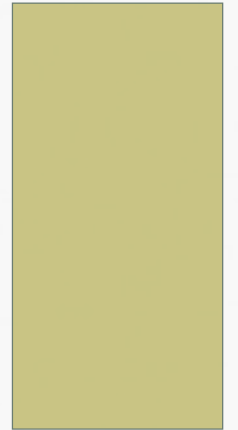


# INTRODUCTION TO METABOLISM

DR. USMAN GHANI



# OBJECTIVES

By the end of this lecture the First Year students will be able to:

- Understand the concept of metabolic pathways
- Identify types and characteristics of 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**
- Metabolism consists of:
  - Energy consuming (**anabolic**) pathways
  - Energy producing (**catabolic**) pathways

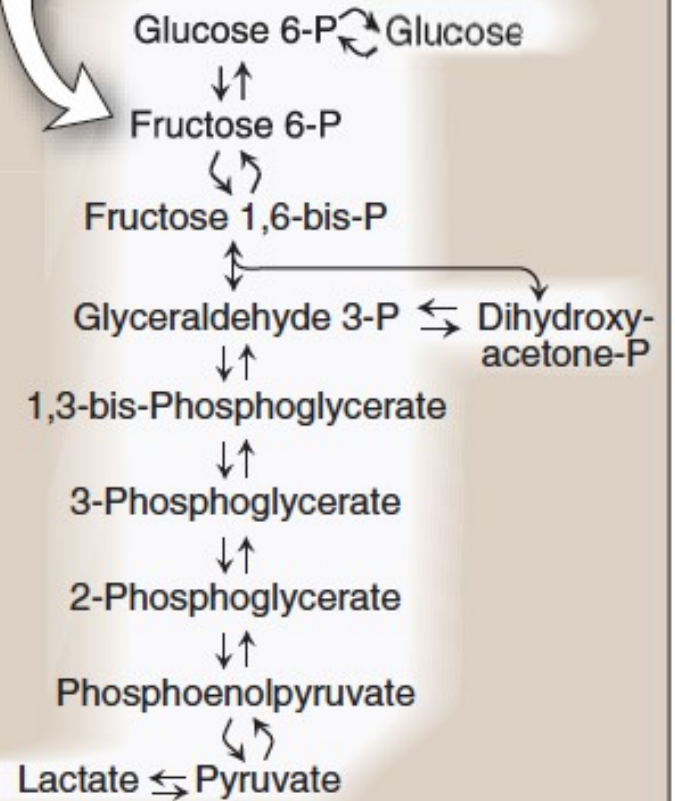
# PATHWAY VS CHEMICAL REACTION

## Metabolic Pathway

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

