

Chemical Reactions & Chemical Equations



WHY CHEMICAL REACTIONS are IMPORTANT in MEDICINE?

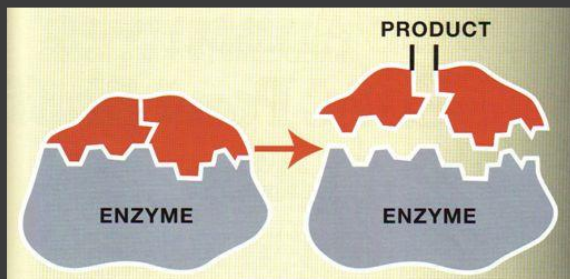
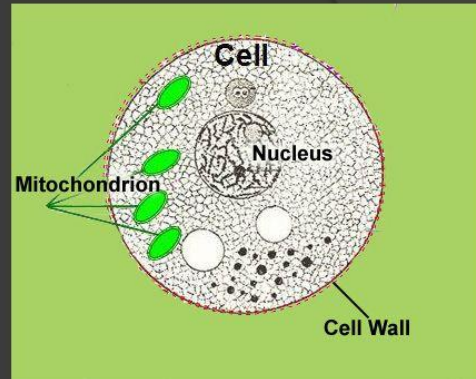
-because ALL CHANGES that happen in our body and in our environment are DUE TO SOME KIND OF CHEMICAL REACTION going on

→ *creation of ATP, synthesis of drugs, effect of the drugs in the body, Enzyme-substrate interactions, enzyme inactivation drug-DNA interactions...*

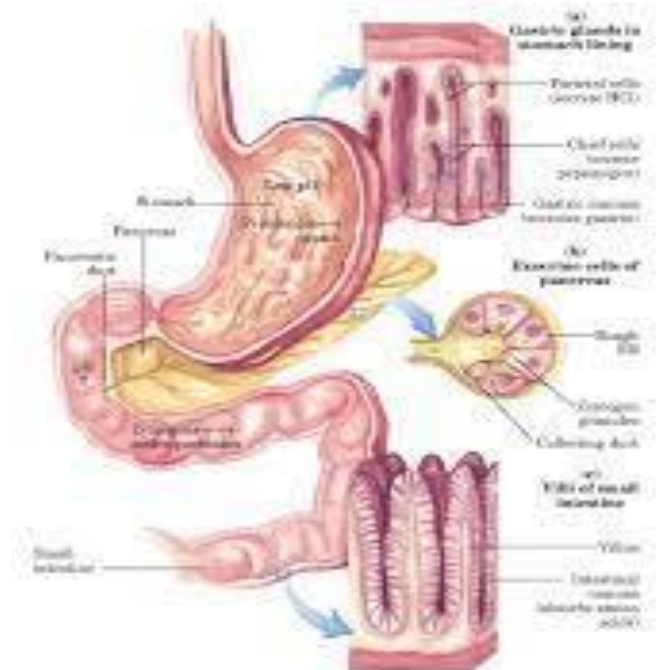
all these systems consider some type of chemical reaction...

Biology 2.4

Energy and Chemical Reactions in Cells



Protein digestion



Aim: To revise the purpose of enzymes, how they work, and examine the factors which affect enzyme catalysed reactions.

How many chemical reactions happen in our body?

Since we have about 200 trillion cells and each one performs millions of chemical reactions, the total number of chemical reactions in the human body is about 400 billion per second every second of your life.

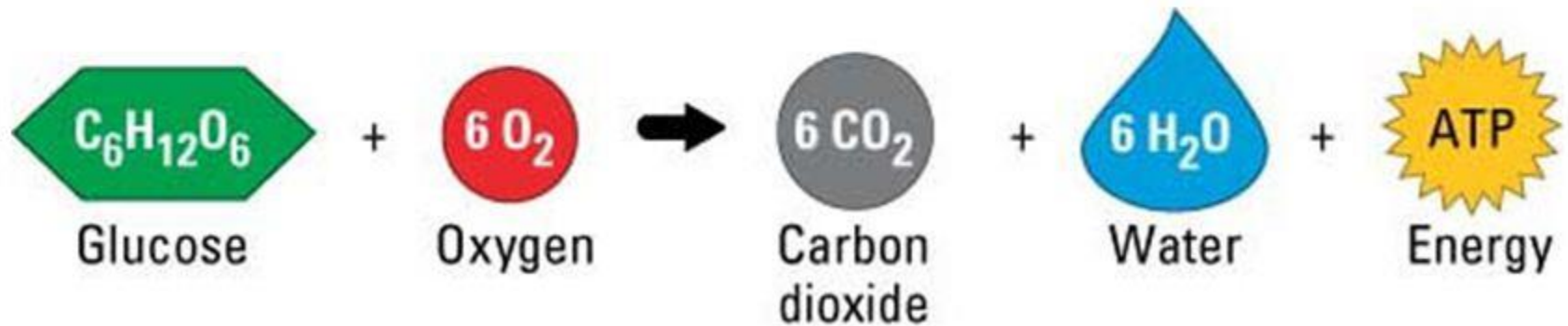
That's 4 times the amount of stars in our galaxy which is a mere 100 billion



Chemical Reactions in Cells

- To keep your body alive, your cells undergo *countless* chemical reactions.
 - **Many of these reactions are occurring 24/7.**

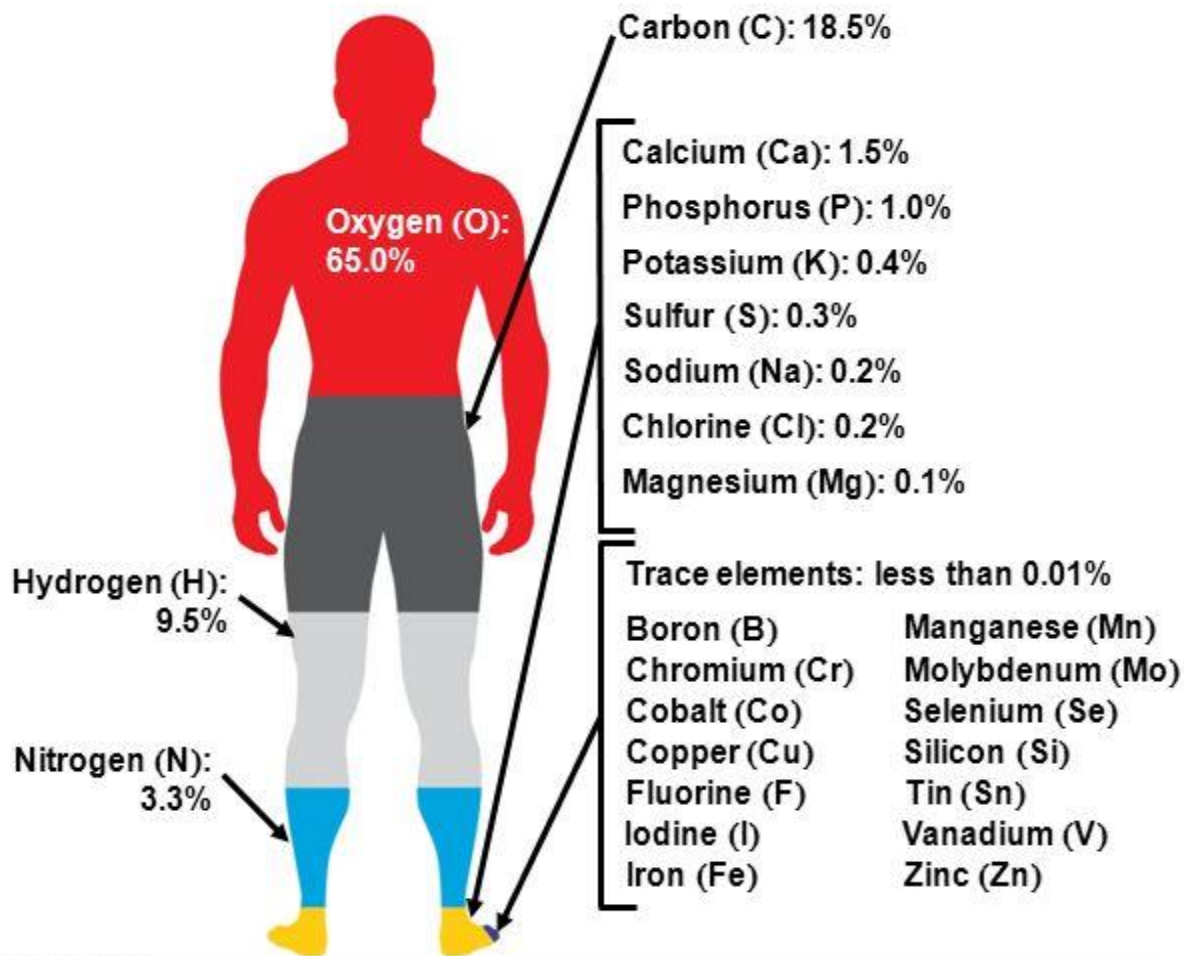
These chemical reactions drive cellular processes!



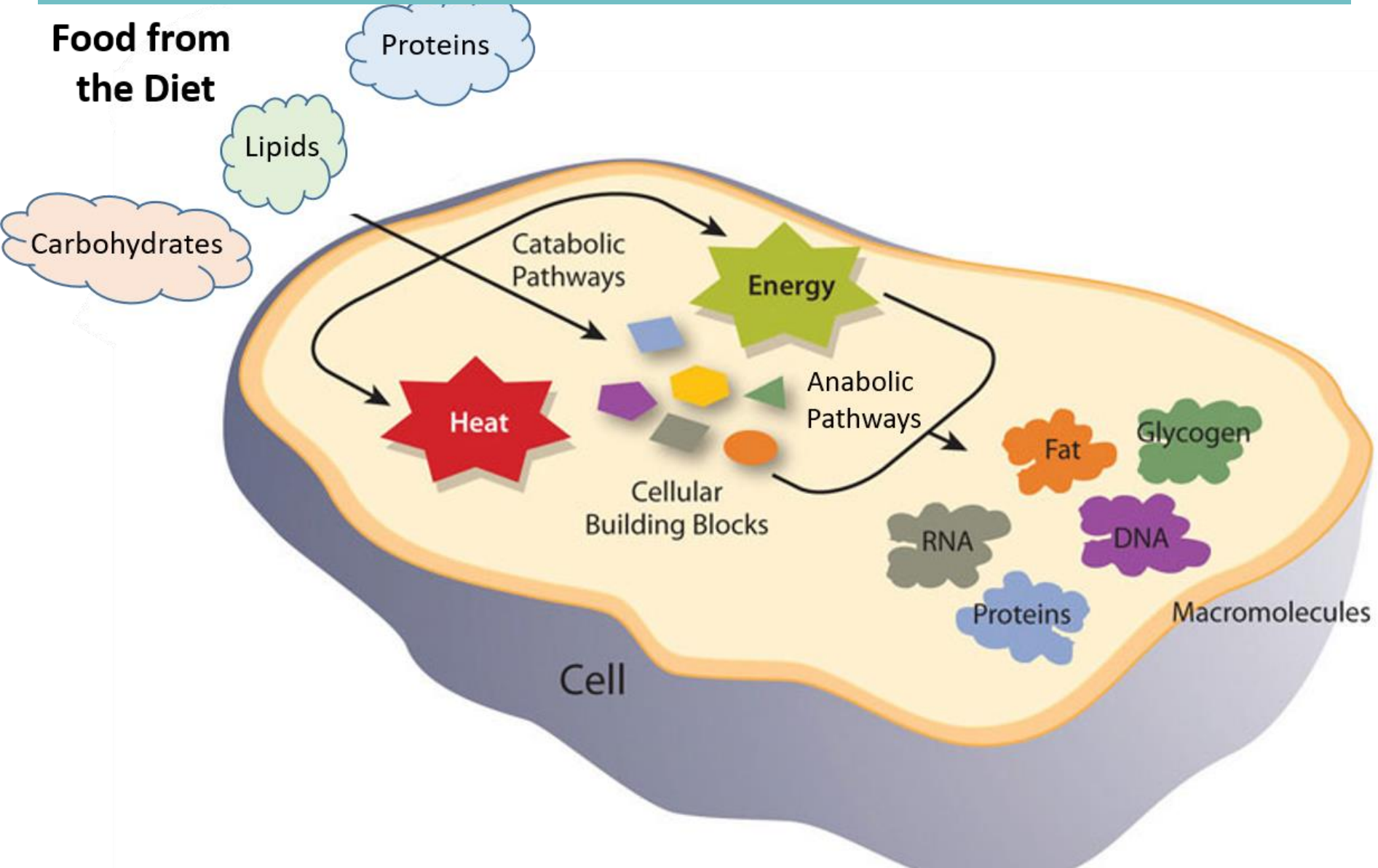
Chemistry of Life

- Twenty-five elements are essential to life.
- Four elements make up about 96% of the weight of the human body:

