Lecture 27: Introduction to Metabolism

Key Points
- Catabolism
- Anabolism
- Glycolysis
- Fatty acid metabolism
- Citric acid (TCA, Krebs) cycle

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

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 (TCA): Inner matrix of mitochondria
- Oxidative Phosphorylation: Inner membrane of mitochondria

Energy Transactions: Organic compounds (e.g. glucose) → Electron Carriers → Proton Gradient → ATP

Energy Utilization:
- Chemical synthesis reactions (e.g. protein synthesis, DNA synthesis)
- Mechanical work (e.g. transport, muscle function)
- Electrical work (e.g. nerve conduction)
Systematic Nomenclature (Enzyme Commission)
For example, the tripeptide aminopeptidases have the code "EC 3.4.11.4", whose components indicate the following groups of enzymes:
- **EC 3** enzymes are hydrolases (enzymes that use water to break up some other molecule)
- **EC 3.4** are hydrolases that act on peptide bonds
- **EC 3.4.11.4** are those hydrolases that cleave off the amino-terminal amino acid from a polypeptide
- **EC 3.4.11.4.4** are those that cleave off the amino-terminal end from a tripeptide

Common Names:
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"

A. **Phosphatase**: Removes a phosphate group from a substrate, via hydrolysis – no ATP/ADP involved. e.g. glucose-6-phosphatase.
B. **Kinase**: transfers a phosphate group from ATP to another compound e.g. hexokinase.
C. **Dehydrogenase**: Removes/adds hydrogens by oxidation/reduction. Usually require NAD⁺/NADH or FAD/FADH₂ as co-factors/co-substrates. e.g. succinate dehydrogenase.

Biochemical Energetics:
1. **Phosphate Hydrolysis**:

2. **Electrons (Redox Chemistry)**
An example of a redox reaction involving inorganic metals: \( \text{Fe}^{3+} + \text{Cu}^+ \leftrightarrow \text{Fe}^{2+} + \text{Cu}^{2+} \)
This reaction can be broken down into two balanced half reactions:
- \( \text{Fe}^{3+} + \text{e}^- \leftrightarrow \text{Fe}^{2+} \)
- \( \text{Cu}^+ \leftrightarrow \text{Cu}^{2+} + \text{e}^- \)
In this case the iron is reduced from the 3⁺ state to the 2⁺ state while the copper is oxidized from the 1⁺ state to the 2⁺ state.
In biological oxidations and reductions the electrons are often carried by protons (i.e. hydrogen atom). Thus a general rule for oxidation-reduction are:
- **Loss of electrons or hydrogen atom (H⁺ + e⁻) = oxidation**
- **Gain of electrons or hydrogen atom = reduction**