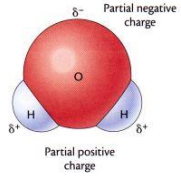
# Chapter 2: Biochemistry

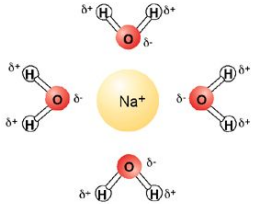
# Biochemistry

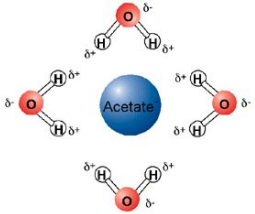
- Biochemistry is the study of chemical makeup and reactions of living matter
- All chemicals in the body are either organic & inorganic
  - Organic compounds contain carbon
    - Carbon is electrically neutral- always shares electrons
  - Everything else is an inorganic compound
    - Includes water, salts, acids & bases

# Inorganic compound: Water's Special Properties

1. **High heat capacity:** absorbs large amounts of heat before changing temp
2. **High heat of vaporization:** need large amounts of heat before evaporates (Sweating)
3. **Polarity:** water is universal solvent
4. **Reactivity:** takes part of many chemical rxns in body
5. **Cushioning:** around organs protects from trauma
   a. Cerebral Spinal Fluid around brain

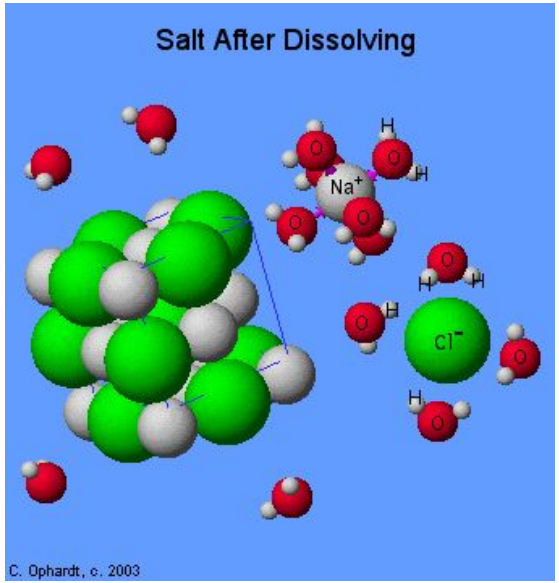


# Inorganic compound: Salts

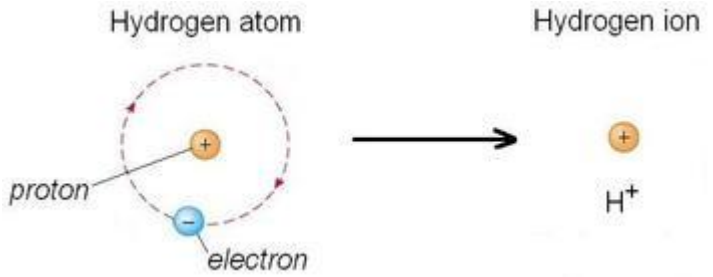
- Contains a cation and anion
  - I.e  NaCl > > Na+ and Cl-
- In water a salt will separate into its ions
  - Na+ and Cl-
- Ions are electrolytes
  - Conduct electrical current in solution
- Important to keep balance of ions in body to maintain homeostasis
  - Kidneys



