Oliver - Biomolecules Notes - Key
FALL SEMESTER 2023

INSTRUCTOR:

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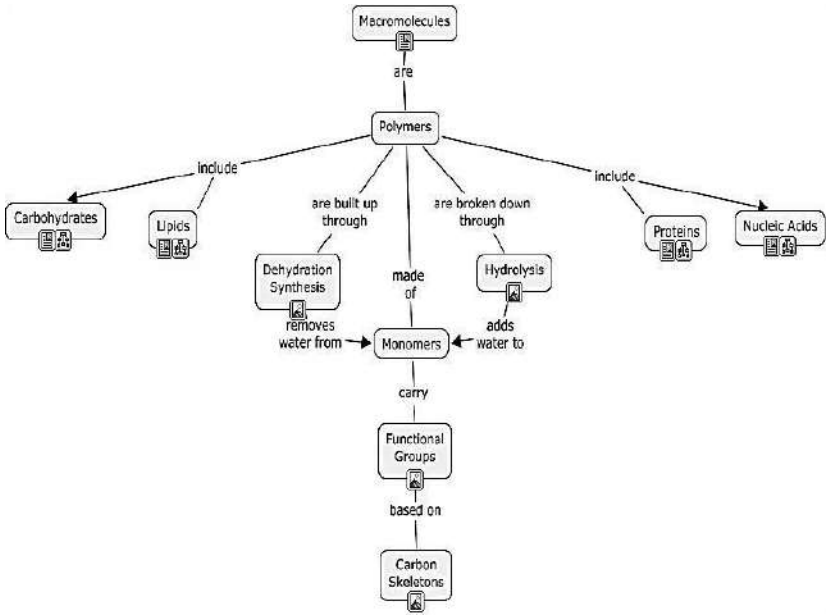
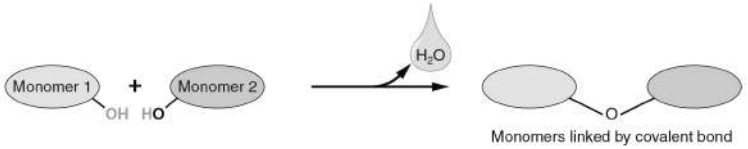
Vocabulary / Key Terms/ Concepts	Biomolecules
activation energy *adhesion* *amino acids* *carbohydrates* *catalyst*	**Student Expectations:** The student is expected to: • ***Distinguish between carbohydrates, lipids, proteins, and nucleic acids by structure*** ☐ Compare and Contrast ***Monomers*** / ***Polymers*** ☐ ***Dehydration synthesis*** / ***Hydrolysis*** in molecule formation ☐ ***Carbohydrates*** contain carbon, hydrogen, and oxygen; usually in a 1:2:1 ratio (example: glucose $C_6H_{12}O_6$) ☐ ***Lipids*** contain mostly carbon and hydrogen ☐ ***Proteins*** contain nitrogen, as well as carbon, hydrogen, and oxygen. They are polymers of molecules called amino acids that have an amino group ($-NH_2$) on one end and a carboxyl group (-COOH) on the other ☐ ***Nucleic acid***s contain hydrogen, oxygen, nitrogen, carbon, and phosphorus. They are assembled from individual monomers known as nucleotides which consist of a 5-carbon sugar, a phosphate group, and a nitrogenous base

cohesion *dehydration synthesis* *enzymes* *hydrolysis* *lipids* *macromolecules* *mixture* *monomers* *monosaccharide* *nucleic acids* *nucleotides*	• ***Identify the function of carbohydrates, lipids, proteins, and nucleic acids*** ☐ ***Carbohydrates***: source of energy; are used as structural materials in organisms ☐ ***Fats or lipids***: nonpolar molecules that store energy and are an important part of cell membranes ➔ ***Phospholipids***: make up the cell membrane / regulate transport. ***Hydrophilic*** heads, ***hydrophobic*** tails ➔ ***Triglycerides***: glycerol with three fatty acids. ***Saturated*** vs ***Unsaturated*** ☐ **Proteins**: chains of ***amino acids***; the sequence of amino acids determines a protein's shape and specific function ➔ Some control the rate of reactions and regulate cell processes ➔ Some are used to form bones and muscles ➔ Some transport substances into and out of the cells ➔ Some help fight disease ➔ ***Enzymes***: raise reaction rate, lower activation energy ☐ **Nucleic acid**: store and transmit hereditary information ➔ ***DNA*** = Deoxyribonucleic Acid ➔ ***RNA*** = Ribonucleic Acid - make proteins • ***Describe energy changes in a chemical reaction*** • ***Identify activation energy as the energy needed to get a reaction started*** • ***Interpret energy-absorbing reaction and energy-releasing reaction graphs*** • ***Identify that enzymes are proteins that act as biological catalysts. They speed up chemical reactions that occur in cells*** • ***Understand that enzymes lower the activation energy needed to get a reaction going*** • ***Explain how enzymes provide a place where reactants can be brought together to react. The reactants are called substrates.*** • ***Understand the factors that can affect enzyme activity*** ☐ pH ☐ temperature • ***Know roles of enzymes include:*** ☐ Regulating chemical pathways ☐ Making materials that cells need

