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Introduction To Metabolism

What is Metabolism?

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- Metabolism is a **network of metabolic /biochemical reactions.**
- Carried out in living cells.
- In a **well organized, integrated and regulated manner.**
- Related to various biomolecules viz
  - **Carbohydrates**
  - **Lipids**
  - **Proteins**
  - **Nucleoproteins**

- Metabolism involves **interconversions of chemical compounds** in the body.

- **Metabolite precursors** are transformed to **end products** via many **specific intermediates.**

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- **Metabolism is the sum of the chemical changes that convert:**
  - **Nutrients into energy.**
  - Chemically **complex substances** of cells into **simpler forms.**
  - Chemically **simple substances** into functional **complex biomolecules.**

The Sun is Energy for Life

- **Phototrophs (Plants)** use light to drive synthesis of organic molecules.
- **Heterotrophs (Animals)** use these as building blocks.
- CO2,O2 and H2O are recycled.

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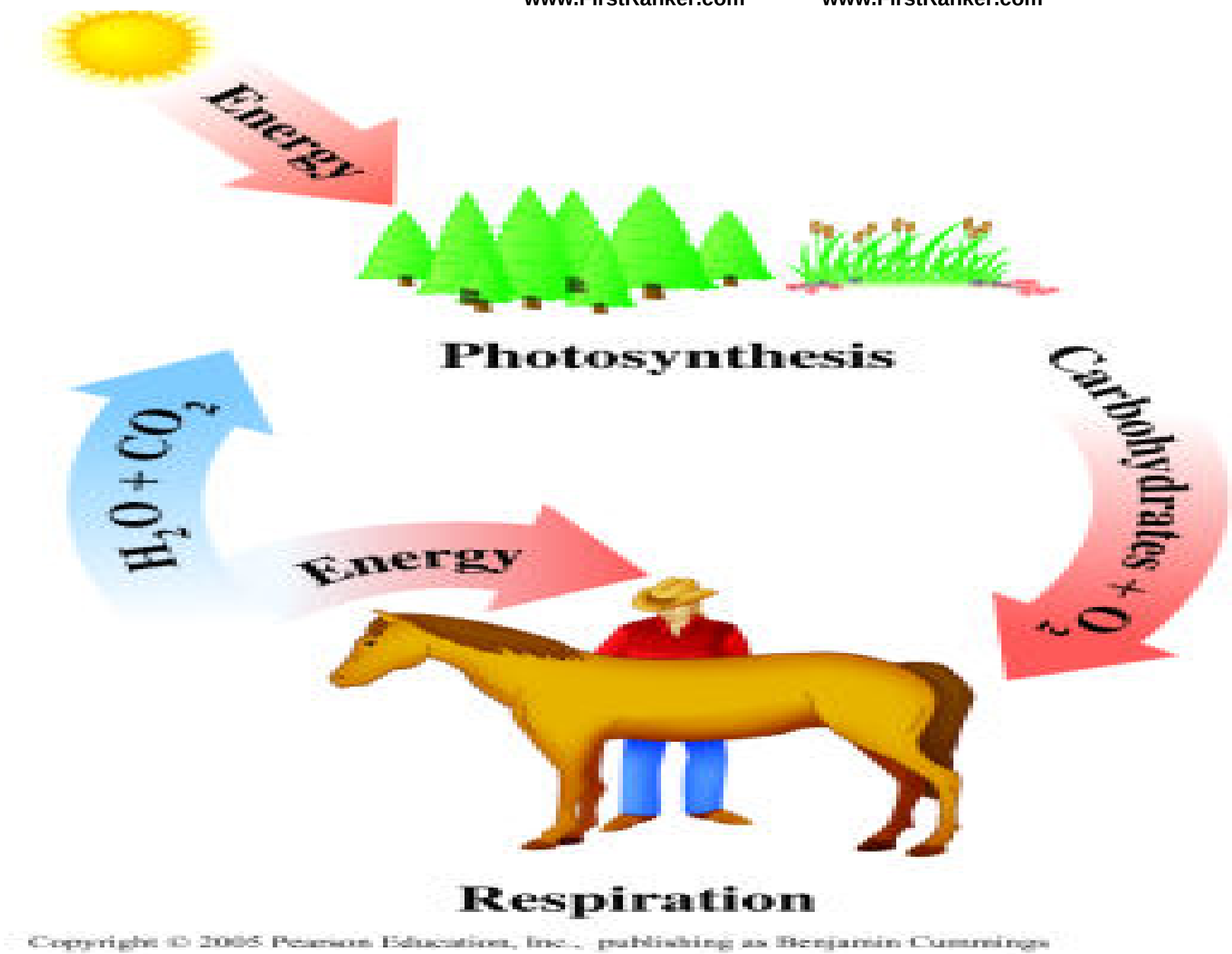

