# Bioenergetics

**Research Proposal** *in* Biochemistry · July 2020

CITATIONS
0

READS
1,176

**1 author:**

Cephas Ajak Awan
Cairo University
**2** PUBLICATIONS **0** CITATIONS

SEE PROFILE

# CAIRO UNIVERSITY

# FACULTY OF ORAL AND DENTAL MEDICINE

## 2019/2020

## RESEARCH TITLE: BIOENERGETICS


- Student name: **Cephas Ajak Awan**
- Student code: **144120190100654**
- ID number: **727**
- Passport number: **R00361832**
- Email: **cephas.awan@dentistry.cu.edu.eg**

- Batch: **2024**
- Student status: **Freshman**
- Academic year: **First year mainstream 2019/2020**
- Course name: **Biochemistry**
- Course code: **BCHM-1**
- Research title: **BIOENERGETICS**

## ❖ ABSTRACT:

The study of the transformation of energy in human cell is known as Bioenergetics.

The study of metabolic pathway is very important to bioenergetics.

The ability to do work is energy and Adenosine Triphosphates (ATP) is the main "energy currency" for organisms.

Living organisms produce adenosine triphosphate (ATP) from energy sources through oxidative phosphorylation.

The terminal phosphate bonds of (ATP) are relatively weak compared with the stronger bonds formed when (ATP) is hydrolysed (broken down by the water) to adenosine diphosphate (ADP) and inorganic phosphate.

The ratio of ATP to ADP concentration in a cell is the "energy charge" of the cell. [1][4]

## ❖ INTRODUCTION:

Bioenergetics is a branch of biochemistry that study how cells transform energy by producing, storing or consuming adenosine triphosphate ATP.

Bioenergetics studies help in describing how living organisms get and change energy from one form to another in order to perform biological work. [3]

Within the cell of living organism, chemical bonds are broken down and made as part of the exchange and transformation of energy. Energy is needed for work like mechanical work and other processes such as chemical synthesis and anabolic processes in growth in our bodies. When wake bonds are broken down to make stronger bonds, the production of stronger bonds allow release of usable energy. [2] [5]

## ❖ AIMS/ RESEARCH PROBLEMS:

I. Energy of chemical reactions (bioenergetics reactions).
II. Energy from degradation of foodstuffs.
III. ATP-ADP cycles
IV. TCA cycle (Krebs' cycle)

## ❖ REVIEW OF LITERATURE:

### A. Energy of chemical reactions (bioenergetics reactions).

Energy is the ability to do work and there are two types of energy in our body.

Heat energy; serve to maintain body temperature while Free energy; used for performance of work e.g. Muscle contraction and nerve impulses transmission.

- **Metabolic pathway**

The series of chemical reactions which took place within a cell is known as metabolic pathway. The reactants, intermediates and products of the series are called metabolites.

- **Metabolism**

It involves the chemical changes of foodstuffs inside the body. Metabolism includes anabolism and catabolism. [6]

In our body, the types of reactions Include the following;

1. **EXERGONIC REACTION**.

Exergonic reaction means the release of energy from spontaneous chemical reaction without any utilization of energy.

The reactions are significant in terms of biology because these reactions have ability to perform work and include most of catabolic reactions in cellular respiration.

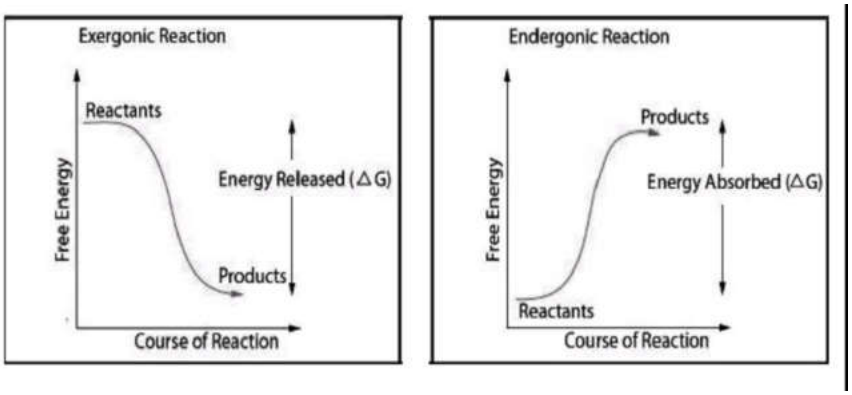
Most of these reactions involve the breaking down of macromolecules into simple compounds to make ATP.

