

## Molecular Biology

### 2.1- Molecules to Metabolism

## Essential idea:

- Living organisms control their composition by a complex web of chemical reactions.

## Nature of Science:

- Falsification of theories—the artificial synthesis of urea helped to falsify vitalism. (1.9)

» Friedrich Wohler was a scientist at the polytechnic school of Berlin. He was then famous as the discoverer of aluminium. He was trying to make ammonium cyanate by mixing ammonium chloride with silver cyanate.

» Instead he got organic urea.

» As he wrote in a letter to the famous chemist Berzelius - I... must tell you that I can make urea without the use of kidneys, either man or dog. Ammonium cyanate is urea.

$$\text{AgOCN (aq)} + \text{NH}_4\text{Cl} \rightarrow \text{H}_2\text{N}-\text{C}(=\text{O})-\text{NH}_2$$

Wohler's synthesis of urea

## Molecular Biology

- Explains living processes in terms of the chemical substances involved
  - Carbon moves from the environment to organisms where it is used to build carbohydrates, proteins, lipids or nucleic acids.
  - DNA is the blueprint for all living organisms

## Molecular Biology

- The approach of a molecular biologist is a reductionist one
- They identify the steps in a metabolic pathway and breakdown each one into its component parts.
- This approach has been a very productive one. (photosynthesis, protein synthesis)

## Carbon

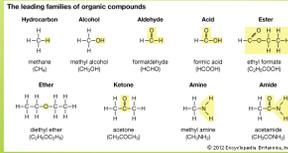
- Atoms can form four covalent bonds allowing a diversity of stable compounds to exist
- Forms the backbone of every organic molecule.
- Covalent bonds are the strongest type of bond between atoms.

Molecule	Ball-and-stick model	Molecular shape	Molecular type
Water		Bent	Polar
Methane		Tetrahedral	Nonpolar
Carbon dioxide		Linear	Nonpolar



## Biological Ideas

- Organic Compounds contain C (also H)



- Vitalism (life force outside physical & chemical laws)



How was Michelangelo influenced by this idea?

## Biological Ideas

- Experiments to Disprove Vitalism
  - Friedrich Wöhler (1828)- made urea
  - Hermann Kolbe (~ 1828)- made acetic acid
  - Stanley Miller and Harold Urey(1953)
    - Primitive atmosphere of earth (water, hydrogen, ammonia, methane)
    - Lightning
    - Produced a variety of amino acids
- Mechanism (all natural phenomena are governed by physical & chemical laws)

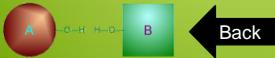
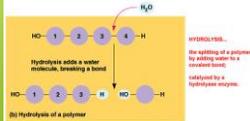
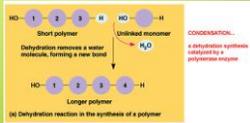
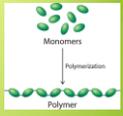


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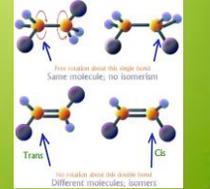
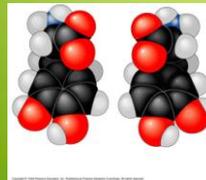
## Polymers

- Compounds made of repeating linked units
- Covalent bonds link monomers
- Condensation reaction
  - Dehydration reaction
  - Form a water molecule
- Hydrolysis: bonds between monomers are broken by adding water (digestion)
- Wide variety of polymers based on few monomers



## Isomers

- Structural Isomers- Differ in covalent arrangement of same atoms
- Geometric Isomers- Differ in spatial arrangement of same atoms
- Enantiomers- Molecules are mirror images or each other



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## Functional Groups

### HYDROXYL

#### STRUCTURE



Ethanol, the alcohol present in alcoholic beverages

#### NAME OF COMPOUNDS

Alcohols (their specific names usually end in -ol)

#### FUNCTIONAL PROPERTIES

- Is polar as a result of the electronegative oxygen atom drawing electrons toward itself.
- Attracts water molecules, helping dissolve organic compounds such as sugars (see Figure 5.3).

## Functional Groups

### CARBONYL

#### STRUCTURE



Acetone, the simplest ketone

#### EXAMPLE



Acetone, the simplest ketone



Propanal, an aldehyde

#### NAME OF COMPOUNDS

Ketones if the carbonyl group is within a carbon skeleton  
Aldehydes if the carbonyl group is at the end of the carbon skeleton

#### FUNCTIONAL PROPERTIES

- A ketone and an aldehyde may be structural isomers with different properties, as is the case for acetone and propanal.

## Functional Groups

### SULFHYDRYL

**STRUCTURE**

(may be written HS—)

**EXAMPLE**

Ethanethiol

**NAME OF COMPOUNDS**

Thiols

**FUNCTIONAL PROPERTIES**

- Two sulfhydryl groups can interact to help stabilize protein structure.

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## Functional Groups

### AMINO

**STRUCTURE**

**EXAMPLE**

Glycine

Because it also has a carboxyl group, glycine is both an amine and a carboxylic acid; compounds with both groups are called amino acids.

**NAME OF COMPOUNDS**

Amine

**FUNCTIONAL PROPERTIES**

- Acts as a base; can pick up a proton from the surrounding solution:

(nonionized)      (ionized)

Ionized, with a charge of 1+, under cellular conditions

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## Functional Groups

### CARBOXYL

**STRUCTURE**

**EXAMPLE**

Acetic acid, which gives vinegar its sour taste

**NAME OF COMPOUNDS**

Carboxylic acids, or organic acids

**FUNCTIONAL PROPERTIES**

- Has acidic properties because it is a source of hydrogen ions.
- The covalent bond between oxygen and hydrogen is so polar that hydrogen ions (H<sup>+</sup>) tend to dissociate reversibly; for example,

Acetic acid      Acetate ion      + H<sup>+</sup>

- In cells, found in the ionic form, which is called a carboxylate group.

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## Functional Groups

### PHOSPHATE

**STRUCTURE**

**EXAMPLE**

Glycerol phosphate

**NAME OF COMPOUNDS**

Organic phosphates

**FUNCTIONAL PROPERTIES**

- Makes the molecule of which it is a part an anion (negatively charged ion).
- Can transfer energy between organic molecules.

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