polar *polymers* *polysaccharides* *proteins* *saturated* *solute* *solution* *solvent* *substrates* *suspension* *unsaturated*	☐ Releasing energy ☐ Transferring information --- **Macromolecules** **Characteristics** - ▪ Large organic molecules. ▪ Also called ***polymers***. ▪ Made up of smaller "building blocks" called **monomers**. ▪ **Biological Macromolecules** are: **1. Carbohydrates** **2. Lipids** **3. Proteins** **4. Nucleic acids (DNA and RNA)**  **Dehydration Synthesis & Hydrolysis –** ▪ Cells **connect monomers** to make **macromolecules** by a process called condensation or ***dehydration synthesis*** (removing a molecule of water). ▪ Cells **break down macromolecules** into **monomers** by a process called ***hydrolysis*** (adding a molecule of water)

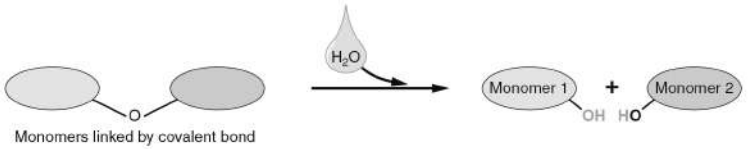
(a) Dehydration synthesis

Monomers are joined by removal of OH from one monomer and removal of H from the other at the site of bond formation.



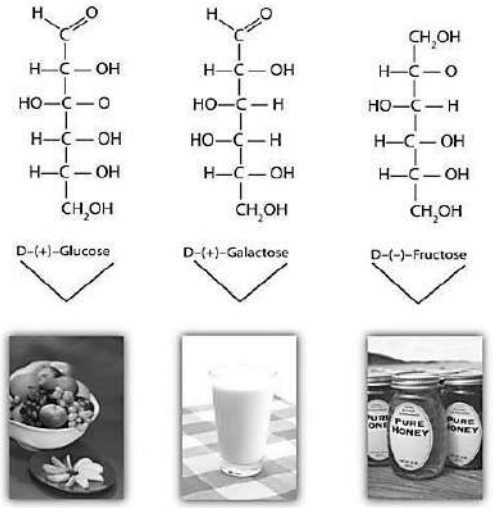
(b) Hydrolysis

Monomers are released by the addition of a water molecule, adding OH to one monomer and H to the other.

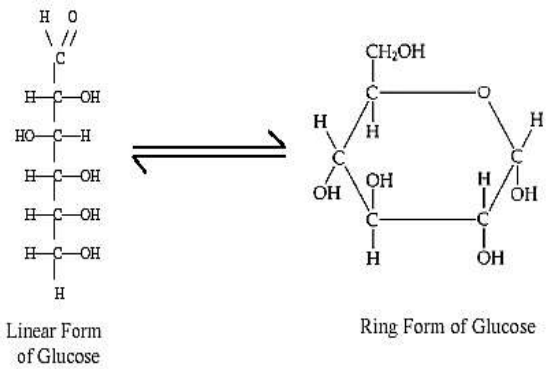


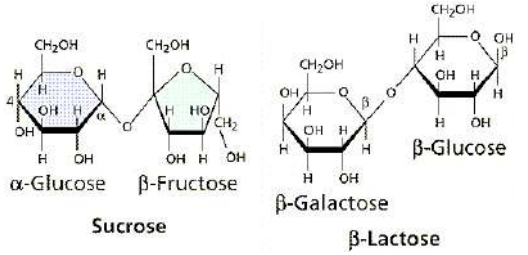
Carbohydrates

- **Carbohydrates** can range in size from small sugar molecules to large strands of sugar molecules bonded together. A biochemical test to indicate the presence of sugar – ***Benedict's solution*** (indicator) – turns green, yellow, orange, or red when heated.
- Elements Used to Form:
  1. **Carbon**
  2. **Hydrogen**
  3. **Oxygen**
- Examples:
  1. **Monosaccharide**

