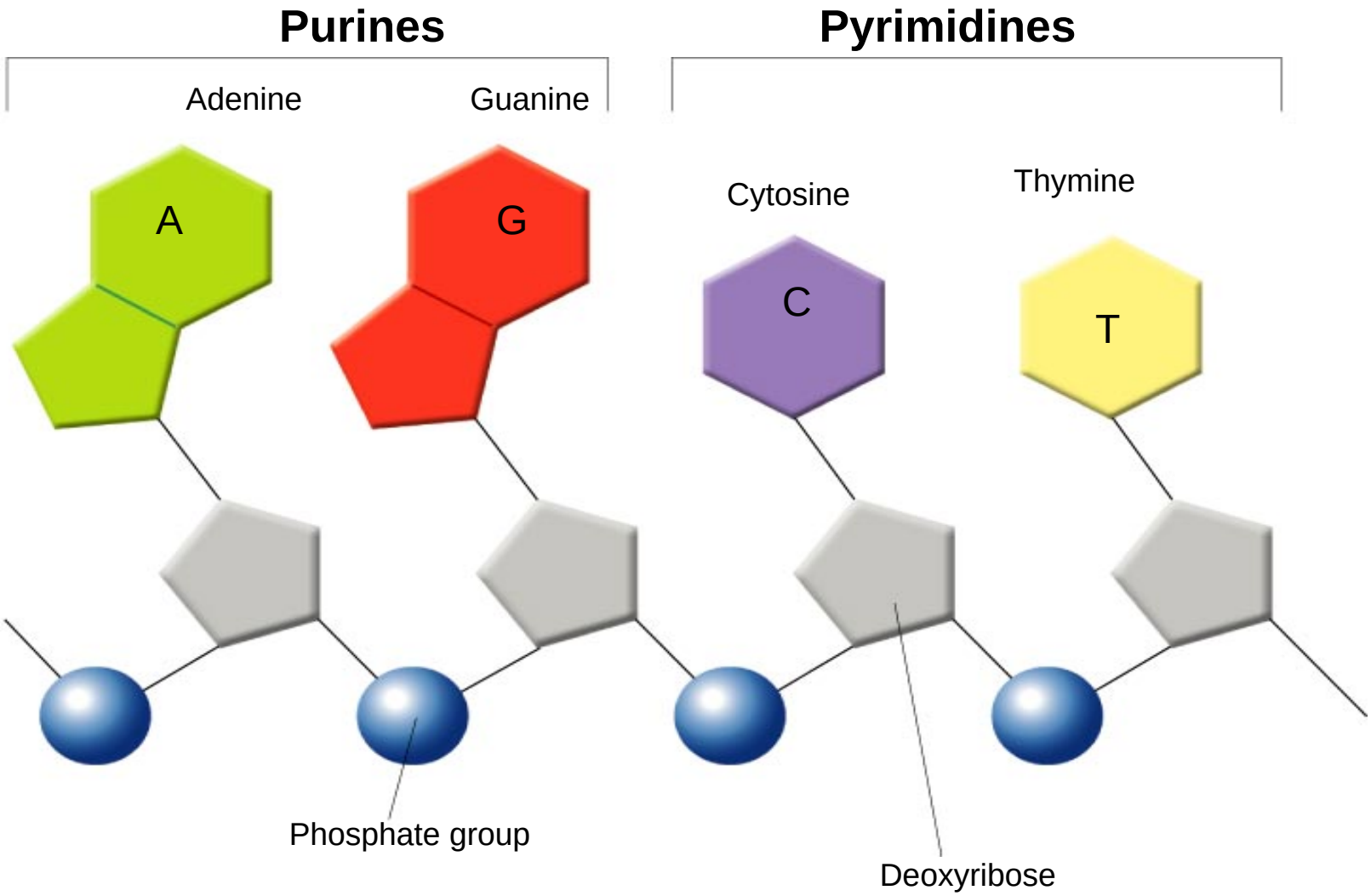
Nucleic Acid Bonding

- DNA is composed of four nitrogenous bases
- The bases are represented by a letter
  1) Adenine (A)
  2) Guanine (G)
  3) Cytosine (C)
  4) Thymine (T)
- The four bases are divided into two classifications based on their chemical structure
  1) **Purines** = have two rings of carbon (A & G)
  2) **Pyrimidines** = have only one carbon ring (T & C)

