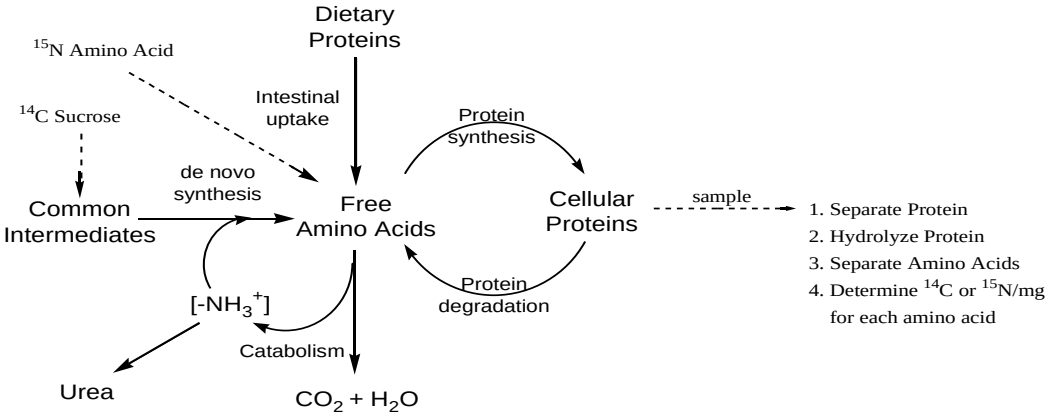
CHEM-643 Intermediary Metabolism **Name/Group _____**
Friday, 19 November 2010
Individual and Group Quiz on Amino Acid Metabolism Case Study Problem, "Plants vs Animals in the Dining Hall"

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.

____ 13. 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 lysine. From these results one can conclude that:

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

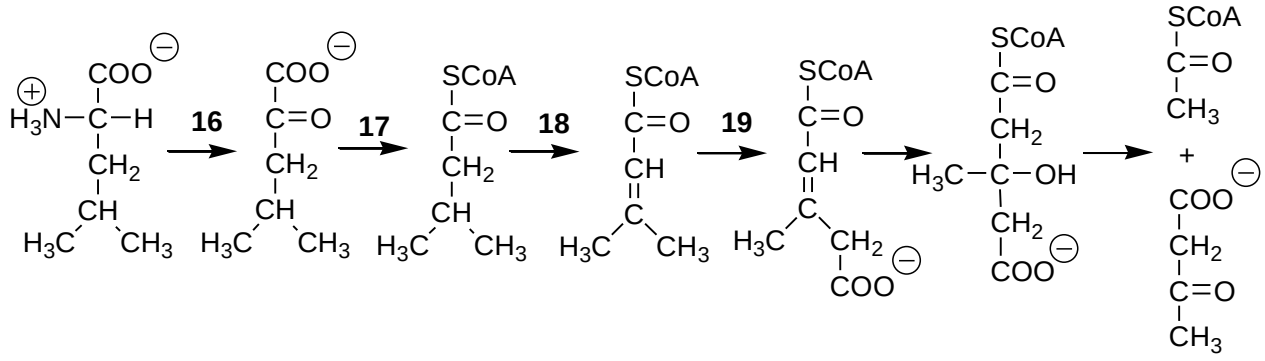
____ 14. Consider the above diagram again. If adult animals were fed a diet high in protein, what would you expect would happen to the rates of various processes indicated?

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

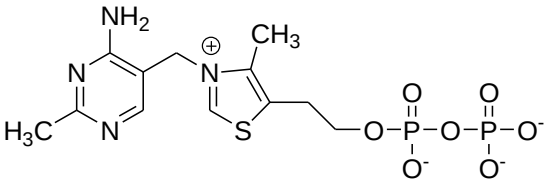
____ 15. Based on the data in Table 3, which of the following amino acids would most likely have the ***longest*** biological half life?

A. Glutamate B. Glycine C. Threonine D. Leucine

The catabolism of leucine to acetyl CoA and acetoacetate is shown below with the first four reactions labeled 16-19 to correspond to the questions that follow. The structures A-D are of various coenzymes/cofactors that may be involved in one or more of the numbered reactions.



A



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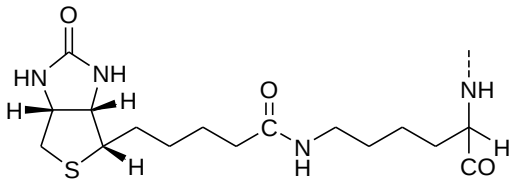

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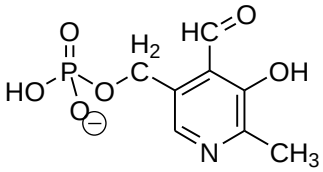
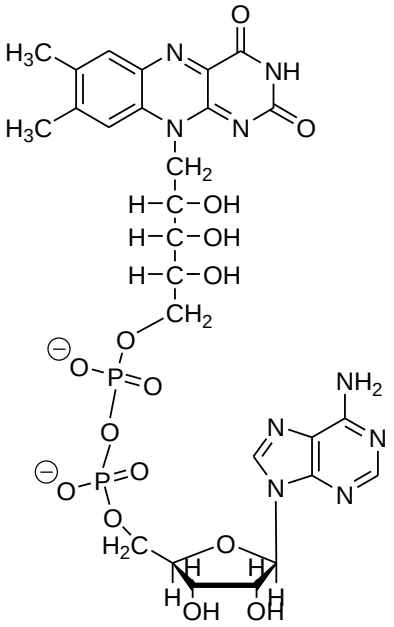


