PETITION

To the
U.S. Department of Agriculture
National Organic Program

To Amend 7 CFR §205.603(d)
To Include Required Amino Acids
As A Synthetic Substance Allowed
For Use in Organic Pet Food Production

Submitted January 30, 2012

By
Pet Food Institute
2025 M St., NW
Suite 800
Washington, D.C. 20036
Tel: 202 367-1120
Fax: 202-367-2120
www.petfoodinstitute.org

Contact Persons: Nancy Cook, nancy@petfoodinstitute.org
Dave Carter, de.carter@comcast.net

Pet Food Institute
2025 M Street, NW, Suite 800
Washington, DC 20036

(202)367-1120
Fax (202) 367-2120

January 18, 2012

Miles McEvoy
Deputy Administrator
USDA/AMS/TMP/NOP
1400 Independence Ave., S.W.
Room 2646-S
Ag Stop 0268
Washington, D.C. 20250-0201

Dear Mr. McEvoy,

The Pet Food Institute (PFI), the trade association comprised of pet food manufacturers which produce 98% of the dog and cat sold in the United States, an $18 B business with an additional $1.2B in exports, formally submits this petition to the U.S. Department of Agriculture's National Organic Program. We request the amendment of §205.603(d) of the National Organic Standards to include required amino acids as synthetic substance allowed for use in organic pet food production on behalf of all Organic pet food producers in the U.S. This petition is being submitted in anticipation of the development of formal regulations governing the certification of pet food under the National Organic Standards.

In accordance with the instructions on the National Organic Program website, we have provided answers to all of the questions below, and in a manner that satisfies the criteria in 7 USC 6517 and 6518, commonly known as the Organic Foods Production Act.

We, of course, are ready to provide any additional information that you, the National Organic Standards Board, or the Technical Advisory Panels may require to complete your review process.

Sincerely,

Nancy K. Cook
Vice President

Table of Contents

Petition Information

Overview and Introduction

The U.S. Department of Agriculture's National Organic Standards recognized from the outset that vitamins, minerals and other required nutrients are essential in formulating certified organic products that will meet the nutritional requirements of humans and animals.

Specifically, §205.603(d)(2) and §205.603(d)(3) allow trace minerals and vitamins to be utilized in livestock for enrichment or fortification when FDA approved. Those nutrients are allowed for use in livestock feed regardless of the method of manufacturing or handling.

Under the current regulations, pet food products seeking certification under the USDA Organic Standards must be produced in accordance with §205.605 and §205.606 of the National Organic Standards. However, this petition is being submitted in anticipation of proposed regulations to allow certification of pet food as organic under §205.603 of the National Organic Standards.

This petition is also being submitted in accordance with the consent of the National Organic Standards Board Livestock Committee—and the National Organic Program—to consider a petition for required nutrients as defined by the National Research Council in the National Academy of Science's Nutrient Requirements of Dogs and Cats.

That decision is consistent with the information supplied to the National Organic Program on June 27, 2011 by the U.S. Food and Drug Administration's (FDA) Center for Veterinary Medicine (CVM). In that communication, the FDA stated, "The CVM relies on the various *ad hoc* expert nutrition committees under the Committee on Animal Nutrition of the National Research Council in the National Academy of Sciences for establishment of which nutrients, and in what amounts, are essential in the diets for specific species of domestic animals to meet that species' daily nutrient requirements. For dogs and cats, the required essential nutrients are listed and described in the 2006 edition *of Nutrient Requirements of Dogs and Cats.*[1] The CVM considers the nutrients listed in Tables 15-3,15-5, 15-8, for dogs, and Tables 15-10, 15-12,15-14 for cats, to be essential nutrients and eligible for supplementation if required to meet and provide the listed MR, or in the absence of a stated value for the MR then the listed value for AI for that nutrient, in products represented to be "complete and balanced." (underline added)

Note - The tables referenced above at included with this petition as Attachment D.

State regulators utilize the Official Publication of the Association of American Feed Control Officials (AAFCO) as a model for the regulation of pet food products, including the nutrient composition of products eligible to be labeled as “complete and balanced.” As explained in the FDA’s June 2011 memorandum, “The AAFCO Dog and Cat Food Nutrient Profiles do not contain any nutrient that has not been determined to be essential and listed in the previously referenced tables in the 2006 edition *of Nutrient Requirements of Dogs and Cats.*”

Accordingly, this petition request approval for the addition of amino acids to add a section §205.603(d)(3) stating “For dogs and cats, synthetic amino acids defined as required by the National Research Council of the National Academy of Sciences.”

While this petition requests the allowance of those materials as a category—consistent with the language in §205.603(d)(2) and §205.603(d)(3), these amino acids are discussed individually to the extent possible throughout this document.

The importance for consideration of all of these required amino acids cannot be understated. Unlike humans, dogs and cats rely on their daily ration of commercially-prepared pet food as their sole source of nutrition. The absence of any of these required amino acids will have a serious detrimental effect upon the health of that pet.

1. The substances’ common names

This petition covers the category of required amino acids. Amino acids categorized as required by the National Research Council’s Nutrient Requirements of Dogs and Cats include all of the following:

- Arginine
- Methionine
- Cysteine
- Lysine
- Taurine
- Tryptophan
- Threonine
- Histidine
- Isoleucine
- Leucine
- Phenylalanine
- Tyrosine
- Valine

2. The official name, address, and telephone number for Pet Food Institute:

Pet Food Institute
2025 M St., NW
Suite 800
Washington, D.C. 20036
Tel: 202 367-1120

Fax: 202 367-2120
Website: www.petfoodinstitute.org

Contact Persons: Nancy Cook, nancy@petfoodinstitute.org
Dave Carter, de.carter@comcast.net

3. The intended or current use of the substance:

The above-listed amino acids are required in the diets of canine and felines. Without the inclusion of the proper levels of these amino acids, dog and cat food formulations cannot be classified as “complete and balanced” under the guidelines of the American Association of Feed Control Officials (and, which guidelines are based upon the NRC Nutrient Requirements of Dogs and Cats). As mentioned above, State regulators utilize the Official Publication of the Association of American Feed Control Officials (AAFCO) as a model for the regulation of pet food products. Accordingly, commercially-produced pet food products cannot be labeled as “complete and balanced unless those products contain the required amino acids in the minimum (and maximum) levels listed in the tables below:

	AAFCO Dog Food Nutrient Profiles Based on Dry Matter			
	Units DM Basis	Growth & Reproduction Minimum	Adult Maintenance Minimum	Maximum
Arginine	%	0.62	0.51	
Histidine	%	0.22	0.18	
Isoleucine	%	0.45	0.37	
Leucine	%	0.72	0.59	
Lysine	%	0.77	0.63	
Methionine-cystine	%	0.53	0.43	
Phenlyalanine-tryosine	%	0.89	0.73	
Threonine	%	0.58	0.48	
Tryptophan	%	0.20	0.16	
Valine	%	0.48	0.39	

	AAFCO Dog Food Nutrient Profiles Based on Calorie Content			
	Units per 1000 kcal ME	Growth & Reproduction Minimum	Adult Maintenance Minimum	Maximum
Arginine	g	1.77	1.46	
Histidine	g	0.63	0.51	
Isoleucine	g	1.29	1.06	
Leucine	g	2.06	1.69	
Lysine	g	2.20	1.80	
Methionine-cystine	g	1.51	1.23	
Phenlyalanine-tryosine	g	2.54	2.09	
Threonine	g	1.66	1.37	
Tryptophan	g	0.57	0.46	
Valine	g	1.37	1.11	

	AAFCO Cat Food Nutrient Profiles Based on Dry Matter			
	Units DM Basis	Growth & Reproduction Minimum	Adult Maintenance Minimum	Maximum
Arginine	%	1.25	1.04	
Histidine	%	0.31	0.31	
Isoleucine	%	0.52	0.52	
Leucine	%	1.25	1.25	
Lysine	%	1.20	0.83	
Methionine-cystine	%	1.10	1.10	
Methionine	%	0.62	0.62	1.50
Phenlyalanine-tryosine	%	0.88	0.88	
Phenylalanine	%	0.42	0.42	
Threonine	%	0.73	0.73	
Tryptophan	%	0.25	0.16	
Valine	%	0.62	0.62	
Taurine (Dry Food)	%	0.10	0.10	
Taurine (Wet Food)	%	0.20	0.20	

	AAFCO Cat Food Nutrient Profiles Based on Calorie Content			
	Units per 1000 kcal ME	Growth & Reproduction Minimum	Adult Maintenance Minimum	Maximum
Arginine	g	3.10	2.60	
Histidine	g	0.78	0.78	
Isoleucine	g	1.30	1.30	
Leucine	g	3.10	3.10	

Lysine	g	3.00	2.08	
Methionine-cystine	g	2.75	2.75	
Methionine	g	1.55	1.55	3.75
Phenlyalanine-tryosine	g	2.20	2.20	
Phenylalanine	g	1.05	1.05	
Threonine	g	1.83	1.83	
Tryptophan	g	0.63	0.40	
Valine	g	1.55	1.55	
Taurine (Dry Food)	g	0.25	0.25	
Taurine (Wet Food)	g	0.50	0.50	

These materials are petitioned as a category for use as a synthetic allowed substance under §205.603(d) of the National Organic Standards.

The Organic Pet Food Recommendation unanimously adopted by the NOSB in November 2008 contained an appendix listing materials for possible petition to the National List for use in pet food. That appendix specifically listed the following amino acids for petition as allowed feed additives under §205.603(d):

- l-arginine - for pet food (amino acid)
- d-l Methionine for pet food (amino acid)
- Carnitine for pet food (amino acid)
- l-cysteine for pet food (amino acid)
- l-lysine, l-lysine monochloride for pet food (amino acids)
- Taurine for pet food (amino acid)
- l-tryptophan for pet food (amino acid)

Because the absence of even one required amino acid prohibits a pet food product from being labeled as complete and balanced, the National Organic Program and the National Organic Standards Board have consented to consider required amino acids as a categorical addition to the National Organic Standards. Accordingly this petition includes all forms to the required amino acids as identified by the National Research Council and as listed in the Official Publication of AAFCO.

However, the list contained in the Appendix of the National Organic Standards Board recommendation identifies those amino acids that are not readily available from agricultural products used in commercially-manufactured pet food products. The other required amino acids not listed in the NOSB recommendation are available in agricultural products and will not need to be utilized in a synthetic format.

4. A list of activities for which the substance will be used – mode of action

Activities

Accordingly, these required amino acids will be used as an ingredient in the following products to be manufactured as "organic" or "made with organic:"

- Wet cat food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction;
- Semi-moist cat food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction;
- Dry cat food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction;
- Wet dog food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction;
  Semi-moist dog food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction;
- Dry dog food formulations labeled as complete and balanced for adult maintenance, and for growth and reproduction; and
- Pet Treats.

Mode of Action

Comprised of 23 different amino acids, proteins are often called the "building blocks" of the tissues. The bodies of dogs and cats can manufacture 13 of these amino acids. The other 10 amino acids, however, must come from dietary meat and plant sources and are called the "essential amino acids". The biological value of a protein is a measure of that protein's ability to supply amino acids, particularly the 10 essential amino acids, and to supply these amino acids in the proper proportions.

Additionally, Taurine, Cysteine and Tyrosine, are recognized by the National Research Council as required amino acids. The reasons for inclusion for these three materials are explained in the following sections of the NRC:

Cysteine:

"Cysteine is an important component of proteins for their secondary structure and a major constituent of hair and glutathione. Since methionine serves as a precursor to cysteine, cysteine is a dispensable amino acid. Because cysteine is made only from methionine and can provide about one-half of the total need for sulfur amino acids, cysteine and methionine must both be considered when establishing the total sulfur amino acid requirement. Therefore, the requirements are presented as the MR of methionine when there is excess cysteine in the diet, and the total sulfur amino acid requirement, which can be met with only methionine, but commonly involves a combination of methionine and cysteine. Cysteine cannot be converted to methionine; so the MR of methionine must be met with methionine." (NRC, 2006, Page 126)

Taurine:

"Taurine is a β-aminosulfonic acid (2-aminoethanesulfonic acid), an essential dietary nutrient for cats but dispensable for dogs fed adequate quantities of sulfur-containing amino acids. Taurine is one of the most abundant free amino acids in mammals, being particularly high in brain, heart, and skeletal muscle. Peak concentrations of taurine occur in the total body of newborns and in neonatal brain and gradually decrease by 75 percent as cats mature, but 10 mmol taurine-kg"[1] is maintained in several tissues in adult cats (Sturman, 1988)."

"Since taurine does not contain a carboxyl group and is a β-amino acid, it is not found in proteins and is made in most species from cysteine. The synthesis of taurine appears to be severely limiting for strict carnivores, but not for most herbivores or omnivores."

"Taurine deficiency causes a multitude of metabolic aberrations and clinical signs. Taurine is involved in fetal development, growth, reproduction, neuro-modulation, sight, hearing, heart function, osmoregulation, fat emulsification, neutrophil function, immune response, antioxidation, and bile acid and xenobiotic conjugation and acts as an anticonvulsant." (NRC, 2006, Page 134)

Tyrosine:

"Although tyrosine is a dispensable amino acid, it is made in animals only from phenylalanine, and tyrosine spares about one-half of the phenylalanine needed by all species examined including dogs and cats. Thus, it is appropriate to consider the amount of phenylalanine required as the sum of phenylalanine plus tyrosine, provided the level of tyrosine in the diet is not higher than that of phenylalanine. Phenylalanine and tyrosine have not been shown to be the most limiting amino acids for growth or nitrogen balance in diets sufficient in protein or in commercial diets formulated using natural ingredients for dogs and cats." (NRC, 2006, Page 128)

5. The source of the substance and a detailed description of its manufacturing or processing procedures from the basic component(s) to the final product.

Source:

Amino acids are present in all proteins. However, purified proteins or purified amino acids, when fed alone without other food ingredients, cannot maintain dogs and cats in good health.

Manufacturing Process:

There are four general ways to obtain amino acids for commercial use: extraction from natural sources, chemical synthesis, fermentation, and enzymatic catalysis.

<u>**Extraction from Natural Sources**</u>

In extraction from natural sources the standard procedure is hydrolysis with aqueous acid, followed by capture of the amino acids by passage of the hydrolysate over a strongly acidic ion exchange resin. After the resin is washed with water, elution with aqueous ammonia frees the amino acids, which are collected in fractions. Extraction is the most economical process for the production of both (*S*)-tyrosine and (*R,R*)-cystine. Reduction of (*R,R*)-cystine gives (*R*)-cysteine. (Journal of Chemical Education, 2004)

Chemical Synthesis

The advantage of a chemical synthesis is that it can be carried out on a very large scale, and often in a continuous way. The great disadvantage, however, is that it typically gives a racemic mixture of the enantiomeric forms of the amino acid. Thus the product of a chemical synthesis must be resolved into the *R* and *S* forms, followed by recovery and recycling via racemization of the undesired enantiomer.

An example of a chemical synthesis is provided by the preparation of (*R,S*)-methionine. Since both the *R* and *S* isomers of methionine can be metabolized by poultry and swine, resolution is not necessary and, in contrast to most other amino acids, chemical synthesis is predominant for the industrial production of methionine, as well as for racemic alanine and glycine.

The first step of the chemical synthesis of methionine is the conjugate addition of methyl mercaptan to acrolein to give β-methylthiopropionaldehyde.

The addition of methyl mercaptan to acrolein takes place by a nucleophilic mechanism. Attack of the conjugate base of methyl mercaptan (p*K*a = 10.7) gives a resonance-stabilized anion, which then accepts a proton on carbon to give the addition product, β-methylthiopropionaldehyde.

