

Advanced Biology: Bioenergetics, Respiration & Chemiosmosis



Use the matching sheet ID when checking answers.

Part A: Bioenergetics Analysis. Solve each advanced cellular respiration and photosynthetic inquiry problem below.

1. During aerobic cellular respiration in eukaryotic mitochondria, what is the immediate source of energy that directly powers the rotary catalytic head of ATP Synthase?

Answer: B. The flow of protons (H⁺ ions) down their electrochemical gradient from the intermembrane space into the mitochondrial matrix (Chemiosmosis)

Peter Mitchell's chemiosmotic hypothesis demonstrated that the electron transport chain pumps H⁺ ions into the intermembrane space; their exergonic diffusion back through ATP synthase generates ATP from ADP and Pi.

2. What is the primary role of molecular oxygen (O₂) in aerobic cellular respiration?

Answer: A. It acts as the final electron acceptor at Complex IV of the mitochondrial electron transport chain, forming metabolic water (H₂O)

Oxygen is highly electronegative, pulling spent electrons through the ETC and combining with protons to form H₂O. Without O₂, the electron transport chain backs up and halts oxidative phosphorylation.

3. In the light-independent reactions (Calvin Cycle) of photosynthesis occurring in plant stroma, what enzyme catalyzes the initial fixation of carbon dioxide (CO₂) onto ribulose-1,5-bisphosphate (RuBP)?

Answer: B. RuBisCO (Ribulose-1,5-bisphosphate carboxylase-oxygenase)

RuBisCO is the vital, highly abundant plant enzyme responsible for the carbon fixation step of the Calvin Cycle, attaching inorganic CO₂ to organic RuBP to produce 3-PGA.

Part B: Bioenergetics Pathway Comparison Matrix. Categorize each metabolic reaction under Cellular Respiration or Photosynthesis.

Sort these items: Glycolysis -> Pyruvate Oxidation -> Krebs Cycle -> Oxidative Phosphorylation; Light-Dependent Photolysis (Thylakoids) -> Calvin Cycle Carbon Fixation (Stroma); Consumes Glucose + O₂ to produce H₂O + CO₂ + ~32 ATP (exergonic energy release); Consumes Sunlight + H₂O + CO₂ to synthesize C₆H₁₂O₆ sugar + O₂ (endergonic energy storage); Utilizes NADH and FADH₂ as high-energy electron carriers to power inner membrane cristae; Utilizes NADPH and ATP synthesized by photosystems I and II to reduce carbon compounds

Aerobic Cellular Respiration (Catabolic)	Photosynthesis (Anabolic)
Glycolysis -> Pyruvate Oxidation -> Krebs Cycle -> Oxidative Phosphorylation; Consumes Glucose + O ₂ to produce H ₂ O + CO ₂ + ~32 ATP (exergonic energy release); Utilizes NADH and FADH ₂ as high-energy electron carriers to power inner membrane cristae	Light-Dependent Photolysis (Thylakoids) -> Calvin Cycle Carbon Fixation (Stroma); Consumes Sunlight + H ₂ O + CO ₂ to synthesize C ₆ H ₁₂ O ₆ sugar + O ₂ (endergonic energy storage); Utilizes NADPH and ATP synthesized by photosystems I and II to reduce carbon compounds