Chemical Reactions

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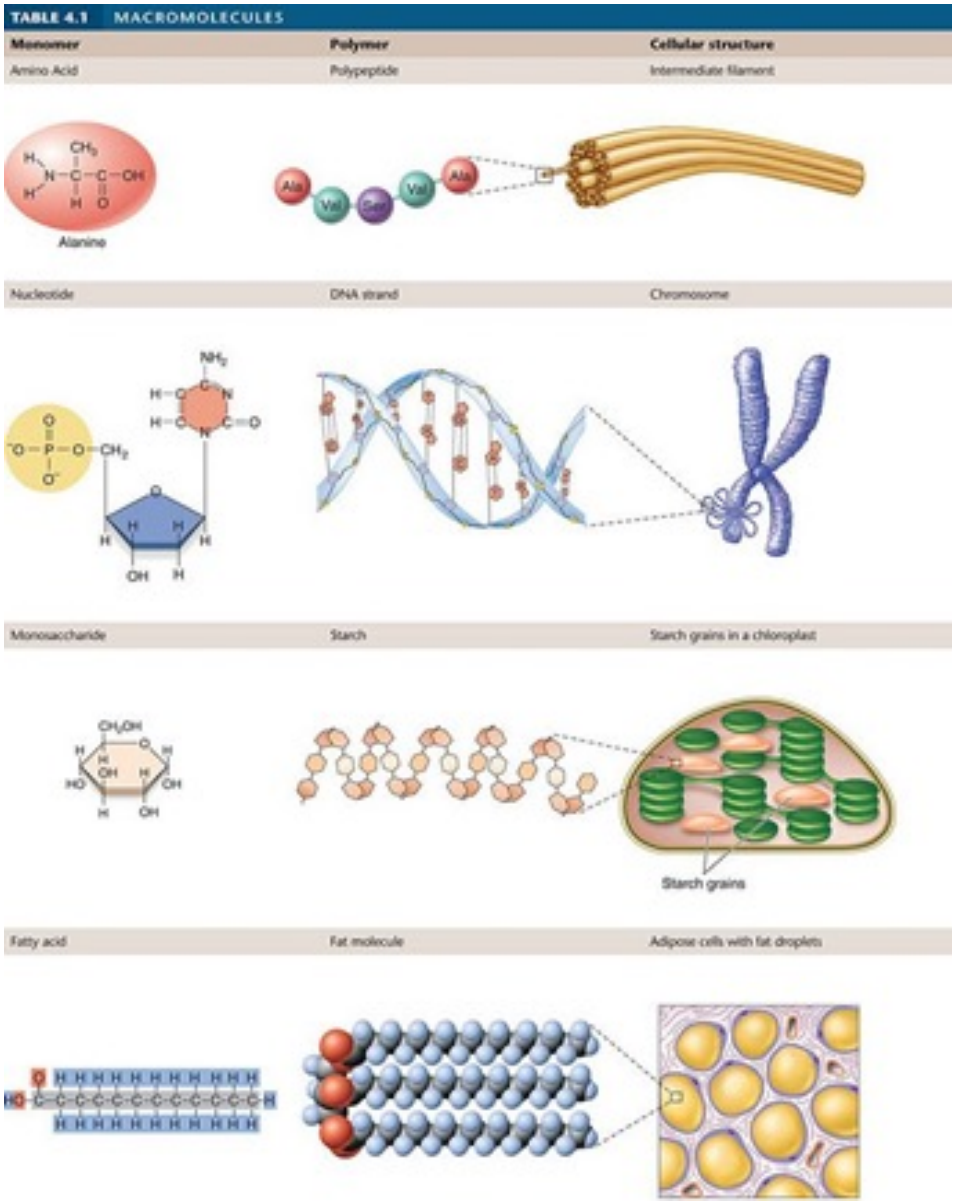
Elements for life



You could start really small...
- Particles of matter
- Atoms
→ - Elements
→ - Molecules
→ - Macromolecules
→ - Cell organelles
- Cells
- Tissues
- Organs
- Systems
- Organisms
- Populations
- Ecosystems
- Biospheres
- Planets
- Planetary Systems with Stars
- Galaxies
- The Universe

.And finish really big.