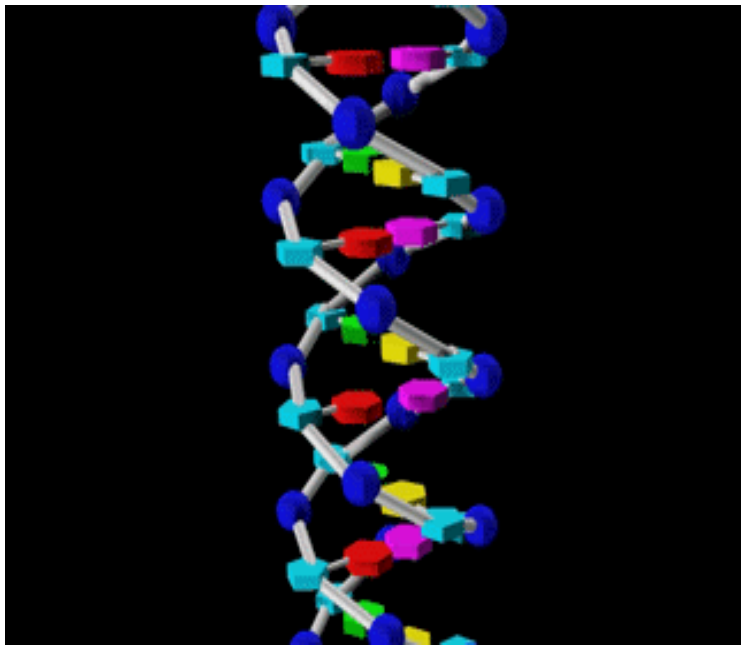
Classification of Nucleotides

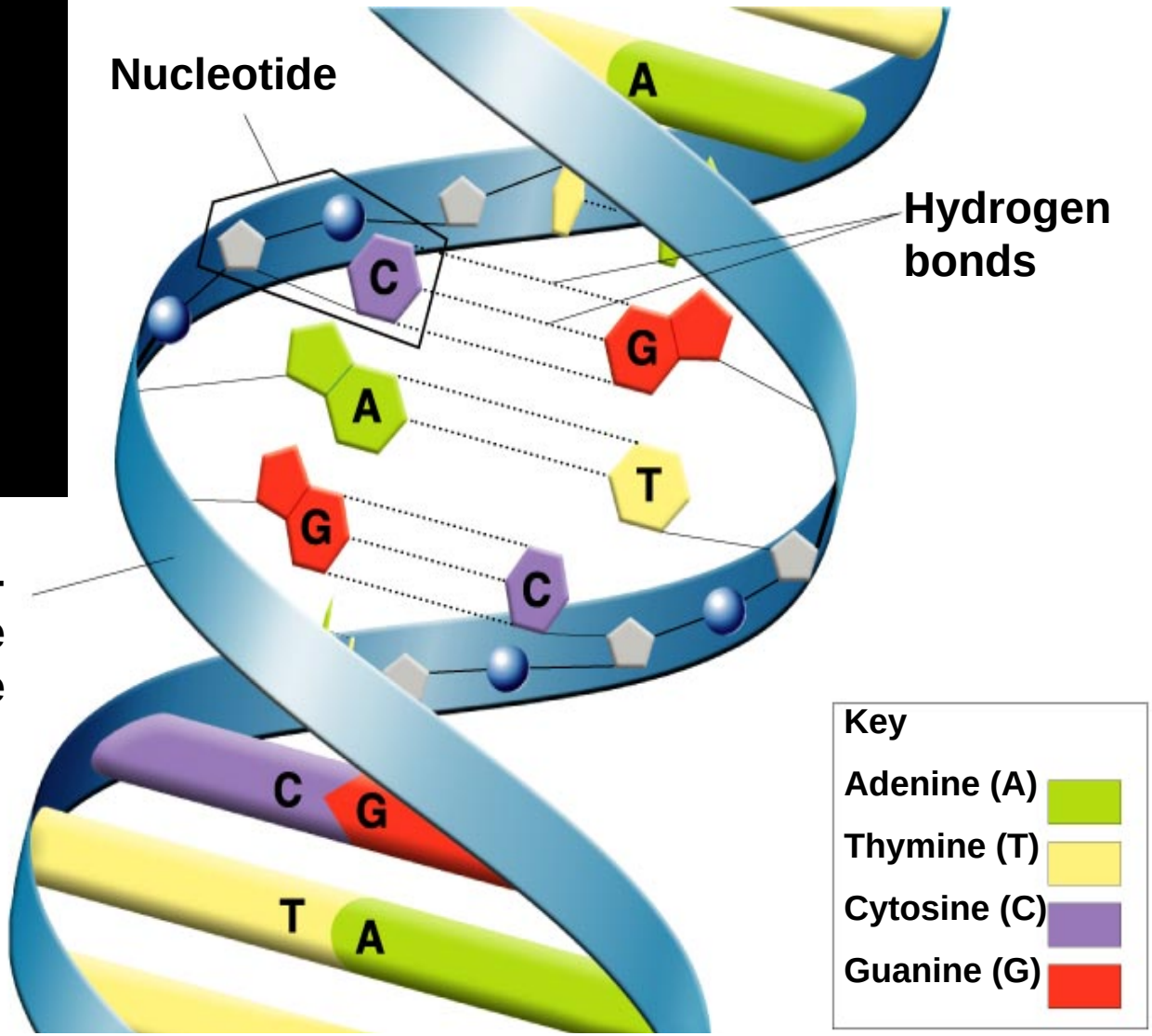


Classification of Nucleotides



Double Helix & Base Pairing





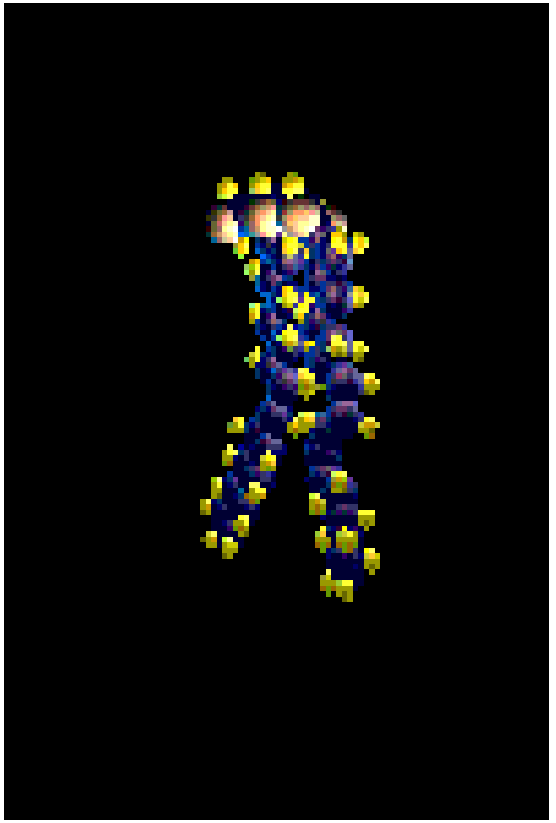
<u>DNA</u>

A with T

G with C

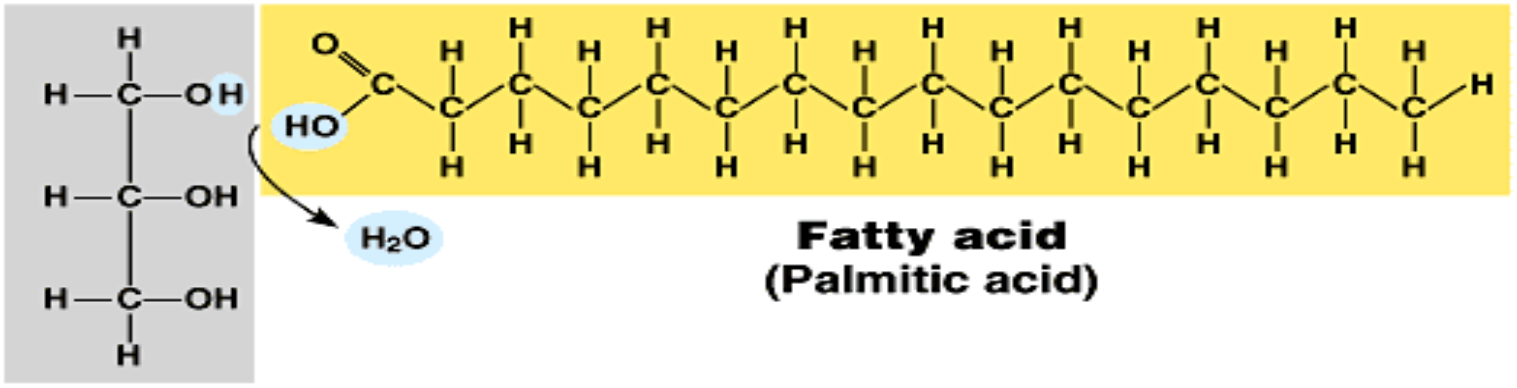
4. Lipids

- “AKA” fats
- Chemical compounds that contain carbon, hydrogen, and oxygen
- Hydrogen and Oxygen could exist in a *many:1* ratio
- *Are the macromolecule exception in that they are not polymers*
- Lipids are formed from smaller molecules through dehydration reactions
- Any fat is constructed from two sub – units
  - Glycerol
  - Fatty acids