# Inorganic compounds: Acids & Bases

## Acids

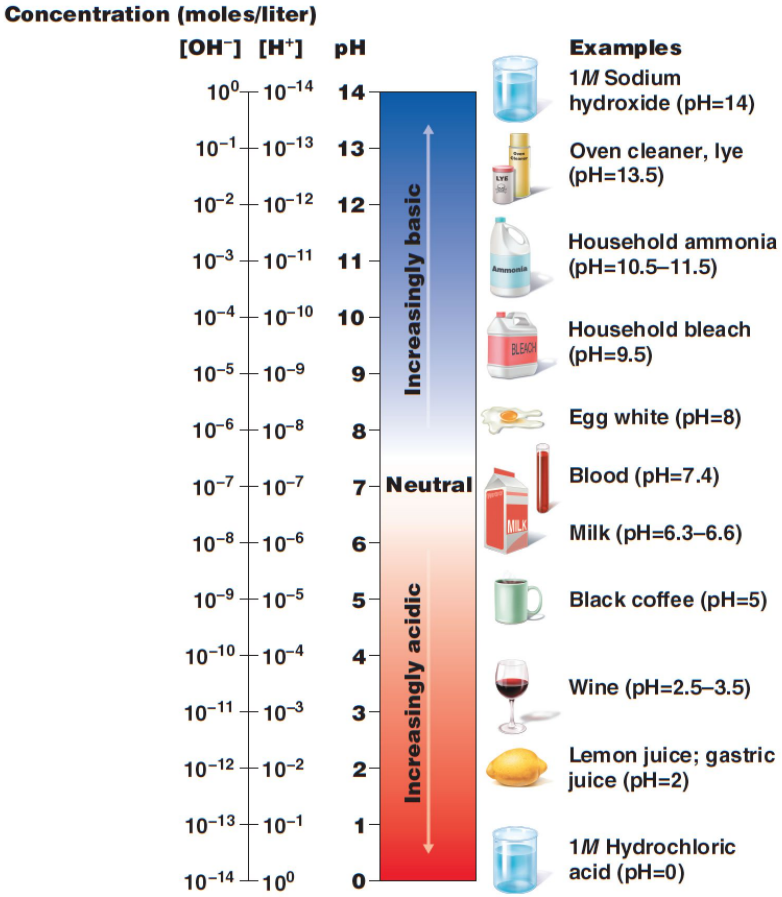
- Releases a hydrogen ion (H+)
  - Proton donor (Just H+ nucleus)
- Example: Hydrochloric Acid (HCl) in stomach
  - HCl -> H+ (proton) and Cl- (anion)




## Bases

- Take up hydrogen ions
  - Proton acceptors
- Bases usually include hydroxides (-OH)
- Completely dissociate in water but then forms water
  - RXN 1: NaOH -> Na+ (cation) and OH- (hydroxide)

**Figure 2.13** The pH scale and pH values of representative substances.




- **<u>Neutralization:</u>** when an acid & a base are mixed they form a water and a salt
  - HCl + NaOH -> NaCl + H2O
  - Called neutralization reaction

# Inorganic Compounds: Buffers

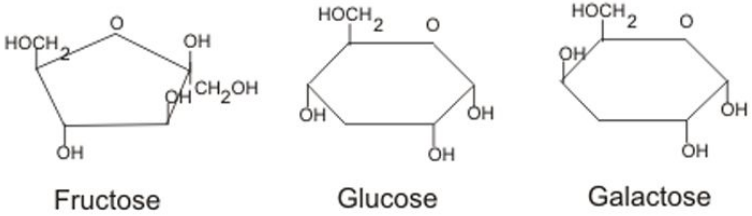
- Cells extremely sensitive to changes in pH
- Buffers help resist abrupt changes of pH in body fluids
  - Release hydrogen ions when pH rises (acts as an acid)
  - Binds to hydrogen ions when pH drops (acts as a base)

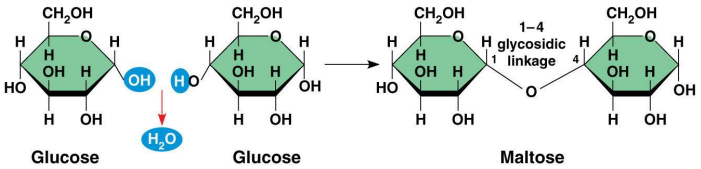
# Organic compounds: Carbohydrates

- Groups of molecules that include sugars & starches
- Functions of carbohydrates :
  - Provides easy access to fuel for cells
  - Cells can only use simple sugars, such as glucose
  - Simple sugars are broken down to release energy
  - If we have too much sugar, it is stored as glycogen (a.k.a FAT)
- Classified by size and solubility
  - Generally the larger the carbohydrate the less soluble it is in water

