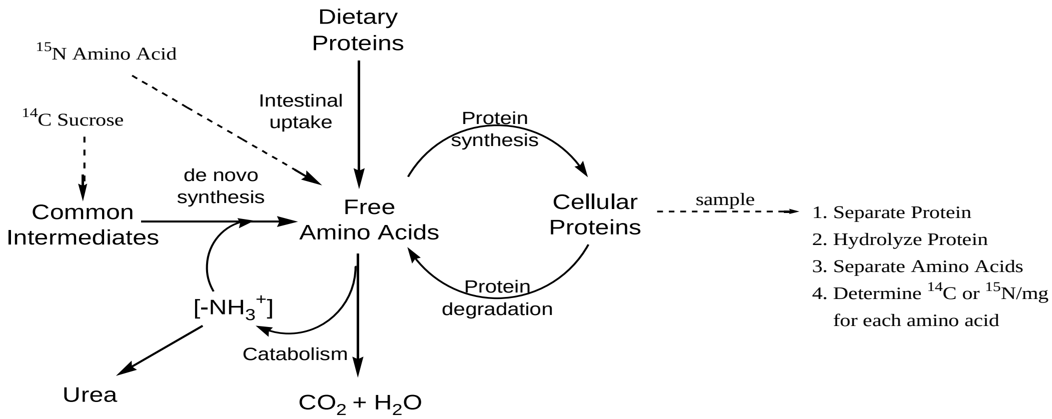
CHEM-643 Intermediary Metabolism **Name/Group ________________________**
Friday, 20 November 2009
Individual and Group Quiz on Amino Acid Metabolism Case Study Problem,
"Plants vs Animals in the Dining Hall"

Select the ***best*** answer. Please note that true statements are not necessarily correct answers or explanations. Tables 1-3 from the case study problem are reproduced on the last page, which you can tear off for use. Your total score will be distributed 60% individual score plus 40% group score.

____ 14. By now you should have a conceptual overview of amino acid metabolism and the Steele (1952) and Aqvist (1951) experiments that might look something like the figure below.



The amount of ^{14}C and ^{15}N in an amino acid will depend on the relative importance of the processes represented by arrows. Consider the results presented in Tables 1 and 3 for threonine. From these results one can conclude that:

A. Threonine synthesis and degradation are much greater than for other amino acids.
B. Threonine synthesis and degradation are much less than for other amino acids.
C. Threonine synthesis is much greater, but degradation is much less than for other amino acids.
D. Threonine synthesis is much less but, degradation is much greater than for other amino acids.

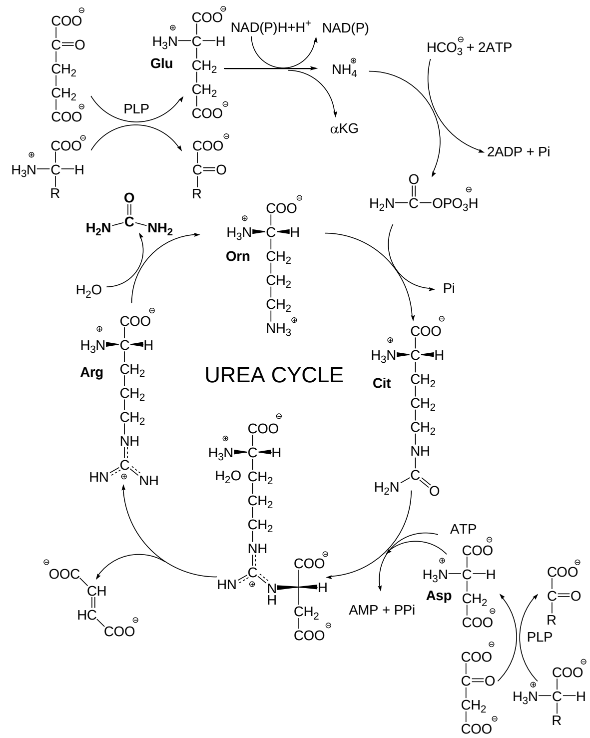
____ 15. Consider the above diagram again. If adult animals were fed a diet high in protein, what would you expect would happen to the rates of various processes indicated?

