MAMMOTH

SCIENCE

Unit 2 - Macromolecules

- *Compare the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.*
- *Analyze and evaluate the evidence regarding formation of simple organic molecules and their organization into long complex molecules having information such as the DNA molecule for self-replicating life.*
- *Investigate and explain cellular processes including homeostasis, energy conversions, transport of molecules, and synthesis of new molecules.*

MAMMOTH
SCIENCE

Menu

Macromolecule Characteristics

Dehydration Synthesis & Hydrolysis

Carbohydrates

Lipids

Proteins/ Enzymes

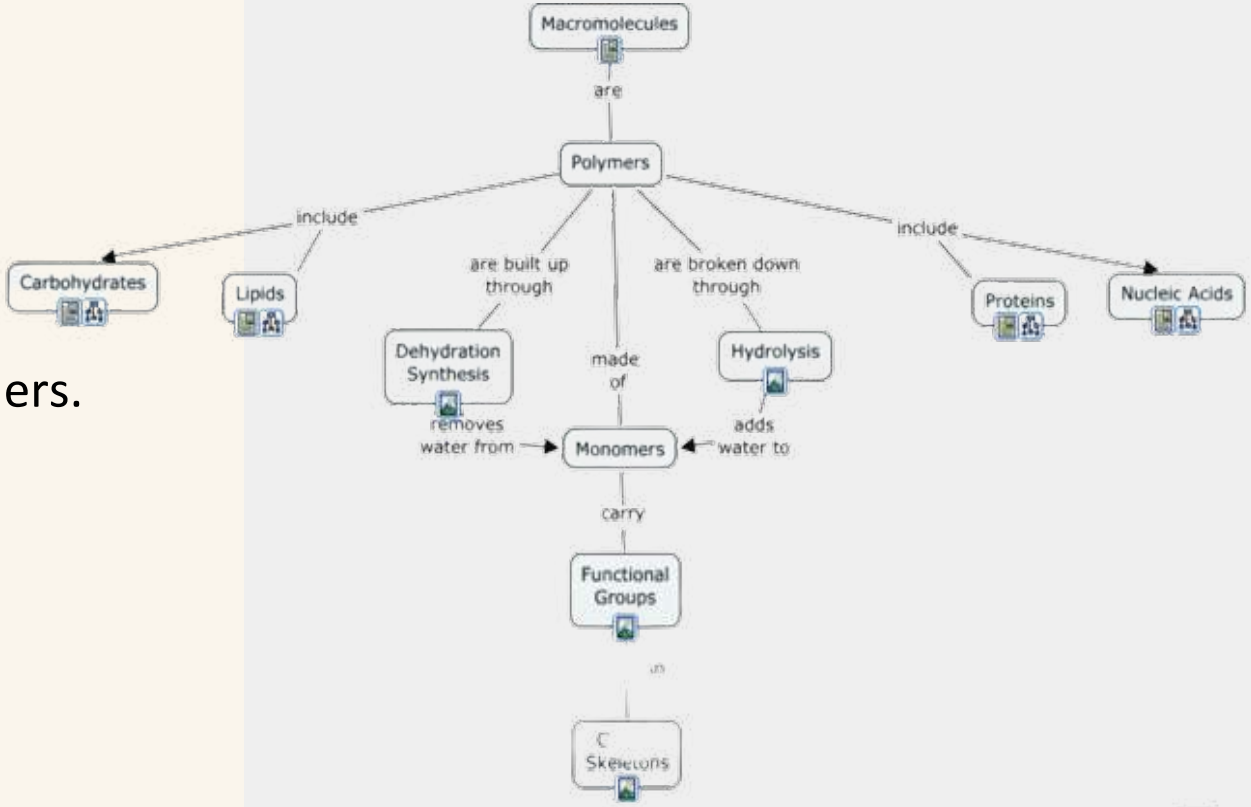
Nucleic Acids

Macromolecules / Biomolecules

Macromolecules

Characteristics -

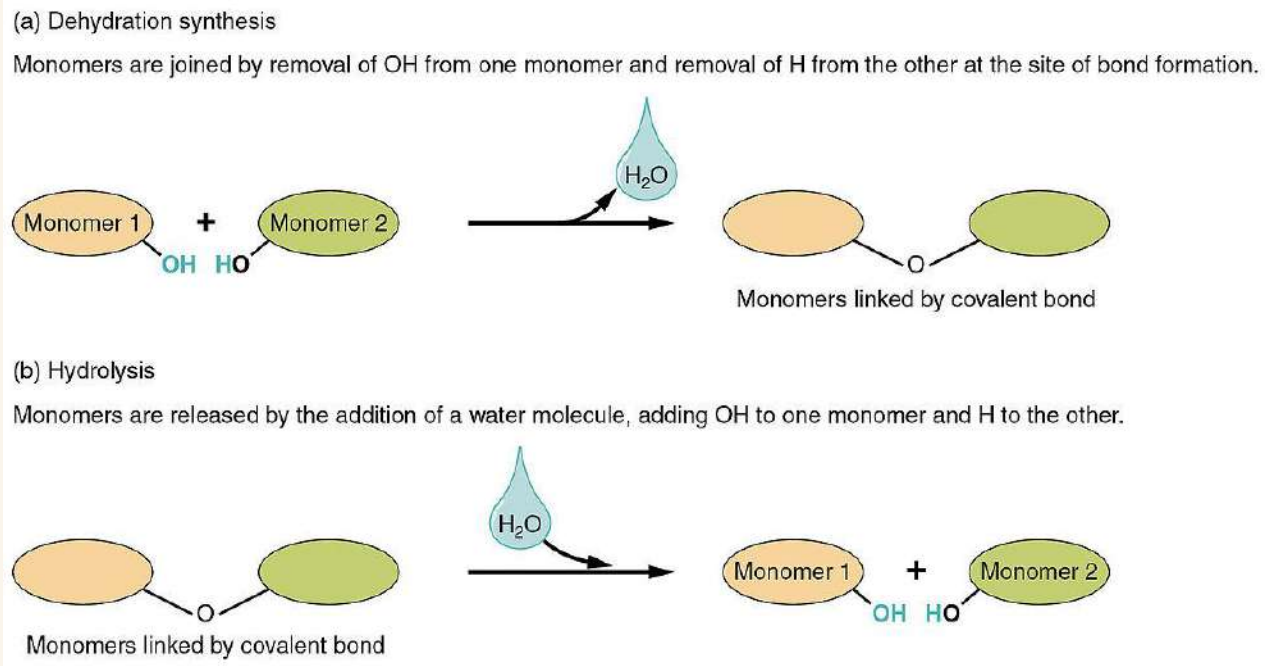
- Large organic molecules.
- Also called ***polymers***.
- Made up of smaller “building blocks” called monomers.
- **Biological Macromolecules** are:
    1. **Carbohydrates**
    2. **Lipids**
    3. **Proteins**
    4. **Nucleic acids (DNA and RNA)**



Dehydration Synthesis vs. Hydrolysis

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)



Carbohydrates

01

Characteristics

- 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**

02

Monomer - Monosaccharide

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.