# GLYCOLYSIS IS A METABOLIC PATHWAY

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

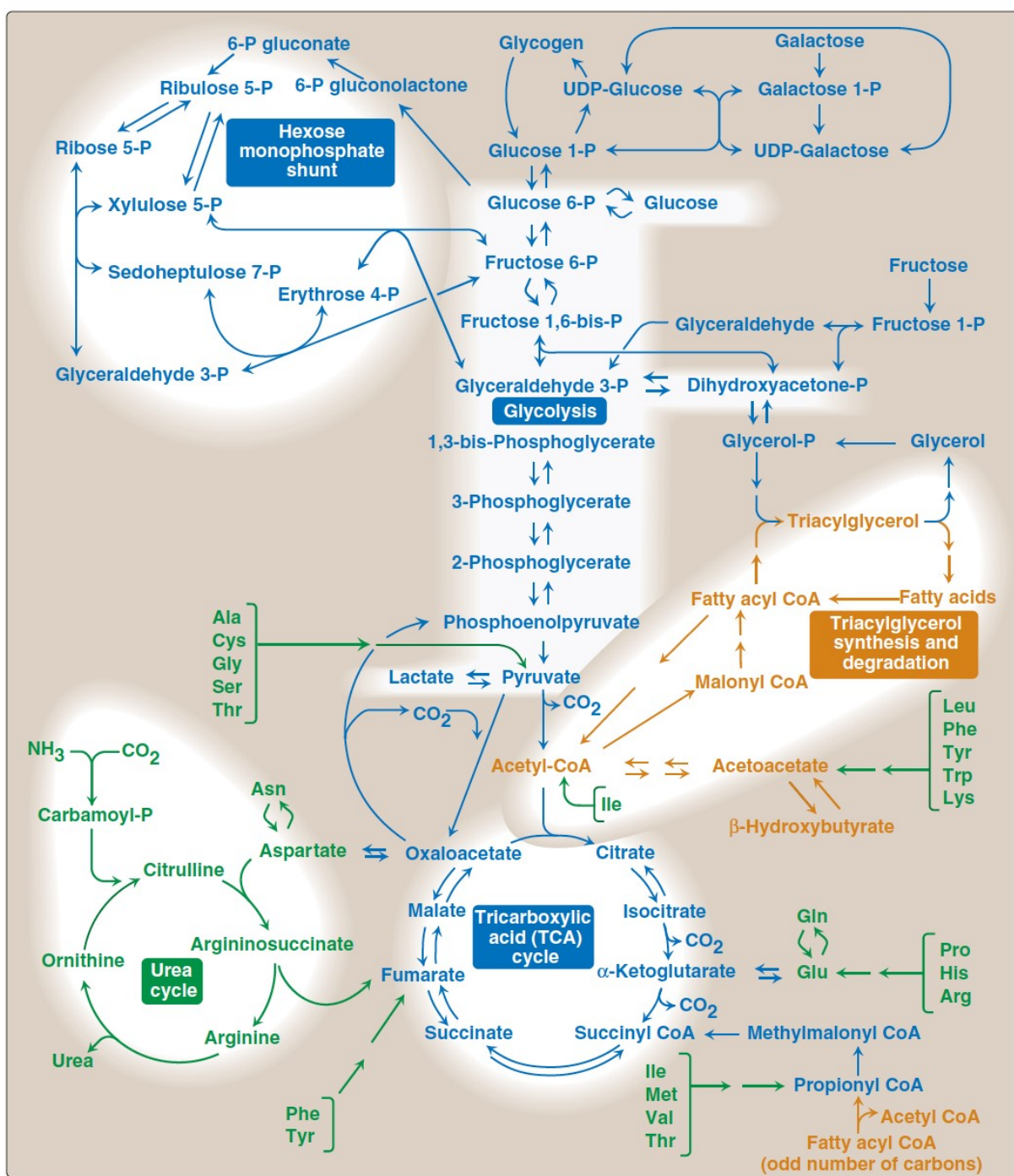


**Figure 8.1**

Glycolysis, an example of a metabolic pathway.

# METABOLIC MAP

- Different pathways can **intersect** to form an integrated and purposeful network of chemical reactions called "The Metabolic Map"



# CLASSIFICATION

- Most pathways can be classified as:
  - Catabolic
  - Anabolic
- Pathways that regenerate a component are called **cycles**



# CATABOLIC PATHWAYS

## Stage I:

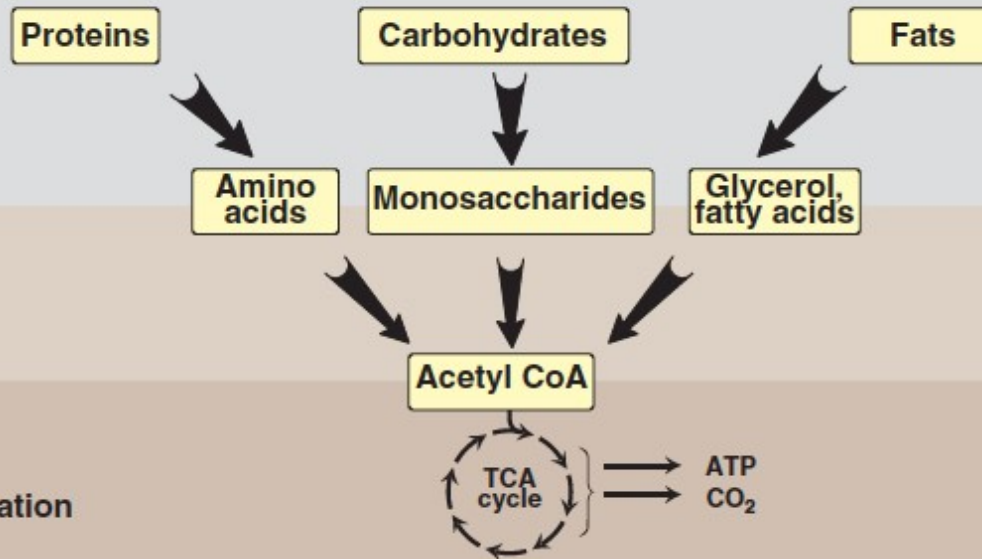
Hydrolysis of complex molecules to their component building blocks

