BIOL/CHEM 3361 and BIOL 6352 **FORM A**

EXAM No. 4 Spring 2011, Marsh and Spiro

NAME: _____

PLEASE MAKE SURE TO BUBBLE YOUR NAME AND STUDENT ID ON THE SCANTRON

There are 50 multiple choice questions, and two short answer questions (on the last page). Write your answer to the short answer question on this paper (NOT on the Scantron), write your name in the space above, and turn in the entire question paper. You will receive zero points if you do not do this.

GLUCONEOGENESIS

1. Gluconeogenesis is the synthesis of:
   a. glucose from non-carbohydrate precursors.
   b. glycogen from glucose.
   c. pyruvate from glucose.
   d. fatty acids from glucose.
   e. glucose from fatty acids.

2. In the gluconeogenic pathway, the three _____ regulated reactions of glycolysis catalyzed by _____, _____ and _____ are replaced by alternative reactions.
   a. exergonic; hexokinase; PFK 1; pyruvate kinase
   b. exergonic; phosphoglucoisomerase; PFK 1; pyruvate kinase
   c. exergonic; PFK 1; triose phosphate isomerase; pyruvate kinase
   d. endergonic; glucokinase; PFK 1; glyceraldehyde-3-phosphate dehydrogenase
   e. endergonic; glucokinase; PFK 1; pyruvate carboxylase

3. All are enzymes unique to gluconeogenesis that are not shared with glycolysis EXCEPT:
   a. phosphoglucoisomerase.
   b. glucose-6-phosphatase.
   c. pyruvate carboxylase.
   d. fructose-1,6-bisphosphatase.
   e. PEP carboxykinase.

4. Glucose-6-phosphatase is located in the _____ and produces _____

   a. mitochondria; lactate
   b. cytosol; glucose
   c. endoplasmic reticulum; glucose-6-phosphate
   d. endoplasmic reticulum; glucose
   e. cytosol; glucose-6-phosphate

5. Gluconeogenesis is not simply reversal of glycolysis since the conversion of 2 pyruvate → glucose by gluconeogenesis requires _____ molecules of ATP/GTP.
   a. 2
   b. 3
   c. 4
   d. 5
   e. 6

GLYCOGEN METABOLISM AND THE PENTOSE PHOSPHATE PATHWAY

6. The highly _____ polysaccharides called limit dextrins are degraded by the action of _____ which has two distinct enzymatic activities known as _____ and _____.
   a. branched; α-amylase; glycogen phosphorylase; α(1→6)glucosidase
   b. branched; debranching enzyme; glucanotransferase; α(1→6)glucosidase
   c. linear; debranching enzyme; glucanotransferase; α(1→6)glucosidase
   d. branched; debranching enzyme; α-amylase; α(1→6)glucosidase
   e. linear; α-amylase; gluconotransferase; glycogen phosphorylase

7. The activity of glycogen phosphorylase is:
   a. the conversion of glucose-1-phosphate to glucose-6-phosphate.
   b. the hydrolysis of ATP.
   c. the phosphorolysis of glycogen to generate glucose-1-phosphate.
   d. to inhibit the production of glucose-1-phosphate.
   e. to synthesize glycogen.

8. Which statement is a correct description of the mechanisms of regulation of glycogen phosphorylase?
   a. phosphorylase 'b' is phosphorylated, and is allosterically activated by AMP.
   b. phosphorylase 'a' and phosphorylase 'b' are interconverted by the allosteric regulator AMP.
   c. phosphorylase 'a' is phosphorylated, and is persistently active.
   d. phosphorylase 'a' is not phosphorylated, and is allosterically activated by AMP.
   e. phosphorylase 'b' is not subject to allosteric regulation by AMP

9. The correct sequence for the hormone-activated enzymatic cascade that leads to activation of glycogen phosphorylase is:

A. Phosphorylation of phosphorylase kinase to activate it
B. Activation of G-protein
C. Activation of adenylyl cyclase to produce cAMP
D. Phosphorylation of glycogen phosphorylase
E. cAMP activation of cAMP-dependent protein kinase

a. A, B, C, D, E
b. B, C, E, A, D
c. C, B, A, D, E
d. B, D, E, A, C
e. E, A, D, C, B

10. All are true for cAMP-dependent protein kinase EXCEPT:
a. glycogen synthase is a substrate.
b. phosphorylase kinase is a substrate.
c. consists of a pair of catalytic subunits.
d. two regulatory subunits block catalytic activity without cAMP binding.
e. phosphorylates glycogen phosphorylase.

