Biochemistry I, Spring Term 2001 - Third Exam:

This exam has a total of 90 points and is divided into three sections. You must do ALL of the questions in parts A and B and only <u>one</u> of the three questions in part C.

There are a total of 9 pages in this exam, *excluding* the formula page. Please check that you have all the pages and write your name on every page before you begin. Use the space provided to answer the questions.

NOTE: It may not be necessary to completely fill the space provided! Clear and succinct answers are appreciated by the graders!

Grade:

Part A: ___________

Part B:

1 ___________

2 ___________

3 ___________

4 ___________

5 ___________

6 ___________

Part C:

____

TOTAL ___________

NAME:________________________________

Section A (24 pts): (3 pts/question). Circle the letter corresponding to the **best** answer.

1. Fatty acids form micelles in water while phospholipids form bilayers because
   - a) fatty acids are completely water soluble while phospholipids are amphipathic.
   - b) fatty acids have three acyl-chains while phospholipids have only one.
   - c) fatty acids have two acyl-chains while phospholipids have three.
   - d) fatty acids have only one acyl-chain while phospholipids have two.

2. Lysozyme is an enzyme that digests
   - a) cellulose
   - b) glycogen
   - c) bacterial cell walls
   - d) starch

3. Which of the following is **not** utilized as a *major* source of energy in cells
   - a) ATP
   - b) $P\text{-}P_i$
   - c) NADH
   - d) Proton Gradient

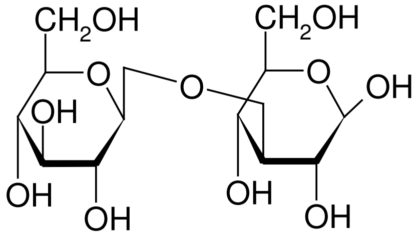
4. Phosphofructokinase, the major controlling enzyme of glycolysis is allosterically inhibited by ___ and activated by ___.
   - a) fructose 2,6 phosphate, AMP
   - b) citrate, ATP
   - c) ATP, PEP
   - d) citrate, ADP

5. Dehydrogenases are enzymes that can
   - a) transfer a phosphate group from ATP to another compound.
   - b) transfer one electron from a substrate to NAD^+.
   - c) transfer two electrons from a substrate to NAD^+
   - d) transfer two electrons from a substrate to $FADH_2$.

6. Which of the following is a common intermediate in the metabolism of sugars and fats?
   - a) acetaldehyde.
   - b) pyruvate.
   - c) acetic acid.
   - d) acetyl-CoA.

7. The hormones, insulin, glucagon and epinephrine, affect glycogen/glucose metabolism
   - a) indirectly, by first stimulating adenylate cyclase to make cAMP.
   - b) indirectly, by causing a conformational change in their appropriate membrane receptors.
   - c) indirectly, by activating protein kinases.
   - d) b & c are correct.

8. The correct name of the disaccharide shown to the right is:
   - a) O-α-D-glucopyranosyl α(1-4)-glucofuranose
   - b) O-α-D-glucopyranosyl α(1-4) glucopyranose
   - c) O-β-D-glucopyranosyl β(1-3) glucopyranose
   - d) O-β-D-glucopyranosyl β(1-4)-glucopyranose



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Section B:

B1 (9 pts) Answer the following questions regarding biological membranes:

i) Suggest one way to maintain membrane fluidity in a biological membrane, briefly justify your answer (3 pts).

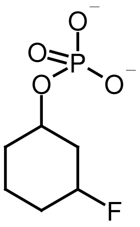
ii) Why is it necessary that biological membranes are fluid? Give one example of a biological process in metabolism that requires a fluid membrane (3 pts).

iii) Compare and contrast **one** structure feature of integral membrane proteins (e.g. bacteriorhodopsin) to typical soluble proteins (3 pts).

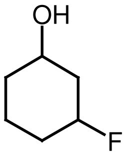
B2 (4 pts):

Aldolase and pyruvate kinase have identical molecular weights, iso-electric points and solubility in ammonium sulfate. How could you separate a mixture of these two proteins? Be as specific as possible in your answer.

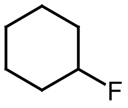
B3: (13 pts) The following four compounds are found in a single metabolic pathway in a rare South American plant. They are shown below in random order.