Importance Of Metabolism

- Normal Metabolism is vital for **health, growth, reproduction and good survival of human beings.**

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Role of Enzymes and Hormones in Metabolism

- **Enzymes along with Coenzymes biocatalyze specific metabolic reactions.**

- Thus Enzymes **are "Functional units of Metabolism"**

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- **Hormones are** chemical messengers of human body. They are **regulators of Enzyme activity.**

  (Hormones Stimulate/Inhibit Enzyme activity)

- **Enzyme** reactions are organized into **discrete pathways.**

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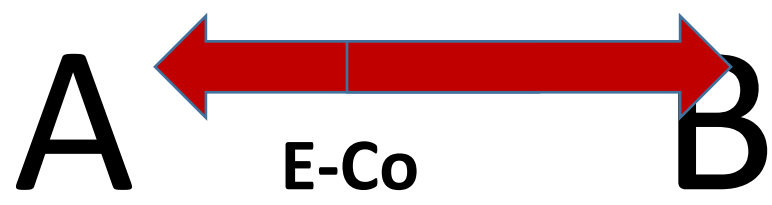
Metabolite

- Metabolite is a **substrate or a reactant** undergoing a biochemical/metabolic reaction.

Metabolic Reaction

- Metabolic reaction is a biochemical reaction where a metabolite is specifically reacted by an Enzyme and Coenzyme to give a product.



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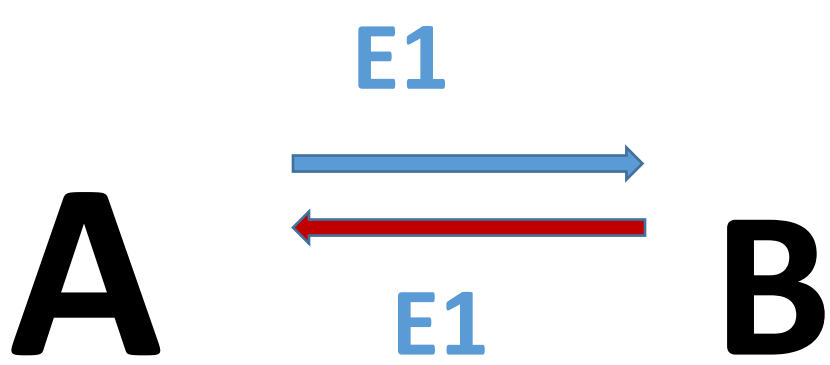
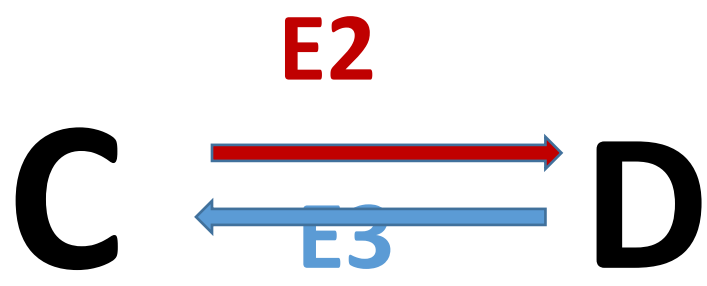
Types Of Metabolic Reactions

- **Reversible Reactions –** Same Enzyme is required.
- Not regulatory steps.



- **Irreversible Reactions-**
  - Different set of Enzyme required.
  - Non equilibrium Reactions.
  - **Regulatory steps.**



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Types Of Biochemical Reactions

- **Oxidation/Dehydrogenation/Hydroxylation**
- **Reduction**
- **Hydrolytic**
- **Carboxylation**
- **Decarboxylation**

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- **Phosphorylation**
- **Dephosphorylation**
- **Amination**
- **Deamination**
- **Isomerization**
- **Hydration**
- **Dehydration**

Metabolic Pathway

- Metabolic pathway is a **series of well defined and significant biochemical reactions** followed one after another giving **intermediate products** and finally **end product** of the pathway.

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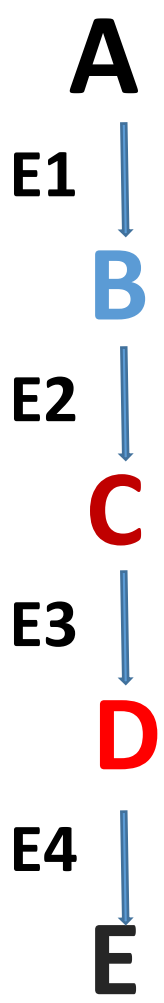

Precursor of the pathway (A)

Intermediates of the pathway (B,C,D)

End Product of the pathway (E)

Organization of Pathways

- Pathways consist of sequential steps.
- The enzymes may be **separate.**
- May form a **multienzyme complex.**
- May be a **membrane-bound system.**
- New research indicates that **multienzyme complexes are more common** than once thought.

