CHEM-643 Biochemistry Name _____
Mid-term Examination
8:00 – 10:00, Friday, 6 November 2009

Dr. H. White - Instructor

There are 9 pages to this examination including this page. The last page can be removed as a work sheet for questions II-1 through II-5. **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 examination is closed book until 9:15AM. You may refer to your assignments and your lecture notes, but not textbooks at that time. You may also refer to the hand-drawn metabolic pathway sheets available from the course website.

This examination will assess your learning, problem-solving skills, and ability to communicate clearly. Parts are 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, those 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	20 Points
II. Problems	90 Points
III. Short Essay	12 Points
Total	122 Points

Exam Statistics

__14-95__ Class Range

___62.0__ Class Mean

Part I - Short Answer Recall Questions (1 point each)

_____ 1. Reductant produced by the light reactions of photosynthesis and used by the Calvin Cycle.

_____ 2. Colored pigments of butterfly wings contain this heterocyclic ring system.

_____ 3. Group of plants that harbor symbiotic nitrogen-fixing bacteria.

_____ 4. Coenzyme involved in the decarboxylation of α-keto acids.

_____ 5. Number of carbon atoms in squalene.

_____ 6. Biosynthetic precursor for fatty acids with methyl groups on every other carbon.

_____ 7. Molar concentration of water in water.

_____ 8. In the realm of membrane lipids, PG stands for what.

_____ 9. Half life of ^{14}C.

_____10. Half life/average residence time for CO_2 in the atmosphere.

_____11. Major source of energy for a marathon runner.

_____12. A function of the pentose phosphate pathway.

_____13. Another function of the pentose phosphate pathway

_____14. Coenzyme associated with adding a carboxyl group to a carbon adjacent to a carbonyl group.

_____15. $\delta^{13}C$ value for carbon in the Peedee belemnite.

_____16. Often a property of the enzyme catalyzing first committed step in a biosynthetic pathway.

_____17. Nucleotide precursor for riboflavin biosynthesis.

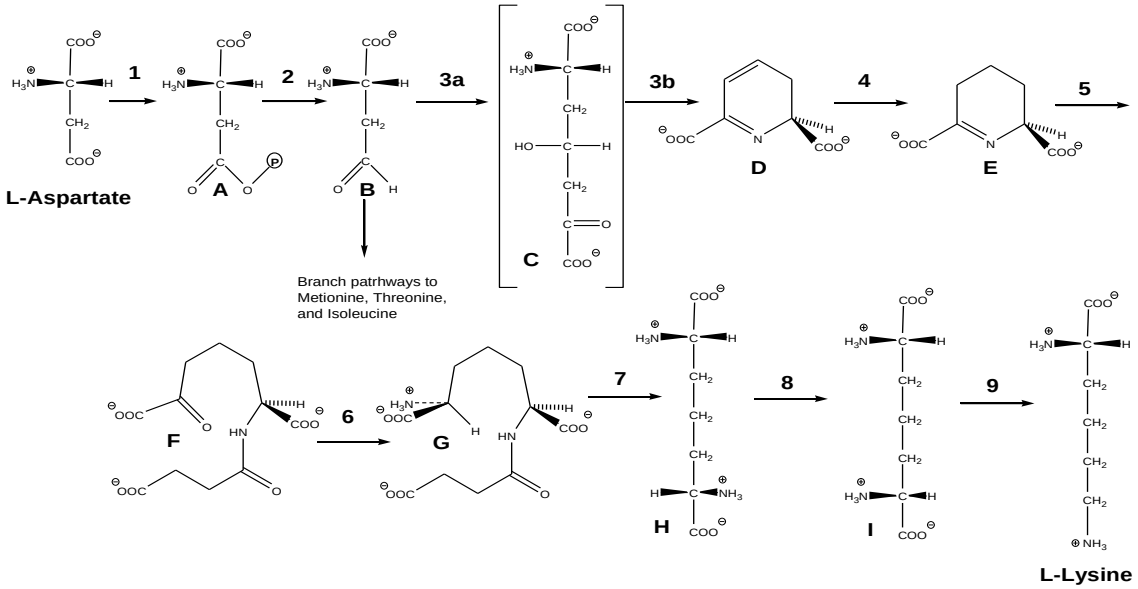
_____18. An enzyme encoded on the human X-chromosome.

_____19. Compound that shuttles fatty acids into the mitochondria for β-oxidation.

_____20. Fatty acid precursor of prostaglandins.

Part II: Problems

1. (30 Points Total) We superficially discussed the lysine biosynthetic pathway presented below, which is found in bacteria, algae, and higher plants, but not fungi. However, you should be able to make more detailed sense of the pathway based on the principles we have developed and explored with other reactions and pathways. Only the intermediates are shown. Thus other substrates and products, and coenzymes are omitted. Please answer the questions relating to this pathway.



(Questions 1a-1n are worth 2 points apiece. Questions 2-5 also refer to the lysine biosynthetic pathway above, but are worth 5 or 8 points each. You may tear off the last sheet of this exam as a work sheet.)

a. In reaction 1, what compound provides the phosphoryl group on Compound A? _____.

b. What would be and appropriate name for the enzyme catalyzing Reaction 1?

