SNS COLLEGE OF PHARMACY AND HEALTH SCIENCES

Biochemistry Unit II Question Bank

Multiple Choice Questions (MCQs)

(10 MCQs, each carrying 1 mark)

1. **Which enzyme catalyzes the rate-limiting step of glycolysis?**
   a) Hexokinase
   b) Phosphofructokinase-1
   c) Pyruvate kinase
   d) Aldolase
   Answer: b) Phosphofructokinase-1
   Explanation: Phosphofructokinase-1 (PFK-1) is the key regulatory enzyme in glycolysis, converting fructose-6-phosphate to fructose-1,6-bisphosphate.

2. **How many net ATP molecules are produced per glucose molecule in glycolysis under aerobic conditions?**
   a) 2
   b) 4
   c) 6
   d) 8
   Answer: a) 2
   Explanation: Glycolysis produces 4 ATP (2 from substrate-level phosphorylation) but consumes 2 ATP, yielding a net of 2 ATP per glucose.

3. **The citric acid cycle occurs in which cellular compartment?**
   a) Cytoplasm
   b) Mitochondrial matrix
   c) Endoplasmic reticulum
   d) Nucleus
   Answer: b) Mitochondrial matrix
   Explanation: The citric acid cycle (Krebs cycle) takes place in the mitochondrial matrix, where pyruvate is oxidized to produce energy.

4. **What is the primary product of the HMP shunt pathway?**
   a) ATP
   b) NADPH
   c) Glucose-6-phosphate
   d) Pyruvate
   Answer: b) NADPH
   Explanation: The hexose monophosphate (HMP) shunt produces NADPH for biosynthetic reactions and ribose-5-phosphate for nucleotide synthesis.

5. **Glucose-6-phosphate dehydrogenase (G6PD) deficiency primarily affects:**
   a) Glycolysis

b) HMP shunt
c) Gluconeogenesis
d) Glycogenesis
Answer: b) HMP shunt
Explanation: G6PD deficiency impairs the HMP shunt, reducing NADPH production, leading to hemolytic anemia due to oxidative stress.

6. **Which glycogen storage disease is caused by a deficiency of glucose-6-phosphatase?**
a) Von Gierke's disease
b) Pompe's disease
c) Cori's disease
d) McArdle's disease
Answer: a) Von Gierke's disease
Explanation: Von Gierke's disease (GSD Type I) results from glucose-6-phosphatase deficiency, causing hypoglycemia and glycogen accumulation.

7. **Gluconeogenesis primarily occurs in which organ?**
a) Brain
b) Liver
c) Muscle
d) Pancreas
Answer: b) Liver
Explanation: Gluconeogenesis, the synthesis of glucose from non-carbohydrate precursors, occurs mainly in the liver to maintain blood glucose levels.

8. **Which hormone lowers blood glucose levels by promoting glucose uptake?**
a) Glucagon
b) Cortisol
c) Insulin
d) Epinephrine
Answer: c) Insulin
Explanation: Insulin facilitates glucose uptake by cells via GLUT4 transporters and promotes glycogen synthesis, lowering blood glucose.

9. **The electron transport chain (ETC) is located in:**
a) Mitochondrial outer membrane
b) Mitochondrial inner membrane
c) Cytoplasm
d) Nucleus
Answer: b) Mitochondrial inner membrane
Explanation: The ETC is embedded in the inner mitochondrial membrane, where it facilitates electron transfer to generate a proton gradient.

10. **Which of the following is an uncoupler of oxidative phosphorylation?**
a) Cyanide
b) Oligomycin
c) 2,4-Dinitrophenol
d) Rotenone

Answer: c) 2,4-Dinitrophenol
Explanation: 2,4-Dinitrophenol uncouples oxidative phosphorylation by dissipating the proton gradient, preventing ATP synthesis.

