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BIO506T Quiz File

Chapter-wise Solved MCQs

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Lesson 1: BIOENERGETICS

1. What is the thermodynamic criterion for whether a biochemical reaction will proceed spontaneously in the forward direction under physiological conditions?

A) A positive standard free-energy change ($\Delta G'^\circ > 0$)
B) A negative actual free-energy change ($\Delta G < 0$)
C) An equilibrium constant (K'_{eq}) equal to 0
D) An increase in total system enthalpy ($\Delta H > 0$)

2. When two sequential chemical reactions are coupled through a common intermediate, how do their thermodynamic parameters combine for the overall reaction?

A) Both $\Delta G'^\circ$ values and K'_{eq} values are additive.
B) Both $\Delta G'^\circ$ values and K'_{eq} values are multiplicative.
C) Standard free-energy changes ($\Delta G'^\circ$) are additive, while equilibrium constants (K'_{eq}) are multiplicative.
D) Standard free-energy changes ($\Delta G'^\circ$) are multiplicative, while equilibrium constants (K'_{eq}) are additive.

3. What is the primary chemical factor responsible for the high standard free energy change of hydrolysis of phosphoenolpyruvate ($\Delta G'^\circ = -61.9\text{ kJ/mol}$)?

A) The immediate tautomerization of the product pyruvate from its enol form to its more stable keto form
B) The ionization of ADP into ADP^{3-} upon phosphate cleavage
C) Electrostatic repulsion between four negative charges on the reactant
D) Resonance stabilization unique only to the reactant state

4. In bioenergetics, phosphorylated biological compounds are classified as "high-energy" compounds if their standard free energy change of hydrolysis ($\Delta G'^\circ$) is:

A) More negative than -25 kJ/mol
B) Less negative than -15 kJ/mol
C) Strictly equal to 0 kJ/mol
D) Positive and greater than $+25\text{ kJ/mol}$

Answer Key

* **1. B** — A reaction is spontaneous in the forward direction when the actual free-energy change (ΔG) is negative.

* **2. C** — Standard free-energy changes ($\Delta G'^\circ$) of sequential reactions are additive, whereas their equilibrium constants (K'_{eq}) are multiplicative.

* **3. A** — Tautomerization of the enol form of pyruvate to the stable keto form drives the high negative free energy change of phosphoenolpyruvate hydrolysis.

* **4. A** — "High-energy" compounds are defined as having a $\Delta G'^\circ$ of hydrolysis more negative than -25 kJ/mol.

Lesson 2: GLUCOSE METABOLISM

1. What are the three main metabolic fates of glucose in animals and vascular plants?

A) Synthesis of urea, conversion to ketone bodies, or storage as triacylglycerols

B) Storage as polysaccharides, oxidation to pyruvate via glycolysis, or oxidation via the pentose phosphate pathway
C) Conversion to cellulose, fermentation to lactate, or direct secretion by liver cells
D) Hydrolysis by glucokinase, conversion to acetoacetate, or reduction to amino acids

2. Which member of the glucose transporter family is sequestered in intracellular vesicles and requires an insulin signal to move into the plasma membrane in skeletal muscle, heart, and adipose tissue?

A) GLUT1
B) GLUT2
C) GLUT3
D) GLUT4

3. Why do untreated Type 1 Diabetes Mellitus patients overproduce ketone bodies (acetoacetate and \(\beta\)-hydroxybutyrate), risking ketoacidosis?

A) Inability to take up blood glucose forces muscle and fat to use stored fatty acids, producing excess acetyl-CoA in the liver.
B) High blood glucose levels directly inhibit hexokinase and block glycogen formation.
C) Insulin deficiency causes glucose to break down into ketone bodies inside blood plasma.
D) GLUT1 and GLUT3 transporters are completely destroyed by high levels of insulin.

4. Non-photosynthetic organisms synthesize glucose from simple three- and four-carbon precursors via which pathway?

A) Glycolysis
B) Gluconeogenesis
C) Pentose phosphate pathway
D) Citric acid cycle

Answer Key

* **1. B** — In animals and plants, glucose is stored (glycogen/starch), oxidized via glycolysis to pyruvate, or oxidized via the pentose phosphate pathway.

