METABOLISM: ANABOLISM AND CATABOLISM

- **Color coding:**
- Very important
- Extra information

"IN ORDER TO SUCCEED, WE MUST FIRST BELIEVE THAT WE CAN"

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OBJECTIVES:

- Understand the concept of metabolic pathway.
- Identify types & characters of metabolic pathways- anabolic and catabolic.
- Identify ATP as the energy currency of cells.

Metabolism : All the chemical reactions taking place inside a cell .(every chemical reaction in our body when we put it together it is called "metabolism") It consist of :

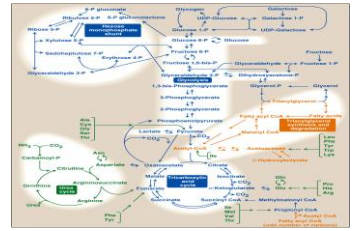
Note : Catabolism give energy to anabolism.

Anabolic: energy consuming Pathways.
- Endergonic function.
- it's need energy to Build.

Catabolic: energy producing Pathways.
- Exergonic function.
- it's produce energy by breaking down.

They are collectively known as metabolism .

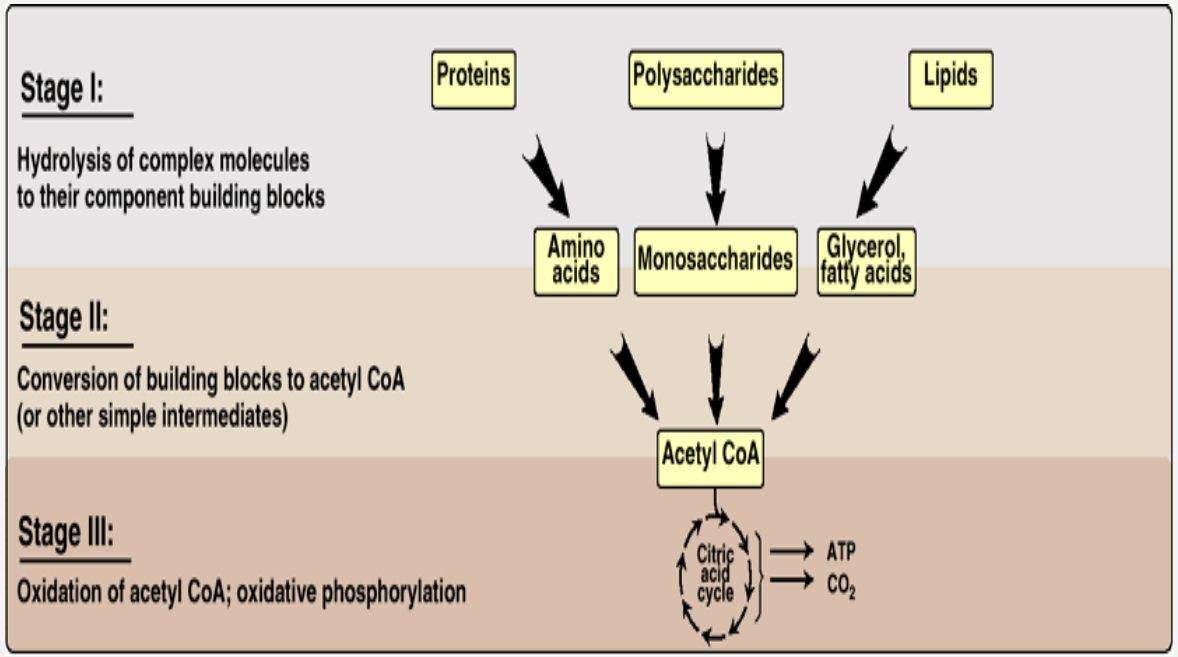
What is pathway ?



