

MCB 102 Exam: Metabolism

1

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 Student I.D. No.: _____
 TA's Name: _____
 Section: _____

Total points = 100.

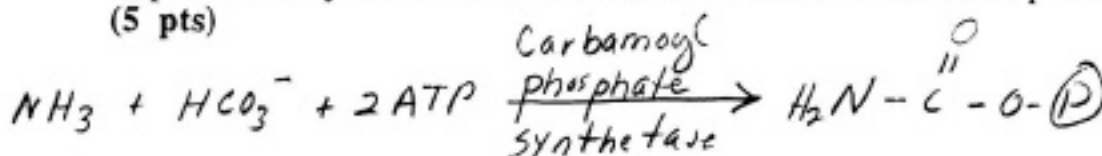
Grader will not read longer than 3 sentences per answer.

1. It was stated long ago that "fats burn in a flame of carbohydrates" (that is fats are most actively metabolized in the presence of carbohydrates). Provide a biochemical explanation for this statement on the basis of metabolism you have learned in this course. (5 pts)

Lipids (fatty acids) are broken down to acetyl-CoA which feeds into citric acid cycle. Cycle tends to stop as intermediates are drained off and cannot be replaced by acetyl CoA.

2. Mammals spend considerable energy to synthesize their primary nitrogen excretion product.

(A) Write the equation for the first reaction of the cyclic pathway by which this excretion product is synthesized and give the name of the responsible enzyme. Use chemical formulas for the reactants and products. (5 pts)



(B) Identify the immediate amino acid source(s) of the nitrogen(s) present in the final excretion product. (4)

Glutamate or Glutamine
 Aspartate

(C) Name the other two nitrogen excretion products and an organism which excretes the product. (2 pts)

NH_3 - Fish (bony) (amino telic)
 Urea - Birds, reptiles (Uricotelic)

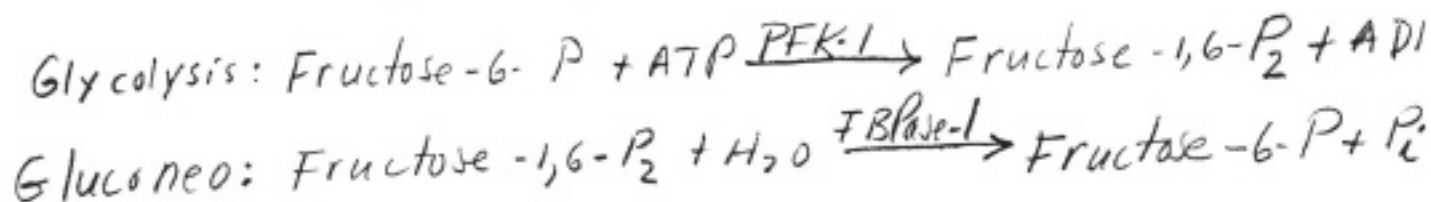
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3. A number of enzymes are activated by phosphorylation catalyzed by specific protein kinases, responsive to extracellular signals. When the signals cease, the phosphorylated proteins do not remain active forever. What type of enzyme accounts for their inactivation? (3 pts)

Phosphatases hydrolyze phosphate from enzyme thereby leading to inactivation.

4. In this class we have seen that metabolic regulation stems from hormones. These hormones regulate enzymes catalyzing key opposing reactions involving reactant and product phosphate esters in both glycolysis and gluconeogenesis.

(A) Using words to identify the reactants and products, write the equations for each of the main opposing regulated reactions of glycolysis and gluconeogenesis. Name the enzyme responsible for each. Include reactants, products. (5 pts).



(B) Name (i) the enzyme in (A) that would be more active in the liver during intense physical exercise and (ii) the primary compound acting on the enzyme under these conditions. (2 pts)

(i) FBPase, (ii) Fructose 2,6-bisphosphate

(C) How would the change in enzyme activity in (B) be manifest in blood? (2 pts)

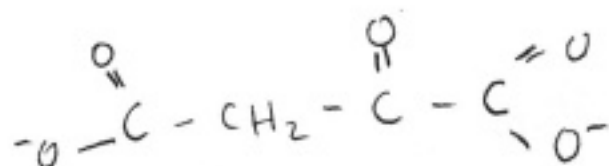
Increased glucose

5. In studying metabolism, we see numerous examples of potential futile cycles that are largely circumvented by specific regulatory controls. Name a circumstance in which a futile cycle would be advantageous. (4 pts)