* **2. D** — GLUT4 is the glucose transporter in skeletal muscle, heart, and adipose tissue that relocates to the plasma membrane upon insulin stimulation.

* **3. A** — Impaired glucose uptake forces reliance on fatty acid breakdown, causing acetyl-CoA accumulation in the liver and conversion to ketone bodies.

* **4. B** — Non-photosynthetic cells synthesize glucose from three- and four-carbon precursors through gluconeogenesis.

Lesson 3: GLYCOLYSIS

1. What is the net yield of ATP and NADH per molecule of glucose processed through complete glycolysis?

A) 4 ATP and 2 NADH
B) 2 ATP and 2 NADH
C) 2 ATP and 4 NADH
D) 4 ATP and 0 NADH

2. Which enzyme catalyzes the first "committed" step of glycolysis and is allosterically inhibited by high ATP levels while being activated by fructose 2,6-bisphosphate in eukaryotes?

A) Hexokinase
B) Phosphofructokinase-1 (PFK-1)
C) Pyruvate kinase
D) Aldolase

3. In step 6 of glycolysis, glyceraldehyde 3-phosphate reacts with which active-site amino acid residue on glyceraldehyde 3-phosphate dehydrogenase to form a covalent thiohemiacetal intermediate?

A) Cysteine (Cys)
B) Histidine (His)
C) Lysine (Lys)
D) Serine (Ser)

4. Under low-oxygen (hypoxic) conditions in active skeletal muscle, why is pyruvate reduced to lactate by lactate dehydrogenase?

A) To produce additional ATP via substrate-level phosphorylation
B) To regenerate \(NAD^+\) from NADH so that glycolysis can continue
C) To stimulate the movement of GLUT4 into plasma membranes
D) To transport acetyl-CoA directly into the mitochondria

Answer Key

* **1. B** — Glycolysis invests 2 ATP in the preparatory phase and generates 4 ATP and 2 NADH in the payoff phase, yielding a net 2 ATP and 2 NADH per glucose.

* **2. B** — PFK-1 catalyzes the first committed glycolytic step and is subject to allosteric inhibition by ATP and activation by fructose 2,6-bisphosphate.

* **3. A** — The aldehyde group of G3P reacts with an essential active-site Cys residue on glyceraldehyde 3-phosphate dehydrogenase to form a thiohemiacetal.

* **4. B** — Reduction of pyruvate to lactate transfers electrons from NADH, regenerating \(NAD^+\) required to sustain the glyceraldehyde 3-phosphate dehydrogenase step of glycolysis.

Lesson 4: GLUCONEOGENESIS

1. Which three steps of glycolysis are essentially irreversible in vivo and must be bypassed by different enzymes during gluconeogenesis?

A) Steps catalyzed by hexokinase, phosphofructokinase-1 (PFK-1), and pyruvate kinase
B) Steps catalyzed by phosphohexose isomerase, aldolase, and enolase
C) Steps catalyzed by glyceraldehyde 3-phosphate dehydrogenase, phosphoglycerate kinase, and mutase
D) Steps catalyzed by triose phosphate isomerase, enolase, and lactate dehydrogenase

2. The first bypass in gluconeogenesis (converting pyruvate to phosphoenolpyruvate) requires which two enzymes operating sequentially?

A) Pyruvate decarboxylase and alcohol dehydrogenase
B) Pyruvate carboxylase and phosphoenolpyruvate carboxykinase (PEPCK)
C) Fructose 1,6-bisphosphatase-1 and glucose 6-phosphatase

D) Lactate dehydrogenase and pyruvate dehydrogenase

3. What is the total energy cost in high-energy phosphate bonds (ATP and GTP) required to synthesize one molecule of glucose from two molecules of pyruvate?

