Macromolecules

Carbohydrates, Lipids, Proteins, Nucleic Acids

Carbohydrates – fuel and building material

- All have the ratio of CH_2O
- Contain carbonyl and multiple hydroxyl groups
- Monosaccharides - Can be 3 to 7 carbons long
  - 6 carbon sugars called hexoses (glucose – aldehyde; fructose – keytone)
  - 3 carbon sugars called trioses
  - 5 carbon sugar called pentose (ribose)
- Disaccharides – form by dehydration synthesis "glycosidic linkage"
  - Sucrose is most prevalent

Carbohydrates – fuel and building material

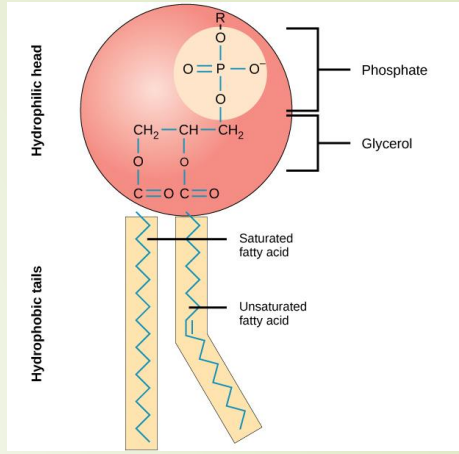
- Polysaccharides
  - Some serve as storage material hydrolyzed as needed to provide sugar for cells (glucose is in alpha configuration causes helical structure)
    - Plants store starch as granules with in cells = stored energy
    - Animals store glycogen in muscle and liver cells = stored energy
      - Depleted in about one day unless replenished by eating
  - Some serve as building material for structures that protect the cell or whole organism
    - Cellulose (glucose is in beta configuration – every glucose monomer is upside down with respect to its neighbors – gives it a straight structure)
    - Chitin – used by arthropods & insects to build exoskeletons & by some fungi
      - Similar to cellulose except glucose monomer has a nitrogen containing appendage.

Lipids – hydrophobic

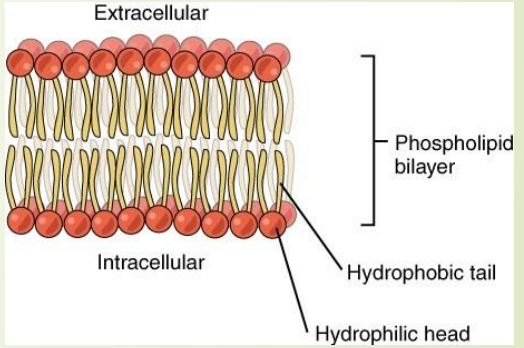
- Waxes, certain pigments, fats, phospholipids, steroids
- Consist mostly of hydrocarbons

- **Fats** = glycerol + 3 fatty acids
  - Main function is energy storage - 1g fat stores 2x more energy than polysaccharide
  - Aka triglycerides
  - **Fatty acid** = 1 long carbon skeleton with carboxyl at one end
    - Bonded by an ester linkage (bond b/w hydroxyl & carboxyl)
  - **Saturated fats** have NO double bonds
    - Pack tightly. Solid at room temp
    - Most animal fats
  - **Unsaturated fats** have at least 1 double bonded C. Creates "kink" in hydrocarbon chain.
    - Don't pack tightly. Liquid at room temp
    - Plant and fish fat. Often called oils

Lipids – hydrophobic



- **Phospholipids** = phosphate group + glycerol + 2 fatty acids
  - Major constituents of cell membranes
  - Hydrophilic head
  - Hydrophobic tails
  - When phospholipids are added to water, they self assemble into double layered structures called **bilayers**
  - **Phospholipid bilayers** form the boundary between cell and its external environment
  - Existence of cells depends on phospholipid bilayer.



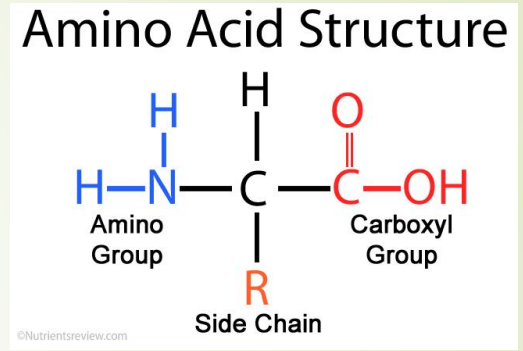
- **Steroids** = carbon skeleton = 4 fused rings
  - Different steroids distinguished by different chemical groups attached to their rings
  - In animals, cholesterol is precursor from which other steroids are synthesized.
    - Synthesized in liver and also obtained from diet

