NAME _____

FINAL EXAM
August 11, 2011
Biochemistry II
BI/CH422S

I.	_____	/57
II.	_____	/23
III.	_____	/29
IV.	_____	/25
V.	_____	/ 6
TOTAL		/140

I. **MULTIPLE CHOICE** (57 points)
Choose the best answer as requested in each question by circling the approporitate letter(s). 3 points each.

1. Which of the following is true of glycogen synthesis and breakdown?

   A. Synthesis is catalyzed by the same enzyme that catalyzes breakdown.
   B. The immediate product of glycogen breakdown is free glucose.
   C. Phosphorylation activates the enzyme responsible for breakdown, and inactivates the synthetic enzyme.
   D. Under normal circumstances glycogen synthesis and glycogen breakdown occur simultaneously and at high rates.
   E. The glycogen molecule "grows" at its reducing end.

2. If a cell were unable to synthesize or obtain tetrahydrofolic acid (H_4 folate), it would probably be deficient in the biosynthesis of:

   A. lysine.
   B. thymidylate (TMP).
   C. malonate.
   D. leucine.

3. When glycerol is converted to glucose via gluconeogenesis, the first *glycolytic* intermediate formed is:

   A. 1,3-bisphosphoglycerate.
   B. ribulose-1,5-bisphosphate.
   C. glycerol-1,3-bisphosphate.
   D. glycerol-3-phosphate.
   E. dihydroxyacetone phosphate.

4. The synthesis of both glycerophospholipids and triacylglycerols involves:

   A. CDP-diacylglycerol.
   B. phosphoethanolamine.
   C. phosphatidate.
   D. CDP-choline.
   E. phosphatidate phosphatase.

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5. Which of the following is *not* true of the reaction catalyzed by ribonucleotide reductase?

   A. It acts on nucleoside *di*phosphates.
   B. Thioredoxin acts as an essential electron carrier.
   C. Its mechanism involves formation of a free radical.
   D. There is a separate enzyme for each nucleotide (ADP, CDP, GDP, UDP).
   E. Glutathione is part of the path of electron transfer.

6. Cholesterol is synthesized from:

   A. acetyl-CoA.
   B. malate.
   C. oxalate.
   D. lipoic acid.
   E. choline.

7. Which of the following statements about the synthesis of isopentenyl pyrophosphate from acetate is *not* true?

   A. Biotin is required.
   B. Carbon dioxide is liberated.
   C. ATP is consumed.
   D. Mevalonate is an intermediate.
   E. NADPH is the electron donor.

8. The carbon skeleton of several amino acids may be derived metabolically from glucose. If glucose labeled with ^{14}C at C-1 were the starting material for amino acid biosynthesis, a product that would be readily formed is:

   A. serine labeled at C-2 (C_α).
   B. glycine labeled at C-1 (COO^-).
   C. serine labeled at C-3 (CH_2OH).
   D. glycine labeled at C-2 (C_α).

9. Precursors for the biosynthesis of the pyrimidine ring system include:

   A. glutamate, NH_3, and CO_2.
   B. glycine, glutamine, CO_2, and aspartate.
   C. glycine and succinyl-CoA.
   D. carbamoyl phosphate and aspartate.

10. Which of the following substrates *cannot* contribute to net gluconeogenesis in mammalian liver?

    A. alanine
    B. palmitate
    C. α-ketoglutarate
    D. glutamate
    E. pyruvate

11. Which of the following statements is *not* true of the pathway by which purine nucleotides are synthesized?

    A. The amino acid glycine is one of the precursors.
    B. The first enzyme in the path is aspartate transcarbamoylase (ATCase).
    C. Inosinate is the purine nucleotide that is the precursor of both adenylate and guanylate.
    D. CO_2 is required for one of the steps in this pathway.

12. In comparing fatty acid biosynthesis with β oxidation of fatty acids, which of the following statements is *incorrect*?

    A. Fatty acid degradation is catalyzed by cytosolic enzymes; fatty acid synthesis by mitochondrial enzymes.
    B. A thioester derivative of crotonic acid (*trans*-2-butenoic acid) is an intermediate in the synthetic path, but not in the degradative path.
    C. A thioester derivative of D-β-hydroxybutyrate is an intermediate in the synthetic path, not in the degradative path.
    D. The condensation of two moles of acetyl-CoA in the presence of a crude extract is more rapid in bicarbonate buffer than in phosphate buffer at the same pH; the cleavage of acetoacetyl-CoA proceeds equally well in either buffer.
    E. Fatty acid biosynthesis uses exclusively NADPH, whereas β oxidation uses exclusively NAD^+.

