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Introduction to metabolism

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IMPORTANT

Extra Info

Drs Notes

Foundation Block - Biochemistry Team

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MED439

Objectives:

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

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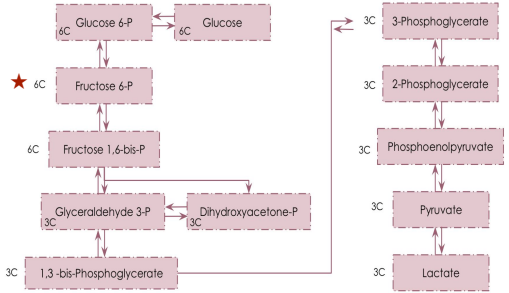
Metabolism

- All the chemical reactions taking place inside a cell are collectively known as Metabolism .

Metabolism consists of :	
Catabolic	Anabolic
Energy producing (Exergenic) "breaking down"	Energy consuming (Endergenic) "building up"

Pathway vs Chemical reaction

- Pathway is a Sequence of reactions .
- **Metabolic Pathway:**
- A multi-step sequence of chemical reactions.
★ A product of first reaction becomes a substrate for second reaction.
- e.g. A → B
B → C
C → D
Each product is a substrate for another reaction .
- Integrated pathways: Metabolism.



Glycolysis , an example of metabolic pathway

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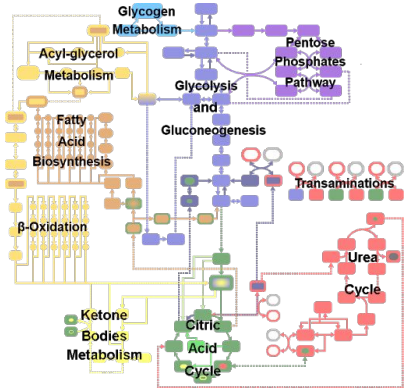
The metabolic MAP

- Different pathways can intersect (تتقاطع مكونين شبكة متكاملة)forming an integrated and purposeful network of chemical reactions "The Metabolic Map" .
- Pathways that regenerate or produce a component are called cycles .
- The purposes of metabolic map:
  1. To get a clear vision .
  2. If there are any changes in one pathway it will help us to know what other pathways will be affected .

- About the metabolic map :
  - فكرتها زي قوقل ماب لو واحد وصف لك تروح مكان بيقول لك تمشي لين جامعة الملك سعود من طريق الامام وبعدين تاخذ يمين , كذا ما راح تقدر تجيه الا من طريق واحد لكن لما يعطيك خريطة او اللوكيشن بالجوال راح يعطيك قوقل ماب اكثر من طريق عشان تصل



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Classification of pathways

Anabolic

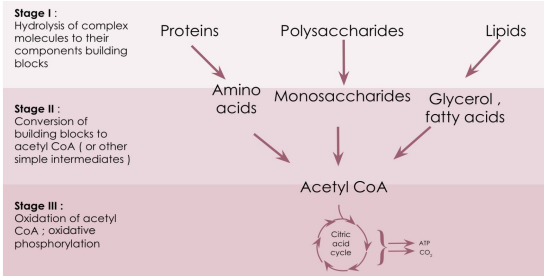
it will make more complex and multiple different molecules from few building blocks

- Precursor molecules into complex molecules
- <u>Endergonic</u> reaction require ATP
  <u>Endergonic</u> = energy consuming
- <u>Divergent</u> process
  <u>Divergent</u> = means We can make complex molecules from few building blocks

Catabolic

it can break down so many complex molecules

- **Stage 1** : hydrolyze the complex molecule to their components building blocks
- **Stage 2**: convert the building blocks into Acetyl CoA
- **Stage 3**: oxidation of acetyl CoA,oxidative phosphorylation
  "To produce ATP"



