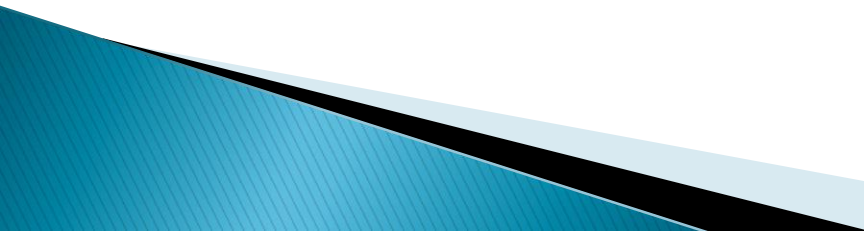


# Metabolism: Anabolism and Catabolism

By

**Dr. Amr S. Moustafa, MD, PhD**

# Objectives


- ▶ **Understand the concept of metabolic pathway**
  - ▶ **Identify types & characters of metabolic pathways– anabolic and catabolic**
  - ▶ **Identify ATP as the energy currency of cells**
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# Metabolism

- ▶ All the chemical reactions taking place inside a cell are collectively known as **METABOLISM**
- ▶ Metabolism consists of:
  - energy consuming (**anabolic**) pathways
  - energy producing (**catabolic**) pathways

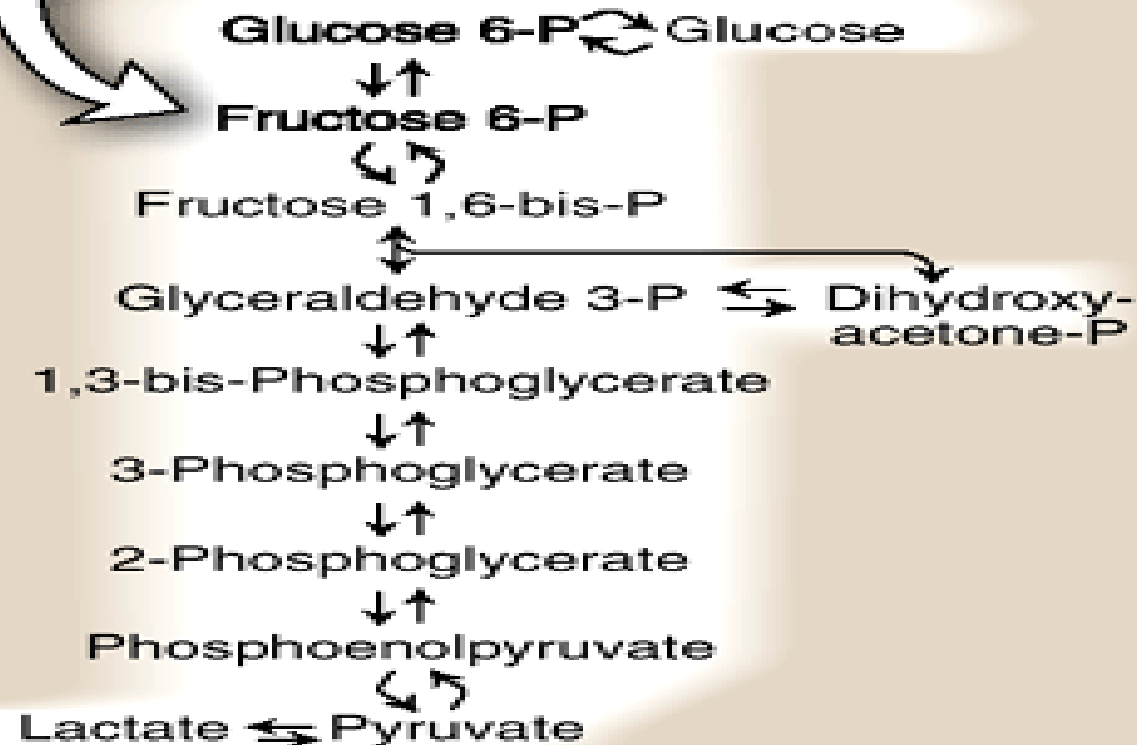
# Pathway **Vs** Chemical Reaction

## Metabolic Pathway:

- **A multi-step sequence of chemical reactions**
  - **A product of first reaction becomes a substrate for second reaction**
  - **Integrated pathways: Metabolism**
- 