## Stage II:

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

## Stage III:

Oxidation of acetyl CoA; oxidative phosphorylation



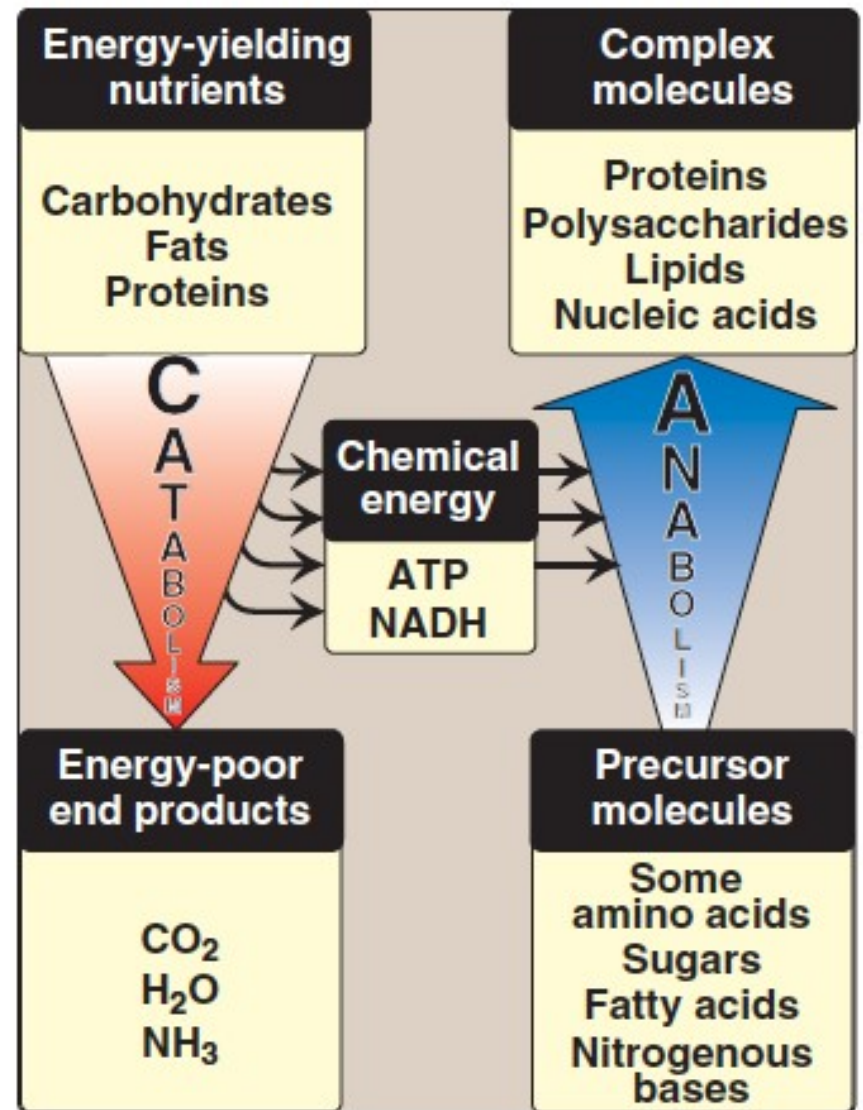
**Figure 8.3**

Three stages of catabolism.

# ANABOLIC PATHWAYS

- Formation of **precursor** molecules into **complex** molecules
- Endergonic reactions (require ATP)
- A **divergent** process (few precursors form more complex products)

# CATABOLISM VS ANABOLISM



**Figure 8.4**

Comparison of catabolic and anabolic pathways.