A. Cellular protein synthesis would increase, but protein degradation would decrease.
B. Cellular protein synthesis and protein degradation would increase.
C. Amino acid synthesis would decrease, but amino acid catabolism would increase.
D. Amino acid synthesis and catabolism would increase.

____ 16. Seeds typically provide a rich source of protein; however, compared to protein in meat, seed proteins are often unbalanced with respect to one or more amino acids that are in disproportionately low amounts. Given that a seed is nutritionally deficient in an amino acid, which of the following amino acids would you automatically exclude as the one limiting nutrient quality?

A. Methionine B. Isoleucine C. Glutamine D. Lysine

The figure to the right depicts the urea cycle in mammals. During the catabolism of proteins for energy, nitrogen from amino acids is channeled into the urea cycle to form urea, a non-toxic compound that is excreted.



____ 17. In a mouse, ^{14}C from dietary sucrose, shows up three days later in arginine found in proteins. Which of the following metabolic precursors of arginine would contain the ***least*** amount of ^{14}C from dietary sucrose?

A. Ornithine

B. Citrulline

C. Pyruvate

D. Bicarbonate

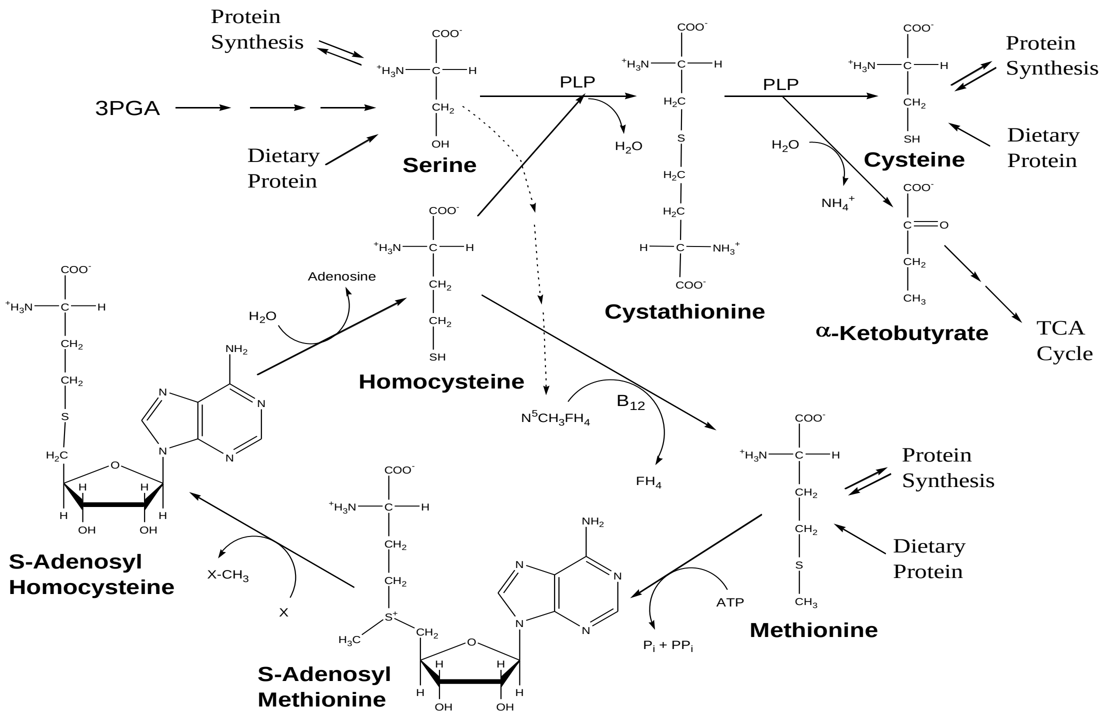
____ 18. Based on the data in Table 3, which of the following transamination reactions would be ***unlikely*** to be involved directly or indirectly in transferring amino groups into the urea cycle?