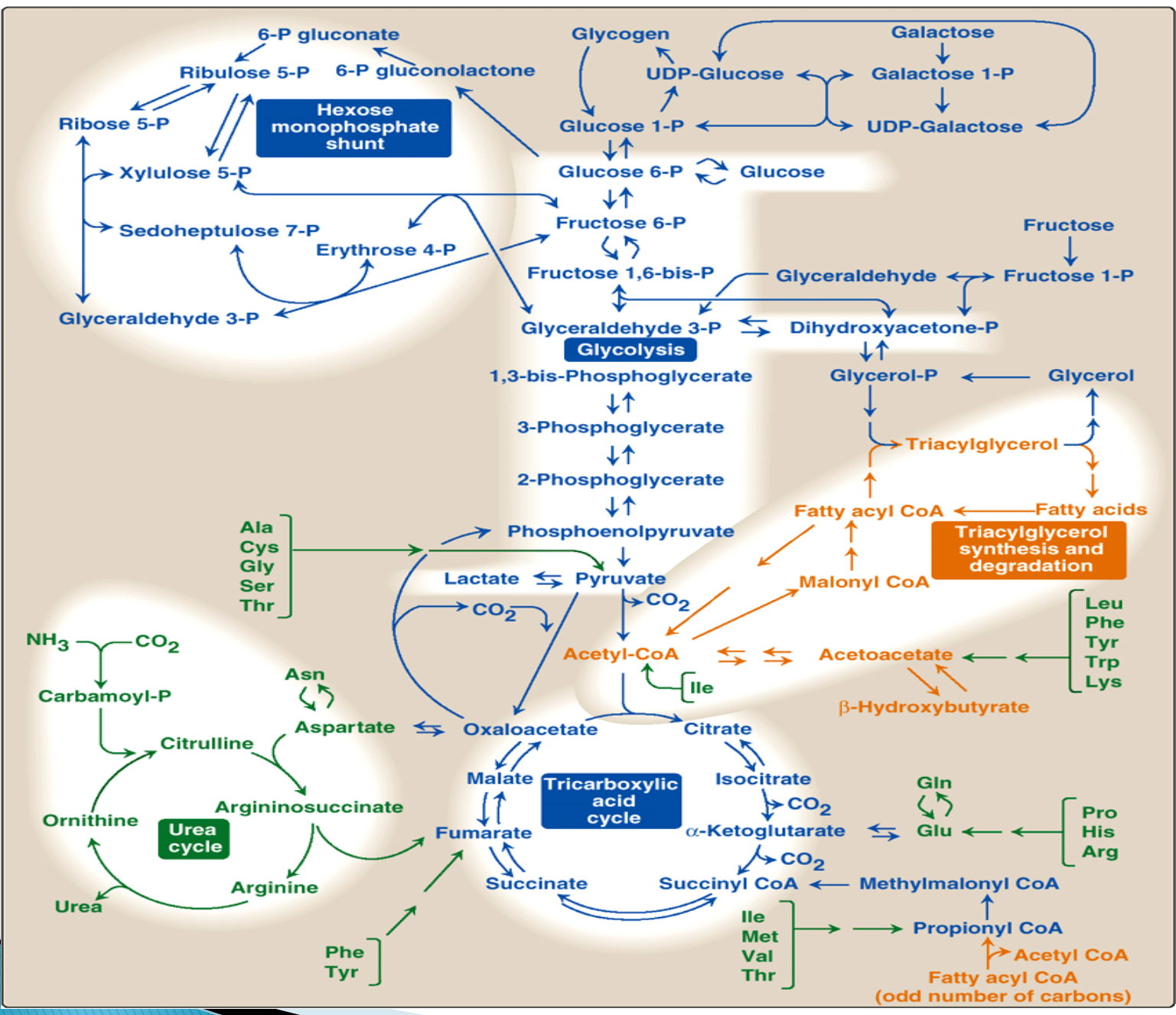
# Glycolysis, an example of a metabolic pathway