13. The ribosyl phosphate moiety needed for the synthesis of orotidylate, inosinate, and guanylate is provided most directly by:

    A. adenosine-5'-phosphate.
    B. guanosine-5'-phosphate.
    C. 5-phosphoribosyl-1-pyrophosphate.
    D. ribulose-5-phosphate.
    E. ribose-5-phosphate.

14. Humans cannot convert dietary:

    A. carbohydrate into stored lipid.
    B. amino acids into stored lipid.
    C. glucose into amino acids.
    D. amino acids into glucose.
    E. fatty acids into glucose.

15. Photosynthetic phosphorylation and oxidative phosphorylation appear to be generally similar processes, both consisting of ATP synthesis coupled to the transfer of electrons along an electron carrier chain. Which of the following is *not* true of both processes?

    A. Both make use of oxygen as a terminal electron acceptor.
    B. Both contain cytochromes and flavins in their electron carrier chains.
    C. Both processes are associated with membranous elements of the cell.
    D. Each represents the major route of ATP synthesis in those cells in which it is found.

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16. Which of the following molecules binds strongly to avidin, a protein found in raw eggs?

A. pantothenic acid
B. folic acid
C. niacin
D. lipoic acid
E. biotin

17. Which of these statements about the regulation of cholesterol synthesis is *not* true?

A. Insulin stimulates HMG-CoA reductase.
B. High intracellular cholesterol stimulates formation of cholesterol esters.
C. Cholesterol acquired in the diet has essentially no effect on the synthesis of cholesterol in the liver.
D. Some metabolite or derivative of cholesterol inhibits HMG-CoA reductase.
E. Failure to regulate cholesterol synthesis predisposes humans to atherosclerosis.

18. In the synthesis of phosphatidylcholine from phosphatidylethanolamine, the methyl group donor is:

A. methanol.
B. *S*-adenosylmethionine (adoMet or SAM).
C. a tetrahydrofolate derivative.
D. choline.
E. serine.

19. Which of the following enzymes is *not* involved in the assimilation of inorganic nitrogen into an organic molecule?

A. glutamine synthetase
B. nitrogenase
C. arginase
D. carbamoyl phosphate synthetase

II. **FILL-IN & MATCHING**. (23 points)

20. Indicate which of the following statements is true (T), and which is false (F). For any statement that you say is false, explain why it is false. (4 pts)

___(a) In a reaction under standard conditions, only the reactants are fixed at 1 M.

___(b) When $\Delta G^{\circ\prime}$ is positive, $K_{eq}' > 1$.

___(c) $\Delta G'$ and $\Delta G^{\circ\prime}$ mean the same thing.

___(d) When $\Delta G^{\circ\prime} = 1.0$ kJ/mol, $K_{eq}' = 1$.

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21. Energy Metabolism (9 pts)

In energy metabolism, sugars are completely oxidized to _____(a), mostly in the _____(b). A key intermediate of this metabolism is acetyl-CoA, a ____(c) carbon compound attached to coenzyme A. During the complete oxidation of a molecule of acetyl-CoA there are _____(d) molecules of _____(e) reduced to _____(f) (a key electron carrier). In addition, FAD is reduced to _____(g). Using the P/O ratio of 3.0 and 2.0 for these two electron carriers, respectively, the mitochondria can produce _____(h) molecules of ATP from each acetyl-CoA that is oxidized. The complete process is called combustion because _____(i) is consumed by reduction to form water. The oxidation of acetyl-CoA and the consumption of _____(i) are different pathways; called the _____(b) and oxidative-phosphorylation, respectively. However, both pathways are tightly coupled by the ratios of ATP/ADP and _____(f)/_____(e). Furthermore, the synthesis of ATP can be uncoupled from _____(j) by compounds like _____(k), which destroy the _____ (l) gradient across the inner mitochondrial _____(m).

22. Regulation; cofactors and enzyme nomenclature: (10 pts)

Match items on the left with the best answer from items on the right. All items on the right are used, some more than once.

Column A		Column B	
____1.	Allosteric effector for activation of phosphofructokinase-1	A.	carboxylases
____2.	Allosteric effector for activation of protein kinase A	B.	decarboxylases
____3.	Allosteric effector for inhibition of ribonucleotide reductase	C.	transaminases
____4.	phosphorylation causes _____.	D.	kinases
____5.	adenylation causes _____.	E.	dehydrogenases
____6.	transfer of phosphoryl groups from ATP	F.	oxidases
____7.	use of oxygen as an electron acceptor	G.	mono-oxygenases
____8.	addition of oxygen to both the substrate and water	H.	dioxygenases
____9.	addition of both oxygen atoms from oxygen to the substrate	I.	isomerases
___10.	transfer of electrons	J.	inhibition of glutamine synthetase
___11.	interconversion of aldose and ketose sugars	K.	synthetases
___12.	transfer of amino groups	L.	methylases
___13.	synthesis utilizing hydrolysis of ATP	M.	fructose 2,6-bisphosphate
___14.	removal of carbon dioxide	N.	cyclic AMP
___15.	use pyridoxal phosphate	O.	dATP
___16.	use biotin	P.	inhibition of glycogen synthase
___17.	use NADH	Q.	fructose 1,6-bisphosphate
___18.	use tetrahydrobiopterin		
___19.	use of SAM		
___20.	substrate that is cleaved using Schiff base-enzyme mechanism		

