ACS Biochemistry Practice Exam (Sample)

Study Guide

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Questions

1. **What is the effect of INSR phosphorylation on IRS-1?**
   - A. It initiates a feedback inhibition.
   - B. It causes a kinase cascade.
   - C. It promotes lipid synthesis.
   - D. It induces protein degradation.

2. **What is the primary function of phosphatidic acid in lipid metabolism?**
   - A. Precursor for nucleotide synthesis
   - B. Precursor to TAGs and phospholipids
   - C. Source of cholesterol
   - D. Inhibitor of fatty acid synthesis

3. **What characteristic of proteins affects their movement in isoelectric focusing?**
   - A. Their size
   - B. Their isoelectric point (pI)
   - C. Their thermal stability
   - D. Their charge density

4. **What is the main function of glycogen in animals?**
   - A. Structural support
   - B. Energy storage
   - C. Cell communication
   - D. DNA storage

5. **At which wavelength does DNA primarily absorb UV light?**
   - A. 200nm
   - B. 230nm
   - C. 260nm
   - D. 300nm

6. How many protons are transferred to the Pside by Complex I during its function?

A. 2

B. 4

C. 6

D. 8

7. What is the main function of transketolase in Stage 3 of the Calvin Cycle?

A. To convert G3P into starch/sucrose

B. To regenerate ribulose 1,5-bisphosphate

C. To fix CO2 into organic compounds

D. To maintain Pi balance in chloroplasts

8. What is the significant product of Step 9 in glycolysis?

A. 3-phosphoglycerate

B. Glyceraldehyde 3-phosphate

C. Phosphoenolpyruvate (PEP)

D. 1,3-bisphosphoglycerate

9. How does the malate-aspartate shuttle contribute to cellular respiration?

A. By directly producing ATP

B. By facilitating the transfer of protons across membranes

C. By maintaining NADH equilibrium in mitochondria

D. By enhancing oxygen transport

10. What role does 2,3-bisphosphoglycerate (BPG) play in hemoglobin function?

A. It increases the affinity of hemoglobin for oxygen

B. It stabilizes the T-state of hemoglobin

C. It enhances the binding of CO2

D. It promotes the R-state of hemoglobin

Answers

1. B
2. B
3. B
4. B
5. C
6. B
7. B
8. C
9. C
10. B

Explanations

1. What is the effect of INSR phosphorylation on IRS-1?

A. It initiates a feedback inhibition.

B. It causes a kinase cascade.

C. It promotes lipid synthesis.

D. It induces protein degradation.

The phosphorylation of the insulin receptor substrate 1 (IRS-1) by the insulin receptor (INSR) plays a critical role in insulin signaling pathways. When the insulin receptor is activated by insulin binding, it undergoes autophosphorylation and subsequently phosphorylates IRS-1. This phosphorylation event is crucial because it allows IRS-1 to interact with various signaling molecules, leading to a cascade of downstream signaling events. These downstream events typically involve the activation of PI3-kinase, which subsequently promotes lipid and glucose metabolism, among other functions in the cell. The process instigated by IRS-1 phosphorylation ultimately results in various cellular responses such as glucose uptake and lipid synthesis, but the key factor here is that the phosphorylation directly triggers a cascade of kinase activation that propagates the insulin signaling pathway. Thus, the phosphorylation of IRS-1 by INSR does more than just initiate a single reaction; it sets off a series of events that are essential for mediating the effects of insulin in the body. This is why the correct response focuses on the initiation of a kinase cascade as a direct consequence of INSR phosphorylation of IRS-1.

2. What is the primary function of phosphatidic acid in lipid metabolism?

A. Precursor for nucleotide synthesis

B. Precursor to TAGs and phospholipids

C. Source of cholesterol

D. Inhibitor of fatty acid synthesis

Phosphatidic acid plays a crucial role in lipid metabolism primarily as a precursor to triacylglycerols (TAGs) and phospholipids. In cellular biochemistry, it is formed through the acylation of glycerol-3-phosphate and serves as a central intermediate in the synthesis of lipids. When energy or structural lipids are needed, phosphatidic acid can be converted into TAGs through the process of esterification, where fatty acids are added to glycerol. Additionally, phosphatidic acid can also serve as a precursor for the synthesis of various phospholipids, which are essential components of cellular membranes. Thus, its function in lipid metabolism is fundamental to maintaining cellular energy balance and membrane integrity. Understanding its role as a building block for these critical lipid types highlights the importance of phosphatidic acid in metabolic pathways, including those involved in energy storage and membrane dynamics.