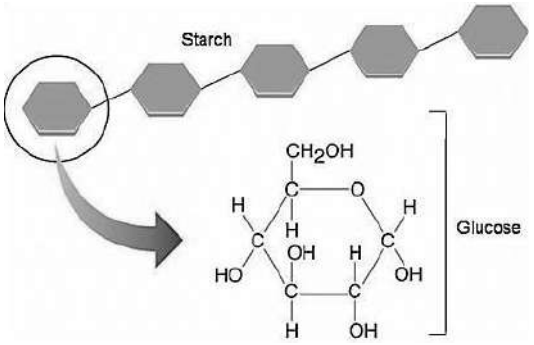


- Called **Simple Sugars** ***(monomer)***.
- Include: **Glucose**, **Fructose** & **Galactose**.
- They have the same chemical formula, $C_6H_{12}O_6$, but have different structures.
- These three sugars are structural isomers:
  - **Glucose** is found in sports drinks.
  - **Galactose** is called "milk sugar"
  - **Fructose** is found in fruits.
- If the compound name ends in **– ose** means it is a sugar.
- In aqueous (watery) solutions, Monosaccharides ***form ring structures***.
- They are the main fuel that cells use for work.



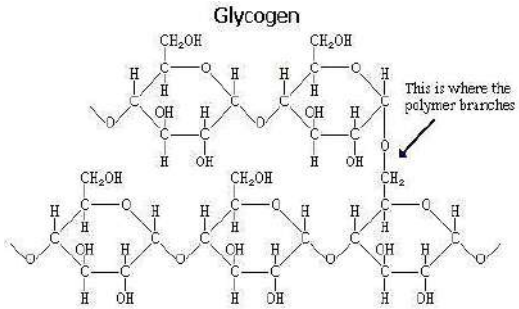


2. **Disaccharide**
   - A ***disaccharide*** is made of **two** sugar molecules joined together.
   - They are joined in the dehydration *process*.
   - There is a glycosidic bond between the two sugars.

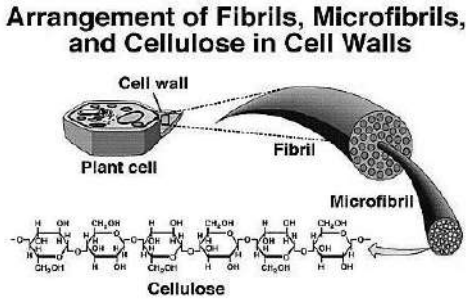


3. **Polysaccharide**

- **Complex** carbohydrates
- Composed of **many** sugar monomers linked together.
- **Polymers** of **monosaccharide** chains.
- Three types of polysaccharides are: **starch**, **glycogen**, and **cellulose**.
  - **Starch –** in ***iodine*** (indicator) turns dark blue or black
    - Starch is an example of a polysaccharide in plants.
    - Plant cells store starch for energy.
    - Potatoes and grains are major sources of starch in the human diet.

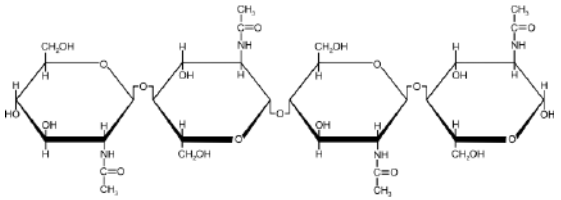


  - **Glycogen**
    - Animals store excess sugar in the form of glycogen.
    - Glycogen is similar in structure to starch because both are made of glucose monomers.
  - **Cellulose**
    - Cellulose is the most abundant organic compound on Earth.
    - It is the structural component of plants.
    - It forms cable-like fibrils in the tough walls that enclose plants.
    - Many animals cannot digest cellulose.
    - It is also known as dietary fiber.



  - **Chitin**
    - **Chitin** is made of **glucose** subunits linked together in a chain.

- Partly derived from non-sugars (nitrogen).
- Composes **exoskeletons** of **insects**, lobsters, and shrimp.
- The cell walls of fungi are also made from **chitin**.
- Chitin fibers are also used for **dissolving sutures**.