D



____ 16. The substrate in reaction 16 reacts with this coenzyme/cofactor.

____ 17. The substrate in reaction 17 reacts with this coenzyme/cofactor.

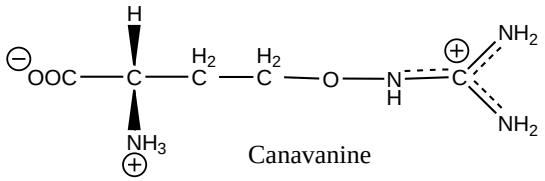
____ 18. The substrate in reaction 18 reacts with this coenzyme/cofactor.

____ 19. The substrate in reaction 19 reacts with this coenzyme/cofactor.

____ 20. Based on the data in Table 3, which of the following transamination reactions would be unlikely to be found in a rat?

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

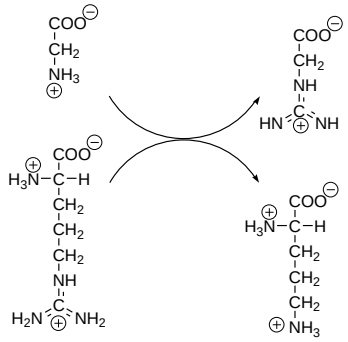
____ 21. Canavanine (below) is a toxic analog of arginine found in the seeds of certain legumes.



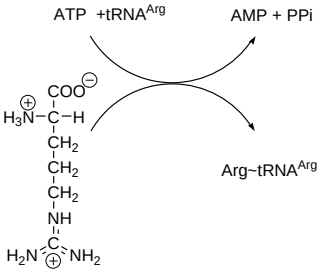
Canavanine

It would make us sick because enzymes we have cannot discriminate between canavanine and arginine. Canavanine is not toxic to germinating legume seeds because their enzymes can discriminate between arginine and canavanine. Several enzyme reactions involving arginine are shown below. Which one would be most responsible for the toxicity associated with canavanine?

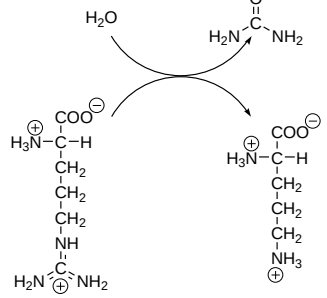
A Glycine amidinotransferase



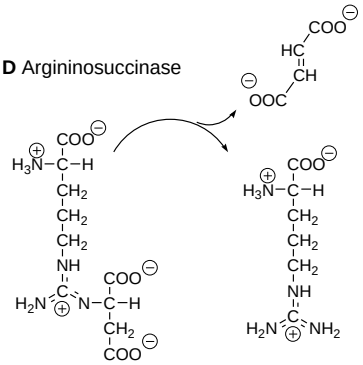
B Arginyl tRNA Synthetase



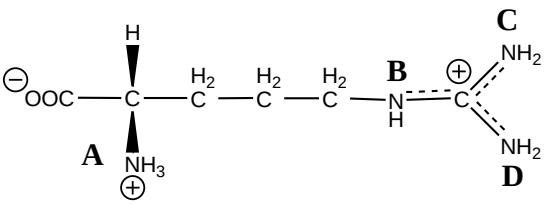
C Arginase



D Argininosuccinase



____ 22. Given the known amino acid metabolic pathways and the patterns of isotope transfer among different amino acid in rats and mice, which of the following statements would reflect the relative ^{15}N content of the four nitrogen atoms (A, B., C, and D below) in the labeled arginine derived from other amino acids in Table 3?



A. A ≈ B ≈ C ≈ D **B**. A > C > D > B **C**. C ≈ D >> A or B **D.** A > C ≈ D > B

____ 23. The primary selective pressure on plants to produce seeds with unbalanced amino acid content is:

A. Germinating seedlings have reduced need for the amino acids produced in low amounts.
B. Plants save energy by producing fewer amino acids.
C. The amino acid content doesn't match the amino acid needs of herbivores.
D. The codon assignments in the genetic code dictates the amino acid composition of seed proteins.

____ 24. Phenylalanine is connected enzymatically to tyrosine in two ways—phenylalanine hydroxylase (defective in phenylketonuria) and aromatic amino acid transaminase. Consider an experiment in which doubly-labeled [^{15}N, 2-^{13}C] phenylalanine were fed to rats and tyrosine were isolated and analyzed by mass spectrometry sometime later. If phenylalanine hydroxylase were the dominant metabolic connection between phenylalanine and tyrosine, one would expect tyrosine to contain:

A. Small amounts of both ^{15}N and ^{13}C.
B. Significant amounts of both ^{15}N and ^{13}C.
C. Small amounts of ^{15}N and significant amounts of ^{13}C
D. Significant amounts of ^{15}N and small amounts of ^{13}C.

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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