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

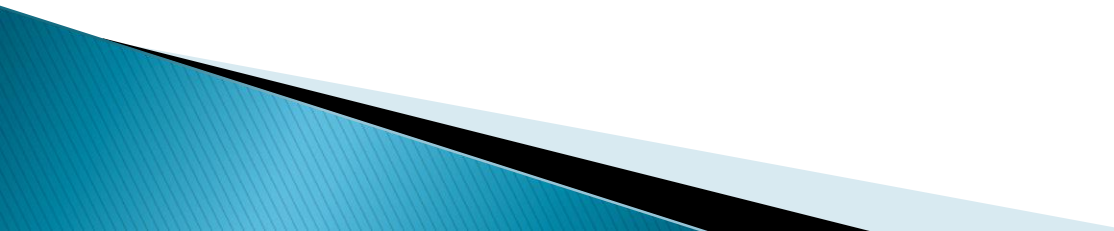


# Metabolic Map

- ▶ Different pathways can intersect, forming an integrated and purposeful network of chemical reactions **“The Metabolic Map”**

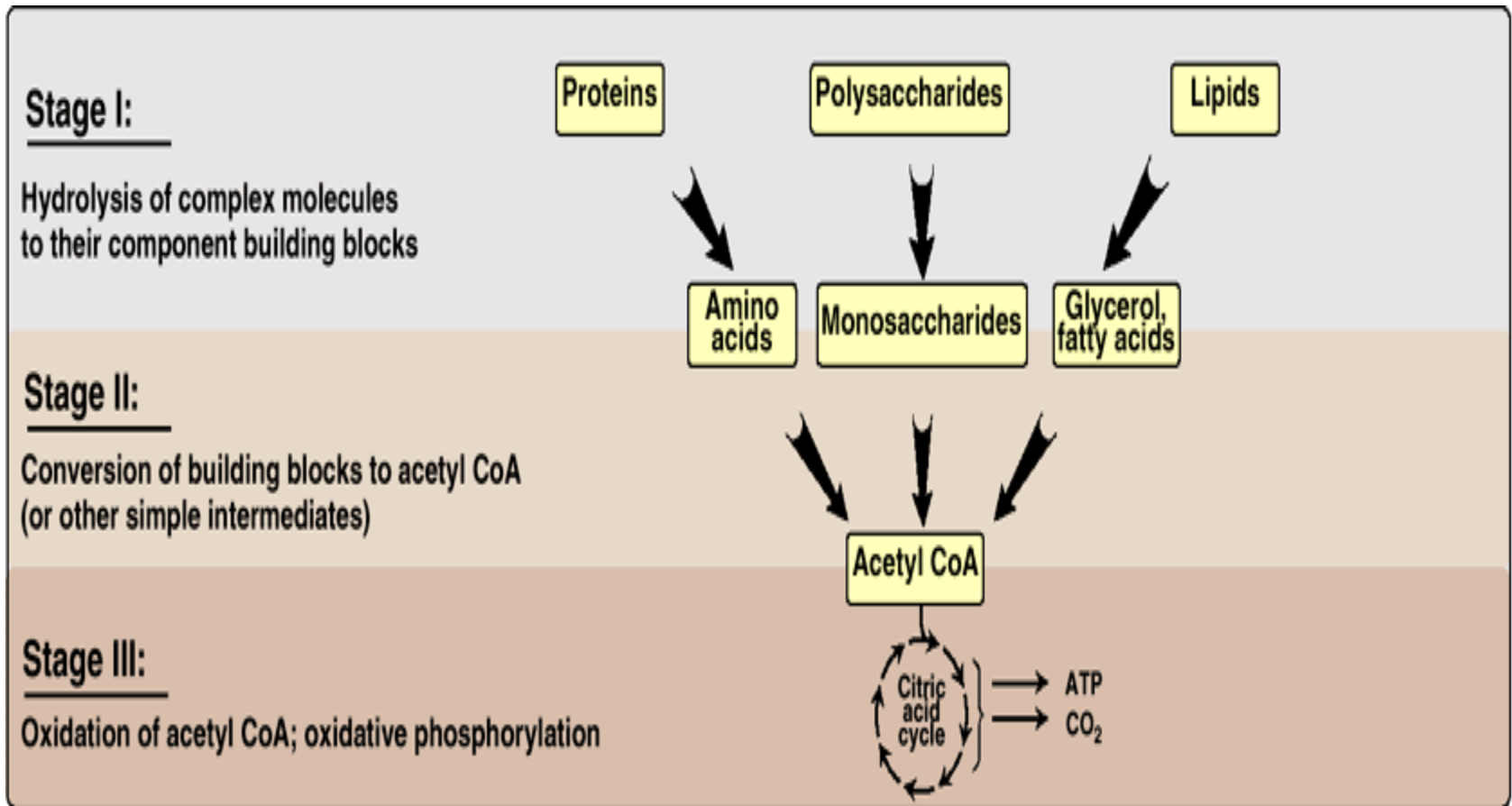


# Classification

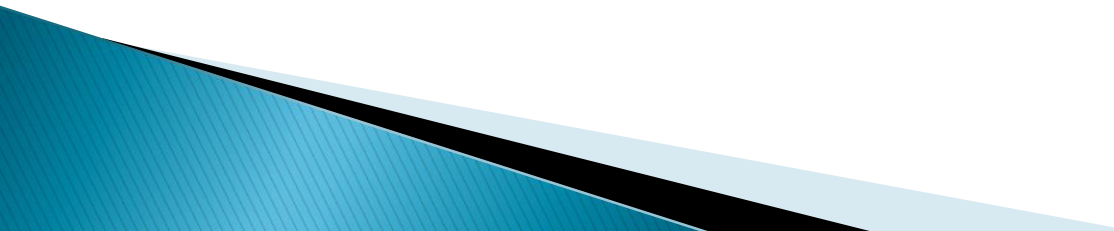
- ▶ **Most pathways can be classified**  
**catabolic**  
**anabolic**
  - ▶ **Note: Pathways that regenerate a component are called cycles**
- 