11. An individual with von Gierke's disease lacks the enzyme _____ which is used to maintain _____. As a result, the individual is _____.
a. glycogen synthase; liver glycogen; prone to lactic acidosis.
b. glycogen glycogen phosphorylase; ATP levels; unable to exercise.
c. debranching enzyme; blood glucose; hypoglycemic.
d. glucose-6-phosphatase; blood glucose; hypoglycemic.
e. glucose-6-phosphatase; muscle glycogen; unable to exercise.

12. The pentose phosphate pathway is a primary source of _____, and of _____, an essential precursor of NAD^+, FAD, CoA, DNA and RNA.
a. ATP; NADH
b. NADH; NADPH
c. NADPH; ribose-5-phosphate
d. ribose-5-phosphate; ATP
e. all are true

13. When a cell with the pentose phosphate pathway needs more pentose phosphates, but no additional NADPH the following happens:
    a. glucose-6-phosphate dehydrogenase is activated.
    b. the oxidative and non-oxidative enzymes of the pentose phosphate pathway are active.
    c. the non-oxidative enzymes produce pentose phosphates from fructose-6-phosphate and glyceraldehyde-3-phosphate.
    d. all enzymes of glycolysis and pentose phosphate pathway are active.
    e. none are true.

THE TCA CYCLE

14. Which of the following is *not* an intermediate of the citric acid cycle?

    a. Acetyl-CoA
    b. Citrate
    c. Oxaloacetate
    d. Succinyl-CoA
    e. α-Ketoglutarate

15. In the TCA cycle, carbon enters the cycle as _____ and exits as _____ with metabolic energy captured as _____, _____ and _____.
    a. pyruvate; water; NADH; ATP; NADPH
    b. acetyl-CoA; CO_2; NADH; ATP; NADPH
    c. succinyl-CoA; CO_2; ATP; NADH; NADPH
    d. acetyl-CoA; CO_2; ATP; NADH; [$FADH_2$]
    e. oxaloacetate; water; NADH; [$FADH_2$]; ATP

16. In eukaryotic cells, glycolysis occurs in the _____, and the TCA cycle reactions take place in _____.
    a. mitochondria; mitochondria
    b. cytoplasm; mitochondria
    c. cytoplasm; cytoplasm
    d. mitochondria; ribosomes
    e. cytoplasm; ribosomes

17. The _____ of pyruvate to acetyl-CoA is catalyzed by _____.
    a. dehydration; pyruvate dehydration complex
    b. oxidative decarboxylation; pyruvate dehydrogenase complex
    c. decarboxylation; pyruvate decarboxylase
    d. phophorylation; pyruvate kinase
    e. none of the above.

18. Order the coenzymes according to their involvement in the reaction catalyzed by the pyruvate dehydrogenase complex.

A. NAD^+
B. CoA-SH
C. TPP
D. Lipoate (lipoamide)
E. [FAD]

a. A, B, C, D, E
b. C, B, A, E, D
c. C, D, B, E, A
d. B, D, E, A, C
e. C, E, D, B, A

19. _____catalyzes citrate isomerization to isocitrate by abstracting _____ from citrate to yield [_____], then _____ in the opposite position to produce isocitrate.

a. Citrate isomerase; CO_2; aconitate; carboxylation
b. Citrate isomerase; water; aconitate; rehydration
c. Aconitase; water; aconitate; rehydration
d. Aconitase; CO_2; isocitrate; carboxylation
e. None is true

20. Fluoroacetate inhibits the TCA cycle. Although it does not inhibit citrate synthase directly, the product of fluoroacetate metabolism inhibits:

a. aconitase.
b. isocitrate dehydrogenase.
c. α-ketoglutarate dehydrogenase.
d. succinate dehydrogenase.
e. pyruvate dehydrogenase.

21. Which enzymes of the TCA cycle catalyze oxidative decarboxylation reactions?

a. malate dehydrogenase and citrate synthase
b. fumarase and succinate dehydrogenase
c. α-ketoglutarate dehydrogenase and succinate dehydrogenase
d. isocitrate dehydrogenase and α-ketoglutarate dehydrogenase
e. aconitase and succinate dehydrogenase

22. α-Ketoglutarate dehydrogenase reaction is a multi-enzyme complex analogous to:

a. pyruvate kinase.
b. glyceraldehyde-3-phosphate dehydrogenase.
c. isocitrate dehydrogenase.
d. pyruvate dehydrogenase.
e. lactate dehydrogenase. malate is similar to lactate (?)