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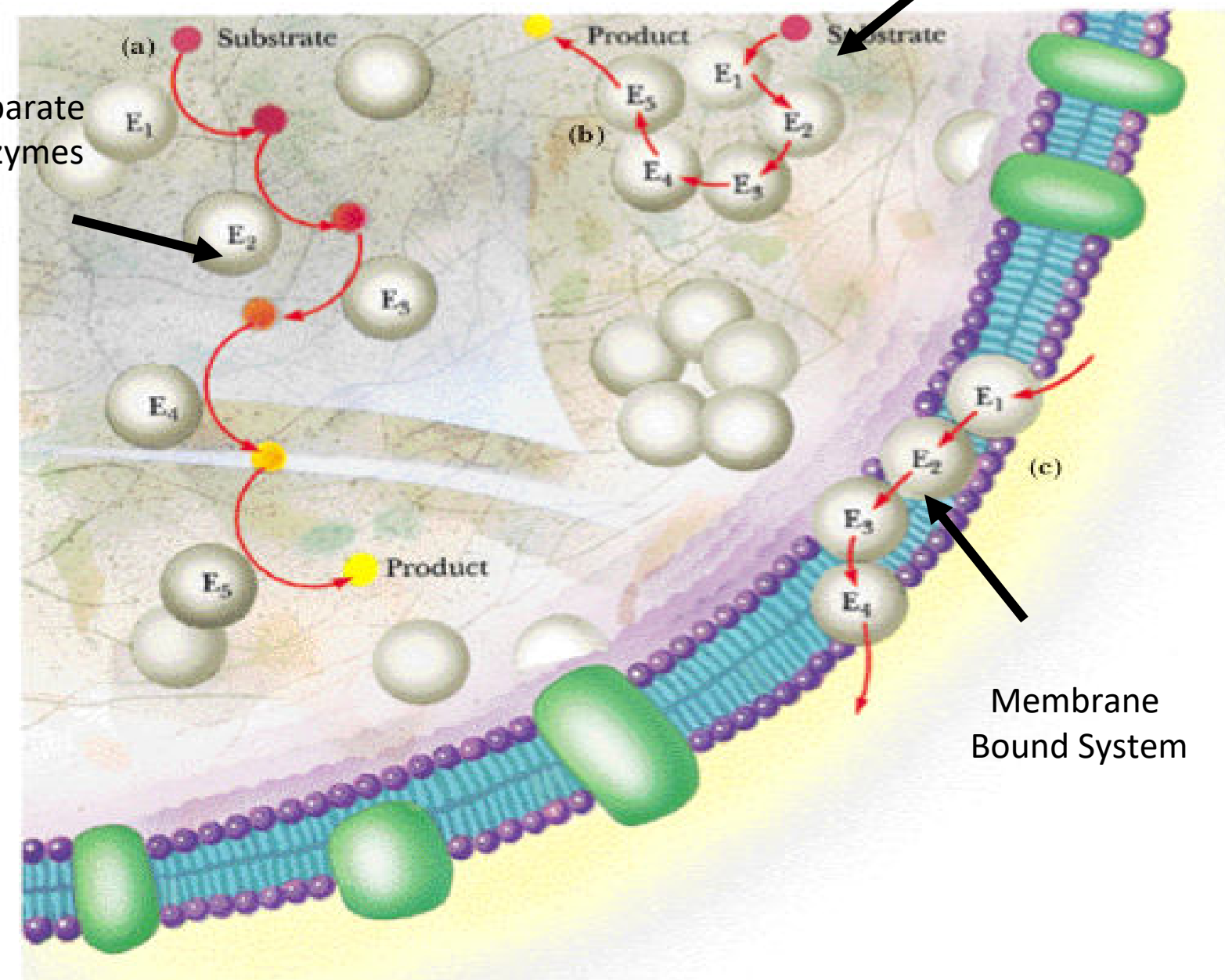
Mutienzyme complex

Separate enzymes



Organization of Pathways

Closed Loop
(intermediates recycled)

Linear
(product of rxns are substrates for subsequent rxns)

Spiral
(same set of enzymes used repeatedly)

