Bioenergetics

Presented By,

Mr. Samarpan Mishra (Assistant Professor)

Specialization – Pharmaceutical Chemistry

Bioenergetics

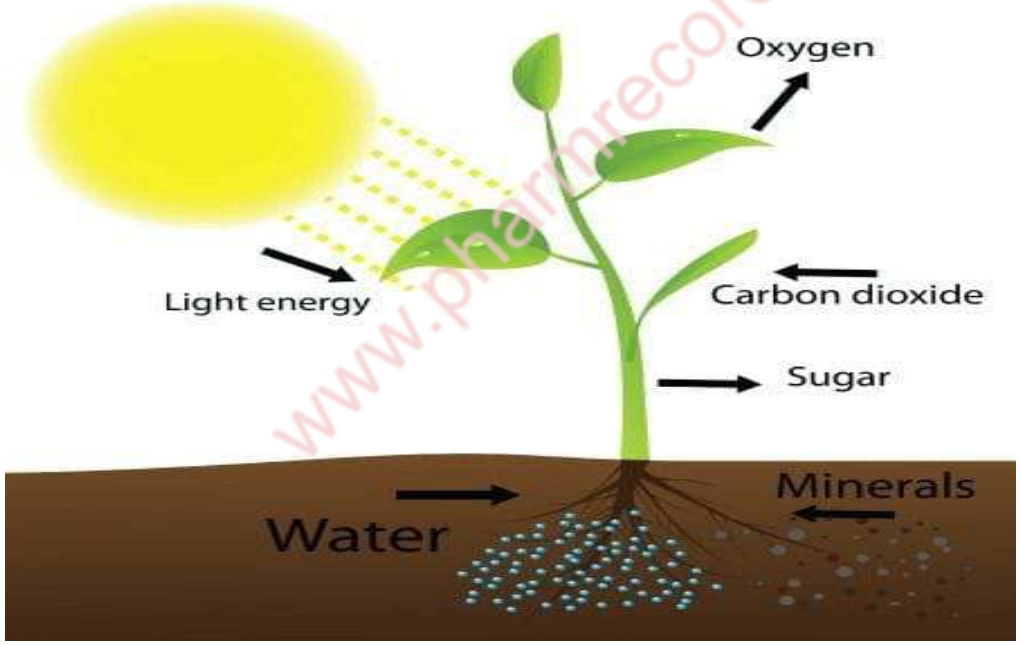
Energy;- **The capacity doing work.**

Just like;- **Car need fule**

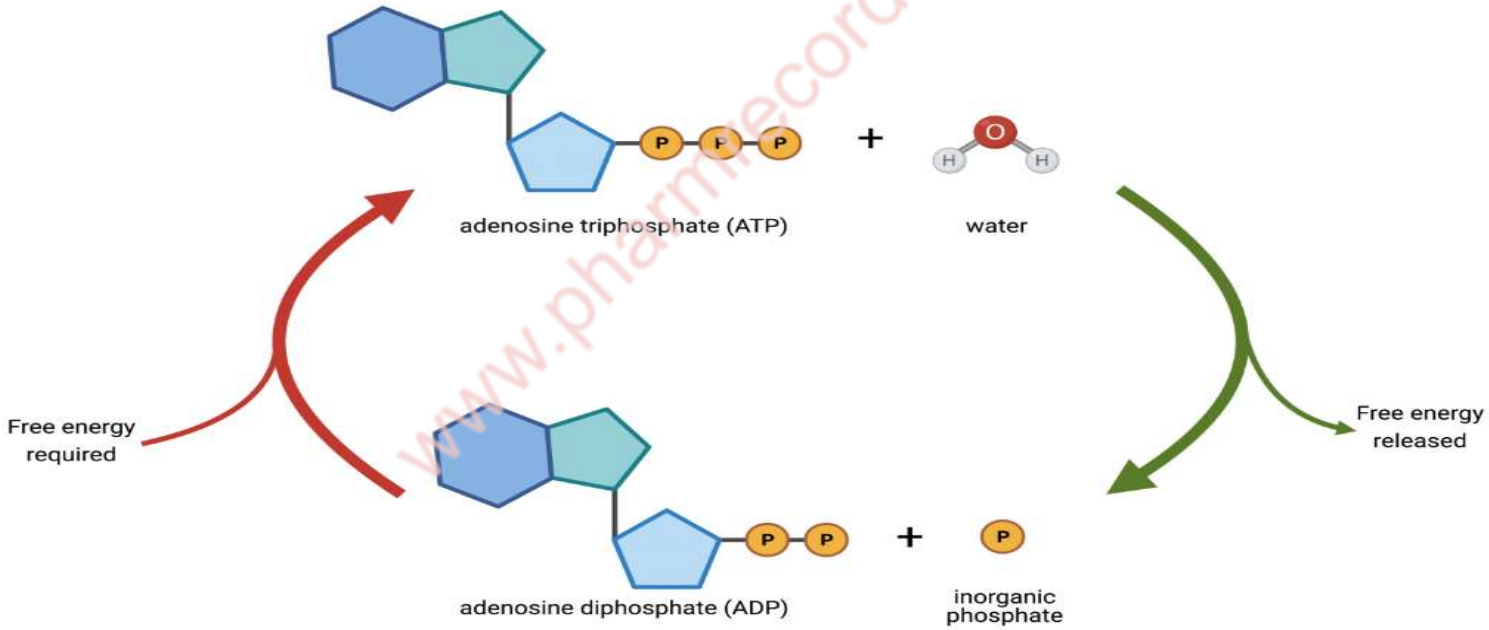
Mixture need energy

Human need energy to work/grow, at a time sleeping body need energy for doing involuntary function like digestion, respiration.

Larger source of energy in earth



ATP (Adenosine Triphosphate)



What is free Energy?

The amount of energy available to do work is free energy/gibbs free energy.

Equestion of gibbs free Energy is;-

$$\Delta G = \Delta H - T\Delta S$$

Where;-

- **ΔG** Gibbs free energy
- **ΔH** Change in enthalpy
- **T** Temperature in k
- **ΔS** Change in entropy

Enthalpy

Enthalpy is the measurement of energy in a thermodynamic system.

The quantity of enthalpy equals to the total content of heat of a system, equivalent to the system's internal energy plus the product of volume and pressure.