03

Disaccharide

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.

Carbohydrates Continued

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.

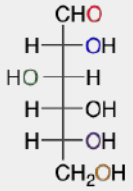
- **Glycogen**
  - Animals store excess sugar in the form of glycogen.
  - Glycogen is similar in structure to starch because both are made of glucose monomers.
- **Cellulose**
  - Cellulose is the most abundant organic compound on Earth.
  - It is the structural component of plants.
  - It forms cable-like 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.

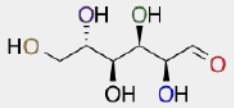
Carbohydrates

01

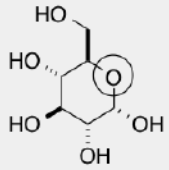
Monosaccharide



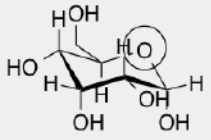
Glucose
Linear Form
Fisher Projection



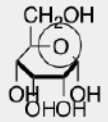
Glucose
Linear Form
Bond Angle Drawing



Glucose
Cyclic Form
Bond Angle Drawing



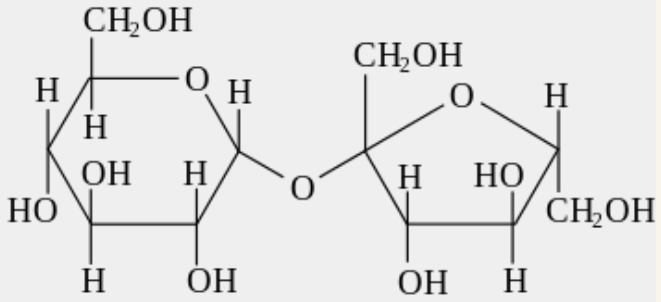
Glucose
Cyclic Form
Chair Conformation



Glucose
Cyclic Form
Haworth Projection

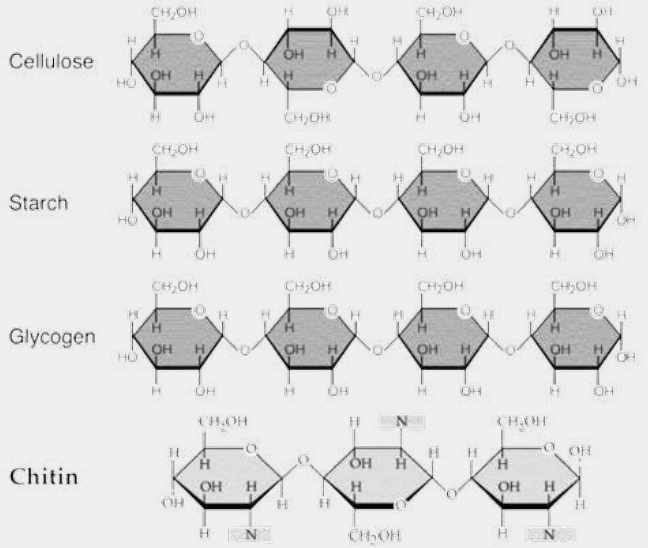
02

Disaccharide



03

Polysaccharide



Lipids

01

Characteristics

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

02

Functions

- 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***)

03

Structure - Fatty acids

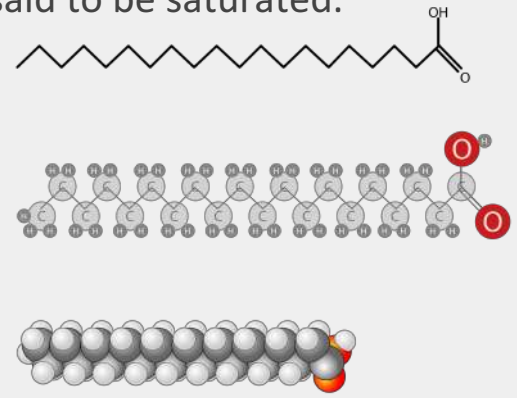
- **Fatty Acids**: a long chain of Hydrogen and Carbon make up lipids. The exception to the monomer/polymer rule is lipids. Lipid base units are not considered monomers. One type of lipid or fat is made up of fatty acids and glycerol molecules in a 3:1 ratio. The bonding of three fatty acids to one glycerol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

Types of Lipids

01

Saturated

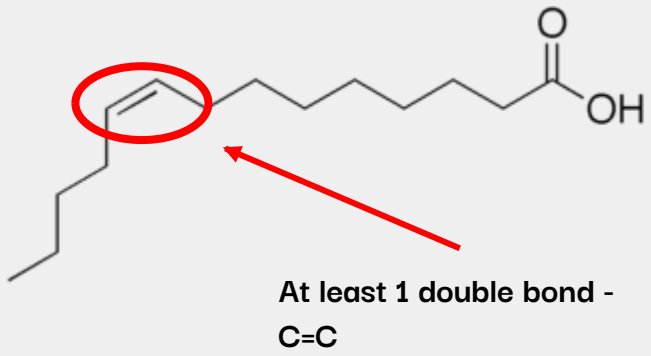
1. **Saturated Fatty Acid**: if each Carbon is bonded by single bonds to other Carbons inside the fatty acid, the fatty acid is said to be saturated.