- Oxygen
- Carbon
- Hydrogen
- Nitrogen



REMEMBER: Majority of chemical reactions in our body consider **CONVERSION** of the **COMPOUNDS** present in the **FOOD** to useful compounds **NEEDED** to **OUR BODY**

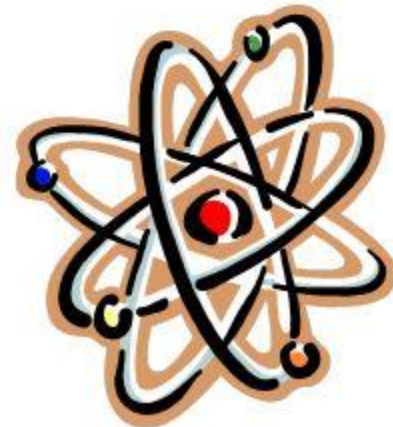
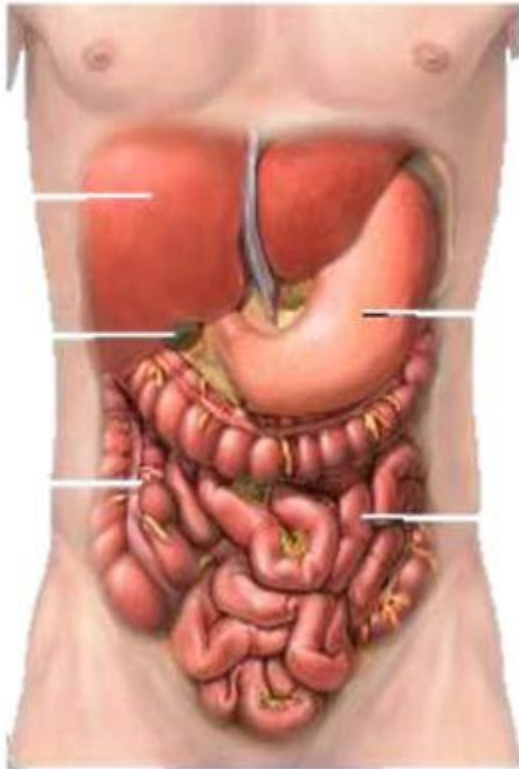


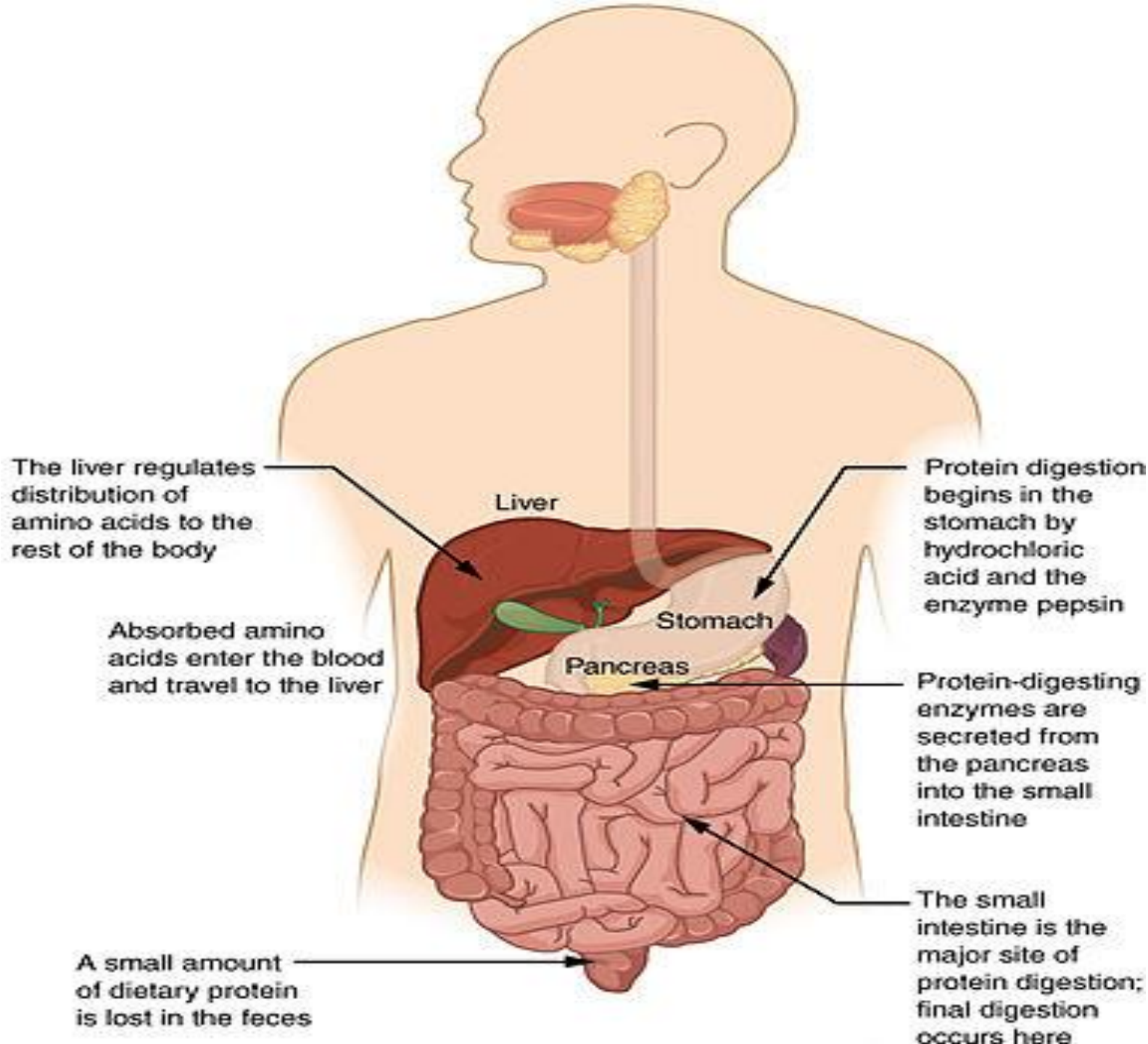


Chemical Reactions

Decomposition/catabolic reaction: When a bond holding atoms together breaks and produces a simpler molecule.

Example: Is needed for foods to be digested and energy to be released for your body to use.





The liver regulates distribution of amino acids to the rest of the body

Liver

Protein digestion begins in the stomach by hydrochloric acid and the enzyme pepsin

Stomach

Absorbed amino acids enter the blood and travel to the liver

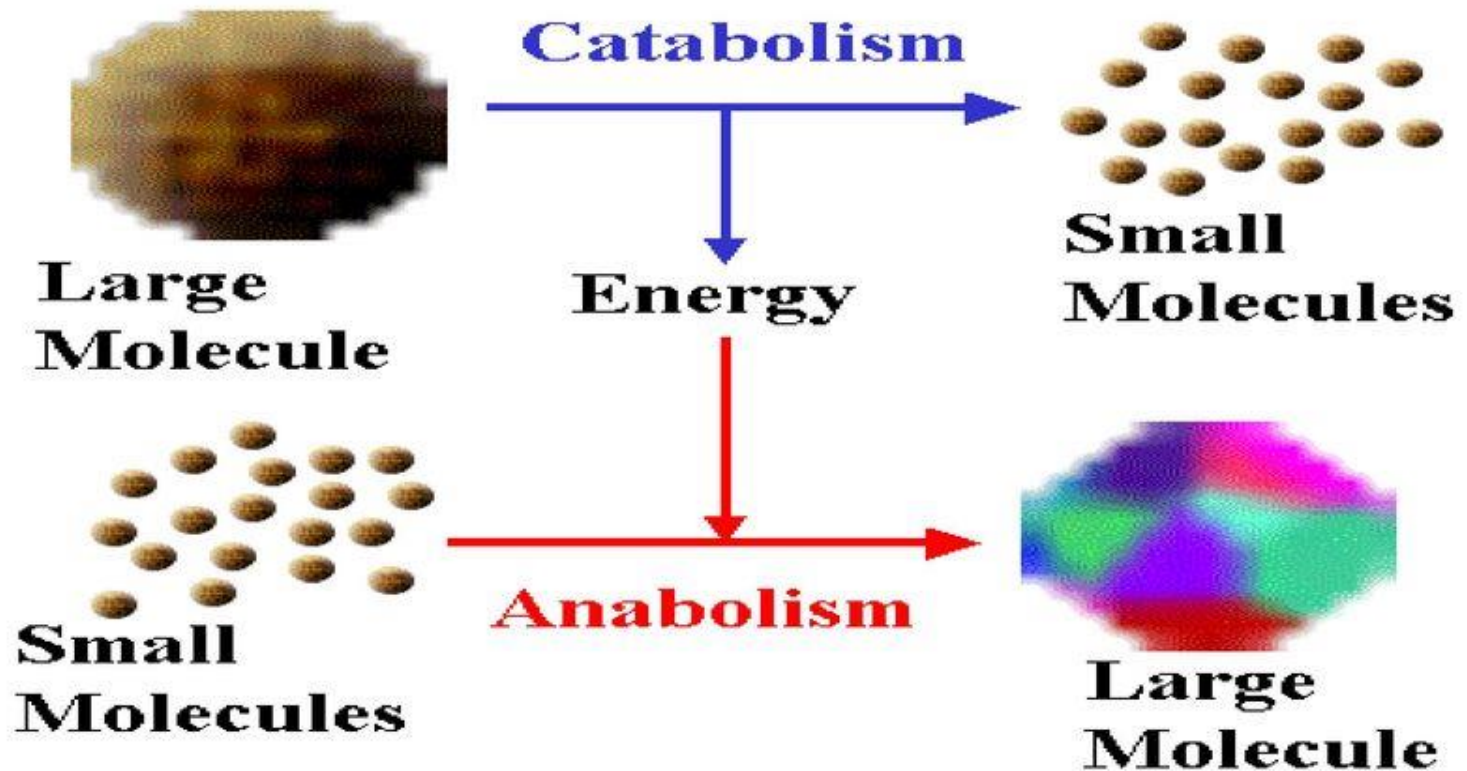
Pancreas

Protein-digesting enzymes are secreted from the pancreas into the small intestine

A small amount of dietary protein is lost in the feces

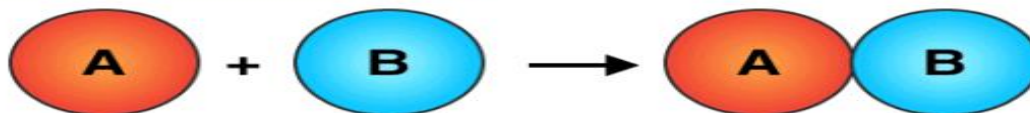
The small intestine is the major site of protein digestion; final digestion occurs here