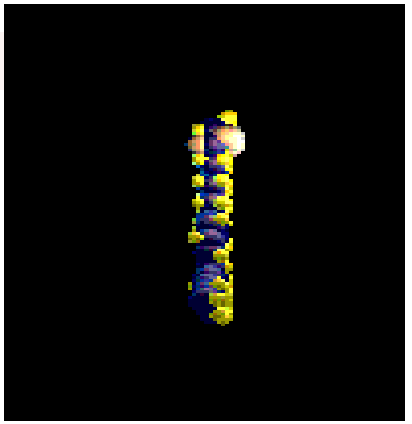
Fat Structure

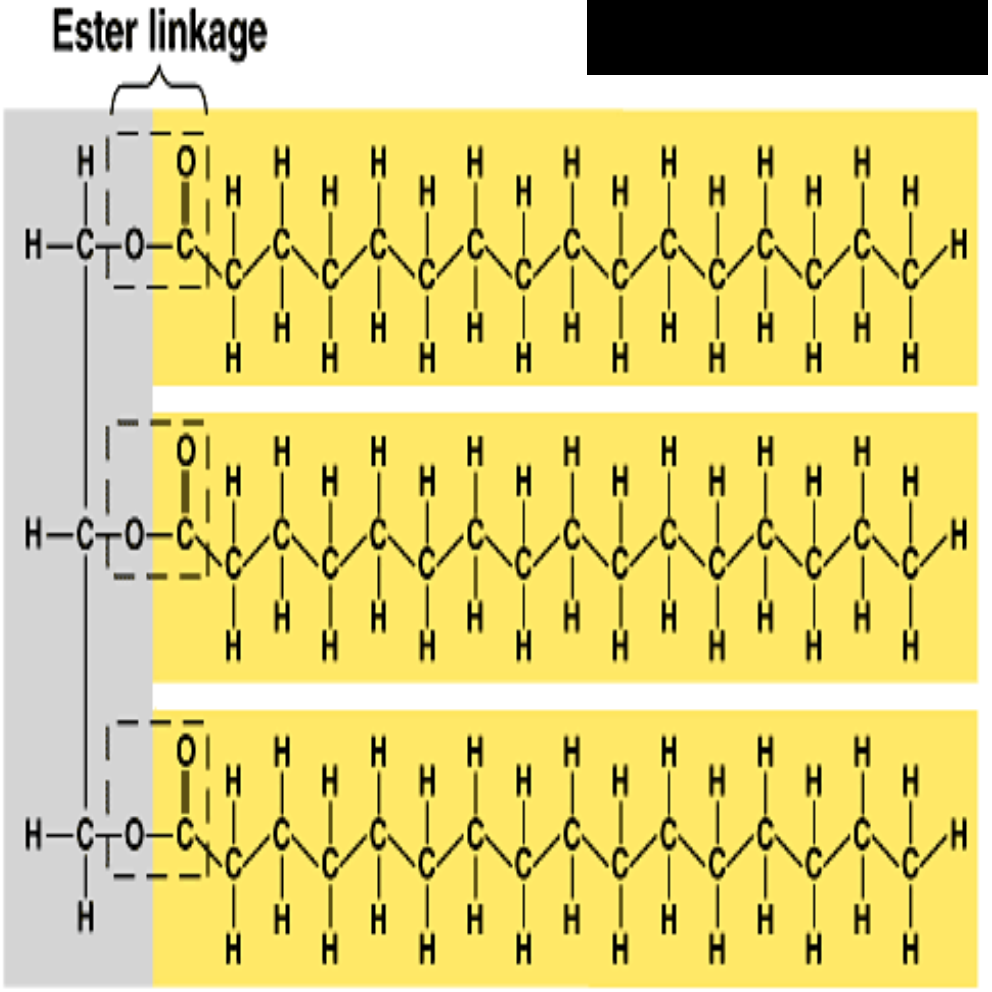
- Glycerol consists of a 3- carbon skeleton with a hydroxyl group attached
- Fatty acid consists of a carboxyl group attached to a long carbon skeleton, often 16 to 18 carbons long
- Joined through dehydration synethesis



Triglycerides

- Complex lipid
- "AKA" triacyglycerol