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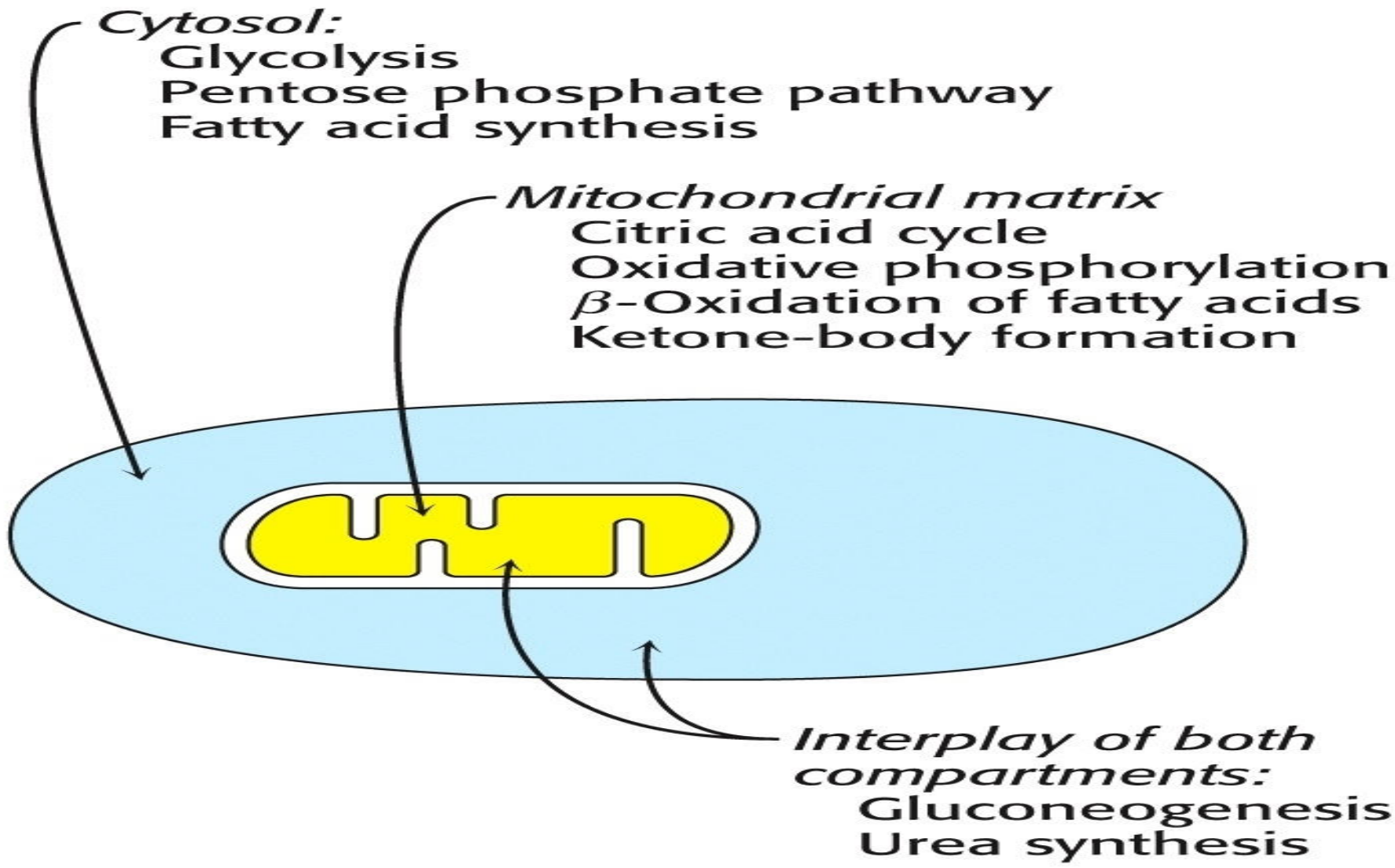
Compartmentalization Of Metabolic Pathways



- Compartmentalization of pathways permits integration and regulation of metabolism.

