Carbon Compounds
Ch 2.3
2.3 Carbon Compounds
A. The Chemistry of Carbon

Organic- any substance that contains carbon except CO₂ and CO.

Carbon is very important to living things
1. Carbon has 4 Valence electrons
   Makes it very versatile
   Will easily bond with H, O, N, P, S..all important for living things

2. Carbon has the ability to form bonds with itself
   a. makes long chains
   b. complex structures

Steroids

Testosterone

FORM DICTATES FUNCTION
FORM = Shape or Its structure
Function = Job it Performs
B. Hydrocarbons and Functional Groups

1. Hydrocarbons: Made of Hydrogen and Carbon Only
   Represent our Fossil Fuels

   a. Alkanes: Hydrocarbon chains containing only single bonds

   Methane
   \[
   \text{H}_2\text{C}\text{H}_4
   \]

   Ethane
   \[
   \text{H}_2\text{C} = \text{C}\text{H}_2
   \]

   Propane
   \[
   \text{H}_3\text{C} = \text{C}\text{H}_3
   \]

   Butane
   \[
   \text{H}_4\text{C} = \text{C}\text{H}_4
   \]

   Octane
   \[
   \text{H}_{10}\text{C} = \text{C}\text{H}_{10}
   \]

   b. Alkenes: Hydrocarbon chains containing at least one DOUBLE bond

   Ethene
   \[
   \text{H}_2\text{C} = \text{C}\text{H}_2
   \]

   Propene
   \[
   \text{H}_3\text{C} = \text{C}\text{H}_3
   \]

   Pentene
   \[
   \text{H}_4\text{C} = \text{C}\text{C} = \text{C}\text{H}_4
   \]
c. **Alkynes**: Hydrocarbon chains containing at least one TRIPLE bond

\[
\text{Propyne} \\
\text{H-CNCC-CN} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H}
\]

\[
\text{H-CC-CN-C} \\
\text{C-H} \\
\text{H}
\]

d. **Aromatic**: Hydrocarbon chains in a ring structure

\[
\text{Benzene} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{H}
\]

\[
\text{Toluene} \\
\text{CH}_3
\]
2. Functional Groups: atoms and ions added to our hydrocarbons to alter their function

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Class of Molecules</th>
<th>Formula</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>Alcohol</td>
<td>R−ON</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Alddehyde</td>
<td>Carbonyl (C=O</td>
<td>R−C=O</td>
<td>Acetaldehyde</td>
</tr>
<tr>
<td>Ketone</td>
<td>/ CO</td>
<td>R−C=O</td>
<td>Acetone</td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>Carbonyl Acids</td>
<td>R−C=O</td>
<td>Acetic Acid</td>
</tr>
<tr>
<td>Anisole</td>
<td>Aromatic</td>
<td>R−H</td>
<td>Anisole</td>
</tr>
<tr>
<td>Organic Phosphates</td>
<td>Phosphate</td>
<td>R−P−O−</td>
<td>2-Phosphoglyceric acid</td>
</tr>
<tr>
<td>Thiols</td>
<td>Sulfhydryl</td>
<td>R−SH</td>
<td>Phenylthiol</td>
</tr>
</tbody>
</table>

Important for our Understanding
C. Macromolecules of Life

Macromolecules

Macro=Large
Large Molecules made up of smaller pieces
Also known as Polymers

A Polymer is made up of many Monomers—small units that combine to form larger ones

Monomer → Many Monomers → Polymer (Macromolecule)
Are all Polymers made up of smaller Monomers!
Carbohydrates
1. Carbohydrates (Sugars and Starches)
   a. Contain Carbon, Hydrogen and Oxygen only
   b. These elements always occur in a 1:2:1 Ratio (C:H:O)
      This is important for identifying them

   ![Glucose and Sucrose structures]

   c. Structure Can be Simple or Complex
      1. Simple Sugars
         a. Monosaccharides- Single Sugar
            Glucose and Fructose
         b. Disaccharides- Double Sugar
            Made from joining two monosachharides together
            *Dehydration Synthesis-building by removing water*
            *Glycosidic Linkage- specific type of dehydration synthesis which joins carbs*

   ![Disaccharide formation]

   c. Polysaccharide- 3 or more single sugars joined together

2. Complex Carbohydrates
   a. Starch- Thousands of monosaccharides joined together
      Cellulose/Fiber from plants
      Glycogen from animals
D. Function:

