KEY-PROBLEM SET #2-METABOLISM

Thursday, May 01, 2008
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MCB102 / Metabolism
Problem Set #2
Spring 2008

These are example problems, which are similar to those you may see on the final exam.

QUESTION 1: TRUE/FALSE. Circle the correct answer, but if the answer is FALSE provide a statement that corrects the one given.

i. Hormones are peptides that bind to extracellular receptors and activate a cascade of reactions in the cell.

TRUE (FALSE)

AND non-peptide small molecules

ii. Glycogen phosphorylase catalyzes the cleavage of glycogen such that the enzyme forms a covalent intermediate with the non-reducing end sugar allowing an inorganic phosphate group then to be added to the C-1 position.

TRUE (FALSE)

Phosphorylase catalyzes glycogen breakdown by having P_i break the $\alpha(1\rightarrow4)$ linkages, making glucose 1-(P).

iii. There can be up to 2,000 non-reducing ends on a glycogen molecule.

(TRUE) FALSE

iv. Amylose differs from glycogen in that the glycosidic linkages are $\beta(1\rightarrow4)$.

TRUE (FALSE)

Amylose differs from glycogen in that the glycosidic linkages are only $\alpha(1\rightarrow4)$; glycogen includes $\alpha(1\rightarrow4)$ and $\alpha(1\rightarrow6)$ linkages.

v. CO_2 is produced in ~~three~~ two reactions in the citric acid cycle.

TRUE (FALSE)

vi. The oxidation of ~~acetyl-CoA~~ fatty acyl-CoA added to isolated, intact mitochondria is stimulated strongly by carnitine.

TRUE (FALSE)

vii. 6-Phosphogluconate is a more ~~reduced~~ oxidized form of glucose 6-phosphate.

TRUE (FALSE)

QUESTION 2: Multiple Choice. Circle the correct answer.

i. Glycogenin:
(A) catalyzes the conversion of starch into glycogen.
(B) is the enzyme responsible for forming branches in glycogen.
(C) is the gene that encodes glycogen synthase.
(D) is the primer on which new glycogen chains are initiated.
(E) regulates the synthesis of glycogen.

ii. Cellular isozymes of pyruvate kinase are allosterically inhibited by:
(A) high concentrations of AMP.
(B) high concentrations of ATP.
(C) high concentrations of citrate.
(D) low concentrations of acetyl-CoA.
(E) low concentrations of ATP.

iii. Glycogen phosphorylase *a* can be inhibited at an allosteric site by:
(A) AMP.
(B) calcium.
(C) GDP.
(D) glucagon.
(E) glucose.

iv. Which of the below is *not* required for the oxidative decarboxylation of pyruvate to form acetyl-CoA?

(A) ATP
(B) CoA-SH
(C) FAD
(D) Lipoic acid
(E) NAD^+

v. Which of the following is *not* true of the citric acid cycle?

(A) All enzymes of the cycle are located in the cytoplasm, except succinate dehydrogenase, which is bound to the inner mitochondrial membrane.
(B) In the presence of malonate, one would expect succinate to accumulate.
(C) Oxaloacetate is used as a substrate but is not consumed in the cycle.
(D) Succinate dehydrogenase channels electrons directly into the electron transfer chain.
(E) The condensing enzyme is subject to allosteric regulation by ATP and NADH.

vi. The role of hormone-sensitive triacylglycerol lipase is to:

(A) hydrolyze lipids stored in the liver.
(B) hydrolyze membrane phospholipids in hormone-producing cells.
(C) hydrolyze triacylglycerols stored in adipose tissue.
(D) synthesize lipids in adipose tissue.
(E) synthesize triacylglycerols in the liver.

vii. 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.

viii. Lipoprotein lipase acts in:

(A) hydrolysis of triacylglycerols of plasma lipoproteins to supply fatty acids to various tissues.
(B) intestinal uptake of dietary fat.
(C) intracellular lipid breakdown of lipoproteins.
(D) lipoprotein breakdown to supply needed amino acids.
(E) none of the above.