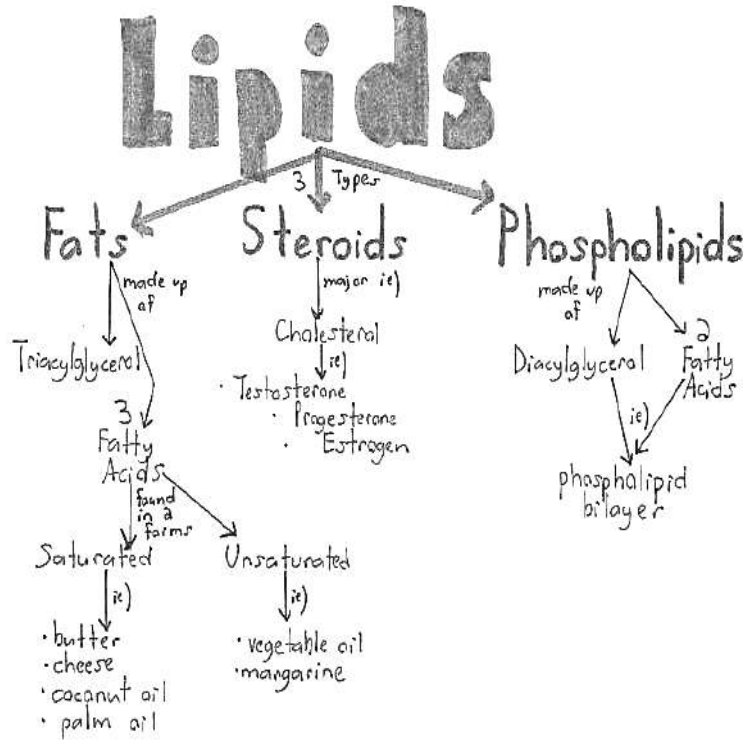
Lipids

Characteristics

- **Lipids** are **hydrophobic** –"water fearing".
- Do **not mix** with water.
- Includes **fats**, **waxes**, **steroids**, **oils, hormones,** & **triglycerides**.
- **Stores** the most **energy**.
- Composed of: **C, H, & O**

Six functions of lipids:

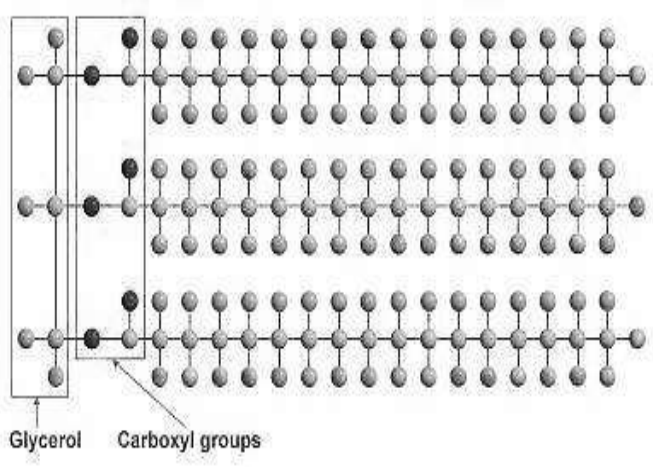
- **Long term energy storage**
- **Protection** against heat loss (**insulation**)
- **Protection** against water **loss**
- **Protection** against physical **shock**



- Chemical messengers (**hormones**)
- Major component of **membranes** (phospholipids)

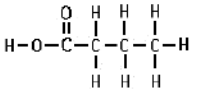
Fatty Acids –

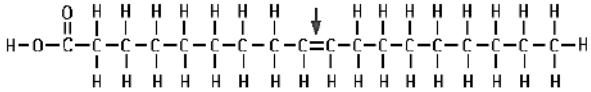
- **Fatty Acids**: a long **chain** of **Hydrogen** and **Carbon** make up lipids. The exception to the monomer/polymer rule is lipids. Lipid base units are not considered monomers. One type of lipid or fat is made up of fatty acids and glycerol molecules in a 3:1 ratio. The bonding of three fatty acids to one glycerol molecule creates a triglyceride