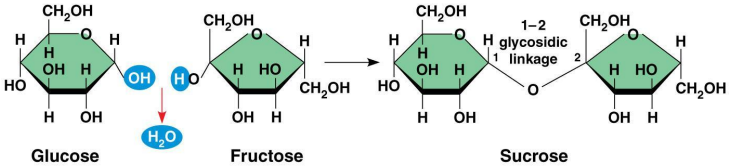
# Classification of Carbohydrates

- Monosaccharides: simple sugars
  - Single chain or single ring structures
  - Carbons, hydrogen, oxygen
  - Examples: glucose, fructose & galactose
- Disaccharides: double sugar
  - Two monosaccharides joined
  - Can’t pass through cell membranes, must be digested into simple sugars
  - Examples (glucose + fructose = sucrose) (glucose + galactose = lactose)



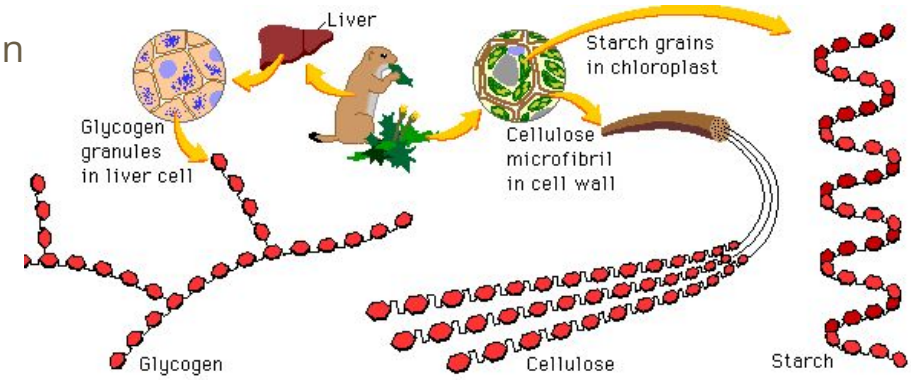

(a) Dehydration reaction in the synthesis of maltose




(b) Dehydration reaction in the synthesis of sucrose

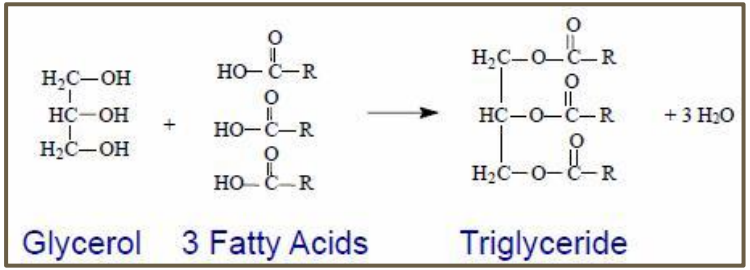
# Classification of Carbohydrates cont.

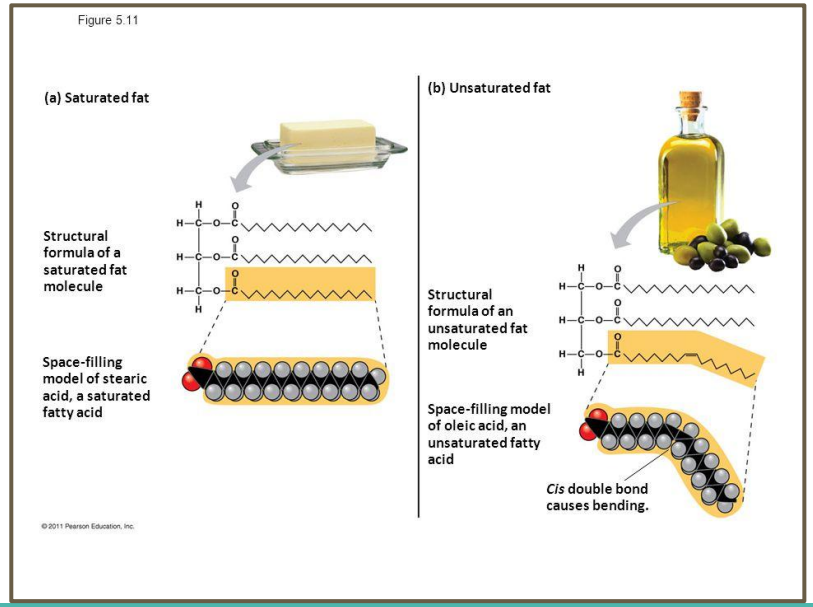
- Polysaccharides: simple sugars linked through a dehydration synthesis
- Large and fairly insoluble
- Majority polysaccharides in the body:
  - Glycogen: storage of carbohydrates in animals
    - Stored in liver and skeletal muscle
    - Blood sugars drop, liver breaks down an
  - Starch: storage of carbs formed by plants
    - Made up of large amounts of glucose