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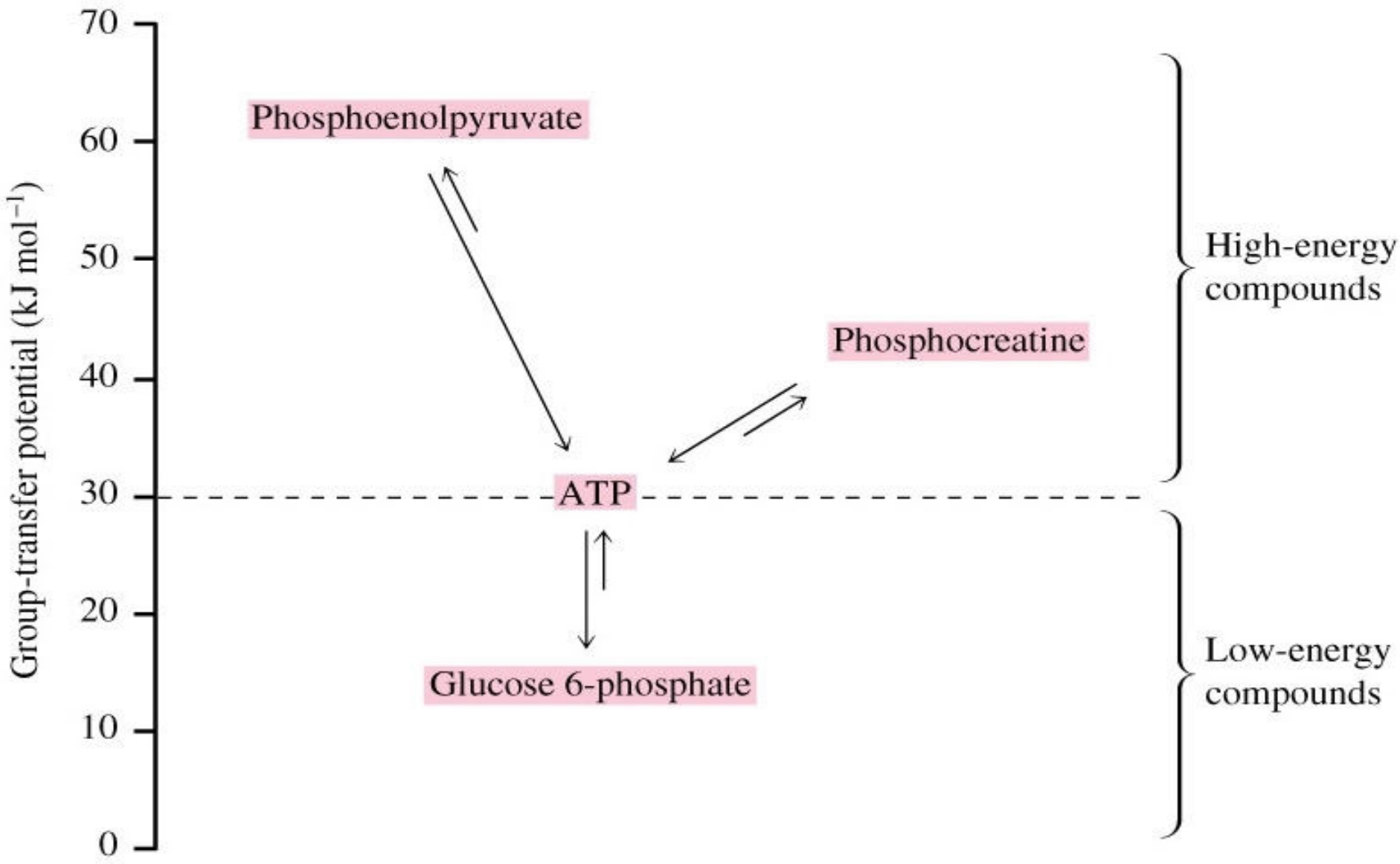
Phosphoryl-group Transfer



Types Of Metabolic Pathway

- **Catabolic**/Degradative /Energy Generating/ATP producing Pathways/Exothermic.

- **Anabolic**/Synthetic/Energy Utilizing/ ATP Using Pathways/Endothermic.

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- Catabolic pathways involve oxidative reactions producing reducing equivalents- **$NADH+H^+$ and FADH2.**
- Catabolic pathways converge to few end products.

