

Lab-wide Learning Outcomes for Cellular Respiration Explored

Knowledge-Based Outcomes

Upon completion of *Cellular Respiration Explored*, students should be able to:

1. Identify where potential energy is stored during respiration, including glucose, ATP, NADH, FADH₂, and the proton gradient.
2. Identify processes in respiration where potential energy is transferred from one place to another, and draw a diagram showing the flow of energy between molecules or other stores of potential energy in each process (e.g., NADH → ETC → proton gradient → ATP).
3. Identify places in respiration where molecules are being oxidized or reduced (especially glucose oxidized to CO₂, and NAD⁺ reduced to NADH).

Cellular Respiration Explored, Part 1: Cellular Respiration: Food, Breath, Exercise

Knowledge-Based Outcomes

Upon completion of *Part 1: Cellular Respiration: Food, Breath, Exercise*, students should be able to:

1. Draw a diagram showing the four major processes occurring during respiration, their relationships, and the relative amounts (none, a little, lots) of ATP produced in each.
2. Name the molecules that bring high-energy electrons into the electron transport chain (NADH, FADH₂) and point to where they are produced (glycolysis, pyruvate processing, the citric acid cycle).
3. Describe the role of ATP in a cell as the energy source in many reactions, describe its relationship to ADP and phosphate, and explain why ATP has more potential energy than ADP.
4. Define reduction as gaining electrons and oxidation as losing electrons.
5. Write down and explain the overall glucose → CO₂ equation (glucose + 6 O₂ → 6 CO₂ + 6 H₂O), and identify that this reaction releases energy.
6. Avoid the misconception that energy is converted into matter.

Skills-Based Outcomes

Upon completion of *Part 1: Cellular Respiration: Food, Breath, Exercise*, students should be able to:

1. In a redox reaction, identify what has been oxidized and what has been reduced based on the movement of electrons.

Cellular Respiration Explored, Part 2: Electron Transport Chain (ETC)

Knowledge-Based Outcomes

Upon completion of *Part 2: Electron Transport Chain (ETC)*, students should be able to:

1. Describe why oxygen is required for the ETC to function and identify that O₂ does not directly react with glucose.
2. Draw and/or interpret a diagram identifying the location (mitochondrial membrane) and primary function of several ETC complexes and ATP synthase, including where NADH and FADH₂ enter, where O₂ is used, and where ATP is made.

Skills-Based Outcomes

Upon completion of *Part 2: Electron Transport Chain (ETC)*, students should be able to:

1. Predict how various perturbations to the ETC will alter ATP production and O₂ consumption.
2. Predict what will happen to whole-organism and cell metabolism based on perturbations to the ETC.
3. Given abnormal whole-organism metabolism or cellular ATP production, formulate a hypothesis that offers a mechanistic explanation for the abnormality.
4. Predict how changes to the H⁺ gradient alter the forces acting on H⁺ ions in mitochondria as well as how these changes alter ATP production.