A. Alanine + Oxaloacetate ↔ Aspartate + pyruvate
B. Valine + Pyruvate ↔ Alanine + α-Ketoisovalerate
C. Phenylalanine + Pyruvate ↔ Alanine + Phenylpyruvate
D. Histidine + α-Ketoglutarate ↔ Glutamate + Imidazolylpyruvate

____ 19. Which of the following compounds would be plentiful in a vegan diet.
A. Cholesterol
B. Polyunsaturated fatty acids
C. Vitamin B_{12}
D. Creatine

____ 20. Leucine is missing from the data in Table 1 because the authors lost the sample. However, given what is known now about leucine metabolism, what would be a reasonable prediction and rationale for the missing data?
A. Because leucine is a lipogenic amino acid, it can't be converted into sugars like sucrose and therefore would be unlabeled.
B. Because leucine is derived from pyruvate that comes from the breakdown of sugars, it should be labeled similarly to alanine, which also comes from pyruvate.
C. Because rats can't biosynthesize leucine, no carbon from sucrose would show up in leucine.
D. Leucine, being the most common amino acid in proteins, would dilute out any labeled carbon in newly synthesized leucine derived from sucrose.

The diagram below illustrates the metabolic pathways that involve cysteine and methionine in mammals. The two questions that follow relate to how well this diagram supports the data in Tables 1-3 of the case study problem.



____ 21. Pick the ***incorrect*** statement. The above diagram is consistent with:

A. Methionine being required for L-cell growth.
B. Cysteine being required for L-cell growth.
C. Methionine becoming labeled from ^{14}C-surcose.
D. Cysteine becoming labeled from ^{14}C-surcose.

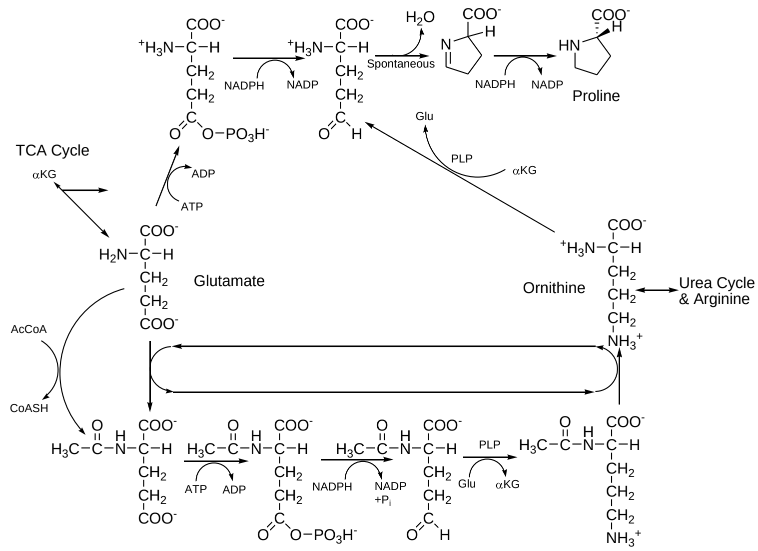
____ 22. Table 3 does not include cysteine or methionine. If these sulfur-containing amino acids had been used, what could you ***predict*** about the distribution of ^{15}N between them two after eight hours based on the diagram above?

A. ^{15}N from methionine would significantly label cysteine, but not the reverse.
B. ^{15}N from cysteine would significantly label methionine, but not the reverse.
C. ^{15}N from methionine or cysteine would not be transferred to the other.
D. ^{15}N from cysteine would significantly label methionine and vice versa.

____ 23. Methionine is classified an essential amino acid for mammals, which means mammals must get the amino acid in their diet to survive, yet it contains radioactivity derived from ^{14}C sucrose. The **best** explanation for this observation is:

A. Experimental Error.
B. Mammals can make methionine, but not enough to survive.
C. Only the methyl group is labeled and comes from serine and glycine.
D. The label is derived from cysteine.

____ 24. The Lehninger textbook notes that in mammals the biosynthetic routes to proline and ornithine/arginine from glutamate may not be separate as described in lecture. Rather the synthesis of proline would branch off of the pathway to arginine from the intermediate ornithine as shown below with the long diagonal line.



The following true statements based on Tables 1 and 3 may or may not support the hypothesis that ornithine is an intermediate in proline synthesis.