02

Unsaturated

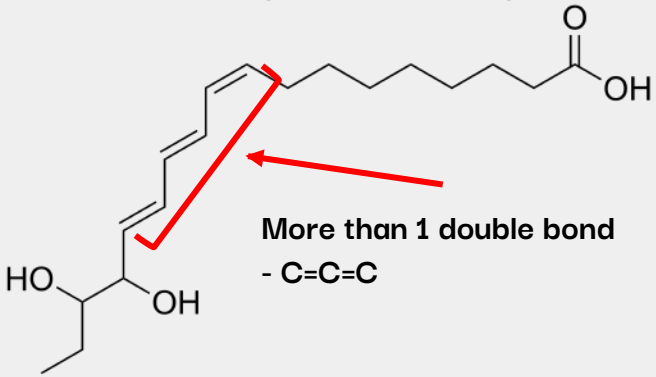
2. **Mono or Unsaturated Fatty Acid**: If a double bond is present, then it is said to be mono-saturated or unsaturated.



03

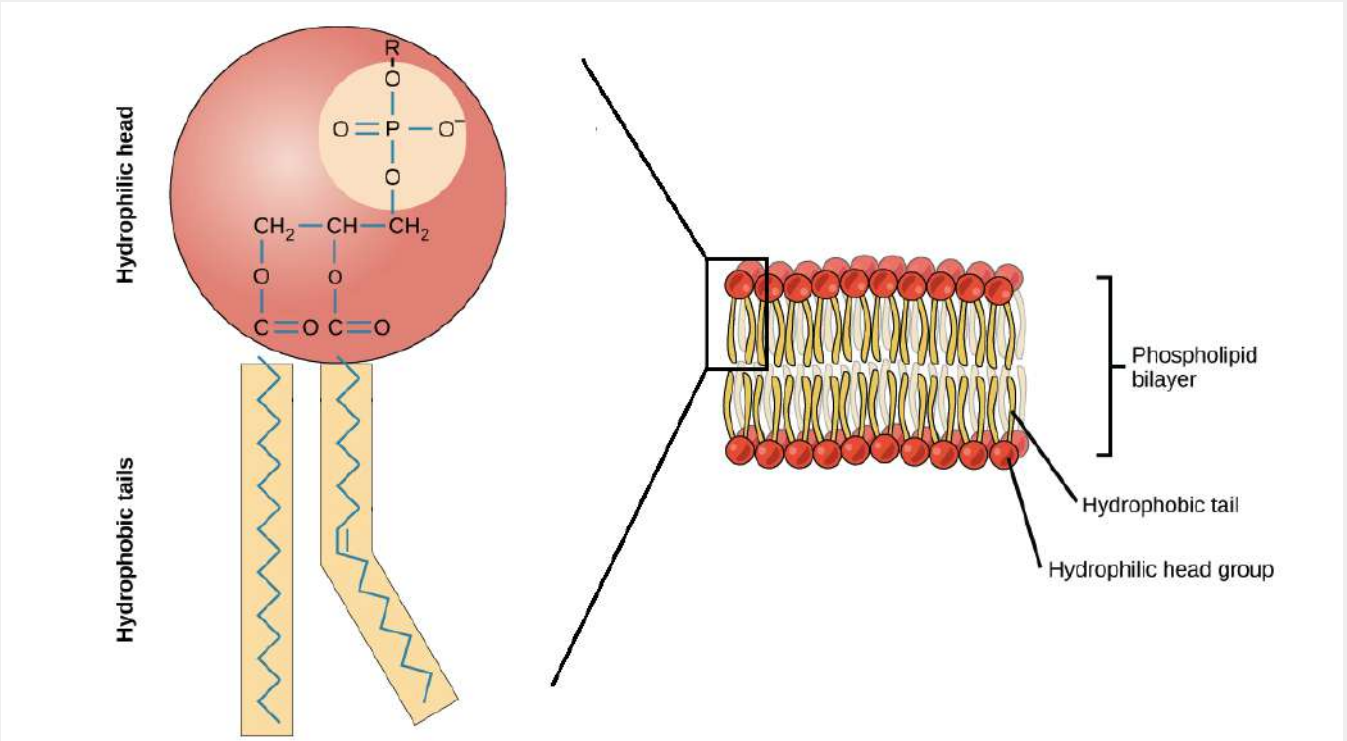
Polysaturated

3. **Polyunsaturated Fatty Acid** - More than one double bond
   - Most animal fats have a high proportion of saturated fatty acids & exist as solids at room temperature (butter, margarine, shortening).



Lipids Continued

4. **Phospholipids** - Cell membranes are made of lipids called phospholipids. Controls what enters and leaves the cell
   - 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.



Phospholipids

Proteins

01
Characteristics

- Composed of
  - ❑ C, H, O, N, sometimes S
- **Monomer**
  - ❑ amino acids
    - 20 different (1 mod)
    - Most structural variation
- **Polymer**: **Polypeptide**
  - ❑ Covalent bonding links
    - Peptide Bond