Chemical Reaction in living organisms



Classification of Chemical Reactions

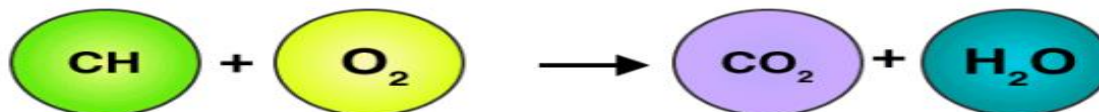
Combination reaction



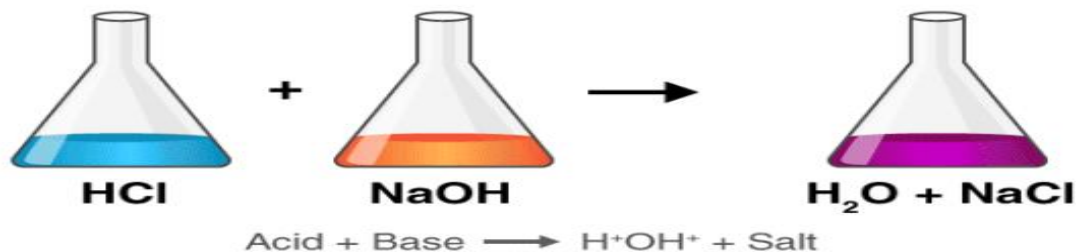
Decomposition reaction



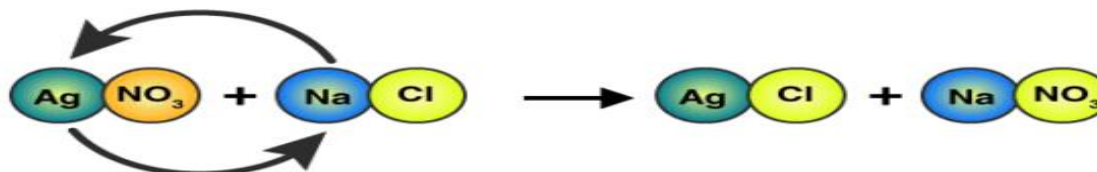
Combustion reaction



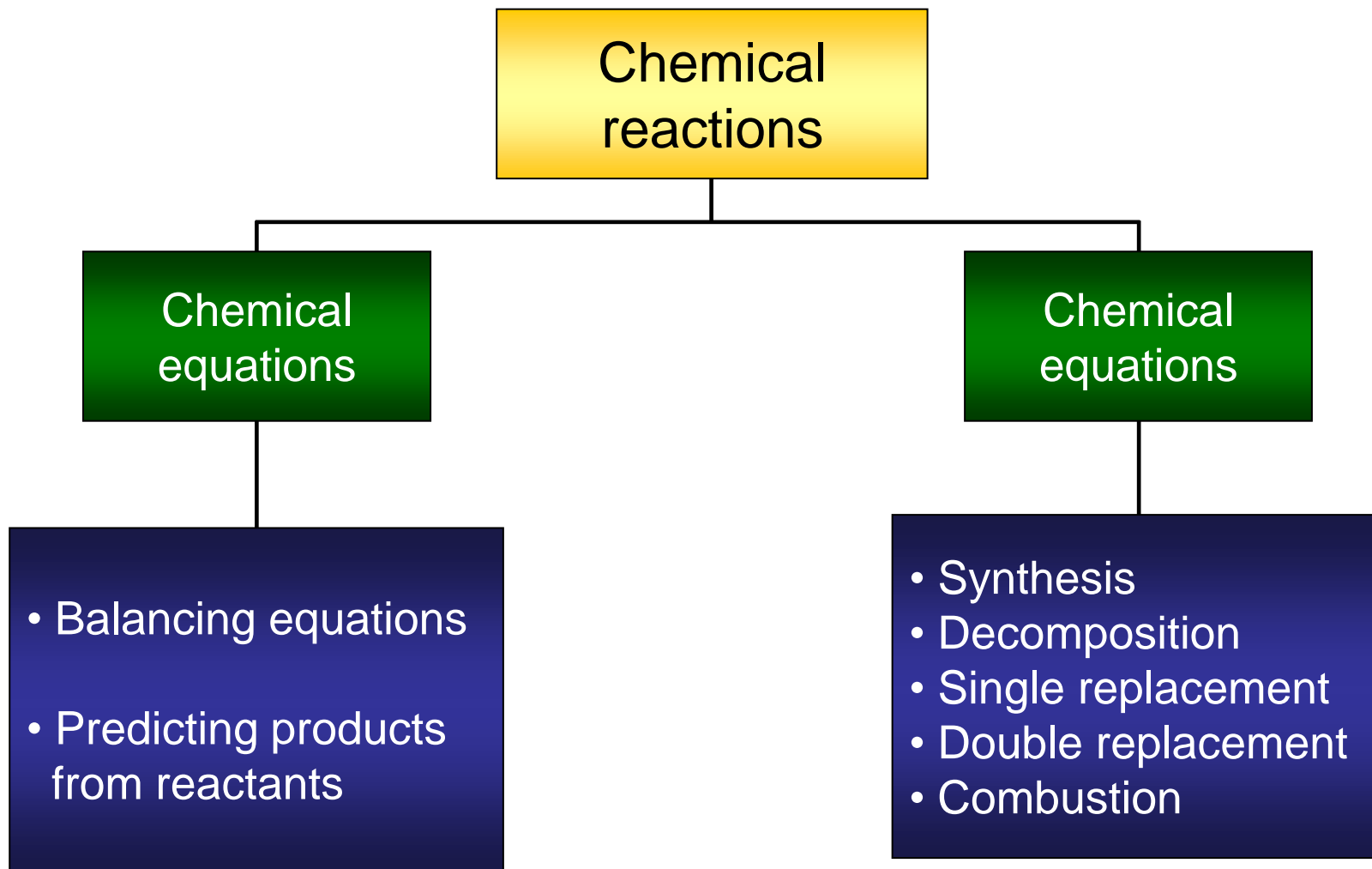
Neutralization reaction



Displacement reaction



Organize Your Thoughts



How a chemical Reaction can be recognized that takes place

Indications of a Chemical Reaction

- Evolution of heat, light,
- Production of a gas
- Formation of a precipitate
- Color change



Color Change



Light Formation

Evidence of Chemical Reactions



Gas Bubbles



Precipitate



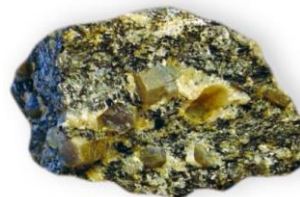
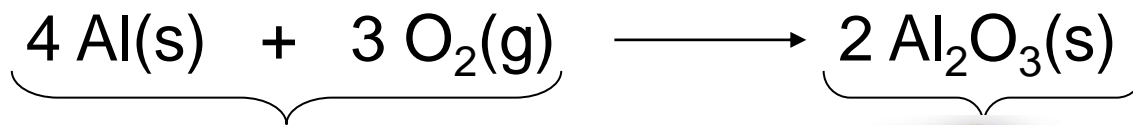
Temperature (Heat) Change

What are Chemical Equations



aluminum oxide

Depict the kind of **reactants** and **products** and their relative amounts in a reaction.



The letters (s), (g), and (l) are the physical states of compounds.

The numbers in the front are called **stoichiometric coefficients**.

Chemical Equations



aluminum oxide
sandpaper



This equation means:

4 Al atoms + 3 O₂ molecules yield 2 molecules of Al₂O₃

or

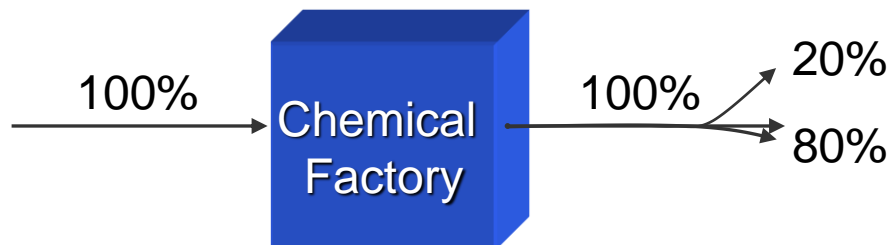
4 Al *moles* + 3 O₂ *moles* yield 2 *moles* of Al₂O₃

| | | | |
|------------------|-------------------------------|---|--|
| 4 mol Al@27g/mol | 3 mol O ₂ @32g/mol | | 2 mol Al ₂ O ₃ @102g/mol |
| 108 g | + 96 g | = | 204 g |

Chemical Equations

Because the same atoms are present in a reaction at the beginning (*reactants*) and at the end (*products*), the amount of matter in a system does not change.

The Law of Conservation of Matter



Chemical Equations

Because of the principle of the **conservation of matter**,

An **equation must be balanced**.

It must have the same number of atoms of the same kind on both sides.



Lavoisier, 1788

Chemical Equations

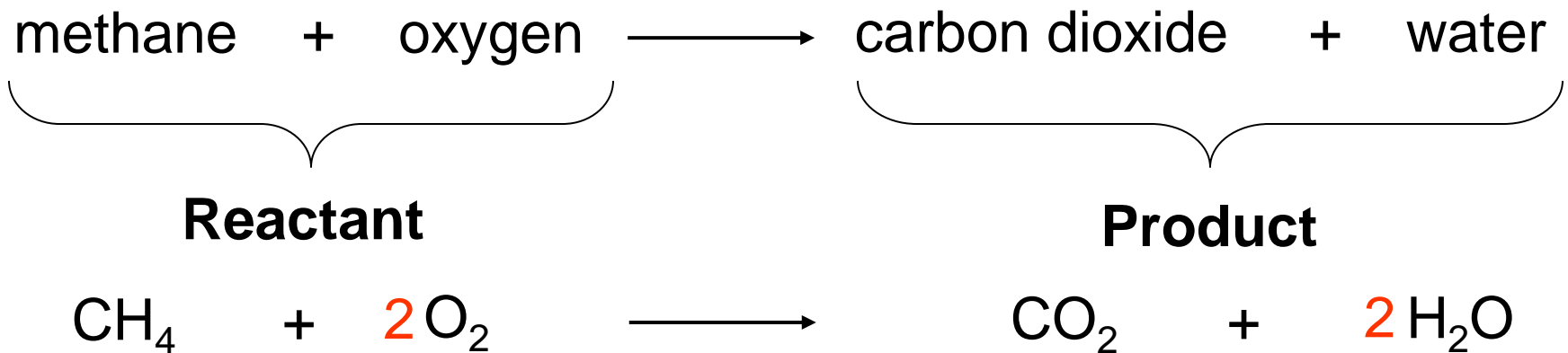
- **Reactants** – the substances that exist **before** a chemical change (or reaction) takes place.
- **Products** – the **new** substance(s) that are formed during the chemical changes.
- **CHEMICAL EQUATION** indicates the reactants and products of a reaction.

REACTANTS → PRODUCTS

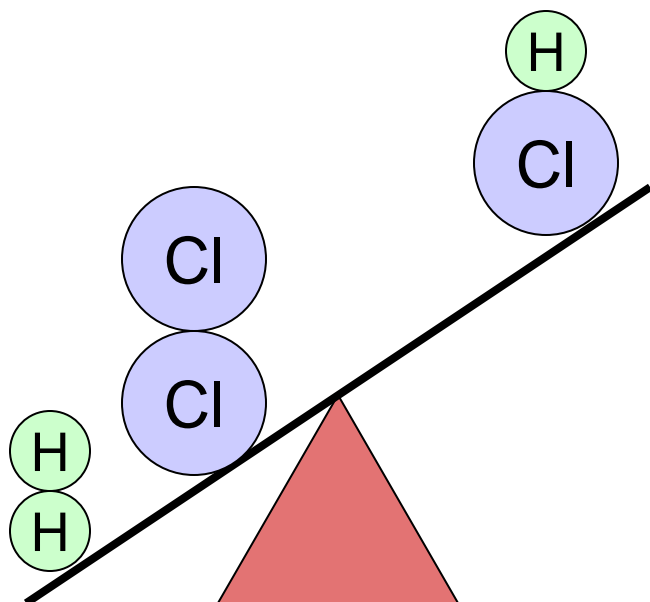
Word Equations

- A WORD EQUATION describes chemical change using the names of the reactants and products.

Write the word equation for the reaction of methane gas with oxygen gas to form carbon dioxide and water.