- A multi step sequence of chemical reactions.
The product of first reaction Becomes a substrate for second reaction.
- **metabolism:** Integrated pathways : .
هذي اذا جمعناها سوا وصار ناتج التفاعل الاول هو المادة المتفاعلة للتفاعل الثاني يصير اسمه metabolism(يعني الpathways
- **example of a metabolic pathway:** Glycolysis.
- **" The Metabolic Map":** Different pathways can intersect forming an integrated and purposeful network of chemical reactions
- Pathways that regenerate a component are called **cycles**.

Metabolic Pathways Classification

catabolic



anabolic

- Precursor molecules into complex molecules.
- Endergonic reactions require ATP.
- Divergent process.

Note: Pathways that regenerate a component are called cycles

Amphibolic Pathways

Amphi = Dual, amphibolic: dual pathway

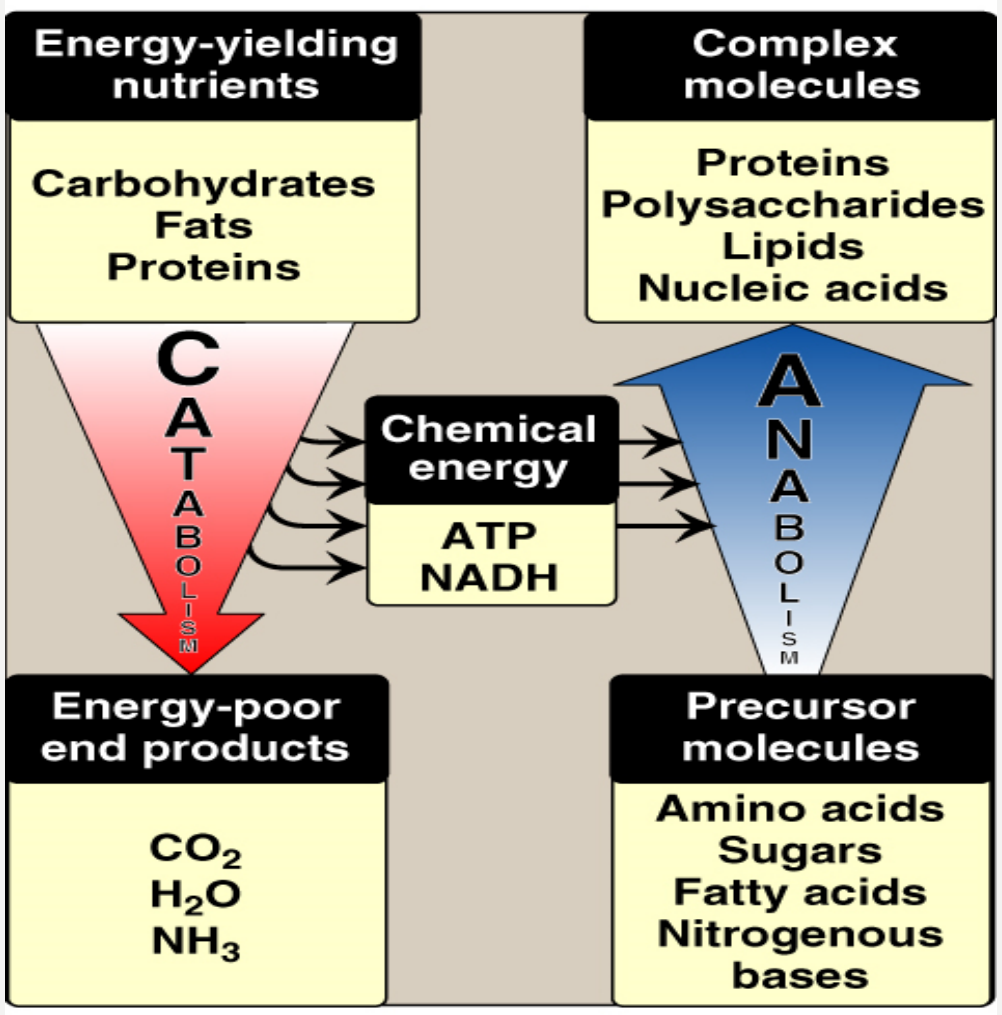
-Example:

- 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.