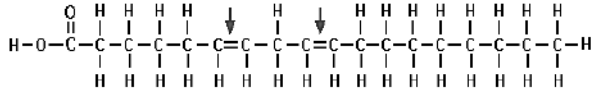


Types of Fatty Acids

1. **Saturated Fatty Acid**: if each Carbon is bonded by **single** bonds to other Carbons inside the fatty acid, the fatty acid is said to be saturated.
2. **Mono or Unsaturated Fatty Acid**: If a **double** bond is present, then it is said to be mono-saturated or unsaturated.
3. **Polyunsaturated Fatty Acid** - **More than one** double bond


Butyric Acid-Saturated Fatty Acid

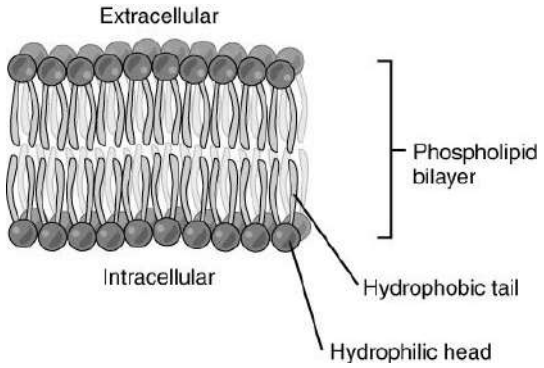

Oleic Acid- Monounsaturated Fatty Acid


Linoleic Acid- Polyunsaturated Fatty Acid

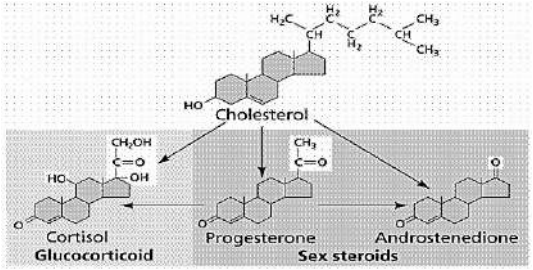
- Most **<u>animal fats</u>** have a high proportion of saturated fatty acids & exist as solids at room temperature (butter, margarine, shortening).

- ***Sudan*** (indicator) can turn a variety of colors in the presence of lipids.
- Most **plant oils** tend to be low in saturated fatty acids & exist as liquids at room temperature (oils).

4. **Phospholipids** - Cell **membranes** are made of **lipids** called **phospholipids**.
   - Phospholipids have a **head** that is **polar** & **attract** water (**hydrophilic**).
   - Phospholipids also have **2 tails** that are **nonpolar** and do **not** attract **water** (**hydrophobic**)



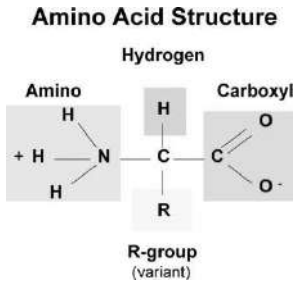
- **Steroids** –
  - The carbon skeleton of steroids is bent to form 4 fused rings.
  - Cholesterol is the "base steroid" from which your body produces other steroids.



Proteins

Characteristics

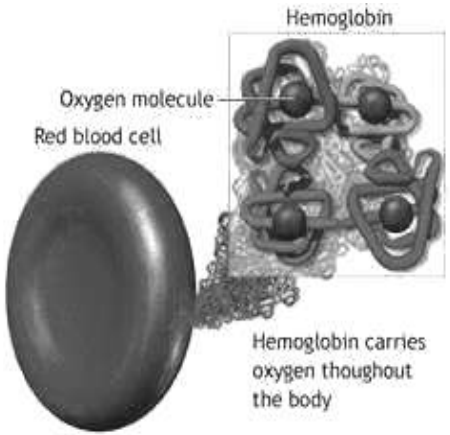
- Composed of
  - **C, H, O, N, sometimes S**
- Monomer
  - amino acids
    - **20** different (1 mod)