A) 2 high-energy phosphate bonds (2 ATP)
B) 4 high-energy phosphate bonds (4 ATP)
C) 6 high-energy phosphate bonds (4 ATP and 2 GTP)
D) 8 high-energy phosphate bonds (6 ATP and 2 GTP)

4. Where is glucose 6-phosphatase, the enzyme catalyzing the final bypass step of gluconeogenesis, specifically located in liver cells?

A) Free in the cytosol
B) On the luminal side of the endoplasmic reticulum
C) Inside the mitochondrial matrix
D) Embedded in the outer plasma membrane

Answer Key

* **1. A** — Gluconeogenesis bypasses the three irreversible reactions of glycolysis catalyzed by hexokinase, PFK-1, and pyruvate kinase.

* **2. B** — Converting pyruvate to PEP requires pyruvate carboxylase (forming oxaloacetate) and phosphoenolpyruvate carboxykinase (converting oxaloacetate to PEP).

* **3. C** — Biosynthesis of one glucose molecule from two pyruvate molecules requires 6 high-energy phosphate bonds (4 ATP and 2 GTP).

* **4. B** — Glucose 6-phosphatase is an \(Mg^{2+}\)-activated enzyme located on the luminal side of the endoplasmic reticulum in hepatocytes, renal cells, and intestinal epithelial cells.

Lesson 5: Pentose Phosphate Pathway (PPP) of Glucose Oxidation

1. What are the two primary non-energy products generated by the oxidative phase of the pentose phosphate pathway?

A) Pyruvate and ATP
B) NADPH and ribose 5-phosphate
C) NADH and FADH2
D) Acetyl-CoA and lactate

2. Which enzyme catalyzes the initial oxidation step of glucose 6-phosphate in the oxidative phase of the pentose phosphate pathway?

A) 6-Phosphogluconate dehydrogenase
B) Lactonase
C) Glucose 6-phosphate dehydrogenase (G6PD)
D) Transketolase

3. Which specific cofactor is required by transketolase in the non-oxidative phase to stabilize a two-carbon carbanion intermediate during sugar transfers?

A) Pyridoxal phosphate (PLP)
B) Thiamine pyrophosphate (TPP)
C) Flavin adenine dinucleotide (FAD)
D) Biotin

4. How does a high ratio of cytosolic NADPH to NADP+ (e.g., 100:1) regulate the partitioning of glucose 6-phosphate in liver cells?

A) High NADPH directly activates G6PD to accelerate the pentose phosphate pathway.
B) Low availability of electron acceptor NADP+ slows down G6PD activity, directing glucose 6-phosphate into glycolysis instead.
C) High NADPH levels induce irreversible degradation of transaldolase.
D) NADPH completely blocks the glycolytic pathway by inhibiting phosphohexose isomerase.

Answer Key

* **1. B** — The oxidative phase produces NADPH for reductive biosynthesis and ribose 5-phosphate as a precursor for nucleic acid and nucleotide synthesis.

* **2. C** — Glucose 6-phosphate dehydrogenase (G6PD) catalyzes the initial oxidation of glucose 6-phosphate to 6-phosphoglucono-δ-lactone.

* **3. B** — Transketolase requires the cofactor thiamine pyrophosphate (TPP) to stabilize a two-carbon carbanion during sugar rearrangement.

* **4. B** — Without sufficient NADP+ to accept electrons, the first step catalyzed by G6PD cannot proceed, slowing the pathway and directing glucose 6-phosphate into glycolysis.

Lesson 6: Feeder pathways of GLYCOLYSIS

1. What compound is directly produced when glycogen phosphorylase attacks the (α1→4) glycosidic linkage at a nonreducing end of glycogen using inorganic phosphate (Pi)?

A) Glucose 6-phosphate
B) Glucose 1-phosphate
C) Fructose 6-phosphate
D) Free D-glucose

2. In liver tissue, how is free dietary D-fructose phosphorylated to enter metabolism?

A) Phosphorylated at C-6 by hexokinase to form fructose 6-phosphate
B) Phosphorylated at C-1 by fructokinase to form fructose 1-phosphate
C) Converted directly to galactose 1-phosphate by galactokinase
D) Hydrolyzed by sucrose phosphorylase

3. Which enzyme converts mannose 6-phosphate into the glycolytic intermediate fructose 6-phosphate?

A) Phosphomannose isomerase
B) Phosphoglucomutase
C) Fructose 1-phosphate aldolase
D) Triose kinase

4. The entry of D-galactose into glycolysis requires initial phosphorylation at C-1 by galactokinase, followed by conversion involving which nucleotide sugar derivative?