β-Methylthiopropionaldehyde is then converted to methionine by the Bucherer method, a modification of the Strecker method in which ammonium carbonate takes the place of ammonia. (Journal of Chemical Education, 2004)

Fermentation Methods

Although it is possible to prepare any natural amino acid by fermentation, a microbiological process, the special mutants that allow production to be done on a large scale have been developed only for the preparation of (*S*)-lysine and (*S*)-glutamic acid. The carbon sources for these syntheses are typically cane or beet molasses, raw sugar, or a starch hydrolysate. Ammonia is the source of nitrogen, and oxygen is provided by passing compressed air into the fermenting mixture.

An early fermentation process for the production of lysine made use of a pair of *E. coli* mutants. Normal *E. coli* can synthesize its own lysine from carbohydrates and ammonia, but the first mutant lacked the α,ε- diaminopimelic decarboxylase that normally converts α,ε--diaminopimelic acid (DAP) to lysine.

After the concentration of DAP had reached a maximum in the presence of the first mutant, the first mutant was removed and another *E. coli* strain was added. This second mutant produced DAP decarboxylase, but lacked lysine decarboxylase, thus allowing lysine to accumulate.

A second method for the production of lysine is a single stage fermentation process, now generally used for the microbial synthesis of lysine. This process makes use of a mutant of *Corynebacterium glucamicum* in which feedback mechanisms of product inhibition are overcome. Molasses is the most common carbon source, and this contains sufficient biotin to provide the more than 30 µg/L needed to suppress the excretion of glutamic acid. (Journal of Chemical Education, 2004)

All amino acids may be produced by fermentation. Whether they will or not depends on the costs of competing technologies such as chemical synthesis or extraction from protein sources. (holisticmed.net, 2003)

The fermentation method has the advantage of mass production at low cost, which was the great impetus for expanding the amino acid market. The manufacturing method of glutamate shifted from the extraction method to the fermentation method in the 1960s. Subsequently, a similar shift to the fermentation method took place for the other amino acids in rapid succession. (Ajinomoto, 2011)

Enzymatic Synthesis of Amino Acids

In the fourth method for synthesis of amino acids, the enzymatic procedures, pure enzymes are used, rather than the enzyme systems of living microorganisms, as in the fermentation methods.

At one time, for example, (*S*)-aspartic acid was produced mainly by the enantioselective, enzyme-catalyzed, addition of ammonia to fumaric acid, a substance that could be sup plied in large quantities and at low cost.

Since only the naturally occurring isomer of aspartic acid was formed, resolution was not necessary. This method has since been supplanted by a continuous microbiological process in which the reacting solution passes over a fixed bed of an immobilized microorganism. (Journal of Chemical Education, 2004)

Choosing between processes depends on available technology, costs of raw material, market prices and sizes, cost of running fermentation versus synthesis reactions, and the environmental impact of the process itself. (holisticmed.net)

	SOURCES OF SIGNIFICANT PRODUCTION			
		Chemical		Enzyme
Amino Acid	**Extraction**	**Synthesis**	**Fermentation**	**Catalyst**
Arginine	Y		Y	
Cystine		Y		Y
Histidine			Y	
Isoleucine			Y	
Leucine	Y		Y	
Lysine	Y		Y	
Methionine				Y
Phenylalanine		Y	Y	Y
Proline			Y	
Threonine		Y	Y	
Tryptophan		Y	Y	Y
Tyrosine	Y		Y	
Valine		Y	Y	
Source: Journal of Chemical Education, 2004				

Synthesis of Amino Acids

Note: The following information was produced by Timothy Paustian, of the University of Wisconsin-Madison

The amino acids synthesis pathways can be grouped into several logical units. These units reflect either common mechanisms or the use of common enzymes that synthesize more than one amino acid. These categories are: simple reactions, branch chain amino acids, aromatic amino acids, threonine/lysine, serine/glycine, and unique pathways. The aromatic amino acids, threonine/lysine and serine/glycine pathways have a common beginning and then diverge to form the amino acid of interest.
Notice that each pathway begins with a central metabolite or something derived from "central metabolism". Using common compounds instead of synthesizing them from scratch saves energy and conserves genes since fewer enzymes are needed to code for the pathways.

Simple Reactions

glutamine, glutamate, aspartate, asparagine and alanine

In most cases these amino acids can be synthesize by one step reactions from central metabolites. They are simple in structure and their synthesis is also straight forward. Glutamate can by synthesized by the addition of ammonia to α-ketoglutarate.

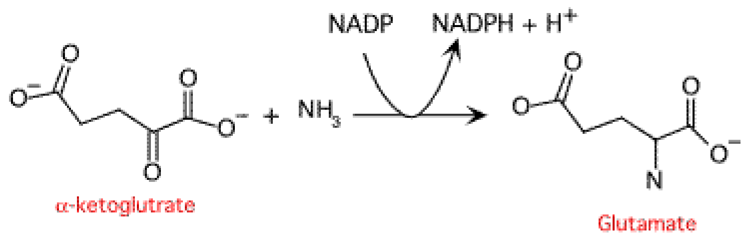


Figure 1 - The synthesis of glutamate

Glutamine is made by the addition of another ammonia molecule to glutamate.

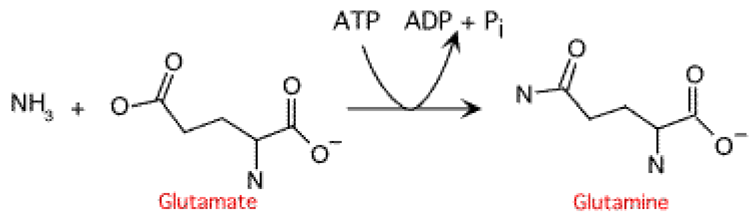


Figure 2 - Synthesis of glutamine

The rest of the simple reactions involve transfer of the amino group (transamination) from glutamate or glutamine to a central metabolite to make the required amino acid. Aspartate is synthesize by the transfer of a ammonia group from glutamate to oxaloacetate.

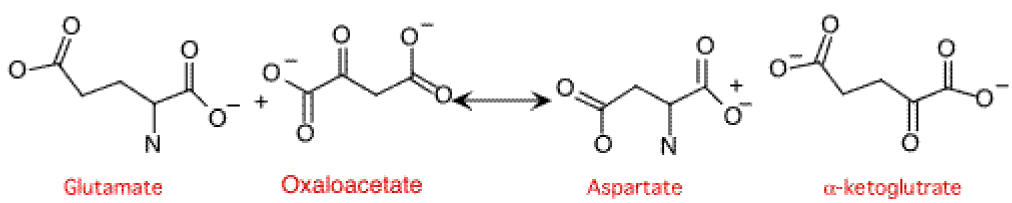
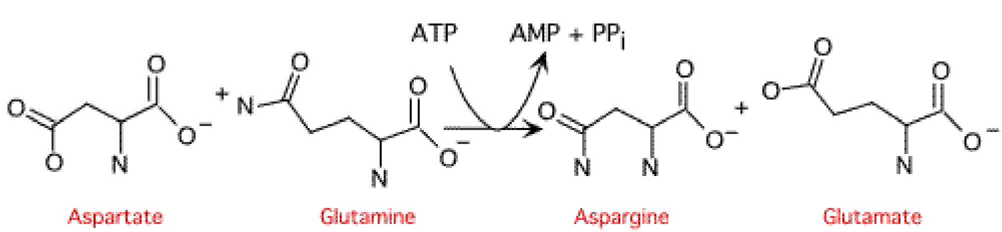


Figure 3 - The synthesis of aspartate

Asparagine is made either by transamination from glutamine or by adding ammonia directly to aspartate.



or

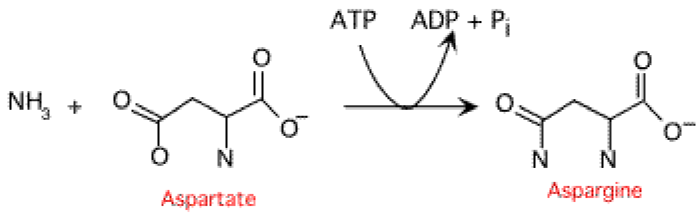


Figure 4 - Formation of asparagine. Notice the use of AMP instead of ADP in this reaction. This releases more energy which is needed to drive the synthesis.

Alanine synthesis is a bit of a mystery. Several reactions have been identified, but it has been impossible to generate an alanine auxotroph and therefore positively identify a required pathway. There are several pathways and the most likely is formation of alanine by transamination from glutamate onto pyruvate. A transamination using valine instead of glutamate is also possible.

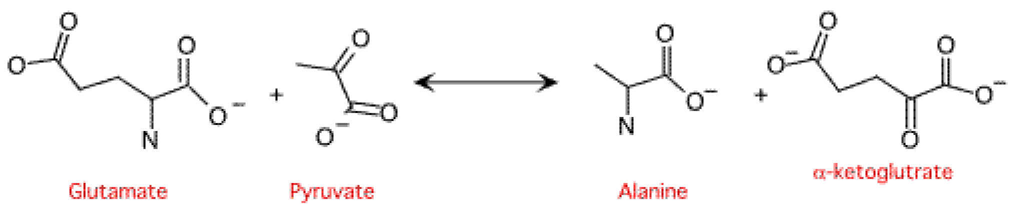


Figure 5 - Synthesis of alanine

Threonine/lysine

Synthesis of threonine and lysine begins by the conversion of oxaloacetate to aspartate semialdehyde. This shared pathway costs one ATP and two NADPH + H^+
Threonine biosynthesis is completed in three steps. First a second reduction with NADPH + H^+, yields homoserine. This is phosphorylated to homoserine phosphate by ATP and finally converted into threonine.

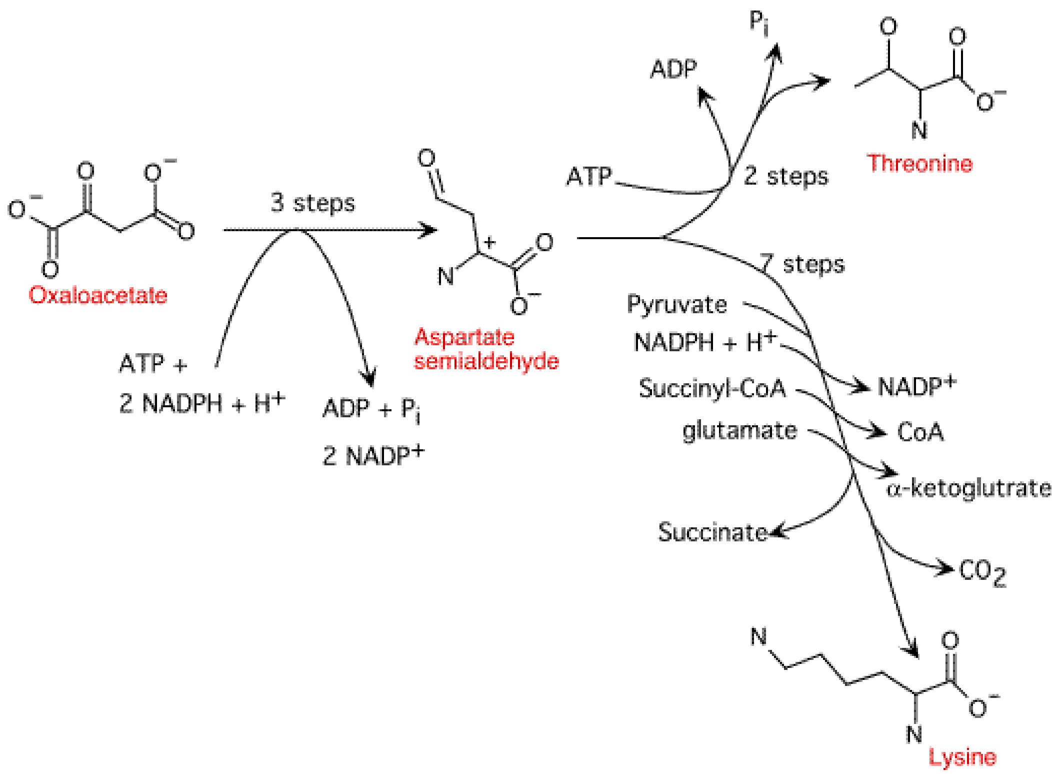


Figure 6 - Synthesis of Threonine and Lysine. Note the amount of energy that is expended in these biosytheses.

The synthesis of lysine has been found to consist of different reactions in different bacterial species. A somewhat generalize pathway is presented. Lysine synthesis involves the addition of pyruvate to aspartate semialdehyde, the use of a CoA intermediate (either acetyl CoA or succinyl-CoA) and the addition of an amino group from glutamate. The group added from CoA (either succinyl or acetyl) serves as a blocking group, protecting the amino group from attack during transamination by glutamate. NADPH + H^+ is required for reduction in the second step of the pathway.

leucine, isoleucine and valine

Examination of the isoleucine pathway versus the valine pathway demonstrates that the only difference is the substitution of an ethyl group instead of a methyl group to the α-carbon of the intermediates. The intermediates are so similar that common enzymes catalyze four steps of each pathway. Isoleucine synthesis begins with threonine, which is deaminated to α-ketobutyrate. From here the 4 step synthesis costs one NADPH + H^+ per amino acid synthesized.

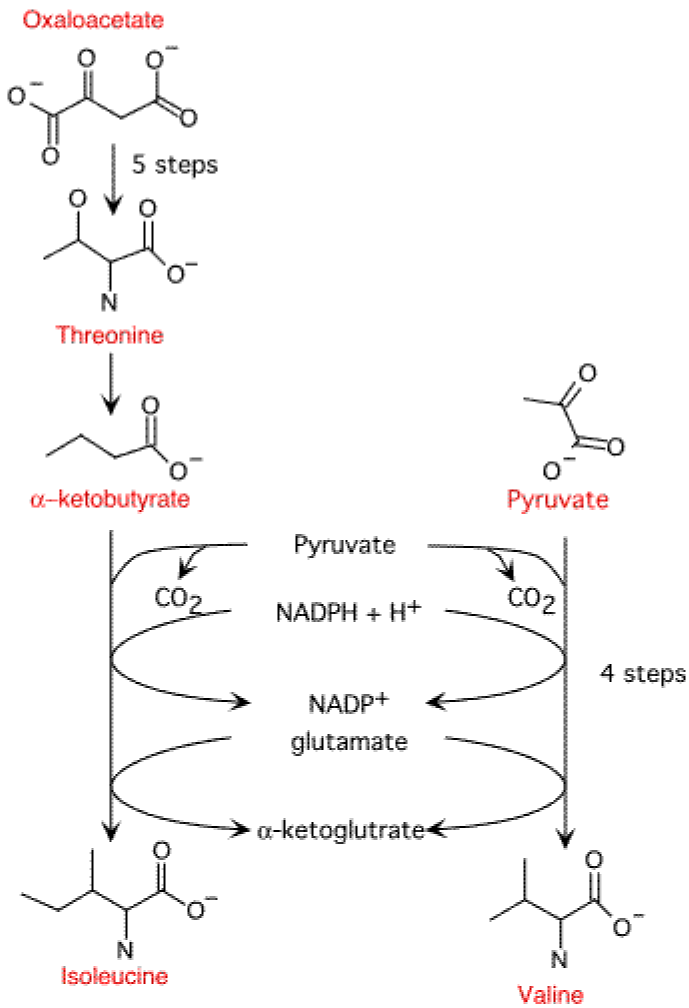


Figure 7 - Synthesis of valine and isoleucine.

Leucine biosynthesis starts off with the last intermediate in the valine synthesis, α-ketoisovalerate. In the first step Acetyl-CoA is used to add an acetyl group to the molecule. Electrons are transferred to NAD^+ (note these can be used for other cellular processes) and one carbon is lost in the form of CO_2 at the fourth step of the pathway. In the final step, the amine from glutamate is added to α-ketoisocaproate to form leucine.