Catabolism Vs Anabolism



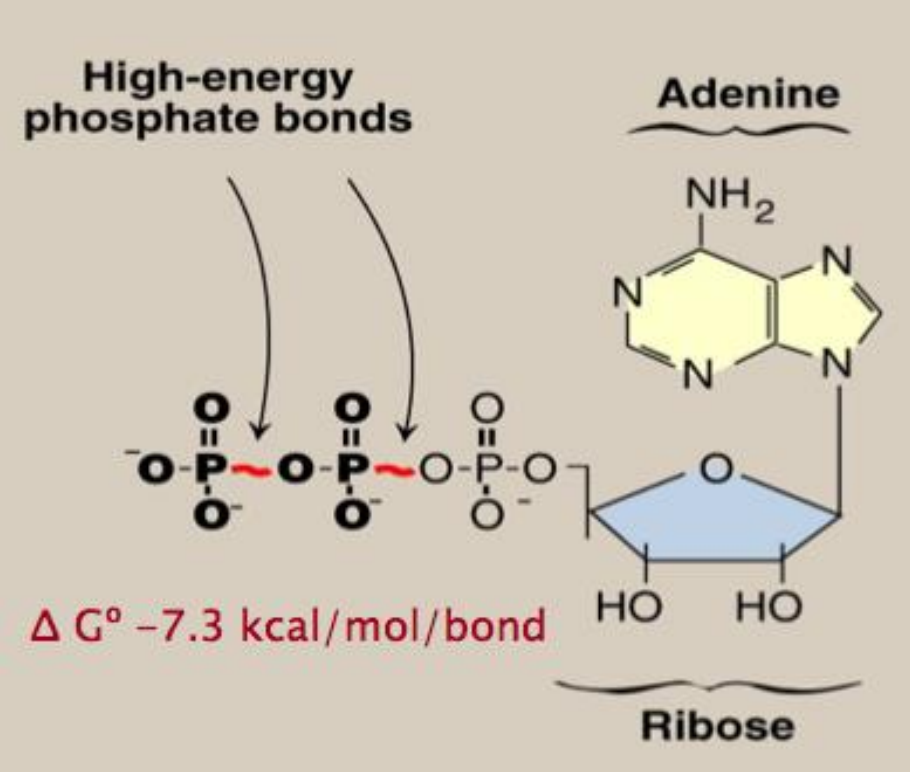
Anabolic	Catabolic
Simple to complex molecules	Complex to simple molecules
Endergonic	Exergonic
Involves reductions	Involves oxidations
Requires NADPH	Requires NAD+
Divergent process	Convergent process

Energy Currency : ATP

ATP + H_2O $\xrightarrow{\text{Hydrolysis}}$ **ADP + P_I**

- ✓ ATP produces energy by breaking one phosphate , they are known as high-energy phosphate bonds .

** check the figure bellow **



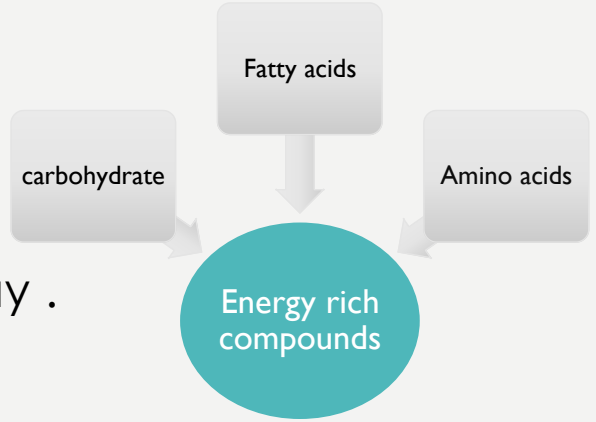
*Notes:

- The free energy liberated in the hydrolysis of ATP is used to drive the endergonic reactions.
- Catabolism reactions produce energy in the form of ATP (exergonic) . This reactions have an enzyme that will link "join" the phosphate and the ADP to form ATP when the feul molecule is oxidized.
- ATP gives energy to the anabolism reactions by breaking the phosphate bond (endergonic). This reactions have an enzyme that will break the phosphate bond from the ATP to give ADP and phosphate.
- This is a point where we will have coupling of endergonic and exergonic reactions at the level of ATP, because endergonic requires energy from ATP and exergonic produces energy in the form of ATP.
- This ATP- ADP cycle is the fundamental mode of energy exchange in biological systems.

