MCB 102 Exam: Metabolism

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TA's Name: _____
Section: _____

1. One of the pathways we covered releases CO_2 from the C-1 position of glucose.

(A) Give the name of that pathway and identify its function. **[3 points]**

Oxidative pentose phosphate pathway (cycle)
Generate NADPH & pentoses

(B) Based on what you have learned in MCB 102, do you believe that it would be easier for anaerobes or aerobes to use this pathway as their major pathway for generating ATP? Justify your answer. **[3 points]**

Aerobes; can obtain energy from the NADPH

2. There are two mechanisms for the incorporation of Pi into ATP in the presence of ADP. One is based in the cytosol and the other located in membrane-enclosed organelles.

(A) Name the two mechanisms and give the name of an enzyme that functions in each for generating ATP. **[4 points]**

Substrate-level phosphorylation (Glyceraldehyde 3-P dehyd.)

H^+-linked phosphorylation (ATP synthase or F_1/F_o CF_1/CF_o)

Full credit for "Oxidative" "Photo"

(B) Which route is used by fermentative bacteria? **[2 points]**

Substrate-level

(C) Which route is utilized by illuminated chloroplasts? **[2 points]**

H^+-linked (photophosphorylation)

(D) Which route is inhibited by 10 mM ammonia? **[2 points]**

H^+-linked

(E) Which route yields a thiohemiacetal compound as an intermediate? **[2 points]**

Substrate-level

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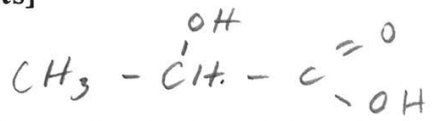
3. (A) Draw the structure of the organic acid that accumulates in muscle during strenuous exercise. **[3 points]**



(B) What is the immediate fate of most of this acid? **[2 points]**

Converted to glucose

(C) Name the pathway by which (B) takes place and also name the major control point of the pathway. **[2 points]**

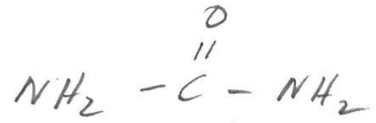
Gluconeogenesis / FBPase-1
("FBPase" ok)

(D) Name the two main regulatory metabolites that control the activity of the enzyme identified in (C). **[2 points]**

AMP
Fru-2,6-P_2

4. ATP is required for the formation of the product mammals use to excrete dietary nitrogen but not, for example, dietary hydrogen.

(A) Name and write the structural formula of the excreted nitrogen product. **[3 points]**



UREA

(B) Bicarbonate and ATP are required for the incorporation of ammonia into an intermediate that is ultimately converted to the product in (A). Write the structural formula and give the name of this intermediate. **[3 points]**

CARBAMOYL PHOSPHATE

(C) Give the name and chemical formula of another nitrogen product that is excreted by bony fish and state why mammals do not excrete this product. **[4 points]**

Ammonia - NH_3. Too toxic

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5. Predict the major biochemical consequence of each of the following mutations.

(A) Mutation of the serine (that serves as phosphorylation control site) to alanine in liver phosphorylase. **[2 points]**

Impaired glycogen breakdown

(B) Production of a liver epinephrine receptor with a Km much lower than normal. **[2 points]**

Enhanced c-AMP
OR Enhanced glycogen breakdown
OR Impaired glycogen synthesis
OR Enhanced gluconeogenesis

(C) Loss of the gene for glycogenin. **[2 points]**

Impaired glycogen synthesis

(D) Loss of nucleotide (AMP,ADP) binding site on phosphofructokinase (PFK-1). **[2 points]**

Impaired glycolysis

(E) Reduced activity of fructose 2,6-bisphosphatase (FBPase-2). **[2 points]**

OR Enhanced glycolysis
OR Impaired gluconeogenesis

6. The standard reduction potentials of the $H_2/2e^-,2H^+$ and the $NAD^+/NADH + H^+$ pairs are -0.42 and -0.32 V, respectively. Using these values, calculate whether there is sufficient energy released in the transport of electrons from H_2 to NAD to effect the synthesis of ATP from ADP and Pi. Assume that the Faraday constant is 100 kJ/V.mol and that the hydrolysis of ATP is exergonic (-30 kJ/mol). **[5 points]**

$\Delta E_0' = E_0'(\text{oxidant}) - E_0'(\text{reductant})$

$-0.32\text{V} - (-.42)\text{V} = +.10\text{V}$

$\Delta G^{0\prime} = -n\,\mathcal{F}\,\Delta E_0' = -(2)(100\ \text{kJ/V·mol})(.10\ \text{V})$

$= -20\ \text{kJ/mol}$

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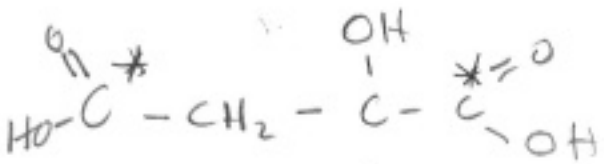
7. What is the fate of the radioactive label when each of the following compounds is converted to malate by the enzymes of the glycolytic pathway, the pyruvate dehydrogenase complex and the citric acid cycle? Assume that the citric acid cycle stops at malate after one turn. Draw the structure of the malate and label the radioactive carbon with an asterisk. Use the back of the page as a worksheet.