Chemical cooking - Chemical Reactions

- Learning Objectives
  - ***Explain*** basic features of chemical reactions (versus physical changes)
  - ***Recognise*** the four basic combinatory changes in chemical reactions
  - ***Identify*** major types of chemical reactions occurring in the body
    - Oxidation-Reduction
    - Acid-base
    - Hydrolysis
    - Condensation

https://www.youtube.com/watch?v=2S6e11NBwiw

CHEMICAL REACTIONS – MAJOR FEATURES

- Synthesis of matter
- Conservation of matter
- Energy is involved
- Kinetic is involved

- Distinct from physical changes such as
  - Change of states, eg. ice to water is NOT a chemical reaction!

CHEMICAL REACTIONS – MAJOR FEATURES

- Synthesis of matter
  - Old bonds are broken and new bonds forms

CHEMICAL REACTIONS – MAJOR FEATURES

- Synthesis of matter
- Conservation of matter

Chemical Reactions – major features

The Law of Conservation of Matter

"Matter is conserved"

- Matter cannot be created or destroyed during any chemical or physical change.

CHEMICAL REACTIONS – MAJOR FEATURES

- Synthesis of matter
- Conservation of matter
- Energy is involved
  - Energy is the capacity to do work
  - Energy transfer is associated with reactions

CHEMICAL REACTIONS – MAJOR FEATURES

First Law of Thermodynamics

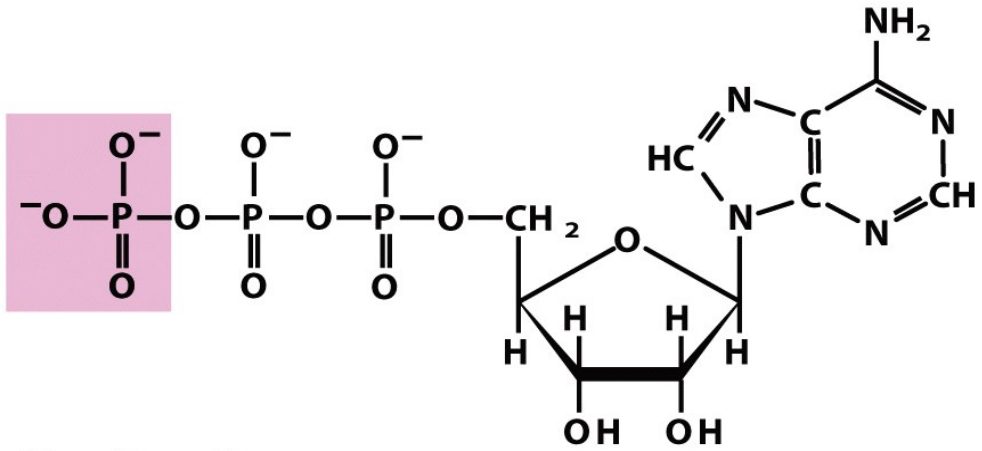
"Energy is conserved"

- The total energy of a system and its surroundings is constant
- For any cyclic process, there is no net change in energy
- Energy cannot be created or destroyed
- Energy can take different forms, such as heat and light etc.

