



METABOLISM: Anabolism and Catabolism

- Color Index:

- **Important.**
- Extra Information.
- **Doctors slides.**

OBJECTIVES :

- ▶ Understand the concept of metabolic pathways .
- ▶ metabolic pathways (anabolic and catabolic).
- ▶ Identify ATP as the energy source for cells .

Metabolism: All the chemical reactions taking place inside a cell are collectively known as **METABOLISM**. It consists of:

Anabolic (بناء):

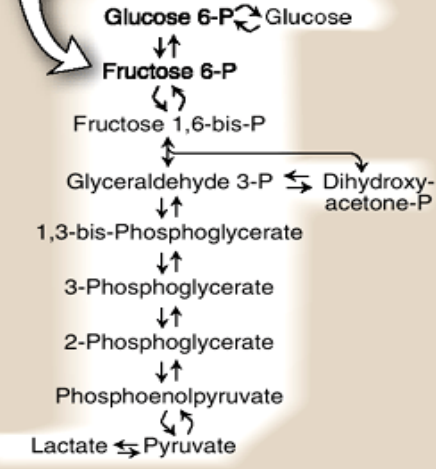
- energy consuming Pathways.
- Endergonic function. (مستهلك للطاقة)



Catabolic (هدم):

- energy producing Pathways.
- Exergonic function. (منتج للطاقة)

The product of one reaction is the substrate of the subsequent reaction. **Glycolysis**



#Metabolic Pathway:

▶ A **multi-step** sequence of chemical reaction. A product of first reaction becomes a substrate for second reaction.

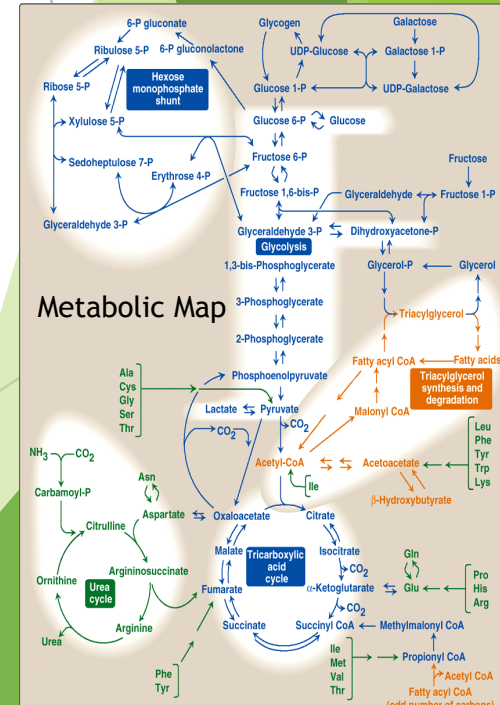
#Integrated pathway: Metabolism (Work together for one purpose)

A pathway has many steps for example: A is converted B(product) then B(substrate) is converted to C ...

- **Glycolysis** is an example of a metabolic pathway

#Metabolic Map: Different pathways can intersect (تقاطع) to form an integrated and purposeful network of chemical reactions

- **Cycles:** Pathways that regenerate a component.



Anabolism takes the energy from catabolism to build large molecules.

Metabolic Pathways Classification

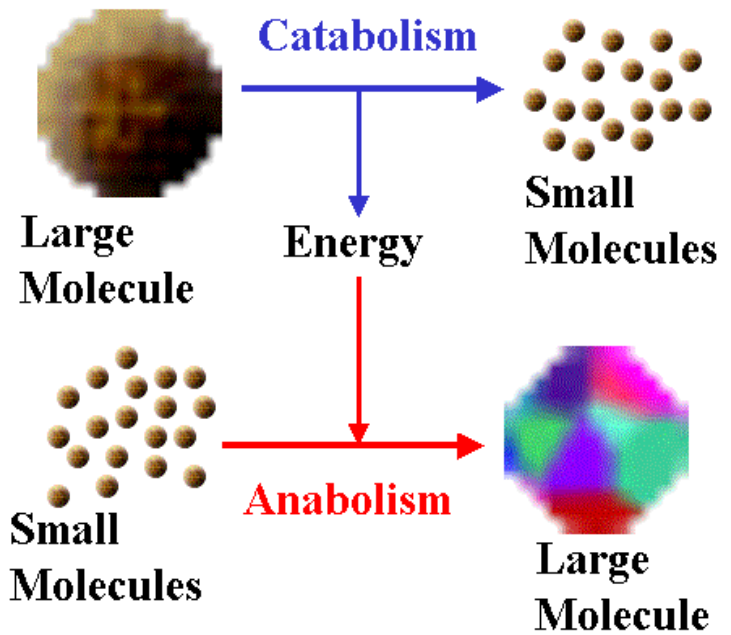
Anabolic

mainly

Catabolic

- Precursor molecules > complex molecule
- Endergonic reactions (require ATP)
- A divergent process (few precursors form more complex products)