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III. **SHORT ANSWER**. (29 points)

23. The conversion of glucose into glucose-6-phosphate, which must occur in the breakdown of glucose, is thermodynamically unfavorable (endergonic). How do cells overcome this problem? (2 pts)

24. Many diabetics do not respond to insulin because of a deficiency of insulin receptors on their cells. How does this affect (a) the levels of circulating glucose immediately after a meal and (b) the rate of glycogen synthesis in muscle? (4 pts)

25. A sample of glycogen from a patient with liver disease is incubated with P_i, normal glycogen phosphorylase, and normal debranching enzyme. The ratio of Glc 1-P to glucose formed in the reaction mixture was 100. What is the patient's most probable deficiency? (3 pts)

26. What is an oxidation? What is a reduction? Can an oxidation occur without a simultaneous reduction? Why or why not? (4 pts)

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27. Many amino acids are broken down to intermediates of the citric acid cycle. (a) Why can't these amino acid "remanants" be directly oxidized to CO_2 in one round of the citric acid cycle? (b) Explain why amino acids that are broken down to pyruvate can have 1/3 of the carbon in pyruvate completely oxidized, but not the other 2/3 carbons in one round of the citric acid cycle. (c) Not all amino acids are anaplerotic for the citric acid cycle. Name three amino acids whose "remanants" are anaplerotic. (10 pts)

28. What are the biological functions of the pentose phosphate pathway? (2 pts)

29. Explain why the phosphorolysis of glycogen is more efficient than the hydrolysis of glycogen in mobilizing glucose for the glycolytic pathway. (2 pts)

30. Why do individuals who are undergoing chemotherapy with methotreaxate often temporarily go bald? (2 pts)

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IV. **PATHWAY**.

Write out the eight steps in the TCA cycle starting from the condensation of acetyl-CoA with oxaloacetate. For each step give the name of the enzyme that catalyzes the reaction (no abbreviations), any cofactors required (abbreviations OK), the name of each intermediate/product(s) and their structures (including acetyl-CoA with oxaloacetate; you can abbreviate phosphate and/or phosphoryl by a circled "P" and Coenzyme A as "CoA").

31. (25 points)

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V. **LABORATORY** (6 points)

32. Match the staining method that best visualizes each of the following molecules. (3 pts)

A. Periodate/Schiff
B. Coomassie Blue
C. Horseradish peroxidase conjugated anti-IgG/chloronapthol

_____ protein to which you have an antibody

_____ glycoprotein

_____ serum protein

33. In the laboratory, quantitative precipitation of a radioactive sample of protein and collection for scintillation counting can be done by __.

A. use of a dye-binding assay
B. use of a Spec-20 to measure the absorance at 260 nm
C. use of a polyacrylamide gel
D. asking your TF to do it for you
E. using TCA and filtration onto glass fiber filter disks
F. using BSA and measuring the absorbance at 280nm in a UV spectrophotometer

Answer Key for Test "FINAL_2011S", 08/10/11

No. in Q-Bank		No. on Test	Correct Answer
19	11	1	C
21	25	2	B
19	8	3	E
20	14	4	C
21	35	5	D
20	23	6	A
20	25	7	A
21	13	8	C
21	34	9	D
19	3	10	B
21	31	11	B
20	10	12	A
21	27	13	C
16	11	14	E
18	20	15	A
30	12	16	E
20	28	17	C
20	21	18	B
21	78	19	C
13	29	20	

0 57
1 54
2 51
3 48
4 45
5 42
6 39
7 36
8 33
9 30
10 27

11 - 24
12 - 21
13 - 18
14 - 15
15 - 12

(a) False; both reactants and products are fixed at 1 M.
(b) False; $\Delta G^{\circ\prime} = -RT \ln K_{eq}'$, so when $K_{eq}' > 1$, the term $-RT \ln K_{eq}'$ (i.e., $\Delta G^{\circ\prime}$) has a negative value.
(c) False; ΔG is a variable dependent upon the physical constant $\Delta G^{\circ\prime}$ and a term that includes T and the concentrations of reactants and products:

$$\Delta G = \Delta G^{\circ\prime} + RT \ln \frac{[\text{product}]}{[\text{reactant}]}$$

(d) False; $\Delta G^{\circ\prime} = -RT \ln K_{eq}'$. When $K_{eq}' = 1$, the logarithmic term = 0, and $\Delta G^{\circ\prime} = 0$.