Laws of Thermodynamics Apply to Living Organisms

- Living organisms cannot create energy from nothing
- Living organisms cannot destroy energy into nothing
- Living organisms may transform energy from one form to another

- In the process of transforming energy, living organisms must increase the entropy of the universe
- In order to maintain organization within the themselves, living systems must be able to extract useable energy from the surrounding, and release useless energy (heat) back to the surrounding



Adenosine triphosphate (ATP) provides energy for many endergonic reactions

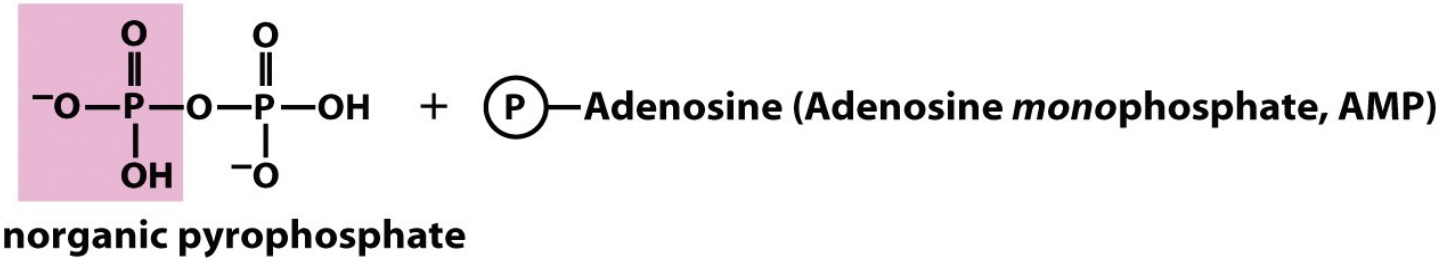


Figure 1-25
Lehninger Principles of Biochemistry, Fifth Edition

CHEMICAL REACTIONS – MAJOR FEATURES

- First reaction in glycolysis is a coupled reaction to ATP conversion to ADP

CHEMICAL REACTIONS – MAJOR FEATURES

- Synthesis of matter
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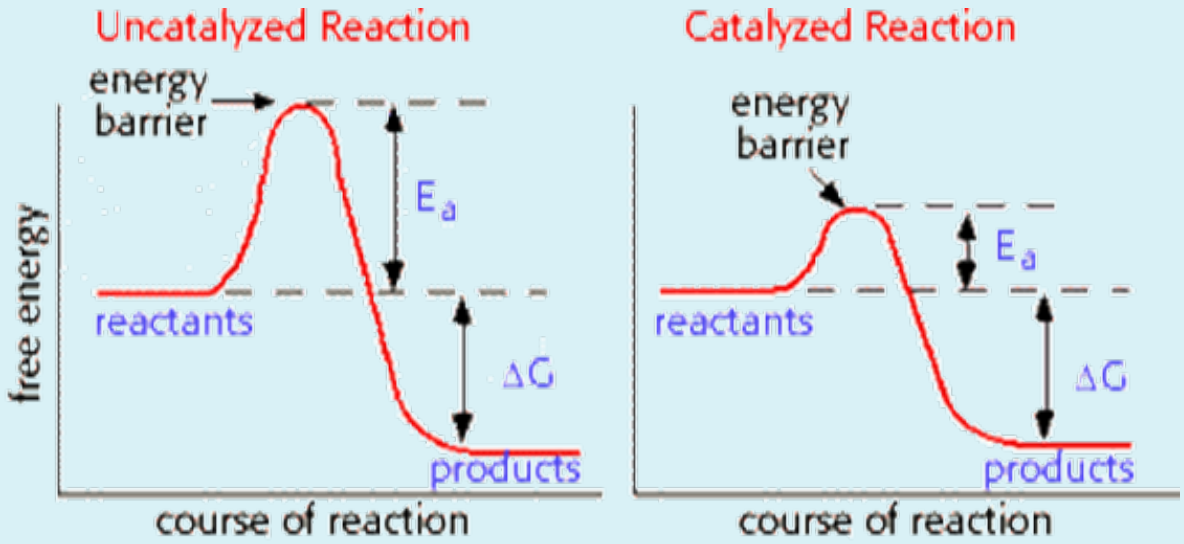
- Kinetic is involved