Free energy is release by an exergonic reaction at constant pressure and temperature. [1][6]

2. **ENDERGONIC REACTION**.

Endergonic reaction is the opposite of exergonic in being non-spontaneous and requires an input of free energy. Most of the anabolic reactions like photosynthesis, DNA and proteins synthesis are endergonic in nature.

Endergonic reactions (build or synthesis) and they are energy consuming reaction unlike exergonic.[1][6]




*The graphs representing exergonic and endergonic reactions*

3. **ISOTHERMIC REACTION**.

There is no energy change that take place.

4. **ACTIVATION ENERGY**.

Activation energy is the available energy for chemical system with potential reactants to result into a chemical reaction. Activation energy also mean the maximum energy needed to start a chemical reaction.[1]

**B. EXAMPLES OF MAJOR BIOENERGETICS PROCESSES**

a) Photosynthesis; is the metabolic pathway used by all the plants in which solar energy(light from the sun) is used to synthesize glucose from carbon dioxide and water. This reaction take place in the chloroplast. The plant cell can undergo photophosphorylation to produce ATP After glucose is synthesized.
b) Ketosis; is a metabolic process whereby ketone bodies are used by the cell for energy (instead of using of glucose). Cells turn to ketosis as a source of energy if the level of glucose is low e.g. during starvation.
c) Glycolysis; is the process of breaking down glucose into pyruvate, producing net eight molecules of ATP (per 1 molecule of glucose) in the process.
d) Gluconeogenesis; is the synthesis of glucose from non-carbohydrate precursors. Its occurs by reversal of glycolysis. The cell synthesize carbon-containing biomolecules like proteins, amino acids, fats, pyruvate, etc to form glucose.[1][5][6]

C. **ENERGY FROM DEGRADATION OF FOODSTUFFS**.

Food molecules are broken down in three stages to produce ATP, proteins, lipids and polysaccharides that make up most of the food we eat must be broken down into smaller molecules which can be used by our cells either as source of energy or as a building block for other molecules.[6]

These are three main stages

i. Stage I;

Hydrolysis of polysaccharides into monosaccharides, triacylglycerol into glycerol and fatty acids, proteins into amino acids. No free energy is obtained in this stage.

ii. Stage II

Conversion of monosaccharides, glycerol's, fatty acids, and amino acids into active acetate (acetyl CoA). Some free energy is obtained in this stage.

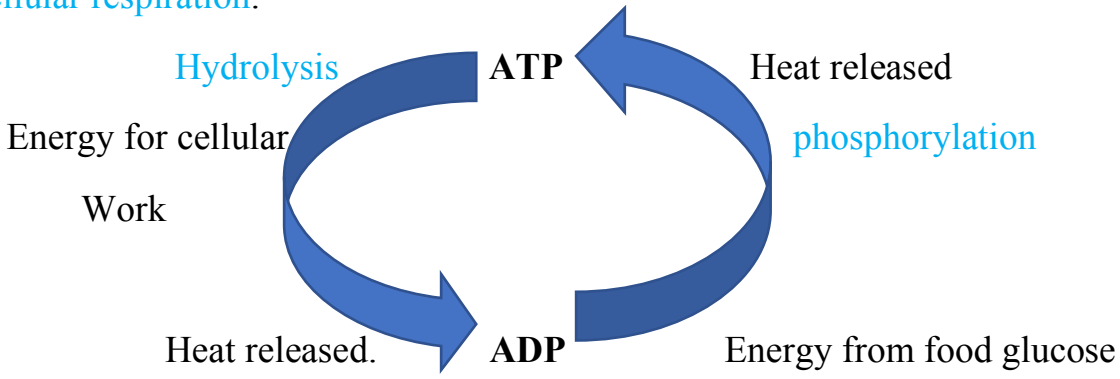
iii. Stage III

Oxidation of active acetate into $CO_2$ and $H_2O$ and reduced coenzymes (hydrogen carriers). This stage produces the maximum amount of energy via citric acid cycle followed by the respiratory chain.

Food energy is expressed in calories. Carbohydrates have an average value of 4.1 calories per gram, proteins have 4.7 calories per gram and fats have an average of 9.3 calories per gram. [6]

## D. ATP/ADP CYCLE (REVERSIBLE REACTION)

The ATP/ADP cycle is that continuous ongoing energy recycling through organic process of low energy adenosine diphosphate (ADP) molecules to high energy adenosine triphosphate(ATP) molecules (binding energy) and subsequent hydrolysis of ATP molecules back to ADP (release energy) facilitated by a complex series of biochemical processes collectively known as cellular respiration.