ix. Acetyl-CoA labeled with ^{14}C in both of its acetate carbon atoms is incubated with unlabeled oxaloacetate and a crude tissue preparation capable of carrying out the reactions of the citric acid cycle. After one turn of the cycle, oxaloacetate would have ^{14}C in:

(A) all four carbon atoms.
(B) no pattern that is predictable from the information provided.
(C) none of its carbon atoms.
(D) the keto carbon and one of the carboxyl carbons.
(E) the two carboxyl carbons.

x. 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

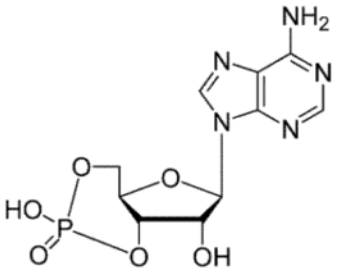
xi. The following fatty acid, in which the indicated carbon is labeled with ^{14}C, is fed to an animal:

$$^{14}CH_3(CH_2)_9COOH$$

After allowing 30 minutes for fatty acid β oxidation, the label would most likely be recovered in:
(A) acetyl-CoA.
(B) beta-hydroxy butyryl-CoA.
(C) both acetyl-CoA and propionyl-CoA.
(D) palmitoyl-CoA.
(E) propionyl-CoA.

QUESTION 3: Structure & function matching.

i. The molecule drawn plays what role(s) in the cell. Circle all that apply.



(a) Amino acid **(b)** Allosteric effector **(c)** Carbohydrate **(d)** Co-enzyme/Cofactor

(e) Energy currency **(f)** Fatty acid **(g)** Glycolysis metabolite **(h)** Hormone

(i) Gluconeogesis metabolite **(j)** Glycogen synthesis or breakdown metabolite

(k) Krebs Cycle intermediate **(l)** Lipid **(m)** Intracellular Signal

(n) Nucleotide **(o)** Oxidizer **(p)** Protein **(q)** Electron carrier

(r) Regulator **(s)** Starch **(t)** Transporter **(u)** Reductant

(v) Vitamin **(w)** Purine **(x)** Extracellular signal **(y)** Pyrimidine

(z) Radical

ii. The iron-sulfur cluster is used for what purpose in the enzyme aconitase. Circle all that apply.

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iii. Consider FAD, the elements of its structure, and its functional roles. Circle all that apply.

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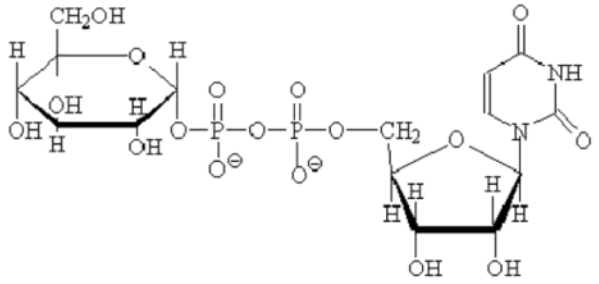
(z) Radical

iv. The structure shown below is used in what capacity in the cell. Circle all that apply.



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(z) Radical

v. Match the cofactors below with their roles in the pyruvate dehydrogenase complex reaction. Write the corresponding letter in the blanks preceding each role.

Cofactors:

(A) Coenzyme A (CoA-SH)
(B) Biotin
(C) NAD^+
(D) NADH
(E) Thiamine pyrophosphate (TPP)
(F) FAD
(G) Lipoic acid in oxidized form
(H) Lipoic acid in the reduced form

Roles:

E ____ Attacks and attaches to the central carbon in pyruvate.

C ____ Oxidizes $FADH_2$.

A ____ Accepts the acetyl group from reduced lipoic acid.

F ____ Oxidizes the reduced form of lipoic acid.

G ____ Initial electron acceptor in oxidation of pyruvate.

QUESTION 4: Short answers. Be as concise as possible, using 2 to 3 sentences for explanations.