- Anabolic **pathways diverge to synthesize many biomolecules.**

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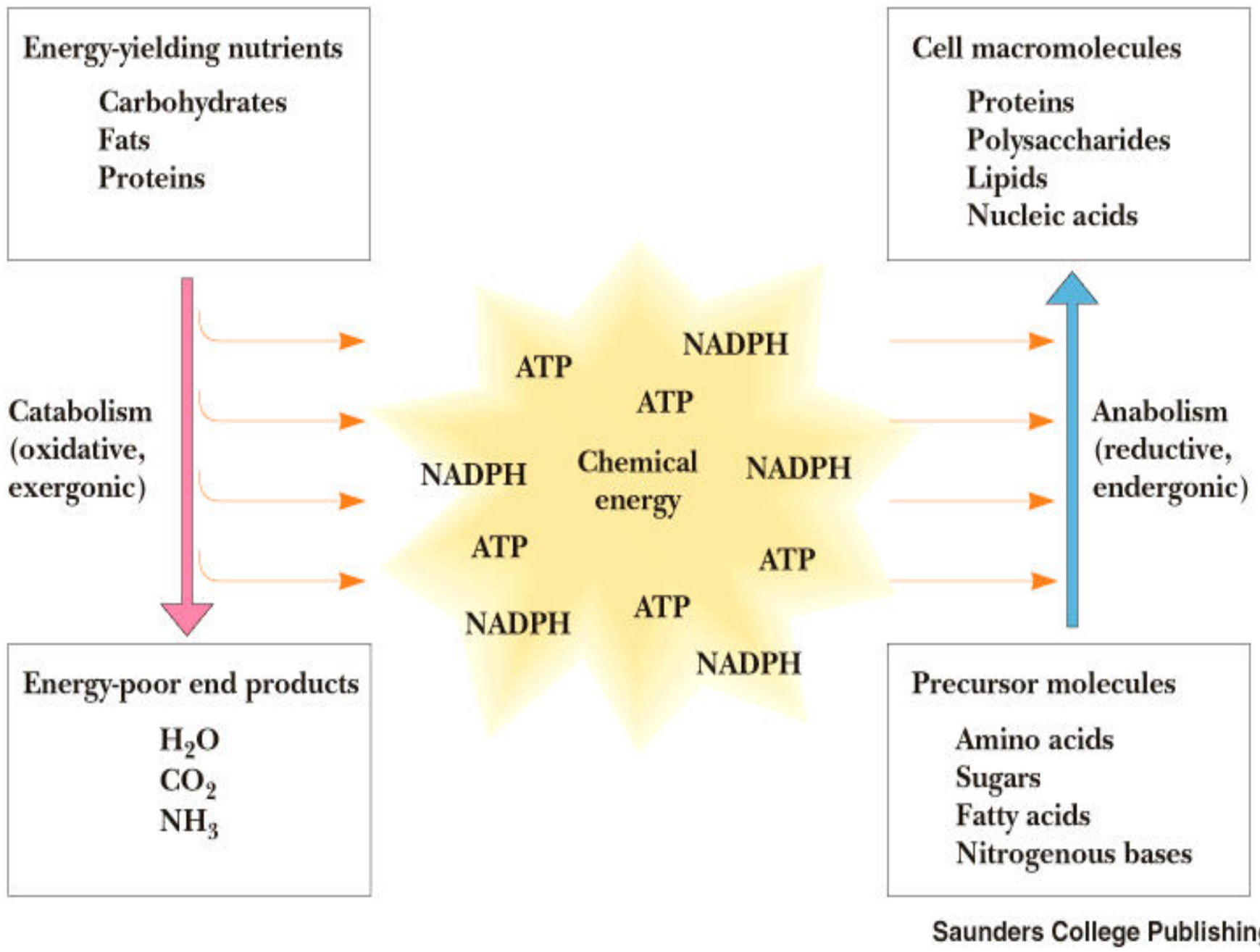
Figure 18.4



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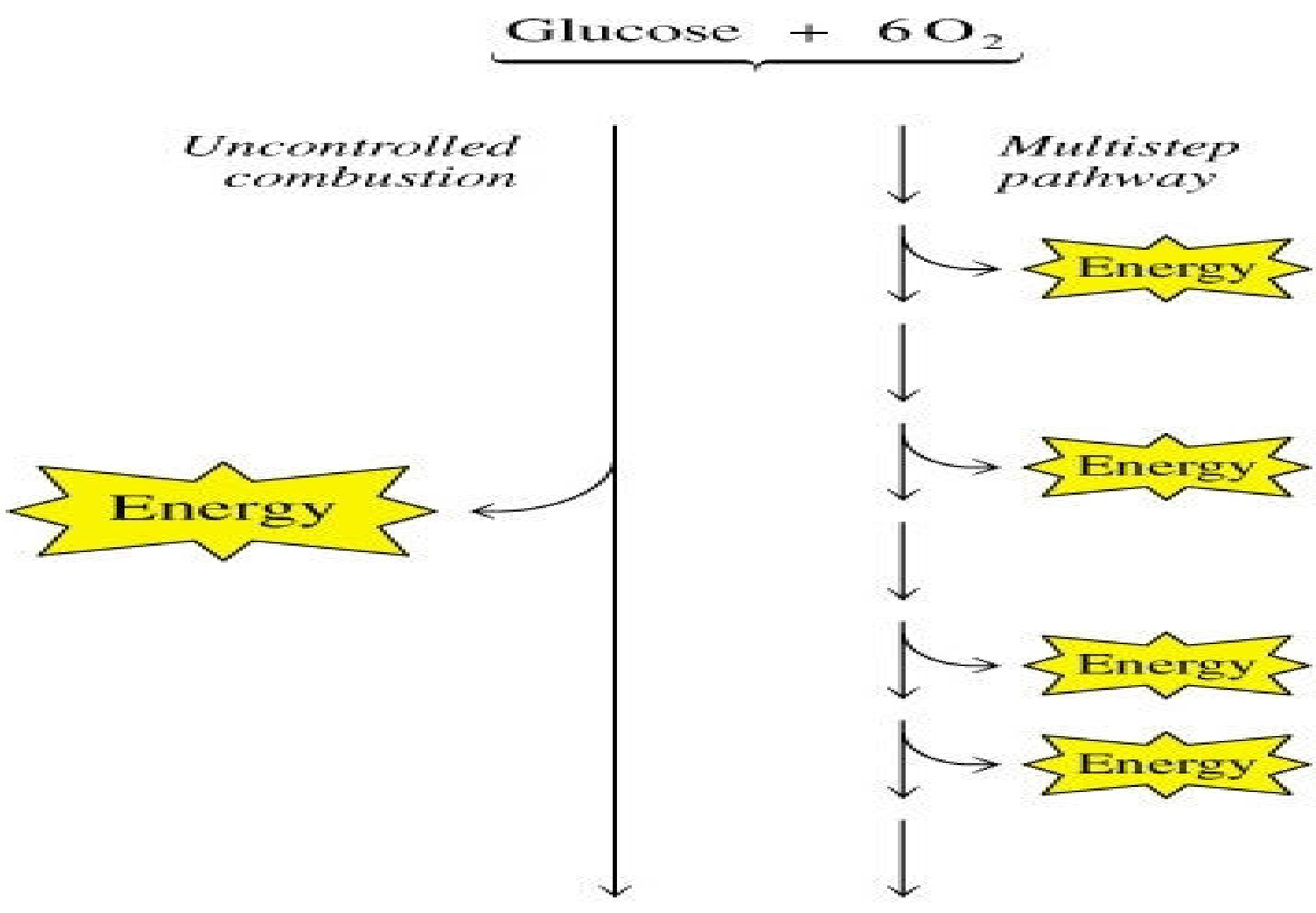