Energy-yielding nutrients > energy-poor products



Stage I:

Hydrolysis of complex molecules to their component building blocks

Proteins

Polysaccharides

Lipids

Amino acids

Monosaccharides

Glycerol, fatty acids

Stage II:

Conversion of building blocks to acetyl CoA (or other simple intermediates)

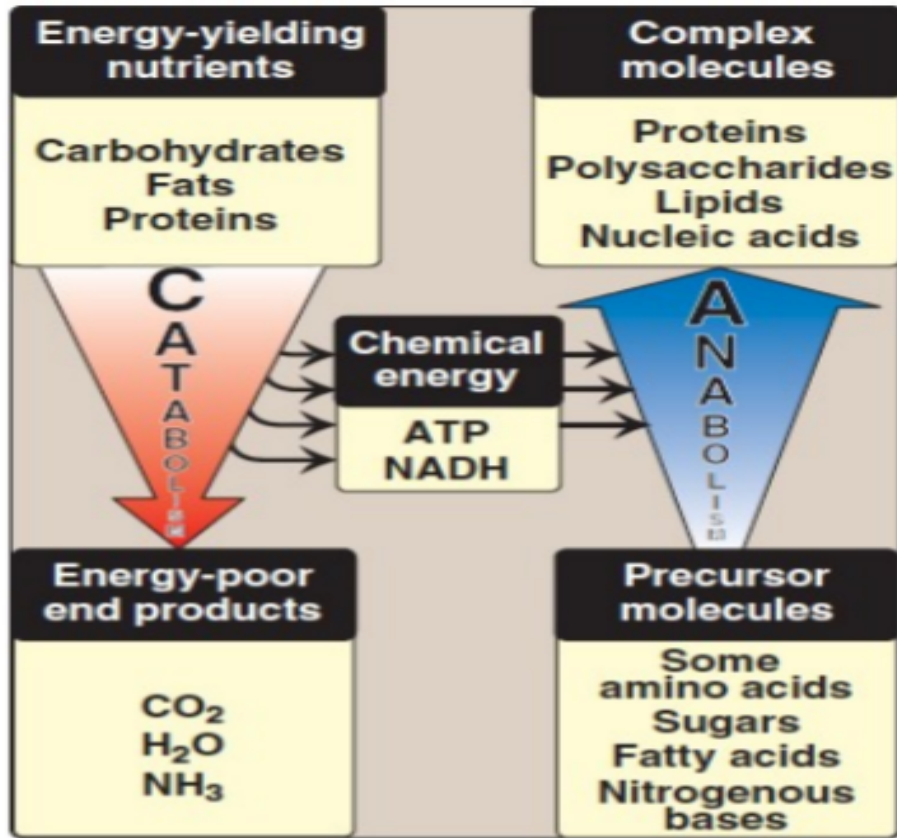
Acetyl CoA

Stage III:

Oxidation of acetyl CoA; oxidative phosphorylation



CATABOLISM VS ANABOLISM



Anabolic	Catabolic
Simple to complex molecules	Complex to simple molecules
Endergonic (ماص للطاقة)	Exergonic (مطلق للطاقة)
Involves reduction	Involves oxidation
Requires NADPH	Requires NAD ⁺
Divergent process (عملية متشعبة)	Convergent process (عملية متقاربة)

During catabolism process, the energy is released (broken down) as ATP and NADH, this is why it is exergonic. Then this energy is used in anabolism process, this is why it is endergonic.

#للربط

Exergonic= Exit energy
Endergonic= Enter

Amphi = Dual (مزدوج), amphibolic: dual pathway (contains Both catabolic and anabolic) (يحتوي على عمليات هدم وبناء)

- **Example:**

Krebs cycle is mainly a **catabolic** cycle, but with some **anabolic** features.

(e.g., part of Krebs cycle is used for the synthesis of glucose from amino acids)

Therefore, **Krebs cycle is amphibolic**. Krebs cycle is used for synthesis of glucose from amino acids .

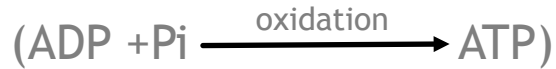
ENERGY CURRENCY: ATP



❖ This **ATP-ADP cycle** is the fundamental mode of energy exchange in biological systems:

1- The free energy liberated (generated) by the hydrolysis of ATP is used to drive the endergonic reactions.

2- ATP is formed from ADP and Pi when fuel molecules are oxidized.