Oxidation-Reduction In Metabolism

- **Oxidation** → lose electron , lose H
- **Reduction** → receive electron , gain H

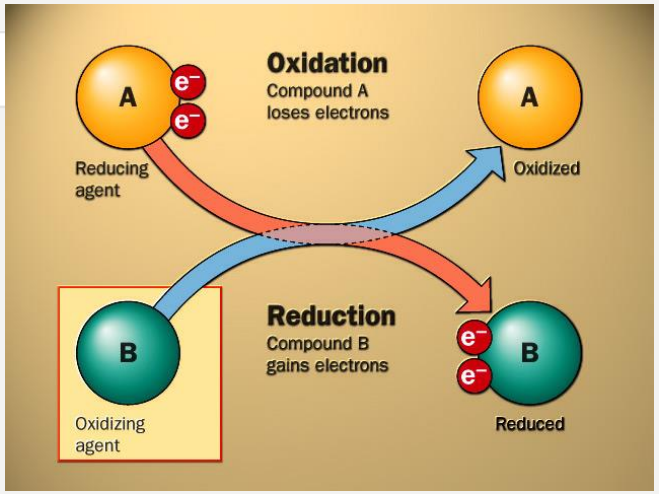
Notes*



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

Gives electron → receives electron

(oxidation of energy-rich compounds = reduction of coenzymes)



more explanation in the next slide

^^

Oxidation-Reduction In Metabolism (Explanation)

Metabolism

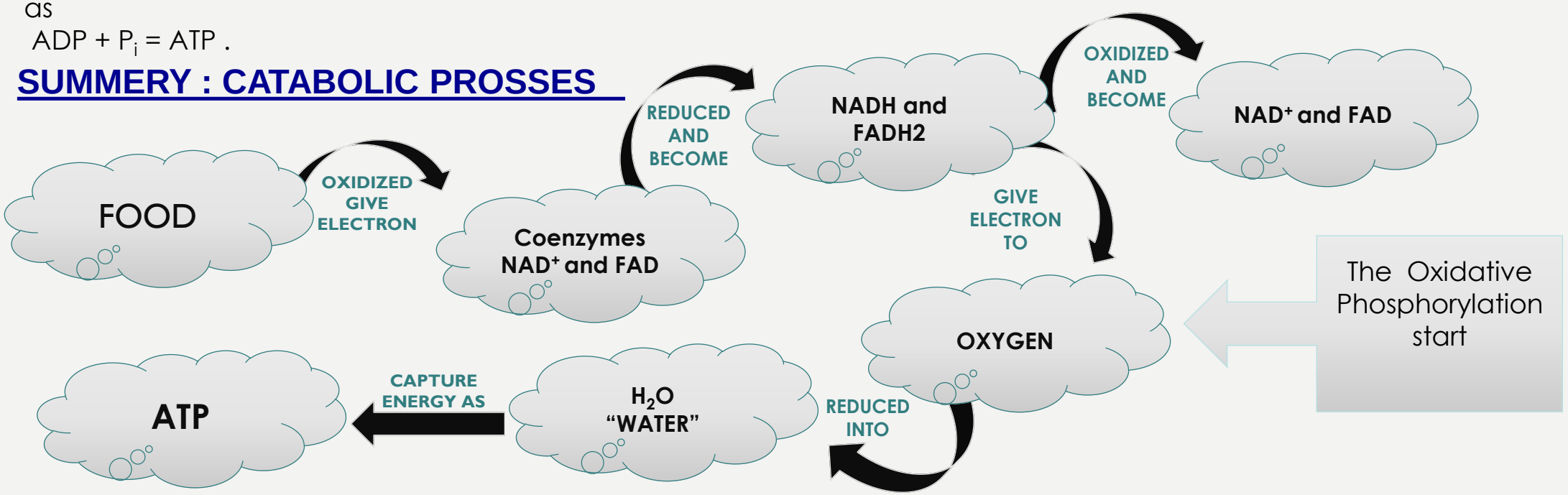
- Food is getting oxidized **-** when something get oxidized something else will get reduced, the transform of electrons have to be there **-** so the coenzymes are the ones whose getting reduced.
- Coenzymes got reduced because they received electrons from the food that have been oxidized and becomes energy-rich .