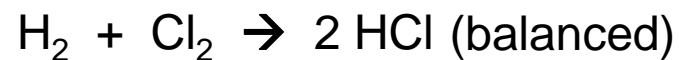
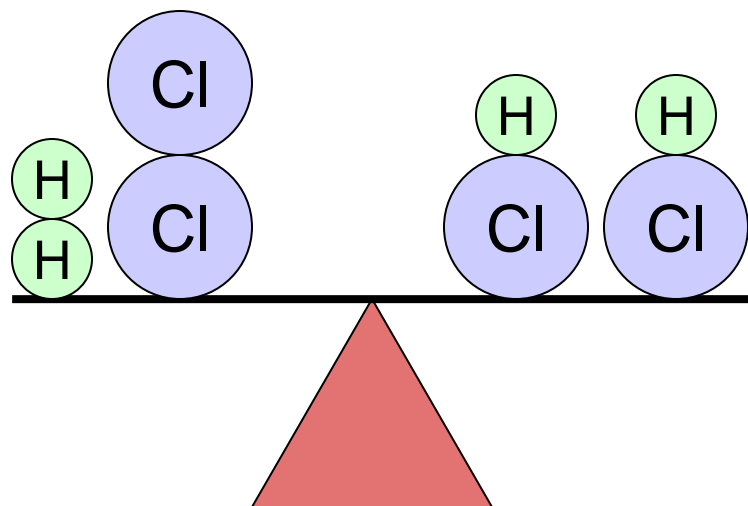


Unbalanced and Balanced Equations



reactants products

| | | |
|----|---|---|
| H | 2 | 1 |
| Cl | 2 | 1 |

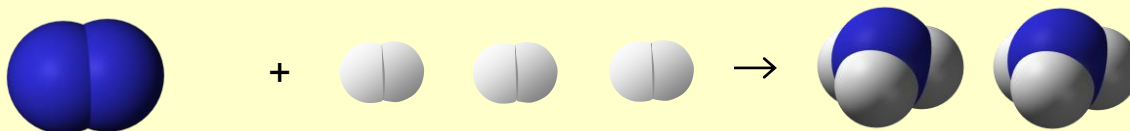
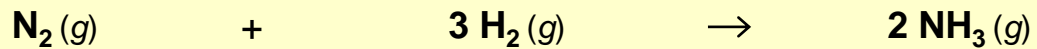


reactants products

| | | |
|----|---|---|
| H | 2 | 2 |
| Cl | 2 | 2 |



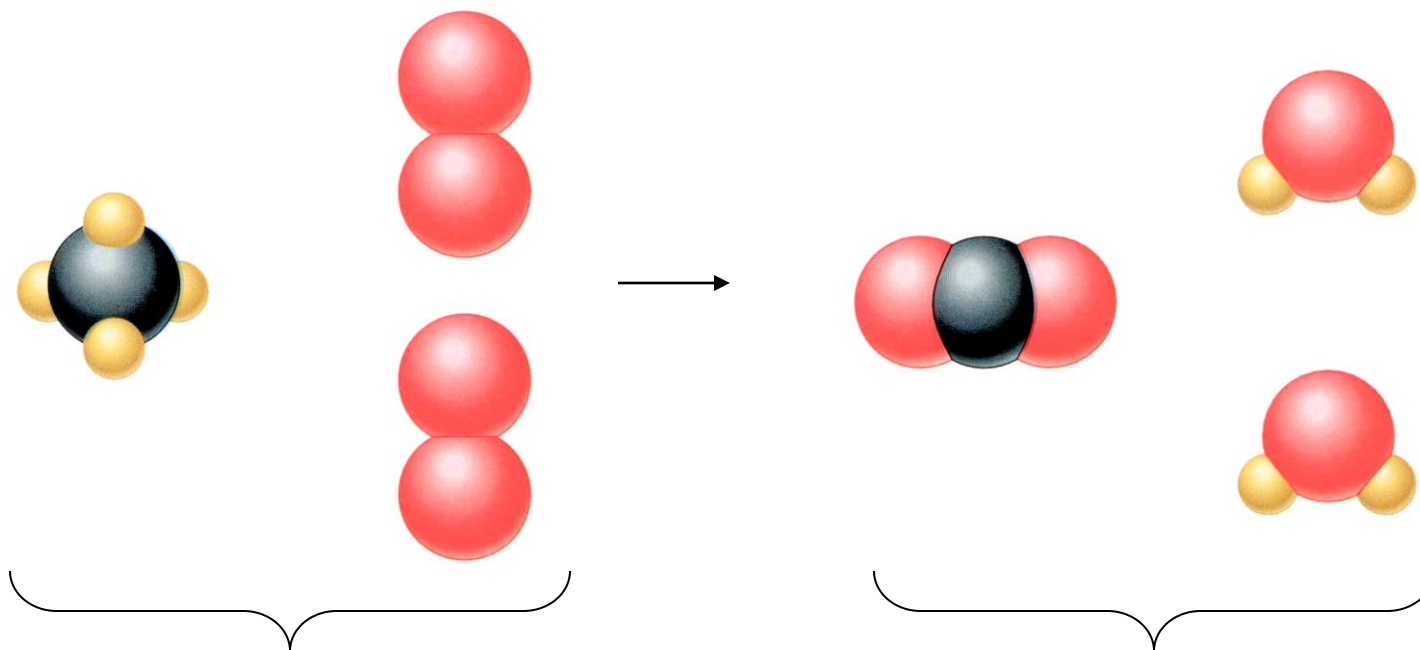
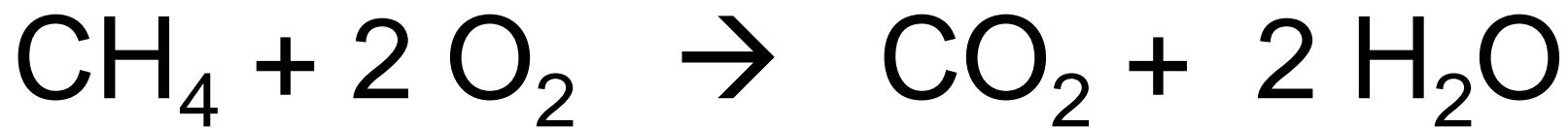
Chemical Equations



“Microscopic recipe” 1 molecule N_2 + 3 molecules H_2 \rightarrow 2 molecules NH_3

“Macroscopic recipe” 1 mol N_2 + 3 mol H_2 \rightarrow 2 mol NH_3





Reactants

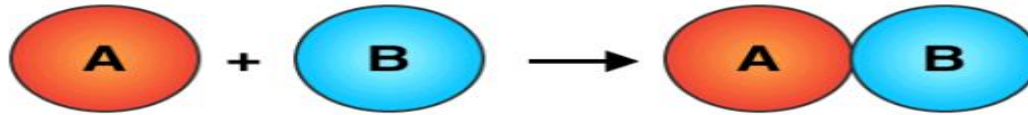
1 C atom
4 H atoms
4 O atoms

Products

1 C atom
4 H atoms
4 O atoms



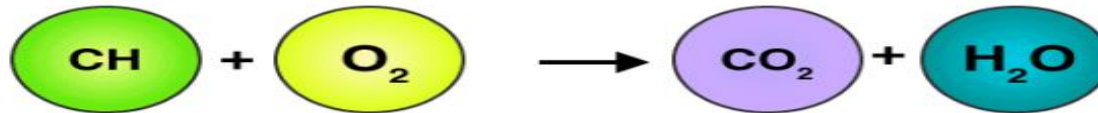
Combination reaction



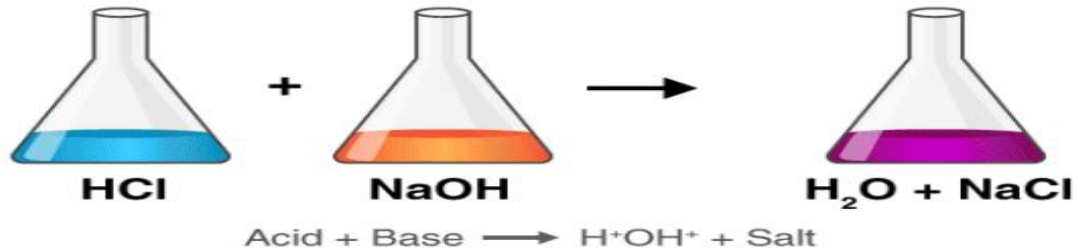
Decomposition reaction



Combustion reaction



Neutralization reaction

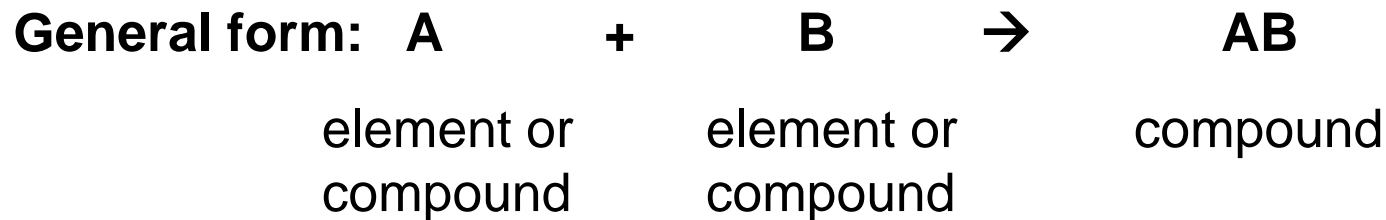
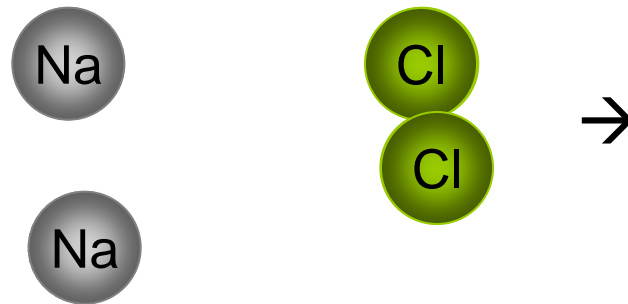


Displacement reaction



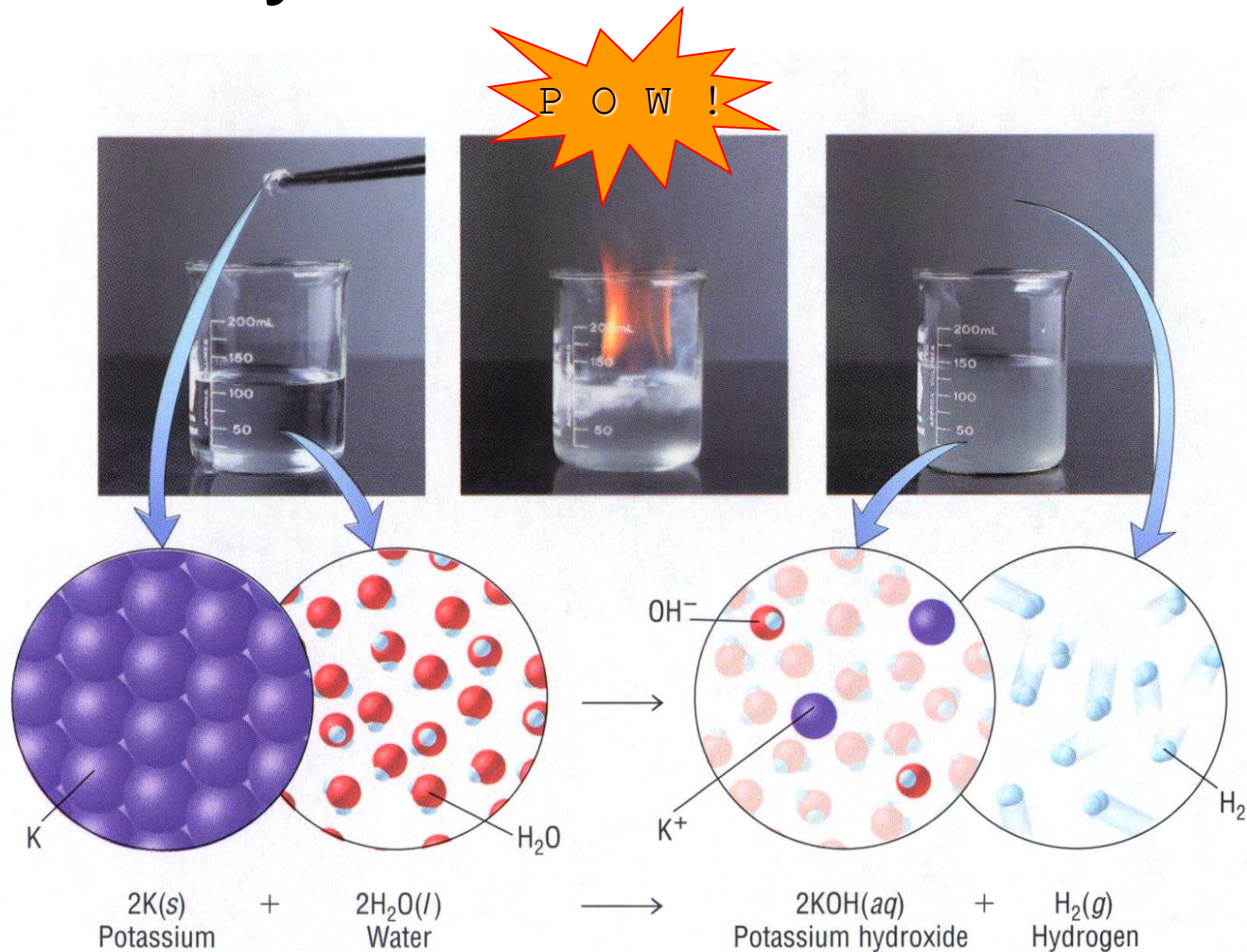
Synthesis Reaction

Direct combination reaction (Synthesis)