Formula;-

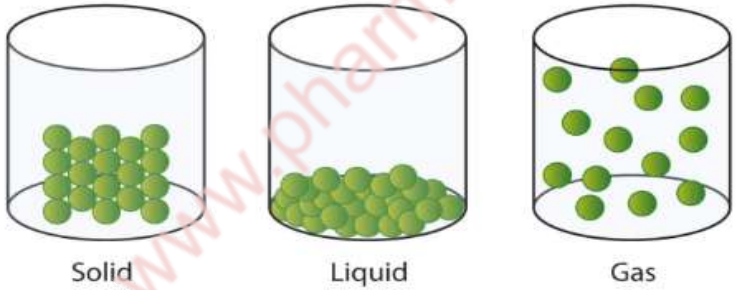
$$H = E + PV$$

Were;-

- H= enthalpy
- E= Internal energy
- P= pressure
- V= volume

Entropy

Thermodynamic viewpoint entropy is defined as a measure of randomness or disorder of a system.



For Ex;- The entropy of solid, where the partials are not free to move, is less then the entropy of gas, where the partial will fill the container.

Enthalpy vs. Entropy

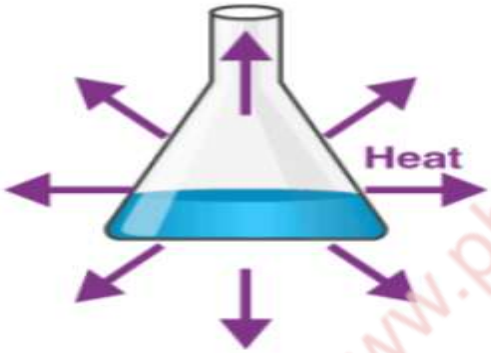
Enthalpy

- Total energy in a system
- H = U + PV
- Total heat energy in a system
- Depends on Temperature, pressure, and composition of the system
- Tells how much heat is present in a system

Entropy

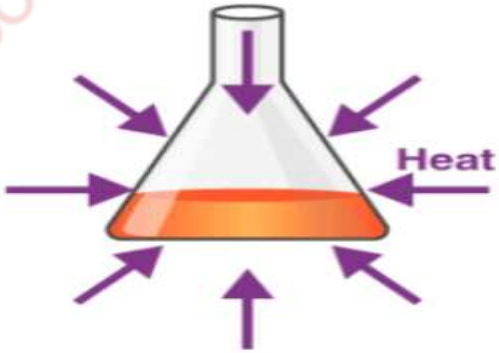
- Measure of disorder in a system
- $\Delta S = \Delta Q / T$
- Randomness of molecules
- Depends on Path taken to reach the current state
- Measures the tendency of a system to become more disordered

Exothermic & Endothermic Reaction



Exothermic Reactions

A reaction that releases energy from the system in the form of heat.



