CHEM-643 Biochemistry Name _____
Mid-term Examination
8:00 – 10:00, Friday, 2 November 2007

Dr. H. White - Instructor

There are 10 pages to this examination including this page. **Write your name on each new page**. Read every question so that you understand what is being asked. If you feel any question is unclear or ambiguous, clearly explain your answer or interpretation. Please call my attention to any errors you encounter.

This is an open notes examination. You may refer to your assignments and your lecture notes, but not textbooks. You may also refer to the metabolic pathway sheets available from the course website.

This examination will assess your learning, problem-solving skills, and ability to communicate clearly. It is intended to be challenging even to the best students in the class. Some of the questions will deal with material you have not seen before and is not in your text; however, the questions can be answered by applying basic principles discussed in the course.

Do not expose your answers to the scrutiny of your neighbors. Please fold under each page before you go on to the next.

Breakdown of the examination by sections:

I. Short Answer	15 Points
II. Problems	83 Points
III. Short Essays	12 Points
Total	110 Points

Exam Statistics

__31-100__ Class Range

___65.2___ Class Mean

_____ Your Rank in class

 Name _____

Part I - Short Answer Questions (1 point each)

_____ 1. A coenzyme in which a pterin ring is found.

_____ 2. Nucleotide from which pterin is synthesized.

_____ 3. Coenzyme associated with reductive biosynthetic reactions.

_____ 4. Coenzyme associated with C-C bond cleavage next to carbonyls.

_____ 5. Vitamin D is derived from this class of compounds.

_____ 6. Isoprenoid compounds containing 15 carbon atoms.

_____ 7. Virtually exclusive metabolic fuel for your brain.

_____ 8. Aspirin inhibits the synthesis of this class of compounds.

_____ 9. Class of enzymes in which ATP is used to generate a phosphorylated product.

_____ 10. Enzyme in *E. coli* that is feedback inhibited by histidine, AMP, GMP, glycine, alanine, and glucosamine-6-P.

_____11. Defining thermodynamic characteristic of the first committed step in a metabolic pathway.

_____ 12. Metal atom other than Fe associated with nitrogen fixation.

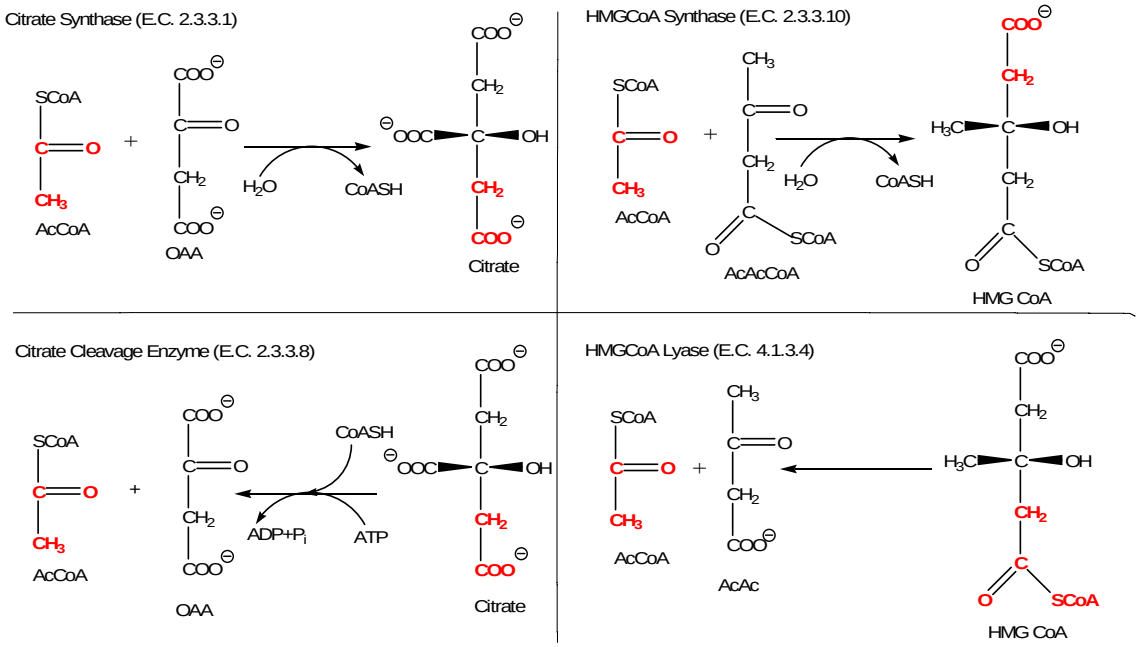
_____ 13. Industrial process that globally exceeds natural biological nitrogen fixation.