(i) Make a list of eight types of regulation on a given enzyme. Indicate which types of regulation tend to change the activity of the enzyme or change the effective concentration of the enzyme by writing "Changes activity" or "Changes concentration," respectively.

transcription
mRNA turnover
translation
Enzyme turnover
— Changes Concentration

Allosteric
Covalent Modification
Compartmentalization
Association w/ Regulatory Protein
— Changes Activity

(ii) Describe two distinct ways that a given enzyme catalyzed reaction may be made favorable even though $\Delta G^{\circ\prime}$ favors the reactants over products.

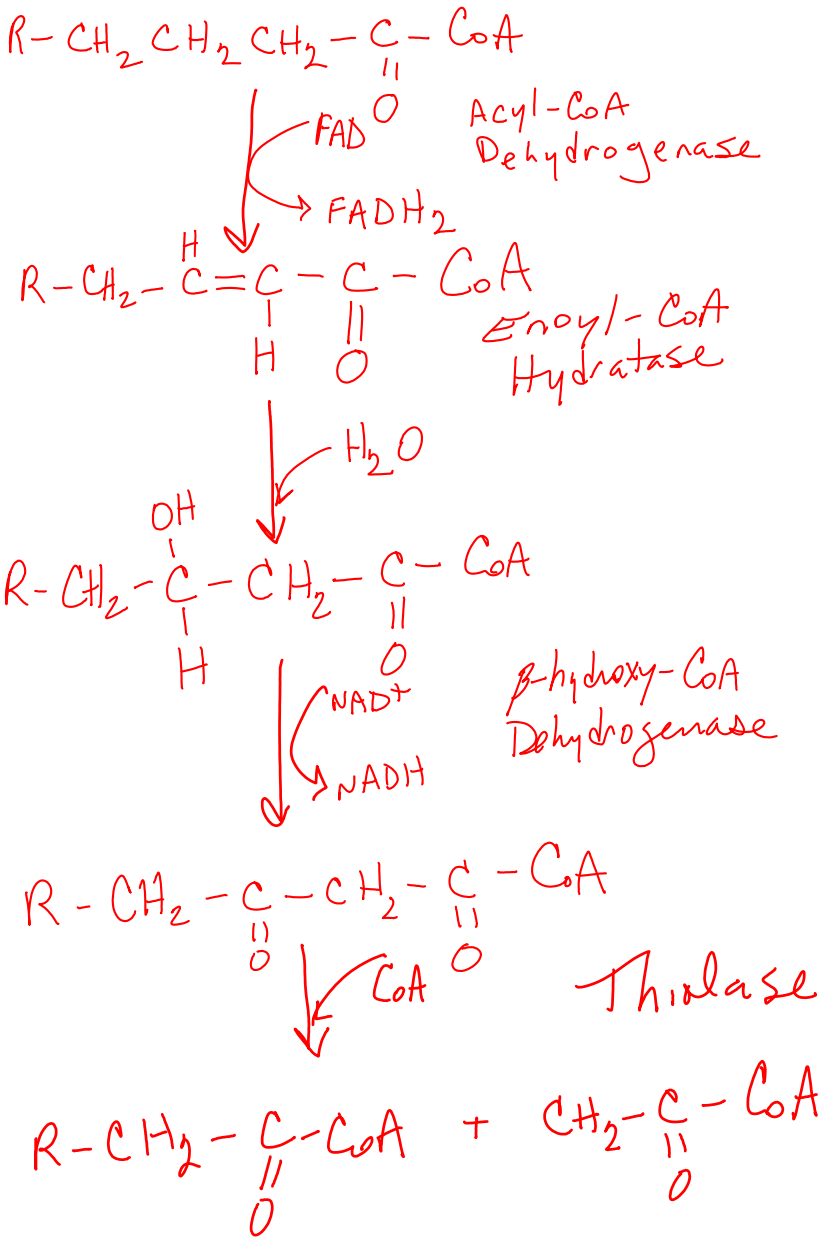
(1) Either increase [reactants] or decrease [products].

