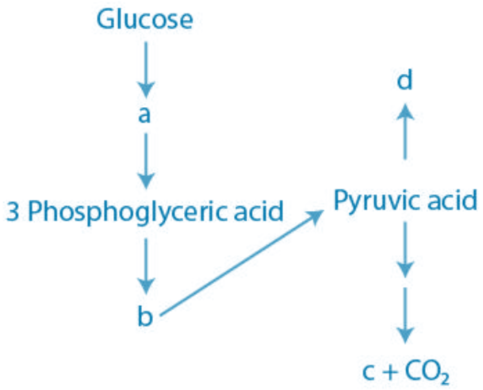
NCERT Exemplar Solutions of Class 11 Biology – Chapter 14: Respiration in Plants

LONG ANSWER TYPE QUESTIONS

1. In the following flow chart, replace the symbols a, b, c and d with appropriate terms. Briefly explain the process and give any two applications of it.



Solution: Symbol Identification:

- **a =** Glyceraldehyde-3-phosphate
- **b =** PEP (Phosphoenol pyruvic acid)
- **c =** C_2H_5OH (Ethanol)
- **d =** Lactic acid

Process Explanation: The process illustrated is **fermentation**, which occurs under anaerobic conditions when oxygen is unavailable for normal aerobic respiration.

Types of Fermentation:

1. **Lactic Acid Fermentation:** Pyruvate → Lactic acid (in muscles, bacteria)
2. **Alcoholic Fermentation:** Pyruvate → Acetaldehyde + CO_2 → Ethanol + CO_2 (in yeast)

Applications:

1. **Alcoholic Beverage Production:**
   - Beer, wine, whisky production
   - Yeast fermentation of sugars
2. **Food Production:**
   - Yogurt and cheese (lactic acid fermentation)
   - Bread making (yeast fermentation)
   - Pickled foods and sauerkraut

Enhanced Explanation: Fermentation allows organisms to continue producing ATP through glycolysis even without oxygen, though much less efficiently than aerobic respiration.

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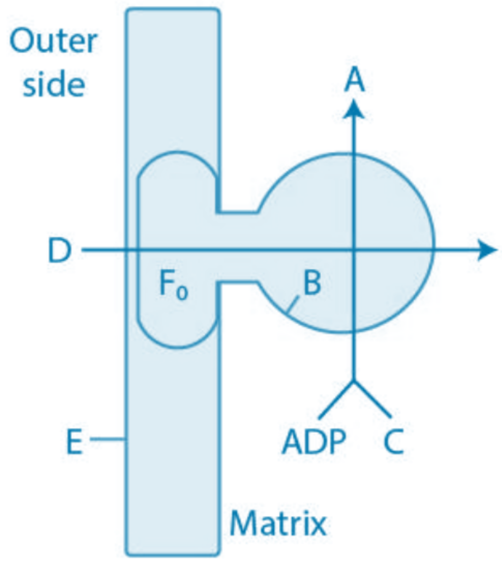
2. Given below is a diagram showing ATP synthesis during aerobic respiration. Replace the symbols A, B, C, D and E by appropriate terms.



Solution: Symbol Identification:

- **A =** ATP
- **B =** F_1 particle
- **C =** P_i (Inorganic phosphate)
- **D =** $2H^+$ (Hydrogen ions/protons)
- **E =** Inner mitochondrial membrane

Enhanced Explanation: This diagram illustrates **chemiosmotic ATP synthesis**:

- Protons ($2H^+$) flow through ATP synthase due to the electrochemical gradient
- F_1 particle contains the catalytic site for ATP synthesis
- ADP + P_i → ATP using energy from proton flow
- The process occurs across the inner mitochondrial membrane

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3. Oxygen is critical for aerobic respiration. Explain its role concerning ETS.

Solution: Oxygen's Critical Role in Electron Transport System:

1. Final Electron Acceptor: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

2. Maintains Electron Flow:

- Removes electrons from Complex IV (Cytochrome oxidase)
- Prevents electron transport chain backup
- Enables continuous NADH and $FADH_2$ oxidation

3. Proton Gradient Formation:

- Electron transport drives proton pumping
- Creates electrochemical gradient across inner membrane
- Powers ATP synthesis through chemiosmosis

4. Regenerates Electron Carriers:

- Oxidizes NADH → NAD^+
- Oxidizes $FADH_2$ → FAD
- Allows continued TCA cycle and glycolysis

Consequences of Oxygen Absence:

- Electron transport ceases
- No proton gradient formation
- ATP synthesis stops
- Cell must rely on anaerobic pathways

Enhanced Explanation: Oxygen serves as the "electron sink" that pulls electrons through the entire transport chain, making it indispensable despite entering at the very end of the process.