# COMPARISON OF CATABOLIC AND ANABOLIC PATHWAYS

## Anabolic

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

## Catabolic

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

# AMPHIBOLIC PATHWAYS

- **Amphi** means dual
- **Amphibolic**: Both catabolic and anabolic

Example:

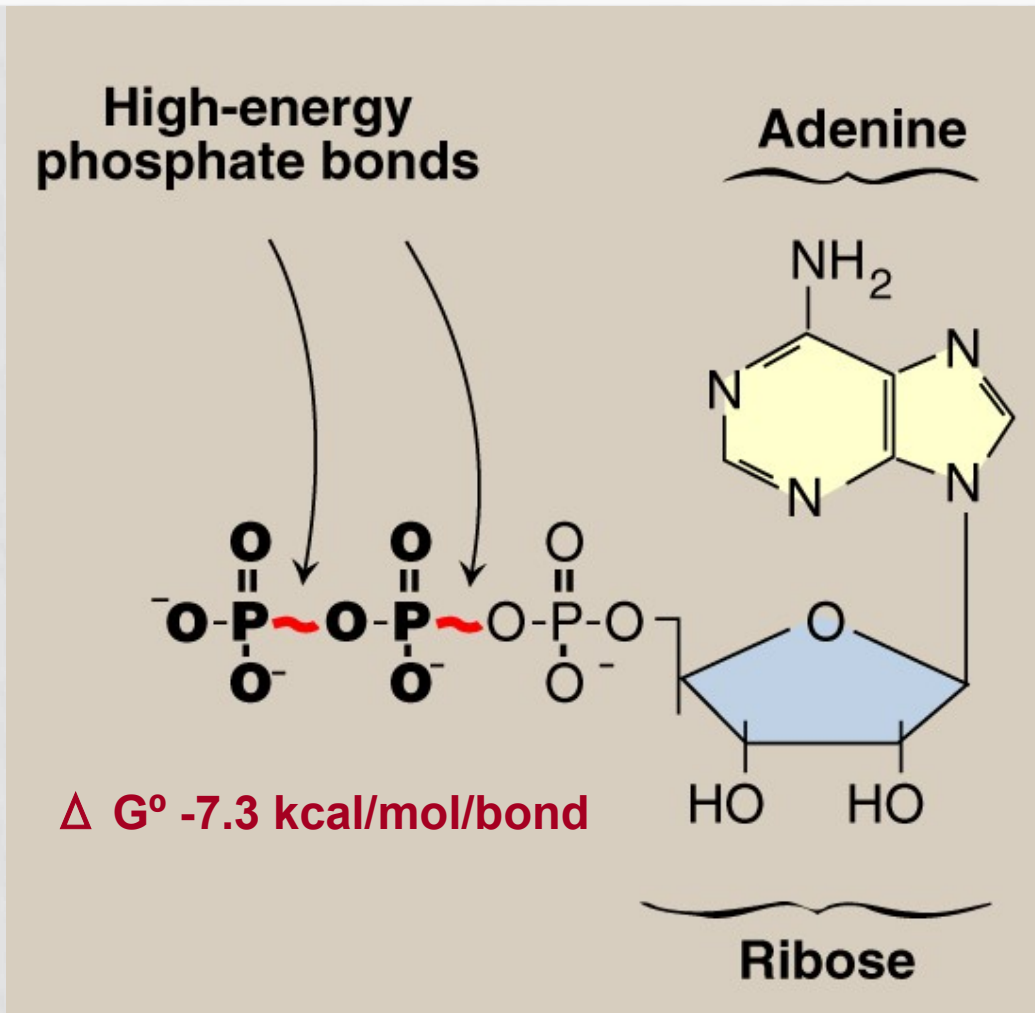
- Krebs cycle is mainly a **catabolic** cycle but with some **anabolic** features
- Krebs cycle is used for the synthesis of glucose from amino acids
- It is amphibolic

# ENERGY CURRENCY: ATP



- The free energy liberated by 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

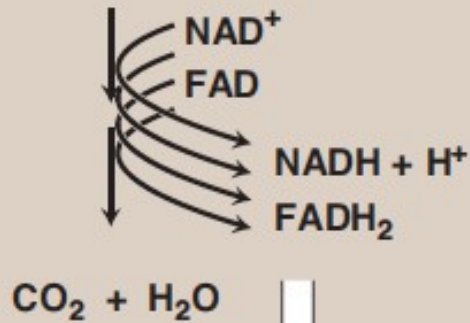
# ADENOSINE TRIPHOSPHATE (ATP)