- Formed by the linkage of three fatty acid tails (*tri*) to a glycerol head

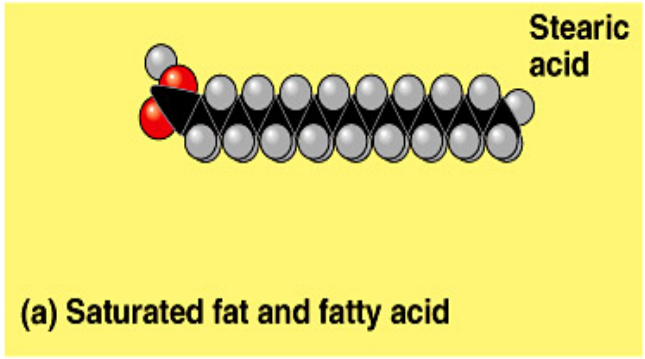




(b) Fat molecule (triacylglycerol)

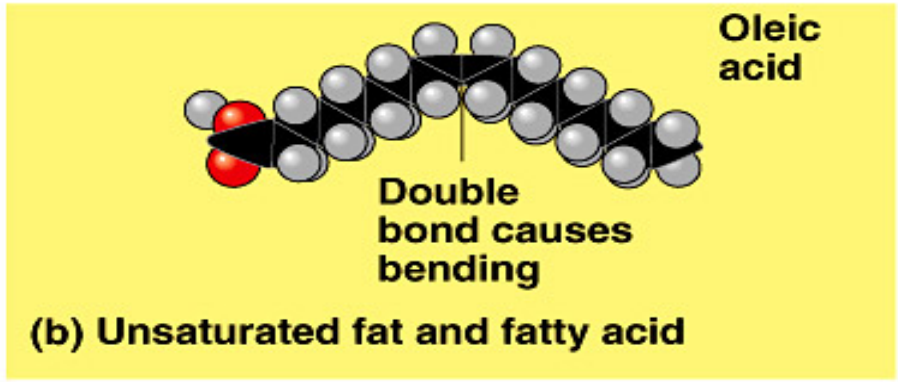
Saturated Fats

- Solid at room temp.
- Found in animal products
- The hydrocarbon tail of this lipid has carbon atoms **saturated** with hydrogen at each bond site
- Contains no double or triple bonds between carbon atoms