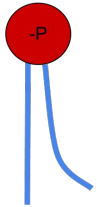
# Organic compounds: Lipids

- Insoluble in water
- Made of carbon, hydrogen & oxygen
- Triglycerides (neutral fats)
  - Fats- solid, oil- liquid… bacon grease!
  - Composed of 3 fatty acid + 1 glycerol
  - Efficient & compact energy
  - Saturated fat → fatty acid chain is straight, solid at room temperature
  - Unsaturated fat → fatty acid chains have double bonds and is “kinked”, do not solidify
    - Olive oil (healthier)

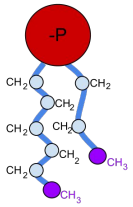


# Organic compounds: Lipids cont.

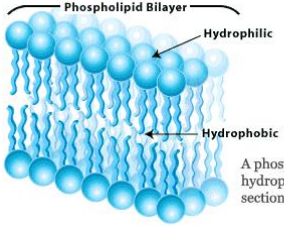



A phospholipid with a hydrophilic head and a hydrophobic tail



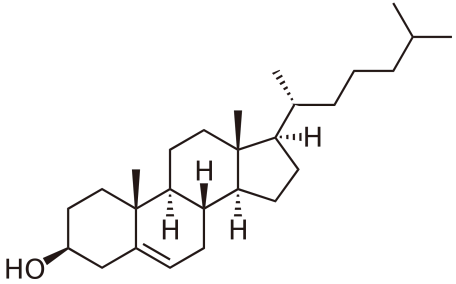

Chemical makeup of a single phospholipid

- Phospholipids: modified triglycerides
  - Distinct chemical property- hydrocarbon tail is nonpolar, phosphorous head polar
  - Compose cell membranes



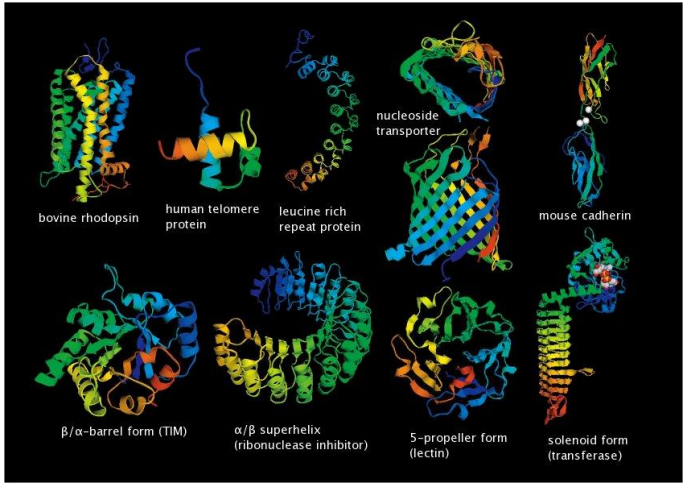

A phospholipid bilayer with hydrophobic and hydrophilic sections indicated.