_____ 14. Structurally, glutamate is to aspartate as lysine is to _____?

_____ 15. $\delta^{13}C$ value for carbon in the Peedee belemnite.

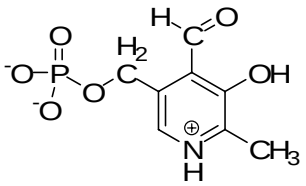
Part II: Problems

1. Four enzymes with similar reactions are laid out for comparison in a way that I had hoped students would have portrayed them in their answer to Question 3 on Problem Set 4.

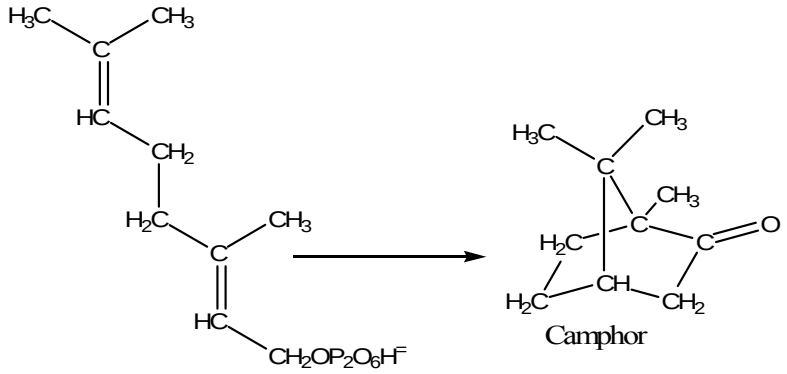


A. (9 points) The standard free energy, $\Delta G^{o\prime}$, for the citrate synthase reaction as displayed above is -32.2 kJ/mol. The $\Delta G^{o\prime}$ for hydrolysis of ATP and CoA thioesters are -30.5 kJ/mol and -31.4 kJ/mol, respectively. From this information, estimate the $\Delta G^{o\prime}$ values for the other three enzymes in the direction of flux in metabolism (direction of the reaction arrows). Please show your work and any assumptions you make.

2. (10 points) Pyridoxal phosphate (PLP) participates as a coenzyme in a variety of metabolic reactions involving amino acids. In addition to the well-known transamination reactions, it is a coenzyme for the decarboxylation of certain amino acids such as histidine. The structure of PLP is shown below. Draw out the mechanism by which PLP would facilitate the decarboxylation of histidine to form histamine.



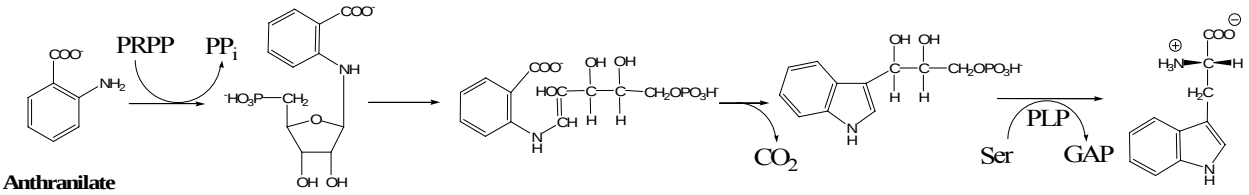
3. (5 points) Camphor is a terpene sometimes used for mothballs. It is derived biosynthetically from geranyl pyrophosphate. **Indicate in both structures below,** which carbon-carbon bonds form in the cyclization.



