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BIOCHEMISTRY 460
FOURTH HOUR EXAMINATION
FORM A ANSWERS

May 10, 2006

NO CALCULATORS ARE NEEDED OR PERMITTED ON THIS EXAM.
NO CELL PHONES MAY BE OUT. (TURN OFF AND PUT ENTIRELY AWAY!)
NO TALKING!

CHECK SCREEN FROM TIME TO TIME FOR CORRECTIONS, CURRENT TIME, ETC.
IF NECESSARY, STAFF WILL REMAIN FOR UP TO 1 ½ HOURS, BUT 50 MIN. SHOULD BE AMPLE TIME.

p. 2	(13 points)	_____
p. 3	(15 points)	_____
p. 4	(17 points)	_____
p. 5	(22 points)	_____
p. 6	(16 points)	_____
p. 7	(17 points)	_____
TOTAL:	(100 points)	_____

1. (13 pts) Fill in the table below from the following choices. Some compounds may be used once as an answer, more than once or not at all. Some questions may have more than one correct answer. Put only one answer. If you put more than one answer, you will NOT get credit for the question. Only use compounds from this list. If you put something not included in this list, you will NOT get credit for the question. All questions do have a correct answer.

Glucose 6-phosphate
 Glucose 1-phosphate
 Glucose 1,6-bisphosphate
 Fructose 6-phosphate
 Fructose 1,6-bisphosphate
 Ribulose 5-phosphate
 Ribulose 1,5-bisphosphate
 Erythrose 4-phosphate
 Glyceraldehyde-3-phosphate
 Glycerol

ADP-Glucose
 UDP-Glucose
 Glycogen
 Cellulose
 Cellobiose
 Tyrosine
 Epinephrine
 Tryptophan
 Pectin
 Starch

Lactate
 Lactose
 Ethanol
 Carbon dioxide (CO₂)
 Oxaloacetate (OAA)
 Fumarate
 Argininosuccinate
 Carbamoyl Phosphate
 Succinate
 Citrate

<u>Description</u>	<u>Compound</u>
Substrate for glycogen phosphorylase	Glycogen
Product of glycogen phosphorylase	Glucose 1-phosphate
Substrate for glycogen synthase	UDP-Glucose
Product of glycogen synthase	Glycogen
Substrate for <u>First Enzyme</u> in <i>oxidative portion</i> of the Pentose Phosphate Pathway	Glucose 6-phosphate
Product of <u>Last Enzyme</u> in <i>oxidative portion</i> of the Pentose Phosphate Pathway	Ribulose 5-phosphate
Intermediate from the carbon shuffling portion of the Pentose Phosphate Pathway that is a precursor for aromatic amino acids	Erythrose 4-phosphate
Substrate of Rubisco	Ribulose 1,5-bisphosphate OR Carbon Dioxide (CO₂)
Product of Fermentation in <i>Muscle Cells</i>	Lactate
Compound that connects the urea cycle to the citrate cycle (is involved in both pathways)	Oxaloacetate (OAA) OR Fumarate
Substrate for sucrose phosphate synthase	UDP-Glucose OR Fructose 6-phosphate
Product of pancreatic lipase	Glycerol
Product of phenylalanine hydroxylase	Tyrosine

2. (3 pts) Which amino acids are products of the shikimate pathway?
- A. lysine, serine, arginine
 - B. methionine, leucine, valine
 - C. aspartate, methionine, threonine
 - D. phenylalanine, tryptophan, tyrosine**
 - E. phenylalanine, tyrosine, histidine
 - F. glutamine, proline, arginine
 - G. alanine, valine, leucine
 - H. histidine
3. (3 pts) Which amino acids are produced from oxaloacetate?
- A. lysine, serine, arginine
 - B. methionine, leucine, valine
 - C. aspartate, methionine, threonine**
 - D. phenylalanine, tryptophan, tyrosine
 - E. phenylalanine, tyrosine, histidine
 - F. glutamine, proline, arginine
 - G. alanine, valine, leucine
 - H. histidine
4. (3 pts) There are two nitrogen atoms eliminated from the human body in the urea molecule. One of these comes from ammonium ion through carbamoyl phosphate. What compound brings the other nitrogen directly to the urea cycle?
- A. Aspartate**
 - B. Asparagine
 - C. Glutamate
 - D. Glutamine
 - E. Methionine
 - F. Lysine
5. (6 pts)
- A. (3 pts) What enzyme is inhibited by RoundUp (glyphosate)? (Circle number of correct answer.)
- 1. DAHP Synthase
 - 2. ATP Synthase
 - 3. Succinate Dehydrogenase
 - 4. Sucrose Phosphate Synthase
 - 5. PEP Carboxylase
 - 6. Nitrogenase
 - 7. EPSP Synthase**
 - 8. Cellulose Synthase
- B. (3 pts) Why does RoundUp (glyphosate) kill plants but not people? (Circle number of correct answer.)
- 1. Both plants and people have the enzyme inhibited by glyphosate (part A), but only the plant form of the enzyme is sensitive to glyphosate.
 - 2. There is an enzyme in the human liver that detoxifies glyphosate so that people can secrete it in their urine, protecting them from the harmful effects it might have on their metabolism.
 - 3. People do not have the enzyme inhibited by glyphosate (part A), so they are not affected by glyphosate like plants are.**
 - 4. People have another pathway in the liver that bypasses the pathway blocked by glyphosate.