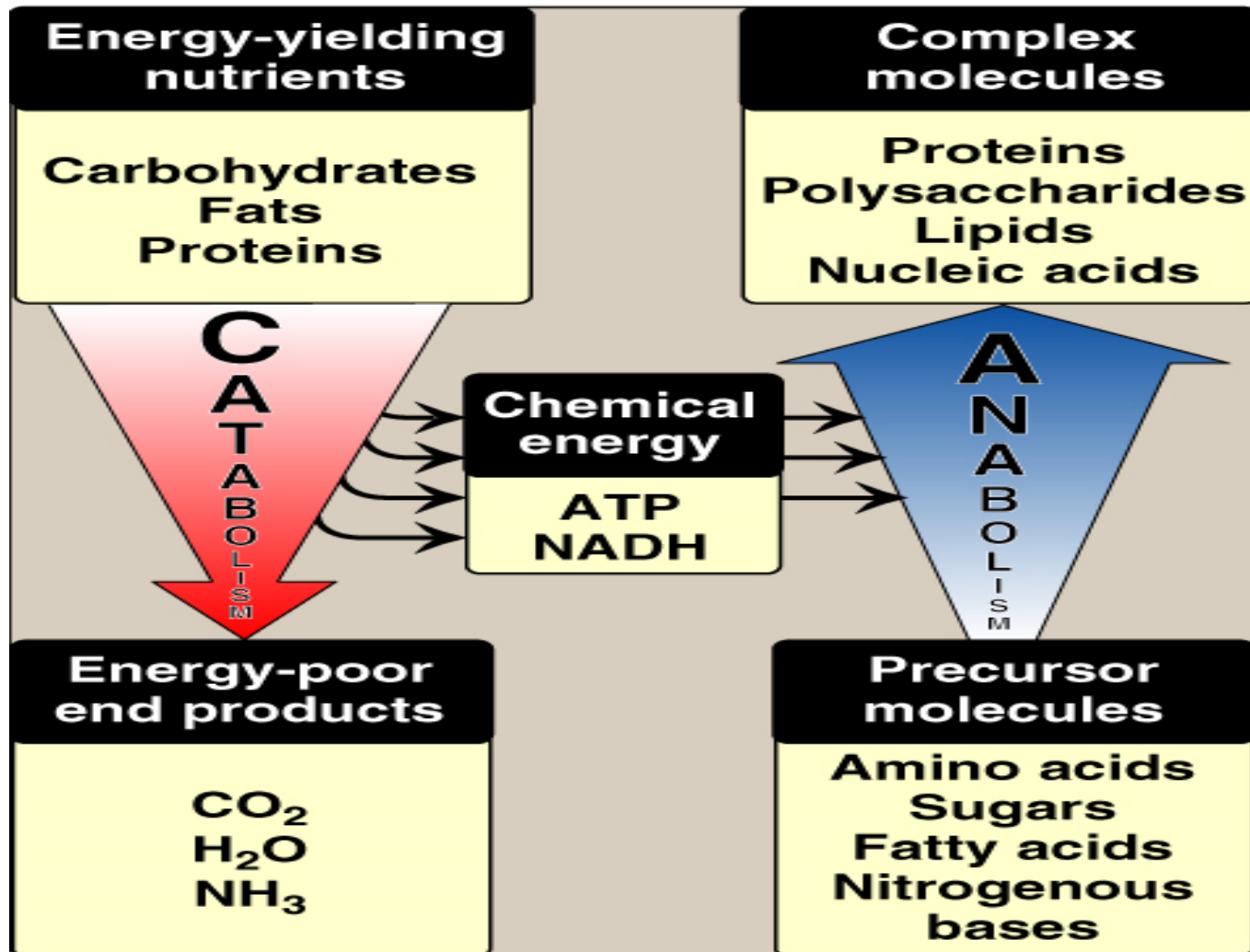
# Catabolic Pathways



# Anabolic Pathways

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

# Catabolism Vs Anabolism



# Comparison of catabolic and anabolic pathways

## Anabolic

- ▶ Simple to complex molecules
- ▶ Endergonic
- ▶ Involves reductions
- ▶ Requires NADPH
- ▶ Divergent process

## Catabolic

- ▶ Complex to simple molecules
- ▶ Exergonic
- ▶ Involves oxidations