Geranyl Pyrophosphate

Camphor

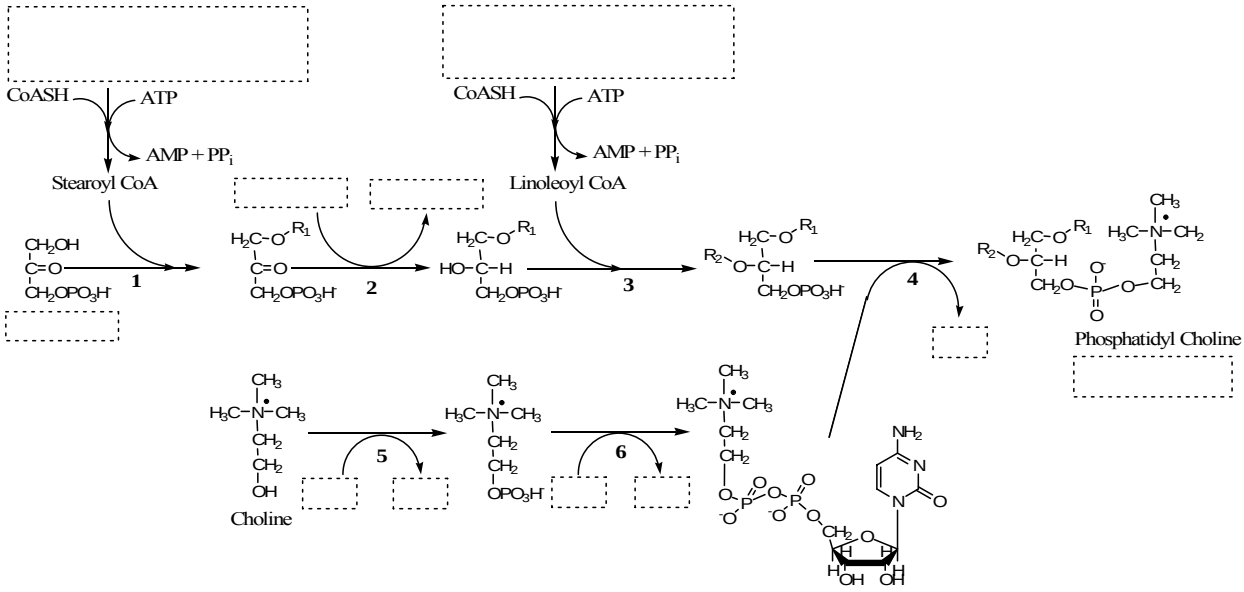
4. Anthranilate is an intermediate in the biosynthesis of tryptophan after it branches from chorismate (not shown). The conversion of anthranilate to tryptophan occurs in four enzymatic steps as shown below. The amounts of each of these enzymes in yeast cells can be manipulated separately by introducing additional gene copies on plasmids. Mutants with decreased activities for one of the four enzymes can also be created. If one measures the flux of anthranilate to tryptophan in these various strains [*Biochem. J.* **287**, 473 (1992)], only strains with less than 20% of the wild type enzyme activity have any significant effect on flux.



a. (6 points) Draw and label the axes for a graph depicting the *in vivo* rate of tryptophan synthesis as a function of the activity of any one of the four enzymes in the pathway.

b. (4 points) Provide a reasonable explanation for the relative insensitivity of flux to the enzyme activity described.

5. The biosynthesis of phosphatidyl choline as it may occur in human liver is depicted below. The questions that follow refer to this figure.



a. (4 points) Draw the structures of stearic acid and linoleic acid in the appropriate boxes.

b. (2 points) Identify by name or common abbreviation the three-carbon substrate for reaction 1.

c. (4 points) Fill in the missing coenzymes or substrate/products in reaction 2.

d. (2 points) Identify the missing product in reaction 4

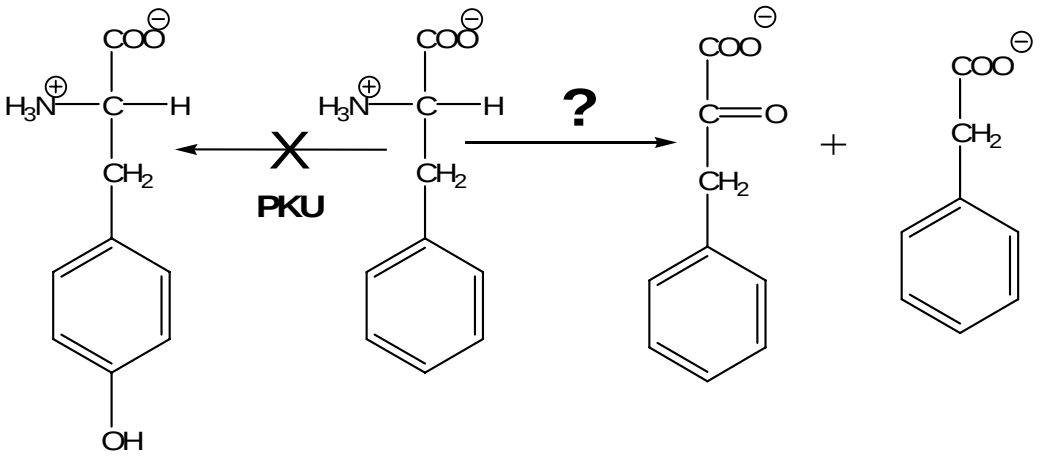
e. (2 points) In the box provided, give another name for phosphatidyl choline.

f. (4 points) Fill in the missing coenzymes or substrate/products in reaction 5.

g. (4 points) Fill in the missing coenzymes or substrate/products in reaction 6.

h. (9 points) Propose a reasonable short pathway for the biosynthesis of choline from serine and methionine.