(A) Pyruvate labeled in the carbonyl carbon. **[4 points]**



Malate

(B) Glucose labeled at C-4. **[4 points]**

Loss of labelled carbon as $^{*}CO_2$
Malate unlabelled

(C) 2-Phosphoglycerate labeled in the carboxyl carbon. **[4 points]**

Loss of labelled carbon as $^{*}CO_2$
Malate unlabelled

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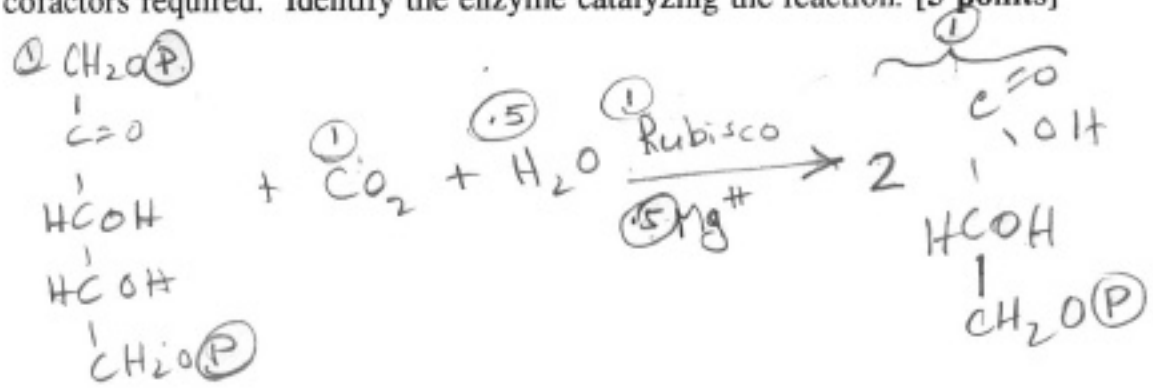
8. (A) Write the equation converting ribulose-1,-5-bisphosphate to 3-phosphoglycerate in chloroplasts. Show the structural formulas of each compound and identify any cofactors required. Identify the enzyme catalyzing the reaction. **[5 points]**



(B) The enzyme in (C) is one of several that are regulated by light in chloroplasts. What would be the major results should this and the other regulatory chloroplast enzymes be de-regulated? **[3 points]**

Futicle cycling
OR Starch could not be effectively built up

9. It is believed that the appearance of atmospheric oxygen on the early earth increased the abundance of certain compounds and enabled the cells that eventually became aerobes to increase dramatically the amount of ATP obtained from glucose.

(A) At the maximum, how many times was ATP increased by oxygen? **[2 points]**

19 - x

(B) Name the ATP-generating process that made this increase possible. **[2 points]**

Oxidative phosphorylation

(C) Name the organelle in which the reactions in (B) take place in eukaryotes. **[2 points]**

Mitochondrion

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KEY

10. During photosynthesis eight photons of light are absorbed. 6

$$2\ H_2O + 2\ NADP^+ + 8\ photons \text{ -----> } 2\ NADPH + 2\ H^+ + O_2$$

(A) Identify the pigment system(s) that absorb these photons. **[3 points]**

Photosystem II / Photosystem I
P680 P700

(B) Which color of visible light is least effective in photosynthesis? **[3 points]** 1/2

Green

(C) Name the biochemical substrates needed for carbon fixation that are formed in the light and give the molar amount of each required for the conversion of one mole of CO_2 to sugar. **[3 points]**

ATP 3
NADPH + H+ 2

(D) Identify four electron carriers needed for the formation of the products in (C) that do not function in respiration. **[4 points]**

Pheophytin
Plastoquinone
A_0 / A_1
Cytochrome f
P_{680} / P_{700}
PC

(E) Textbooks often separate the reactions of photosynthesis into "light" and "dark" reactions. While the concept of "light" reactions can be justified, what is wrong with the term "dark" reactions? **[3 points]**

they take place in the light
OR They are regulated by light

11. Suppose you had to subsist on a diet of whale and seal blubber with little or no carbohydrate.

(A) What would be the effect of carbohydrate deprivation on the utilization of fats for energy? **[3 points]**

Reduced level of oxaloacetate thereby impaired Citric acid cycle

OR Increase in Ketone bodies

(B) If your diet were totally devoid of carbohydrate, would it be better to consume odd- or even-numbered fatty acids. Explain. **[3 points]**

ODD – C_4 acid generated (succinate) needed for Citric acid cycle 2/2