Potassium reacts with Water

Synthesis reaction

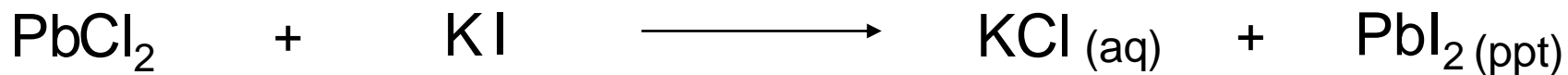


Formation of a solid: AgCl

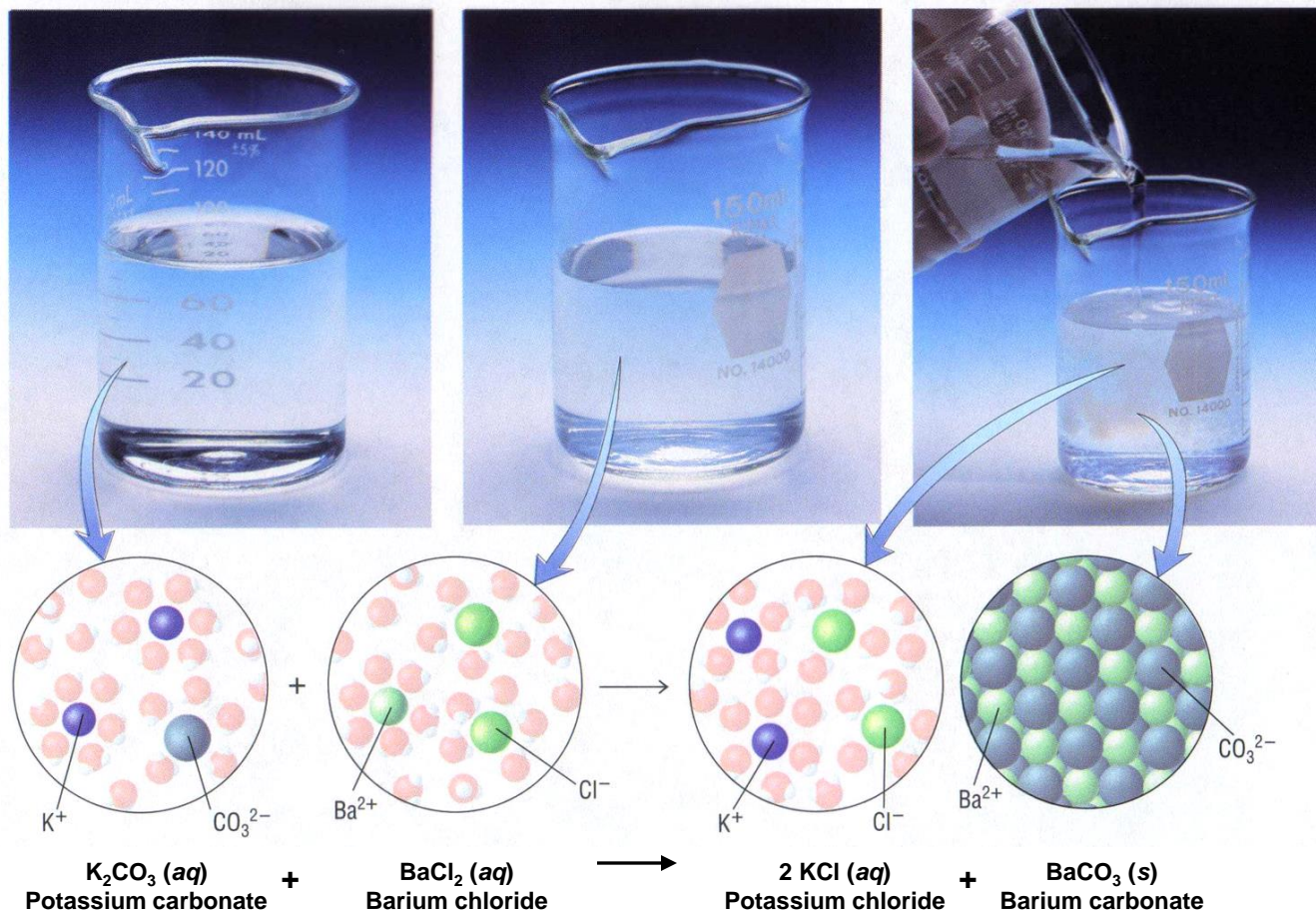




lead (II) chloride + potassium iodide \longrightarrow potassium chloride + lead (II) iodide

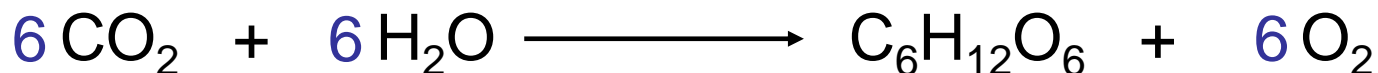


Double Replacement Reaction

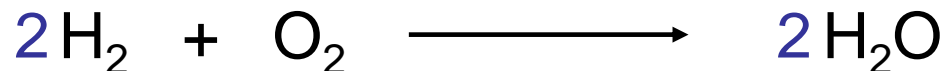


Synthesis Reactions

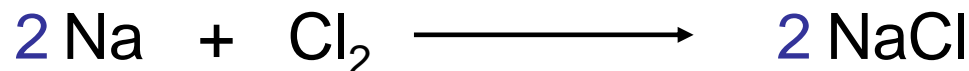
Photosynthesis



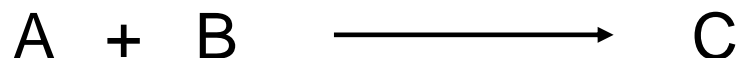
Formation of water



Formation of salt

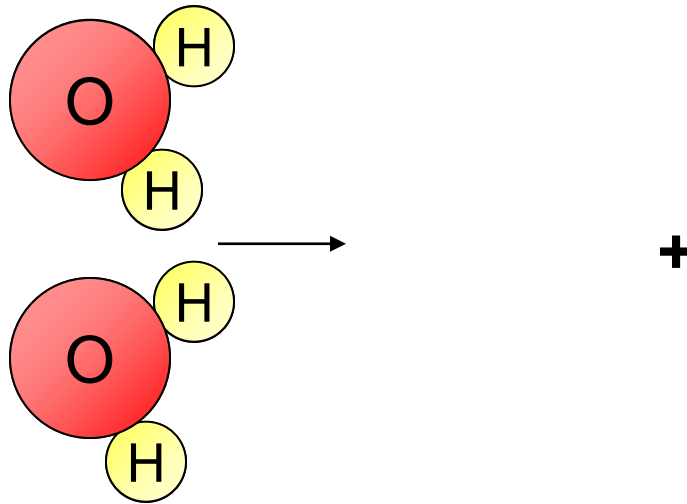


General Form



Decomposition Reaction

Decomposition reaction



General form: AB \longrightarrow

compound

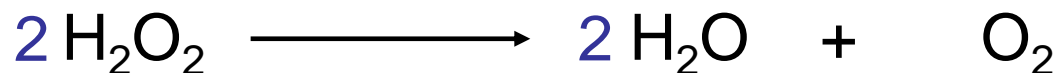
A + B

two or more elements
or compounds

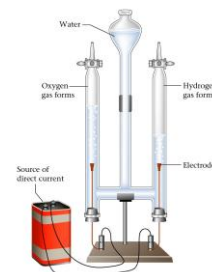
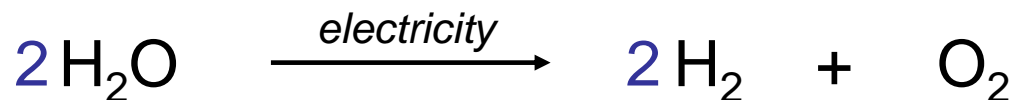


Decomposition Reactions

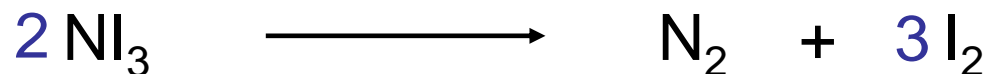
Hydrogen Peroxide



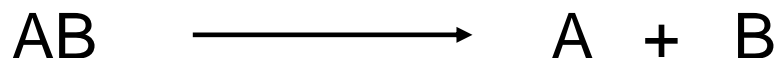
Electrolysis of water



Nitrogen triiodide



General Form



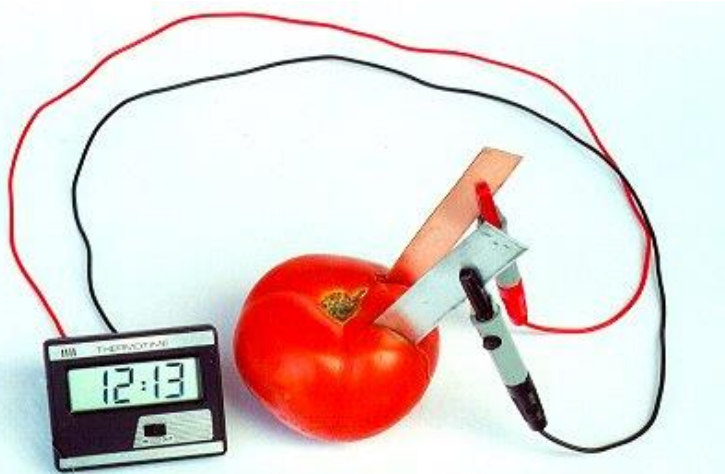
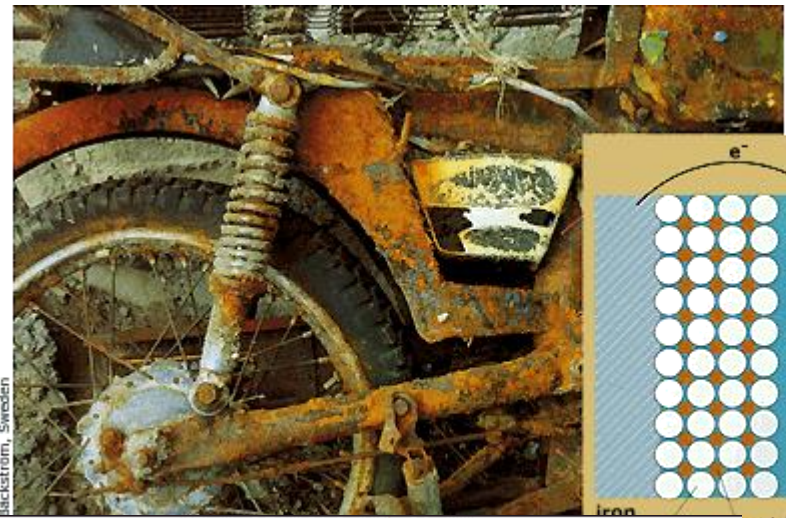
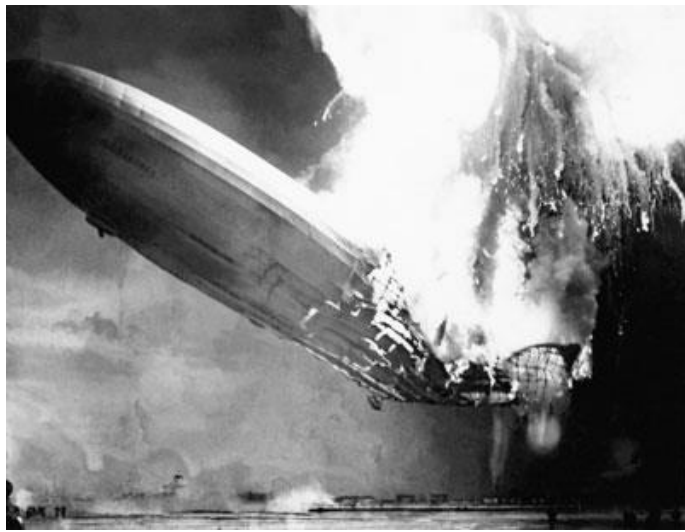
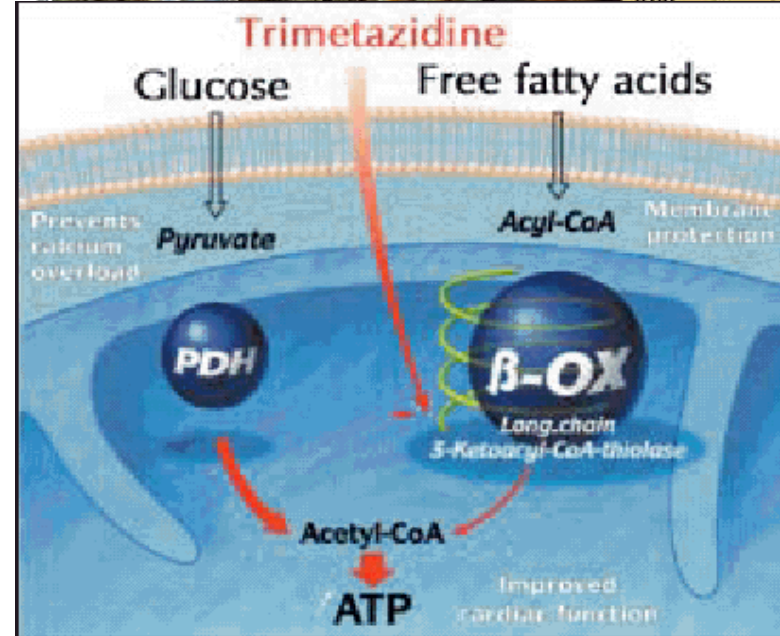


Figure 15 - LCD-Clock powered by a tomato battery.