____/15

6. (12 pts) It is not a good idea for a marathon runner to eat a candy bar about 20 – 30 min before the start of a race. Why is this so? Answer the following questions to help explain this phenomenon.
- A. (2 pts) Intake of a high sugar food will induce production of insulin
(name hormone)
- B. (2 pts, circle correct underlined word from each pair) Binding of this hormone to *liver cell receptors* will activate a signaling pathway that will lead to phosphorylation / dephosphorylation and activation / deactivation of *glycogen synthase*.
- C. (2 pts, circle correct underlined word from each pair) Binding of this hormone to *liver cell receptors* will activate a signaling pathway that will lead to phosphorylation / dephosphorylation and activation / deactivation of *glycogen phosphorylase*.
- D. (2 pts, circle number of correct response) The *net effect on liver cells* of eating the candy bar will be:
1. an uptake of glucose from the blood and storage of glucose in the form of glycogen in the liver cells.
 2. a breakdown of glycogen in the liver cells and release of glucose to the blood.
- E. (2 pts, circle number of correct response) Binding of the hormone (part A above) to the *adipose cell receptors* will also affect fatty acid metabolism. It will lead to:
1. breakdown of triacylglycerides in adipose cells and secretion of fatty acids and glycerol
 2. conversion of glucose and fatty acids into triacylglycerols in adipose cells
- F. (2 pts, circle correct underlined word) The overall net effect of eating the candy bar is that there will be more / less glucose and fatty acids available to the muscles during the first part of the race.

7. (5 pts)

- A. (3 pts) What enzyme catalyzes the reaction in gluconeogenesis that bypasses the glycolytic reaction catalyzed by phosphofructokinase-1 (PFK-1) (i.e., what gluconeogenic enzyme opposes phosphofructokinase-1)?
Fructose 1,6-bisphosphatase
- B. (2 pts, circle correct word) Does AMP activate or inhibit this gluconeogenic enzyme?
Activates Inhibits Neither

8. (4 pts, 2 pts each) Which of the following statements are TRUE (T) and which are FALSE (F)? (Circle letter of correct answer for each.)
- T / **F** Liver cells can use acetyl-CoA to make OAA, which can then be converted to pyruvate as a substrate for gluconeogenesis.
- T / **F** When the muscle has enough energy and the liver needs more energy, muscle cells secrete glucose for transport to the liver via the Cori Cycle.
9. (4 pts) The first committed step in *fatty acid synthesis* is: (circle letter of correct answer)
- A. The carboxylation of acetyl-CoA to form malonyl-CoA by the enzyme acetyl-CoA carboxylase.**
- B. The activation by the enzyme acyl-CoA synthetase to form a fatty acyl-CoA.
- C. Attachment of the acyl group to carnitine by the enzyme carnitine acyltransferase I.
- D. The condensation of acetyl-ACP and malonyl-ACP to form acetoacetyl-ACP.
10. (4 pts) The citrate shuttle is used to move acetyl-CoA from the mitochondrial matrix to the cytosol. It also produces NADPH, which can be used in fatty acid biosynthesis.
- A. (2 pts) For production of one molecule of laurate (12:0) in fatty acid synthesis in the cytosol, how many molecules of acetyl-CoA are moved out of the mitochondrion by this shuttle?
6 (six)
- B. (2 pts) How many NADPH molecules are produced by this shuttle in moving that many acetyl-CoA units?
6 (six)
11. (4 pts)
- A. How many molecules of NADPH are required for biosynthesis of laurate (12:0)?
10 (ten)
- B. Besides the citrate shuttle, what is another major source of cytosolic NADPH that can be used for fatty acid biosynthesis? (Just name the overall pathway, not specific enzyme or reaction.)
Pentose Phosphate Pathway
12. (6 pts)
- A. (2 pts) From the β -oxidation of the fatty acid myristate (14:0), how many molecules of acetyl-CoA are produced?
7 (seven)
- B. (2 pts) What reduced coenzyme(s) is/are produced by β -oxidation of fatty acids (write correct form of reduced cofactor(s))?
NADH and FADH₂
- C. (2 pts) How many molecules of *each* reduced coenzyme are produced by oxidation of one molecule of myristate (14:0)?
6 NADH and 6 FADH₂