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- Some pathways serve both in catabolism and anabolism ,those are **Amphibolic pathways.**

- **Amphibolic Pathways** occur at the **crossroads of metabolism.**

- **Amphibolic pathways links** between **Anabolic and Catabolic pathways.**

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Regulation of Metabolic Pathways

- Regulation means **stimulation and inhibition of pathways** as per cellular need.
- **Hormones regulate** the metabolic pathways.
- Metabolic pathways are regulated to allow the organism to **respond to changing conditions.**

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- Every **metabolic pathway** has its **specific regulatory enzymes/key enzymes.**

- **Hormones regulate** by either stimulating /inhibiting the **regulatory/key enzymes** of the pathway.

Modes Of Metabolic Regulation

- **Allosteric regulation**
- **Covalent modification**
- **Control of enzyme levels**
- **Compartmentalization**
- **Metabolic specialization of organs**

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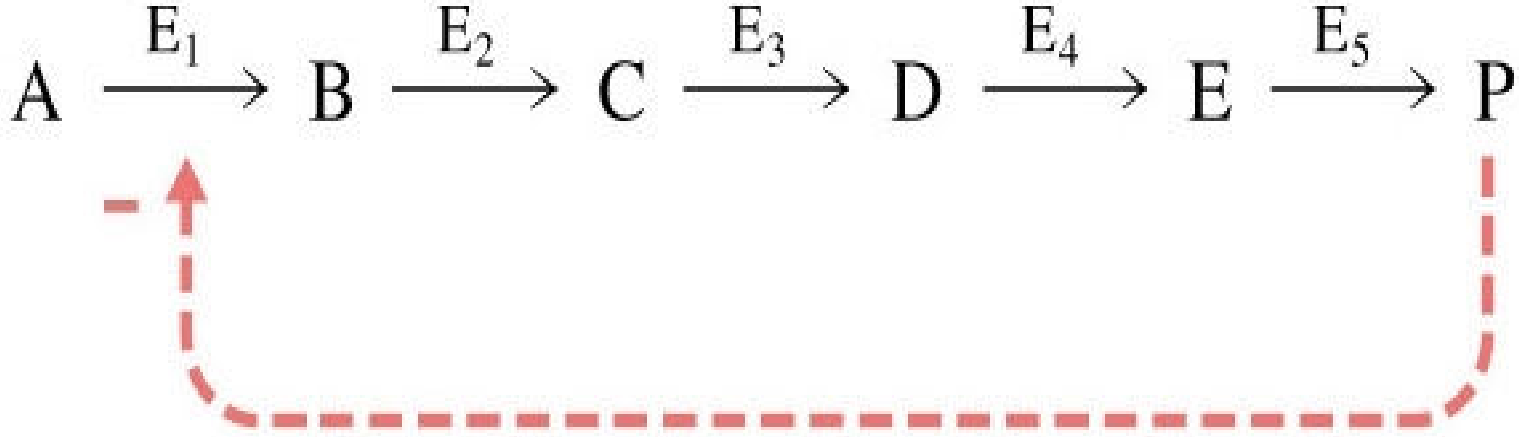
- **Feedback inhibition** – product of pathway down regulates activity of early step in pathway



