BIOLOGICAL FRAMEWORKS FOR ENGINEERS

Session #14 [Cellular Energetics]

General Objectives:

- ✓ Discuss the importance of energy to the body and metabolism
- ✓ Discuss cellular respiration in detail and compare with known systems

Central Framework:

- ✓ Cellular energetics involves the complex transformation of chemical bonds into free energy for the cell to utilize; nature's storage and handling of energy may provide insight into our engineering of energy solutions

Interactive Activity:

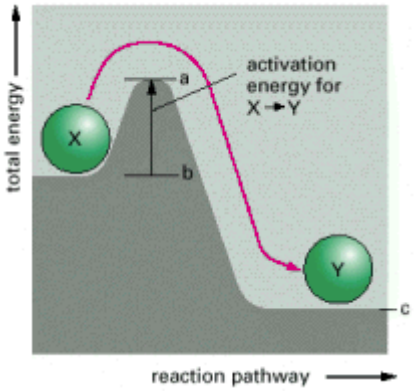
- ✓ Discussions on cellular processes to produce energy efficiently.

Session Outline:

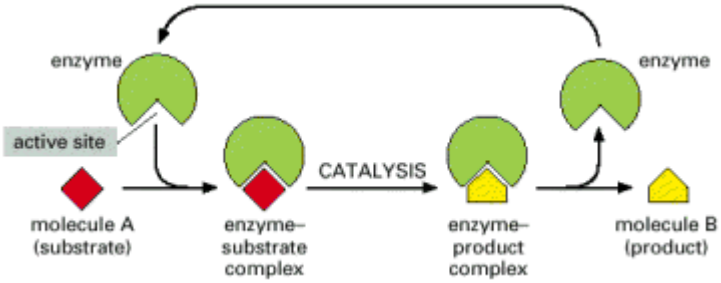
A. Basics of Energy

1. Thermodynamics – the science of energy transformations (Including within a single cell and an entire ecosystem)

2. Energy Conversion
   Fuels (such as a hydrocarbons – gasoline, wood, etc.)
   Burned to release heat (chemical energy is converted to heat)
   Heat is then converted into useful energy (e.g. electricity)



Enzymes



B. Energy in Biologic Systems

1. Cellular Activity Requiring Energy (Why do we need energy?)

a. Mechanical work – cells can change their physical location or shape and move structures within.

b. Transport work – cells need to pump substances across the membrane

c. Chemical work – endergonic process of polymerization (making proteins)