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4. Enumerate the assumptions in making the respiratory balance sheet. Are these assumptions valid for a living system? Compare fermentation and aerobic respiration.

Solution: Assumptions in Respiratory Balance Sheet:

1. Sequential Pathway Operation:

- Glycolysis → TCA cycle → ETS occur in sequence
- No pathway interference or bypass

2. Complete Substrate Utilization:

- Glucose is the sole respiratory substrate
- No other substrates enter at intermediate steps

3. Efficient Electron Transport:

- All NADH from cytoplasm enters mitochondria
- No electron leakage or alternative pathways

4. No Intermediate Utilization:

- Respiratory intermediates aren't used for biosynthesis
- Complete conversion to end products

Validity in Living Systems: These assumptions are **partially valid** but **oversimplified**:

- Cells use multiple substrates simultaneously
- Respiratory intermediates serve biosynthetic functions
- Alternative pathways exist for electron transport
- Regulation varies with cellular conditions

Comparison: Fermentation vs. Aerobic Respiration

Aspect	Fermentation	Aerobic Respiration
Oxygen requirement	Absent	Essential
ATP yield	2 ATP/glucose	~38 ATP/glucose
End products	Organic compounds (lactic acid, ethanol)	$CO_2 + H_2O$
Substrate oxidation	Partial	Complete

Aspect	Fermentation	Aerobic Respiration
Electron acceptor	Organic molecules	Oxygen
Location	Cytoplasm only	Cytoplasm + Mitochondria

Enhanced Explanation: While respiratory balance sheets provide useful theoretical frameworks, real cellular metabolism is more complex, with interconnected pathways and multiple regulatory mechanisms.

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5. Give an account of Glycolysis. Where does it occur? What is the end product? Trace the fate of these products in both aerobic and anaerobic respiration.

Solution: Glycolysis Overview: Definition: The metabolic pathway that converts glucose (6C) into two molecules of pyruvate (3C), producing ATP and NADH.

Location: Cytoplasm of the cell

Overall Reaction: Glucose + $2NAD^+$ + 2ADP + $2P_i$ → 2Pyruvate + 2NADH + 2ATP + $2H_2O$ + $4H^+$

End Products:

- **2 Pyruvate molecules** (3C each)
- **2 ATP molecules** (net gain)
- **2 NADH molecules**

Glycolysis Steps (Simplified):

Phase 1: Energy Investment (Steps 1-5)

- Glucose → Glucose-6-phosphate (ATP consumed)
- Glucose-6-phosphate → Fructose-6-phosphate
- Fructose-6-phosphate → Fructose-1,6-bisphosphate (ATP consumed)
- Splitting into two 3-carbon molecules

Phase 2: Energy Payoff (Steps 6-10)

- Glyceraldehyde-3-phosphate → 1,3-bisphosphoglycerate (NAD^+ → NADH)
- 1,3-bisphosphoglycerate → 3-phosphoglycerate (ATP produced)
- Conversions leading to PEP
- PEP → Pyruvate (ATP produced)

Fate of Products:

Under Aerobic Conditions:

1. **Pyruvate:**
   - Enters mitochondria
   - Pyruvate dehydrogenase converts to Acetyl CoA
   - Enters TCA cycle for complete oxidation
2. **NADH:**
   - Transported into mitochondria (malate-aspartate shuttle)
   - Oxidized in electron transport chain

  - Generates ~2.5 ATP per NADH

Under Anaerobic Conditions:

Option 1: Lactic Acid Fermentation (muscles)

- Pyruvate + NADH → Lactic acid + NAD^+
- Regenerates NAD^+ for continued glycolysis
- No additional ATP produced

Option 2: Alcoholic Fermentation (yeast)

- Pyruvate → Acetaldehyde + CO_2
- Acetaldehyde + NADH → Ethanol + NAD^+
- Regenerates NAD^+ for continued glycolysis

Enhanced Explanation: Glycolysis is evolutionarily ancient and can operate with or without oxygen, making it a crucial metabolic pathway for energy production under varying cellular conditions. The fate of its products determines whether the cell will extract maximum energy (aerobic) or maintain basic energy production during oxygen limitation (anaerobic).