- Steroids: four hydrocarbon rings
  - Most important: cholesterol (eggs, meat, & cheese)
    - In cell membranes, synthesizes vitamin D
    - Only need small amounts of cholesterol



# Organic Compound: Proteins

- 10 to 30% of cells
  - Plays role in structural material and cell function
- Structure of the protein determines how it functions in the body
- Proteins are composed of hydrogen bonds
- If pH drops or the temperature rises, hydrogen bonds can break destroying the protein. This is called protein denaturation.
  - Usually is reversible if conditions return to homeostasis

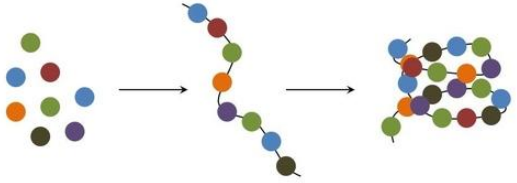


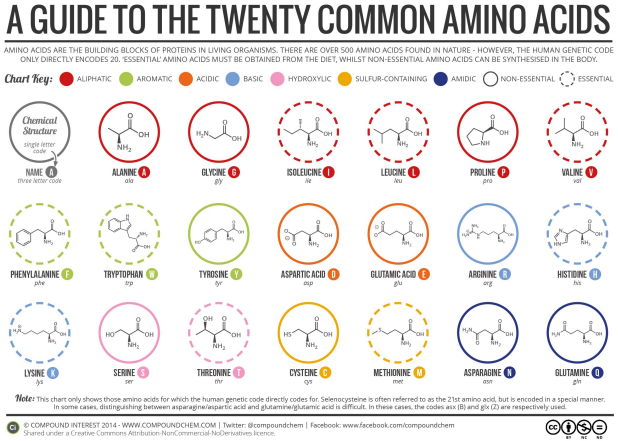
# Proteins & Amino Acids

Building blocks of protein are amino acids

- 20 different amino acids
  - Amino acids (aa): made up of an acid and a base- proton acceptor or proton donor
- Aa are linked by a peptide bond to form chains = protein

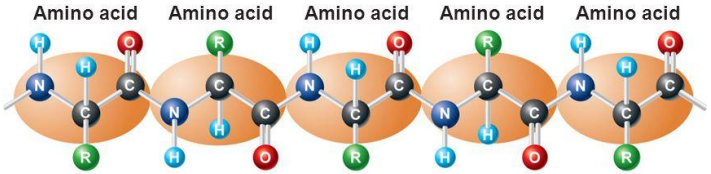
- Most proteins are made of 100 to 100,000 aa
  - Two aa= dipeptide three aa= tripeptide
    10+= polypeptide
- Different combinations of aa form different proteins
  - Like letters that combine to form different words



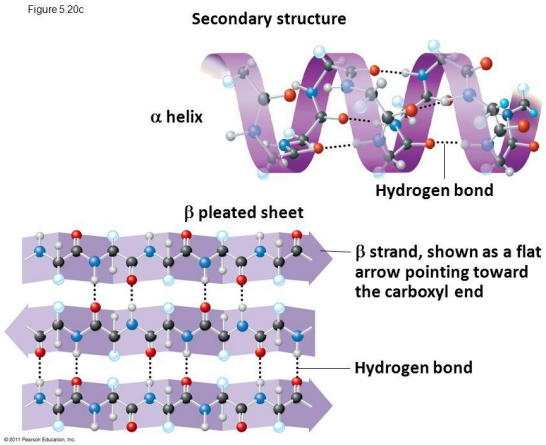
# The Four Structural levels of proteins

1. **Primary structure:** looks like a chain of amino acid
   a. Backbone for protein molecule




**(a) Primary structure:**
The sequence of amino acids forms the polypeptide chain.

2. **Secondary Structures**
   a. Alpha-helix: most common, resembles a slinky or coil
      i. Formed by coiling primary structure stabilized by hydrogen bonds



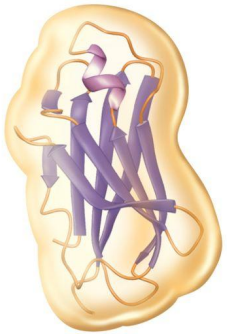

   a. Beta-pleated sheet: do not coil but link side to side by hydrogen bonds
      i. Like an accordion

# The Four Structural levels of proteins cont.

3. Tertiary structure: When alpha helix and/ or beta sheet folds on itself to form a compact sphere

- This is called a globular protein
- Uses both hydrogen & covalent bonds

Figure 2.19c Levels of protein structure.