02
Functions

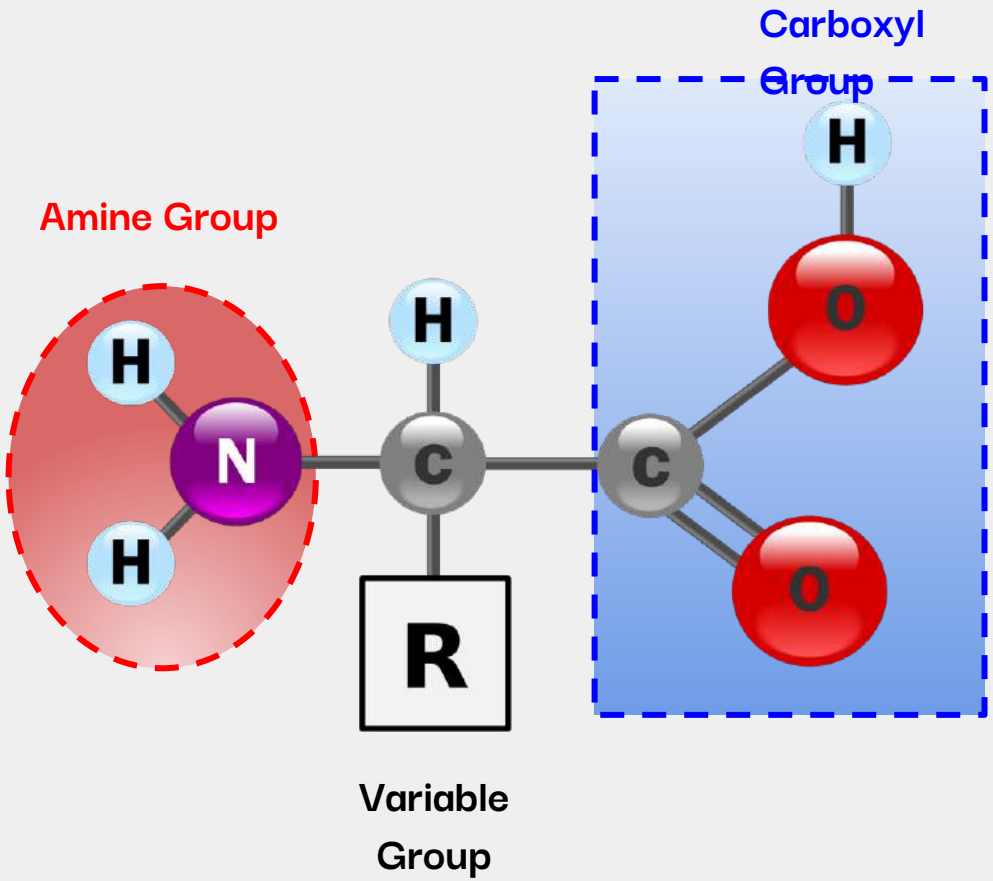
- Essential to Life – ***Biuret*** (indicator) turns purple/lavender with protein, pink with amino acid.
- **Build structure**
- **Movement**:
  - ❑ Makes up muscle tissue
- **Transport**:
  - ❑ Carries oxygen in an organism (hemoglobin).

03
Functions Cont'

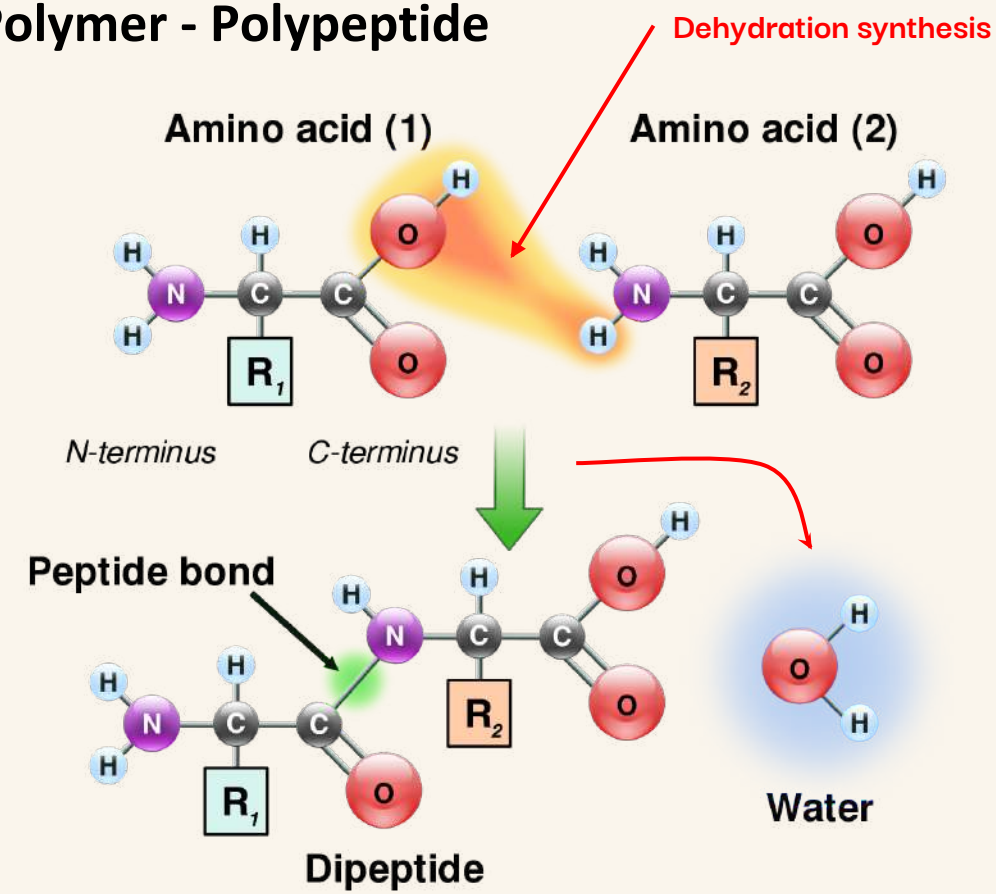
- **Immunity**:
  - ❑ Helps fight off foreign invaders
  - ❑ antibodies
- **Enzymes**: (more below)
  - ❑ Speed up chemical reactions
  - ❑ amylase and pepsin
- **Energy source**
  - ❑ 1 gram = 4 kcal of energy

Proteins - Amino Acid / Polypeptide

Monomer - Amino Acid



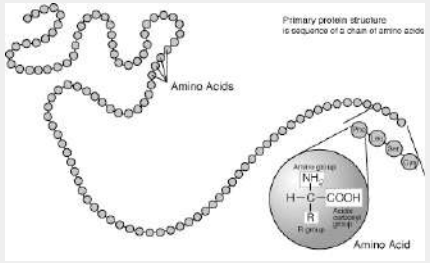
Polymer - Polypeptide



Protein Structures

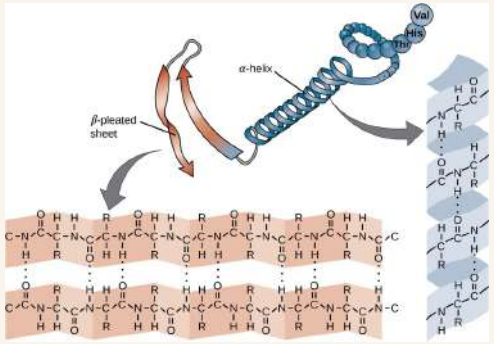
Primary Structure

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



Secondary Structure

- **Secondary protein structures** occur when protein chains coil(helix) or fold(pleated)