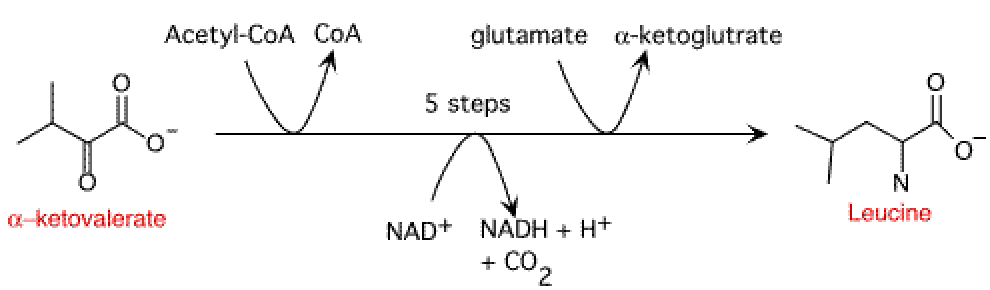


Figure 8 - Synthesis of leucine

tryptophan, phenylalanine and tyrosine

Synthesis of the aromatic amino acids begins with the synthesis of chorismate - an important intermediate for many biosynthetic pathways. Phosphoenol pyruvate and erythrose 4-phosphate serve as beginning substrates for the pathway. A price of one NADPH + H^+ and one ATP is exacted for every chorismate formed. In the sixth step of the synthesis another phosphoenol pyruvate molecule is added to the growing molecule.

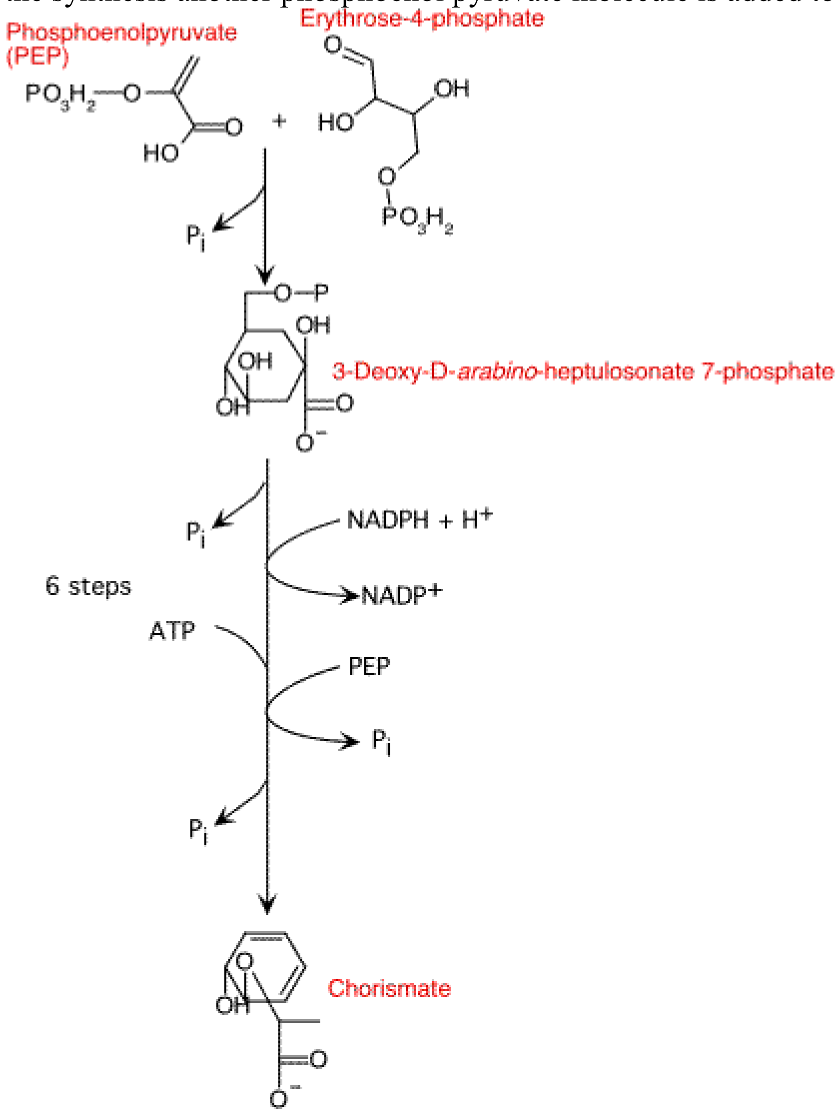


Figure 9 - Synthesis of chorismate

Phenylalanine

Chorismate is converted to phenylpyruvate in two steps and phenylalanine is synthesized by a transamination reaction with glutamate. No energy is required to run these reactions.

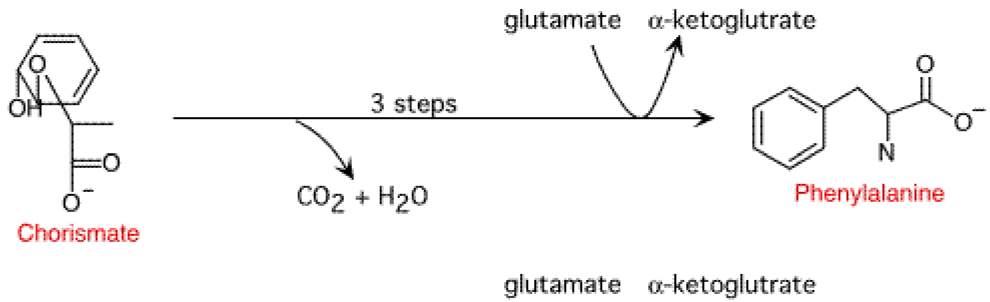


Figure 10 - Synthesis of phenylalanine

Tyrosine

The synthesis of tyrosine is very similar to the synthesis of phenylalanine, but the reactions are carried out by different enzymes under different regulatory control. NADH is created in the formation of 4-hydroxyphenylpyruvate. Tyrosine is made by a similar transamination reaction as that seen in phenylalanine synthesis.

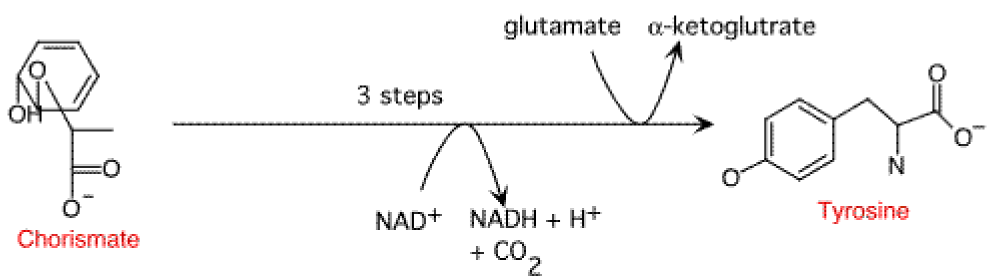


Figure 11 - Synthesis of tyrosine

Tryptophan

Trytophan synthesis is complex and involves 5 steps from chorismate. Glutamate donates an amine group in the first step of the pathway and pyruvate is lost from chorismate. In the next three steps a ribose sugar is added, this eventually contributes to the 5 membered ring of tryptophan. Energy is contributed to the process in the form of hydrolysis of pyrophosphate. This hydrolysis helps drive the addition of the ribose sugar in the second step of the reaction. In the last step of the pathway serine serves as the donor of the α carbon amino group of tryptophan.

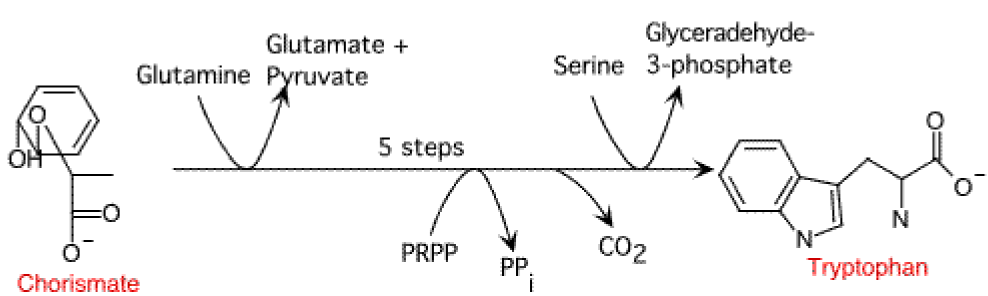


Figure 12 - Synthesis of tryptophan

Unique pathways

cysteine, methionine, histidine and arginine

These pathways involve something unusual, either the structure of the amino acid is different enough than the other common amino acids, or sulfur is involved in their synthesis. In any case, unique enzymes are involved in every step of the way. Here we just examine what they start with and how much it costs the cell.

Cysteine

Synthesis of cysteine is a two step reaction. Serine and acetyl-CoA combine to form *O*-acetylserine. Sulfide from sulfur assimilation is then added to *O*-acetylserine to form cysteine. The pathway for cysteine synthesis was covered in sulfate assimilation.

Methionine

Methionine is synthesized from oxaloacetate. Succinyl-CoA participates and cysteine donates a sulfur group to the molecule. Oxaloacetate is first converted into homoserine as described above in the threonine biosynthetic pathway. Homoserine then has a sulfur attached to the end in two steps and finally methionine is formed by the addition of a methyl group.

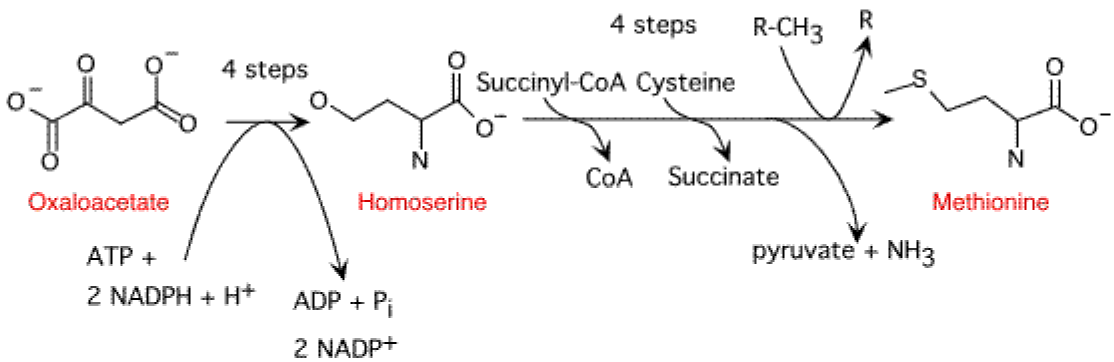


Figure 13 - Synthesis of methionine. The donor of the methyl group (R) is a methyl carrier in the cell, N^5,N^{10}-Methylene terahydropteroyl.

Histidine

The synthesis of histidine is long and complex and its pathway is intertwined with nucleic acid biosynthesis (specifically purine). The pathway seems to be universal in all organisms able to synthesize histidine. The first five steps of the pathway take ribose from phosphoribosyl pyrophosphate (PRPP) and transform it into Imadiazoleglycerol phosphate. Once the imadiazole ring is formed, glutamate donates the α-amino group and the newly formed amine is oxidized to histidine in the last step of the pathway. Energy is required in the form of ATP (in this case elements of the ATP molecule actually becomes part of the amino acid) and pyrophosphate which is lost from phosphoribosyl pyrophosphate and ATP help drive the reaction.

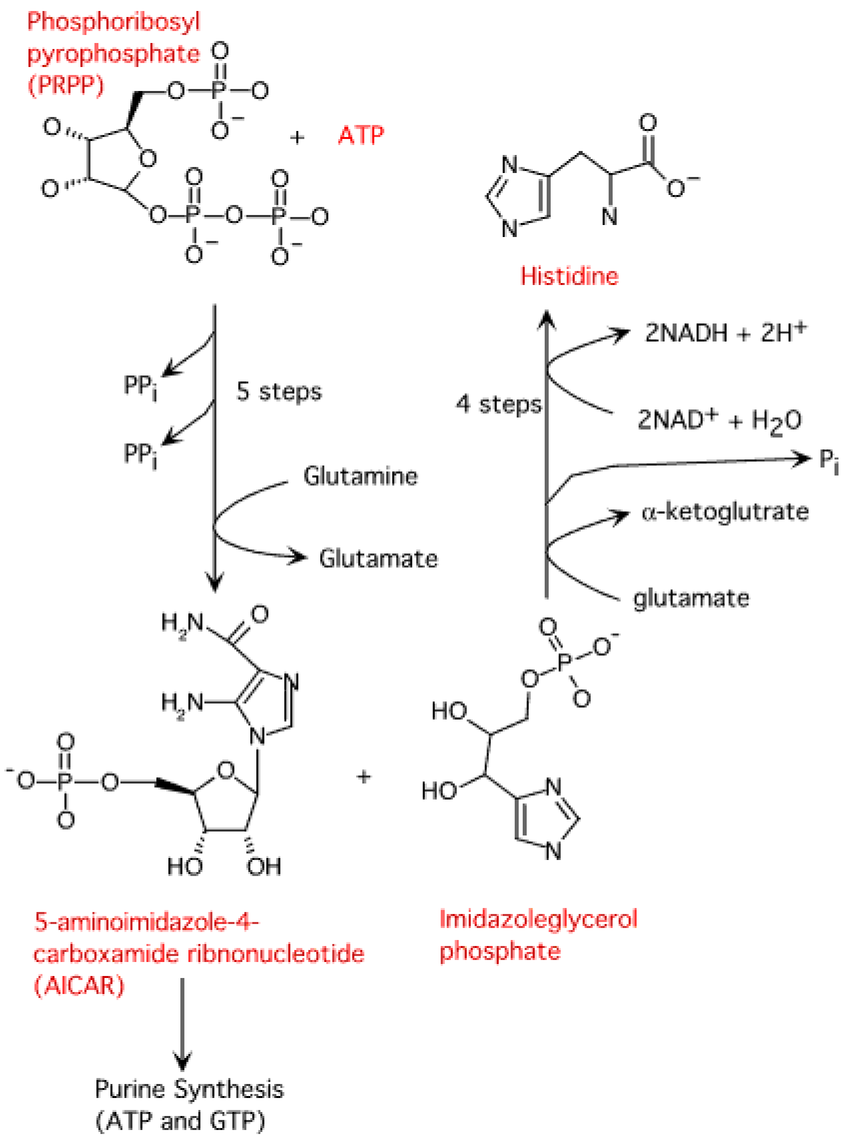


Figure 14 - Synthesis of Histidine

Investigations into histidine biosynthesis have yielded many insights into microbial metabolism that have contributed greatly to our understanding of how cells function at the genetic and biochemical level. Work in this area is still yielding important results.

Arginine

Synthesis of arginine is an eight step process starting with the amino acid glutamate. Two ATP and one NADPH + H^+ are utilized to synthesize each arginine.

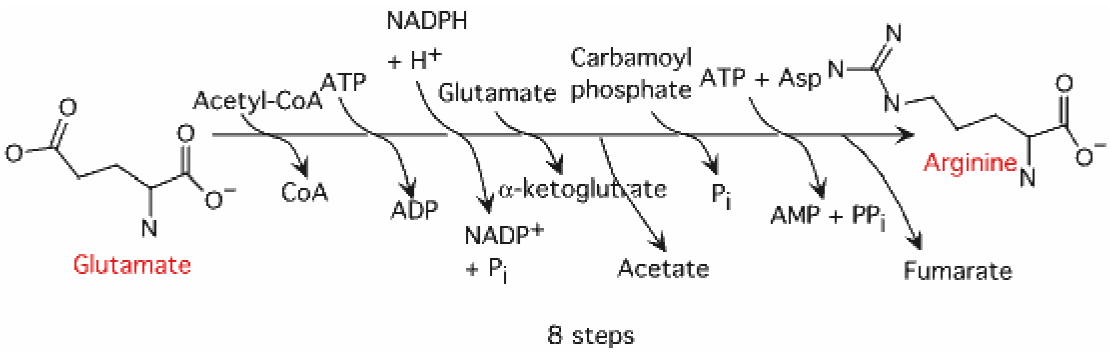


Figure 15 - Synthesis of arginine

Taurine

Taurine was first isolated from ox bile in 1827 by German scientists Fredrich Tiedemann and Leopold Gmelin. The name, taurine, is a derivative of the Latin term, taurus.