30 1 21

a. carbon dioxide
b. TCA cycle
c. 2
d. 3
e. NAD+
f. NADH
g. $FADH_2$
h. 11
i. oxygen
j. electron transport
k. dinitrophenol
l. proton
m. membrane

Answer Key for Test "FINAL_2011S", 08/10/11

No. in Q-Bank	No. on Test		Correct Answer
30	2	22	1 M,
			2 N,
			3 O,
			4 P,
			5 J,
			6 D,
			7 F,
			8 G,
			9 H,
			10 E/F/G/H,
			11 I,
			12 C,
			13 K,
			14 B,
			15 C/B,
			16 A,
			17 E,
			18 G,
			19 L,
			20 Q
14	47	23	Cells often drive a thermodynamically unfavorable reaction in the forward direction by coupling it to a highly exergonic reaction through a common intermediate. In this example, to make glucose-6-phosphate formation thermodynamically favorable, cells transfer phosphoryl groups from ATP to glucose. ATP "hydrolysis" is highly exergonic, making the overall reaction exergonic. (Numerical solution below not required.)
22	46	24	(a) Circulating [glucose] is high because cells do not respond to the insulin signal to take up glucose. (b) Insulin is unable to activate phosphoprotein phosphatase-1 in muscle, so glycogen synthesis is not stimulated. Moreover, glycogen synthesis is much reduced by the lack of available glucose in the cell.
19	50	25	The deficiency is in branching enzyme (Type IV glycogen storage disease). The high ratio (normal is ~10) of Glc 1-P to glucose indicates abnormally long chains of α(1->4)-linked residues with few α(1->6)-linked branch points (which result in free glucose).
13	34	26	Oxidation is the loss of electrons; reduction is the gain of electrons. Free electrons are unstable (do not occur), so whenever an electron is released by oxidation of some species, an electron must be accepted by reduction of another species.

Glucose + P_i ⟶ glucose-6-phosphate + H_2O $\quad \Delta G^{\circ\prime} = +13.8$ kJ/mo

ATP + H_2O ⟶ ADP + P_i $\quad \Delta G^{\circ\prime} = -30.5$ kJ/mol

Sum: ATP + glucose ⟶ ADP + glucose-6-phosphate $\quad \Delta G^{\circ\prime} = -16.7$ kJ/mol

No. in Q-Bank	No. on Test	Correct Answer
15	56	27 (a) These "remanants" do not get oxidized directly in one round of the citric acid cycle because they are all C3 or C4 compounds and each round of the citric acid cycle only produces 2 CO_2 molecules. Those that make acetyl-CoA are not oxidized in one round because the carbons produced in one round come from the carboxylates of oxaloacetate, not acetyl-CoA. (b) The pyruvate derived from amino acids is converted to acetyl-CoA by the Pyruvate Dehydrogenase Complex after oxidation of the carboxylate (1 of the 3 carbons) to CO_2. The remaining 2/3 carbons (as acetyl CoA) are NOT completely oxidized in one round of the citric acid cycle for the same reason that the 2/3 or pyruvate are not (see (a)). (c) Asp, Phe, Tyr, Ile, Met, Val, Ala, Glu, Gln, Asn, Pro
14	86	28 The pentose phosphate pathway produces pentose phosphates (for nucleotide synthesis) and NADPH (reducing agent for biosynthetic processes).
14	75	29 Phosphorolysis yields glucose-1-phosphate, which can be converted into glucose-6-phosphate without the investment of energy from ATP. Hydrolysis of glycogen yields free glucose, which must be converted into glucose-6-phosphate (at the expense of ATP) before it can enter glycolysis.
21	77	30 Methotrexate kills rapidly proliferating cells, such as cancer cells and those of hair follicles. Consequently, hair falls out.
19	49	31 ?
29	2	32 C; A; B
29	6	33 E

Structure Name enzyme Cofactor

AcetylCoA

OAA Cit-Synth

Citrate

Aconitase FeS

Isocitrate

CO_2 ICDH NAD^+

CO_2 αKG αKGDHC TPP, Lip_8, FAD, NAD^+, CoA

Succ CoA

Succ Succ CoA Synth GTP, P_i

Fumr SuccDH FAD

Mal fumrase Mn

OAA MalDH NAD^+