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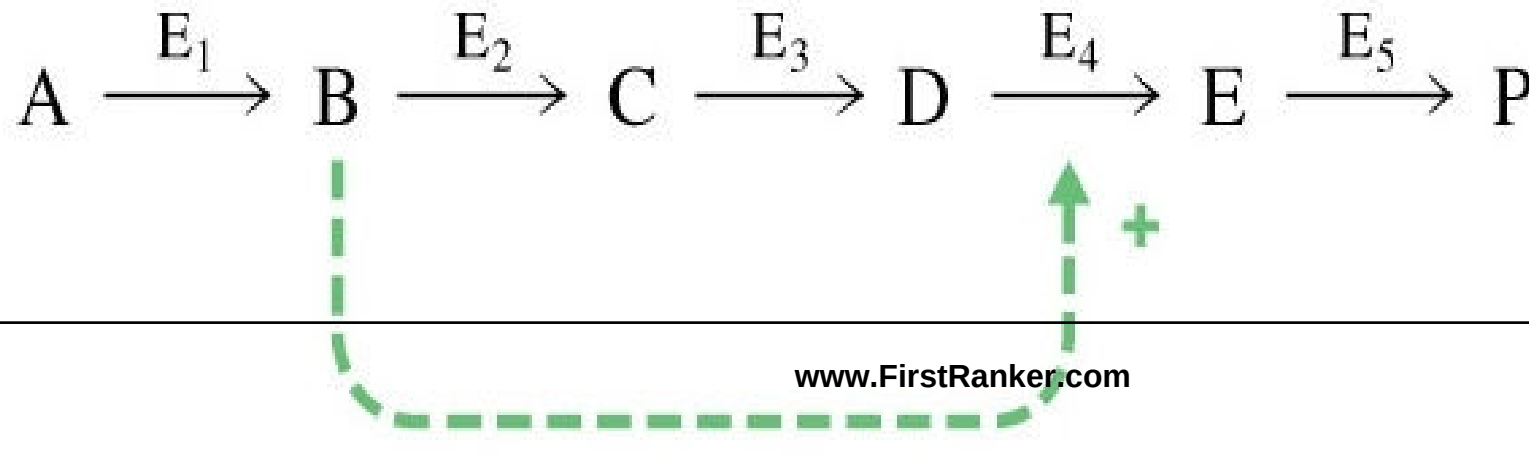
- **Feedforward activation** – metabolite produced early in pathway activates down stream enzyme



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Regulating Related Catabolic and Anabolic Pathways

- **Anabolic & catabolic pathways** involving the **same compounds** are **not the same**.
- **Some steps** may be **common to both**
- **Others** must be **different** - to ensure that each pathway is spontaneous.
- This also **allows regulation** mechanisms to turn **one pathway onn and the other off.**

Modes Of Enzymes Regulation

- Alteration in membrane permeability.
- Conversion of Inactive to Active form.
- Stimulation of mRNA translation.
- Induction of new mRNA formation.
- Repression of mRNA formation.

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- **Knowledge of normal metabolism is essential for :**
- Understanding adaptations of
  - **Starvation**
  - **Exercise**
  - **Pregnancy and lactation.**
- Understanding of metabolic disorders.

Abnormal Metabolism Is Due To

- Nutritional Deficiencies
- Enzyme Defects
- Hormonal Defects
- Drug and Toxin Interactions

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- **Normal Enzyme** and **Hormonal** activities gives **normal metabolism** and health to human body.
- **Defect in Enzymes** and **Hormones derange the normal metabolism**.

Derangement in Metabolism

- Any defect or derangement in normal pattern of metabolism leads to **metabolic disorders.**
- **Mutation in Genes** of Enzymes, forms defective Enzymes.
- Congenital defect of Enzyme leads to **Inborn Error Of Metabolism.**

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Inborn Error Of Metabolism

- **Congenital deficiency** of any single **Enzyme** of a metabolic pathway leads to **Inborn Errors of Metabolism.**

Enzyme Deficiency of a Metabolic Pathway

- **Blocks** the **metabolic reaction.**
- **Blocks** the **metabolic pathway.**
- **Accumulates** and **excrete intermediate product** of the pathway.
- **No formation** of **end product** of the pathway.
- **Affects** other **interrelated** metabolic **pathways.**

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Methods Used to Study Metabolism

- **Metabolic Reactions/Metabolic Pathways were studied :**
  - **Using whole organism/Cellular fractions**
  - **Using Metabolic Probes.**
  - **Using Radioisotopes.**

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