(2) Couple the unfavorable Reaction to a more thermodynamically favorable one.

(iii) For each two-carbon increase in the length of a saturated fatty acid chain, how many additional moles of ATP can be formed upon complete oxidation of one mole of the fatty acid to CO_2 and H_2O?

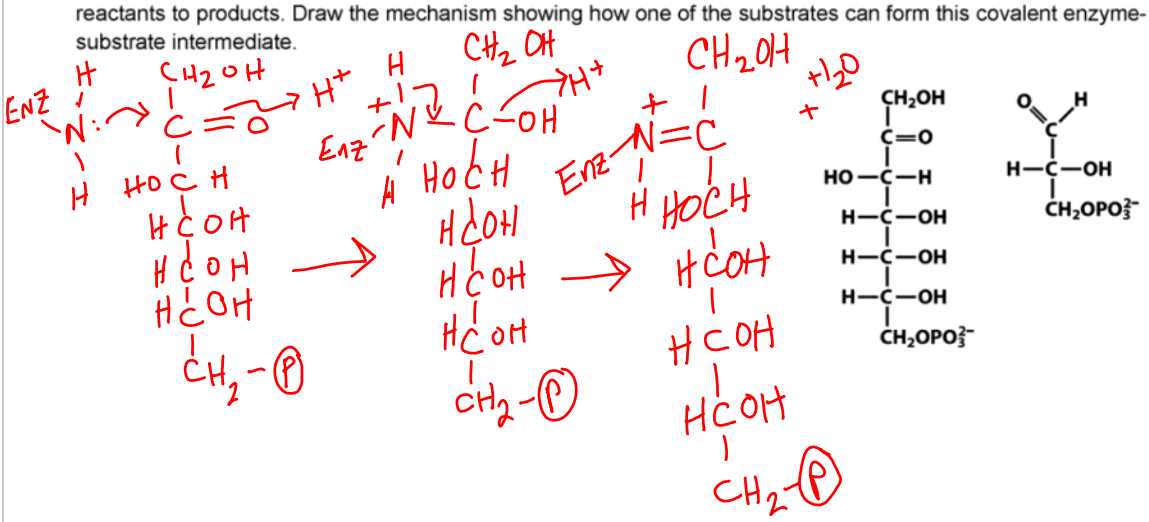
Each —CH_2—CH_2— unit yields 14 extra ATP molecules. The two oxidations of the β-oxidation pathway produce 1 $FADH_2$ and 1 NADH, which yield 1.5 and 2.5 ATP, respectively, by oxidative phosphorylation. The extra acetyl-CoA, when oxidized via the citric acid cycle, yields another 10 ATP equivalents: 3 NADH, 1 $FADH_2$, and 1 GTP (which is equiv. to an ATP).

(iv) Draw the four basic steps in the oxidation of a saturated fatty acid (the β-oxidation pathway). Show structures, name enzymes, and indicate where any cofactors participate.



QUESTION 5: Mechanism.

(i) Using the following sugars as reactants in an enzyme catalyzed reaction for transaldolase, consider a likely mechanism for the formation of the covalent enzyme-substrate intermediate in the conversion of these reactants to products. Draw the mechanism showing how one of the substrates can form this covalent enzyme-substrate intermediate.



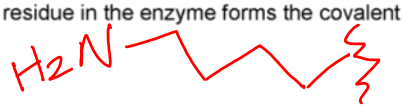
(ii) Where does this reaction occur in the cell?

Cytosol

(iii) What is the name of the pathway in which this reaction plays a major role?

Pentose Phosphate Pathway

(iv) What residue in the enzyme forms the covalent bond with the substrate? Draw the side chain structure.



Lysine

(v) What is the general name of the covalent bond found between the enzyme & substrate in the linked intermediate?

Schiff Base

(vi) What purpose does the enzyme-substrate covalent bond serve in the reaction mechanism?

Creates a strong electron sink that allows for the C-C bond to be broken inbetween the C3 AND C4 carbons. The cleavage here creates a carbanion that is stabilized by the Schiff base.