Oxidative Phosphorylation

- the reduced coenzymes will be oxidized to produced NAD^+ and FAD , they will give their electrons to the oxygen. The oxygen accept the electron from NADH and $FADH_2$, that's why we call it **cellular respiration** and the energy is captured as

ADP + P_i = ATP .

SUMMERY : CATABOLIC PROSSES



REGULATION OF METABOLISM REGULATE THE REACTIONS …

Withier it's catabolism or anabolism, it should be according to the cell's need .
For regulating it needs signals …

1- Intracellular signals: (inside cell)

- **Substrate availability** (if the substrates needed are available in cell).

اذا كل المواد الي نحتاجها للتفاعل موجودة يبدأ التفاعل ، اذا فيه نقص ما يتم التفاعل .

- **Product inhibition** (ability of the products to control the metabolism).

عند توافر مواد ناتجة كثيرة و كافية للخلية هنا الخلية توقف التفاعل ، وعند حدوث نقص تبدأ التفاعل مره ثانيه .

- **Allosteric activators**(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).

2- Intercellular communications: (between cells)

Chemical signaling (hormones) from outside the cell :

Second messenger: cAMP, cGMP,
Ca\ phosphatidylinositol.

الهرمونات لما تفرز يكون معها رساله معينه تبي توصلها لخليه محددة . لما توصل للخلية يكون فيه على سطح الخلية مستقبلات لها ، هذي المستقبلات تنقل الرساله الى الخلية عن طريق السكند ماسنجرز

Intracellular signals in the REGULATION OF METABOLISM *summary*

Withier it's catabolism or anabolism, it should be according to the cell's need .
For regulating it needs signals …

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 avalible → it will activate it and will make product
- if there're lots of products there will be ..

Metabolic Fuel

Substance used for energy production.

- **The most common metabolic fuels are :**
  CARBOHYDRATES → LIPIDS → PROTEINS (little existent).
- These are: glucose, fatty acids and amino acids.
- CARBOHYDRATES from inside and outside the body can be converted into GLUCOSE .
- GLUCOSE is the major metabolic fuel of most tissues .

Biochemistry Team 435

Summary

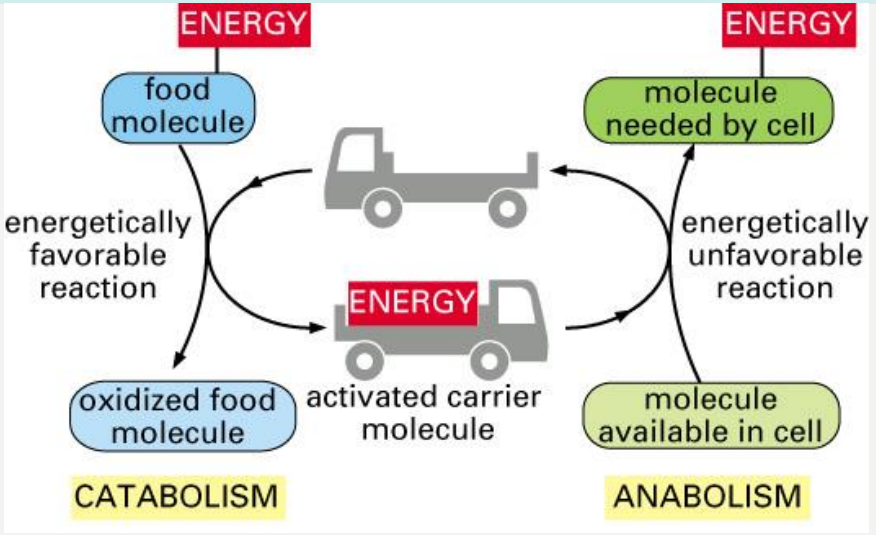
❖ Metabolism: chemical reactions taking place inside a cell.