CHEMICAL REACTIONS – MAJOR FEATURES

- Kinetic refers to the rate of reactions
- Enzymes can change the rate of reactions and speed up reactions



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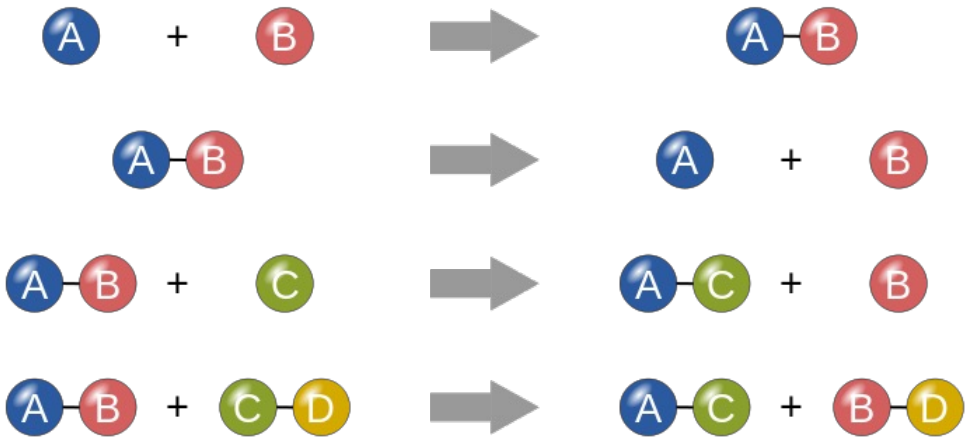
Four basic types of combinatory changes



1. Synthesis
2. Decomposition
3. Single displacement
4. Double displacement

CHEMICAL REACTIONS – CLASSIFY BY TYPES

- Chemical reactions can be classified in many ways, for example by the:
  - Types of products
  - **Types of reactants**
  - **Reaction outcome**
  - Reaction mechanism

CHEMICAL REACTIONS – CLASSIFY BY TYPES

- By **the types of reactants**
  - Redox (oxidation-reduction) reactions
  - Acid-base reactions
- By **the reaction outcome**
  - Condensation
  - Hydrolysis

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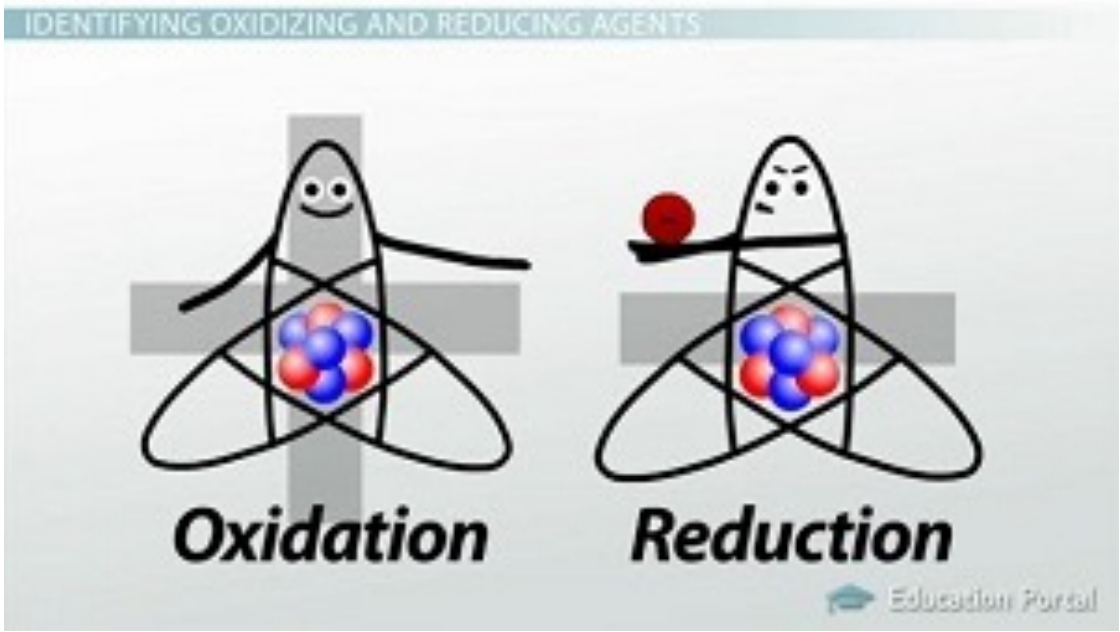
CHEMICAL REACTIONS – OXIDATION-REDUCTION