Endothermic Reaction

A reaction that the system absorbs energy from its surrounding in the form of heat.

Endothermic Reaction vs. Exothermic Reaction

Endothermic Reaction

- Absorb heat energy from the surrounding
- Temperature decreases during reaction.
- Enthalpy of reaction is lower then that of products.
- Energy should be given to the system.
- Ex;- melting of ice, photosynthesis etc.

Exothermic Reaction

- Releases heat energy to the surrounding.
- Temperature decreases during reaction .
- Enthalpy of reaction is higher then that of product.
- Energy is released from the system.
- Ex;- freezing of water, combustion. Etc.

Energy rich compounds

Definition:-Energy-rich compounds, like ATP, contain high-energy bonds that release significant energy upon hydrolysis, making them crucial for cellular processes and the universal energy currency in living organisms.

- Those compound produce free energy that is greater or equal to that of ATP (△G is -7.3 kcal/mol) are termed high energy compounds.
- Low-energy compounds have an energy yield of less than -7.3 kcal/mol.

Higher energy compound

Compound	ΔG.(cal/mol)
Phosphoenol pyruvate	-14.8
Carbamoyl phosphate	-12.3
Cyclic AMP	-12
Pyrophosphate	-8.0
Acetyl CoA	-7.7
ATP ⟶ ADP+Pi	-7.3

Low energy compounds

Compound	ΔG.(cal/mol)
ADP → AMP+Pi	-6.6
Fractose-6-phosphate	-3.8
Glucose-1-phosphate	-5.0
Glucose-6-phosphate	-3.3

Classification of Energy-rich compounds

Energy-rich compounds, characterized by high-energy bonds, are classified into five main groups:-

1. **Pyrophosphates:**-These are phosphate esters with two phosphate groups linked together, like ATP (adenosine triphosphate).
2. **Acyl Phosphates:**-These compounds contain an acyl group linked to a phosphate group, examples include acetyl-phosphate.
3. **Enol Phosphates:**-These have a phosphate group attached to an enol, a molecule with a carbon-carbon double bond and an alcohol group.
4. **Thiol Phosphates:**-These are characterized by a phosphate group linked to a sulfur atom.
5. **Phosphagens/Guanido Phosphates:**-These are high-energy phosphate reserves, such as creatine phosphate and arginine phosphate.

ATP & Its significances

ATP, or adenosine triphosphate, is the primary energy-carrying molecule in cells, acting as the "energy currency" by storing and releasing energy through the breaking and reforming of its phosphate bonds, fueling various cellular processes.

Significances

1. **Muscle Contraction:** ATP provides the energy for muscle fibers to contract.
2. **Nerve Impulse Transmission:** ATP is essential for transmitting nerve signals.
3. **Protein Synthesis:** ATP provides the energy needed to build proteins.
4. **Chemical Synthesis:** ATP is used to power various chemical reactions within the cell.
5. **Ion Transport:** ATP is used to move ions across cell membranes.
6. **DNA and RNA Synthesis:** ATP is a component of DNA and RNA and provides energy for their synthesis.
7. **Intracellular Signaling:** ATP provides the energy that enzymes need to activate second messengers.

Cyclic AMP & Its significances

Cyclic AMP (cAMP), a crucial intracellular second messenger, plays a vital role in regulating various cellular processes, including metabolism, gene expression, and immune function, by activating protein kinase A (PKA) and other downstream effectors.

Significances

1. **Metabolism:**-cAMP is involved in regulating metabolism, including mobilizing glucose and fatty acid reserves, glycogenolysis in muscle, and lipolysis in adipose tissue.
2. **Hormone Action:**-cAMP mediates the action of many hormones on their target cells, acting as an intracellular agent.
3. **Gene Regulation:**-cAMP plays a role in the regulation of gene expression, influencing transcription and protein synthesis.
4. **Neurotransmission:**-cAMP is involved in the regulation of neurotransmitter synthesis and the function of ion channels in the nervous system.
5. **Immune Function:**-cAMP is involved in regulating immune responses, including suppressing innate immune functions and modulating inflammation.
6. **Other Cellular Processes:**-cAMP influences various other cellular processes, including secretion, cell proliferation, differentiation, migration, and apoptosis.
7. **Therapeutic Potential:**-The widespread involvement of cAMP in cellular processes makes it a target for therapeutic interventions in various diseases, such as cancer, diabetes, heart failure, and neurological disorders.

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THANK YOU