Long Answer Questions

(Answer 1 out of 2, 10 marks)

1. **Describe the glycolysis pathway, its energetics, and its significance in cellular metabolism.**
   Answer:
   Glycolysis Pathway: Glycolysis is a 10-step metabolic pathway occurring in the cytoplasm, converting one glucose molecule (6 carbons) into two pyruvate molecules (3 carbons).
   - **Steps**:
     1. Glucose → Glucose-6-phosphate (by hexokinase, uses 1 ATP).
     2. Glucose-6-phosphate → Fructose-6-phosphate (by phosphoglucose isomerase).
     3. Fructose-6-phosphate → Fructose-1,6-bisphosphate (by phosphofructokinase-1, uses 1 ATP).
     4. Fructose-1,6-bisphosphate → Glyceraldehyde-3-phosphate (G3P) + Dihydroxyacetone phosphate (DHAP) (by aldolase).
     5. DHAP → G3P (by triose phosphate isomerase).
     6. G3P → 1,3-Bisphosphoglycerate (by G3P dehydrogenase, produces 2 NADH).
     7. 1,3-Bisphosphoglycerate → 3-Phosphoglycerate (by phosphoglycerate kinase, produces 2 ATP).
     8. 3-Phosphoglycerate → 2-Phosphoglycerate (by phosphoglycerate mutase).
     9. 2-Phosphoglycerate → Phosphoenolpyruvate (by enolase).
     10. Phosphoenolpyruvate → Pyruvate (by pyruvate kinase, produces 2 ATP).
         Energetics:
   - Consumes 2 ATP (steps 1 and 3).
   - Produces 4 ATP (steps 7 and 10, substrate-level phosphorylation) and 2 NADH.
   - Net yield: 2 ATP and 2 NADH per glucose.
     Significance:
   - Provides energy (ATP) and reducing power (NADH) for cellular processes.

- Generates pyruvate for aerobic (citric acid cycle) or anaerobic (lactate fermentation) metabolism.
- Supplies intermediates (e.g., G3P) for biosynthetic pathways.
- Universal pathway in all cells, critical for energy production in low-oxygen conditions.

2. **Explain the citric acid cycle, including its pathway, energetics, and significance.**
   Answer:
   Citric Acid Cycle Pathway: The citric acid cycle (Krebs cycle) is an 8-step cyclic pathway in the mitochondrial matrix, oxidizing acetyl-CoA to CO_2 while generating energy carriers.
   - **Steps**:
     1. Acetyl-CoA + Oxaloacetate → Citrate (by citrate synthase).
     2. Citrate → Isocitrate (by aconitase).
     3. Isocitrate → α-Ketoglutarate (by isocitrate dehydrogenase, produces 1 NADH and 1 CO_2).
     4. α-Ketoglutarate → Succinyl-CoA (by α-ketoglutarate dehydrogenase, produces 1 NADH and 1 CO_2).
     5. Succinyl-CoA → Succinate (by succinyl-CoA synthetase, produces 1 GTP, equivalent to 1 ATP).
     6. Succinate → Fumarate (by succinate dehydrogenase, produces 1 $FADH_2$).
     7. Fumarate → Malate (by fumarase).
     8. Malate → Oxaloacetate (by malate dehydrogenase, produces 1 NADH).
        Energetics: Per acetyl-CoA (one glucose yields two acetyl-CoA):
   - 3 NADH (3 × 2.5 ATP via ETC ≈ 7.5 ATP).
   - 1 $FADH_2$ (1.5 ATP via ETC).
   - 1 GTP (equivalent to 1 ATP).
   - Total per glucose (two cycles): ~20 ATP (via oxidative phosphorylation).
     Significance:
   - Central hub of metabolism, oxidizing carbohydrates, fats, and proteins.
   - Produces high-energy electron carriers (NADH, $FADH_2$) for ATP synthesis via ETC.
   - Supplies intermediates (e.g., α-ketoglutarate, oxaloacetate) for biosynthesis of amino acids and heme.
   - Generates CO_2 as a metabolic waste product.