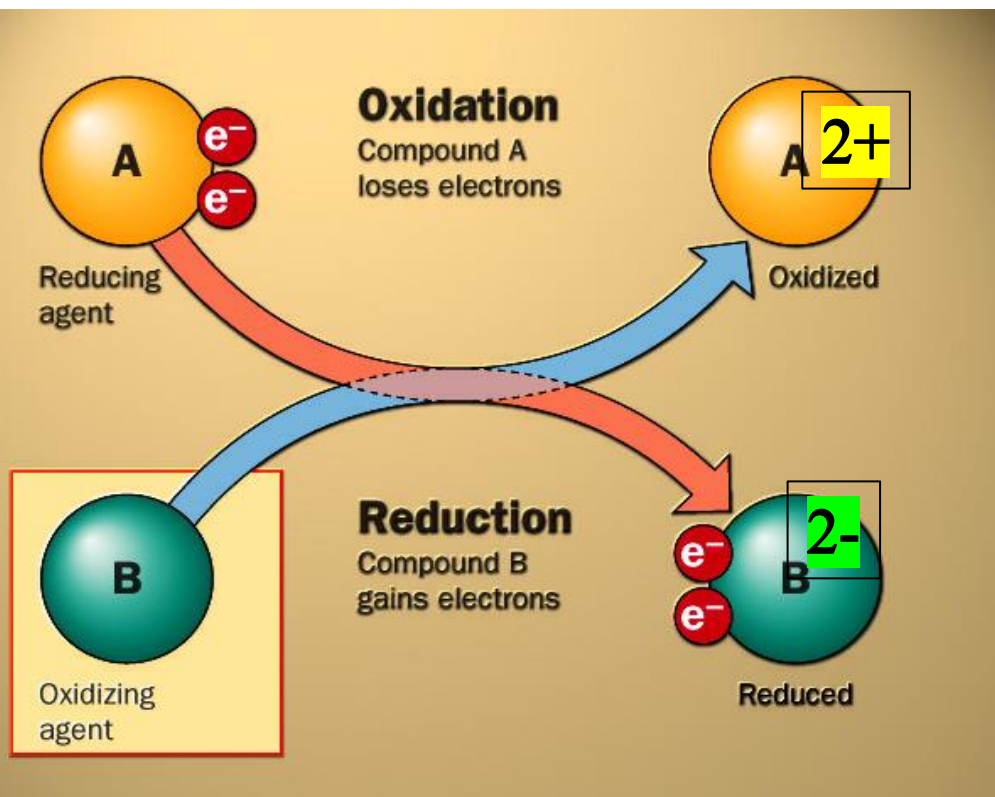


Oxidation-Reduction Reactions

In the oxidation-reduction reactions THERE IS an EXCHANGE of ELECTRONS taking place between the REACTANTS

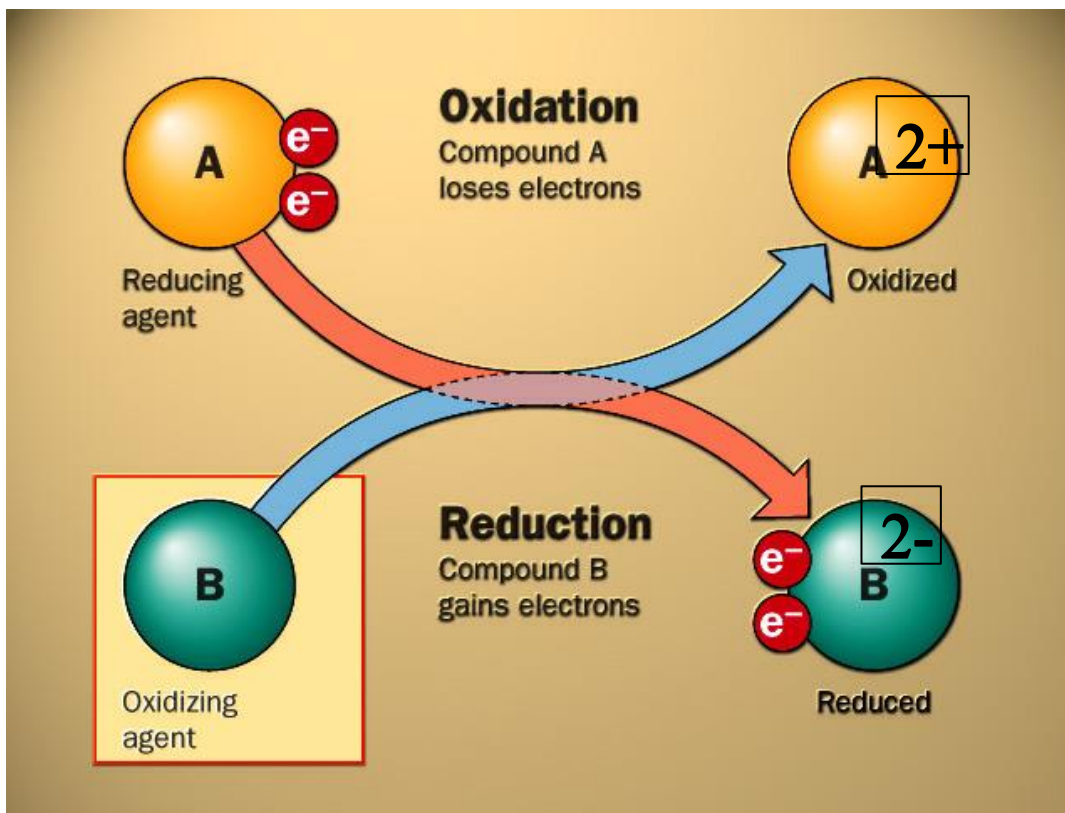
The LOSS of Electrons is named OXIDATION (“LEO”)

The GAIN of Electrons is named REDUCTION (“GER”)

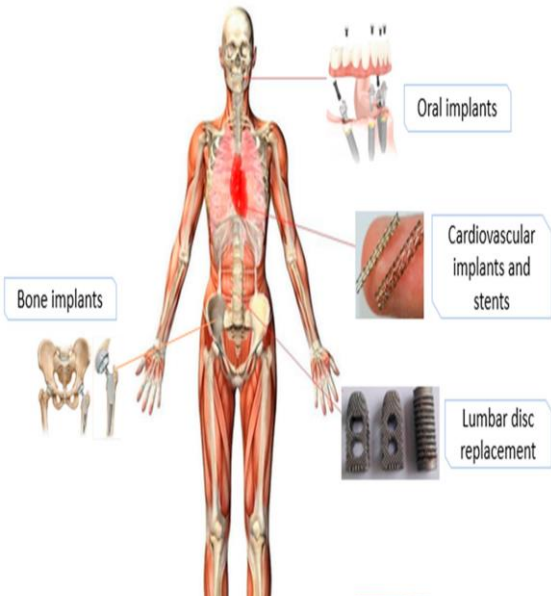


*The process of loss of electron is named oxidation, BUT, the compound that loses the electrons is named **REDUCING AGENT** (compound A in this picture) because The electrons it has released have REDUCED the other compound (B in this picture)*

*The process of gain of electrons is reduction, BUT...the compound that gains electrons is named **OXIDIZIGN AGENT** (compound B in this picture) because The electrons it has received have OXIDIZED the other compound (A in this picture)*



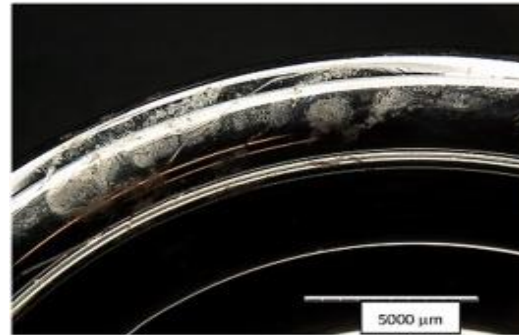
Examples of Oxidation-Reduction Reactions important for MEDICINE



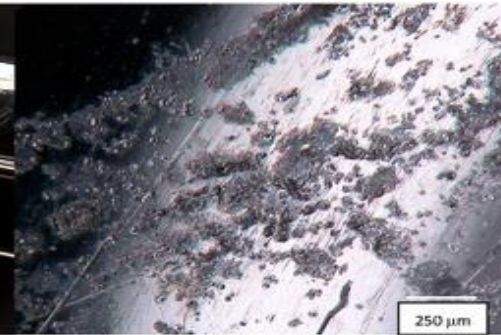
Stainless steel - nonimplantable medical equipment and devices, dental and orthopaedics implants, catheters (good corrosion resistance, low price, biocompatibility, chemical stability, intoxicity)

Titanium and its alloys - dental and orthopaedics implants (good corrosion resistance, absence of tissue toxicity and allergic reactions, good strength, low elastic modulus)

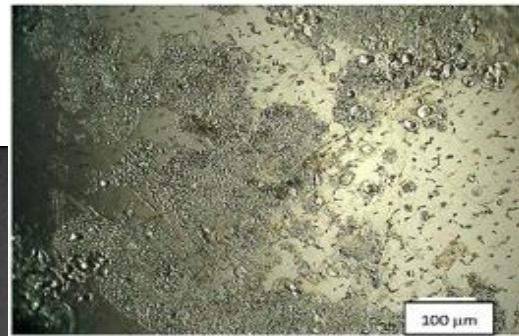
Cobalt-Chrome - dental and orthopaedics implants (high wear-resistance and biocompatibility, release of metal particles and ions (Co and Cr), causing implant loosening,



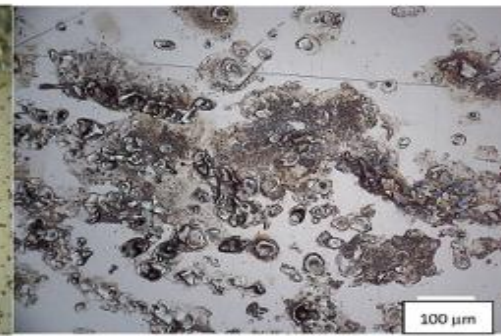
A



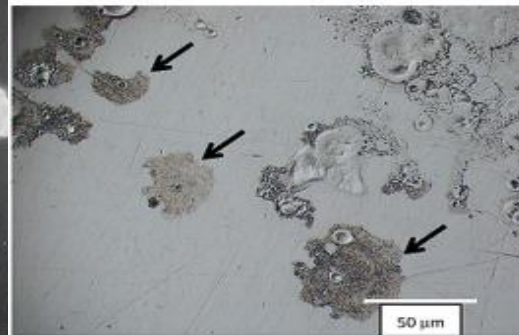
B



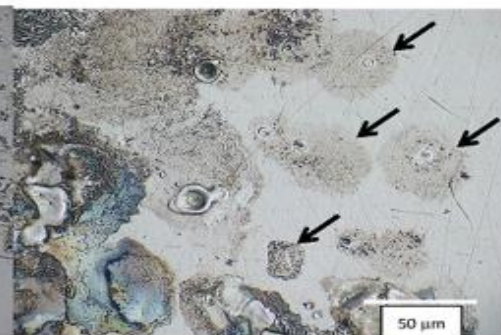
C



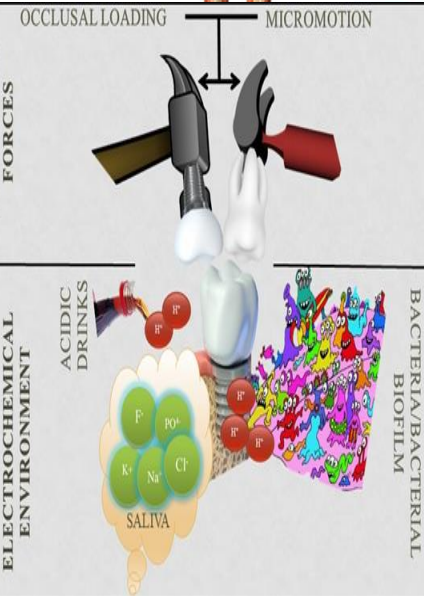
D



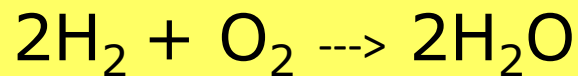
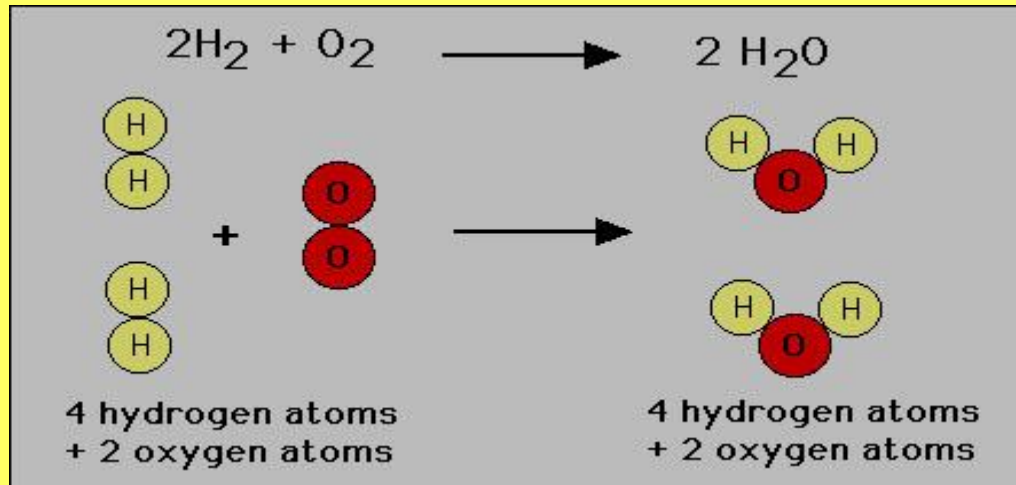
E