## Metabolism

Carbohydrates  
Fatty acids  
Amino acids

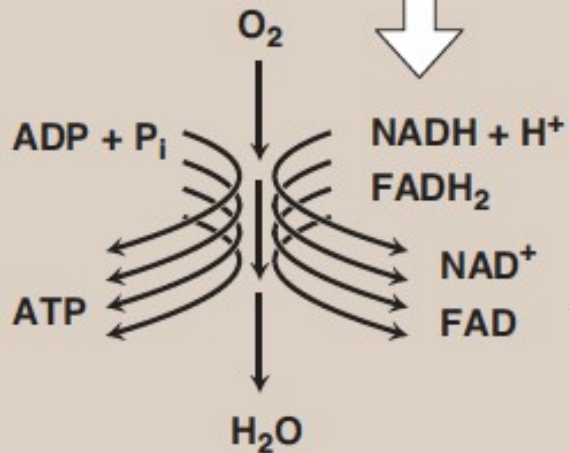


Energy rich  
compounds

Transfer of electrons

Energy-rich  
Reduced  
coenzymes

## Oxidation-Reduction in Metabolism



Oxidized  
coenzymes

## Oxidative phosphorylation



# OXIDATION / REDUCTION

## Oxidation:

Loss of hydrogen

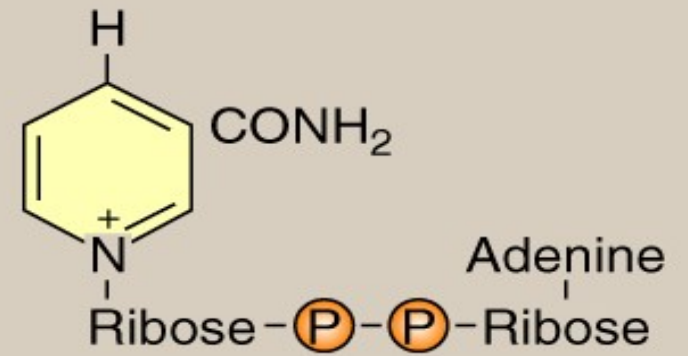
Loss of electrons

## Reduction:

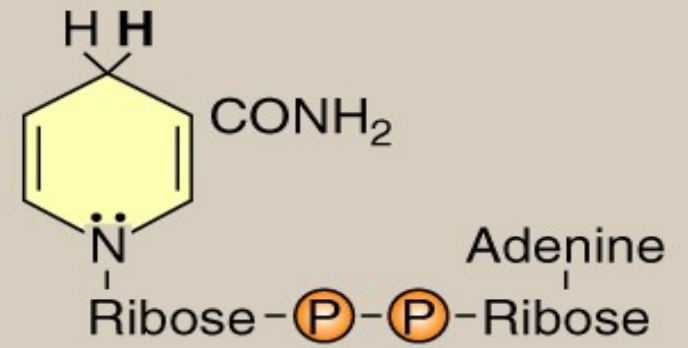
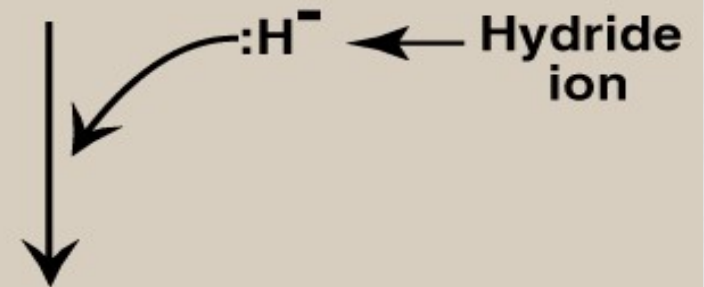
Gain of hydrogen