- Involves transfer of one or more electrons from a reducing agent to an oxidizing agent

  $Mg + O_2 \rightarrow MgO$

  - Magnesium burns in oxygen to form magnesium oxide. The product is an ionic compound, made up of Mg^{2+} and O^{2-}.
  - Each magnesium atom gives up 2 electrons and gets oxidized.
  - Each oxygen atom accepts 2 electrons and gets reduced.

CHEMICAL REACTIONS



http://www.youtube.com/watch?v=lQ6FBA1HM3s

https://www.youtube.com/watch?v=lQ6FBA1HM3s (2.20-2.35)

CHEMICAL REACTIONS – OXIDATION-REDUCTION

CHEMICAL REACTIONS –

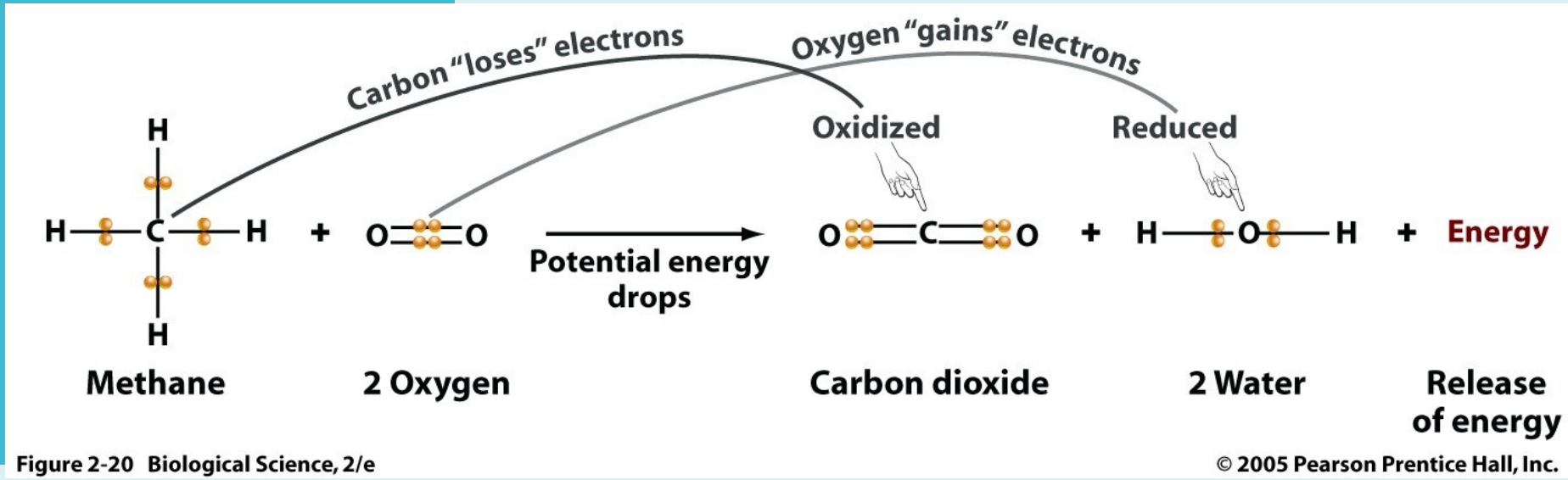
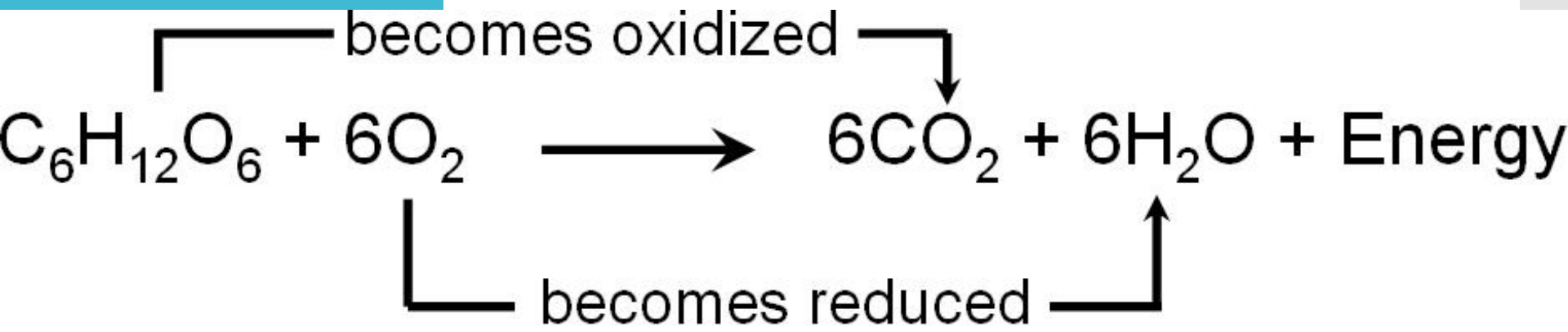


