Enzymes and Metabolic Pathways

Today’s Topics
• Enzyme Regulation
  – Competitive
  – Allosteric
• Oxidation and Reduction
• Catabolic and Anabolic Reactions
• Start Glycolysis

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Principal Ways of Regulating Enzymes

• Competitive Inhibition
• Allosteric Inhibition
• Covalent Modification (phosphorylation)

Competitive Inhibitors:
• bind to active site "unproductively" and block true substrates’ access

S & I bind to same site

“other” “site”
Allosteric Inhibitors
distort the enzyme so the substrates no longer fit

(Can also have Positive Regulators that help the enzyme work Better)

Covalent regulators:
Phosphorylation

Depends on relative concentration
Optimal conditions can vary for different enzymes.

Enzymes control metabolic pathways. Each step catalyzed by a different enzyme.

Feed back loops:

Your cells harvest energy from glucose in small steps:

Sometimes an electron is only partially lost or gained:

If one thing gets oxidized, another becomes reduced:

- Reduced compound A (reducing agent) becomes oxidized.
- Oxidized compound A (oxidizing agent) becomes reduced.
- Reduced compound B (reducing agent) becomes oxidized.
- Oxidized compound B (oxidizing agent) becomes reduced.

Reactants:
- CH₄ + 2O₂ → CO₂ + Energy + 2 H₂O
- Methane (reducing agent) + Oxygen (oxidizing agent) → Carbon dioxide + Water

Change the degree of electron sharing in covalent bonds.

Sometimes a bond is only partially broken or formed.
Oxidation, Reduction, and Energy

Most reduced state
Highest free energy

Methane (CH₄)

Most oxidized state
Lowest free energy

Highly oxidized

Methanol (CH₃OH)

Formaldehyde (CH₂O)

Formic acid (HCOOH)

Carbon dioxide (CO₂)

Oxidation Series of Carbon

Saturated Hydrocarbon

Unsaturated Hydrocarbon

Alcohol

Carbonyl

Carboxylic Acid

Carbon Dioxide

Highly reduced

How is energy harvested upon oxidation?

• **Direct ATP production**
  - "Substrate Level Phosphorylation"

  ![Phosphorylation Process](image)

• **Electron Carriers**
  - NAD, NADP, FAD
  - Can "cash in" reduced carriers for ATP
  - "Oxidative Phosphorylation"

Substrate-level Phosphorylation

![Substrate-level Phosphorylation](image)

NAD⁺ is an electron carrier
(see also NADP⁺ and FAD)

![NAD oxidation](image)
NAD+/NADH Is an Electron Carrier

Glycolysis: A catabolic pathway
Note: Starches are first digested to glucose. (No energy harvested)

General Catabolic Pathway
- Step down the oxidation series of carbon in a series of Discrete Steps
  - Some activation step
  - Oxidation step, with energy harvest
  - Reorganization step
  - Another oxidation step, another harvest
  - Another reorganization etc. etc.
  - Yield product of pathway

Glycolysis Summary

What goes in?
What comes out?
Where does it occur?

Energy Investment phase
Energy Payoff phase