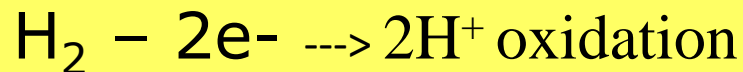
F



Oxidation-Reduction process in the Water formation from molecules of H₂ and O₂

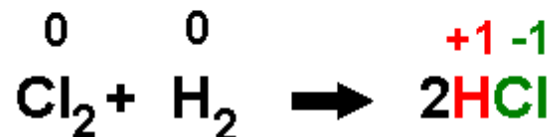


In this equation we have two so-called half reactions



Examples of Oxidation-Reduction Reactions

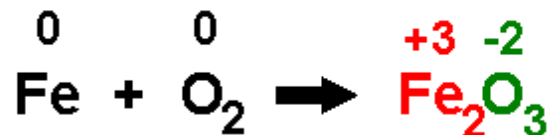
Chlorine Gas and Hydrogen Gas
form Hydrochloric Acid



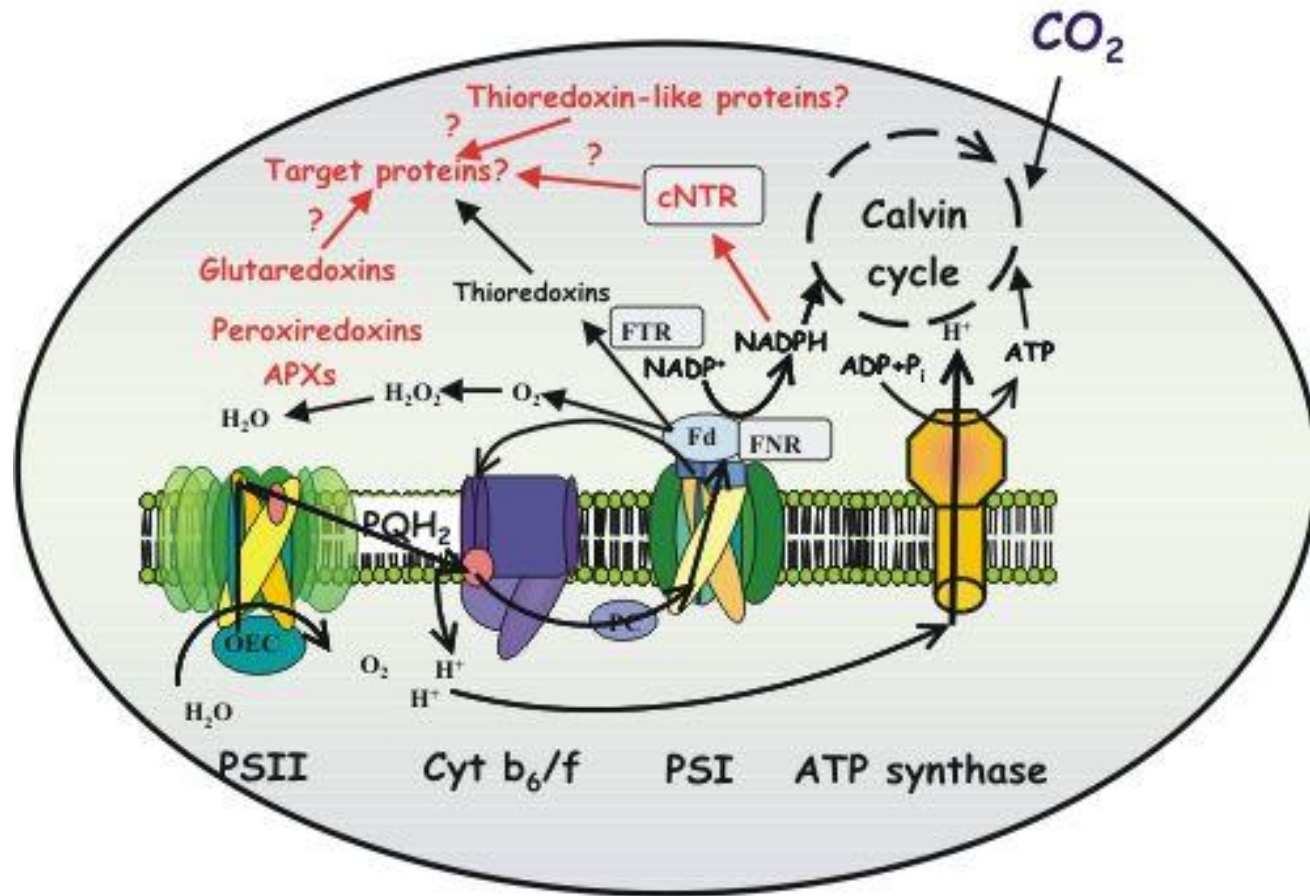
Ethane burns in Oxygen gas to give
Carbon Dioxide and Water



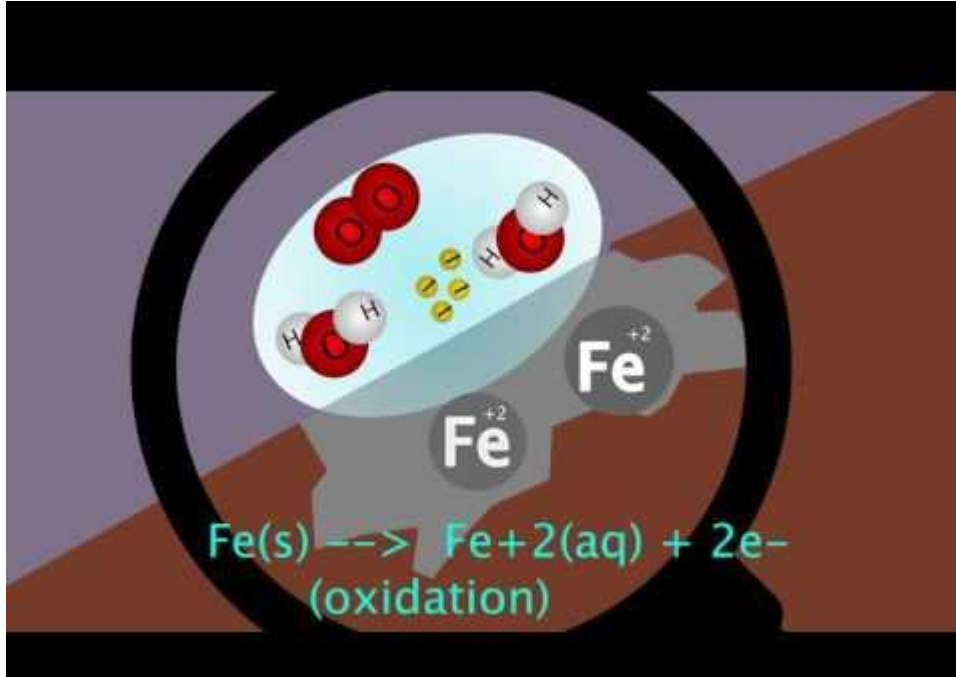
Iron metal reacts with oxygen to form
ferrous oxide, also called rust.



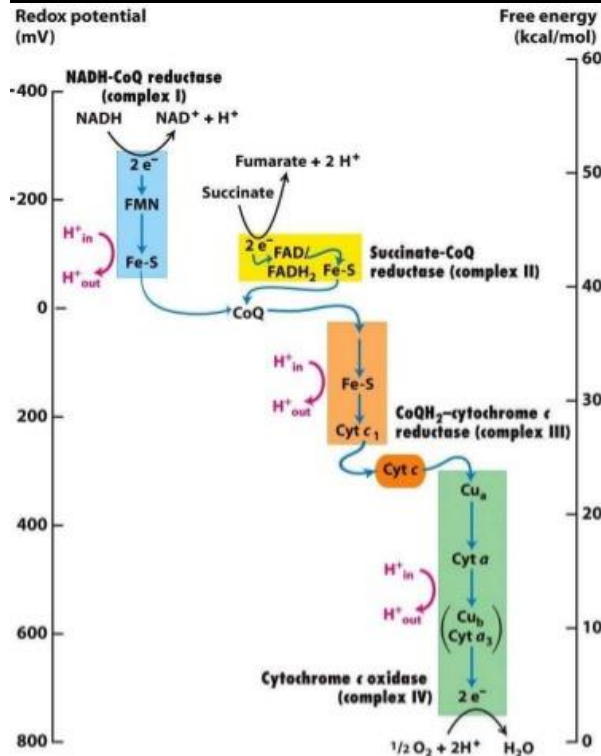
Why Oxidation_Reduction Reactions are Important in Medicine?