_____

c. What coenzyme would be required for Reaction 2? _____

d. What type of reaction occurs in Reaction 3a? _____

e. What three-carbon compound is a substrate in Reaction 3a. _____

f. Reaction 3b involves two steps with the loss of 2 water molecules, but there is no requirement for ATP. What is favorable about these reactions that they can proceed without ATP?

i. _____

ii. _____

g. What is would you call the C=N bond in Compound D?_____

h. What type of reaction is Reaction 4? _____

i. What is the source of the four carbon compound added to Compound E in Reaction 5? _____

j. What coenzyme and nitrogen donor would be needed in Reaction 6? _____ and _____

k. What would be the fate of the other product of Reaction 7? _____

l. Why would Reaction 7 be favored in the direction of biosynthesis? _____

m. What kind of reaction is Reaction 8? _____

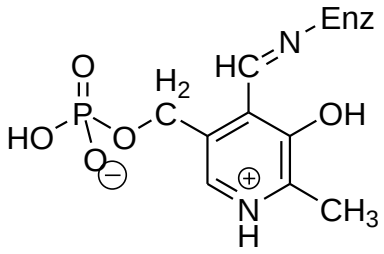
n. Which enzyme(s) in this pathway would be likely to be inhibited by lysine? Identify by reaction number(s). _____

2. (5 Points) If there were a mutation that reduced the synthesis of the enzyme catalyzing Reaction 8 to half its normal amounts, what would be the likely effect on the synthesis of lysine? Explain your answer.

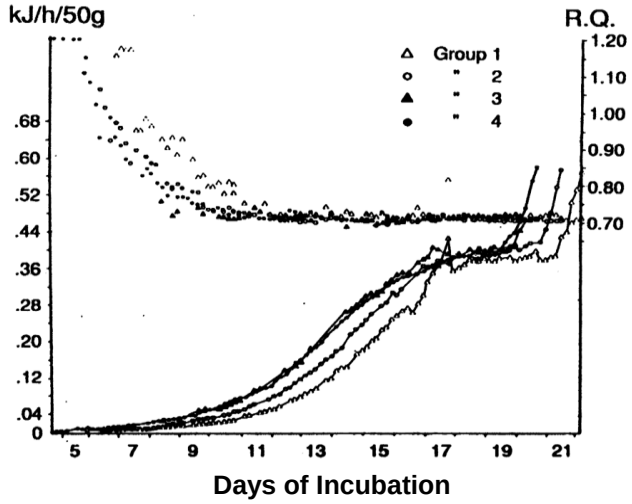
3. (5 Points) If ^{15}N aspartate were used as a precursor for lysine in this pathway, both nitrogens of lysine would be equally labeled. Explain?

4. (5 Points) At first glance, Reaction 8 might seem superfluous, but it is not. Analyze and explain.

5. (8 Points) Reaction 9 is a PLP-dependent decarboxylation. Draw a reasonable mechanism for this reaction. The structure of PLP bound to an active site lysine is given below.



6. (15 Points) An egg contains all of the nutrients necessary for the 21 day development of a fertilized egg into a newly hatched chick. CO_2 and O_2 in the air surrounding a tray of chicken eggs were monitored during incubation and the ratio of CO_2 produced to O_2 consumed (Respiratory Quotient, R.Q.) was determined as a function of time as was the rate of energy consumption as a function of time. The results at four incubation temperatures are shown in the graph to the right.



From Decuypere et al. (1979) *Ann. Biol. Anim. Biochem. Biophys*. **19**, 1717-1723.

a. (10 Points) What do these data say about the metabolism of a chick embryo during incubation and relate it to the composition of an egg.

b. (5 Points) The shell of an egg is porous and permits the exchange of gases like CO_2, O_2, and H_2O. Over the course of incubation a substantial amount of water evaporates. How does the embryo avoid dehydration?

7. (20 Points) The South African plant, *Dichapetalum cymosum*, contains fluoroacetate, FCH_2COO^-, a highly toxic compound that can kill animals that eat its leaves. As it turns out, fluoroacetate is not toxic itself but is metabolized as if it were acetate and converted in a couple of reactions into the actual toxic compound. Hearts from normal and fluoroacetate-fed rats were perfused with glucose for 15 minutes and then analyzed for glycolytic and TCA cycle intermediates. The figure below compares the metabolite concentrations in fluoroacetate-poisoned rat hearts as a percentage of the amounts in normal controls.

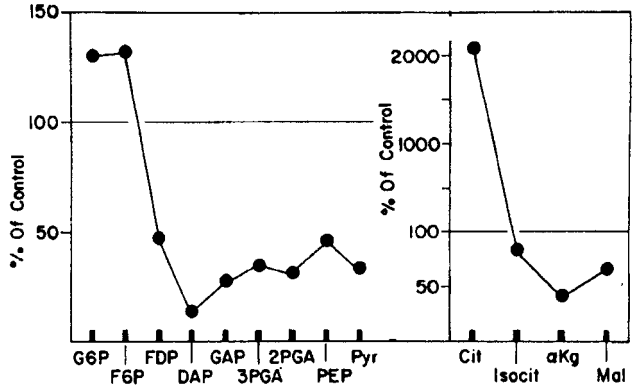


Figure modified from Williamson J.R. (1967) *J. Biol. Chem*. **242**, 4476-4485.