A) ADP-glucose
B) UDP-galactose / UDP-glucose
C) CDP-galactose
D) GDP-mannose

Answer Key

* **1. B** — Glycogen phosphorylase catalyzes an attack by inorganic phosphate (Pi) on (α1→4) glycosidic linkages, yielding glucose 1-phosphate.

* **2. B** — Liver fructokinase catalyzes the phosphorylation of D-fructose specifically at C-1 to yield fructose 1-phosphate.

* **3. A** — D-Mannose is phosphorylated to mannose 6-phosphate by hexokinase, which is then isomerized to fructose 6-phosphate by phosphomannose isomerase.

* **4. B** — Galactose 1-phosphate is converted to UDP-galactose and UDP-glucose derivatives via UDP-glucose:galactose 1-phosphate uridylyltransferase and UDP-glucose 4-epimerase.

Lesson 7: Nucleotides and Nucleic Acids

1. What term describes the observed increase in optical absorbance at 260 nm when double-stranded DNA undergoes thermal denaturation into single strands?

A) Hypochromicity
B) Hyperchromicity
C) Isoelectric focusing
D) Fluorescence quenching

2. Alkaline hydrolysis degrades RNA into 2',3'-cyclic diesters of mononucleotides. Why does DNA NOT undergo alkaline hydrolysis under the same conditions?

A) DNA contains thymine instead of uracil.
B) DNA lacks a 2'-hydroxyl group on its deoxyribose sugar ring.
C) DNA double helices are protected by histones in alkaline solutions.
D) Phosphodiester bonds in DNA are noncovalent.

3. Which rule regarding base composition applies to typical single-stranded RNA molecules?

A) $A = U$ and $G = C$ apply strictly in all cases.
B) Total purines always equal total pyrimidines in a 1:1 ratio.
C) Chargaff's rules do not apply because RNA is single-stranded ($G \neq C$ and $A \neq U$).
D) Thymine pairs with adenine in equal molar concentrations.

4. In the secondary structure of transfer RNA (tRNA), what specific nucleotide sequence is located at the 3' end of the acceptor arm to bind amino acids?

A) 5'-AUG-3'
B) Cytosine-Cytosine-Adenine (CCA) at the 3' end
C) 5'-UAA-3'
D) 3'-GGC-5'

Answer Key

* **1. B** — Unwinding and disruption of base stacking in double-stranded DNA causes an increase in UV light absorption at 260 nm termed hyperchromicity.

* **2. B** — RNA hydrolysis in alkali relies on nucleophilic participation of its 2'-hydroxyl group, which is absent in 2'-deoxyribose of DNA.

* **3. C** — Because RNA is single-stranded, Chargaff's base-pairing rules do not apply, meaning $G \neq C$ and $A \neq U$.

* **4. B** — The acceptor arm terminates at the 3' end with an unpaired CCA sequence, where the 3'-OH group binds a specific amino acid.

Lesson 8: Enzymes

1. How do enzymes accelerate the rates of chemical reactions without altering the reaction equilibrium point?

A) By increasing the standard free-energy change (\(\Delta G'^\circ\)) of the reaction
B) By lowering the activation energy (\(\Delta G^\ddagger\)) for the transition state
C) By increasing the total enthalpy (\(\Delta H\)) of the system
D) By consuming reactants to shift equilibrium toward products

2. According to Michaelis-Menten kinetics, what does a numerically small (low) Michaelis constant (\(K_m\)) signify about an enzyme?