- ▶ Requires NAD<sup>+</sup>
- ▶ Convergent process

# Amphibolic Pathways

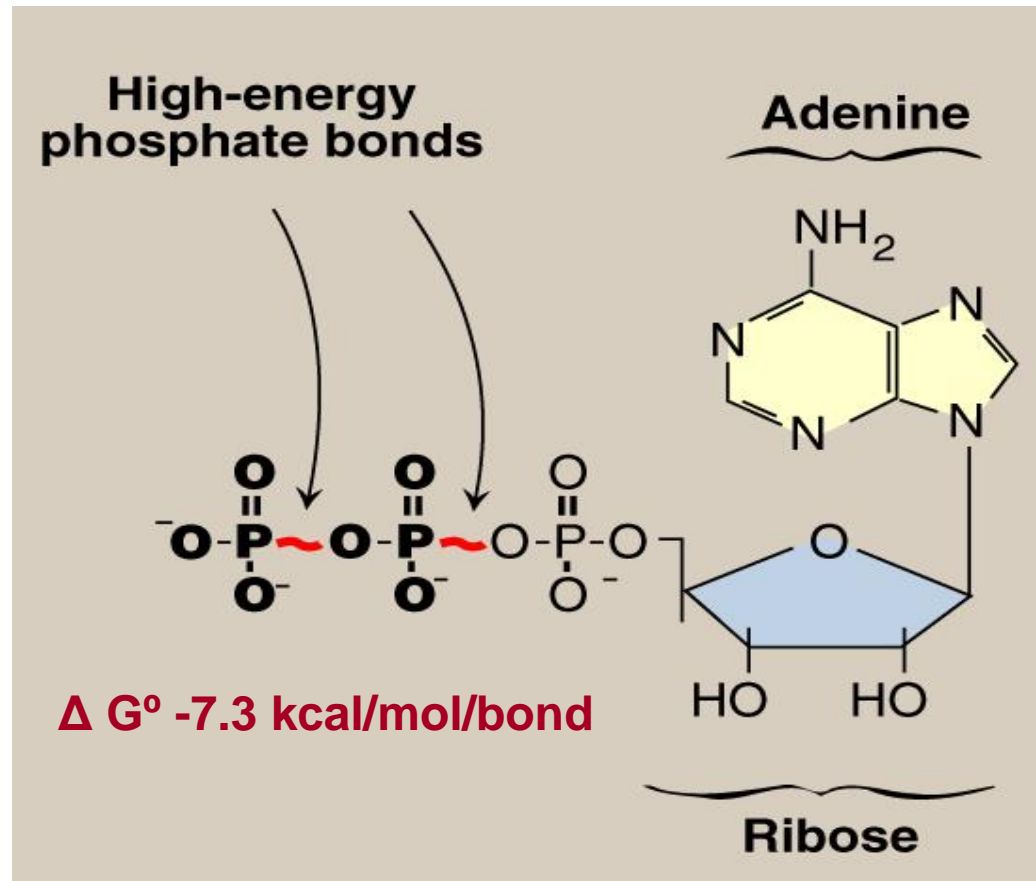
- ▶ **Amphi = Dual, amphibolic: dual pathway**
  - ▶ **For example,**  
**Krebs cycle is mainly a **catabolic** cycle,**  
**but with some **anabolic** features,**  
**e.g., part of Krebs cycle is used for the**  
**synthesis of glucose from amino acids**
- Therefore, **Krebs cycle is amphibolic****