❖ Metabolic pathways: (e.g.: glycolysis)
- Multi-steps sequence of chemical reactions.
- A product of 1st reaction becomes a substrate for 2nd reaction.
- Integrated pathways → metabolism.

❖ Metabolic map: different pathways can intersect forming an integrated and purposeful network of chemical reactions.

❖ Pathways that regenerate a component are called cycles.

❖ Most pathways can be classified:
- Catabolic (energy producing) pathway.
- Anabolic (energy consuming) pathway.



* Complex → simple.
* Exergonic.
* Oxidations.
* Requires NAD+.
* Convergent.

* Simple → complex.
* Endergonic.
* Reductions.
* Requires NADH.
* Divergent.

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Summary

❖ Amphibolic (e.g.: Krebs cycle):
It's mainly a catabolic cycle but with some anabolic features.

❖ Hydrolysis of ATP is used to drive the endergonic reactions.
$ATP + H_2O \rightarrow ADP + P_i + energy$
❖ ATP is formed from ADP and P_i when fuel molecules are oxidized.
$ADP + P_i \rightarrow ATP$
❖ ATP-ADP cycles is the fundamental mode of energy exchange in biological systems.

❖ Fuel molecules:
- Glucose is the major metabolic fuel.
- Fatty acids.
- Amino acids (little extent).

❖ Difference between oxidization and reduction:

oxidation	reduction
Loss of hydrogen Loss of electrons	Gain of hydrogen Gain of electrons

❖ Regulation of metabolism:

Intracellular signaling	Intercellular communications
• Substrate availability • Product inhibition • Allosteric modulator (activator/inhibitor)	• Chemical signaling (hormones): second messenger cAMP, cGMP Ca/phosphatidylinositol

Videos

- Overview of Metabolism - Anabolism and Catabolism :
https://www.youtube.com/watch?v=ST1UWnenOo0&index=4&list=PLgLExqo2buqtRLeP75l38GMBNjS7t7ReP

-important Video:
https://youtu.be/fWQKlMqzkgo

MCQ's

1- Breaking one phosphate bond from an ATP molecule in metabolism :
a. Store energy b. produce energy c. reduce molecule weight

2- Catabolism reactions producing energy in the form of ATP :
a. exergonic b. endergonic c. non

3- Where we will have coupling of endergonic and exergonic reactions ?
a. Metabolism of glucose b. at ATP level c. never

4- Receive electron :
a. Transfer NADH into NAD^+ b. Transfer NAD^+ into NADH c. Non

5- In cellular respiration energy captured as :
a. NADH and FADH b. ADP c. ATP

6- When there're lots of products of Substrate availability there will be :
a. Intercellular communications b. Product inhibition c. Allosteric activator

7- First messenger in metabolism regulation :
a. Blood b. Molecules that are generated inside the cell c. Hormone

1.B
2.A
3.B
4.B
5.C
6.B
8.C

9. B
10. C
11. T
12. A
13. F

9- The major metabolic fuel of most tissues :

a. Fatty acids b. Glucose c. Amino acids

10: Pathways that regenerate a component are called:

a. Anabolism.
b. Catabolism.
c. Cycles.

11: The Metabolic Map is: Different pathways can intersect forming an integrated and purposeful networks of chemical reactions. (T) or (F)

12: cells use hormones for:

a. Intracellular communications.
b. Intracellular signals.

13: IF the substrate availability is high that means the cell is going to shut down the reaction. (T)or(F)

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