Taurine occurs naturally in food, especially in seafood and meat, and it is a normal metabolite in humans. It is a metabolic product of sulphur-containing amino acids, and it is mainly biosynthesized from cysteine in the liver (SCF, 1999).

Today, a small amount taurine is still derived from bovine and ovine sources. This natural taurine, however, is essentially a by-product from the production of cholic acid, deoxycholic acid and other bile acids, and is therefore available in extremely limited supplies. New Zealand Pharmaceuticals, Ltd., for example, produces 800 tons of bile acids each year from oxen, cattle and sheep bile. Of that amount, only 20 tons consists of taurine for all markets.

Most taurine today is synthesized from methionine, Vitamin E and cysteine.

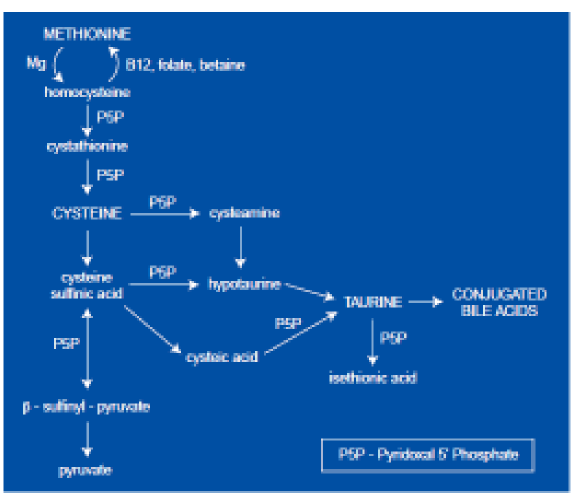


Figure 16 - Synthesis of taurine

Commercial Suppliers:

Many companies commercially supply required amino acids as ingredients for livestock feed and pet food. Major suppliers include—but are not limited to—the following companies:

Ajinomoto Heartland LLC
8430 West Bryn Mawr Avenue,
Suite 650, Chicago, IL 60631-3421
Tel: +1 (773) 380-7000
Fax: +1 (773) 380-7006

Changshu Yudong Chemical Company
Wangshi Haiyu Town
Changshu City
Jungshu Province, China PC 215519
Tel +86-512-52565808
Fax +86-512-52561808
E-mail: yonglida@public1.sz.js.cn
Website: www.yudongchem.com

Qianjiang Yongan Pharmaceutical Co., LTD
No. 16 Zhuze Road
Qianjiang, China
Tel: + 86-728-6202727/6201636
Fax: +86-728-6202797
E-mail: yasales@chinataurine.com
Website: www.chinataurine.com

Changshu Yudong Chemical Company
Wangshi Haiyu Town
Changshu City
Jungshu Province, China PC 215519
Tel +86-512-52565808
Fax +86-512-52561808
E-mail: yonglida@public1.sz.js.cn
Website: www.yudongchem.com

Zone Industrielle Grasbesch
L-3370 Leudelange
G.D. de Lusombourg
Tel: +352-49-89-770
Fax: +352-49-89-771
Email: sales@taurinepffg.com
Website: www.taurinepffg.com

New Zealand Pharmaceuticals Ltd.
Po Box 1869, Palmerston North, 4440,
New Zealand
+64 6 9523840
market@nzp.co.nz
www.nzp.co.nz

6. A summary of any available previous reviews by State or private certification programs or other organizations of the petitioned substance

These required amino acids not been previously petitioned, but has been allowed for use in pet food products certified as "organic", or" made with organic," since October 2002.

Following the 2004 directive by NOP that pet food products could be certified under 7 CFR § 205.605 and §205.606, certifiers have relied upon the guidance from the NOP regarding the use of taurine and other required nutrients for pet food products. In November 2006, the NOP issued a notice in response to a complaint, reading, in part:

> *"The complaint that resulted in the opening of this case questioned the use of the nutrients docosahexenoic acid (DHA) and arachidonic acid (ARA) in an organic (redacted). The resulting investigation led to questions concerning the use of the nutrients, nucleotides and taurine. FDA permits the use of all four in (redacted). Accordingly, provided the nutrients in question are in full compliance with FDA rules and regulations, they would comply with the NOP National List as currently written." (underline added)*

The 2006 notice established a basis for including amino acids (sometimes referred to as "accessory nutrients" in human food) under the materials allowed to be included in certified organic food under §205.605(b) "*Nutrient vitamins and minerals, in accordance with 21 CFR 104.20, Nutritional Quality Guidelines For Foods*."Certifiers relied upon this guidance as approval for allowing the use of required nutrients in pet food products certified as "organic" and "made with organic."

In early 2010, the USDA National Organic Program issued a memorandum to certifiers specifying that 21 CFR 104.20 covered only vitamins and minerals, and thus could not be utilized as justification for including amino acids and other nutrients in certified organic food products. The NOP has subsequently issued a directive outlining a transition period for enforcement of the new interpretation.

In addition, the NOSB in November 2008 unanimously adopted a recommendation regarding changes in the organic regulations to support labeling of organic pet food. The NOP is currently developing proposed regulations based upon the 2008 NOSB recommendation. As recommended by the NOSB, §205.603 would be amended to include the synthetic substances allowed for use in organic pet food. §205.603 already includes allowances for the inclusion of vitamins and trace minerals in certified organic livestock production.

7. Information regarding EPA, FDA, and State regulatory authority registrations, including registration numbers

U.S. Environmental Protection Agency (EPA)

The U.S. Environmental Protection Agency does not regulate amino acids, so these materials are not listed on the EPA List 4 list of inert pesticide ingredients.

U.S. Food and Drug Administration (FDA)

The federal regulations, enforced by the United States Food and Drug Administration (FDA), establish standards applicable for all animal feeds: proper identification of product, net quantity statement, manufacturer's name and address, and proper listing of ingredients. (FDA, 2010)

The regulatory role of the U.S. Food and Drug Administration in the area of required amino acids was addressed in a June 27, 2011 letter from FDA's Center for Veterinary Medicine to the Standards Division of the USDA National Organic Program.

In that letter, CVM states: "The Center for Veterinary Medicine (CVM) is the Center within FDA that has regulatory authority over animal feeds and the ingredients used to formulate animal feed products. For animal feeds, including foods for dogs and cats, the CVM has not established or promulgated any minimum requirements (MR), adequate intakes (AI), recommended allowances (RA) or other reference standards for daily nutrient intakes for any particular nutrient. The CVM relies on the various *ad hoc* expert nutrition committees under the Committee on Animal Nutrition of the National Research Council in the National Academy of Sciences for establishment of which nutrients, and in what amounts, are essential in the diets for specific species of domestic animals to meet that species' daily nutrient requirements. For dogs and cats, the required essential nutrients are listed and described in the 2006 edition *of Nutrient Requirements of Dogs and Cats.*[1] The CVM considers the nutrients listed in Tables 15-3,15-5, 15-8, for dogs, and Tables 15-10, 15-12, 15-14 for cats, to be essential nutrients and eligible for supplementation if required to meet and provide the listed MR, or in the absence of a stated value for the MR then the listed value for AI for that nutrient, in products represented to be "complete and balanced."

State Regulatory Authority

Most states also enforce their own labeling regulations under their state feed laws. States commonly adopt model pet food regulations established by the Association of American Feed Control Officials (AAFCO). These regulations are more specific in nature, covering aspects of labeling such as the product name, the guaranteed analysis, the nutritional adequacy statement, feeding directions, and calorie statements. (FDA, 2010). Within the pet food industry, the Dog and Cat Food Nutrient Profiles listed in the Official Publication of AAFCO is widely recognized as the definitive source of information regarding nutritional adequacy in pet food products.

As explained in the FDA CVM June 27, 2011 letter, however, the FDA relies upon the Committee on Animal Nutrition of the National Research Council as the definitive source of information regarding the nutritional requirements of dogs and cats:

> "The AAFCO Dog and Cat Food Nutrient Profiles do not contain any nutrient that has not been determined to be essential and listed in the previously referenced tables in the 2006 edition of *Nutrient Requirements of Dogs and Cats.* The 2006 edition *of Nutrient Requirements of Dogs and Cats* contains some additional specific fatty acids as essential required nutrients for specific life stages of dogs and cats that are not currently listed in the AAFCO Dog and Cat Food Nutrient Profiles. The AAFCO Dog and Cat Food Nutrient Profiles are presently under consideration for revision, but what the specific revisions will be cannot be stated at this time. As previously indicated, FDA CVM relies on the Committee on Animal Nutrition of the National Research Council in the National Academy of Sciences for establishment of which nutrients are essential in the diets of animals, not the AAFCO Dog and Cat Food Nutrient Profiles."

The required amino acids are recognized as GRAS under the following sections of 21 CFR

- Arginine §582.5145
- Methionine §582.5475
- Cysteine §582.5271
- Lysine §582.5411
- Taurine §573.980
- Tryptophan §582.5915
- Threonine §582.5881
- Histidine §582.5361
- Isoleucine §582.5381
- Leucine §582.5406
- Phenylalanine §582.5590
- Tyrosine §582.5920
- Valine §582.5925

All amino acids referenced in 21 CFR §582, except Methionine and Cysteine, are declared GRAS for both the L- and DL- form. For methionine, §582.5475 makes no reference to L- or DL form. Cysteine is declared GRAS for L- form only

U.S. Department of Agriculture (USDA)

Amino acids in animal feed are not specifically regulated by the U.S. Department of Agriculture.

Clean Air Act

These required amino acids to not contain any hazardous air pollutants. These amino acids to not contain any Class 1 Ozone depletors, nor do they contain any Class 2 Ozone depletors.

Clean Water Act

These amino acids are not listed as Hazardous Substances under the CWA, nor is it listed as Priority or Toxic Pollutants under the CWA.

OSHA

These amino acids are not considered highly hazardous by OSHA.

8. The Chemical Abstract Service (CAS) number or other product numbers of the substance and labels of products that contains the petitioned substance

Chemical Abstract Numbers

Common Name	L- CAS No.	DL- CAS No.	Other
Arginine	74-79-3		
Methionine	63-68-3	59-51-8	
Cysteine	52-90-4		
Lysine	56-87-1	70-54-2	
Taurine			107-35-7
Tryptophan	73-22-3	54-12-6	
Threonine	72-19-5	80-68-2	
Histidine	71-00-1	4998-57-6	
Isoleucine	73-32-5	328-39-2	
Leucine	61-90-5	328-39-2	
Phenylalanine	63-91-2	150-30-1	
Tyrosine	60-18-4	556-03-6	
Valine	72-18-4	516-06-3	

Labels of Products

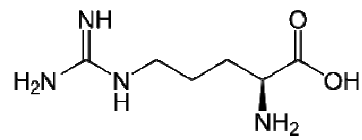
Attachment A contains actual ingredient labels from current conventional and certified “Made with Organic” products in the marketplace.

9. The substance's physical properties and chemical mode of action

Physical Properties

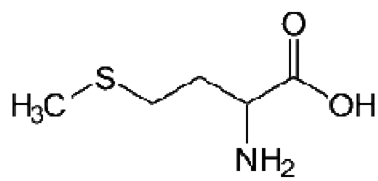
Arginine

Molecular Formula:	$C_6H_{14}N_4O_2$
Molecular Weight:	174.203 g/mol
Cas Number:	L - 74-79-3



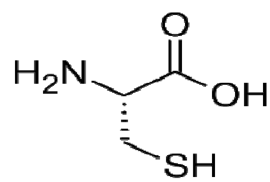
Methionine

Molecular Formula:	$C_5H_{11}NO_2S$
Molecular Weight:	149.214 g/mol
Cas Numbers:	L – 63-68-3
	DL – 59-51-8



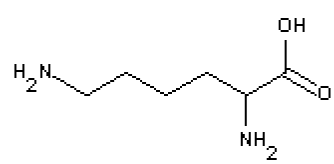
Cysteine

Molecular Formula:	$C_3H_7NO_2S$
Molecular Weight:	121.16 g/mol
Cas Number:	L- 52-90-4



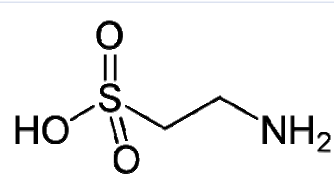
Lysine

Molecular Formula:	$C_6H_{14}N_2O_2$
Molecular Weight:	146.189 g/mol
Cas Numbers:	L- 56-87-1
	DL- 70-54-2



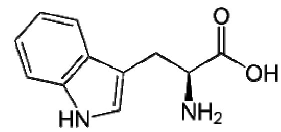
Taurine

Molecular Formula:	$C_2H_7NO_3S$
Molecular Weight:	125.149 g/mol
Cas Number:	107-35-7



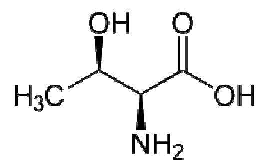
Tryptophan

Molecular Formula:	$C_{11}H_{12}N_2O_2$
Molecular Weight:	204.229 g/mol
Cas Numbers:	L- 73-22-3
	DL- 54-12-6



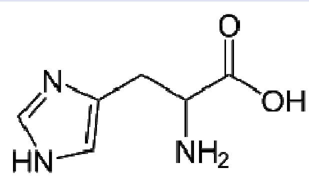
Threonine

Molecular Formula:	$C_4H_9NO_3$
Molecular Weight:	119.12 g/mol
Cas Numbers:	L- 72-19-5
	DL- 80-68-2



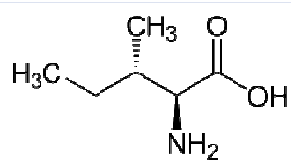
Histidine

Molecular Formula:	$C_6H_9N_3O_2$
Molecular Weight:	155.156 g/mol
Cas Numbers:	L- 71-00-1
	DL- 4998-57-6



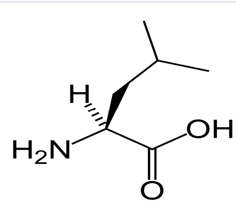
Isoleucine

Molecular Formula:	$C_6H_{13}NO_2$
Molecular Weight:	131.175 g/mol
Cas Numbers:	L- 73-32-5
	DL- 328-39-2

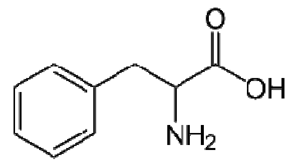


Leucine

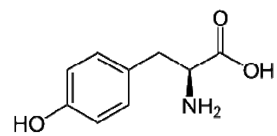
Molecular Formula:	$C_6H_{13}NO_2$
Molecular Weight:	131.175 g/mol
Cas Numbers:	L- 61-90-5
	DL- 328-39-2



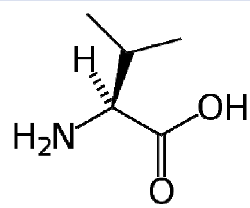
Phenylalanine

Molecular Formula:	$C_9H_{11}NO_2$	
Molecular Weight:	165.192 g/mol	
Cas Numbers:	L- 63-91-2	
	DL- 150-30-1	

Tyrosine

Molecular Formula:	$C_9H_{11}NO_3$	
Molecular Weight:	181.191 g/mol	
Cas Numbers:	L- 60-18-14	
	DL- 556-03-6	

Valine

Molecular Formula:	$C_5H_{11}NO_2$	
Molecular Weight:	117.148 g/mol	
Cas Numbers:	L- 72-18-4	
	DL- 516-06-3	

Characteristics

With the exception of proline, all amino acids present in most proteins are α-amino acids and have α-amino and α-carboxyl groups, both of which are involved in the peptide bonds that are essential for protein structure.

