

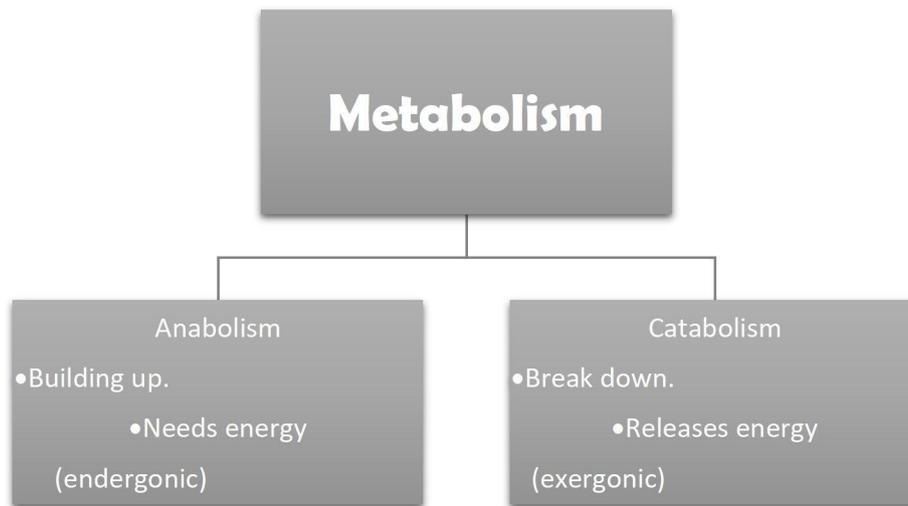


Biochemistry II

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Metabolism





- Energy is considered the capacity of the organism to do work. **Two types of energy are considered in our body:**
- **Heat energy:** It maintains the body temperature.
- **Free energy:** It is available for the performance of work

❖ **Energy Bonds:**

I. Low energy bonds:

- Give 2000 – 3000 cal/bond.
- e.g. glucose-6-phosphate.

II. High energy bonds:

- Give 10,000-16,000 cal/bond.
- e.g.: ATP, ADP, creatine phosphate.

❖ **Collection and storage of free energy:**

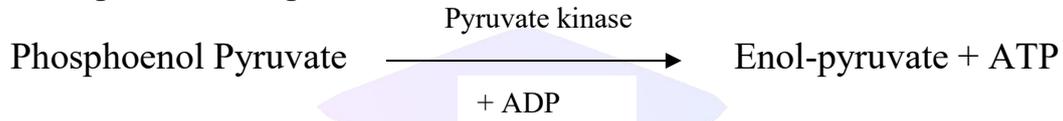
Free energy liberated during the degradation of foodstuffs is collected and stored in the form of high energy phosphate bonds in ATP and creatine phosphate.

❖ Mechanism of collection of energy:

Free energy is collected in the form of high energy phosphate bonds at 2 levels:

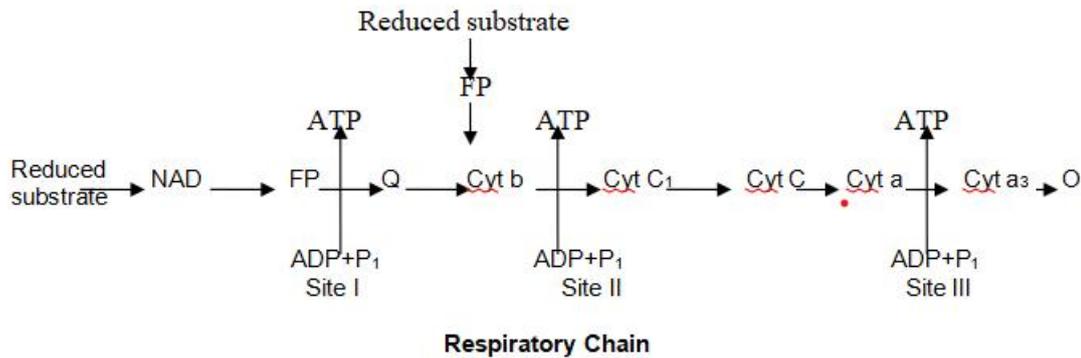
a- Substrate level phosphorylation:

A high energy bond is formed in the substrate while being oxidized, then ATP is generated, e.g.:



b- Respiratory chain (Electron Transport Chain, ETC):

It is a series of hydrogen and electron carriers present near the inner mitochondrial membrane. Its function is to transfer hydrogen and electrons from reduced substrates, resulting from biological reactions, to oxygen forming water and producing energy.



- Respiratory chain shows that the oxidation and phosphorylation are taking place at the same time; a process called **coupled oxidative phosphorylation**
- If these two processes are uncoupled the process of oxidation will occur without phosphorylation and so energy will be lost in the form of **heat**
- Substances which uncouple respiratory chain oxidation from phosphorylation are called uncouplers e.g.: **dicumarol**, **arsenate**, **thyroxin** and **calcium ions**.
- From respiratory chain the oxidation of $\text{NADH} + \text{H}^+$ produces **3 ATP** (P/O = 3/1) while oxidation of FADH_2 gives only **2 ATP** (P/O = 2/1).