# Energy Currency: ATP



- ▶ The free energy liberated in the hydrolysis of ATP is used to drive the endergonic reactions
- ▶ ATP is formed from ADP and  $\text{P}_i$  when fuel molecules are oxidized
- ▶ This **ATP-ADP cycle** is the fundamental mode of energy exchange in biological systems

# Adenosine Triphosphate (ATP)



# Oxidation-Reduction in Metabolism

E-rich compounds e.g.,

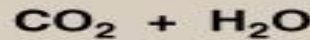
## Metabolism

Carbohydrates  
Fatty acids  
Amino acids

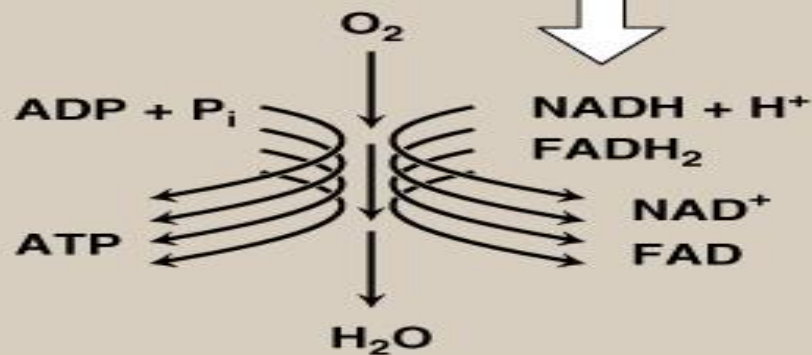
Oxidation



E-rich  
reduced coenzymes



ETC



## Oxidative phosphorylation



# Oxidation/Reduction

## Oxidation:

Loss of hydrogen

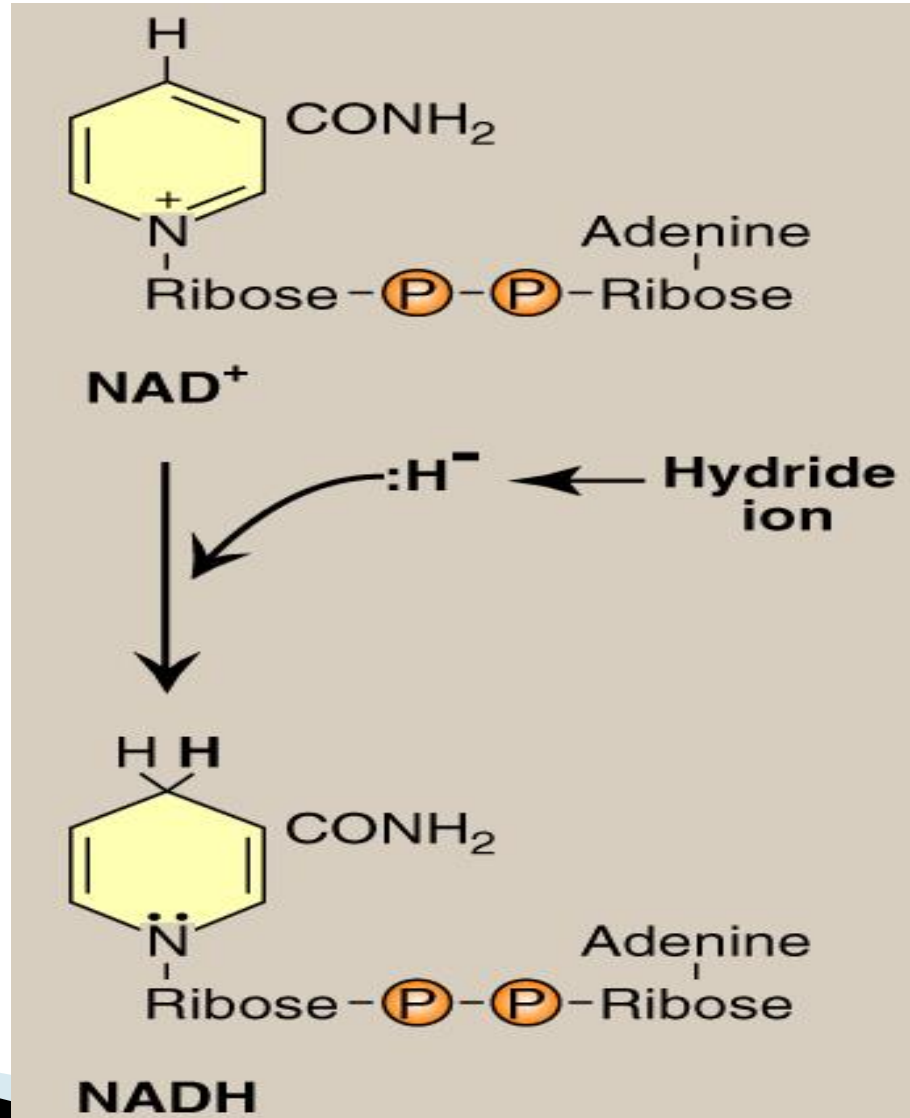
Loss of electrons

## Reduction:

Gain of hydrogen

Gain of electrons

