Introduction

* Organic Chemistry
  * The chemistry of carbon
* Why carbon?
  * Backbone of all life
    * Any object on earth that contains carbon is considered as being organic
      * Not to be confused with organic foods
  * Has the ability to make four chemical bonds
    * Remember, carbon has four valence electrons
There are four groups of organic compounds:
- Carbohydrates
- Lipids
- Proteins
- Nucleic acids

They exist in the form of monomers or polymers.
- Polymers are two/more monomers joined together.
  - Via polymerization
Carbohydrates
Carbohydrates
Introduction

* Mainly used for energy
* Other names for carbohydrates
  * Sugars
  * Saccharide
  * Starches*

Also known as

Starches Saccharides Sugars
Categories of Carbohydrates

* There are three broad categories of carbohydrates
  * Monosaccharides
  * Disaccharides
  * Polysaccharides
Monosaccharides

Carbohydrates
* **Monosaccharides, also called simple sugars,** are divided into three categories based on the number of carbons within the compound—and have a basic empirical formula.

* \( \text{C}_n\text{H}_{2n}\text{O}_n \)
* When \( n = 3 \)
  * Called a triose sugar
* When \( n = 5 \)
  * Called a pentose sugar
* When \( n = 6 \)
  * Called a hexose sugar
The monosaccharides, based on the number of carbons present \{triose, pentose & hexose\}, can exist in two isomeric forms.

- **Aldose**
  - An aldose sugar is identified by the presence of the functional group called the aldehyde.

- **Ketose**
  - A ketose sugar is identified by the presence of the functional group called the ketone.
Monosaccharides

<table>
<thead>
<tr>
<th>Aldoses Triose sugars (C₃H₆O₃)</th>
<th>Pentose sugars (C₅H₁₀O₅)</th>
<th>Hexose sugars (C₆H₁₂O₆)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Glyceraldehyde" /></td>
<td><img src="image" alt="Ribose" /></td>
<td><img src="image" alt="Glucose" /></td>
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<tr>
<td><img src="image" alt="Ribose" /></td>
<td><img src="image" alt="Ribulose" /></td>
<td><img src="image" alt="Fructose" /></td>
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<tr>
<td><img src="image" alt="Dihydroxyacetone" /></td>
<td><img src="image" alt="Ribulose" /></td>
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</tr>
<tr>
<td><img src="image" alt="Fructose" /></td>
</tr>
</tbody>
</table>
Monosaccharides

AKA Sugars

Triose
- Aldose
  - Glyceraldehyde
- Ketose
  - Dehydroxyacetone

Pentose
- Aldose
  - Ribose
- Ketose
  - Ribulose

Hexose
- Aldose
  - Glucose
- Ketose
  - Fructose
Carbohydrates

Dissacharides
Disaccharides

- Di-saccharides
  - Polymer
  - Combines **two** monosaccharides
    - **Sucrose**
      - Glucose & Fructose joined together
    - **Lactose**
      - Glucose & Galactose
**Polysaccharides**

- **Polysaccharide**
- Polymer
- **Combines many monosaccharides together**
- **Cellulose**
  - Several thousand $\beta$-glucose molecules joined together.
The principal sites of dietary carbohydrate digestion are the mouth and intestinal lumen.

This digestion is rapid and is catalyzed by enzymes known as glycoside hydrolases (glycosidases) that hydrolyze glycosidic bonds.
Lipids

Organic Compounds/Marcromolecules
* Commonly called fat
* Composed of two parts
  * Glycerol
  * Fatty acids
Digestion of Lipids

* The digestion of lipids begins in the stomach, catalyzed by an acid stable lipase (lingual lipase) that originates from glands at the back of the tongue.
* Triglycerol {TAG} molecules are the primary target the enzyme {lipase}.

* These same TAGs are also degraded by a separate gastric lipase, secreted by the gastric mucosa.
Nucleic Acids
Nucleic acids make up chromosomes and are composed of multiple nucleotides joined together.

Hence, a nucleic acid is a polynucleotide.

