

**BIOC\*3560 Structure and Function in Biochemistry  
Fall 2015 Study Questions #6 & Answers (Example Final Exam)**

The following is a mock exam which includes some multiple choice questions to help you prepare for the Final Examination. I would recommend that you answer the questions before you look at the answers, which are listed at the bottom of the question set. Each question is worth 1 mark.

1. In the voltage-gated sodium channel,
  - a. helix S6 is the voltage sensor
  - b. helix S4 is the voltage sensor
  - c. helix S4 contains the inactivation gate
  - d. one subunit is responsible for activation
  - e. one subunit is responsible for selectivity
  
2. Which of the following best describes the effects of insulin signaling on glycogen synthase kinase 3 (GSK3) and glucose transporters in liver cells?
  - a. inactivation of GSK3 and inhibition of GluT4 transporters
  - b. inactivation of GSK3 and internalization of GluT4 transporters
  - c. inactivation of GSK3 and movement of GluT4 transporters to the cell surface
  - d. activation of GSK3 and movement of GluT4 transporter to the cell surface
  - e. activation of GSK3 and internalization of GluT4 transporters
  
3. When applied to isolated kidney tissue, ouabain (a toxin that blocks the  $\text{Na}^+ / \text{K}^+$  ATPase) inhibits  $\text{O}_2$  consumption by 40%. This means that in kidney
  - a. a  $\text{K}^+ / \text{O}_2$  exchanger is inhibited by ouabain
  - b. a  $\text{K}^+ / \text{O}_2$  exchanger is activated by ouabain
  - c. a  $\text{Na}^+ / \text{O}_2$  exchanger is inhibited by ouabain
  - d. approximately 40% of ATP is consumed by the  $\text{Na}^+ / \text{K}^+$  ATPase
  - e. ouabain blocks  $\text{O}_2$  uptake
  
4. Which of these cofactors participates directly in most of the oxidation-reduction reactions in the fermentation of glucose to lactate?
  - a. ADP
  - b. ATP
  - c. FAD/FADH<sub>2</sub>
  - d. Glyceraldehyde 3-phosphate
  - e. NAD<sup>+</sup>/NADH
  
5. The metabolic function of the pentose phosphate pathway is:
  - a. act as a source of ADP biosynthesis.
  - b. generate NADPH and pentoses for the biosynthesis of fatty acids and nucleic acids.
  - c. participate in oxidation-reduction reactions during the formation of H<sub>2</sub>O.
  - d. provide intermediates for the citric acid cycle.
  - e. synthesize phosphorus pentoxide.
  
6. Transport of fatty acids from the cytoplasm to the mitochondrial matrix requires:
  - a. ATP, carnitine, and coenzyme A.
  - b. ATP, carnitine, and pyruvate dehydrogenase.
  - c. ATP, coenzyme A, and hexokinase.
  - d. ATP, coenzyme A, and pyruvate dehydrogenase.
  - e. carnitine, coenzyme A, and hexokinase.

7. What is the correct order of function of the following enzymes of  $\beta$  oxidation?
1.  $\beta$ -Hydroxyacyl-CoA dehydrogenase
  2. Thiolase
  3. Enoyl-CoA hydratase
  4. Acyl-CoA dehydrogenase
- a. 1, 2, 3, 4
  - b. 3, 1, 4, 2
  - c. 4, 3, 1, 2
  - d. 1, 4, 3, 2
  - e. 4, 2, 3, 1
8. Ketone bodies are formed in the liver and transported to the extrahepatic tissues mainly as:
- a. acetoacetyl-CoA.
  - b. acetone.
  - c. beta-hydroxybutyric acid.
  - d. beta-hydroxybutyryl-CoA.
  - e. lactic acid.
9. A hydropathy plot is used to
- a. determine the water-solubility of a protein.
  - b. deduce the quaternary structure of a membrane protein.
  - c. determine the water content of a native protein.
  - d. extrapolate for the true molecular weight of a membrane protein.
  - e. predict whether a given protein sequence contains membrane-spanning segments.
10. The specificity of the potassium channel for  $K^+$  over  $Na^+$  is mainly the result of the:
- a. differential interaction with the selectivity filter protein.
  - b. hydrophobicity of the channel.
  - c. phospholipid composition of the channel.
  - d. presence of carbohydrates in the channel.
  - e. presence of cholesterol in the channel.
11. Which of the following is *not* involved in the *specificity* of signal transduction?
- a. Interactions between receptor and signal molecules
  - b. Location of receptor molecules
  - c. Structure of receptor molecules
  - d. Structure of signal molecules
  - e. Transmembrane transport of signal molecules by receptor molecules
12. Which of the following does *not* involve cyclic AMP?
- a. Regulation of glycogen synthesis and breakdown
  - b. Regulation of glycolysis
  - c. Signaling by acetylcholine
  - d. Signaling by epinephrine
  - e. Signaling by glucagon
13. The specificity of signaling pathways includes all of the following *except*:
- a. flippase-catalyzed movement of phospholipids from the inner to the outer leaflet.
  - b. migration of signal proteins into membrane rafts.
  - c. phosphorylation of target proteins at Ser, Thr, or Tyr residues.
  - d. the ability to be switched off instantly by hydrolysis of a single phosphate-ester bond.
  - e. the assembly of large multiprotein complexes.