23. The coenzymes listed below are associated with α-ketoglutarate dehydrogenase complex EXCEPT:

a. [FAD].
b. TPP.
c. lipoamide.
d. NAD^+.
e. biotin.

24. The only reaction of the citric acid cycle that is a substrate-level phosphorylation is catalyzed by:

a. malate dehydrogenase.
b. citrate synthase.
c. isocitrate dehydrogenase.
d. succinyl-CoA synthetase.
e. fumarase.

25. The correct sequence of electron transfer in the succinate dehydrogenase reaction mechanism is:

A. Coenzyme Q (UQ).
B. [FAD].
C. iron-sulfur clusters.
D. Complex III.

a. A, B, C, D
b. B, C, D, A
c. B, C, A, D
d. C, B, D, A
e. C, D, A, B

26. The oxidation of malate to oxaloacetate is not thermodynamically favored under standard conditions. It occurs because:

a. it involves substrate-level phosphorylation.
b. it is coupled with a strong reduction.
c. it is coupled with ATP hydrolysis.
d. oxaloacetate is used in the next reaction which has a negative ΔG.
e. the previous reaction has a large negative ΔG.

27. How many NADH molecules are produced in the TCA cycle per molecule of acetyl-CoA oxidized?

a. 1
b. 2
c. 3
d. 4
e. 5

28. The anaplerotic reactions associated with the TCA cycle are needed because of the:

a. use of many of the TCA cycle intermediates in biosynthesis.
b. oxidative nature of the TCA cycle.
c. decarboxylation reactions.
d. production of GTP and reduced coenzymes.
e. irreversible nature of some of the TCA cycle reactions.

29. Which one of the following enzymatic activities would be decreased by thiamine deficiency?

a. Fumarase
b. Isocitrate dehydrogenase
c. Malate dehydrogenase
d. Succinate dehydrogenase
e. α-Ketoglutarate dehydrogenase complex

ELECTRON TRANSPORT AND OXIDATIVE PHOSPHORYLATION

30. The standard reduction potentials (E'°) for the following half reactions are given.

$$\text{Oxaloacetate} + 2H^+ + 2e^- \rightarrow \text{malate} \qquad E'^{\circ} = -0.166 \text{ V}$$
$$NAD^+ + 2H^+ + 2e^- \rightarrow NADH + H^+ \qquad E'^{\circ} = -0.320 \text{ V}$$

If you mixed oxaloacetate, malate, NAD^+, and NADH together, all at l M concentrations and in the presence of malate dehydrogenase, which of the following would happen *initially*?

a. Oxaloacetate and malate would become oxidized; NAD^+ and NADH would become reduced.
b. Oxaloacetate would become reduced, NADH would become oxidized.
c. No reaction would occur because all reactants and products are already at their standard concentrations.
d. Malate would become oxidized, NAD^+ would become reduced.
e. Malate would become oxidized, NADH would be unchanged because it is a cofactor.

31. All can typically carry only one electron EXCEPT:
    a. UQH_2.
    b. Cyt b_L.
    c. Cyt b_H.
    d. Fe-S clusters.
    e. Cyt c_1.

32. ATP made in glycolysis and the TCA cycle is the result of _____ phosphorylation, and NADH-dependent ATP synthesis is the result of _____ phosphorylation.
    a. oxidative; substrate-level
    b. oxidative; electron
    c. substrate-level; electron
    d. substrate-level; oxidative
    e. proton-gradient; oxidative

33. Where does the energy that drives ATP synthesis in mitochondria come from?
    a. The proton gradient.
    b. NAD^+ and FAD.
    c. The electron gradient.
    d. The oxidation states of the complexes.
    e. Molecular oxygen.

34. Redox couples with a large _____ reduction potential have a strong tendency to undergo _____ so NADH is a strong _____ agent.
    a. positive; reduction; oxidizing
    b. negative; oxidation; reducing
    c. negative; reduction; oxidizing
    d. positive; oxidation; reducing
    e. positive; oxidation; oxidizing

35. All of the following are membrane bound EXCEPT:
    a. cytochrome oxidase.
    b. Succinate dehydrogenase.
    c. cytochrome *c*.
    d. Complex III.
    e. coenzyme Q.

36. Complex I and Complex II produce a common product which is:
    a. NAD^+.
    b. FAD.
    c. reduced coenzyme Q.
    d. reduced cyt *c*.
    e. reduced O_2.