Short Answer Questions

(Answer 2 out of 3, 5 marks each)

1. **Discuss the significance of the HMP shunt and the consequences of G6PD deficiency.**
   Answer:
   HMP Shunt Significance: The hexose monophosphate shunt (pentose phosphate pathway) is a cytoplasmic pathway parallel to glycolysis.
   - Produces **NADPH** for reductive biosynthesis (e.g., fatty acid and cholesterol synthesis) and maintaining reduced glutathione to combat oxidative stress.
   - Generates **ribose-5-phosphate** for nucleotide and nucleic acid synthesis.
   - Provides flexibility in carbohydrate metabolism by interconverting sugars.
     G6PD Deficiency: Glucose-6-phosphate dehydrogenase (G6PD) is the rate-limiting enzyme of the HMP shunt. Its deficiency reduces NADPH production, impairing glutathione regeneration. This leads to:
   - Hemolytic anemia due to oxidative damage to red blood cells, triggered by drugs (e.g., primaquine), infections, or fava beans.
   - Symptoms include jaundice, fatigue, and dark urine.
   - Common in populations with malaria prevalence due to partial resistance to the parasite.

2. **Describe glycogen metabolism pathways and name two glycogen storage diseases.**
   Answer:
   Glycogen Metabolism Pathways:
   - **Glycogenesis**: Synthesis of glycogen from glucose in the liver and muscle.
     - Glucose → Glucose-6-phosphate (by hexokinase/glucokinase).
     - Glucose-6-phosphate → Glucose-1-phosphate (by phosphoglucomutase).
     - Glucose-1-phosphate + UTP → UDP-glucose (by UDP-glucose pyrophosphorylase).
     - UDP-glucose adds to glycogen chain (by glycogen synthase).
   - **Glycogenolysis**: Breakdown of glycogen to glucose-1-phosphate.
     - Glycogen → Glucose-1-phosphate (by glycogen phosphorylase).
     - Glucose-1-phosphate → Glucose-6-phosphate (by phosphoglucomutase).

- In liver, glucose-6-phosphate → Glucose (by glucose-6-phosphatase) for blood glucose maintenance.
  Glycogen Storage Diseases (GSD):

- **Von Gierke's Disease (GSD I)**: Deficiency of glucose-6-phosphatase, leading to glycogen accumulation, hypoglycemia, and hepatomegaly.
- **Pompe's Disease (GSD II)**: Deficiency of lysosomal acid maltase, causing glycogen buildup in lysosomes, leading to muscle weakness and cardiac issues.

3. **Explain the mechanism of oxidative phosphorylation and the role of ETC inhibitors.**
   Answer:
   Oxidative Phosphorylation Mechanism: Oxidative phosphorylation occurs in the mitochondrial inner membrane, coupling electron transport to ATP synthesis.

   - The **electron transport chain (ETC)** comprises complexes I–IV. NADH and $FADH_2$ donate electrons, which pass through complexes, pumping protons (H^+) from the matrix to the intermembrane space, creating a proton gradient.
   - Complex V (ATP synthase) uses the proton gradient's energy (proton-motive force) to drive ATP synthesis from ADP + Pi via chemiosmosis.
   - Oxygen is the final electron acceptor, forming water.
     ETC Inhibitors:
   - **Rotenone**: Inhibits Complex I, blocking NADH oxidation, reducing proton pumping and ATP synthesis.
   - **Cyanide**: Inhibits Complex IV (cytochrome c oxidase), preventing electron transfer to oxygen, halting the ETC and ATP production.
   - **Oligomycin**: Inhibits ATP synthase, blocking proton re-entry, stopping ATP synthesis despite an intact proton gradient.
     These inhibitors disrupt energy production, leading to cellular dysfunction or death, and are used in research to study mitochondrial function.