# Introduction to Metabolism

Required reading in Horton: 10.1-10.5. Nelson: 13.1 Bioenergetics and Thermodynamics.

**Key Points**

* Catabolism
* Anabolism
* Glycolysis
* Fatty acid metabolism
* Citric acid (TCA, Krebs) cycle
* Electron transport
* Oxidative phosphorylation (ATP synthesis)

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| **Metabolic pathways are:**   1. Conserved in different organisms. 2. Overall irreversible (but most of the individual steps are not) 3. Consist of a number of small changes. 4. Usually committed after the initial steps 5. Regulated (usually at initial step(s)) 6. Compartmentalized in eukaryotes | **What you need to know:**   1. Input and output metabolites 2. Steps that control flux 3. How flux is controlled 4. Cellular location of metabolic Steps 5. Selected enzyme mechanisms 6. Selected substrates/products   **What you should not do**: Memorize pathways. |

**Catabolism [degradative]** – conversion of a diverse set of compounds to a small number of simple compounds for energy production.



**Anabolism [synthetic]** – conversion of a small number of simple compounds to complex organic molecules.

**Central Pathways of Energy Production:**

Intracellular locations:

* Glycolysis - cytosol
* Fatty Acid Oxidation: Inner matrix of mitochondria
* Citric Acid Cycle: Inner matrix of mitochondria
* Oxidative Phosphorylation: Inner membrane of mitochondria

**Energy Currency:**

Stored in the following ways:

* "High energy" chemical species (i.e. phosphoanhydride bonds in ATP):



* Redox compounds
* Membrane potentials (concentration gradient and voltage difference)

**Energy Utilization:**

* Chemical synthesis reactions (e.g. protein synthesis, DNA synthesis
* Mechanical work (e.g. transport, muscle function)
* Electrical work (e.g. nerve conduction)

**Overall Energy Interconversion During Oxidation of Glucose:**



Overall Reaction: C6H12O6 + 6 O2 → 6CO2+6 H2O + Energy (ATP) ΔGo = -2823 kJ/mol

Glycolysis + Citric Acid Cycle: C6H12O6 + 6H2O → 6CO2 + 24H+ + 24 e- + 4ATP

Electron Transport (oxidative phosphorylation): 24 e- + 6O2 +24 H+ →12 H2O + proton gradient across membrane.

ATP synthesis: Proton gradient + ADP & Pi → ATP

(Enzyme is also called ATPase, reverse reaction was 1st studied.)



**General Enzyme Nomenclature:**

Name - usually consists of three parts:

i) the substrate is used to name the enzyme,

Keep in mind that many enzymatic reactions run in both directions in metabolism, consequently the “product” may be used to name the enzyme.

ii) the nature of the chemical reaction.

iii) most names end in *“-ase”*

**Enzymes Involved in Group Transfer Reactions:**

**A. Phosphatase**: Removes a phosphate group from a substrate, no ATP/ADP required. A phosphatase is distinct from an ATPase.

**B. Kinase**: transfers a phosphate group from ATP to another compound (i.e. hexokinase, galactose kinase, pyruvate kinase). A kinase is distinct from an ATPase

**C. Mutase**: Common use is to move phosphates to different positions on sugars (i.e. phosphoglycerate mutase).

**D. Dehydrogenase**: Removes/adds hydrogens by oxidation/reduction. Usually require NAD+/NADH or FAD/FADH2 as co-factors/co-substrates).

**E. Isomerase**: converts one isomer to another (i.e. phosphoglucoisomerase, triose phosphate isomerase)

**F. Enolase**: converts C=C group to alcohol. No change in oxidation state.

**G. Synthase**: Usually an enzyme that combines two things to make a new compound.