Notes: تلخيص للكلام

- ATP is the source of energy in the anabolism reactions by breaking down the phosphate bond *they are known as high energy phosphate bonds* (endergonic).

- Endergonic: the absorption of energy.



- Catabolism reactions generate energy in the form of ATP by linking the phosphate to the ADP (exergonic).

- Exergonic: is the release of energy.



- This is a point where we will have reaction coupling because endergonic and exergonic are directly linked 😊: endergonic requires energy from ATP and exergonic produces energy in the form of ATP.

What is ATP?

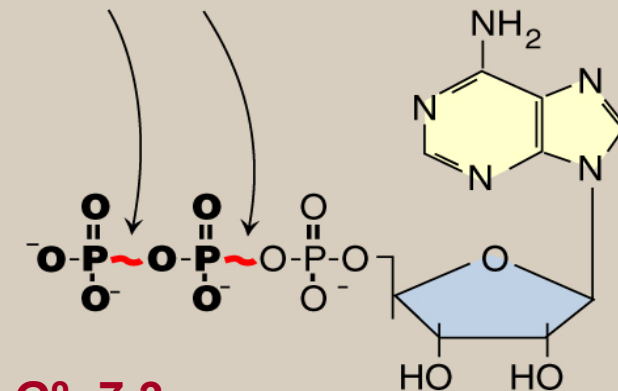
Team434



Adenosine Triphosphate (ATP)

High-energy phosphate bonds

Adenine



$\Delta G^\circ -7.3$
kcal/mol/bond

Ribose

Oxidation & Reduction in metabolism

Oxidation: Loss of hydrogen Loss of electrons.

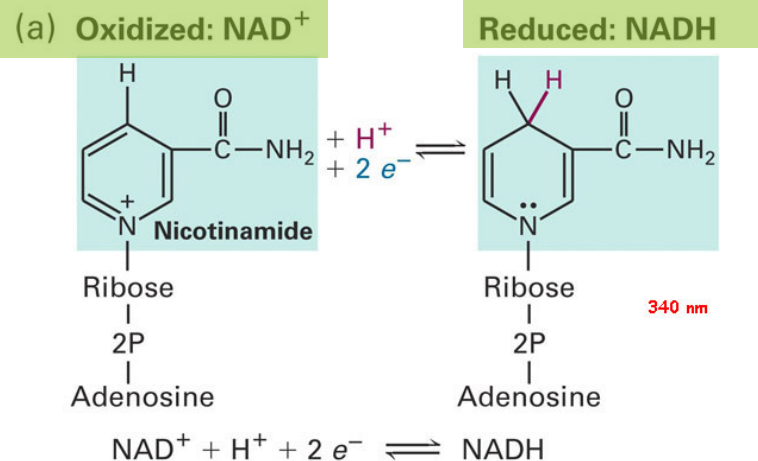
Reduction: Gain of hydrogen Gain of electrons.

- **Energy rich compounds:**
carbohydrates, fatty acids, amino acids.

energy rich compounds ال
نحصلها غالباً من الغذاء.

- Catabolic is **OXIDATION** pathway, and Anabolic is **REDUCTION** pathway.
- In oxidation energy-rich compounds are oxidized (broken down).