14. There is reciprocal regulation of glycolytic and gluconeogenic reactions interconverting fructose-6-phosphate and fructose-1,6-bisphosphate. Which one of the following statements about this regulation is *not* correct?

- a. Fructose-2,6-bisphosphate activates phosphofructokinase-1.
- b. Fructose-2,6-bisphosphate inhibits fructose-1,6-bisphosphatase.
- c. The fructose-1,6-bisphosphatase reaction is exergonic.
- d. The phosphofructokinase-1 reaction is endergonic.
- e. This regulation allows control of the direction of net metabolite flow through the pathway.

15. Which one of the following statements about membranes is true?

- a. Most plasma membranes contain more than 70% proteins.
- b. Sterol lipids are common in bacterial plasma membranes.
- c. Sterol lipids are common in human cell plasma membranes.
- d. Sterol lipids are common in plant cell plasma membranes.
- e. The plasma membranes of all cell types within a particular organism have basically the same lipid and protein composition.

16. Membrane proteins:

- a. are sometimes covalently attached to lipid moieties.
- b. are sometimes covalently attached to carbohydrate moieties.
- c. are composed of the same 20 amino acids found in soluble proteins.
- d. diffuse laterally in the membrane unless they are anchored
- e. have all of the properties listed above.

17. An integral membrane protein can be extracted with:

- a. a buffer of alkaline or acid pH.
- b. a chelating agent that removes divalent cations.
- c. a solution containing detergent.
- d. a solution of high ionic strength.
- e. hot water.

18. Which of these is a general feature of the lipid bilayer in all biological membranes?

- a. Individual lipid molecules are free to diffuse laterally in the surface of the bilayer.
- b. Individual lipid molecules in one face (monolayer) of the bilayer readily diffuse (flip-flop) to the other monolayer.
- c. Polar, but uncharged, compounds readily diffuse across the bilayer.
- d. The bilayer is stabilized by covalent bonds between neighboring phospholipid molecules.
- e. The polar head groups face inward toward the inside of the bilayer.

19. The fluidity of the lipid side chains in the interior of a bilayer is generally increased by:

- a. a decrease in temperature.
- b. an increase in fatty acyl chain length.
- c. an increase in the number of double bonds in fatty acids.
- d. an increase in the percentage of phosphatidyl ethanolamine
- e. the binding of water to the fatty acyl side chains.

20. Integrins are:

- a. membrane proteins that are involved in ion transport.
- b. membrane proteins that are involved in sugar transport.
- c. membrane proteins that mediate cell adhesion.
- d. proteins of the extracellular matrix that bind to cell surface proteins.
- e. proteins that are found at the membrane-cytoplasm interface.