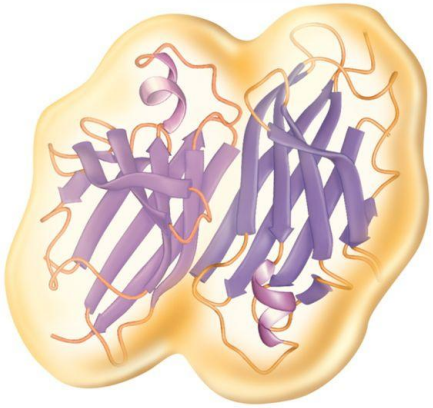


Tertiary structure of prealbumin (transthyretin), a protein that transports the thyroid hormone thyroxine in serum and cerebro-spinal fluid.

**(c) Tertiary structure:**
Superimposed on secondary structure. α-Helices and/or β-sheets are folded up to form a compact globular molecule held together by intramolecular bonds.

4. Quaternary structure: When multiple tertiary structures (polypeptide chains) combine together

Figure 2.19d Levels of protein structure.



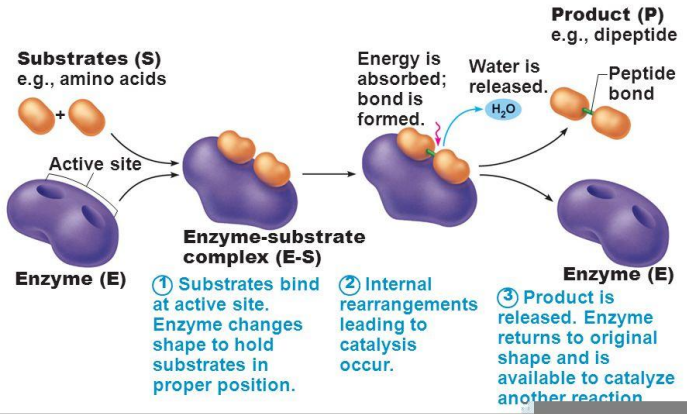
Quaternary structure of a functional prealbumin molecule. Two identical prealbumin subunits join head to tail to form the dimer.

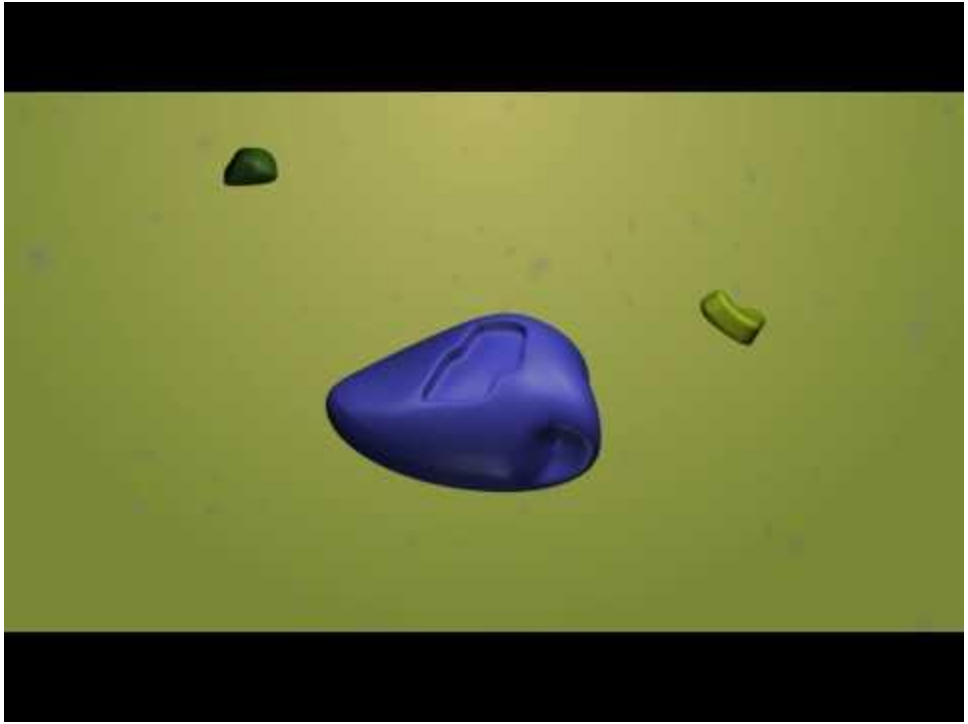
**(d) Quaternary structure:**
Two or more polypeptide chains, each with its own tertiary structure, combine to form a functional protein.