6. Phenylketonuria (PKU) gets its name from the phenylketones that accumulate and appear in the urine of people who, due to a mutation in the gene for phenylalanine hydroxylase, cannot convert phenylalanine to tyrosine.



a. (4 points) Based on common reactions in intermediary metabolism, how is phenylpyruvate formed from phenylalanine? Show the reactions involved and indicate which, if any, coenzymes are needed.

b. (6 points) Based on common reactions in intermediary metabolism, how is phenylacetate formed from phenylpyruvate? Show the reactions involved and indicate which, if any, coenzymes are needed.

7. (8 points) When tadpoles undergo metamorphosis to become frogs the obvious morphological changes are also accompanied by significant metabolic changes as shown in the figure and data below. These data come from an article by Philip P. Cohen entitled, "Biochemical differentiation during amphibian metamorphosis" *Science* **168**, 533 (1970). Cohen measured the activity of a number of enzymes in the liver of adult frogs and premetamorphic tadpoles and expressed them as a ratio.

Liver Enzyme Activity	**Frog/Tadpole Activity Ratio**
Carbamyl phosphate synthetase	30
Ornithine transcarbamylase	8
Argininosuccinate synthase	35
Argininosuccinase	20
Arginase	30
Glutamate dehydrogenase	10
Lactate dehydrogenase	0.4
Glucose 6-P dehydrogenase	0.5
Malate dehydrogenase	1.4
Glutamate-oxaloacetate transaminase	5

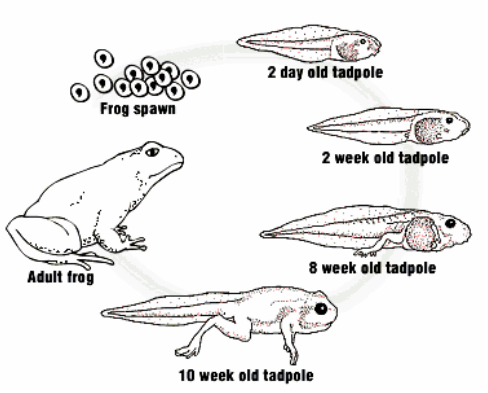


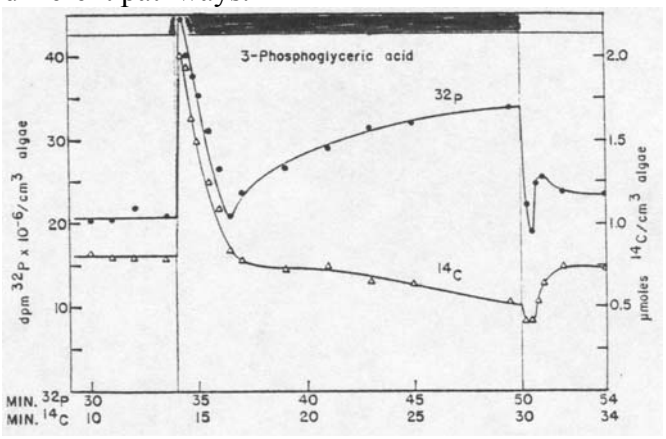
Image http://dj003.k12.sd.us/SCHOOL%20NOTES/chapter_12.htm

Based on the enzyme activity ratios reported, what conclusions can you make about the metabolic changes that occur during amphibian metamorphosis?

Part III Essay Question

Writing reflects how you think. Among the "right answers" I will read for the following questions, some will be better than others because they show greater depth of understanding, avoid extraneous or inaccurate information, provide a more logical structure, use appropriate examples, and choose words with precision. Better quality answers will receive higher marks. Therefore organize your thoughts before you write. Strive to write not that you may be understood, but rather that you cannot possibly be misunderstood. Stream of consciousness answers are rarely well organized or clearly presented. **Answer <u>only one</u> of the two questions that follow**.

1. (12 points) The figure below depicts the incorporation of ^{14}C from carbon dioxide and ^{32}P from phosphate into 3-phosphoglycerate in the transition from light to dark in a photosynthetic algae. Explain in your own words, what is going on here. Include how the flux changes in different pathways.



2. (12 Points) Fix your attention on a particular carbon atom in a glucose molecule (identify it) that you consumed at your last meal. In a narrative (no structures), generate a reasonable story of the fate of that carbon atom involving several tissues and at least three different metabolic pathways before exiting as carbon dioxide.