# NAD<sup>+</sup>/ NADH



# **Regulation of Metabolism**

## **Intracellular signals:**

**Substrate availability**

**Product inhibition**

**Allosteric activators**

## **Intercellular communications:**

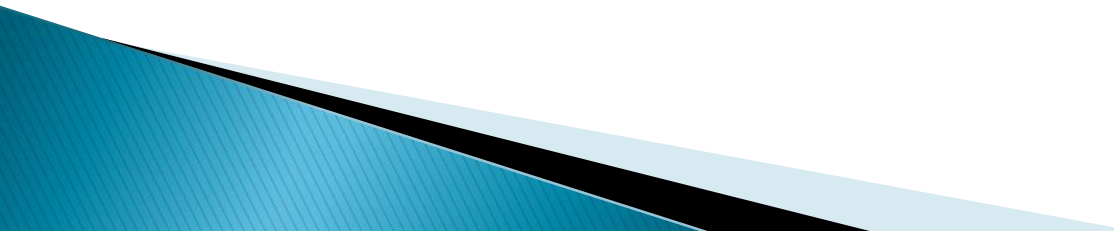
**Chemical signaling (hormones):**

**Second messenger**

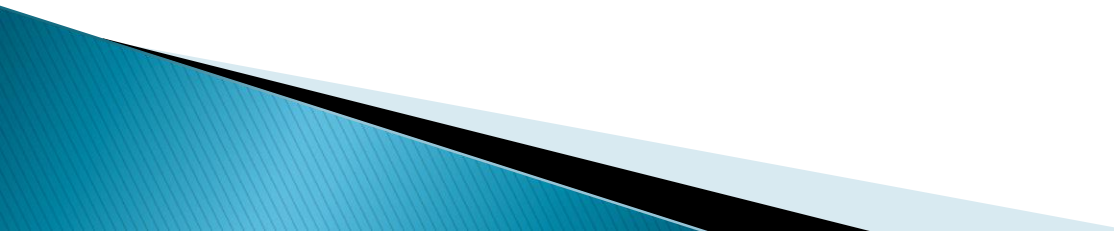
**cAMP, cGMP**

**Ca/phosphatidylinositol**

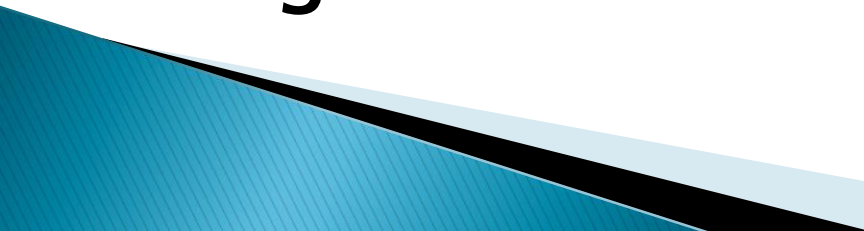
# Metabolic Fuel

- ▶ Carbohydrates & lipids (**mainly**) and proteins (**little extent**) are used for energy production
  - ▶ These are– glucose, fatty acids and amino acids
  - ▶ Glucose is the major metabolic fuel of most tissues
- 

# Take Home Message-1

- ▶ **Metabolism is the sum of all biochemical pathways that occur inside the cells.**
  - ▶ **A metabolic pathway is a multistep sequences of enzyme-catalyzed reactions.**
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# Take Home Message-2