Chemical Mode of Action

Each amino acid has a side chain on the α-carbon that ranges in size from a hydrogen atom to an indole ring. The various side chains contribute to the secondary and tertiary structure of protein, and several are often conjugated to various other groups, such as phosphate and amino sugars. Also of nutritional importance are the acidic and basic side chains in proteins that can accept or donate protons, depending on the pH of the medium in which the protein is present. Acid-precipitated proteins (e.g., casein) have protons added to the car-boxyl group side chains. These protons, together with those on the basic side chains, are released during digestion, absorption, and utilization and contribute to metabolic acido-sis. Amino acids are important in providing building blocks for many important biologically active compounds plus countless peptides and proteins.

Chemical interactions with other substances, especially substances used in organic production

There is no evidence of negative interaction with substances used in organic production.

Toxicity and environmental persistence

In humans, symptoms of amino acid toxicity are damage to kidneys. Consuming large amounts of amino acids, increases the levels of these compounds in the bloodstream. As a result, kidneys must filter high quantities of compounds out of the blood, which can cause kidney strain over time. An amino acid overdose can also have a negative effect on the liver. Amino acid metabolism releases ammonia, a toxic compound. Very high doses of amino acids can lead to a temporary buildup in ammonia in the liver, which can prove harmful.

Here is the specific toxicity information for the required amino acids encompassed in this petition:

Arginine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells.
Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: May affect genetic material. Some Laboratory experiments have resulted in mutagenic effects. Although some dietary studies in animals have demonstrated that arginine deficiency can impair reproductive organ development as well as having adverse effects on gestation and lactation, we did not locate any literature on possible adverse reproductive effects of supplemental arginine during human pregnancy.
Special Remarks on other Toxic Effects on Humans: Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause gastrointestinal tract irritation with nausea, vomiting, and diarrhea. The toxicological properties of this substance have not been fully investigated.

Methionine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in animal.

Cysteine

Toxicity to Animals: Acute oral toxicity (LD50): 660 mg/kg [Mouse].
Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.
Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Not available.

Lysine

Toxicity to Animals: Acute oral toxicity (LD50): 10000 mg/kg [Rat].
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Not available.
Special Remarks on other Toxic Effects on Humans: Acute Potential Health Effects: Skin: May cause skin irritation. Expected to be a low hazard. Eyes: May cause eye irritation.
Expected to be a low hazard. Inhalation: May cause respiratory tract irritation. Expected to be a low hazard Ingestion:
Expected to be a how hazard. Ingestion of large amounts may cause gastric disturbances. It may affect behavior (ataxia), respiration (dyspnea).

Taurine

Toxicity to Animals: Acute oral toxicity (LD50): >5000 mg/kg [Rat].
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data. May affect genetic material (mutagenic)
Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause digestive tract irritation. The toxicological properties of this substance have not been fully investigated. May also affect behavior (somnolence,), metabolism.

Tryptophan

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Hazardous in case of ingestion. Slightly hazardous in case of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Not available.

Threonine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Histidine

Toxicity to Animals: Acute oral toxicity (LD50): 15000 mg/kg [Mouse].
Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.
Other Toxic Effects on Humans: Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Isoleucine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant, permeator), of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Leucine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Extremely hazardous in case of inhalation. Very hazardous in case of ingestion.

Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in animal.

Phenylalanine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Not available.

Tyrosine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).
Special Remarks on Toxicity to Animals: LD50 [Mouse] - Route: Intraperitoneal; Dose: >1450 mg/kg
Special Remarks on Chronic Effects on Humans: May affect genetic material (mutagenic). May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data. No human data has been found.
Special Remarks on other Toxic Effects on Humans: Acute Potential Health Effects: Skin: May cause skin irritation Eyes: May cause eye irritation Inhalation: Dust may cause respiratory tract irritation. Ingestion: May cause digestive tract irritation. Ingestion of large (toxic) amounts may also affect the liver , cause corneal disease, keratitis, tachycardia and hypertension or bradycardia and hypotension. Chronic Potential Health Effects: Ingestion: Prolonged or repeated ingestion may affect the urinary system, blood, and behavior. Skin: Prolonged or repeated contact may cause dermatitis.

Valine

Toxicity to Animals: LD50: Not available. LC50: Not available.
Chronic Effects on Humans: Not available.
Other Toxic Effects on Humans: Hazardous in case of ingestion. Slightly hazardous in case of skin contact (irritant), of inhalation.
Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Environmental impacts from its use or manufacture;

Use:

There is no evidence of negative environmental impact from the use of essential amino acids in pet food. Excess amino acids are excreted from pets—as in other mammals, as a component of nitrogen in urine. In cows, for example, free amino acids comprise 1.3 percent of the nitrogen component in urine. (Bristow, 1992)

Because most pet foods are complete and balanced, there should be minimal impact on the environment.

Arginine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation: Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Methionine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Cysteine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Lysine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Taurine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Tryptophan

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Threonine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Histidine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Isoleucine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Leucine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Phenylalanine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Tyrosine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.
Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Valine

Ecotoxicity: Not available.
BOD5 and COD: Not available.
Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Manufacture

As mentioned in Section 5, amino acids are typically synthesized through one of four processes:
Extraction from natural sources;
Chemical synthesis
Fermentation; and
Enzymatic synthesis.

Effects on human health

As in dogs and cats, amino acids are an important part of the human nutritional intake.

Amino acids are critical to life, and have many functions in metabolism. One particularly important function is to serve as the building blocks of proteins, which are linear chains of amino acids. Amino acids can be linked together in varying sequences to form a vast variety of proteins. Twenty-two amino acids are naturally incorporated into polypeptides and are called proteinogenic or standard amino acids. Of these, 20 are encoded by the universal genetic code. Nine standard amino acids are called "essential" for humans because they cannot be created from other compounds by the human body, and so must be taken in as food.

Amino acids in human food are regulated under 21 CFR §172.

Amino acid toxicity is rare, and protein restriction for patients with renal or liver failure is obsolete because this only aggravated malnutrition. A true example of protein toxicity consists of gastrointestinal hemorrhage that precipitates hepatic encephalopathy in liver insufficiency, most likely because hemoglobin is an unbalanced protein because it lacks the essential amino acid isoleucine. (Soeters, 2004)

Studies have shown that excessive intake of some amino acids may lead to some disturbances. Both the age of the subject, and the adequacy of the diet with respect to protein, caloric intake, vitamins, as well as the relative 0rooportion of amino acids in the diet influence the individual's susceptibility to the amino acid load. (Deshpande, 2002). However, this is not a relevant concern, given that these materials are not intended for human consumption in this petitioned use.

Effects on soil organisms, crops or livestock

Soil Organisms

Amino acids are commonly produced from microorganisms found in natural soil. One gram of natural soil contains about 100 million microorganisms. From these a useful one can be picked out.

Generally, microorganisms produce the 20 kinds of amino acids only in the amounts necessary to themselves. They have a mechanism for regulating the quantities and qualities of enzymes to yield amino acids only in the needed amounts. Therefore, it is necessary to release this regulatory mechanism in order to manufacture the target amino acid in large amounts.

Crops or Livestock

Chains of carbon, with each carbon atom linked to other carbons, form the "backbone" of organic molecules. These carbon chains, with varying amounts of attached oxygen, H, N, P and S, are the basis for both simple sugars and amino acids and more complicated molecules of long carbon chains or rings. Depending on their chemical structure, decomposition is rapid (sugars, starches and proteins), slow (cellulose, fats, waxes and resins) or very slow (lignin). (UN FAO 1998)

Many plants, including important agricultural crops, form symbioses with soil microorganisms that take N2 gas out of the atmosphere and convert it to forms that are useful for growth (called N fixation). In some cases, plants will take up simple amino acids from soil. Organic nitrogen actually exists in many forms in soil, including as free amino acids, and can be bound in large organic molecules that are associated with soil minerals. (Penn State, 2011)

The amino acids contained in this petitions are either required or recommended to adequate livestock nutrition.

10. Safety information about the substance

Material Safety Data Sheets

Attachment A includes Material Safety Data Sheets for all of the petitions amino acids in this category.

Substance Report from the National Institute of Environmental Health Studies

The Food and Drug Administration (FDA) does not require a National Institute of Environmental Health Studies report for taurine. Therefore a NIEHS report has not been developed. The information contained in this petition under Section 9 covers the safety of human health and environment.

11. Research information about the substance which includes comprehensive substance research reviews and research bibliographies, including reviews and bibliographies which present contrasting positions to those presented by the petitioner in supporting the substance's inclusion on or removal from the National List.

The National Research Council's *Nutrient Requirements of Dogs and Cats* (2006) stands as the primary source of scientific information regarding the amino acid requirements for dogs and cats. The 2006 publication was developed by an ad hoc committee convened by the NRC Committee on Animal Nutrition in 2000.

As explained in the preface of the 2006 publication "Throughout the study process, the (ad hoc) committee sought input from various sources. We held public meetings in conjunction with professional meetings and invited experts to speak with us as we completed our task. Over the course of 3 years, the committee held six meetings and four public sessions. We acquired data and information from various public and private organizations. By combining a thorough literature review with critical analysis of scientific data and professional experiences, the committee developed recommendations that are firmly founded in science. (NRC, 2006)"

12. Petition Justification Statement

Overview

The U.S. Department of Agriculture's National Organic Standards recognized from the outset that vitamins, minerals and other required nutrients are essential in formulating certified organic products that will meet the nutritional requirements of humans and animals.

Specifically, §205.603(d)(2) and §205.603(d)(3) allow trace minerals and vitamins to be utilized in livestock for enrichment or fortification when FDA approved. Similarly, §205.605(b) allows food products labeled as "organic" or "made with organic" to contain nutrient vitamins and minerals, in accordance with 21 CFR 104.20, Nutritional Guidelines for Foods. Those nutrients are allowed for use in livestock feed and human food regardless of the method of manufacturing or handling.

Under the current regulations, pet food products seeking certification under the USDA Organic Standards must be produced in accordance with §205.605 and §205.606 of the National Organic Standards. Certain nutrients required by cats and/or dogs are not included in §205.605, §205.606, and are not referenced in 21 CFR 104.20(b). Without the inclusion of those nutrients, however, commercially-produced pet foods cannot be labeled as *Complete and Balanced* under the model regulations developed by the

Association of American Food Control Officials in accordance with the National Research Council's *Nutritive Requirements of Cats and Dogs*.

The specific levels of required and recommended nutrients (including amino acids) are listed in the following tables of the National Research Council's *Nutritive Requirements of Cats and Dogs*.

Table 15-3 Nutrient Requirements for Growth of Puppies after Weaning
Table 15-5 Nutrient Requirements for Adult Dogs for Maintenance
Table 15-8 Nutrient Requirements for Bitches for Late Gestation and Peak Lactation
Table 15-10 Nutrient Requirements for Growth of Kittens after Weaning
Table 15-12 Nutrient Requirements for Adult Cats for Maintenance
Table 15-14 Nutrient Requirements for Queens for Late Gestation and Peak Lactation

The tables referenced above are all included with this petition as Attachment D.

It is important to note that the NRC is recognized as the authoritative source of nutrient information within the international community. For example, The European Pet Food Industry Federation's August 2011 report entitled Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs, contains the following table:

TABLE A_4 – Substantiation of nutrient recommendations for dogs

GENERAL			
1	Amino acids, trace elements, vitamins (Adult dogs)	Unless indicated with an * and substantiated hereafter, the values recommended for adult dogs are the levels recommended by NRC 2006 increased by 20% to compensate for the lower energy requirement of household dogs (see Annex I) compared to the energy intake assumed by NRC.	[a] NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: Nutrient Requirements of Dogs and Cats. The National Academic Press, Washington, DC. 2006: pp. 359-360, table 15-4.

(European Pet Food Industry Federation, 2011)

State regulators utilize the model regulations in the Official Publication of AAFCO as the basis of determining if a commercial pet food product qualifies to be labeled as complete and balanced. The specific levels of required amino acids identified in the Official Publication of AAFCO are listed on Pages 7-9 of this petition.

Other references on this topic include:

Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations, James Morris, Department of Molecular Biosciences, School of Veterinary Medicine, University of California, Davis. Nutrition Research Reviews, 2002, 15 Pages 153-168.

The carnivore connection to nutrition in cats, Debra L. Zoran, DVM, PhD, DACVIM Journal of the American Veterinary Association, Vol. 221, No. 11, December, 1, 2002 http://catinfo.org/docs/zorans_article.pdf

Comparative Nutrition of Cats and Dogs, D H Baker, and G L Czarnecki-Maulden, Annual Review of Nutrition, Vol. 11: 239-263 (Volume publication date July 1991)

Additional studies used in the preparation of this petition are included in Attachment F.

Why the synthetic substance is necessary for the production of an organic product.

Because dogs and cats rely on commercially-prepared foods as their sole source of nutrition, it is vital that those commercial food products contain all of the nutrients required for healthy growth and adult maintenance. Accordingly, the American Association of Feed Control Officials (AAFCO) have developed model regulations, based upon the National Research council's *Nutrient Requirements of Dogs and Cats*, regarding the level of nutrients for a commercially-produced pet food to be labeled as *complete and balanced*. The term *complete and balanced* means that the formula supplies a nutritionally adequate diet when fed according to label instructions.

Deficiency of even one of the essential amino acids can have damaging—and even fatal—effects on the animal. Within the order Carnivora, cats are more sensitive than dogs and ferrets to hyperammonaemia resulting from consumption of an arginine-free diet. Cats are exquisitely sensitive to arginine deficiency, for there is no other example in a mammalian species where consumption of a single meal lacking an essential nutrient can lead to death. (Morris, 2002)

Nonsynthetic substances or alternative cultural methods that could be used in place of the petitioned synthetic substance

Dogs and cats have been domesticated over the past thousands of years, but their digestive tract remains largely unchanged from the time when they acted as predators in the wild. Consequently, their protein (amino acid) requirements remain largely unchanged from the time when the animals consumed diets consisting of freshly-killed animals. This historic diet included more than simply the muscle meat of the prey, and included the hide, fur, bones, --and for dogs--the contents of the stomach.

Consequently a diet consisting exclusively of fresh-killed game (for cats), and a combination of fresh killed game and plant matter (for dogs), could contain the levels of amino acids required for growth and maintenance in dogs and cats. Evidence shows that animals existing in the wild do not have as long of a lifespan as those consuming complete and balanced pet food.

Replicating the nutrient levels contained in a diet of freshly-killed game and foraged plant matter (for dogs) is extremely difficult in a commercially-manufactured food product. For example, the heat required during processing to meet the food safety requirements for commercially manufactured food products also decreases the bioavailability of several endogenous amino acids—particularly taurine (Zoran, 2002). Accordingly, additional incremental amounts of these nutrients must be added to commercially manufactured products.

Further, even though cats do not have the ability to synthesize these amino acids, the amino acids are not conserved. In fact, utilization of taurine, arginine, methionine and cystein is higher in cats than in dogs. (Zoran, 2002)

Not all of the required amino acids will require the use of synthetic materials. As mentioned above, amino acids are derives from many animal and plant sources. The following table ists the dietary sources of the amino acids:

Amino Acid	Dietary Sources - Animal	Dietary Sources - Plant
Arginine	cottage cheese, beef, pork, poultry, wild game, seafood	wheat germ, flour, buckwheat, oatmeal, peanuts, nuts, seeds (pumpkin, sesame, sunflower), chick peas, soybeans
Methionine	eggs, fish, meats	Cereal grains, Seeds (sesame, pumpkin), nuts
Cysteine	Cottage cheese, eggs, pork, poultry (chicken, turkey, duck), yogurt	garlic, broccoli, Brussels sprout, oats, red peppers, wheat germ, sprouted lentils
Lysine	Beef, cheese, eggs, fish, milk, poultry	Amaranth, beans (kidney, Navy) Soybean, lentils,
Taurine	Meat, seafood	
Tryptophan	Beef, eggs, fish, lamb, pork, poultry (chicken, turkey), spirulina,	Bananas, nuts (almond, pistachio, cashew), potatoes, seeds (pumpkin, sesame), soybeans
Threonine	cottage cheese, poultry, fish, meat,	Lentils
Histidine	Cheese, eggs, meat, poultry, pork	Brewer's yeast, rice, rye, wheat
Isoleucine	Cheese, eggs, fish, lamb, poultry (chicken, turkey)	soy protein, seaweed
Leucine	beef, fish, , chicken, eggs,	Almonds, beans, chickpea, corn, oats, peanuts, rice, soybeans,
Phenylalanine	Beef, cheese, fish, poultry, pork, yogurt	Nuts, seeds, soy products
Tyrosine	cheese, cottage cheese, fish, poultry (chicken, turkey), yogurt,	Almonds, lima beans, peanuts, seeds (pumpkin, sesame) soy products,
Valine	cottage cheese, fish, poultry	,Peanuts, sesame seeds, and lentils

(WHO, 2007(, Virginia-Maryland Regional Veterinary College, 2010)

The following required amino acids are generally available through organically-produced dietary sources:

- Histidine
- Isoleucine
- Leucine

- Phenylalanine-tyrosine
- Valine

As noted by the NOSB in its November 2008 recommendation regarding Certified Organic Pet Food, the following amino acids are not generally available from organically produced agricultural products, and must be added in a synthetic format:

- l-arginine
- d-l Methionine
- l-cysteine
- l-lysine
- Taurine
- l-tryptophan
- l-threonine

Because of the specific minimum (and in some cases, maximum) level of these essential nutrients that must be present in a formulated food product to be recognized as complete and balanced, small amounts of the synthetic materials are used to balance the formulations, and to compensate for the loss that occurs through the normal manufacturing process.

