



PHARMACOLEARN

It's Important to Know!

BP203T — Biochemistry

B.Pharm Semester 2 · Unit 2 — Bioenergetics and Biological Oxidation

Unit II: Bioenergetics and Biological Oxidation

This unit explains how cells capture, transfer and use energy. Learn the meaning of free energy, oxidation-reduction reactions, high-energy compounds, the electron transport chain and oxidative phosphorylation.

Bioenergetics

Bioenergetics is the study of energy changes in biological systems. A reaction with a negative change in Gibbs free energy is thermodynamically favourable under the stated conditions. ATP couples energy-releasing reactions to energy-requiring reactions.

ATP contains phosphoanhydride bonds. ATP hydrolysis can provide energy for biosynthesis, active transport and mechanical work. ATP is continually formed and used rather than stored as a large long-term energy reserve.

Oxidation-reduction reactions

Oxidation is loss of electrons or hydrogen, or gain of oxygen. Reduction is gain of electrons or hydrogen, or loss of oxygen. Oxidation and reduction occur together in a redox reaction.

NAD⁺ and FAD are important electron carriers. NADH and FADH₂ transfer reducing equivalents to the respiratory chain. The exact ATP yield per molecule of NADH or FADH₂ depends on the accounting convention and shuttle assumptions, so use the value specified by the teacher or examination scheme.

Biological oxidation and the electron transport chain

The electron transport chain is located in the inner mitochondrial membrane in eukaryotic cells. Electrons pass through protein complexes and mobile carriers to molecular oxygen, which is reduced to water. Energy released during electron transfer pumps protons across the inner membrane.

The proton gradient stores electrochemical energy. ATP synthase uses proton movement back across the membrane to form ATP from ADP and inorganic phosphate. This process is called oxidative phosphorylation.

Electron transport chain in order

1. Complex I, NADH dehydrogenase, accepts electrons from NADH and transfers them to ubiquinone. It pumps protons.
2. Complex II, succinate dehydrogenase, accepts electrons from succinate through FADH₂ and transfers them to ubiquinone. It does not pump protons.
3. Ubiquinone, also called coenzyme Q, is a mobile lipid-soluble carrier that transfers electrons to Complex III.
4. Complex III, the cytochrome bc₁ complex, transfers electrons from ubiquinol to cytochrome c and pumps protons.
5. Cytochrome c is a mobile carrier that transfers electrons from Complex III to Complex IV.
6. Complex IV, cytochrome c oxidase, transfers electrons to oxygen and forms water. It pumps protons.
7. ATP synthase, sometimes called Complex V, uses the proton-motive force to phosphorylate ADP.

ATP yield accounting

This draft uses the modern convention of approximately 2.5 ATP per mitochondrial NADH and 1.5 ATP per FADH₂. Complete oxidation of one glucose is therefore approximately 30 to 32 ATP, depending on the cytosolic NADH shuttle. Older textbooks may use 3 ATP per NADH and 2 ATP per FADH₂ and report a higher total. State the convention in a numerical answer.

High-energy compounds

High-energy compounds have hydrolysis reactions with a large negative free-energy change under cellular conditions. ATP, phosphocreatine and some thioesters are examples. Their role is to transfer or provide energy for cellular work.

Unit II: Frequently asked questions

Q: What is oxidative phosphorylation?

A: It is the formation of ATP linked to electron transfer through the respiratory chain. The chain creates a proton gradient, and ATP synthase uses that gradient to make ATP.

Q: What is the role of oxygen in aerobic respiration?

A: Oxygen is the terminal electron acceptor in the mitochondrial respiratory chain. It combines with electrons and protons to form water.

Q: What is the difference between oxidation and reduction?

A: Oxidation is loss of electrons or hydrogen, while reduction is gain of electrons or hydrogen. They occur together in redox reactions.

Q: Which electron transport complexes pump protons?

A: Complexes I, III and IV pump protons. Complex II transfers electrons but does not pump protons.

Unit II: Key takeaways

- ATP couples energy release to cellular work.

- NADH and FADH₂ carry reducing equivalents.
- The respiratory chain establishes a proton gradient.
- ATP synthase uses proton flow to form ATP.
- Oxygen is the terminal electron acceptor in aerobic mitochondrial respiration.
- Complexes I, III and IV pump protons, while ubiquinone and cytochrome c are mobile carriers.

Unit II: Clinical correlation

Clinical correlation: ketosis. When carbohydrate use is limited and fatty acid oxidation increases, the liver produces ketone bodies. Accumulation of ketone bodies can lower blood pH in severe insulin deficiency.