A) High affinity of the enzyme for its substrate
B) Low affinity of the enzyme for its substrate
C) Complete absence of substrate saturation at any concentration
D) Low maximum velocity (\(V_{max}\)) of the reaction

3. In a double-reciprocal (Lineweaver-Burk) plot, how is \(V_{max}\) determined from the graphed line?

A) The x-intercept equals \(-1/K_m\).
B) The slope equals \(K_m/V_{max}\).
C) The y-intercept equals \(1/V_{max}\).
D) The area under the curve equals \(V_{max}\).

4. How do competitive inhibitors affect the kinetic parameters \(V_{max}\) and \(K_m\) of an enzyme-catalyzed reaction?

A) They decrease \(V_{max}\) and leave \(K_m\) unchanged.
B) They leave \(V_{max}\) unchanged while increasing the apparent \(K_m\).
C) They decrease both \(V_{max}\) and \(K_m\) equally.
D) They increase \(V_{max}\) and decrease \(K_m\).

Answer Key

* **1. B** — Enzymes accelerate reactions solely by lowering the activation energy (\(\Delta G^\ddagger\)) required to reach the transition state, leaving equilibrium (\(K_{eq}\)) unchanged.

* **2. A** — A low \(K_m\) value indicates that only a low concentration of substrate is required to half-saturate the enzyme, reflecting high substrate affinity.

* **3. C** — Taking the reciprocal of both sides of the Michaelis-Menten equation yields a straight-line plot where the y-axis intercept equals \(1/V_{max}\).

* **4. B** — Competitive inhibitors bind reversibly to the active site; increasing substrate concentration overcomes the inhibition (unchanged \(V_{max}\)), but increases the apparent \(K_m\).

Lesson 9: Water ,pH & Buffer Systems

1. How many neighboring water molecules can a single water molecule form hydrogen bonds with in its nearly tetrahedral orbital arrangement?

A) 2

B) 3
C) 4
D) 6

2. What is the value of the ion product of water ($K_w = [\text{H}^+][\text{OH}^-]$) in pure water and aqueous solutions at 25°C?

A) $1.8 \times 10^{-16}\text{ M}^2$
B) $1.0 \times 10^{-14}\text{ M}^2$
C) 55.5 M
D) $1.0 \times 10^{-7}\text{ M}$

3. During the titration of a weak acid with a strong base, what relationship holds true at the titration midpoint?

A) The concentration of weak acid becomes zero ($[\text{HA}] = 0$).
B) The pH of the solution is equal to the $\text{p}K_a$ of the weak acid ($\text{pH} = \text{p}K_a$).
C) The solution reaches maximum acidity ($\text{pH} < 2.0$).
D) The acid dissociation constant (K_a) becomes equal to K_w.

4. A conjugate acid-base pair acts as an effective buffer within what characteristic pH range relative to its $\text{p}K_a$?

A) Within 0.1 pH unit of its $\text{p}K_a$
B) Within approximately ± 1 pH unit of its $\text{p}K_a$
C) Strictly above pH 8.0 regardless of $\text{p}K_a$
D) Between pH 1.0 and pH 3.0 for all weak acids

Answer Key

* **1. C** — Each water molecule can form hydrogen bonds with as many as four neighboring water molecules due to its nearly tetrahedral orbital geometry.

* **2. B** — The ion product of water (K_w) at 25°C is $K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}\text{ M}^2$.

* **3. B** — At the midpoint of a weak acid titration, equimolar amounts of proton donor and acceptor are present and $\text{pH} = \text{p}K_a$.

* **4. B** — A weak acid-base pair is an effective buffer in a pH zone near its $\text{p}K_a$ (e.g., $\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-}$) with $\text{p}K_a = 6.86$ buffers between pH 5.9 and 7.9).

Lesson 10: Citric Acid Cycle- (CAC)- 1

1. What is the ordered sequence of substrate binding for mammalian citrate synthase in the first reaction of the citric acid cycle?

A) Acetyl-CoA binds first, creating a binding site for oxaloacetate.
B) Oxaloacetate binds first, inducing a conformational change that creates a binding site for acetyl-CoA.
C) Both acetyl-CoA and oxaloacetate bind simultaneously without any conformational change.
D) Citroyl-CoA binds first, followed by the simultaneous release of acetyl-CoA and oxaloacetate.