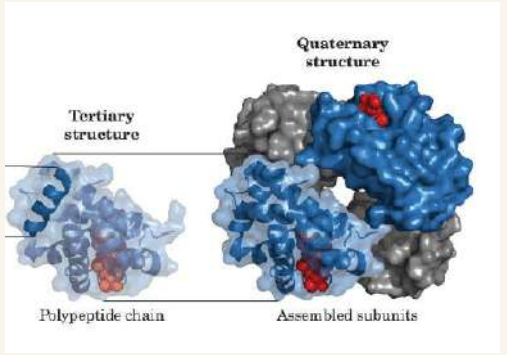


Tertiary Structure

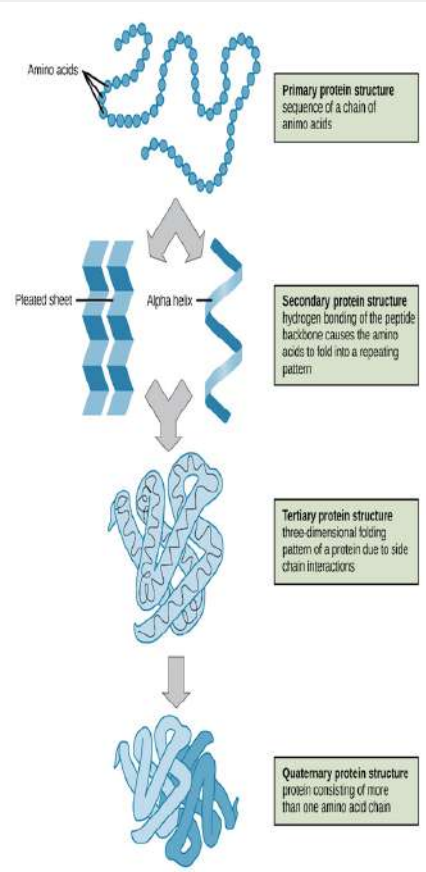
- When protein chains called polypeptides join together, the **Tertiary structure** forms because R groups interact with each other.
- Secondary structures bent and folded into a more complex 3-D arrangement of linked polypeptides
- Bonds: H-bonds, ionic, disulfide bridges (S-S)

Quaternary Structure

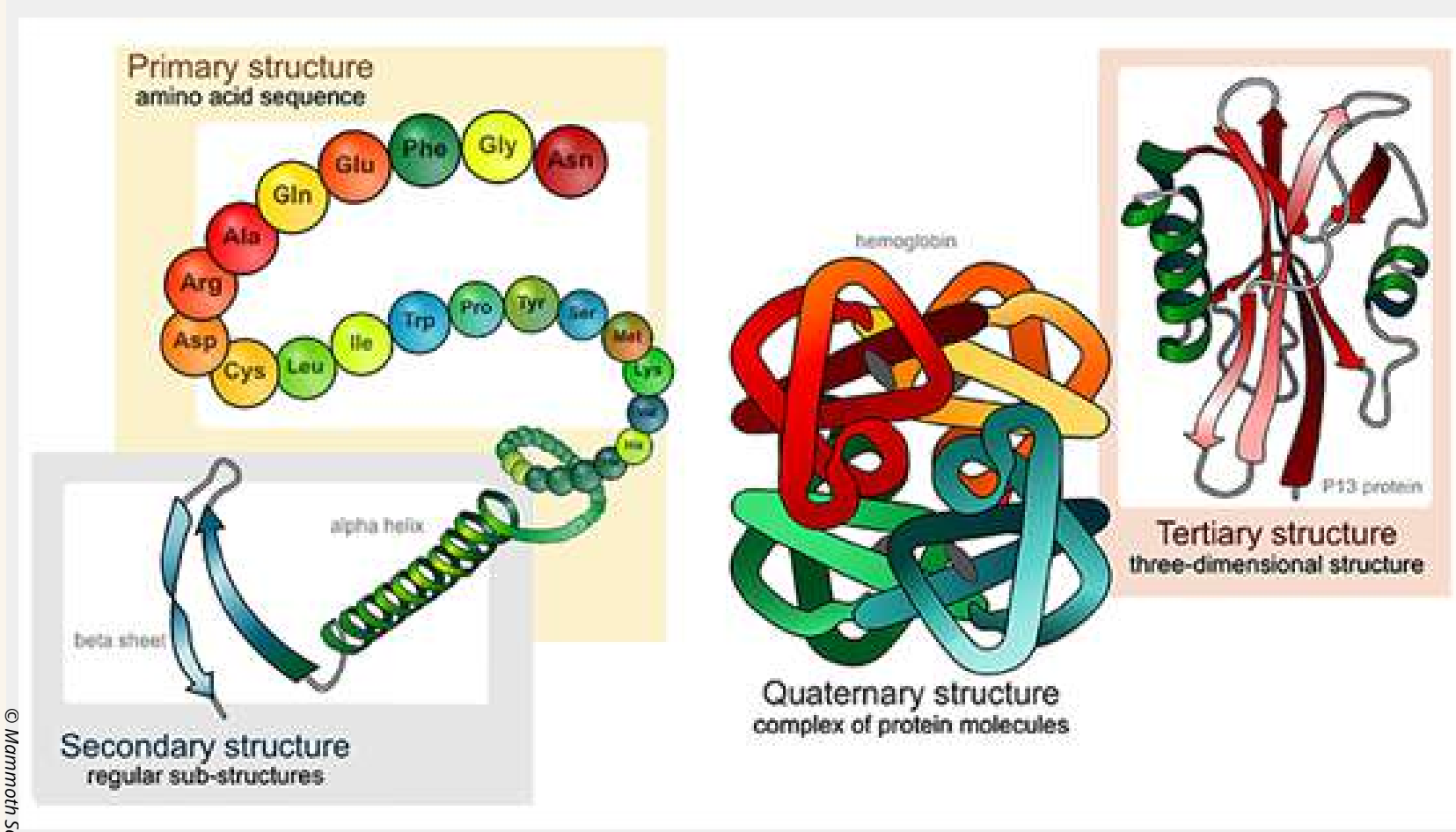
- **Quaternary Structure**: Composed of 2 or more “subunits”.