• **What is meant by: P\O ratio = 2:1 and when does this occur?**

Answer

In electron transport chain if original carrier (hydrogen and electron carrier) was FAD, 2 ATP are formed for each oxygen forming water

Carbohydrate Metabolism

I- Digestion

II- Absorption

- It occurs mainly in the small intestine.
- Polysaccharides and oligosaccharides are not absorbable.
- Monosaccharides are absorbed from the jejunum.

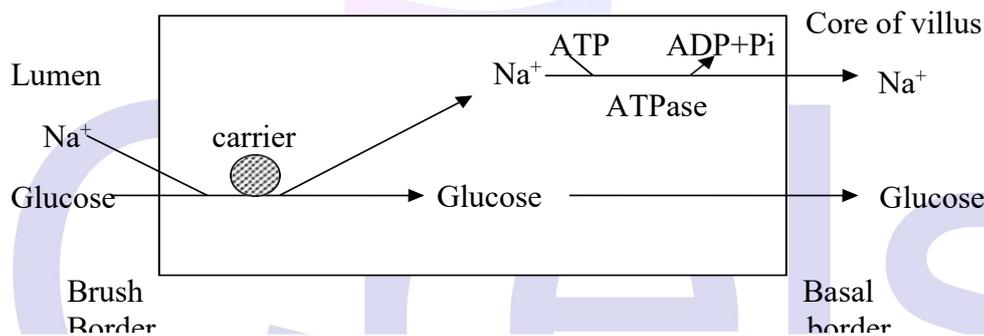
❖ Absorption of sugars occurs by:

1- Passive diffusion:

This depends on the concentration gradient of the sugar between the intestinal lumen, mucosal cells and blood plasma.

2- Active transport:

- There are 2 active transport systems, one for glucose and galactose and the other for other hexoses.
- The first system needs simultaneous absorption of Na^+ by a common carrier present in the brush border of the mucosal cells in the presence of ATP.
- Absorption increases by T_4 and corticosteroids but insulin has no effect.
- It decreases in case of diarrhea.



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❖ **Fate of absorbed sugars:**

1- Utilization by tissues in the form of:

A-Oxidation:

- ✓ **Major pathways:** Via glycolysis, oxidative decarboxylation and Krebs' cycle.
- ✓ **Minor pathways:** Via pentose shunt and uronic acid pathway.

B-Conversion to other substances such as:

- 1- Ribose and deoxyribose in the structure of RNA and DNA.
- 2- Galactose in lactose of milk and galactolipids.
- 3- Fructose in semen.
- 4- Glucuronic acid in the liver for detoxication.

2- Storage:

Excess glucose is stored as glycogen in liver and muscles and as triglycerides in adipose tissues.

3- Excretion in urine:

- Excess blood glucose excreted by the kidney in the urine if the blood level exceeds the normal renal threshold (180 mg\dl)
- Normally, no detectable glucose in urine.

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Major Pathway of Glucose Oxidation

A- Glycolysis

- It is the breakdown of glucose into pyruvate in the presence of O₂ or to lactate in absence of O₂.
- It occurs in **the cytosol of every cell**. Physiologically, it ends with lactate only in muscles during exercise (due to lack of oxygen) and in RBCs (due to absence of mitochondria).

➤ **Comment on glycolysis:**

All reactions are reversible except glucokinase (GK), phosphofructokinase (PFK) and pyruvate kinase (PK).

Glucokinase	Hexokinase
<ul style="list-style-type: none">• Present in adult liver• acts only on glucose• Its synthesis is increased by insulin and carbohydrate feeding but decreased by starvation.	<ul style="list-style-type: none">• present in all tissues except adult liver• It is of low specificity• not affected by insulin, carbohydrate feeding or starvation• It is inhibited by glucose-6-phosphate

❖ **Regulation:**

- 1- Glycolysis is regulated by factors which control the activity of the 3 irreversible reactions.
- 2- Insulin induces the synthesis of GK, PFK, PK, while glucagons and adrenaline inhibit this synthesis.
- 3- Carbohydrate feeding increases insulin secretion, thus increasing the synthesis of the 3 irreversible enzymes in the liver. So, glycolysis will be increased in the liver.
- 4- During starvation, there is decreased secretion of insulin and increased secretion of anti-insulin hormones. This decreases the synthesis of GK, PFK and PK. This inhibits glycolysis in the liver.

❖ **Importance of glycolysis:**

- 1- Glycolysis provides the mitochondria with **pyruvate**, an important source of **oxaloacetate** which is the primer of Krebs' cycle.
- 2- It provides **dihydroxyacetone phosphate**, which is convertible to **glycerol** for **lipogenesis**.
- 3- It liberates a little amount of energy from glucose. This is very important during muscular exercise and also provides most of the energy required by RBCs.

4- Energy yield in the absence of O₂:

- 2 ATP in step 1 and 3 (glucokinase and phosphofructokinase)
 - +2 ATP in step 7 (phosphoglycerate kinase).
 - +2 ATP in step 10 (pyruvate kinase).
-
- + 2 ATP

5- Energy yield in the presence of O₂:

- 2 ATP in step 1 and 3 (glucokinase and phosphofructokinase)
 - +2 ATP in step 7 (phosphoglycerate kinase).
 - +2 ATP in step 10 (pyruvate kinase).
 - +6 ATP are obtained from the oxidation of 2 NADH + H⁺ through the respiratory chain.
- Net= 8 ATP**

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