

Biological and Biochemical Foundations of Living Systems Sample Paper 2

Passage I (Questions 1–5)

A laboratory is characterizing a newly discovered mammalian peptide hormone that stimulates glycogen breakdown in hepatocytes. The hormone binds a G-protein-coupled receptor that activates adenylate cyclase. Subsequent experiments show that addition of the hormone rapidly elevates intracellular cAMP and leads to phosphorylation of glycogen phosphorylase. When hepatocytes are pretreated with a phosphodiesterase inhibitor, the magnitude and duration of the hormone response both increase.

In a parallel series of experiments the same hormone is applied to adipocytes, where it promotes hormone-sensitive lipase activity and release of free fatty acids.

Question 1

The immediate second messenger generated after hormone binding is:

- a) Calcium ion
- b) cAMP
- c) Diacylglycerol
- d) Inositol trisphosphate

Correct Answer: b) cAMP

Explanation:

The passage states that the receptor activates adenylate cyclase, which produces cAMP.

Question 2

Phosphorylation of glycogen phosphorylase converts the enzyme from its inactive to its active form. This is an example of:

- a) Allosteric regulation by AMP
- b) Covalent modification
- c) Competitive inhibition
- d) Substrate-level phosphorylation

Correct Answer: b) Covalent modification

Explanation:

Addition of a phosphate group is a reversible covalent modification that activates glycogen phosphorylase.

Question 3

The phosphodiesterase inhibitor prolongs the hormone response by:

- a) Preventing degradation of cAMP
- b) Blocking the hormone receptor
- c) Inhibiting protein kinase A
- d) Accelerating re-synthesis of glycogen

Correct Answer: a) Preventing degradation of cAMP

Explanation:

Phosphodiesterases hydrolyze cAMP; their inhibition therefore elevates and prolongs the cAMP signal.

Question 4

In adipocytes the same hormone ultimately increases the activity of hormone-sensitive lipase. The most direct mechanism is:

- a) cAMP-dependent phosphorylation of the lipase
- b) Direct binding of the hormone to the lipase
- c) Transcriptional induction of the lipase gene within seconds
- d) Allosteric activation by free fatty acids

Correct Answer: a) cAMP-dependent phosphorylation of the lipase

Explanation:

Hormone-sensitive lipase is activated by protein-kinase-A-mediated phosphorylation downstream of the cAMP cascade.

Question 5

If a non-hydrolyzable GTP analogue were introduced into the hepatocytes, the expected effect on the hormone pathway would be:

- a) Permanent activation of the G protein and continuous cAMP production
- b) Immediate termination of all signaling
- c) Blockade of receptor–G-protein interaction
- d) Conversion of the receptor into a tyrosine kinase

Correct Answer: a) Permanent activation of the G protein and continuous cAMP production

Explanation:

Non-hydrolyzable GTP keeps the G α subunit in its active state, so adenylate cyclase remains stimulated.

Independent Questions (Questions 6–9)

Question 6

Which of the following is a ketose sugar?

- a) Glucose
- b) Galactose
- c) Fructose
- d) Mannose

Correct Answer: c) Fructose

Explanation:

Fructose contains a ketone group at C2; the others are aldoses.

Question 7

The start codon on an mRNA molecule is recognized by:

- a) An aminoacyl-tRNA carrying methionine (or formyl-methionine in prokaryotes)
- b) A release factor protein
- c) The 5' cap-binding complex alone
- d) An uncharged tRNA

Correct Answer: a) An aminoacyl-tRNA carrying methionine (or formyl-methionine in prokaryotes)

Explanation:

Initiator tRNA charged with Met (or fMet) base-pairs with the AUG start codon.

Question 8

In oxidative phosphorylation the proton-motive force is used directly by:

- a) Complex I
- b) Complex III
- c) ATP synthase
- d) Cytochrome c

Correct Answer: c) ATP synthase

Explanation:

ATP synthase harnesses the electrochemical proton gradient to drive ATP synthesis.

Question 9

A point mutation that changes a codon from UAC to UAA is best described as:

- a) Silent
- b) Missense

- c) Nonsense
- d) Frameshift

Correct Answer: c) Nonsense

Explanation:

UAA is a stop codon; the mutation therefore truncates the polypeptide and is classified as nonsense.