Produce heat

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6. A variety of intermediates are fed into the citric acid cycle. If aspartate is transaminated, name the intermediate that is incorporated into this cycle and draw its structure. (4 pts)



Oxaloacetate

7. ATP is synthesized in chloroplasts by two electron transport pathways.

(A) Name these two electron transport pathways. (4 pts)

Cyclic / Noncyclic

(B) Until Mitchell's work, the mode of action of uncouplers was not understood. According to his chemiosmotic hypothesis, explain how an uncoupler such as dinitrophenol exerts its effect on chloroplasts. (4 pts)

Equilibrates protons on both sides of membrane, dissipating the gradient

(C) What regulatory effect does the photosynthetic electron transport chain have on the activity of enzymes of the reductive pentose phosphate (Calvin) cycle? (2 pts)

Activation

(D) Name the by-product of one of these electron transport chains that is essential for the life of almost all eukaryotes. (2 pts)

O₂

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8. Suppose you had a pet dog that ate mainly fat meat.

(A) What class of compounds we have studied would the animal, for practical purposes, be unable to synthesize? (2 pts)

Carbohydrates

(B) What type of compounds would be enriched in the animal's blood? [Hint: These compounds are typical of diabetes.] (2 pts)

Ketone bodies

(C) Identify the pathway by which these compounds are mainly broken down for energy. (2 pts)

Citric acid cycle

9. Diabetes mellitus is a chronic disease resulting from insulin resistance or lack of insulin secretion. State the consequence of insulin deficiency on the breakdown of glycogen, glucose, fatty acids and amino acids. An indication of increase or decrease in breakdown is sufficient. (4 pts)

Glycogen - Increase

Glucose - Decrease

Fatty acids - Increase

Amino acids - Increase

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10. As we have seen, organisms use ATP to drive thermodynamically unfavorable metabolic reactions. In some cases, this applies to electron transport reactions when ATP is used to drive electrons "uphill" against an electrochemical gradient. Assuming an energy of hydrolysis of -30 kJ/mol , calculate how many electron volts one could generate from the conversion of ATP to ADP + Pi using a 2 electron couple. The Faraday constant is $100 \text{ kJ/V}\cdot\text{mol}$ (5 pts)

$$\Delta G'^{\circ} = -n F \Delta E'_0$$

$$-30 \text{ kJ/mol} = (-2)(100 \text{ kJ/V}\cdot\text{mol})(\Delta E'_0)$$

$$\frac{-30 \text{ kJ/mol}}{-200 \text{ kJ/V}\cdot\text{mol}} = \Delta E'_0 = 0.15 \text{ V}$$

11. We have seen that a number of coenzymes are synthesized from vitamins.

(A) Name an enzyme we have studied in association with glycolysis that would be affected by a diet deficient in thiamin. (4 pts)

Pyruvate dehydrogenase

(B) Which cyclic pathway of animals would you expect to be slowed down by this deficiency? (2 pts)

Citric acid cycle

(C) What would be the effect of this deficiency on oxygen demand? (2 pts)

Decrease

(D) What would be the effect of thiamin deficiency on the (a) lactic and (b) ethanol fermentations? (4 pts)

(a) Increase (b) slow down Δ

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12. If the statement below is true, write "T"; if false, write "F."
- (A) F The reductive pentose phosphate cycle requires equimolar ATP and NADPH + H⁺ for the synthesis of carbohydrates from CO₂. (1 pt)
- (B) T One of the main functions of the oxidative pentose phosphate pathway is to generate NADPH + H⁺. (1 pt)
- (C) T When degraded, amino acids can give rise to acetyl-CoA and pyruvate. (1 pt)
- (D) F The enzyme Rubisco occurs only in photosynthetic organisms. (1 pt)
- (E) F An *E. coli* mutant lacking fructose 1, 6 -bisphosphatase would be able to grow on glycerol. (1 pt)
13. According to contemporary ideas on evolution (Fill in the blanks),
- (A) Mitochondria were derived from bacteria
(purple bacteria). (2 pts)
- (B) Chloroplasts were derived from cyano bacteria
 _____. (2 pts)
- (C) The bulk of the oxygen in the atmosphere was produced by Photosystem II of oxygenic photosynthesis (4 pts).
14. In the first recorded experiment in biology, Van Helmont found in the mid-17th century that only a minor part of the dry weight of plants can be accounted for by matter taken up from the soil. Since he provided only water to the young willow tree (sapling) used in these experiments, Van Helmont concluded that the bulk of the plant material was derived from this source. What do we now know to be wrong with his conclusion? (3 pts)

Missed CO₂