Gain of electrons

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



**NAD<sup>+</sup>**



**NADH**

# REGULATION OF METABOLISM

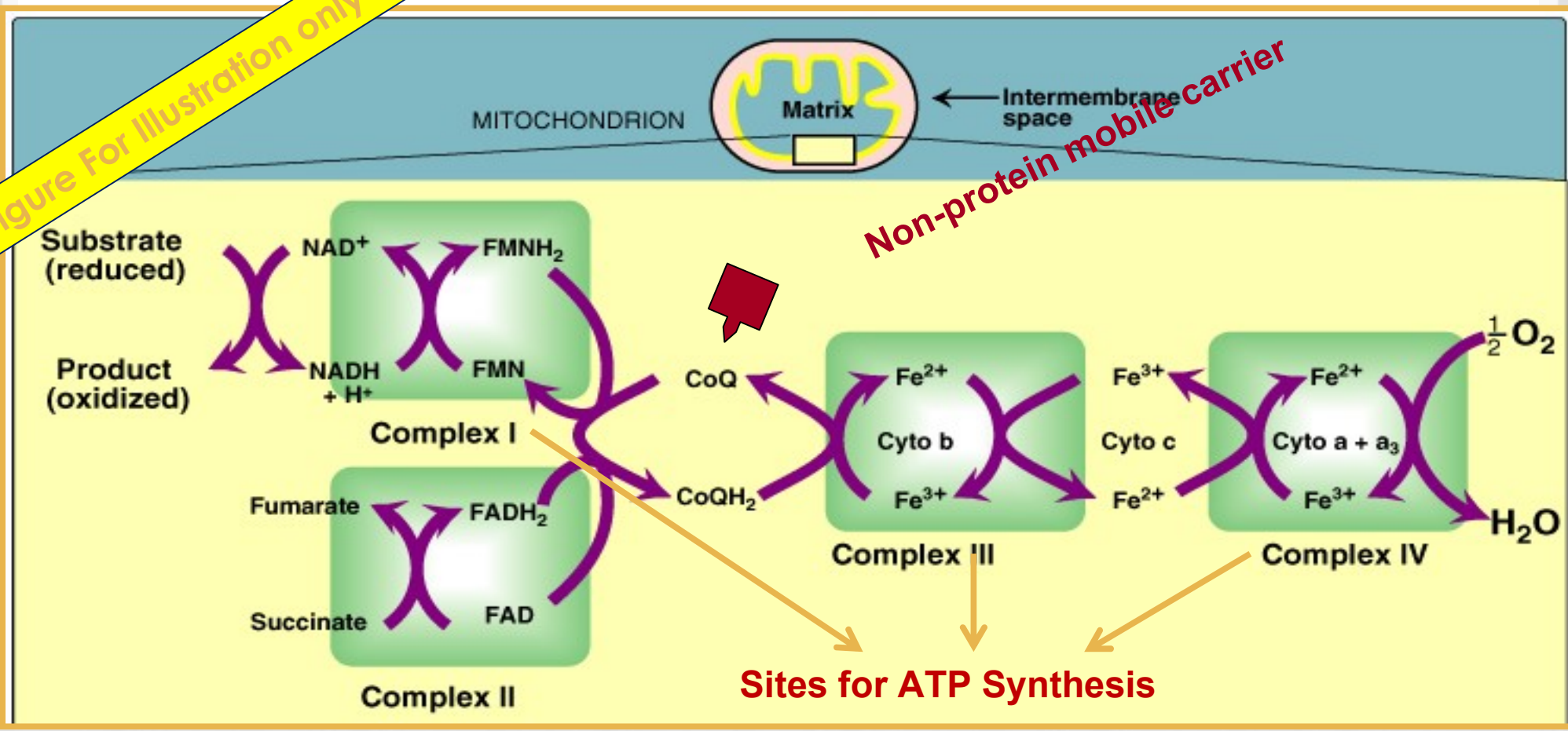
- **Intracellular signals:**
  - Substrate availability
  - Product inhibition
  - Allosteric activators or inhibitors
- **Intercellular communications:**
  - Chemical signaling (hormones):  
Second messenger
    - cAMP, cGMP
    - $\text{Ca}^{++}$ /phosphatidylinositol

# METABOLIC FUEL

- Carbohydrates and lipids (**mainly**) and proteins (**little extent**) are used for energy production
- **Glucose** and **fatty acids** are a **major** source of energy
- **Amino acids** are a **minor** source of energy
- Glucose is the major metabolic fuel of most tissues

# ELECTRON TRANSPORT CHAIN (ETC)

Figure for illustration only



Electron transport and ATP synthesis are tightly coupled processes

# 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

# REFERENCES

- Lippincott's Illustrated Reviews, Biochemistry, 5th edition, Denise R. Ferrier, Lippincott Williams & Wilkins, USA, pp 91-94.