21. Which of these statements about facilitated diffusion across a membrane is true?
- A specific membrane protein lowers the activation energy for movement of the solute through the membrane.
  - It can increase the size of a transmembrane concentration gradient of the diffusing solute.
  - It is impeded by the solubility of the transported solute in the nonpolar interior of the lipid bilayer.
  - It is responsible for the transport of gases such as O<sub>2</sub>, N<sub>2</sub>, and CH<sub>4</sub> across biological membranes.
  - The rate is not saturable by the transported substrate
22. Glucose transport into erythrocytes is an example of:
- active transport.
  - antiport.
  - electrogenic uniport
  - facilitated diffusion.
  - symport.
23. Movement of water across membranes is facilitated by proteins called:
- annexins.
  - aquaporins.
  - hydroporins.
  - selectins.
  - transportins.
24. Scatchard analysis can provide information on:
- enzyme cascades.
  - enzyme mechanisms.
  - gated ion channels.
  - protein phosphorylation.
  - receptor-ligand interactions.
25. The ion channel that opens in response to acetylcholine is an example of a \_\_\_\_\_ signal transduction system.
- G protein
  - ligand-gated
  - receptor-enzyme
  - serpentine receptor
  - voltage-gated
26. Which of the following statements concerning receptor enzymes is correct?
- They are not usually membrane-associated proteins.
  - They contain an enzyme activity that acts upon a cytosolic substrate.
  - They contain an enzyme activity that acts upon the extracellular ligand.
  - They have a ligand-binding site on the cytosolic side of the membrane.
  - They have an active site on the extracellular side of the membrane.
27. Protein kinase A (PKA) is:
- activated by covalent binding of cyclic AMP.
  - affected by cyclic AMP only under unusual circumstances.
  - allosterically activated by cyclic AMP.
  - competitively inhibited by cyclic AMP.
  - noncompetitively inhibited by cyclic AMP.

28. Calmodulin is a(n):
- allosteric activator of calcium-dependent enzymes.
  - allosteric inhibitor of calcium-dependent enzymes.
  - calcium-dependent enzyme.
  - cell surface calcium receptor.
  - regulatory subunit of calcium-dependent enzymes.
29. Which one of the following signaling mechanisms is used most predominantly in plants?
- Cyclic-nucleotide dependent protein kinases
  - DNA-binding nuclear steroid receptors
  - G protein-coupled receptors
  - Protein serine/threonine kinases
  - Protein tyrosine kinases
30. Steroid hormones are carried on specific carrier proteins because the hormones:
- are too unstable to survive in the blood on their own.
  - cannot dissolve readily in the blood because they are too hydrophobic.
  - cannot find their target cells without them.
  - need them in order to pass through the plasma membrane.
  - require subsequent binding to specific receptor proteins in the nucleus.
31. During strenuous exercise, the NADH formed in the glyceraldehyde 3-phosphate dehydrogenase reaction in skeletal muscle must be reoxidized to  $\text{NAD}^+$  if glycolysis is to continue. The most important reaction involved in the reoxidation of NADH is:
- dihydroxyacetone phosphate  $\rightarrow$  glycerol 3-phosphate
  - glucose 6-phosphate  $\rightarrow$  fructose 6-phosphate
  - isocitrate  $\rightarrow$   $\alpha$ -ketoglutarate
  - oxaloacetate  $\rightarrow$  malate
  - pyruvate  $\rightarrow$  lactate
32. Which of the following statements is *not* true concerning glycolysis in anaerobic muscle?
- Fructose 1,6-bisphosphatase is one of the enzymes of the pathway.
  - It is an endergonic process.
  - It results in net synthesis of ATP.
  - It results in synthesis of NADH.
  - Its rate is slowed by a high  $[\text{ATP}]/[\text{ADP}]$  ratio.
33. In comparison with the resting state, actively contracting human muscle tissue has a:
- higher concentration of ATP.
  - higher rate of lactate formation.
  - lower consumption of glucose.
  - lower rate of consumption of oxygen
  - lower ratio of NADH to  $\text{NAD}^+$ .
34. Which of the following is a cofactor in the reaction catalyzed by glyceraldehyde 3-phosphate dehydrogenase?
- ATP
  - $\text{Cu}^{2+}$
  - heme
  - $\text{NAD}^+$
  - $\text{NADP}^+$
35. Glycogen is converted to monosaccharide units by:
- glucokinase.
  - glucose-6-phosphatase
  - glycogen phosphorylase.
  - glycogen synthase.

e. glycogenase.

36. Which of the following compounds *cannot* serve as the starting material for the synthesis of glucose via gluconeogenesis?

- a. acetate
- b. glycerol
- c. lactate
- d. oxaloacetate
- e.  $\alpha$ -ketoglutarate

37. An enzyme used in both glycolysis and gluconeogenesis is:

- a. 3-phosphoglycerate kinase.
- b. glucose 6-phosphatase.
- c. hexokinase.
- d. phosphofructokinase-1.
- e. pyruvate kinase.

38. In humans, gluconeogenesis:

- a. can result in the conversion of protein into blood glucose.
- b. helps to reduce blood glucose after a carbohydrate-rich meal.
- c. is activated by the hormone insulin
- d. is essential in the conversion of fatty acids to glucose.
- e. requires the enzyme hexokinase.