37. Which complex reduces molecular oxygen?
    a. complex I
    b. complex II
    c. complex III
    d. UQH/UQH_2 pool
    e. complex IV

38. Complex I contains all of these components EXCEPT:
    a. [FMN].
    b. 2Fe-2S clusters.
    c. 4Fe-4S clusters.
    d. cytochrome *c*.
    e. a "proton pump."

39. Which of the following is a two-electron donor?
    a. FAD
    b. Fe-S
    c. NADH
    d. NAD^+
    e. cyt *c*

40. In mitochondria, all of the following are properties of coenzyme Q EXCEPT:
    a. hydrophobic.
    b. can easily diffuse in the membrane.
    c. shuttles from complex I and complex II to complex IV.
    d. it has an isoprenoid tail.
    e. it has three oxidation states.

41. Which of the following mediate electron transfer between protein complexes?

    A. UQ/UQH_2
    B. Cyt *c*
    C. Complex III

    a. A only
    b. B only
    c. C only
    d. B & C
    e. A & B

42. Complex III takes up _____ proton(s) on the matrix side of the _____ membrane and releases _____ protons on the intermembrane side for each pair of _____ passed through the Q cycle.

a. two; inner; four; electrons
b. one; inner; two; protons
c. two; inner; four; protons
d. one; outer; two; electrons
e. none are true

43. The final electron acceptor in the electron transport chain is:

a. molecular oxygen.
b. H_2O.
c. cytochrome *c*.
d. UQ.
e. NAD^+.

44. The complete reduction of one molecule of oxygen (O_2) requires how many electrons?

a. two
b. three
c. four
d. eight
e. six

45. What molecule is the electron donor to complex III?

a. cytochrome *c*
b. UQH_2
c. NADH
d. H_2O
e. $FADH_2$

46. Which of the following complex(es) translocate protons in the inner mitochondrial membrane?

1. Complex I
2. Complex II
3. Complex III
4. Complex IV

a. 1, 3 & 4
b. 1 & 2
c. 1, 2 & 4
d. 4 only
e. all of the above

47. All of the following are properties of ATP synthase EXCEPT:
    a. the F_1 component is attached to the integral membrane component F_0.
    b. the F_O component is hydrophilic.
    c. the F_O component forms a transmembrane channel for protons.
    d. the beta-subunits have the catalytic site for ATP synthesis.
    e. the ring of *c* subunits form a rotor with respect to the alpha and beta subunits.

48. The mechanism for proton driven ATP synthesis depends on _____ neutralization of the negative charge on c-subunit _____ residues as the rotor turns causing the ____-subunit to turn relative to the three ____-subunits of F_1.
    a. electron; Ser; c; γ.
    b. proton; Ser; b; β.
    c. proton; Asp; β; γ.
    d. electron; Arg; c; γ.
    e. proton; Asp; γ; β.

49. All are properties of uncouplers EXCEPT:
    a. They dissipate the proton gradient.
    b. ATP/ADP ratio increases in the presence of an uncoupler.
    c. Electron transport continues in the presence of an uncoupler.
    d. They were briefly used as weight-loss drugs.
    e. Heat is produced in the presence of an uncoupler.

50. What is the P/O ratio?
    a. the number of ATP molecules made for each molecule of oxygen reduced.
    b. the number of protons pumped for each two electrons transferred.
    c. the number of protons pumped for each molecule of oxygen reduced.
    d. the number of ATP molecules made for each two electrons transferred.
    e. the number of ATP molecules made for each proton pumped.

PLEASE WRITE YOUR NAME ON THE FRONT OF THE QUESTION PAPER AND TURN EVERYTHING IN AT THE END (WITHOUT SEPARATING), OR YOU WILL GET NO CREDIT. WRITE YOUR ANSWERS ON THIS PAGE NOT THE SCANTRON.

The oxidation of succinate in bacteria is accompanied by the translocation of 6 protons across the cytoplasmic membrane. Assume that the bacterial ATP synthase contains 12 c subunits. How many ADP molecules are phosphorylated for each 2 electrons originating from succinate? (Remember that bacteria do not need to export ATP, so you do not need to account for the energetic cost of ATP transport).
[5 points]

In the Table shown below, write 'increase', 'decrease' or 'no change' in each space to indicate what happens to the rates of NADH oxidation, oxygen consumption and ATP synthesis in the presence of an uncoupler, or an inhibitor of Complex 1. [**5 points**]

	NADH oxidation	**Oxygen consumption**	**ATP synthesis**
Uncoupler	increases	increases	decreases
Complex 1 inhibitor			