Unsaturated Fats

- Liquids at room temp.
- Found in plant & fish oils & legumes
- The carbons are **not saturated** with hydrogen bonds
- May contain one or more double or triple bonds between carbon atoms



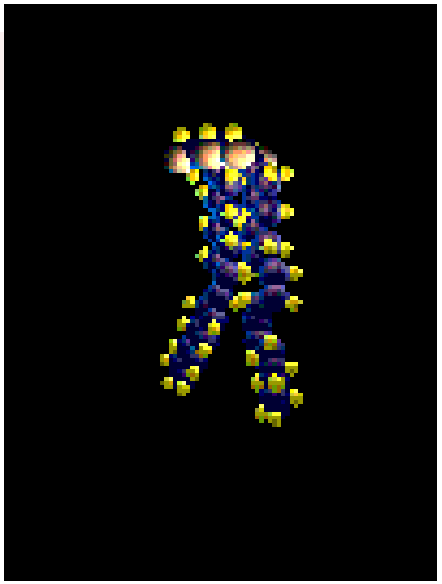
Fat Functions

- Animals:
  - Energy storage
  - Waterproof coverings
  - Insulation
  - Cushioning of organs
  - Cell membranes
- Plants:
  - Oils for seed dispersion
  - Cell membranes

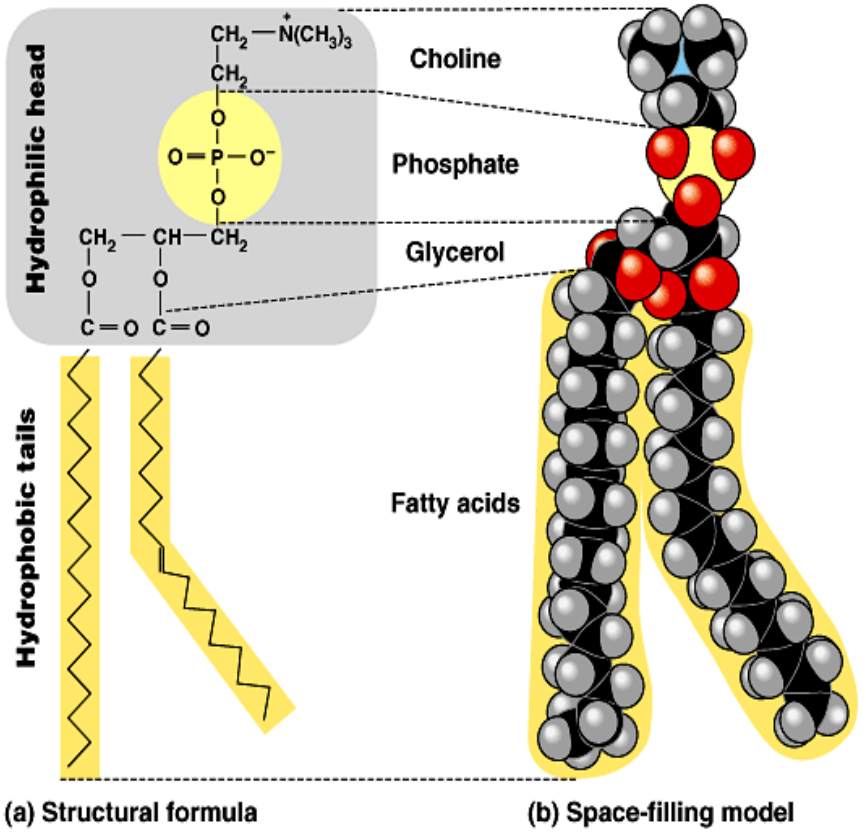
Phospholipids

- Phospholipids = major components of cell membranes of various organisms
- Phospholipids have two fatty acids attached to glycerol & a phosphate group at the third position
- The phosphate group carries a negative charge giving the molecule polarity
- Phospholipids interaction with water determine what can and cannot pass the cell membrane