3. What characteristic of proteins affects their movement in isoelectric focusing?

A. Their size

B. Their isoelectric point (pI)

C. Their thermal stability

D. Their charge density

The correct answer is that the isoelectric point (pI) of proteins significantly affects their movement in isoelectric focusing. Isoelectric focusing is a technique used to separate proteins based on their charge. Each protein has a specific pI, which is the pH at which it carries no net electrical charge. During isoelectric focusing, a pH gradient is established within a gel or an electric field. Proteins will migrate within this gradient until they reach the point where the pH equals their pI. At this point, the protein does not migrate any further because it has no net charge, meaning that the electrochemical forces acting on it are balanced. Therefore, the specific pI of a protein determines where it will stop moving within the gradient. While size, thermal stability, and charge density may influence protein behavior in other contexts, they do not fundamentally dictate the specific pH at which proteins will cease to migrate in isoelectric focusing. This makes the isoelectric point the primary characteristic influencing the movement of proteins in this particular method of separation.

4. What is the main function of glycogen in animals?

A. Structural support

B. Energy storage

C. Cell communication

D. DNA storage

The primary function of glycogen in animals is energy storage. Glycogen is a polysaccharide that serves as a form of stored glucose, which is a crucial source of energy. When the body requires glucose for metabolic processes—such as during exercise or between meals—the glycogen stored in the liver and muscles is broken down into glucose molecules through a process called glycogenolysis. This quick release of glucose helps maintain blood sugar levels and provides energy to various tissues and organs. In particular, the liver regulates blood glucose levels by releasing glucose into the bloodstream when needed, while muscle glycogen is primarily utilized for energy during physical activity. This dual role allows animals to efficiently manage energy resources and respond to varying energy demands. The other answer choices do not reflect the primary role of glycogen. Structural support is typically provided by proteins or polysaccharides like cellulose in plants. Cell communication is more closely associated with signaling molecules and receptors rather than glycogen. DNA storage is the function of nucleic acids, not glycogen, which does not play a role in storing genetic material. Thus, glycogen's main function as an energy storage molecule is essential for the overall energy management in animal physiology.

5. At which wavelength does DNA primarily absorb UV light?

- A. 200nm
- B. 230nm
- C. 260nm
- D. 300nm

DNA primarily absorbs UV light at a wavelength of 260 nm due to the presence of its aromatic bases, namely adenine, thymine, guanine, and cytosine. These bases contain π (pi) electrons that can engage in electronic transitions when exposed to UV light. The energy from the UV light at this specific wavelength is just right to excite these electrons to a higher energy state, resulting in a maximum absorbance peak. This property is widely used in biochemistry to quantify DNA concentration in a sample using spectrophotometry. The absorbance at 260 nm is particularly significant because it allows researchers to evaluate the purity of DNA as well; for instance, the ratio of absorbance at 260 nm to that at 280 nm can indicate the presence of proteins, which also absorb UV light but at 280 nm. Thus, 260 nm is a key wavelength for assessing nucleic acids in various laboratory applications.

6. How many protons are transferred to the Pside by Complex I during its function?

- A. 2
- B. 4
- C. 6
- D. 8

Complex I, also known as NADH:ubiquinone oxidoreductase, is a crucial enzyme in the electron transport chain that plays an essential role in cellular respiration. During its function, Complex I catalyzes the transfer of electrons from NADH to ubiquinone (coenzyme Q), while simultaneously pumping protons from the mitochondrial matrix into the intermembrane space, which contributes to the proton motive force needed for ATP synthesis. When NADH binds to Complex I, two electrons are extracted from NADH, leading to the reduction of ubiquinone to ubiquinol. As these electrons are transferred through the multiprotein complex, a total of four protons are translocated across the inner mitochondrial membrane into the intermembrane space. This translocation is crucial because it creates a gradient that will be utilized by ATP synthase to generate ATP. The correct response indicates that four protons are indeed transferred to the Pside (intermembrane space) during the function of Complex I. This movement of protons is pivotal in the process of oxidative phosphorylation, highlighting the efficiency and importance of electron transport in energy production within the cell.