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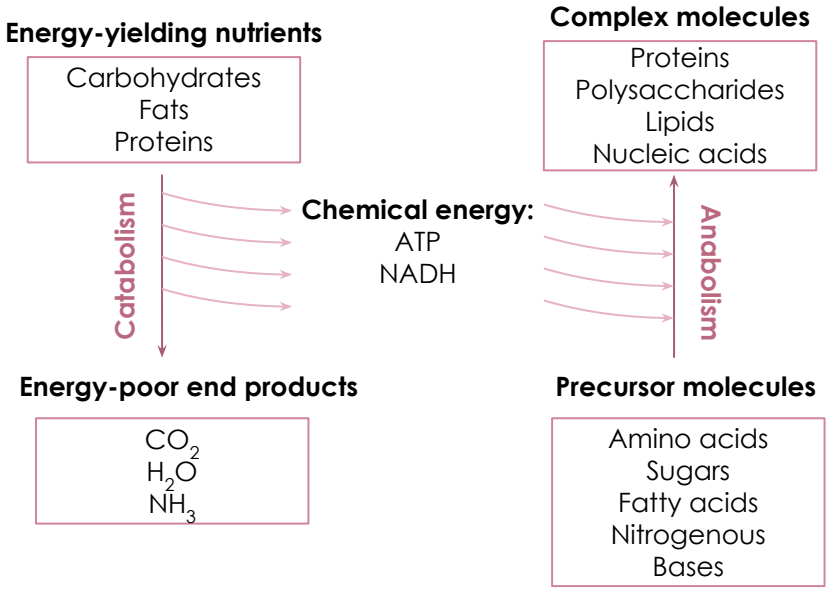
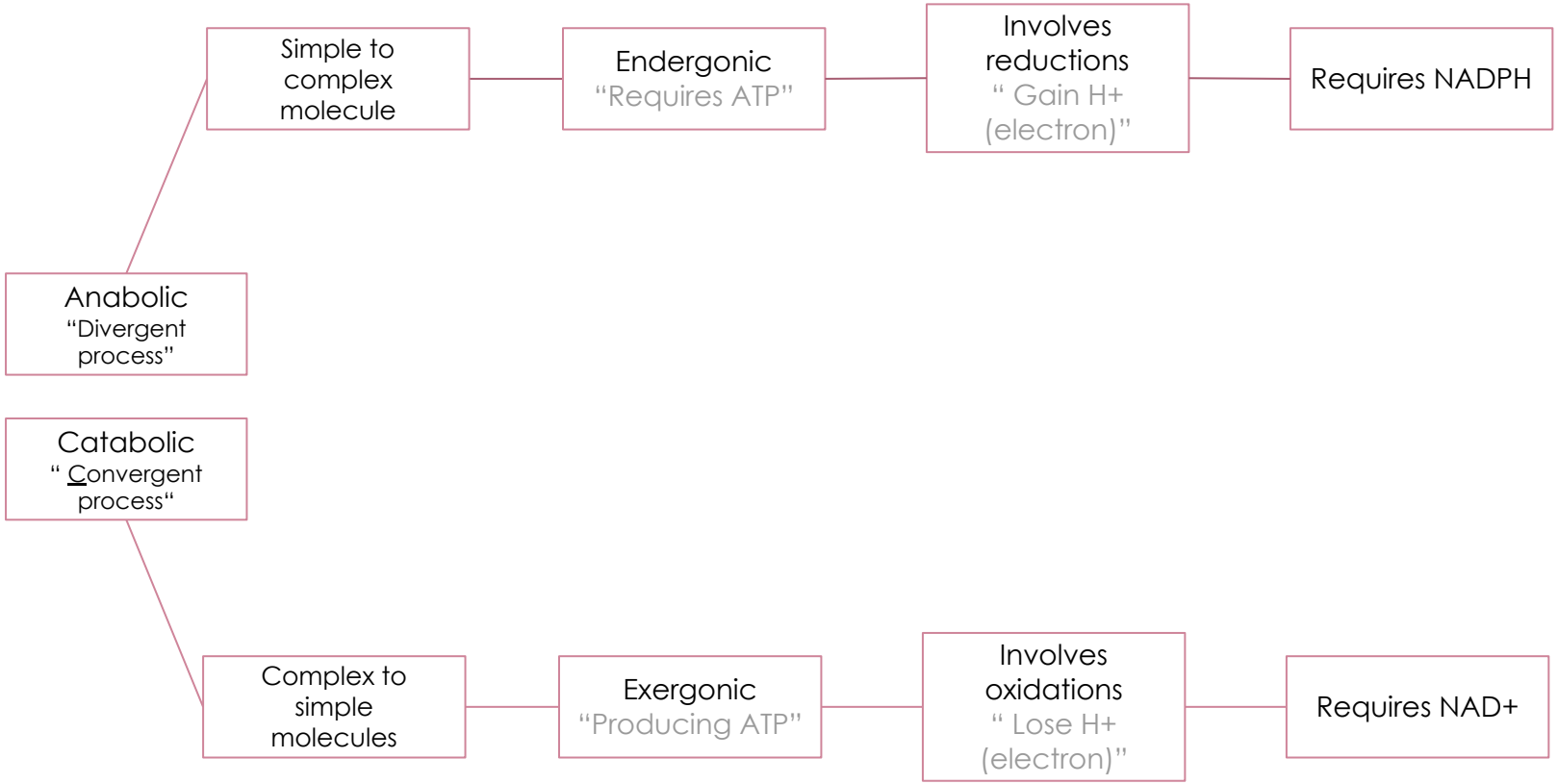
Catabolism vs Anabolism