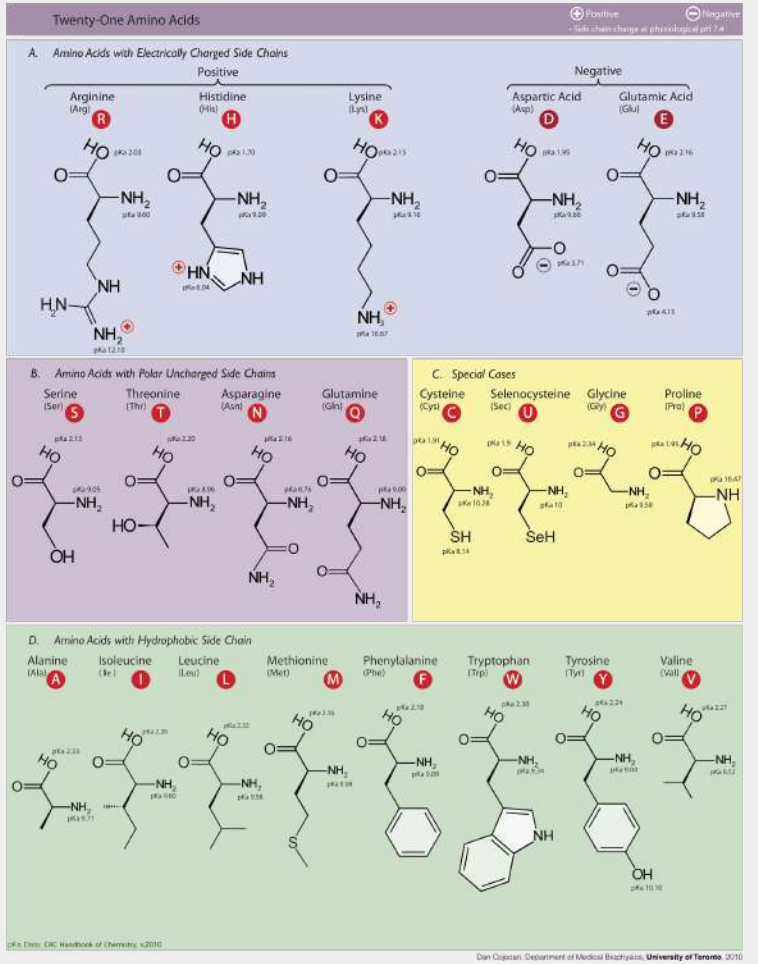


Summary



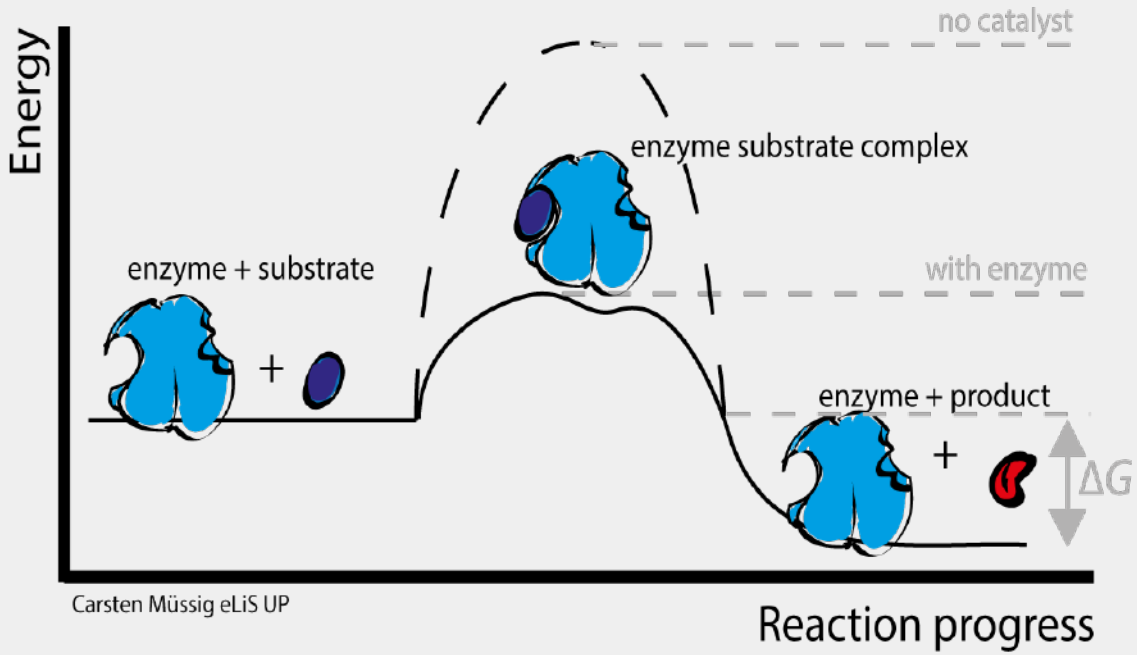
Protein Structures Summary



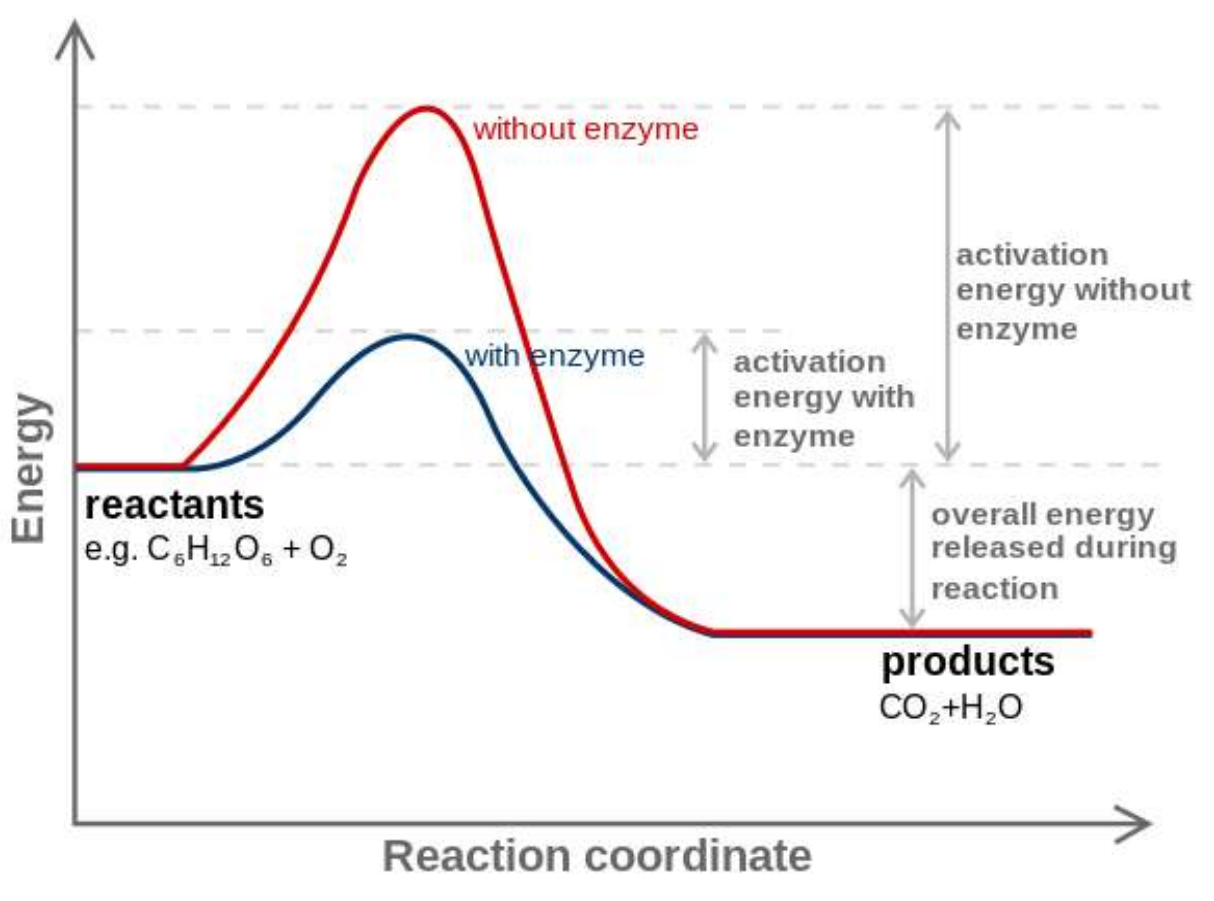


Enzymatic Activity

- **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.**
  5. This site is specific for the object it will hold, called the **substrate**.
  6. There are just as many enzymes as there are substrates.