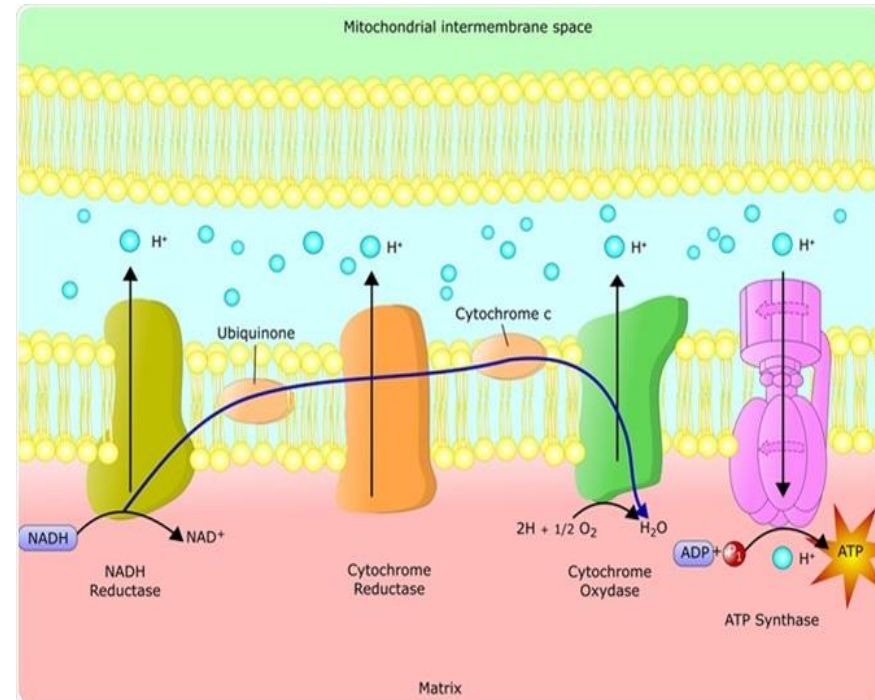
Corrosion of bioimplants

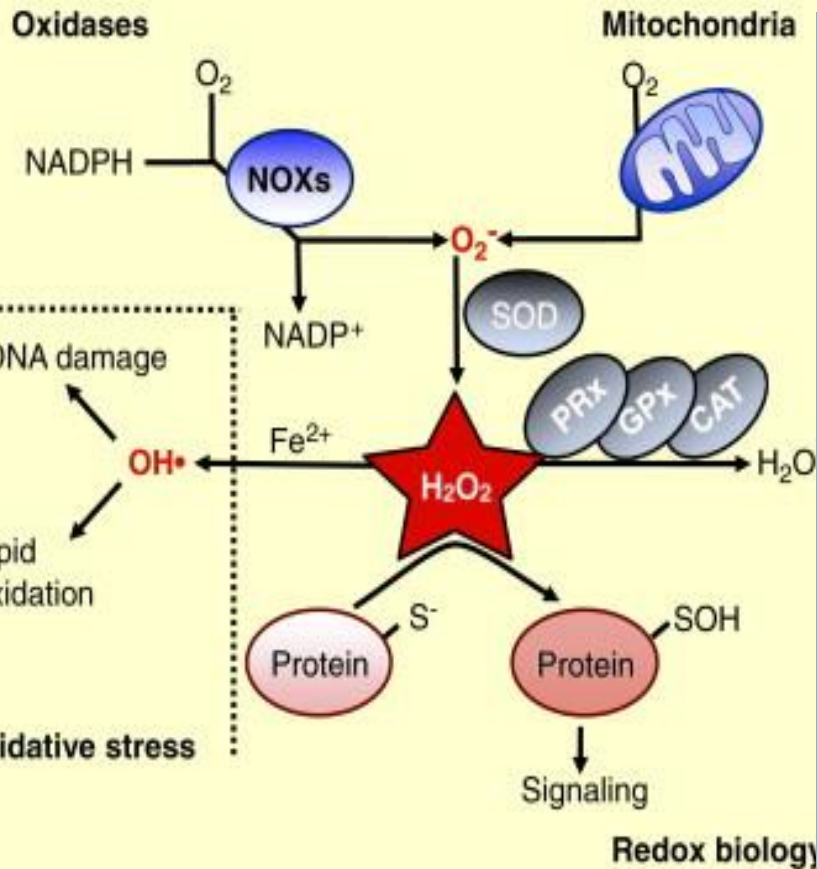


Electron Transfer Chain and Production of ATP



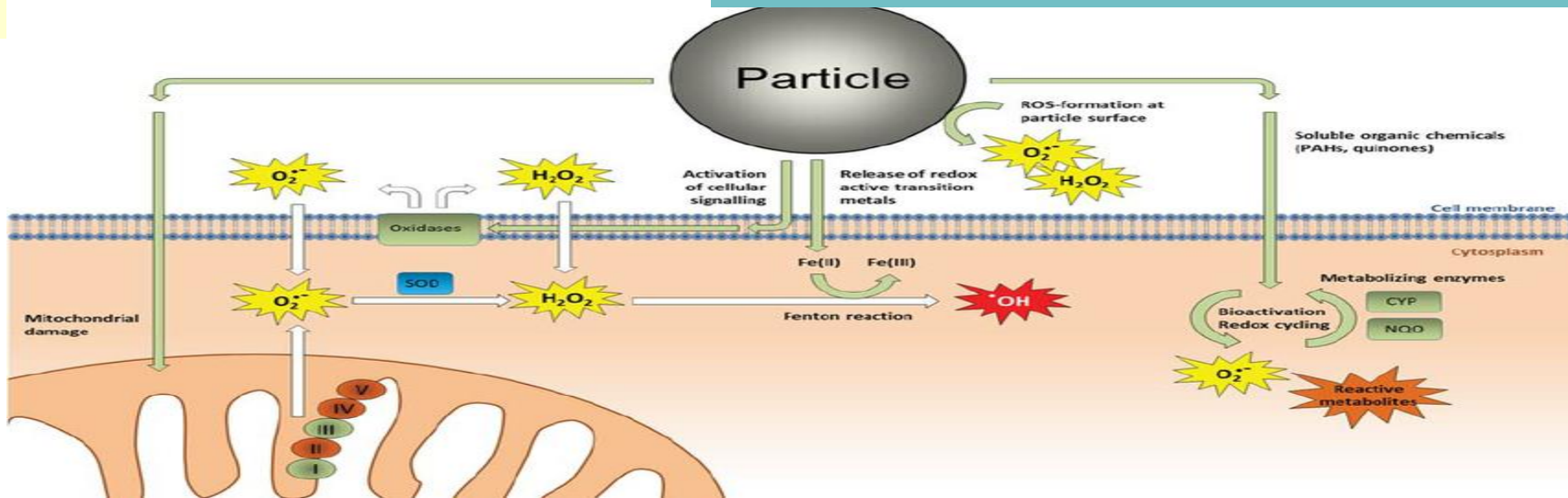
Levels of Redox potential and Free energy in Electron Transport Chain Complexes





Reactions of cell-membrane damaging or lipid-peroxidation with Reactive Oxygen Species (ROS) are also Oxidation-Reduction Reactions...

...Substances that give electrons to ROS and neutralize their effects are Called **ANTIOXIDANTS!!** Important For increasing immunity in our body



Enzyme-substrate interactions are crucial for understanding the action of defined ENZYMES and the conditions affecting their activity...

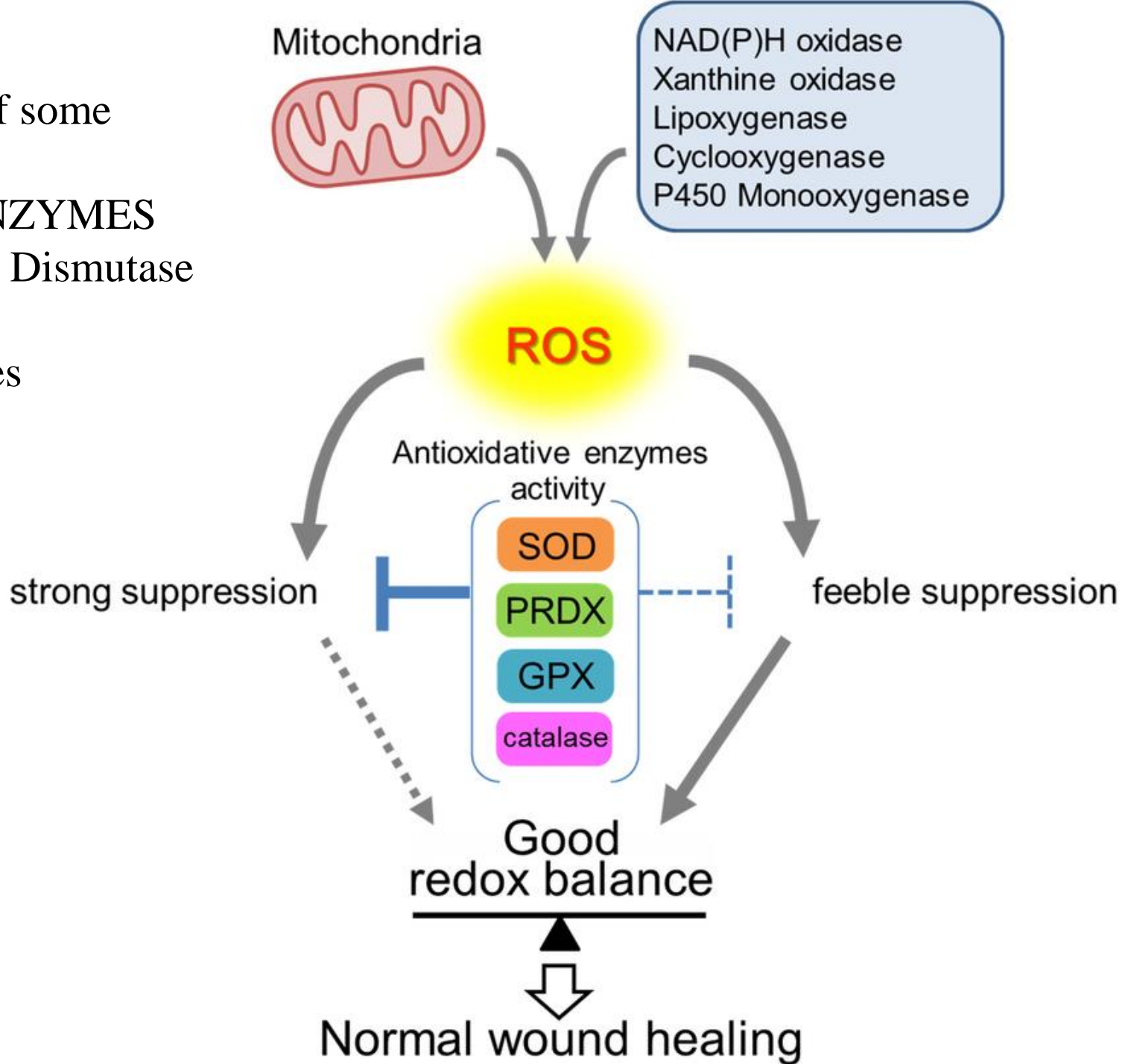
-glucose oxidase

-superoxide dismutase

-peroxidases...



Examples of some
so-called
REDOX ENZYMES
Superoxide Dismutase
Peroxidases
Cytochromes
..



Many drugs and medicals are exhibiting their effect via Oxidation-reduction reactions

Examples:

Vitamin C

Vitamin A and K

Adrenalin

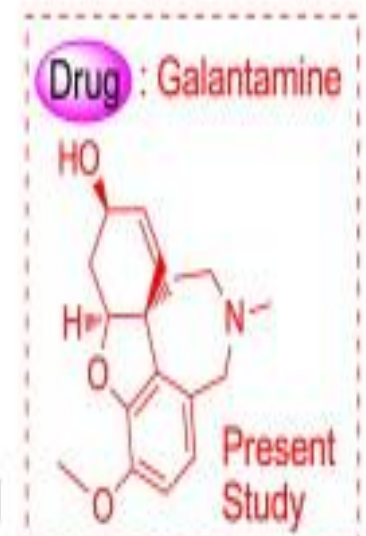
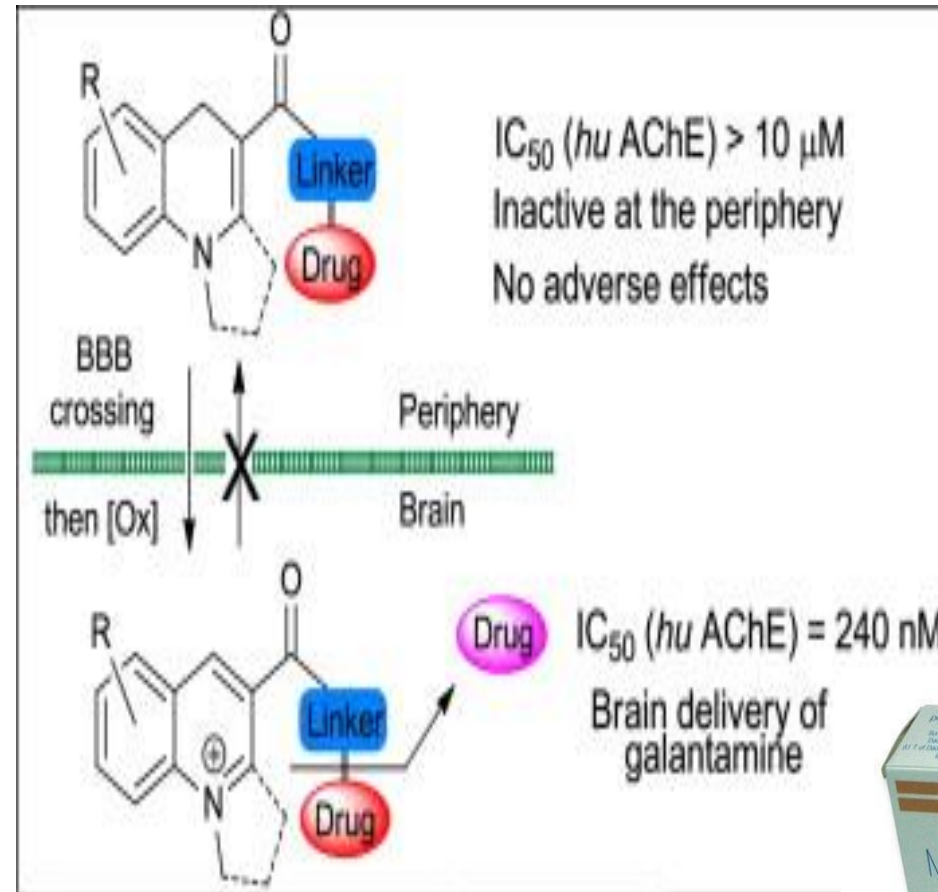
Dopamine

Antibiotics...

Other important oxidation-reduction chemicals used in Everyday medicine

→ Hydrogen Peroxide H_2O_2

→ NaClO sodium hypochlorite





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