39. Which of the following statements about the pentose phosphate pathway is correct?

- a. It generates 36 mol of ATP per mole of glucose consumed.
- b. It generates 6 moles of  $\text{CO}_2$  for each mole of glucose consumed
- c. It is a reductive pathway; it consumes NADH.
- d. It is present in plants, but not in animals.
- e. It provides precursors for the synthesis of nucleotides.

40. Which of the following enzymes acts in the pentose phosphate pathway?

- a. 6-phosphogluconate dehydrogenase
- b. Aldolase
- c. Glycogen phosphorylase
- d. Phosphofructokinase-1
- e. Pyruvate kinase

ANSWERS:

1. B
2. C
3. D
4. E
5. B
6. A
7. C
8. C
9. E
10. A
11. E
12. C
13. A
14. D
15. C
16. E
17. C
18. A
19. C
20. C
21. A
22. D
23. B
24. E
25. B
26. B
27. C
28. E
29. D
30. B
31. E
32. B
33. B
34. D
35. C
36. A
37. A
38. A
39. E
40. A

**PART II – (28 marks total) Answer questions 1 – 3 in the space provided (10 marks for each question.**

**Question 1**

(A) What is the committed step in the  $\beta$ -oxidation of fatty acids? Name the integral membrane protein that mediates this step. Identify the compound that is primarily responsible for regulation of this step. (3 marks)

1. **transport into mitochondria**
2. **fatty-acyl-carnitine/carnitine transporter**
3. **malonyl-CoA inhibits carnitine acyltransferase I**

(B) In mammals, fatty acid synthesis and fatty acid oxidation occur by biochemically distinct pathways. How do these pathways differ in terms of (a) cellular location, (b) electron carrier used, (c) 2-carbon species used/produced (d) organization of enzymes involved. (4 marks)

	<b><u>synthesis</u></b>	<b><u>oxidation</u></b>
a)	<b>cytoplasm</b>	<b>mitochondria</b>
b)	<b>NADPH</b>	<b>NADH / FADH<sub>2</sub></b>
c)	<b>malonyl-CoA</b>	<b>acetyl-CoA</b>
d)	<b>single polypeptide</b>	<b>separate proteins</b>

(C) (a) What kinds of forces or bonds anchor an integral membrane protein in a biological membrane? (b) What forces hold a peripheral membrane protein to the membrane? (c) What might one do to solubilize each of the two types of membrane proteins? (3 marks)

**(a) The forces that hold integral membrane proteins in the membrane are hydrophobic interactions between hydrophobic domains of the protein and the fatty acyl chains of the bilayer interior.**

**(b) Peripheral membrane proteins associate with membranes primarily through ionic interactions and hydrogen bonds between charged and polar side chains of the protein and polar head groups of membrane lipids.**

**(c) To remove integral membrane proteins, it is generally necessary to use detergents, which convert membranes into “soluble” micelles. Peripheral membrane proteins can often be released by extraction with buffers of high or low salt concentration, high or low pH, or low concentrations of divalent cations.**

## Part II - Question 2

- (A) Signals carried by hormones must eventually be terminated; the response continues for a limited time. Discuss three different mechanisms for signal termination, using specific systems as examples. (3 marks)

**Hormonal responses may be terminated by:**

- 1. removal of the second messenger (degradation of cAMP, resequestration of  $\text{Ca}^{2+}$ )**
  - 2. dephosphorylation of the target protein (by phosphoprotein phosphatases)**
  - 3. self inactivation of G proteins (by hydrolysis of bound GTP to GDP)**
- (B) The stewardess just served you a delicious meal of fish and after you have completed it and licked your chops, the passenger next to you informs you that it was Puffer fish. What might be the cause of your death and how? (2 marks)

**Puffer fish (tetrodotoxin)**

- 1. puffer fish contains a toxin known as tetrodotoxin, which is a complex organic heterocyclic molecule**
  - 2. tetrodotoxin blocks the voltage-gated sodium channels in nerve tissue which impairs the neural impulse causing first paralysis then death**
- (C) What are three differences between ion channels and ion transporters? (3 marks)

- 1. The rate of ion movement through channels is much greater**
- 2. Ion transporters exhibit saturation, whereas ion channels do not**
- 3. Ion channels open and close in response to external stimuli or events such as ligand-binding or changes in electrical potential across the membrane**