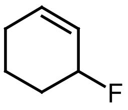
I



II



III



IV

i) Based on your knowledge of chemical changes observed in metabolism, place the compounds in their most likely order in this pathway (i.e. II→I→III→IV) (6 pts)

ii) Provide the name of **one** the enzymes that catalyzes a step of this pathway (don't worry about getting the correct organic nomenclature for the substrate (e.g. "III-breakase" is fine) (2 pts)

iii) Indicate the enzyme cofactor (ie. NADH) and/or co-substrates (i.e. ATP) associated with **one of the three** steps in this pathway. (3 pts).

iv) Which step in this pathway is most likely regulated and by which compound? (2 pts)

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B4 (13 pts): Aldolase catalyzes the reaction:

Fructose 1,6-bisphosphate → dihydroxyacetone phosphate + glyceraldehyde-3-phosphate.

i) How would you describe the changes in the sugars that occur due to this reaction. Give your answer in terms of the type of sugar (aldose/ketose) and the number of carbons.(3 pts)

ii) The standard free energy for this reaction is: $\Delta G^0 = +24$ kJ/mol. The actual free energy change (ΔG) for this reaction is 0.0 kJ/mol in some tissues. Given that the normal intracellular concentration of Fructose 1,6-bisphosphate is 30 μM (30×10^{-6} M) and that of dihydroxyacetone phosphate is 150 μM (150×10^{-6} M), what is the concentration of glyceraldehyde-3-phosphate during normal metabolism? (10 pts)

B5: (8 pts) *Briefly* describe how the energy associated with reduced compounds (i.e. NADH) is converted to ATP during oxidative phosphorylation.

B6: (4 pts) Most fatty acids in biological membranes have an even number of carbons. Why is this the case?

Part C: Do **ONE** of Question C1, C2, or C3.

C1: (15 pts) Do both part A and part B of this question.

You just finished an enormous meal of a hamburger, french fries, and a milkshake (strawberry of course!).
Part A:
Indicate the metabolic fate of **two** of the following **three** nutrients that were contained in this meal (you can draw a simple diagram if you like).

a) Amino acids from the hamburger and milk.
b) Starch from the french fries and the hamburger bun.
c) Fats from the milk, french fries, and hamburger.

In your answer, you should indicate the names of major metabolic pathways that are involved. Give the names of as many key intermediates as possible as well as a rough estimate of the type *and* amount of energy produced by metabolism of your chosen food. (10 pts)

Part B: Answer **one** of the following **two** questions, using the space provided on *the next page*. Please indicate the question that you are answering (5 pts).

i) Your insulin levels would rise after this meal. How does this affect the synthesis or degradation of glycogen in the liver as well as the muscle? Give specific information on how insulin regulates these processes.

OR

ii) You took your biochemistry final exam shortly after finishing this meal. The anxiety prompted the release of high levels of epinephrine (adrenaline) during the exam. Explain how the production of epinephrine may be beneficial to your final grade, given that your brain can only use glucose as its principal energy source.

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C1 - Part B answer here.

C2. (15 pts) Answer **ONE** of the following **three** questions.

i) In biosynthetic and degradative pathways, several steps are similar, often catalyzed by the same enzyme. Other steps are different, catalyzed by one or more different enzymes. As an example of the latter, pick one such step in either glycolysis/gluconeogenesis, fatty acid degradation/synthesis, or glycogen degradation/synthesis and answer the following:

a) What is the thermodynamic reason for the necessity of different steps?
b) How does the chemistry differ for the biosynthetic and degradative pathway? Relate this difference in chemistry to your answer in part a.

OR

ii) Glycolysis and the TCA (citric acid cycle, Krebs cycle) are regulated by the energy state of the cell. Select **one** of the more important regulatory steps in **either** pathway and discuss how the regulation is used to sense, or measure, the energy state (i.e. high or low energy) of the cell and how this sensing helps the cell balance its energy needs.

OR

iii) A popular diet these days is a high protein/low carbohydrate diet. In this diet, carbohydrates are limiting and have to be used for biosynthetic purposes (such as amino acid synthesis), not energy production. Describe the coordinated regulation of carbohydrate and amino acid metabolism such that the carbohydrates (which are 'essential' nutrients in humans) are not heavily utilized for energy production while on this diet.

C3: (15 Points) Answer **BOTH** of the following.

i) What is the structural basis of the substrate specificity of lysozyme? Your answer should include details of the structure of the substrate as well as the enzyme (6 pts)

AND

ii) A step in glycolysis, conversion of glyceraldehyde-3-phosphate to bis-phosphoglycerate, is an example of oxidative phosphorylation. The structure of glyceraldehyde-3-phosphate and bis-phosphoglycerate are shown on the right. Explain the reaction mechanism that couples phosphorylation of glyceraldehyde-3-phosphate to reduction of NAD$^+$ (9 pts).