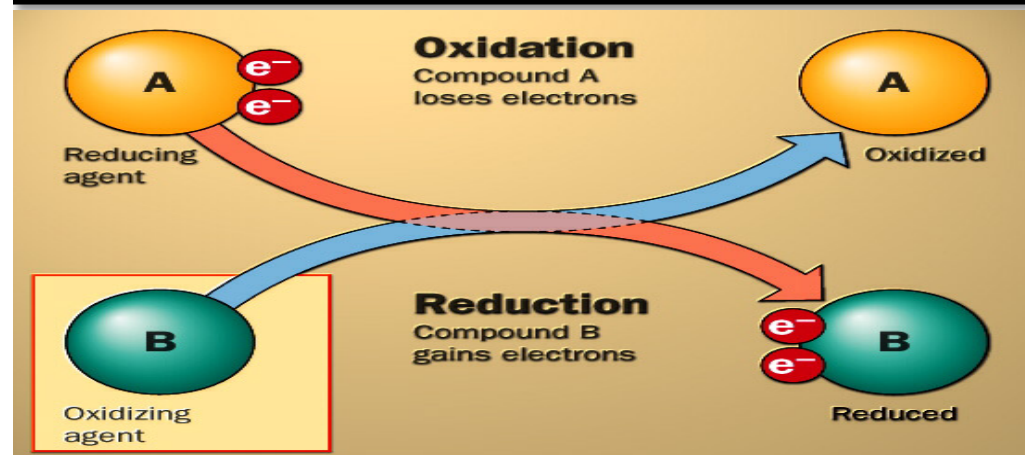
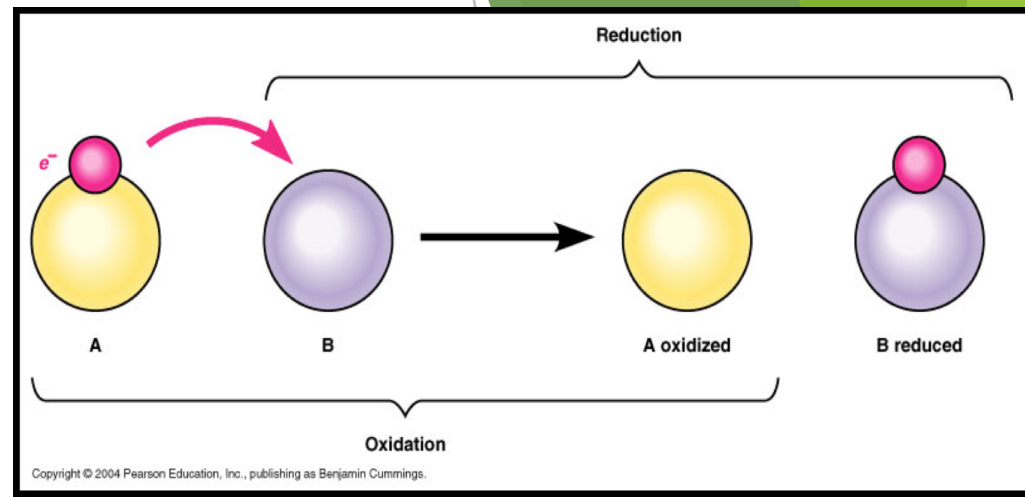
- Energy rich compounds are oxidized and they lose their electron.
- When coenzymes NAD^+ is reduced (gains hydrogen) it'll become $NADH$



NAD: Nicotin-amide adenine di-nucleotide.



Loss of electrons is oxidation
Gain of electrons is reduction



في عمليات الأيض (metabolism) يحدث نقل للإلكترونات من الغذاء (oxidized) إلى الكواينازيمز (reduced).

- Reducing agent: Food. يسبب اختزال الكواينازيمز
- Oxidizing agent: coenzymes يسبب أكسدة الغذاء.

REGULATION OF METABOLISM

to control metabolism we should have signals these signals could be

Intracellular signals
“inside the cell”

- **Substrate availability**

(if the substrates needed are available in cell)

- **Product inhibition**

- (a type of enzyme inhibition: it is ability of the products to control the metabolism)

- **Allosteric activators or inhibitors**

(allosteric regulation is the regulation of enzymes or other proteins by the binding of an effector molecule at the protein's allosteric site; that is, a site other than the protein's active site)

Intercellular communications
“between cells”

-Chemical signaling
(hormones: first messenger)

-Second messengers*:
(cAMP, cGMP)
(Ca⁺⁺/phosphatidylinositol)

Explanation of the concept 😊

Metabolic regulation allows organisms to respond to signals and interact actively with their environments.

the *regulation* of an enzyme in a pathway is how its activity is increased and decreased in response to signals.

*a substance whose release within a cell, promoted by a hormone and which brings about a response by the cell

Intracellular signals (within the cell) :

◆ This kind of regulation is very fast !

Allosteric activator

allosteric regulation is the regulation of enzymes or other proteins by the binding of an effector molecule at the protein's allosteric site; that is, a site other than the protein's active site

Product inhibition

Feedback inhibition to shut off the enzyme

Substrate availability

- if substrate is less → it won't activate it.
- If the substrate needed is available → it will activate it and will make product
- if there're lots of products there will be ..

METABOLIC FUEL

Carbohydrates and lipids (**mainly**) and proteins (**little extent**) are used for energy production*

Glucose, fatty acids and Amino acids are major source of energy

#Glucose is the major metabolic fuel of most tissues

CARBOHYDRATES → LIPIDS → PROTEINS (little existent)

الكربوهيدرات و الدهون هي المصدر الأساسي المستخدم لإنتاج الطاقة.
البروتينات تستخدم أيضًا لكن بشكل أقل.

Take home message

- ▶ Metabolism is the sum of all biochemical pathways that occur inside the cells.
- ▶ A metabolic pathway is a multistep sequences of enzyme-catalyzed reactions.
- ▶ Catabolism is a convergent process that provides energy to cells in the form of ATP.
- ▶ Anabolism is a divergent process that consumes energy for the synthesis of complex molecules.
- ▶ Metabolic pathways are tightly regulated and highly integrated.
- ▶ ATP is the energy currency of the cells

► Girls team members:

نوره الشبيب

Online quiz

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نوره السهلي.