1. Most Carbs are readily available sources of energy
   Energy is stored in the bonds between Carbon Atoms
   It is released by the breaking of bonds between monosaccharide through a process called
   **HYDROLYSIS-breaking apart by adding water**

   Once broken down into monosaccharides they are dismantled by Respiration

2. Some Starches are Structural Components
   Chitin is made of Cellulose and is found in cell walls of plants and the exoskeleton of insects
LIPIDS

Fats
2. Lipids (Fats, Oils, and Waxes)
   a. Contains Carbon, Hydrogen, and Oxygen (Same as Carbs)
   b. Ratio is different from Carbs ($C_{a lot}$, $H_{a lot}$, $O_{not so much}$)
   c. Structure:

   **Monomers are Glycerol and Fatty Acids**

   Lipids are made when a glycerol molecule bonds with fatty acids

   **Fatty Acid**

   Joined together by Dehydration Synthesis known as

   **ESTER LINKAGE**
1. Fats/Oils (Triglycerides):
- 1 Glycerol Molecule and 3 Fatty Acid Chains
- Fat is solid at Room Temperature
- Oil is a liquid at Room Temp

Fats can be **Saturated** or **Unsaturated**

**Saturated**

**Unsaturated (MONO)**

**Unsaturated (POLY)**

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**The Biologic Importance of Saturated Fat**

- **Cell Membranes**: Require 50% saturated fatty acids to be "waterproof" and function properly.
- **Heart**: Prefers saturated long-chain 18-carbon palmitates and 16-C stearic acid (over polyunsaturated oils).
- **Bones**: Need saturated fats to mineralize calcium effectively.
- **Liver**: They protect from the adverse effects of alcohol and medications like acetaminophen.
- **Lungs**: Long saturated, which prevent emphysema and other breathing disorders, is composed entirely of 15-16 carbon acids.
- **Hormones**: They function as signaling messengers for hormone production.
- **Immune System**: Saturated fats play an important role here. They:
  - Promote white blood cell development, invading bacteria, viruses, and fungi.
  - Aid in fighting infections and immune responses.
- **Soybean Oil**: 18:2 delta 9,12 (linoleic acid) and 18:3 delta 9,12,15 (alpha-linolenic acid) make up 50% of soybean oil.
- **Olive Oil**: 75% of its fatty acids are monounsaturated and the rest are polyunsaturated.
- **Avocado Oil**: 73% unsaturated and 27% saturated.
- **Fish Oil**: Mainly unsaturated with omega-3 PC-PUFA.
- **Tuna Oil**: Unsaturation.
- **Caviar Oil**: Contains high levels of unsaturated fatty acids, including omega-3 PC-PUFA.
- **Male Reproductive System**: It contains fatty acids that promote sperm motility.
- **General Health**: Eating saturated fats lowers consumption of health-damaging carbohydrates and polyunsaturated vegetable oils.
Unsaturated Fats can be **CIS** or **TRANS** fats

The bend makes it easier to digest and less likely to congest arteries
2. Functional Lipids

1 Glycerol Molecule attached to two Fatty Acids and something else that alters its function

EX: Phospholipid

Create a membrane that protects a cell from the outside environment
3. Waxes and Cholesterol (Steroids)
   a. Waxes: One fatty acid chain linked to an alcohol

<table>
<thead>
<tr>
<th>Type</th>
<th>Structural Formula</th>
<th>Source</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beeswax</td>
<td>CH₁₄(CH₂)₁₂-C-O-(CH₂)₁₉CH₃</td>
<td>Honeycomb</td>
<td>Candles, shoe polish, wax paper</td>
</tr>
<tr>
<td>Carnauba wax</td>
<td>CH₁₆(CH₂)₂₄-C-O-(CH₂)₁₈CH₃</td>
<td>Brazilian palm tree</td>
<td>Waxes for furniture, cars, floors, shoes</td>
</tr>
<tr>
<td>Jojoba wax</td>
<td>CH₁₈(CH₂)₁₈-C-O-(CH₂)₁₇CH₃</td>
<td>Jojoba</td>
<td>Candles, soaps, cosmetics</td>
</tr>
</tbody>
</table>

b. Steroids: a carbon skeleton with a 4 ring structure

Cholesterol: Lipoproteins

HDL: High Density Lipoprotein 
aka: Good Cholesterol: increases the transport of saturated fats for digestion: prevents clogging of arteries