The main functions of ATP in cellular function includes;

a. It helps in transporting organic substance as sodium, calcium, potassium through the cell membrane.
b. It synthesizes chemical compounds like proteins and cholesterol.
c. It helps in Supplying energy for mechanical work e.g. muscle contraction.

"molecular units of currency" of intracellular energy transfer is known as ATP [1]

E. **ENERGY LEVELS OF CHEMICAL BONDS**.

| HIGH ENERGY BONDS | LOW ENERGY BONDS |
|---|---|
| On hydrolysis, they give >7.3 Kcal/mol | On hydrolysis, they give <7.3 Kcal/mol |
| Designed as (~) | Designed as (-) |
| Examples; ATP and creatine phosphate (high energy phosphate bonds) | Examples; phosphate water bonds e.g. G-6-P low energy bond |

[6]

High energy phosphate bonds;

| ATP | Creatine phosphate |
|---|---|
| Currency of energy in the cell | Storage form of energy |
| Produced in exergonic reactions | Excess ATP is converted to creatine phosphate. |
| Consumed in endergonic reaction | |

[6]

Creatine + ATP $\underset{\text{CPK}}{\rightleftharpoons}$ creatine + ADP

F. **TCA CYCLE**;

A series of chemical reactions used by the aerobic organisms to release a stored energy is known as tricarboxylic acid (TCA) cycle or the citric acid (CAC) cycle or Krebs' cycle. It takes place via the oxidation of acetyl CoA derived from carbohydrates, proteins and fats into carbon dioxide and chemical energy inform of ATP.

Three molecules of ATP will be formed when one molecule of substrate is oxidised through NADH in the electron transport chain and when oxidised through $FADH_2$ , two ATP molecules will be formed.

Examples of reactions and number of ATP molecules formed. [1]

1. 2 succinyl CoA ⟶ 2 succinate (2GTP=2ATP) 2ATP molecules.
2. 2 malate ⟶ 2 oxaloacetate (2NADH+2H) (2x3) 6 ATP molecules.

**Energy shuttles**.

I. NADH: Delivers higher energy electrons to electron transport chain where they will trigger the production of 2 to 3 ATP molecules. When it is oxidized it is left as positive charge $NAD^+$

II. $FADH_2$ ; it carries high energy electrons to the electron transport chain where they power production of 1 to 2 ATP molecules. When it is oxidized it is left as FAD.

III. GTP: GTP can easily be converted to ATP in the cell. [1]

❖ PROBLEMS AND SOLUTIONS:

The flow of energy is the origin of biological complexity, its decline leads to complex diseases. The flow of energy in our bodies is through mitochondria, symbiotic bacteria encompass the mitochondrial DNA (mtDNA) and thousand of nuclear genes.

Defects in mitochondria or bioenergetics deficits or mutation of genes lead to neuropsychiatric diseases like Alzheimer and Parkinson disease, metabolic diseases like diabetes, cancer, autoimmune disease, obesity and aging. The solution is that we focus on energy (vital force) and information to boast our energetic systems. [2]

❖ **CONCLUSION**:

Recent studies on the role of bioenergetics in human evolution suggested that life requires not only anatomy but also the vital force (energy) that animate anatomy. Our bodies function better when a constant flow of energy through our bodies is maintain throughout. The food we eat contains reducing equivalent, breathe oxygen and react to the reducing equivalents. The oxygen within our mitochondria generate the energy necessary to build, maintain and animate our structures.

Therefore, bioenergetics is very important phenomenon for studies.

## REFEREES


1. Dr Sumanta Mondal, bioenergetics presentation December 2017 DOI: 10.1314/RG.2.2.25798.78406 https://www.researchgate.net/publication/321938062
2. D.C. Wallace, cold spring Harb symp quant Biol. Author manuscript: available in PMC 2015 April. https://www.ncbi.nlm.gov/pmc/articles/PMC4405153/
3. Definition of bioenergetics; https://www.nature.com/subjects/bioenergetics
4. Molecular biology of the cell 4th edition https://www.ncbi.nlm.nih.gov/books/NBK21054/
5. Park S. Novel, in physiochemistry and environmental plant physiology (fourth edition) 2009 https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioenergetics
6. Prof. Dr. Dina Sabry Professor of medical biochemistry and molecular Biology faculty of Medicine, Cairo University book I&II. Medical Biochemistry and molecular Biology for Dentists. Pages; 145, 146 and 147