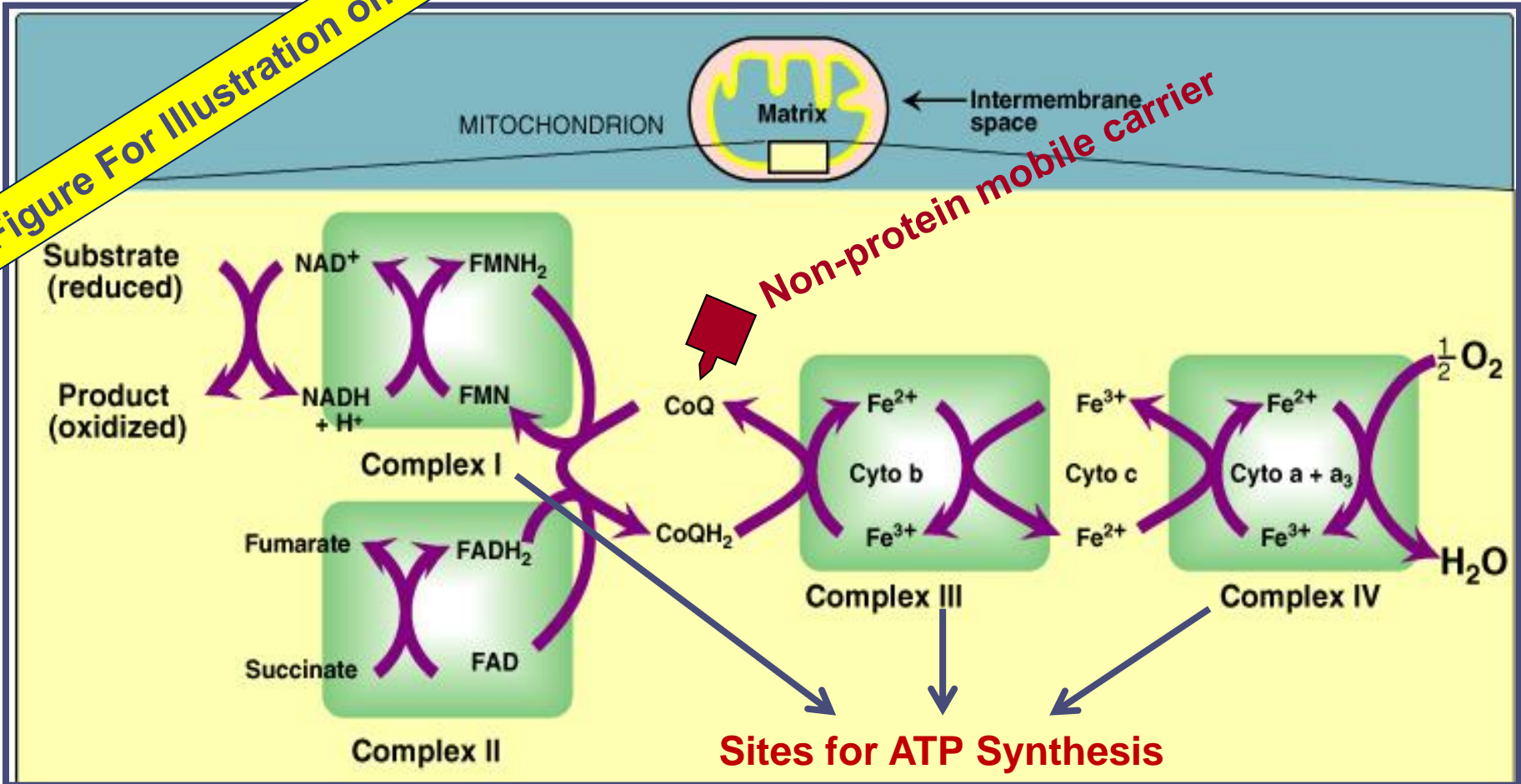
- ▶ **Catabolism is a convergent process that provides energy to cells in the form of ATP.**
  - ▶ **Anabolism is a divergent process that consumes energy for the synthesis of complex molecules.**
  - ▶ **Metabolic pathways are tightly regulated and highly integrated.**
- 

# Take Home Message-3

- ▶ ATP is the energy currency of the cells

# Electron Transport Chain (ETC)

Figure For Illustration only



Electron transport and ATP synthesis are tightly coupled processes