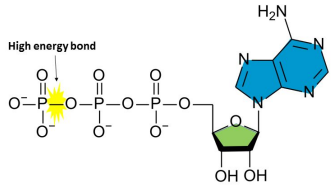


Comparison of Catabolic and Anabolic pathways



Energy currency: ATP

$$ATP + H_2O = ADP + P_i$$



▵ G° 7.3 kcal/mol/bond

- Adenosine Triphosphate= ATP
  - Which consists of (3 Phosphate groups + Nitrogen Base "Adenosine").
  - When ATP loses its 3rd phosphate group, will become ADP + P group and the energy released (when fuel molecules are oxidized).
- The free energy liberated in the hydrolysis of ATP is used to drive the endergonic reactions means if you hydrolyze them , they will produce a lot of energy .
- ATP is formed from ADP and P_i when fuel molecules are oxidized .
- This ATP-ADP cycle is the fundamental mode of energy exchange in biological systems.

Amphibolic pathway

1. Amphi = Dual, amphibolic: dual pathway (both catabolic and anabolic).
2. 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**.

Regulation of metabolism

1. **Intracellular signals (inside the cell):**

a. Substrate availability:
if the substrates needed are available in cell .

b. Product inhibition:
a type of enzyme inhibition: it is ability of the products to control the metabolism .

c. 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.

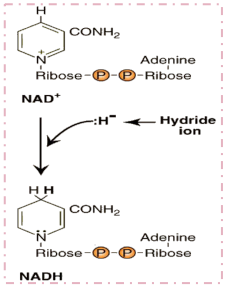
2. **Intercellular communications:**

a. Chemical signaling :
- hormones or neurotransmitters : first messenger.

b. Second messengers :
- (cAMP, cGMP) c= cyclic m= mono .
- (Ca++ /phosphatidylinositol) .

A hormone (1st) binds to a receptor outside the cell, leading to the activation of cell messengers (2nd) inside the cell .