  7. 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.**

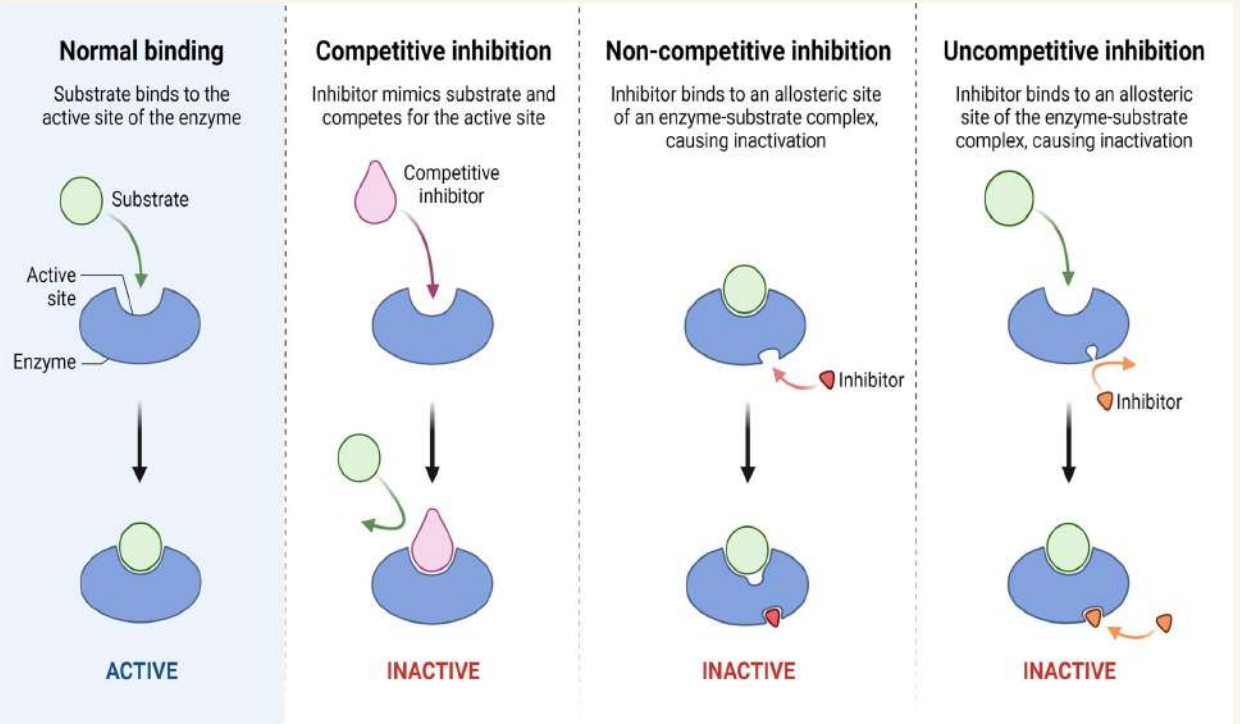


Enzymatic Activity



Rate vs Energy Graph - lowers activation energy

Enzyme Action & Inhibition



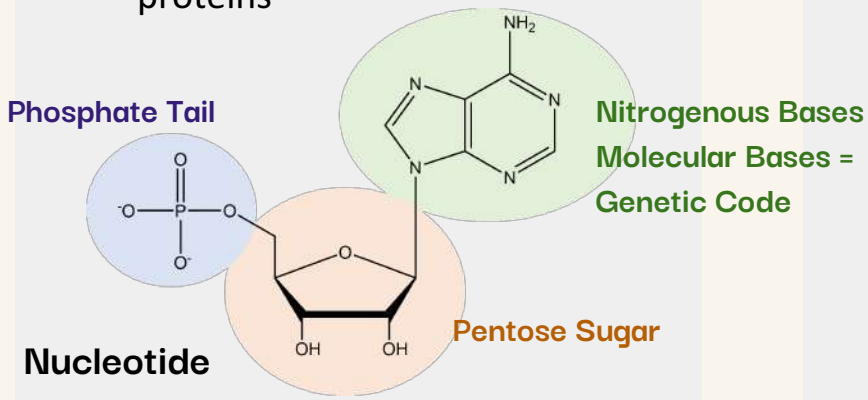
Nucleic Acids

01
Characteristics

- **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)