Proteins – have many functions

- **Protein functions**
  - Enzymatic proteins – selective acceleration of chemical reactions
    - Ex) digestion
  - Storage proteins – storage of amino acids
    - ex) casein protein of milk is major source of amino acids for baby mammals; ovalbumin protein of eggwhite
  - Hormonal proteins – coordination of an organisms activities
    - Ex) insulin secreted by pancreas causes other tissue to take up glucose
  - Contractile motor proteins – movement
    - Ex) movement of muscles, cilia, flagella
  - Defensive proteins – protect against disease
    - Ex) antibodies inactivate & destroy bacteria and viruses
  - Transport proteins – transport substances
    - Ex) across cell membranes; transport throughout the body
  - Receptor proteins – response of cell to chemical stimuli
    - Ex) receptors built into membrane of nerve cell can detect signaling molecules released by other nerve cells
  - Structural proteins – support
    - Ex) keratin – protein of hair, horns, feathers, and other skin appendages; collagen; elastin; silk fibers

Proteins – have many functions

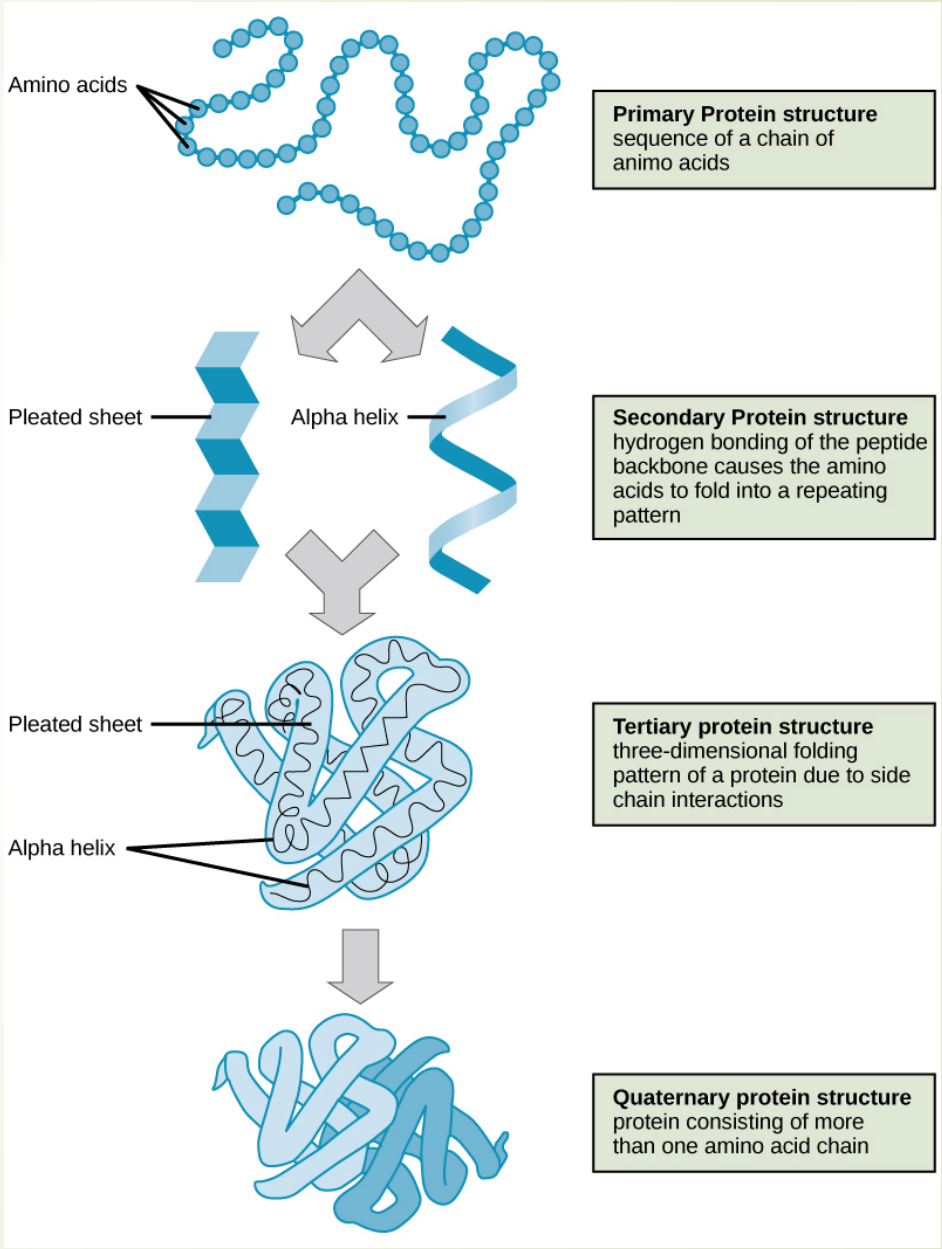
- Proteins are made up of polymers of amino acids called polypeptides
- R group differs with each amino acid
- The alpha carbon bonds to the R group
- There are 20 amino acids
  - 9 are nonpolar hydrophobic
  - 6 are polar hydrophilic
  - 2 are charged acidic hydrophilic (have negative charge)
  - 3 are charged basic hydrophilic (have positive charge)