- **NAD^+/NADH:**



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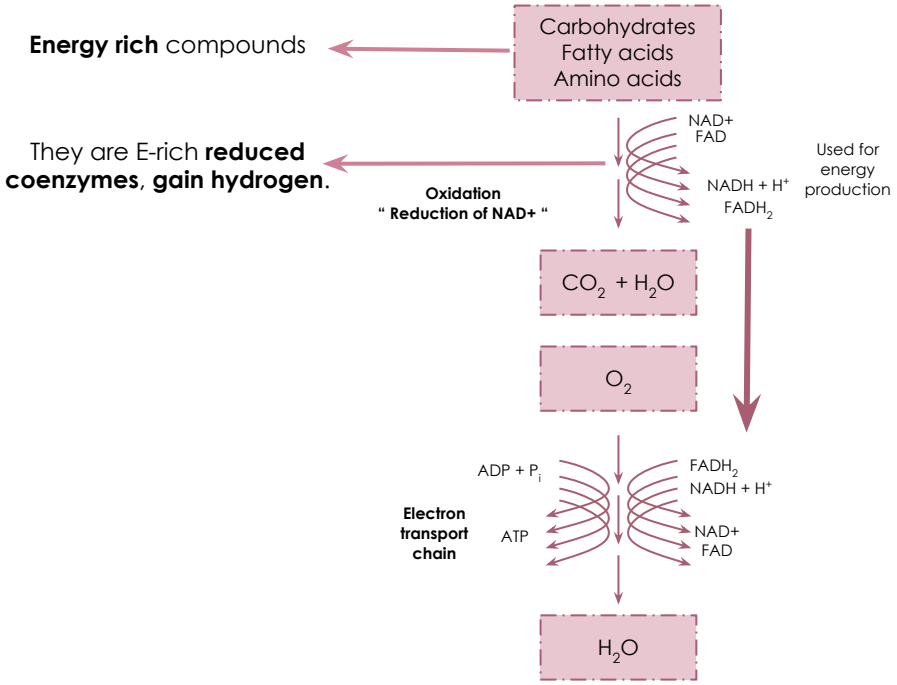
Oxidation and Reduction in metabolism

- Metabolic fuel :
- Carbohydrates and lipids (mainly) and proteins (little extent) are used for energy production.
- In metabolism there will be transfer of electrons from food (reducing agent or oxidized) to coenzyme (oxidation agent or reduced)
- Glucose and fatty acids are The major source of energy while Amino acids are The minor source of energy .
- Glucose is the major metabolic fuel of most tissues .
- **NAD**= **N**icotin-amide **A**denine **D**i-nucleotide

1. Oxidation " catabolic " :
   a. Loss of Hydrogen .
   b. Loss of electron .
2. Reduction " anabolic " :
   a. Gain of hydrogen .
   b. Gain of electrons .



- From NADH to NAD+ (oxidation) "loss of hydrogen"
- From NAD+ to NADH (reduction) "gain of hydrogen"

Take home messages

- 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.

Quiz

Q1 : what is the pathway that Producing energy ?			
A) Anabolic Pathway	B) Catabolic Pathway	C) Both A&B	D) None of them
Q2 : ATP is ….. ?			
A) Adenosine twophosphate	B) Adenotine Triphosphate	C) Adenosine Triphosphate	D) Adrenal Triphosphate
Q3 : Which types of pathways that Krebs cycle use ?			
A) Anabolic pathway	B) Catabolic pathway	C) Amphipolic pathway	D) None of them
Q4 : From NADH to NAD+ by …… ?			
A) Oxidation reaction	B) Reduction reaction	C) Both A&B	D) None of them
Q5 : All the chemical reactions taking place inside a cell are known as :			
A) Metabolism	B) Glycogenesis	C) Catabolism	D) Glycolysis
Q6 : Fat are catabolized into …… then into Acetyl CoA ?			
A) monosaccharides	B) Amino acids	C) Glycerol , fatty acids	D) Peptidoglycan

SAQs :

Q1: What is the pathway that consumes ATP ?

Q2: Define the pathway reaction and give an example .

Q3: What is the reduction reaction ?

Q4: Hydrolysis of ATP will produce ?

★ **MCQs Answer key:**

1) B 2) C 3) C 4) A 5) A 6) C

★ **SAQs Answer key:**

1) Anabolic pathway

2) multi-step sequence of chemical reactions like glycolysis

3) gains electron or H+

4) ADP+P_i (free energy)

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"Opportunities don't happen , you create them."
* Chris Grosser

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