d. Organization –

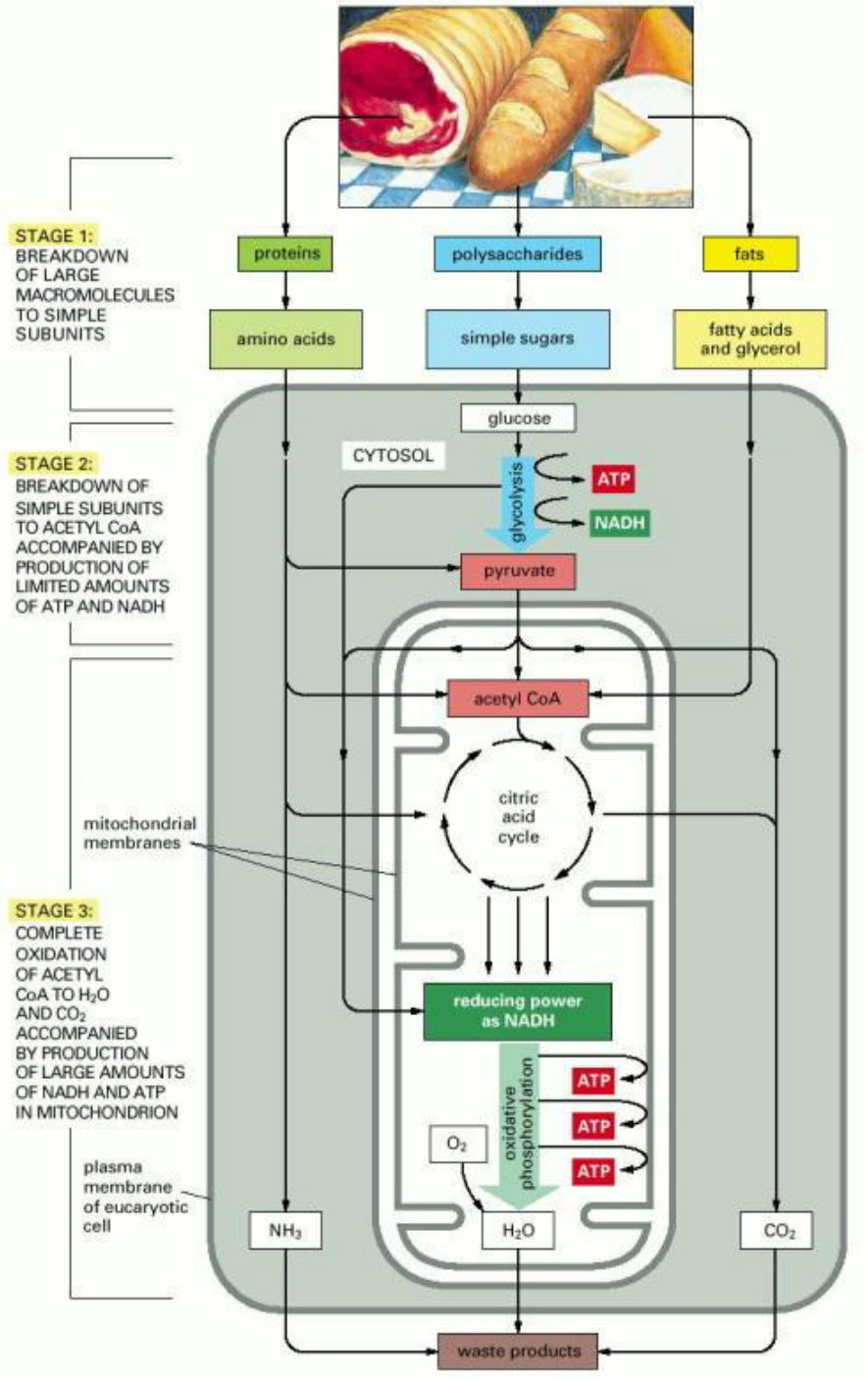
2. Metabolism –a collection of chemical reactions by which cells convert what they have (food, raw materials) into what they need (energy - ATP).

   Fuel (carbohydrates, fats, etc.) "burned," but energy is recaptured in the form of other high-energy chemical compounds (e.g., ATP). These compounds then donate their energy to endothermic processes

3. ATP (adenosine triphosphate) – "energy currency" of the cell

4. Cellular Respiration (breakdown of food and synthesis of ATP)

Fuel	Pathways used to break it down
Carbohydrate (glucose)	glycolysis / Citric Acid (Krebs) cycle / e^- transport
Fat (fatty acid)	oxidation / Citric Acid (Krebs) cycle / e^- transport


STAGE 1:
BREAKDOWN OF LARGE MACROMOLECULES TO SIMPLE SUBUNITS
STAGE 2:
BREAKDOWN OF SIMPLE SUBUNITS TO ACETYL CoA ACCOMPANIED BY PRODUCTION OF LIMITED AMOUNTS OF ATP AND NADH
STAGE 3:
COMPLETE OXIDATION OF ACETYL CoA TO H_2O AND CO_2 ACCOMPANIED BY PRODUCTION OF LARGE AMOUNTS OF NADH AND ATP IN MITOCHONDRION
proteins
polysaccharides
fats
amino acids
simple sugars
fatty acids and glycerol
glucose
CYTOSOL
glycolysis
ATP
NADH
pyruvate
acetyl CoA
citric acid cycle
mitochondrial membranes
reducing power as NADH
oxidative phosphorylation
ATP
ATP
ATP
O_2
NH_3
H_2O
CO_2
plasma membrane of eucaryotic cell
waste products