Figure 2-20 Biological Science, 2/e

CHEMICAL REACTIONS – OXIDATION-REDUCTION



CHEMICAL REACTIONS – ACID-BASE

- Three theories of acid-base behaviour
  - The Arrhenius theory
  - **The Bronsted-Lowry theory**
  - The Lewis theory

CHEMICAL REACTIONS – ACID-BASE

Using the Bronsted-Lowry theory, an acid is defined as a proton donor and a base as a proton acceptor.

- acid (1) + base (2) ⇌ base (1) + acid (2)

Where acid (1) and base (1) are a conjugate acid-base pair, as are acid (2) and base (2).

- Acids are defined weak or strong depending on whether the equilibrium favor the reactants or products

$HCl(aq) + H_2O\ (l) \rightarrow H_3O^+(aq) + Cl^-(aq)$

$NH_3(aq) + HCl(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$

CHEMICAL REACTIONS – ACID-BASE

Completely ionized in water, hence favour product, so HCl is a strong acid!

$$HCl(aq) + H_2O\ (l) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

The proton transfer from HCl to NH_3 is poor, hence favor reactant, so NH_3 and NH_4^+ are weak base and acid

$$NH_3(aq) + HCl(aq) \rightarrow NH_4^+(aq) + Cl^-(aq)$$

CHEMICAL REACTIONS – CONDENSATION

- Polymers can be formed in basically 2 ways:
  A. Linking small molecules together, which is a kind of addition reaction
  B. Combining 2 molecules (either the same or different) with the elimination of a stable small molecule such as water (H_2O)