2. Which citric acid cycle enzyme is bound to the inner mitochondrial membrane in eukaryotes and utilizes a covalently bound FAD prosthetic group?

A) Isocitrate dehydrogenase
B) Succinate dehydrogenase

C) Malate dehydrogenase
D) Aconitase

3. Why is the highly endergonic reaction catalyzed by L-malate dehydrogenase (\(\Delta G'^\circ = +29.7\text{ kJ/mol}\)) pulled forward in intact cells to form oxaloacetate?

A) Oxaloacetate is rapidly degraded by a cytosolic phosphatase.
B) Oxaloacetate is continually consumed by the highly exergonic citrate synthase reaction, keeping its cellular concentration extremely low.
C) The reaction is coupled directly to the hydrolysis of two ATP molecules.
D) High levels of NADH force the enzyme to run exclusively in the forward direction.

4. Which anaplerotic enzyme catalyzes the ATP-dependent carboxylation of pyruvate to replenish oxaloacetate in mammalian liver and kidney cells?

A) Pyruvate carboxylase
B) Phosphoenolpyruvate carboxykinase
C) Malic enzyme
D) Pyruvate decarboxylase

Answer Key

* **1. B** — Oxaloacetate binds first to citrate synthase, inducing a conformational change in the flexible domain that creates the binding site for acetyl-CoA.

* **2. B** — Succinate dehydrogenase is a flavoprotein tightly bound to the inner mitochondrial membrane containing covalently bound FAD.

* **3. B** — Continual removal of oxaloacetate by citrate synthase keeps its concentration extremely low in the cell, pulling the malate dehydrogenase reaction forward.

* **4. A** — Pyruvate carboxylase catalyzes the reversible carboxylation of pyruvate to oxaloacetate using energy from ATP to replenish cycle intermediates.

Lesson 11: The Pyruvate Dehydrogenase (PDH) Complex-2

1. Which step in the five-reaction sequence catalyzed by the pyruvate dehydrogenase (PDH) complex is rate-limiting and checks substrate specificity?

A) Step 1: Decarboxylation of pyruvate and attachment of the hydroxyethyl group to TPP on E1
B) Step 2: Oxidation of the hydroxyethyl group to an acetyl group on E2
C) Step 3: Transesterification of the acetyl group to Coenzyme A to form acetyl-CoA
D) Step 5: Transfer of electrons from \(\text{FADH}_2\) to \(\text{NAD}^+\) on E3

2. What is the functional role of the lipoyllysyl moiety attached to dihydrolipoyl transacetylase (\(\text{E}_2\))?

A) It decarboxylates pyruvate directly in the \(\text{E}_1\) active site.
B) It acts as a long, flexible swinging arm that carries acetyl groups and electrons between \(\text{E}_1\), \(\text{E}_2\), and \(\text{E}_3\) active sites.
C) It accepts electrons directly from NADH to regenerate oxidized FAD.
D) It converts GTP to ATP via substrate-level phosphorylation.

3. Which coenzyme acts as the ultimate electron acceptor in the final reaction (Step 5) of the pyruvate dehydrogenase complex sequence?

A) Thiamine pyrophosphate (TPP)

B) FAD
C) \(\text{NAD}^+\)
D) Lipoic acid

4. What metabolic advantage is provided by "substrate channeling" in the pyruvate dehydrogenase complex?

A) It allows intermediates to diffuse freely into the cytosol for glycolysis.
B) It prevents side reactions and theft of the activated acetyl group by keeping intermediates bound to the complex.
C) It eliminates the requirement for coenzymes like TPP and FAD.
D) It reverses the overall reaction so acetyl-CoA can be converted back to pyruvate.

Answer Key

* **1. A** — Step 1 (decarboxylation of C-1 and attachment of C-2 to TPP on \(\text{E}_1\)) is the slowest step and limits the overall rate of the PDH complex reaction.