Beneficial effects to the environment, human health (pet health), or farm ecosystem from use of the synthetic substance that support the use of it instead of the use of a nonsynthetic substance or alternative cultural methods.

Effect on the Environment

These required amino acids allows for the formulation of pet foods with the correct balance of these amino acids for the diet of cats and dogs. While most attention is dedicated to minimum requirements, excess levels of certain required nutrients can create an imbalance that can be detrimental to the pet, and results in higher levels of amino acids being excreted by the animal. As stated above, excess amino acids are excreted as a component of nitrogen in the urine of these animals. Formulation of pet food products with the appropriate levels of required amino acids will reduce the amount of excess amino acids excreted by the animal.

Effect on Human (and Animal) Health

The essentiality of these amino acids comprises the foundation of this petition for their addition to §205.603 of the National List.

As explained in the NRC, "Dietary protein is required for two reasons. First, protein provides amino acids that dogs and cats cannot synthesize (essential amino acids) but are required for synthesis of the many proteins in the body. Second, protein provides dispen- sable amino acids (amino acids that can be synthesized if appropriate nitrogen and carbon sources are provided) that animals need for maintenance, growth, gestation, and lactation. Dispensable amino acids provide nitrogen and carbon for the synthesis of any needed dispensable amino acid and carbon for gluconeogenesis and/or energy. Dispensable amino acids also provide nitrogen and/or structural components necessary to make other compounds that are essential for life, such as purines, pyrimidines, heme, various hormones, neurotransmitters, and/or neuromodulators (e.g., thyroxine, catecholamines, y-aminobutyric acid, taurine).

"For either dogs or cats that consume primarily animal tissue, amino acids also provide carbon chains for gluconeogenesis to supply glucose to tissues that require it (e.g., red blood cells, nervous tissue) to maintain normal tissue metabolism. As for most other animals, the following 10 amino acids have been shown to be essential for both dogs and cats: arginine (Arg), histidine (His), isoleucine (He), leucine (Leu), lysine (Lys), methionine (Met), phenylalanine (Phe), threonine (Thr), tryptophan (Trp), and valine (Val). In omnivores and certain herbivores (e.g., rats, chicks), removal of a single essential amino acid results in a decrease in food intake that is known to be a primary neuroresponse caused by the lack of the limiting essential amino acid (Gietzen, 1993). In cats, the limited work available (e.g., Hardy et al., 1977; Rogers and Morris, 1979) shows that food intake does not decrease as quickly as in rats after initial consumption of diet devoid of an essential amino acid. Although food intake does decrease with time, the depression is not as severe as in omnivores and herbivores. (NRC, 2006)"

The negative interactions among amino acids have, for the most part, not been studied in humans. (Baker, 2008)

References for Justification Statement

American Association of Feed Control Officials (2011) Official Publication, Oxford, IN

Ajnomoto (2011) Encyclopedia of Amino Acids. http://www.ajinomoto.com/amino/eng/product.html

Baker, David H (2008) Animal Models in Nutrition Research, American Society for Nutrition Journal Vol. 138, pp 391-396.

Briston, Andrew W.; Whitehead, David C.; Cockburn, John E (1992) Nitrogenous constituents in the urine of cattle, sheep and goats. Journal of the Science of Food and Agriculture, Volume 59, Issue 3, pp 387-394.

Deshpande, S.S. (2002) Handbook of Food Toxicology, Mercel Decker, Inc., New York, NY

European Pet Food Industry Federation (2011) Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs, B-1050 Bruxelles. http://www.nutricao.vet.br/pdfs/FEDIAF_Nutritional_Guidelines_-_final_version_6-09-11.pdf

Holisticmed.net (2003) Amino acid Production.
http://www.holisticmed.net/aspartame/aminoacid.pdf

FDA (2010) Pet Food Labels – General, Center for Veterinary Medicine, March

Journal of Chemical Education (2004) Commercial Production of MSG and Other Amino Acids, Cornell College, Mount Vernon, IA

Morris, James (2002) Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations. Department of Molecular Biosciences, School of Veterinary Medicine, University of California, Davis. Nutrition Research Reviews, 15 Pages 153-168.
http://journals.cambridge.org/download.php?file=%2FNRR%2FNRR15_01%2FS0954422402000070a.pdf&code=395e67a2405fe3e7ef0a6e06d5ccf9fa

Morris, James; and Rogers, Quinton (1978) Arginine: An Essential Amino Acid for the Cat, Journal of Nutrition, 108 Pages 1944-1953.
http://jn.nutrition.org/content/108/12/1944.full.pdf

National Research Council (2006) Nutrient Requirements of Dogs and Cats, Animal Nutrition Series, NRC of the National Academes, Washington, D.C.

Paustian, Timothy (2000) Synthesis of Amino Acids. University of Wisconsin, Madison

Penn State (2011) The N Cycle, Crops and Soil Sciences, State College, PA
http://cropsoil.psu.edu/research/kaye-lab/lab-logo

Soeter, Peter; van de Poll, Marcell; van Geemer, Wim; van Gemert, Dejong, Cornelis (2004) Amino Acid Adequacy in Pathophysiological States, *The American Society for Nutritional Sciences* J. Nutr. 134:1575S-1582S, June 2004

UN FAO (1998) Organic matter decomposition and the soil food web
http://www.fao.org/docrep/009/a0100e/a0100e05.htm

UN World Health Organization (2007) Protein and Amino Acid Requirements in Human Health, Joint Report of WHO/FAO/UNU Expert Commission,
http://whqlibdoc.who.int/trs/WHO_TRS_935_eng.pdf

Virginia-Maryland Regional College of Veterinary Medicine (2010) Nutrition for the Adult Cat, http://www.vetmed.vt.edu/vth/sa/clin/cp_handouts/Nutrition_Adult_Cat.pdf

Virginia-Maryland Regional College of Veterinary Medicine (2010) Nutrition for the Adult Dog http://www.vetmed.vt.edu/vth/sa/clin/cp_handouts/Nutrition_Adult_Dog.pdf

Zoran, Debra L., DVM, PhD, DACVIM (2002) The carnivore connection to nutrition in cats. Journal of the American Veterinary Association, Vol. 221, No. 11, December, 1. http://catinfo.org/docs/zorans_article.pdf

13. Commercial Confidential Information Statement

There is no confidential Business Information being submitted with this petition.

Attachment A
Current Ingredient Labels
of Conventional
And Made with Organic Products Containing the
Petitioned Materials

Below are current labels of conventional and certified "Made with Organic" pet food products containing materials included in this petition. The petitioned materials are underlined in these examples:

Current conventional wet cat food label, with taurine, L-lysine and DL-methionine:

Water, Beef, Beef By-Product, Pork By-Products, Pork Liver, Wheat Flour, Corn Starch, Rice Flour, Powdered Cellulose, Chicken Liver Flavor, Soybean Oil, Corn Gluten Meal, Calcium Sulfate, Guar Gum, Locust Bean Gum, Carrageenan, Brewers Dried Yeast, Dicalcium Phosphate, Iron Oxide, Calcium Carbonate, Choline Chloride, <u>DL-Methionine</u>, <u>Taurine</u>, Iodized Salt, <u>L-Lysine</u>, Potassium Chloride, Vitamin E Supplement, Thiamine Mononitrate, Zinc Oxide, Ferrous Sulfate, Niacin, Manganous Oxide, Copper Sulfate, Pyridoxine Hydrochloride, Calcium Pantothenate, Vitamin B12 Supplement, Riboflavin, Biotin, Calcium Iodate, Vitamin D3 Supplement, Folic Acid, Sodium Selenite.

Current conventional dry cat food with taurine and L-arginine:

Chicken By-Product Meal, Corn Gluten Meal, Brewers Rice, Whole Grain Corn, Animal Fat (preserved mixed tocopherols and citric acid), Powdered Cellulose, Chicken Liver Flavor, Lactic Acid, Soybean Oil, Soybean Mill Run, Potassium Chloride, Choline Chloride, Calcium Sulfate, Calcium Carbonate, Iodized Salt, Natural Flavor, DL-Methionine, Vitamin E Supplement, vitamins (L-Ascorbyl-2-Polyphosphate (source of vitamin C), Vitamin E Supplement, Niacin, Thiamine Mononitrate, Vitamin A Supplement, Calcium Pantothenate, Riboflavin, Biotin, Vitamin B12 Supplement, Pyridoxine Hydrochloride, Folic Acid, Vitamin D3 Supplement), Potassium Citrate, <u>Taurine</u>, Fish Oil, minerals (Ferrous Sulfate, Zinc Oxide, Copper Sulfate, Manganous Oxide, Calcium Iodate, Sodium Selenite), preserved with mixed Tocopherols and Citric Acid, <u>L-Arginine</u>, Phosphoric Acid, Beta-Carotene, Rosemary Extract.

Current conventional dry cat food with taurine and DL-methionine:

Chicken Meal, Ground Whole Corn, Corn Gluten Meal, Chicken Fat (Preserved with Mixed Tocopherols), Ground Whole Brown Rice, Ground Whole White Rice, Tomato Pomace (Source of Lycopene), Herring Meal, Avocado, Natural Flavor, Egg Product, Chicory Root, Salt, Whey, Potassium Chloride, Vitamins (Choline Chloride, a-Tocopherol Acetate (Source of Vitamin E), Niacin, Vitamin A Acetate, Thiamine Mononitrate (Source of Vitamin B1), Calcium Pantothenate, Pyridoxine Hydrochloride (Source of Vitamin B6), Menadione Sodium Bisulfate Complex, Riboflavin Supplement, Ascorbic Acid (Source of Vitamin C), Vitamin D3 Supplement, Vitamin B12 Supplement, Folic Acid, Biotin), Minerals (Zinc Sulfate, Zinc Amino Acid Chelate, Iron Amino Acid Chelate, Ferrous Sulfate, Copper Sulfate, Manganese Amino Acid Chelate, Copper Amino Acid Chelate, Manganous Oxide, Sodium Selenite, Calcium Iodate), Avocado Oil, Lecithin, <u>Taurine</u>, Calcium Carbonate, Parsley Flakes, Kelp Meal, <u>DL-Methionine</u>, Yucca Schidigera Extract, Inositol.

Current dry dog food with taurine and L-carnitine:

Venison Meal, Dried Potatoes, Potato Starch, Potato Protein, Pea Protein, Sunflower Oil (preserved with mixed Tocopherols), Chicken Fat (preserved with mixed Tocopherols), Dried Plain Beet Pulp, Natural Flavors, Flaxseed, Potassium Chloride, Salt, Powdered Cellulose, Choline Chloride, Zinc Sulfate, Taurine, Vitamin E Supplement, Ferrous Sulfate, L-Ascorbyl-2-Polyphosphate (source of Vitamin C), Potassium Iodide, Copper Sulfate, L-Carnitine, Niacin Supplement, Calcium Pantothenate, Biotin, Manganous Oxide, Thiamine Mononitrate (Vitamin B1), Selenium, Vitamin A Supplement, Pyridoxine Hydrochloride (Vitamin B6), Riboflavin Supplement (Vitamin B2), Vitamin D3 Supplement, Vitamin B12 Supplement, Folic Acid, Rosemary Extract.

Current certified "Made with Organic" dry cat food with taurine:

Organic Chicken, Chicken Meal, Organic Peas, Organic Brown Rice, Organic Barley, Pea Protein, Organic Chicken Fat (Naturally Preserved with Mixed Tocopherols and Citric Acid), Salmon Meal, Organic Flaxseed, Natural Chicken Flavor, Dried Egg Product, Minerals (Zinc Proteinate, Iron Proteinate, Copper Proteinate, Manganese Proteinate, Calcium Iodate, Sodium Selenite), Calcium Sulfate, Salt, Vitamins (Vitamin E Supplement, Niacin, L-Ascorbyl-2-Polyphosphate, Vitamin A Supplement, Riboflavin, Calcium Pantothenate, Thiamine Mononitrate, Vitamin B12 Supplement, Pyridoxine Hydrochloride, Biotin, Folic Acid, Vitamin D3 Supplement), Choline Chloride, Taurine, Potassium Chloride, Yeast Culture (Saccharomyces cerevisiae), Dried Enterococcus faecium Fermentation Product, Dried Lactobacillus acidophilus Fermentation Product, Dried Aspergillus niger Fermentation Extract, Dried Trichoderma longibrachiatum Fermentation Extract, Dried Bacillus subtilis, Fermentation Solubles, Rosemary Extract

Current Certified "Made With Organic" dog food with L-carnitine:

Organic Chicken, Chicken Meal, Organic Brown Rice, Organic Millet, Organic Peas, Organic Oats, Tomato Pomace, Chicken Fat (Naturally Preserved with Mixed Tocopherols and Citric Acid), Salmon Meal, Natural Chicken Flavor, Organic Flaxseed, Organic Quinoa, Dried Egg Product, Minerals (Zinc Proteinate, Iron Proteinate, Copper Proteinate, Manganese Proteinate, Calcium Iodate, Sodium Selenite), Organic Apples, Organic Carrots, Organic Broccoli, Organic Pumpkin, Organic Pears, Potassium Chloride, Salt, Calcium Carbonate, Choline Chloride, Vitamins (Vitamin E Supplement, L-Ascorbyl-2-Polyphosphate, Vitamin A Supplement, Calcium Pantothenate, Niacin, Riboflavin, Vitamin B12 Supplement, Biotin, Thiamine Mononitrate, Pyridoxine Hydrochloride, Folic Acid, Vitamin D3 Supplement), Chondroitin Sulfate, L-Carnitine, Yeast Culture (Saccharomyces cerevisiae), Dried Enterococcus faecium Fermentation Product, Dried Lactobacillus acidophilus Fermentation Product, Dried Aspergillus niger Fermentation Extract, Dried Trichoderma longibrachiatum Fermentation Extract, Dried Bacillus subtilis, Fermentation Solubles, Rosemary Extract

Current Certified "Made With" gog food with taurine:

Organic Chicken, Organic Brown Rice, Chicken Meal, Organic Oats, Organic Millet, Organic Barley, Organic Grain Sorghum, Organic Peas, Organic Potatoes, Chicken Fat (Naturally stabilized with Mixed Tocopherols), Organic Canola Oil, Organic Flaxseed, Dicalcium Phosphate, Organic Carrots, Calcium Carbonate, Natural Flavor, Salt, Potassium Chloride, Organic Spinach, Organic Cranberries, Organic Tomato Pomace, Choline Chloride, Zinc Proteinate, Ferrous Sulfate, Zinc Sulfate, Vitamin E Supplement, Vitamin B-12 Supplement, Taurine, Manganese Sulfate, Niacin, Riboflavin (Vitamin B-2), Copper Proteinate, Copper Sulfate, Calcium Pantothenate, Vitamin A Acetate, Inositol, Folic Acid, Pyridoxine Hydrochloride (Vitamin B-6), Thiamine Mononitrate (Vitamin B-1), Vitamin D-2 Supplement, Biotin, Potassium Iodate, Cobalt Sulfate, Sodium Selenite, Yucca Schidigera Extract, Organic Parsley, Organic Rosemary, Dried Kelp, Ascorbic Acid (source of Vitamin C).