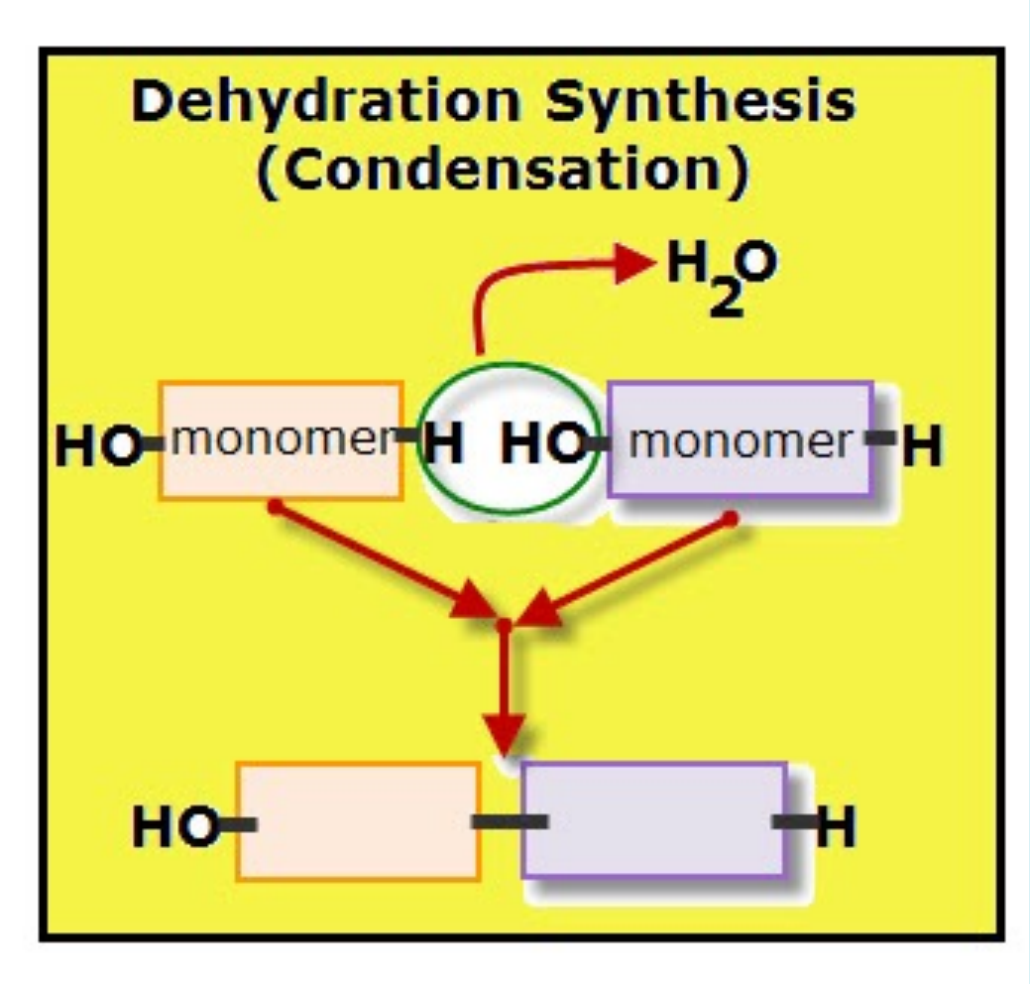
CHEMICAL REACTIONS – CONDENSATION

- **B** is a condensation reaction! (A is NOT) –featuring BOTH addition and elimination reactions.
- Eg. Starch and cellulose are both polymers of glucose, where glucose are joined together with concurrent elimination of water.

$$nC_6H_{12}O_6 \rightarrow -[-C_6H_{10}O_5-]-n + nH_2O$$

CHEMICAL REACTIONS – CONDENSATION

CHEMICAL REACTIONS – CONDENSATION



CHEMICAL REACTIONS – HYDROLYSIS

- When water is involved in a reaction
- $AB + HOH \rightleftharpoons AH + BOH$

CHEMICAL REACTIONS – HYDROLYSIS

- Proteins are hydrolyzed to amino acids
- Fats are hydrolyzed to fatty acids and glycerol
- Starch and complex sugars are hydrolyzed to simple sugars

- Anions of weak acids dissolve in water to give basic solutions.

$$CH_3COO^-(aq) + H_2O\ (l) \rightarrow CH_3COOH(aq) + OH^-(aq)$$

CHEMICAL REACTIONS – HYDROLYSIS