* **2. B** — The lipoyllysyl arm on \(\text{E}_2\) is a 5 nm flexible tether that channels acetyl groups and electrons between the active sites of \(\text{E}_1\), \(\text{E}_2\), and \(\text{E}_3\).

* **3. C** — In step 5, reduced \(\text{FADH}_2\) on \(\text{E}_3\) transfers a hydride ion to \(\text{NAD}^+\), forming NADH and regenerating oxidized FAD.

* **4. B** — Substrate channeling prevents the loss or theft of intermediates by other enzymes and keeps local intermediate concentrations high.

Lesson 12: Glyoxylate cycle

1. Which two enzymes are unique to the glyoxylate cycle and absent from the standard citric acid cycle?

A) Citrate synthase and aconitase
B) Isocitrate lyase and malate synthase
C) Pyruvate carboxylase and malate dehydrogenase
D) Succinate dehydrogenase and fumarase

2. How does the glyoxylate cycle achieve the net synthesis of carbohydrates from acetyl-CoA where the citric acid cycle cannot?

A) By bypassing the two decarboxylation steps of the citric acid cycle, preventing loss of carbon as \(\text{CO}_2\)
B) By producing four molecules of ATP directly through substrate-level phosphorylation
C) By converting \(\text{CO}_2\) directly into glucose using light energy
D) By eliminating the need for oxaloacetate in citrate formation

3. In germinating plant seeds, in which specialized organelle do the primary reactions of the glyoxylate cycle take place?

A) Mitochondrion
B) Chloroplast
C) Glyoxysome
D) Endoplasmic reticulum

4. How is the partitioning of isocitrate between the citric acid cycle and the glyoxylate cycle regulated in cells?

A) Reversible phosphorylation of isocitrate dehydrogenase by a protein kinase inactivates it, shunting isocitrate to the glyoxylate cycle.
B) High levels of ATP directly degrade malate synthase.
C) Isocitrate lyase is activated exclusively when isocitrate dehydrogenase is fully dephosphorylated.
D) Acetyl-CoA inhibits isocitrate lyase and stimulates fumarase.

Answer Key

* **1. B** — Isocitrate lyase and malate synthase are the two enzymes unique to the glyoxylate cycle.

* **2. A** — Cleavage of isocitrate by isocitrate lyase bypasses the two \(\text{CO}_2\)-releasing decarboxylation steps of the citric acid cycle, enabling net carbon retention.

* **3. C** — In plants, the glyoxylate cycle occurs in specialized peroxisomes termed glyoxysomes.

* **4. A** — Phosphorylation by a specific protein kinase inactivates isocitrate dehydrogenase, directing isocitrate into the glyoxylate cycle.

Lesson 13: Fatty Acid Catabolism

1. Which system is required to transport long-chain fatty acids (containing 14 or more carbons) from the cytosol into the mitochondrial matrix for \(\beta\)-oxidation?

A) The glycerol 3-phosphate shuttle
B) The carnitine shuttle
C) The citrate-malate antiporter
D) The malate-aspartate shuttle

2. What is the first reaction step in the four-step \(\beta\)-oxidation cycle of saturated fatty acyl-CoAs in mitochondria?

A) Hydration of a double bond by enoyl-CoA hydratase
B) Dehydrogenation between the \(\alpha\) and \(\beta\) carbons by acyl-CoA dehydrogenase to form \(trans\text{-}\Delta^2\text{-enoyl-CoA}\)
C) Thiolytic cleavage by thiolase
D) Oxidation of an alcohol group by \(\beta\)-hydroxyacyl-CoA dehydrogenase

3. Oxidation of monounsaturated fatty acids containing a \(cis\text{-}\Delta^3\) double bond (such as oleate breakdown intermediates) requires which auxiliary enzyme to re-enter standard \(\beta\)-oxidation?

A) 2,4-dienoyl-CoA reductase
B) \(\Delta^3,\Delta^2\)-enoyl-CoA isomerase
C) Propionyl-CoA carboxylase
D) Acyl-CoA oxidase

4. The final pass through the \(\beta\)-oxidation sequence for an odd-numbered fatty acid yields one molecule of acetyl-CoA and one molecule of propionyl-CoA. Which coenzyme is required by methylmalonyl-CoA mutase to convert L-methylmalonyl-CoA into succinyl-CoA?