02
Functions

- **Functions**
  1. Transmits hereditary / genetic information
  2. Leads to the formation of proteins

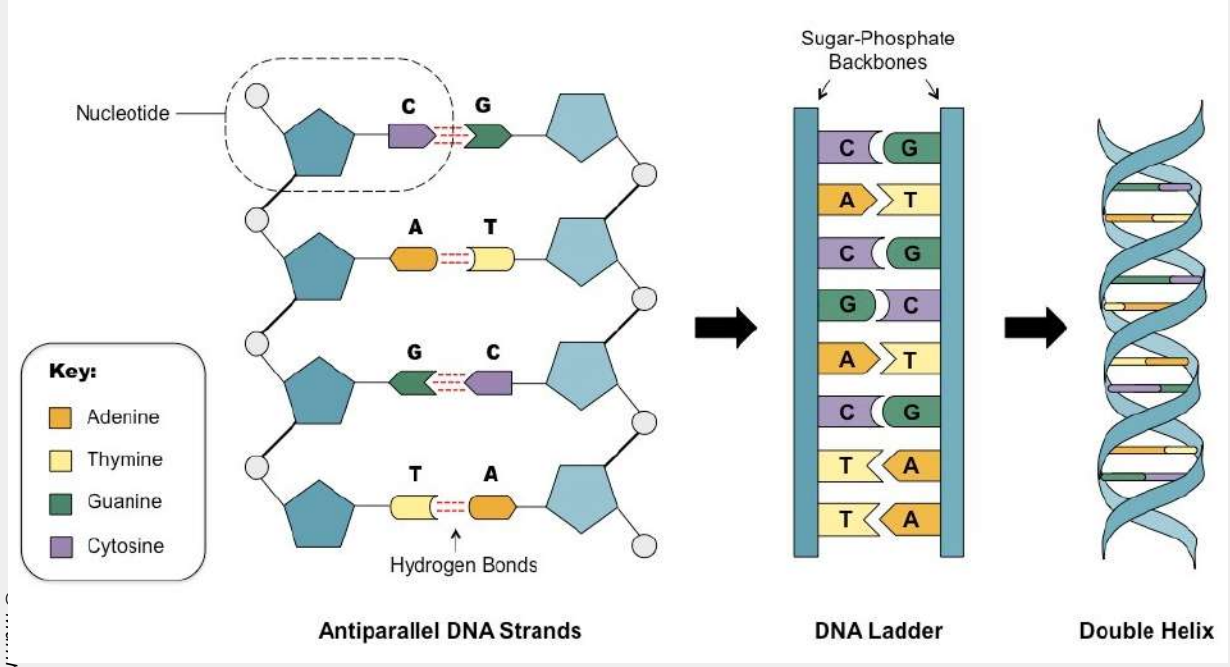


03
2 Polymers

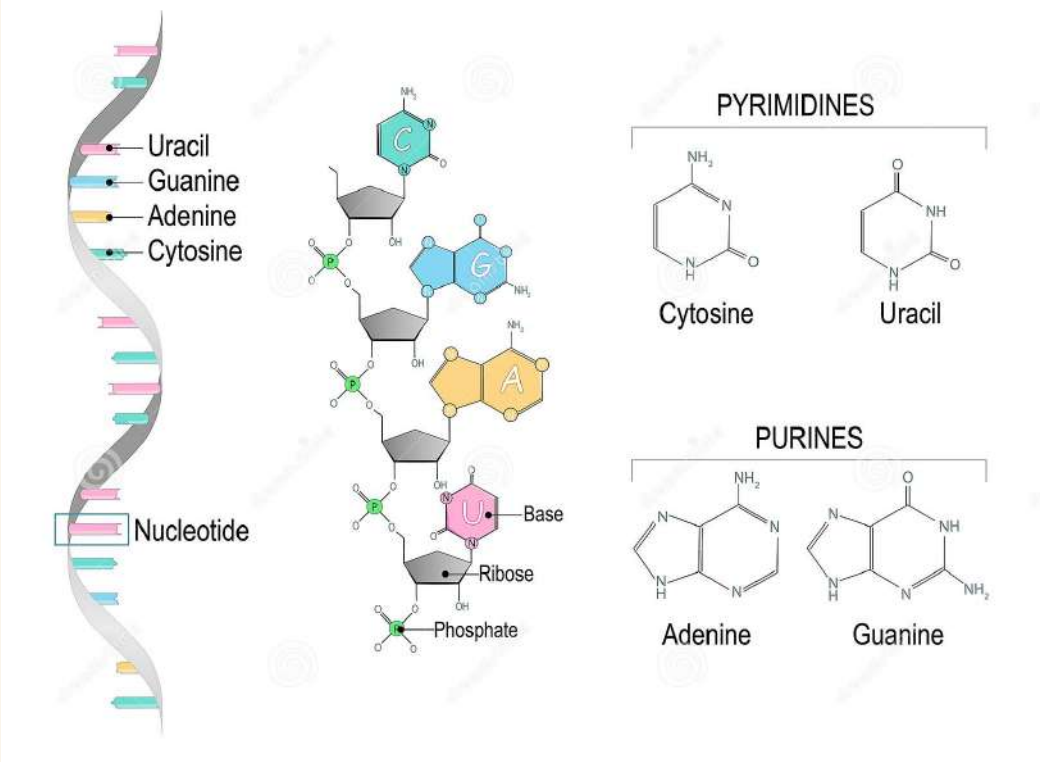
- **Two types:**
  1. **Deoxyribonucleic acid** (**DNA**-double helix)
  2. **Ribonucleic acid** (**RNA**-single strand)

Nucleic Acid Comparison

Deoxyribonucleic Acid



Ribonucleic Acid



Thank you!

Do you have any questions?

instructor@email.com

xxx-xxx-xxxx