**Part II - Question 3**

(A) In the glycolytic path from glucose to phosphoenolpyruvate, two steps are practically irreversible. What are these steps, and how is each bypassed in gluconeogenesis? What advantages does an organism gain from having separate pathways for anabolic and catabolic metabolism? What are the disadvantages? (5 marks)

- 1. The two irreversible steps in glycolysis are conversion of glucose to glucose-6-phosphate catalyzed by hexokinase, and conversion of fructose-6-phosphate to fructose 1,6 biphosphate.**
- 2. The first reaction is bypassed during gluconeogenesis by the reaction catalyzed by glucose-6-phosphatase, an enzyme unique to liver.**
- 3. The second is bypassed by fructose 1,6-bisphosphatase (FBBase-1).**
- 4. By having separate pathways that employ different enzymes, an organism is able to control anabolic and catabolic processes separately, avoiding futile cycles.**
- 5. A potential disadvantage is the need to produce separate sets of enzymes for catabolism and anabolism.**

(B) Identify the major chemical features that distinguish phosphatidylcholine from a sphingomyelin. Use of a diagram is acceptable. (3 marks)

- 1. backbone of PC is glycerol  
backbone of sphingomyelin is sphingosine**
- 2. PC contains 2 fatty acyl chains  
sphingomyelin has only 1 fatty acyl chain**
- 3. PC has ester-linked fatty acyl chains  
sphingomyelin has an amide linked fatty acyl chain**

(C) You are studying a newly discovered protein. Biochemical analysis reveals that it is associated with membranes and can only be extracted with detergent. Hydropathy plots do **not** indicate that it contains a transmembrane helix. (i) Are these data consistent with an actual membrane protein? (ii) Identify a protein structure consistent with these observations. (2 marks)

- i) yes**
- ii)  $\beta$  barrel or lipid-anchored (GPI-anchor, etc.) protein**

**PART III – (10 marks) Answer either question 4 or question 5, NOT BOTH.**

**Question 4**

(A) Describe the biochemical events, initiated by the phosphorylation of the insulin receptor that lead to the formation of glycogen synthase *a* in the liver. Use of a diagram is acceptable. (4 marks)

- 1. insulin receptor phosphorylates IRS-1**
- 2. protein-protein interactions/signaling cascade (PI-3 kinase)**
- 3. PKB-mediated phosphorylation of GSK-3 → inactivated**
- 4. prevents phosphorylation of glycogen synthase *a* → active**

(B) Identify two important differences between the signalling pathway in (A) and one that can be triggered by epinephrine to inhibit glycogen synthase. (2 marks)

**Any 2 of the following:**

- 1. receptor for epinephrine is serpentine receptor / not an enzyme (kinase)**
- 2. heterotrimeric GTP-binding proteins**
- 3. adenylyl cyclase (adenylate cyclase)**
- 4. cAMP**
- 5. PKA phosphorylates glycogen synthase**

(C) Describe the activity cycle of the Na<sup>+</sup> / K<sup>+</sup> ATPase. Use of a diagram is acceptable. (4 marks)

- 1. 3 Na<sup>+</sup> bind inside cell**
- 2. ATPase is phosphorylated → Na<sup>+</sup> released outside cell**
- 3. 2 K<sup>+</sup> bind outside cell**
- 4. ATPase is dephosphorylated → K<sup>+</sup> released inside cell**

### Part III - Question 5

- (A) Explain the importance of membrane rafts in cell signaling pathways. (2 marks)

**Rafts are membrane regions enriched in sphingolipids and sterols, which can sequester certain signalling proteins (usually ones from the same pathway), increasing the probability of productive interactions between them.**

- (B) Other than glycogen synthesis, identify four possible metabolic fates for glucose 6-phosphate in the liver. (4 marks)

**Any 4 of the following**

- 1. glycolysis -> citric acid cycle -> ATP**
- 2. glycolysis -> acetyl-CoA -> fatty acids**
- 3. glycolysis -> amino acids**
- 4. dephosphorylation -> export**
- 5. pentose phosphate pathway**

- (C) Describe one allosteric mechanism and one mechanism involving covalent modification by which acetyl-CoA carboxylase activity is regulated. (4 marks)

- 1. citrate activates and palmitate inhibits by binding to effector sites on the acetyl-CoA carboxylase enzyme, which are allosteric forms of control for this enzyme and the synthesis of fatty acids**
- 2. PKA-mediated phosphorylation inhibits by covalently modifying the enzyme and switching it to the less active form**