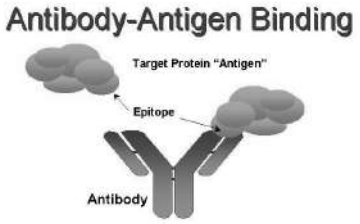


- Most structural variation

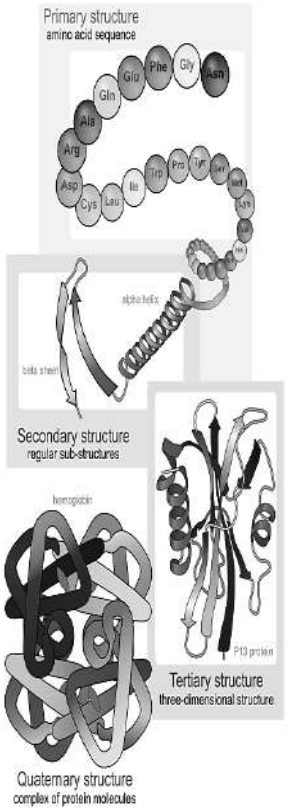
Functions

- Essential to Life – ***Biuret*** (indicator) turns purple/lavender with protein, pink with amino acid.
- Build **structure**
- **Movement**:
  - Makes up **muscle** tissue
- **Transport**:
  - Carries oxygen in an organism (**hemoglobin**).
- **Immunity**:
  - Helps fight off foreign invaders
  - **antibodies**
- **Enzymes**: (more below)
  - **Speed** up **chemical reactions**
  - amylase and pepsin
- **Energy** source
  - 1 gram = 4 kcal of energy
- **Polymer**: **Polypeptide**
- Covalent bonding links
  - **Peptide** Bond

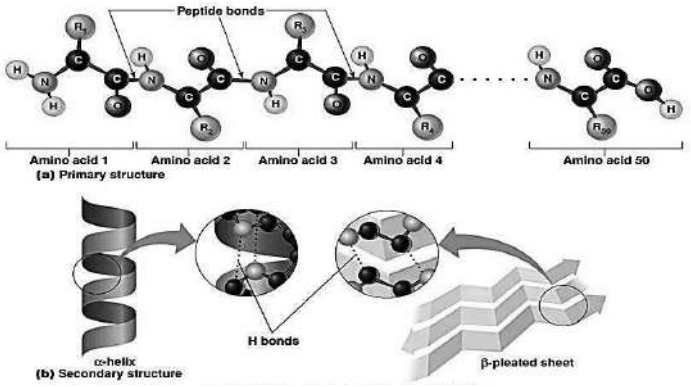




- **Four Shapes**

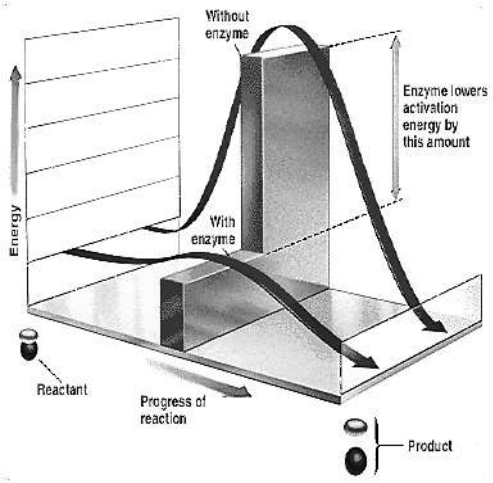


  - The **Primary structure** is the specific sequence of amino acids in a protein. Called a **polypeptide**.

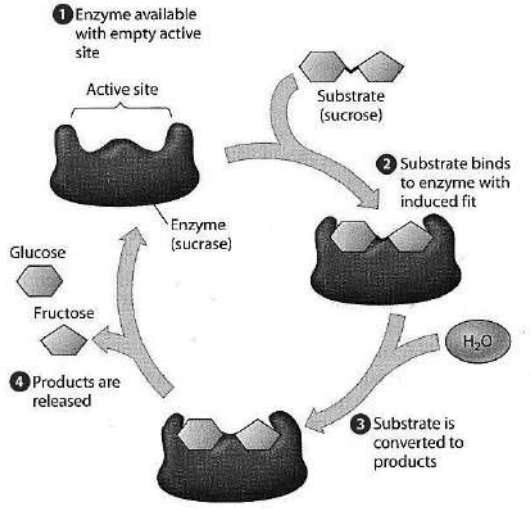


  - **Secondary protein structures** occur when protein chains coil(helix) or fold(pleated)
  - When protein chains called polypeptides join together, the **Tertiary structure** forms because R groups interact with each other.
  - Secondary structures bent and folded into a more complex 3-D arrangement of linked polypeptides
  - Bonds: H-bonds, ionic, disulfide bridges (S-S)
  - **Quaternary Structure**: Composed of 2 or more “subunits”.