13. (4 pts) Sucrose phosphate synthase (SPS) is inhibited by sucrose and inorganic phosphate (Pi). Why does it make sense that Pi inhibits this enzyme?
- A. High Pi levels indicate that photosynthesis is very active, therefore SPS should be inhibited.
 - B. High Pi levels indicate that photosynthesis is inactive, therefore SPS should be inhibited.**
 - C. Pi acts as a primary messenger in plant cells and is produced to tell neighboring cells to shut off sucrose production.
 - D. Pi acts as a second messenger in plant cells, and is produced in response to hormonal signaling, turning off production of sucrose, similar to how the insulin signaling pathway turns off glucose production in the human liver.
14. (4 pts) Which of the following are primary mechanisms by which intracellular cholesterol levels in the liver are regulated? Circle letters of all correct answers. More than one answer may be correct.
- A. High intracellular levels of cholesterol inhibit the enzyme HMG-CoA reductase, which shuts down de novo cholesterol synthesis.**
 - B. High intracellular levels of cholesterol inhibit synthesis of the LDL receptor, which reduces receptor-mediated endocytosis and thereby decreases cholesterol uptake from the serum.**
 - C. High intracellular levels of cholesterol target the enzyme HMG-CoA reductase for ubiquitination, leading to its rapid degradation.
 - D. Low intracellular levels of cholesterol lead to increased expression of the mRNA for the enzyme HMG-CoA reductase.
 - E. None of the above.
15. (8 pts) Acetyl-CoA carboxylase catalyzes the first committed step in the biosynthesis of fatty acids.
- A. (4 pts) Name two allosteric regulators of acetyl-CoA carboxylase. Indicate for each whether it is a stimulator or inhibitor of the enzyme.
Stimulator: Citrate
Inhibitor: AMP OR Palmitoyl-CoA
(Any two of these 3 answers)
 - B. (4 pts) Name two hormone regulators of acetyl-CoA carboxylase. Indicate for each whether action of the hormone results in stimulation or inhibition of the enzyme.
Stimulator: Insulin
Inhibitor: Glucagon OR Epinephrine (adrenaline)
(Any two of these 3 answers)

16. (3 pts) The nodules on roots of legumes that are involved in nitrogen fixation are red in color due to the presence of a protein called leghemoglobin. What purpose does this protein serve?
- A. It binds oxygen and makes it available to the nitrogenase enzyme complex, which needs oxygen to function properly.
 - B. It is part of the nitrogenase complex.
 - C. **It binds oxygen to help keep it away from the nitrogenase enzyme complex, which is inhibited by oxygen.**
 - D. It has nothing to do with nitrogen fixation; it serves a different function in legume roots.
17. (14 pts) For each metabolic disorder listed below, give the name of the enzyme that is defective.

Disorder/Disease	Enzyme affected/responsible (2 pts each)
von Gierke's disease: build-up of glycogen in the liver because glucose-6P accumulates and activates glycogen synthase	glucose-6-phosphatase
McArdle's disease: individuals suffer from exercise-induced cramps and muscle pain due to their inability to degrade muscle glycogen	(muscle) glycogen phosphorylase
Cori's disease: structure of both liver and muscle glycogen in these individuals contains short outer chains in the glycogen particle that cannot be removed, thus blocking complete degradation	glycogen debranching enzyme
Andersen's disease: Results in the synthesis of large unbranched glycogen molecules that are insoluble and cause the immune system to attack and destroy liver cells	glycogen branching enzyme
Erythropoetic Porphyrria: Leads to buildup of uroporphyrinogen I, urine turns red, the skin becomes light sensitive and teeth glow in the dark	uroporphyrinogen III cosynthase
Phenylketonurea: Mental retardation caused by build-up of phenylalanine and phenylpyruvate	phenylalanine hydroxylase
Albinism: Lack of melanin in skin.	tyrosinase

Survey Question: (0 pts)

T / F When Dr. Gang went to the Tihutsa Pass in Transylvania, he was bitten in the neck by a vampire. That is why I never went to visit him during his office hours—I didn't want to become a vampire too!

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