A) Thiamine pyrophosphate (TPP)
B) Biotin
C) Coenzyme \(\text{B}_{12}\) (\(5'\)-deoxyadenosylcobalamin)
D) Flavin adenine dinucleotide (FAD)

Answer Key

* **1. B** — Fatty acids with 14 or more carbons cannot pass directly through mitochondrial membranes and require the three enzymatic reactions of the carnitine shuttle.

* **2. B** — Step 1 of \(\beta\)-oxidation is the FAD-dependent dehydrogenation between C-2 (\(\alpha\)) and C-3 (\(\beta\)) catalyzed by acyl-CoA dehydrogenase.

* **3. B** — \(\Delta^3,\Delta^2\)-enoyl-CoA isomerase isomerizes \(cis\text{-}\Delta^3\text{-enoyl-CoA}\) to \(trans\text{-}\Delta^2\text{-enoyl-CoA}\), which can then be acted upon by enoyl-CoA hydratase.

* **4. C** — Methylmalonyl-CoA mutase requires coenzyme \(\text{B}_{12}\) (\(5'\)-deoxyadenosylcobalamin) to catalyze the intramolecular rearrangement of L-methylmalonyl-CoA to succinyl-CoA.

Lesson 14: Ketone Bodies

1. Which three chemical species are collectively classified as "ketone bodies" produced by the liver during fatty acid oxidation?

A) Acetoacetate, D-\(\beta\)-hydroxybutyrate, and acetone
B) Pyruvate, lactate, and alanine
C) Oxaloacetate, citrate, and malate
D) Propionyl-CoA, methylmalonyl-CoA, and succinyl-CoA

2. In hepatic ketogenesis, condensation of acetoacetyl-CoA with acetyl-CoA produces which key intermediate before free acetoacetate is released?

A) Malonyl-CoA
B) \(\beta\)-hydroxy-\(\beta\)-methylglutaryl-CoA (HMG-CoA)
C) Propionyl-CoA
D) Citroyl-CoA

3. Why is the liver capable of producing and exporting ketone bodies to extrahepatic tissues, but unable to use ketone bodies as its own fuel source?

A) The liver lacks the mitochondrial membrane transporter for D-\(\beta\)-hydroxybutyrate.
B) The liver lacks the enzyme \(\beta\)-ketoacyl-CoA transferase (thiophorase) required for acetoacetate activation.
C) The liver cannot carry out the citric acid cycle under any conditions.
D) The liver converts all excess acetoacetate into glycogen.

4. What critical metabolic benefit does ketone body formation provide to the liver during starvation or untreated diabetes when citric acid cycle intermediates are depleted?

A) It directly produces 32 ATP molecules without consuming oxygen.
B) It frees coenzyme A (\(\text{CoA-SH}\)), allowing continued \(\beta\)-oxidation of fatty acids to proceed.
C) It raises blood pH to counteract lactic acidosis in skeletal muscle.
D) It completely shuts down gluconeogenesis in hepatocytes.

Answer Key

* **1. A** — The three ketone bodies formed in the liver during fatty acid oxidation are acetone, acetoacetate, and D-\(\beta\)-hydroxybutyrate.

* **2. B** — Acetoacetyl-CoA condenses with acetyl-CoA to form \(\beta\)-hydroxy-\(\beta\)-methylglutaryl-CoA (HMG-CoA), which is then cleaved to yield free acetoacetate and acetyl-CoA.

* **3. B** — Hepatocytes lack \(\beta\)-ketoacyl-CoA transferase (thiophorase), preventing them from activating acetoacetate to acetoacetyl-CoA for local energy production.

* **4. B** — Exporting ketone bodies releases free coenzyme A (\(\text{CoA-SH}\)) in hepatocytes, allowing \(\beta\)-oxidation of fatty acids to continue when the citric acid cycle slows down.

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End of Quiz

BIO506T — 56 solved MCQs
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