- The physical and chemical properties of the side chain determine the unique characteristics of a particular amino acid
- Peptide bonds form from dehydration synthesis between amino acids
- A functional protein is one or more polypeptides precisely twisted, folded, and coiled into a molecule of unique shape.
  - Amino acid sequence determines this.

Proteins – have many functions

- Protein Structure
  - Primary – linear chain – sequence of amino acids
  - Secondary – results from hydrogen bonding between polypeptide backbone
    - Alpha – helix (coiled)
    - Beta – pleated (accordian)
  - Tertiary – results from the interactions of the R group side chains (hydrogen bonds, disulfide bridges)
    - Hydrophobic side chains usually cluster toward the core of the protein
  - Quaternary – happens when a protein consists of 2 or more polypeptide chains



Proteins – have many functions

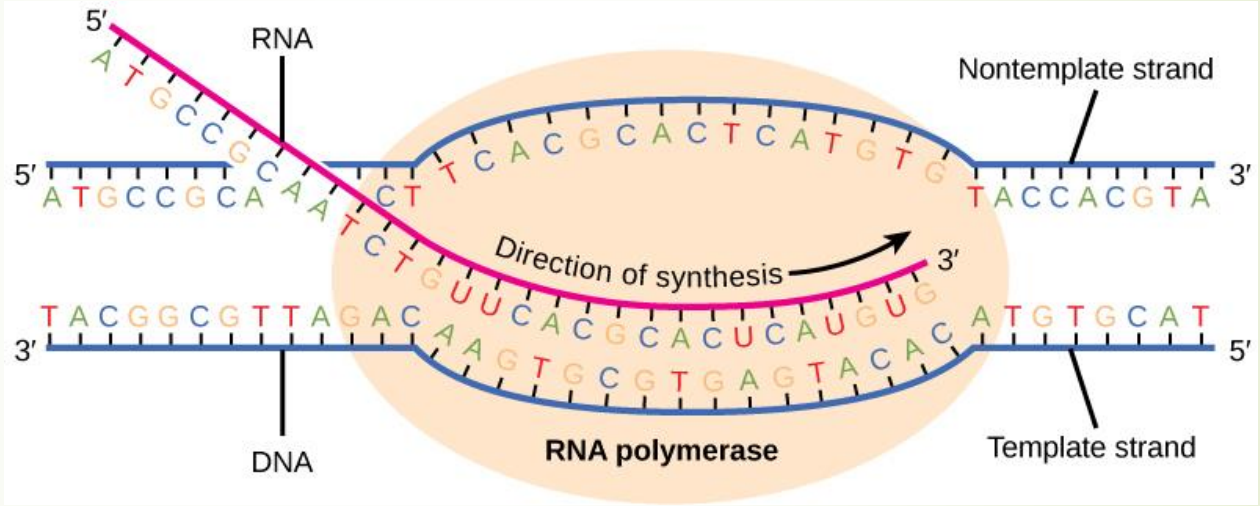
- Protein Structure
  - Also depends on physical and chemical conditions of environment
    - pH, salt, temperature can all affect the weak chemical bonds and interactions
  - Denaturation – when proteins unravel and lose their native shape making them biologically inactive
  - Most proteins become denatured if they are transferred from an aqueous environment to a nonpolar solvent such as ether or chloroform
  - Sometimes denatured proteins can return to their functional shape
  - Misfolding of polypeptides is a serious problem in cells
    - Ex) Alzheimers, Parkinson's, and mad cow disease

Nucleic Acids – store, transmit, & help express heredity info

- Polymers made up of nucleotide monomers
- DNA – provides directions for its own replication, directs RNA synthesis, and thru RNA controls protein synthesis
- **Nucleotides** = nitrogenous base + 5 carbon sugar + one or more phosphate groups
- Nitrogenous bases
  - Pyrimidine – one 6 member ring C (cystine & thymine)
  - Purines – 6 member ring + 5 member ring (adenine & guanine)
- Sugar – deoxyribose or ribose

Nucleic Acids – store, transmit, & help express heredity info

- 2 – sugar-phosphate backbones run in opposite 5' to 3' directions from each other = antiparallel



- Hydrogen bonds form between the two nitrogenous bases

- In DNA, A→T and C→G
- In RNA, A→U and C→G