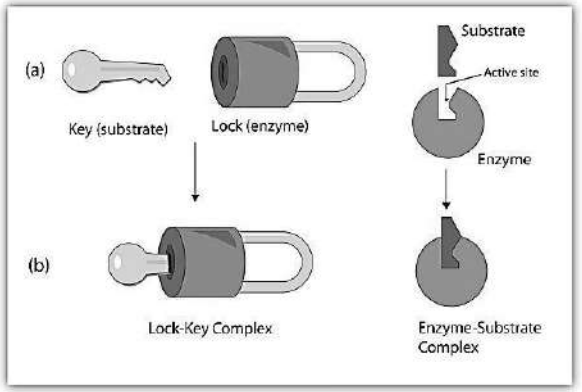
Enzymatic Activity



- **Many proteins act as biological catalysts or enzymes.**
  1. Thousands of different enzymes exist in the body.
  2. Enzymes **control** the **rate** of chemical **reactions** by weakening bonds, thus **lowering** the amount of **activation energy** needed for the reaction.
  3. This is accomplished by **binding** to the **reactants**.
  4. They will then twist or bend the material, lowering the energy needed to split it.
- **The enzyme contains an opening called its activation (active) site.**
  1. This **site** is specific for the **object** it will hold, called the **substrate**.
  2. There are just as many **enzymes** as there are **substrates**.
  3. The **enzyme** system is the enzyme and substrate **combined**.
- Most are **proteins**.
- They **decrease** the activation **energy** of a reaction.
- They **Speed** up the **reaction…**



- They are **specific** to the **substrate**.
  - They allow the substrate to fit into the active site like a ball in to a glove, holding it tight. (***Lock and Key Model***)
- They can be reused – **NEVER DESTROYED**.

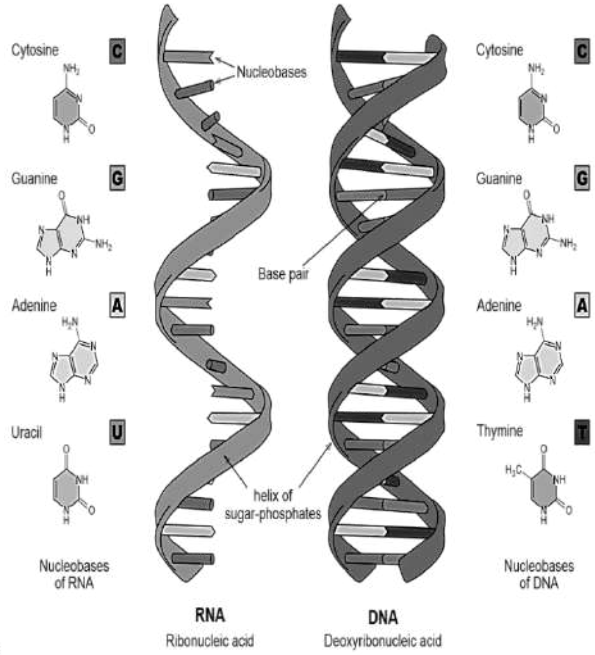


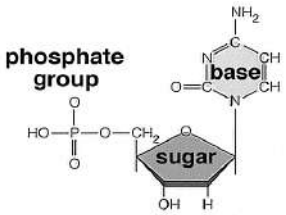
- Some Common Enzymes:

Active Site	Enzyme	Effect on Food
mouth	*salivary amylase*	breaks down starches into disaccharides
stomach	*pepsin*	breaks down proteins into peptides
small intestine (from pancreas)	*amylase*	continues starch breakdown
small intestine (from pancreas)	*trypsin*	continues breakdown of protein
small intestine (from pancreas)	*lipase*	breaks down fat
small intestine	*maltase, sucrase, lactase*	breaks down remaining disaccharide into monosaccharide
small intestine	*peptidase*	breaks down di-peptides into amino acids

Nucleic Acids

- **Two types:**
  1. **Deoxyribonucleic acid (DNA-double helix)**
  2. **Ribonucleic acid (RNA-single strand)**
- **Nucleic acids** are composed of long chains of **nucleotides** (monomer) linked by dehydration synthesis.
- Composed of the Elements: **C, H, O, N & P**
- **Nucleotides** include:
  - A **phosphate** group
  - A **pentose** sugar (5-carbon)
  - A **nitrogenous** bases:
    - ★ Adenine (A)
    - ★ Thymine (T) - ***DNA only***
    - ★ Uracil (U) - ***RNA only***
    - ★ Cytosine (C)
    - ★ Guanine (G)





Notes Summary