Attachment B - Material Safety Data Sheets

Arginine

Health	1
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Arginine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Arginine

Catalog Codes: SLA2320, SLA3623, SLA1477

CAS#: 74-79-3

RTECS: CF1934200

TSCA: TSCA 8(b) inventory: L-Arginine

CI#: Not available.

Synonym: 2-Amino-5-guanidinovaleric acid; L-Arginine

Chemical Name: Arginine

Chemical Formula: C6H14N4O2

Contact Information:
Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396
US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**
Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Arginine	74-79-3	100

Toxicological Data on Ingredients: L-Arginine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention if irritation occurs.

p. 1

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO_2), nitrogen oxides (NO, NO_2...).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing.

If you feel unwell, seek medical attention and show the label when possible. Keep away from incompatibles such as oxidizing agents.

Storage:
Light sensitive. Store in light resistant containers. Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 24°C (75.2°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Crystalline powde)

Odor: Not available.

Taste: Not available.

Molecular Weight: 174.2 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: 235°C (455°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in cold water, hot water. Insoluble in diethyl ether. Sparingly soluble in alcohol

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, light

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Light sensitive.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May affect genetic material. Some Laboratory experiments have resulted in mutagenic effects. Although some dietary studies in animals have demonstrated that arginine deficiency can impair reproductive organ development as well as having adverse effects on gestation and lactation, we did not locate any literature on possible adverse reproductive effects of supplemental arginine during human pregnancy.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause gastrointestinal tract irritation with nausea, vomiting, and diarrhea. The toxicological properties of this substance have not been fully investigated.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Arginine

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R40- Possible risks of irreversible effects. S2- Keep out of the reach of children. S36/37- Wear suitable protective clothing and gloves.

HMIS (U.S.A.):

- **Health Hazard:** 1
- **Fire Hazard:** 1
- **Reactivity:** 0
- **Personal Protection:** E

National Fire Protection Association (U.S.A.):

- **Health:** 1
- **Flammability:** 1
- **Reactivity:** 0
- **Specific hazard:**

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/11/2005 11:20 AM

Last Updated: 11/01/2010 12:00 PM

Methionine

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
DL-methionine MSDS

Section 1: Chemical Product and Company Identification

Product Name: DL-methionine

Catalog Codes: SLM4135

CAS#: 59-51-8

RTECS: PD0456000

TSCA: TSCA 8(b) inventory: DL-methionine

CI#: Not available.

Synonym: DL-2-Amino-4-(methylthio)butyric acid

Chemical Formula: C5H11NO2S

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{DL-}methionine	59-51-8	100

Toxicological Data on Ingredients: DL-methionine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:

p. 1

After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing in case of insufficient ventilation, wear suitable respiratory equipment if you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

p. 2

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solid powder.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 149.21 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposes. (281°C or 537.8°F)

Critical Temperature: Not available.

Specific Gravity: 1.34 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol.

Solubility: Soluble in cold water, methanol.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in animal.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: DL-methionine

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 06:06 PM

Last Updated: 11/01/2010 12:00 PM

Cysteine

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Cysteine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Cysteine

Catalog Codes: SLC3907

CAS#: 52-90-4

RTECS: HA1600000

TSCA: TSCA 8(b) inventory: L-Cysteine

CI#: Not available.

Synonym: 2-Amino-3-mercaptopropanoic acid

Chemical Formula: C3H7NO2S

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Cysteine	52-90-4	100

Toxicological Data on Ingredients: L-Cysteine: ORAL (LD50): Acute: 1890 mg/kg [Rat]. 660 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Examine the lips and mouth to ascertain whether the tissues are damaged, a possible indication that the toxic material was ingested; the absence of such signs, however, is not conclusive. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Wear suitable protective clothing in

p. 2

case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 121.16 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Soluble in cold water.

Section 10: Stability and Reactivity Data

p. 3

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 660 mg/kg [Mouse].

Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

p. 4

Federal and State Regulations: TSCA 8(b) inventory: L-Cysteine

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R22- Harmful if swallowed. R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 05:03 PM

Last Updated: 11/01/2010 12:00 PM

Lysine

Material Safety Data Sheet
L-Lysine monohydrochloride MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Lysine monohydrochloride

Catalog Codes: SLL1405, SLL1700, SLL1165, SLL1315

CAS#: 657-27-2

RTECS: OL5600000

TSCA: TSCA 8(b) inventory: L-Lysine monohydrochloride

CI#: Not available.

Synonym: 2,6-Diaminohexanoic acid hydrochloride; L-Lysine Hydrochloride; Lysamine; Lysine hydrochloride; Lysine monohydrochloride; Darvyl

Chemical Name: L-Lysine monohydrochloride

Chemical Formula: C6-H14-N2-O2.HCl

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396
US Sales: 1-800-901-7247
International Sales: 1-281-441-4400
Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
L-Lysine monohydrochloride	657-27-2	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention if irritation occurs.

p. 1

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Slightly explosive in presence of open flames and sparks. Non-explosive in presence of shocks.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: As with most organic solids, fire is possible at elevated temperatures.

Special Remarks on Explosion Hazards:
Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe dust. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

p. 2

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Granular solid or Powdered solid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 182.68 g/mole

Color: White. Off-white.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Not available.

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, incompatible materials, dust generation.

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): [illegible] mg/kg [illegible].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:
[illegible]

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
[illegible]

Toxicity of the Products of Biodegradation: [illegible]

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
[illegible]

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Lysine monohydrochloride

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. S24/25- Avoid contact with skin and eyes.

HMIS (U.S.A.):

- **Health Hazard:** 1
- **Fire Hazard:** 1
- **Reactivity:** 0
- **Personal Protection:** E

National Fire Protection Association (U.S.A.):

- **Health:** 1
- **Flammability:** 1
- **Reactivity:** 0
- **Specific hazard:**

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 06:03 PM

Last Updated: 11/01/2010 12:00 PM

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

p. 6

Taurine

Health	1
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Taurine MSDS

Section 1: Chemical Product and Company Identification

Product Name: Taurine

Catalog Codes: SLT2014

CAS#: 107-35-7

RTECS: WX0175000

TSCA: TSCA 8(b) inventory: Taurine

CI#: Not available.

Synonym: 2-Aminoethanesulfonic acid; 2-Aminoethylsulfonic acid; 2-Sulfoethylamine

Chemical Name: Taurine

Chemical Formula: C2-H7-N-O3-S

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Taurine	107-35-7	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention if irritation occurs.

p. 1

Skin Contact:
Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO_2), nitrogen oxides (NO, NO_2...).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Slightly explosive in presence of open flames and sparks. Non-explosive in presence of shocks.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: As with most organic solids, fire is possible at elevated temperatures

Special Remarks on Explosion Hazards:
Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe dust. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

p. 2

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Crystalline solid. Crystalline powder.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 125.14 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: 300°C (572°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in cold water. Solubility in water: 65 g/l

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, dust generation, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): >5000 mg/kg [Rat].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data. May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause digestive tract irritation. The toxicological properties of this substance have not been fully investigated. May also affect behavior(somnolence,), metabolism.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Taurine

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. S24/25- Avoid contact with skin and eyes. S26- In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S28- After contact with skin, wash immediately with plenty of water. S36- Wear suitable protective clothing.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 12:00 AM

Last Updated: 11/01/2010 12:00 PM

Tryptophan

Health	1
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Tryptophan MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Tryptophan

Catalog Codes: SLT3700, SLT1684

CAS#: 73-22-3

RTECS: YN6130000

TSCA: TSCA 8(b) inventory: L-Tryptophan

CI#: Not available.

Synonym: Tryptophan; L-alpha-aminoindole-3-propionic acid; (-)-Tryptophan; (S)-alpha-Amino-1H-indole-3-propanoic acid; (S)-alpha-Aminoindole-3-propionic acid; (S)-Tryptophan; 1-beta-3-Indolylalanine; 1H-Indole-3-alanine, (S)-; 1H-Indole-3-propanoic acid, alpha-amino-, (S)-; 2-Amino-3-indolypropanoic acid; 3-Indol-3-ylalanine; Alanine, 3-indol-3-yl; L-Tryptophane; L-alpha-Amino-3-indolepropionic Acid; Indole-3-alanine; Propionic acid, 2-amino-3-indol-3-yl; Tryptophane; L-Tryptofan

Chemical Name: L-Tryptophan

Chemical Formula: C11-H12-N2-O2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Tryptophan	73-22-3	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

p. 1

Section 4: First Aid Measures

Eye Contact:
[illegible]

Skin Contact:
[illegible]

Serious Skin Contact: [illegible]

Inhalation:
[illegible]

Serious Inhalation: [illegible]

Ingestion:
[illegible]

Serious Ingestion: [illegible]

Section 5: Fire and Explosion Data

Flammability of the Product: [illegible]

Auto-Ignition Temperature: [illegible]

Flash Points: [illegible]

Flammable Limits: [illegible]

Products of Combustion: [illegible]

Fire Hazards in Presence of Various Substances:
[illegible]

Explosion Hazards in Presence of Various Substances:
[illegible]

Fire Fighting Media and Instructions:
[illegible]

Special Remarks on Fire Hazards: [illegible]

Special Remarks on Explosion Hazards:
[illegible]

Section 6: Accidental Release Measures

Small Spill:
[illegible]

Large Spill:
[illegible]

Section 7: Handling and Storage

p. 2

Precautions:
Keep away from heat. Keep away from sources of ignition. Do not ingest. Do not breathe dust. Wear suitable protective clothing. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Crystalline solid.)

Odor: Odorless.

Taste: Bitter. (Slight.)

Molecular Weight: 204.23 g/mole

Color: White. White to yellowish.

pH (1% soln/water): 5.5 - 7.0

Boiling Point: Not available.

Melting Point:
Melting Point: 282 deg. C Decomposition temperature: 289°C (552.2°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Soluble in hot water. Partially soluble in cold water. Insoluble in diethyl ether. Slightly soluble in acetic acid. Solubility in water: 8.23 g/l @ 0 deg. C; 11.4 g/l @ 25 deg C; 17.1 g/l @ 50 deg. C; 27.95 g/l @ 75 deg. C; 49.9 g/l @ 100 deg. C. Insoluble in chloroform. Soluble in hot alcohol and solutions of dilute acids, and alkali hydroxides.

p. 3

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Protect from light

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): >16000 mg/kg [Rat].

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects based on animal test data. May cause cancer based on animal test data. May affect genetic material (mutagenic)

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: May cause eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: Causes severe initial nausea. May affect behavior/central nervous system (drowsiness, headache, excitement, somnolence, insomnia, muscle weakness, antanxiety), respiration (acute pulmonary edema), skin (dermatitis). May affect blood and cause L-Tryptophan induced eosinophilia myalgia syndrome. This illness is characterized by musculoskeletal symptoms including myalgias, arthralgias, and paresthesias. The physical findings consist of muscle tenderness, neuropathies, rash, peripheral and periorbital edema, eosinophilia. Chronic Potential Health Effects: Ingestion: Prolonged or repeated ingestion may affect the liver, metabolism (weight loss), blood (changes in red blood cell count, eosinophilia), and respiration (dyspena, chronic pulmonary edema), urinary system.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

p. 4

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Tryptophan

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. S24/25- Avoid contact with skin and eyes.

HMIS (U.S.A.):

- **Health Hazard:** 1
- **Fire Hazard:** 1
- **Reactivity:** 0
- **Personal Protection:** E

National Fire Protection Association (U.S.A.):

- **Health:** 1
- **Flammability:** 1
- **Reactivity:** 0
- **Specific hazard:**

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/11/2005 12:50 PM

Last Updated: 11/01/2010 12:00 PM

Threonine

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Threonine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Threonine

Catalog Codes: SLT1276, SLT1846, SLT3139

CAS#: 72-19-5

RTECS: XO8590000

TSCA: TSCA 8(b) inventory: L-Threonine

CI#: Not available.

Synonym: L-2-Amino-3-hydroxybutyric acid

Chemical Formula: C4H9NO3

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Threonine	72-19-5	100

Toxicological Data on Ingredients: L-Threonine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Potential Chronic Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Avoid contact with eyes Wear suitable protective clothing in case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible.

p. 2

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 119.12 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposes. (256°C or 492.8°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Easily soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Threonine

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36- Irritating to eyes.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

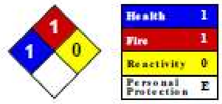
References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:30 PM

Last Updated: 11/01/2010 12:00 PM

Histidine



Material Safety Data Sheet
L-Histidine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Histidine

Catalog Codes: SLH2317, SLH3163, SLH1843

CAS#: 71-00-1

RTECS: MS3070000

TSCA: TSCA 8(b) inventory: L-Histidine

CI#: Not available.

Synonym: (S)-alpha-Amino-1H-imidazole-4-propionic acid

Chemical Formula: C6H9N3O2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Histidine	71-00-1	100

Toxicological Data on Ingredients: L-Histidine: ORAL (LD50): Acute: 15000 mg/kg [Rat]. 15000 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant).

Potential Chronic Health Effects:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact: Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used.

p. 1

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Wear suitable protective clothing in case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label.

p. 2

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Crystalline solid.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 155.16 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposes. (287°C or 548.6°F)

Critical Temperature: Not available.

Specific Gravity: 1.44 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Partially soluble in cold water. Very slighty soluble in methanol. Insoluble in diethyl ether.

Section 10: Stability and Reactivity Data

Federal and State Regulations: TSCA 8(b) inventory: L-Threonine

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36- Irritating to eyes.

HMIS (U.S.A.):

- **Health Hazard:** 2
- **Fire Hazard:** 1
- **Reactivity:** 0
- **Personal Protection:** E

National Fire Protection Association (U.S.A.):

- **Health:** 2
- **Flammability:** 1
- **Reactivity:** 0
- **Specific hazard:**

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:30 PM

Last Updated: 11/01/2010 12:00 PM

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 15000 mg/kg [Mouse].

Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Special Remarks on other Toxic Effects on Humans: Nuisance dust.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Histidine

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC):
This product is not classified according to the EU regulations.

HMIS (U.S.A.):

- **Health Hazard:** 1
- **Fire Hazard:** 1
- **Reactivity:** 0
- **Personal Protection:** E

National Fire Protection Association (U.S.A.):

- **Health:** 1
- **Flammability:** 1
- **Reactivity:** 0
- **Specific hazard:**

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:20 PM

Last Updated: 11/01/2010 12:00 PM

Isoleucine

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Isoleucine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Isoleucine

Catalog Codes: SLI1882, SLI1222, SLI1645

CAS#: 73-32-5

RTECS: NR4705000

TSCA: TSCA 8(b) inventory: L-Isoleucine

CI#: Not available.

Synonym: 2-Amino-3-methylvaleric acid

Chemical Formula: C6H13NO2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Isoleucine	73-32-5	100

Toxicological Data on Ingredients: L-Isoleucine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of inhalation.

Potential Chronic Health Effects:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of inhalation. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO_2), nitrogen oxides (NO, NO_2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing in case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

p. 2

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Powdered solid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 131.17 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposes. (284°C or 543.2°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Partially soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Dermal contact. Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant, permeator), of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Isoleucine

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

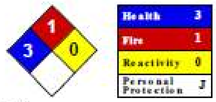
Other Special Considerations: Not available.