I. The ^{14}C content of proline is essentially same as that of arginine.
II. The ^{14}C content of proline is much less than that of glutamate.
III. ^{15}N from arginine is readily transferred to proline.

Which of the above statements support the branched pathway compared to the direct pathway to praline from glutamate?

A. I and II   B. I and III   C. II and III   D. I, II, and III

Table 1. Specific radioactivity of amino acids biosynthesized from ^{14}C sucrose in three days by a mouse (Steele, 1952).

Amino Acid	nCi/mgC	Amino Acid	nCi/mgC	Amino Acid	nCi/mgC	Amino Acid	nCi/mgC
Glutamate	19.0±1.9	Threonine	0.09±0.02	Valine	0.02±0.01	Lysine	0.0±0.02
Aspartate	15.8±0.9	Serine	8.4±0.1	Phenylalanine	0.02±0.07	Histidine	0.07±0.08
Alanine	26.5±3.3	Glycine	5.1±0.2	Tyrosine	0.0±0.07	Cystine	3.3±0.3
Proline	3.1±0.1	Isoleucine	0.06±0.05	Arginine	3.0±0.2	Methionine	1.03±0.06

Table 2. Growth of mouse L cells in media lacking the indicated amino acid (Eagle, 1955).

Amino Acid	Cell Growth	Amino Acid	Cell Growth	Amino Acid	Cell Growth	Amino Acid	Cell Growth
Glutamate	3.6 - 4.5	Threonine	0.2	Valine	0.06 - 0.2	Lysine	0.2 - 0.5
Aspartate	3.6 - 6.1	Serine	2.5 - 2.8	Phenylalanine	0.3 - 0.4	Histidine	0.3 - 0.4
Alanine	2.2 - 2.6	Glycine	3.6 - 3.7	Tyrosine	0.06 - 0.2	Cystine	0.1 - 0.3
Proline	2.4 - 6.8	Isoleucine	0.1 - 0.4	Arginine	0.4 - 0.9	Methionine	0.3 - 0.4
		Leucine	0.4 - 0.6	Tryptophan	0.3 - 0.4		

Table 3. Distribution of ^{15}N among the amino acids of liver proteins 8 hours after intravenous injection of various amino acid sources of ^{15}N. Values are normalized to the ^{15}N content of the source amino acid (100) incorporated into protein (Aqvist, 1951).

	Amino acids incorporated into rat liver proteins														
^{15}N-Amino Acid	Glu	Asp	Ala	Pro	Thr	Ser	Gly	Leu	Ile	Val	Phe	Tyr	Arg	Lys	His
Glutamate	100	50	74	12	3	46	19	31	nd	20	14	20	34	4	2
Aspartate	186	100	125	29	2	40	38	49	111	nd	26	38	60	15	25
Alanine	77	44	100	16	<1	23	21	38	40	29	9	10	33	4	3
Proline	23	14	18	100	1	5	3	4	5	5	1	2	11	2	<1
Threonine[(1)]	6	5	5	2	100	20	14	1	2	4	2	5	5	1	<1
Serine	9	9	12	2	14	100	50	3	2	2	2	6	9	1	1
Glycine	19	12	16	1	0	88	100	nd	nd	nd	3	nd	16	<1	2
Leucine	30	15	25	nd	<1	7	7	100	25	12	3	7	11	0	<1
Isoleucine	28	14	23	11	<1	9	8	34	100	15	8	12	10	4	3
Valine	34	19	29	7	0	12	10	46	41	100	5	6	14	1	2
Phenylalanine	24	12	18	2	<1	3	2	3	5	3	100	74	10	7	2
Tyrosine[(2)]	23	13	16	3	<1	4	4	4	5	4	44	100	9	1	1
Arginine[(3)]	34	23	20	18	2	6	1	nd	nd	nd	11	10	100	13	5
Lysine[3]	23	19	12	5	3	8	3	nd	nd	nd	6	nd	9	100	4
Histidine[3]	28	25	30	6	2	8	10	nd	nd	nd	9	nd	24	6	100

1. Slightly contaminated with ^{15}N serine. Data from one rat only.
2. Administered by a stomach tube. Animals killed after 12 hours.
3. ^{15}N excess significantly less than for other administered amino acids.

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