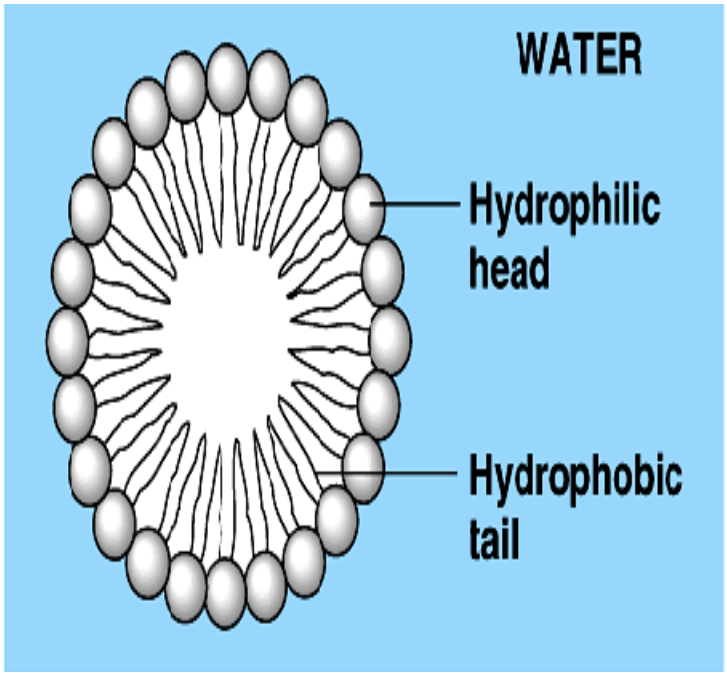
Phospholipid Structure

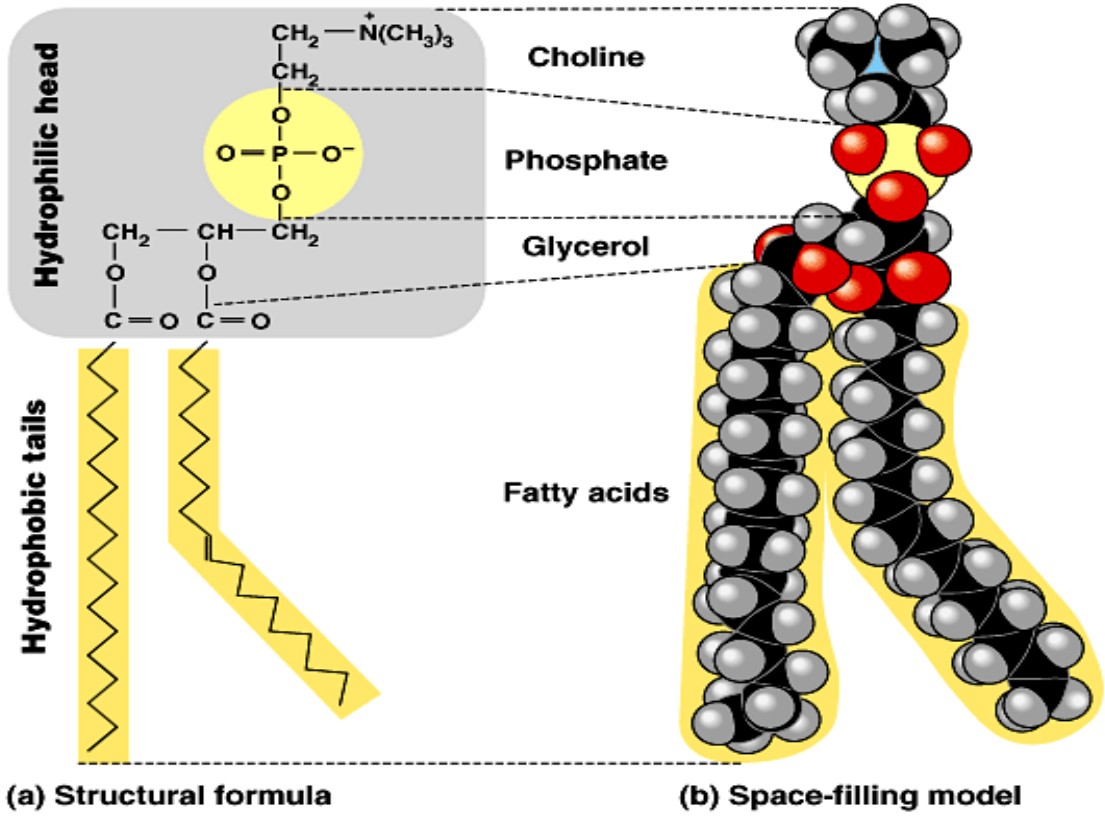


- The fatty acid tail is hydrophobic (repels H_2O)
- Phosphate head group is hydrophilic (loves H_2O)
- As phospholipids are added to water, they self-assemble with the hydrophobic tails pointing toward the center and the hydrophilic heads on the outside



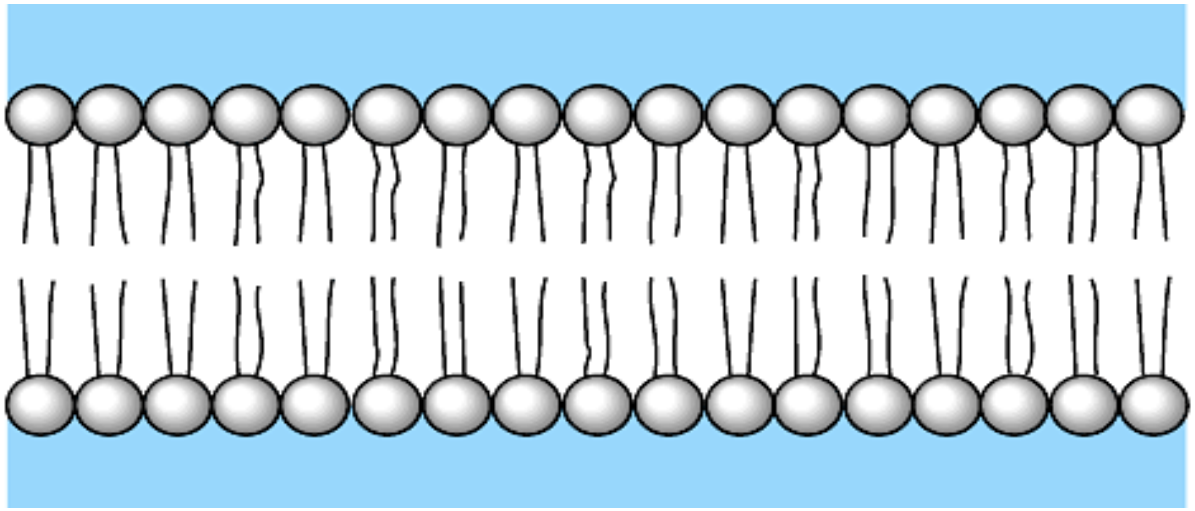
Phospholipid Structure





Bilayers

- At the surface of a cell phospholipids are arranged as a bilayer
- The arrangement of heads & tails creates a bilayer between the cell and its external environment



(b) Phospholipid bilayer

Steroids

- Fat-based molecule composed of four fused carbon rings and a functional group
- Chemical basis of many animal hormones
- Human hormones include:
  - Cholesterol = nerve cell function
  - Testosterone = male sexual hormone
  - Estrogen & Progesterone = female sexual hormones