7. What is the main function of transketolase in Stage 3 of the Calvin Cycle?

A. To convert G3P into starch/sucrose

B. To regenerate ribulose 1,5-bisphosphate

C. To fix CO_2 into organic compounds

D. To maintain Pi balance in chloroplasts

Transketolase plays a pivotal role in the Calvin Cycle, particularly in the regeneration of ribulose 1,5-bisphosphate (RuBP), which is essential for the cycle to continue. In Stage 3 of the Calvin Cycle, the primary focus is on regenerating materials that allow the cycle to sustain ongoing carbon fixation. Without sufficient RuBP, the cycle cannot effectively capture CO_2, hindering overall photosynthesis. Transketolase catalyzes the transfer of two-carbon units in the form of ketose sugars, facilitating the conversion of intermediates derived from glyceraldehyde 3-phosphate (G3P) into ribulose 5-phosphate (Ru5P), which is then converted to RuBP. This process is crucial because RuBP is the molecule that reacts with CO_2 to initiate the carbon fixation process. Therefore, transketolase's function in regenerating RuBP ensures that the cycle can perpetuate, allowing continuous CO_2 incorporation and sugar production. The other choices relate to different functions or stages that are not directly associated with the specific role of transketolase in the Calvin Cycle's regeneration phase, making them less relevant within this context.

8. What is the significant product of Step 9 in glycolysis?

A. 3-phosphoglycerate

B. Glyceraldehyde 3-phosphate

C. Phosphoenolpyruvate (PEP)

D. 1,3-bisphosphoglycerate

In glycolysis, Step 9 is the conversion of 2-phosphoglycerate to phosphoenolpyruvate (PEP), catalyzed by the enzyme enolase. This step is critical as it involves the removal of a water molecule from 2-phosphoglycerate, resulting in the formation of PEP, which has a high-energy phosphate bond. This energy-rich compound is crucial for the subsequent step of glycolysis, where PEP donates its phosphate group to ADP to form ATP, thereby driving the substrate-level phosphorylation process. Phosphoenolpyruvate has one of the highest phosphoryl transfer potentials among all known compounds, making it an ideal intermediate in the energy-producing phase of glycolysis. The importance of this step lies not only in the formation of PEP but also in setting the stage for the generation of ATP, which is a key goal of glycolysis.

9. How does the malate-aspartate shuttle contribute to cellular respiration?

A. By directly producing ATP

B. By facilitating the transfer of protons across membranes

C. By maintaining NADH equilibrium in mitochondria

D. By enhancing oxygen transport

The malate-aspartate shuttle plays a critical role in cellular respiration, particularly in the transport of reducing equivalents from the cytosol into the mitochondria, where the electron transport chain resides. This process is essential for maintaining the balance of NADH, which is generated during glycolysis in the cytosol. When glucose is metabolized through glycolysis, NAD+ is reduced to NADH. However, the inner mitochondrial membrane is impermeable to NADH, necessitating mechanisms to transfer the reducing equivalents into the mitochondria. The malate-aspartate shuttle allows the conversion of NADH in the cytosol into malate, which can then be transported into the mitochondria. Inside the mitochondria, malate is oxidized back to oxaloacetate, regenerating NADH in the mitochondrial matrix. This NADH can then enter the electron transport chain, leading to ATP production. By facilitating this transfer, the malate-aspartate shuttle helps maintain the proper equilibrium of NADH and NAD+ between the cytosol and the mitochondria, which is vital for efficient energy production and metabolic balance during cellular respiration.

10. What role does 2,3-bisphosphoglycerate (BPG) play in hemoglobin function?

A. It increases the affinity of hemoglobin for oxygen

B. It stabilizes the T-state of hemoglobin

C. It enhances the binding of CO_2

D. It promotes the R-state of hemoglobin

2,3-bisphosphoglycerate (BPG) plays a crucial role in hemoglobin function by stabilizing the T-state (tense state) of hemoglobin. This stabilization effects the oxygen-binding properties of hemoglobin, essentially reducing its affinity for oxygen. When BPG binds to hemoglobin, it interacts with the beta chains, promoting a conformational change that favors the T-state, which is predominant when hemoglobin is not bound to oxygen. This state allows for more efficient release of oxygen to tissues that are actively respiring, where oxygen is needed the most. In high-altitude conditions or situations where oxygen is scarce, elevated levels of BPG are produced, which enhances the ability of hemoglobin to release oxygen. Thus, BPG acts as a modulator of hemoglobin function, ensuring that tissues receive adequate oxygen during metabolic activity. The other options pertain to functions that are not attributed directly to BPG. For example, increasing oxygen affinity, enhancing CO_2 binding, or promoting the R-state (relaxed state) are not accurate roles of BPG, as these processes either contradict BPG's role or are facilitated by other factors.