Examples

* DNA
  * Deoxyribonucleic Acid
* RNA
  * Ribonucleic Acid
Nucleotides

* Nucleotides have three components
  * Sugar
  * Phosphate Group
  * Nitrogenous Bases
Nucleic Acids—Nucleotides

**Nucleotide**

- Three main components
  - **Nitrogenous base**
    - Adenine; Guanine; Cytosine; Thymine; Uracil
      - Uracil is only found in the Nucleic Acid RNA
      - Thymine is only found in the Nucleic Acid DNA
  - **Sugar**
    - Deoxyribose
      - DNA ONLY
    - Ribose
      - RNA ONLY
  - **Phosphate group**
Components of Nucleotides

- Phosphate group
- Nitrogenous base
- 5-carbon sugar

Pyrimidines:
- Cytosine (C)
- Uracil (U)
- Thymine (T)

Purines:
- Adenine (A)
- Guanine (G)
Proteins
Proteins I

* **Functions**
  * Provide support
  * Used for storage
  * Transports other substances
* Composed of polypeptides
  * A sequence of **amino acids**
* **Proteins** can become "active"
  * **Enzymes**
    * Regulate metabolism
Amino Acids

* Over 300 amino acids have been described in nature
  * However, only 20 common as constituents of mammalian proteins
The 20 common amino acids found in proteins are linked together by peptide bonds.

The sequence contains information necessary to generate a protein molecule with a unique 3D shape.

Proteins have four organizational levels:
- Primary
- Secondary
- Tertiary
- Quaternary
Structures of Proteins

* **Primary Structure**
  * Long chain of amino acids

* **Secondary Structure**
  * Polypeptide chain folded into
  * $\alpha$ helical structure.
    * Keratins
  * $\beta$ helical structure.

* **Tertiary Structure**
  * Occurs when the helix folds on into itself
    * Globular proteins

* **Quaternary Structure**
  * Combination of a number of polypeptide chains along with associated non protein groups
Secondary Structure
Alpha vs. Beta
Quaternary Structure

* Consist of **two or more polypeptide chains** that may be structurally identical or totally unrelated
  * Two subunits
    * **Dimeric**
  * Three subunits
    * **Trimeric**
  * Several subunits
    * **Multimeric**
Quaternary Structure

Figure 4-20: Essential Cell Biology, 2/e. (© 2004 Garland Science)
Classes of Proteins
There are three general classes of proteins.

- **Globular**
- **Fibrous**
- **Conjugated**
Globular Proteins

* **Globular Proteins**
  * Hemeproteins
    * Hemoglobin
    * Myoglobin
Fibrous Proteins

* **Collagen**
  * Most abundant protein in human body

* **Elastin**
  * Tough
  * High tensile strength
  * Connective tissue protein with rubber like properties
  * Found in lungs, walls of large blood vessels and elastic ligaments
**α-Keratins**
* Proteins that form tough fibers
  * Hair, nail, hooves, feathers, outer epidermal layer of mammals, intermediate filaments of cytoskeleton in certain cells

**Actin & Myosin**
* Used in the contractile motion of muscle tissue
Conjugated Proteins

* **Conjugated Proteins**
  * Proteins that sometimes occur in **combination with a non-protein substance** (prosthetic group)
    * Hemoglobin
Digestion of Proteins I

Dietary proteins

Mouth

Stomach

Small intestine

Intestinal lining

HCl, pepsin

Denatured and partially hydrolyzed protein

Trypsin, chymotrypsin, aminopeptidase, carboxypeptidase

Small peptides, amino acids

Active transport

Amino acids in bloodstream
Most proteins in the body are constantly being synthesized and then degraded, permitting the removal of abnormal or unneeded proteins.

For many proteins, regulation of synthesis determines the concentration of protein in the cell, with protein degradation assuming a minor role.
* **Rate of turnover:** In healthy adults, the total amount of protein in the body remains constant*, because the rate of protein synthesis is just sufficient to replace the protein that is degraded.

* This process, called **protein turnover**, leads to the hydrolysis and resynthesis of 300–400 g of body protein each day.

* The rate of protein turnover varies widely for individual proteins.
Review
Review

Organic Macromolecules

Carbohydrates
- Monosaccharides
  - Triose: Aldose, Ketose, Dihydroxyacetone
  - Pentose: Aldose, Ketose, Ribose, Ribulose, Pentose
  - Hexose: Aldose, Ketose, Glucose, Fructose, Galactose

Disaccharides

Polysaccharides

Lipids
- Phospholipids
- Neutral lipids
- Fats

Nucleic Acids
- DNA
- RNA

Proteins
- Primary Structure
- Secondary Structure
- Tertiary Structure
- Quaternary Structure

Nucleotide Bases
- Purines: Adenine, Guanine
- Pyrimidines: Cytosine, Thymine, Uracil

Sugar Phosphate

Protein Structures
- Primary
- Secondary
- Tertiary
- Quaternary
- Dimeric
- Trimeric
- Multimeric

Conjugated