Based on these data and the information provided:

a. (6 Points) What can you conclude from the data about the primary site of action of the toxic compound?

b. (4 Points) What is a likely candidate for the toxic compound?

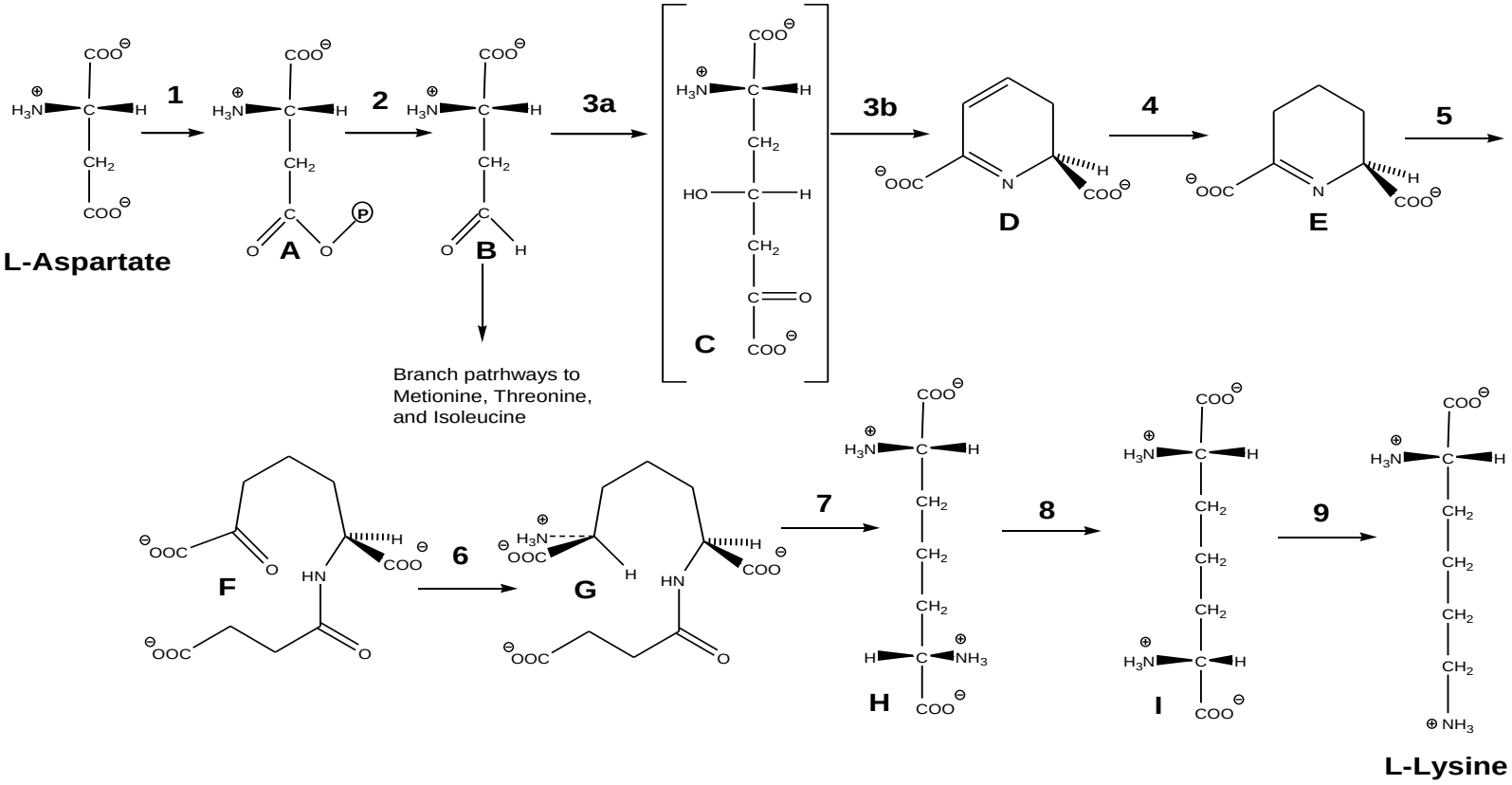
c. (5 Points) How is the toxic compound made from fluoroacetate?

d. (5 Points) Why is it toxic?

Part III Essay Question (12 Points)

Writing reflects how you think. Among the "right answers" I will read for the following question, some will be better than others because they show greater depth of understanding, avoid extraneous or inaccurate information, use knowledge from previous learning, 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.

1. Biochemistry is full of examples of modular assembly through covalent polymerization or non-covalent self-association.
    a. Concisely describe and illustrate an example of each.
    b. Discuss the advantages of modular assembly and the distinctive properties of molecules that are the modular units.


L-Aspartate
1
2
3a
3b
4
5
A
B
C
D
E
Branch patrhways to
Metionine, Threonine,
and Isoleucine
6
7
8
9
F
G
H
I
L-Lysine