# Proteins: Enzymes

- Enzymes are proteins that act as catalysts meaning they speed up the rate of a chemical rxn
  - Can not be used up or changed
  - Enzymes are specific: meaning they each complete a different action
- Some enzymes need a cofactor (like an ion) to "be switched on" to work
- The substance the enzyme works on is called the substrate
- How it works:
  - Enzymes active site binds to substrate creating an enzyme-substrate complex
  - Complex undergoes internal rearrangement to create a new product
  - The enzyme releases the products of the reaction

Figure 2.21 Mechanism of enzyme action.





# Clinical Application- Albinism

- Genetic disorder
- Caused by defective enzyme involved in metabolism of amino acid
- Protein melanin can’t be synthesized

# Drop off.... Pick up.

Part 1: Draw a line down the middle of the left side of your notebook. Label one column “Drop off” and the other “Pick up”

1. In the drop off column list as many ideas, diagrams and pictures that answers the EQ for the day.
2. Make sure to connect both Biochemistry lectures.
3. Feel free to review notes, use textbooks or any other resources in the classrooms. (Without technology).

Part 2: Walk around the room. When the music stops “drop off” an idea with your partner and “pick up” an idea from your partner. Repeat.

| | |
|---|---|
| **Label & List** | |
| **Equation** | |
| **Notice** | |
| **Speculate** | |
| **Explain/ Evaluate** | |
| **Summary** | |

| | |
|---|---|
| **Label & List** | ➢ Title:<br>➢ Independent & Dependent variables with units |
| **Equation** | |
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| **Label & List** | ➢ Title:<br>➢ Independent & Dependent variables with units |
| **Equation** | ➢ State relationship (direct, inverse, linear, exponential, other) |
| **Notice** | ➢ What do you notice happening?<br>○ State what happens with the graph: As the IV _____, the DV _____<br>➢ Identify properties of the graph |
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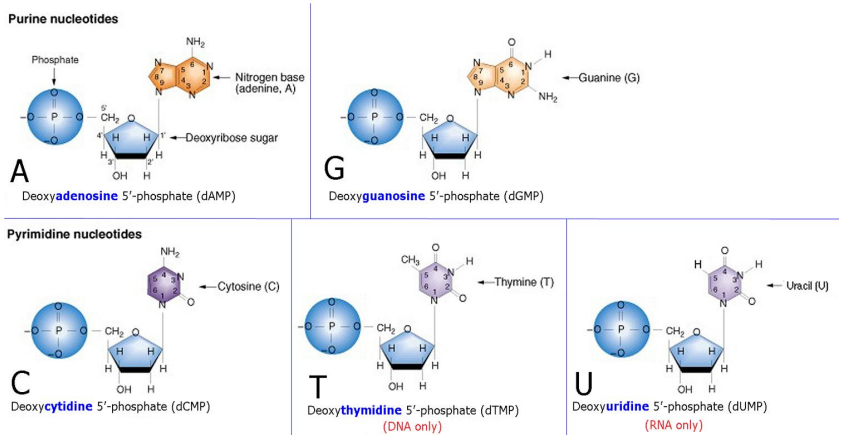
| **Notice** | ➢ What do you notice happening?<br>○ State what happens with the graph: As the IV _____, the DV _____<br>➢ Identify properties of the graph |
| **Speculate** | ➢ What can you speculate about the graph?<br>○ What inferences can be made about the graph? |
| **Explain/ Evaluate** | ➢ Explain your speculation section and how it relates to your observations.<br>➢ What question is not addressed by the graph that would allow for better understanding? |
| **Summary** | ➢ What have you learned? How can you answer the EQ? |