LDL: Low Density Lipoprotein 
aka: Bad Cholesterol: Decreases the transport of triglycerides causing them to accumulate as plaque in arterial walls
Steroids: have the same shape as cholesterol but generally serve as hormones in the body

Androgen: aka. male hormone responsible for development of male primary and secondary sexual characteristics and tissue building

Female Sex hormones: Responsible for the development of primary and secondary sexual characteristics and regulation of menstruation

Modern birth control pills (YAZ) introduce synthetic progesterone to trick the body into thinking it is pregnant. Progesterone prevents further ovulation during pregnancy.
Anabolic Steroids: Synthetic versions of male hormones that promote accelerated tissue growth
d. Functions
   1. Act as Energy Storage
   2. Serve as a membrane to protect the cell from the outside environment
   3. Serve as chemical messengers (hormones) in the body
Nucleic Acids
3. Nucleic Acids
   a. Very large Macromolecules
   b. Contain Carbon, Hydrogen, Oxygen, and Nitrogen and Phosphorous

   c. Function:
      Information Carrying Molecules: DNA and RNA
      Carry instructions for Building Proteins

   d. Structure:
      *Monomers are called nucleotides*
      *They contain one of each of the following*

      a. 5 Carbon Sugar (Deoxyribose or Ribose)
      b. Phosphate Group
      c. Nitrogenous Base
         a. Adenine
         b. Guanine
         c. Cytosine
         d. Thymine/Uracil (Different in DNA and RNA)

![Diagram of 2-Deoxyribose and Ribose](image)

(Klug & Cummings 1997)

The Sequence of Nitrogenous Bases makes up the genetic code= instructions for building proteins
Proteins

Examples of foods high in protein: beef, chicken, salmon, eggs, beans, black beans, and nuts.
4. Proteins
   a. Made up of Carbon, Hydrogen, Oxygen, and Nitrogen
   b. Structure

Monomers are Amino Acids

**Amino Acid Structure**

- **Amino**
  - \( \text{H} \)
  - \( + \text{H} \)
  - \( \text{N} \)

- **Carboxyl**
  - \( \text{C} \)
  - \( \text{O} \)
  - \( \text{OH} \)

R-group (variant)

- **Hydrogen**
  - \( \text{H} \)

All Amino Acids have the same *Amino group* \((\text{NH}_3)^+\)
Amino means Nitrogen

and *Carboxyl group* \((\text{COO})^-\)
This makes it an acid

The **R-Group** is for the rest of the molecule...There are 20 different R groups......meaning there are 20 different amino acids
Amino Acid Structure

Hydrogen

Amino

+ H  N  H

Carboxyl

C  O  O-

R-group
(variant)
A. Amino acids with electrically charged side chains

Positive

Arginine (Arg)

Histidine (His)

Lysine (Lys)

Negative

Aspartic acid (Asp)

Glutamic acid (Glu)

B. Amino acids with polar but uncharged side chains

Serine (Ser)

Threonine (Thr)

Asparagine (Asn)

Glutamine (Gln)

C. Special cases

Cysteine (Cys)

Glycine (Gly)

Proline (Pro)

D. Amino acids with hydrophobic side chains

Alanine (Ala)

Isoleucine (Ile)

Leucine (Leu)

Methionine (Met)

Phenylalanine (Phe)

Tryptophan (Trp)

Tyrosine (Tyr)

Valine (Val)
When two Amino Acids are joined together water is removed...This is known as ___________ ___________.

In Proteins it is known as a Peptide Bond!

A molecule of water is removed from two glycine amino acids to form a peptide bond.

Four Levels of Structure:
1. Primary- Sequence of Amino Acids (Polypeptide)
2. Secondary- Polypeptide bends
3. Tertiary- Folds into a 3 Dimensional Polypeptide
4. Quaternary- different Polypeptides come together to make a functional protein

Polypeptide

Protein

Alpha Helices

Beta Pleated Sheets
c. Functions (7)

1. Proteins are structural components of tissue
2. Enzymes - carry out all of the bodies chemical reactions
3. Transport materials
4. Contract to create movement
5. Act as Hormones - chemical messengers
6. Store materials
7. Antibodies for the immune system defense

Hemoglobin is a protein that carries oxygen in red blood cells