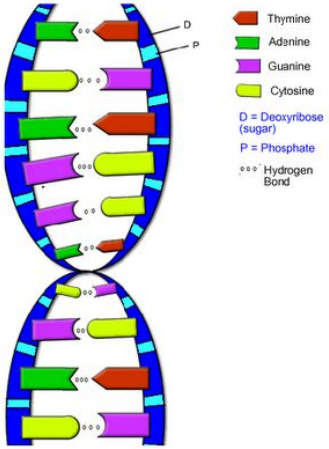
# Organic Compounds: Nucleic Acids (DNA & RNA)

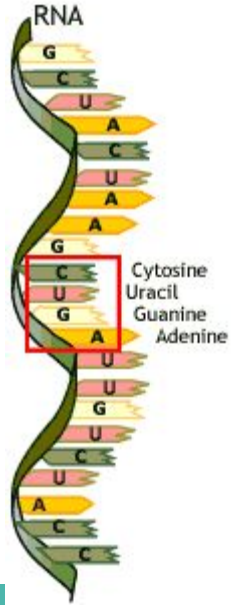
- Made of carbon, oxygen, hydrogen, nitrogen, and phosphorus
- Two classes: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)
- Structural unit of DNA & RNA: nucleic acids called nucleotides
  - Made of Nitrogen base, pentose sugar and phosphate group
  - Five types: Adenine (A), Guanine (G), Cytosine (C), Thymine (T), and Uracil (U)



# DNA & RNA

- DNA: found in nucleus and is the genetic material of life
  - Directions for protein synthesis-
  - Double stranded chain called a double helix
  - Nucleotides: A,G, C, T
    - A-T and G-C
- RNA: carries out protein synthesis
  - Single strands of nucleotides
  - Nucleotides: A,G, C, U
    - A-U and G-C
  - Three forms: messenger RNA, ribosomal RNA, and transfer RNA

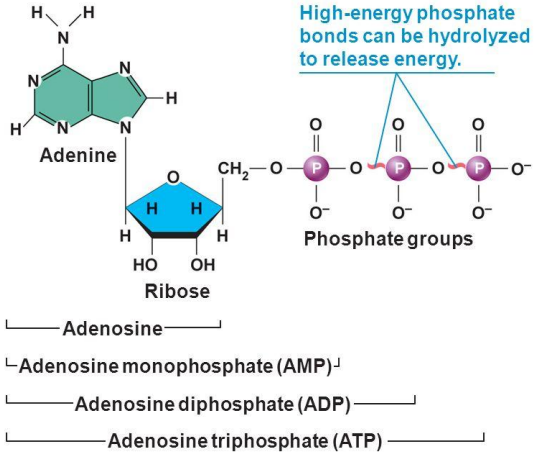


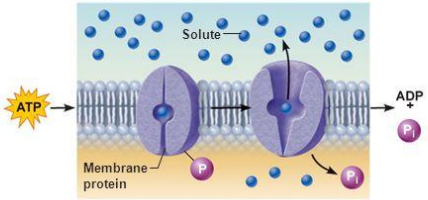



# Organic Compound: Adenosine Triphosphate

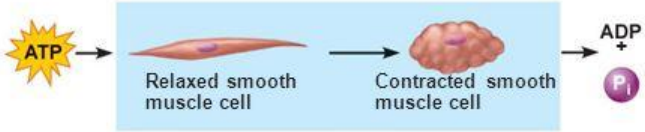
- When glucose is broken helps create ATP
- ATP is an unstable energy storing molecule
  - Three negative phosphate groups which repel each other
  - When bonds broken, releases energy and molecule becomes stable
    - Lose a phosphate group to become stable
- Drives biochemical reactions

Figure 2.23 Structure of ATP (adenosine triphosphate).




(a) **Transport work:** ATP phosphorylates transport proteins, activating them to transport solutes (ions, for example) across cell membranes.




(b) **Mechanical work:** ATP phosphorylates contractile proteins in muscle cells so the cells can shorten.