Created: 10/10/2005 08:20 PM

Last Updated: 11/01/2010 12:00 PM

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

Leucine



Material Safety Data Sheet
L-Leucine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Leucine

Catalog Codes: SLL1264, SLL1642, SLL1054

CAS#: 61-90-5

RTECS: OH2850000

TSCA: TSCA 8(b) inventory: L-Leucine

CI#: Not available.

Synonym: 2-Amino-4-methylvaleric acid

Chemical Formula: C6H13NO2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Leucine	61-90-5	100

Toxicological Data on Ingredients: L-Leucine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Extremely hazardous in case of eye contact (irritant), of inhalation. Very hazardous in case of ingestion. Inflammation of the eye is characterized by redness, watering, and itching.

Potential Chronic Health Effects:
Extremely hazardous in case of eye contact (irritant), of inhalation. Very hazardous in case of ingestion. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

Skin Contact: No known effect on skin contact, rinse with water for a few minutes.

Serious Skin Contact: Not available.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Avoid contact with eyes In case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible.

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

p. 2

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Splash goggles. Lab coat.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Boots. Gloves. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 131.17 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Sublimes. (144°C or 291.2°F)

Critical Temperature: Not available.

Specific Gravity: 1.293 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Extremely hazardous in case of inhalation. Very hazardous in case of ingestion.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in animal.

Special Remarks on other Toxic Effects on Humans: Nuisance dust.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Leucine

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS D-2B: Material causing other toxic effects (TOXIC).

DSCL (EEC): R41- Risk of serious damage to eyes.

HMIS (U.S.A.):

Health Hazard: 3

Fire Hazard: 1

Reactivity: 0

Personal Protection: j

National Fire Protection Association (U.S.A.):

Health: 3

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Not applicable. Lab coat. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:21 PM

Last Updated: 11/01/2010 12:00 PM

Phenylalanine

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-Phenylalanine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Phenylalanine

Catalog Codes: SLP4771, SLP1942, SLP3751

CAS#: 63-91-2

RTECS: AY7535000

TSCA: TSCA 8(b) inventory: L-Phenylalanine

CI#: Not available.

Synonym: L-alpha-Aminohydrocinnamic acid

Chemical Formula: C9H11NO2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}Phenylalanine	63-91-2	100

Toxicological Data on Ingredients: L-Phenylalanine LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Potential Chronic Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available.
DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

p. 1

[illegible]

Section 5: Fire and Explosion Data

[illegible]

Section 6: Accidental Release Measures

[illegible]

Section 7: Handling and Storage

[illegible]

p. 2

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solid crystalline powder.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 165.19 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposes. (283°C or 541.4°F)

Critical Temperature: Not available.

Specific Gravity: 1.29 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: 0% (w/w).

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, diethyl ether.

Solubility:
Soluble in cold water. Partially soluble in methanol, diethyl ether.

Section 10: Stability and Reactivity Data

p. 3

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

p. 4

Federal and State Regulations: TSCA 8(b) inventory: L-Phenylalanine

Other Regulations: Not available..

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36- Irritating to eyes.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

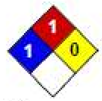
Other Special Considerations: Not available.

Created: 10/10/2005 08:46 PM

Last Updated: 11/01/2010 12:00 PM

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall ScienceLab.com be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if ScienceLab.com has been advised of the possibility of such damages.

Tyrosine



Health	1
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
L-tyrosine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-tyrosine

Catalog Codes: SLT3931, SLT1912, SLT3205

CAS#: 60-18-4

RTECS: YP2275600

TSCA: TSCA 8(b) inventory: L-tyrosine

CI#: Not available.

Synonym: p-Tyrosine; L-Beta-(p-Hydroxyphenyl)alanine; (-)-alpha-Amino-p-hydroxyhydrocinnamic acid; (S)-alpha-Amino-4-hydroxybenzenepropanoic acid; Benzenepropanoic acid, alpha-amino-4-hydroxy-, (S)-; L-Phenylalanine, 4-hydroxy-; Propanoic acid, 2-amino-3-(4-hydroxyphenyl)-, (S)

Chemical Name: L-Tyrosine

Chemical Formula: C9H11NO3

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
{L-}tyrosine	60-18-4	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant).

Potential Chronic Health Effects:
Slightly hazardous in case of skin contact (sensitizer). CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

p. 1

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. WARM water MUST be used. Get medical attention if irritation occurs.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: CLOSED CUP: 176°C (348.8°F).

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO_2), nitrogen oxides (NO, NO_2...).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Slightly explosive in presence of open flames and sparks.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards:
As with most powdered organic solids, fire is possible at elevated temperatures or by contact with an ignition source.

Special Remarks on Explosion Hazards:
Fine dust dispersed in air in sufficient concentrations, and in the presences of an ignition source is a potential dust explosion hazard.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

p. 2

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance:
Solid. (Powdered solid. Crystalline powder. Crystals solid.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 181.19 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Not available.

Melting Point: Decomposition temperature: 344°C (651.2°F)

Critical Temperature: Not available.

Specific Gravity: Density: 1.456 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: The product is more soluble in oil; log(oil/water) = 2.3

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility:
Very slightly soluble in cold water. Insoluble in diethyl ether, acetone. Solubility in water: 0.453 g/l @ 25 C. Insoluble in absolute alcohol. Soluble alkaline solutions. Slightly soluble in acetic acid.

p. 3

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, ignition sources, dust generation, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: LD50 [Mouse] - Route: Intraperitoneal; Dose: >1450 mg/kg

Special Remarks on Chronic Effects on Humans:
May affect genetic material (mutagenic). May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data. No human data has been found.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation Eyes: May cause eye irritation Inhalation: Dust may cause respiratory tract irritation. Ingestion: May cause digestive tract irritation. Ingestion of large (toxic) amounts may also affect the liver , cause corneal disease, keratitis, tachycardia and hypertension or bradycardia and hypotension. Chronic Potential Health Effects: Ingestion: Prolonged or repeated ingestion may affect the urinary system, blood, and behavior. Skin: Prolonged or repeated contact may cause dermatitis.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

p. 4

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-tyrosine

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. S24/25- Avoid contact with skin and eyes. S28- After contact with skin, wash immediately with plenty of water. S37- Wear suitable gloves. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:32 PM

Last Updated: 11/01/2010 12:00 PM

Valine

Health	1
Fire	1
Reactivity	0
Personal Protection	[illegible]

Material Safety Data Sheet
L-Valine MSDS

Section 1: Chemical Product and Company Identification

Product Name: L-Valine

Catalog Codes: SLV1000, SLV1126, SLV1268

CAS#: 72-18-4

RTECS: YV9361000

TSCA: TSCA 8(b) inventory: L-Valine

CI#: Not available.

Synonym: L-alpha-Aminoisovaleric acid

Chemical Formula: C5H11NO2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: 1-800-901-7247
International Sales: 1-281-441-4400

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
L-Valine	72-18-4	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
Slightly hazardous in case of eye contact (irritant), of ingestion, of inhalation. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available.

Section 4: First Aid Measures

Eye Contact: Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used.

Skin Contact: No known effect on skin contact, rinse with water for a few minutes.

Serious Skin Contact: Not available.

p. 1

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...).

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust.

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:

p. 2

Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Boots. Gloves. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solid crystalline powder.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 117.15 g/mole

Color: White.

pH (1% soln/water): Not available.

Boiling Point: Decomposes.

Melting Point: 315°C (599°F)

Critical Temperature: Not available.

Specific Gravity: 1.23 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility:
Partially soluble in cold water. Very slightly soluble in methanol, acetone.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Not available.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Slightly hazardous in case of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Passes through the placental barrier in human.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: L-Valine

Other Regulations: Not available.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 1

Reactivity: 0

Personal Protection: a

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Not applicable. Lab coat. Not applicable. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:32 PM

Last Updated: 11/01/2010 12:00 PM

Attachment C -- June 27, 2011 Memorandum from FDA CVM to USDA NOP

DEPARTMENT OF HEALTH & HUMAN SERVICES

Food and Drug Administration
Rockville MD 20857

June 27, 2011

Ms. Shannon Nally
Standards Division
United States Department of Agriculture
National Organic Program
1400 Independence Avenue SW
Room 2646-S, STOP 0268
Washington, District of Columbia 20250

Dear Ms. Nally:

We are responding to your e-mail request of May 31, 2011 for clarification on how the United States Food and Drug Administration (FDA) determines which nutrients are required in the diets of animals other than man and the acceptability of ingredients used to supplement animal diets in order to meet specific nutrient requirements.

The regulations in Title 21 of the *Code of Federal Regulations* (21 CFR) Parts 500 to 599 [21 CFR 500-599] that pertain to the labeling and formulation of animal feeds, including foods for dogs and cats, do not contain a corresponding or homologous Part to 21 CFR 104, Nutritional Quality Guideline for Foods which applies ONLY to foods for people. Part 104 of 21 CFR sets Daily Reference Values (DRV) or Recommended Daily Intakes (RDI) for 21 nutrients that may be added to certain foods for people under the conditions specified within the regulation.

The Center for Veterinary Medicine (CVM) is the Center within FDA that has regulatory authority over animal feeds and the ingredients used to formulate animal food products. For animal feeds, including foods for dogs and cats, the CVM has not established or promulgated any minimum requirements (MR), adequate intakes (AI), recommended allowances (RA) or other reference standards for daily nutrient intakes for any particular nutrient. The CVM relies on the various *ad hoc* expert nutrition committees under the Committee on Animal Nutrition of the National Research Council in the National Academy of Sciences for establishment of which nutrients, and in what amounts, are essential in the diets for specific species of domestic animals to meet that species' daily nutrient requirements. For dogs and cats, the required essential nutrients are listed and described in the 2006 edition of *Nutrient Requirements of Dogs and Cats*.[1] The CVM considers the nutrients listed in Tables 15-3, 15-5, 15-8, for dogs, and Tables 15-10, 15-12, 15-14 for cats, to be essential nutrients and eligible for supplementation if required to meet and provide the listed MR, or in the absence of a stated value for the MR then the listed value for AI for that nutrient, in products represented to be "complete and balanced."

[1] National Research Council (NRC). 2006. *Nutrient Requirements of Dogs and Cats*. Washington, D.C.: National Academy Press.

FDA regulates the ingredients added to animal foods, one purpose of which can be to supply nutrients to the finished product. Ingredients that FDA finds acceptable for inclusion in animal feeds may be found in several lists, publications and locations. Title 21 CFR Part 573, Food Additives Permitted in Feed and Drinking Water of Animals lists the additives that FDA has formally approved for the indicated intended use contained in the specific regulations. Substances that are generally recognized as safe (GRAS) for an intended use in animal feeds are listed in 21 CFR 582 and 21 CFR 584. The CVM has recently initiated a GRAS Notification Pilot Program similar to the GRAS Notification Pilot Program for ingredients in foods for people administered by the FDA Center for Food Safety and Applied Nutrition. Although at the time of this letter no substances have completed the CVM GRAS Notification process, eventually substances for which CVM has no questions regarding a GRAS determination made by a stakeholder will be indicated at http://www.fda.gov/AnimalVeterinary/Products/AnimalFoodFeeds/GenerallyRecognizedasSafeGRASNotifications/ucm192224.htm. Finally, although not formally approved through the food additive approval process or reviewed under the GRAS Notification Pilot Program, CVM generally allows the use of ingredients defined in Official Names and Definitions of Feed Ingredients in the *Official Publication* (OP) of the Association of American Feed Control Officials (AAFCO) in animal feeds within the specifications or restrictions contained in a particular ingredient's definition. At this time the Official Names and Definitions of Feed Ingredients in the OP of the AAFCO is likely the most comprehensive listing of ingredients acceptable for use in animal feeds.

Many dog and cat foods, possibly even the majority, are formulated to be complete nutrition products, similar in concept and objective to total mixed rations for cattle and complete feeds for swine and poultry. It is generally not possible to attain all required nutrients from a combination of typical food ingredients used to make dog and cat foods without including one or more specific nutrient supplements in the products. This is especially true for one or more required vitamins, minerals, and a few amino acids, and such nutrient supplements are not likely to meet the definition or standard for being organically produced. The National Organic Program (NOP) undoubtedly will have encountered such occurrences in the diets (or rations) required for cattle to produce organic milk and for the production of pork or poultry that can be labeled as organic. A notable required nutrient for cats that will likely not have merited consideration in the diets of other organic feeds is a requirement for the beta-sulfonic amino acid taurine. Because of losses in taurine content during processing and because taurine deficiency manifests as serious, irreversible blindness, heart failure, reproductive, and developmental failure, all complete cat foods are supplemented with synthetic taurine. The food additive regulation for taurine at 21 CFR 573.980 is for use in the feed of growing chickens. However, given the scientific determinations of the need for taurine in the diets of cats and the National Research Council's declaration of taurine as being essential for cats, CVM has not objected to inclusion of taurine in the diets for cats. The feed ingredient definition 6.12 for taurine in the OP of the AAFCO indicates it may be used in the diets for cats and dogs. There may be other nutrient-supplement ingredients specific to dog and cat foods that the NOP Standards Board has not considered before in regards to the formulation of diets for other animal species. Taurine is simply the most obvious example.

Your e-mail mentions the AAFCO Dog and Cat Food Nutrient Profiles. These profiles contain a list of required nutrients and recommended concentrations for those nutrients in dog or cat food products if a manufacturer wants to claim the product is complete and balanced based on the product containing the nutrient concentrations listed in the particular profile. Such claims are enforced by various states through the state's feed laws and regulations if that state has adopted the AAFCO Model Regulations for Pet Food and Specialty Pet Food that are also contained in the OP of the AAFCO. The AAFCO Dog and Cat Food Nutrient Profiles do not contain any nutrient that has not been determined to be essential and listed in the previously referenced tables in the 2006 edition of *Nutrient Requirements of Dogs and Cats*. The 2006 edition of *Nutrient Requirements of Dogs and Cats* contains some additional specific fatty acids as essential required nutrients for specific life stages of dogs and cats that are not currently listed in the AAFCO Dog and Cat Food Nutrient Profiles. The AAFCO Dog and Cat Food Nutrient Profiles are presently under consideration for revision, but what the specific revisions will be cannot be stated at this time. As previously indicated, FDA CVM relies on the Committee on Animal Nutrition of the National Research Council in the National Academy of Sciences for establishment of which nutrients are essential in the diets of animals, not the AAFCO Dog and Cat Food Nutrient Profiles.

In terms of concentrations of nutrients to meet some reference standard for daily nutrient intakes, the values in the AAFCO Dog and Cat Food Nutrient Profiles generally are equivalent to the AI or the RA amounts listed in the 2006 edition of *Nutrient Requirements of Dogs and Cats*. This is to provide a safety factor to ensure that minimum requirements are met should any interference in nutrient availability occur due to interactions between ingredients or from nutrient losses over the product's shelf life. Such formulations above absolute minimum requirements will generally not dictate whether a specific nutrient supplement is needed to be used, as in the case of taurine discussed above. The need for supplementation will exist regardless, only the amount used to meet a given reference standard will vary.

I hope the information in this letter is helpful in clarifying the following points:

1. The nutrients FDA consider essential in dog and cat foods and the source of the designation for essentiality.
2. The various listings for ingredients the FDA considers to be acceptable for use in animal feeds, including ingredients for supplementation of specific nutrients in diets for animals. Please note, such ingredients may not meet the National Organic Program's criteria for being considered acceptable in organic products, but are acceptable for use in animal feeds under FDA's policies and authority.
3. The relationship between the 2006 edition of *Nutrient Requirements of Dogs and Cats* and the AAFCO Dog and Cat Food Nutrient Profiles.

You may contact me by telephone (240-453-6865), telefacsimile (240-453-6882) or email (william.burkholder@fda.hhs.gov) and refer to DAF 11177 if you have any questions concerning the content of this letter.

Sincerely,

William J. Burkholder

William J. Burkholder, DVM, PhD, DACVN
Nutrition and Labeling Team
Division of Animal Feeds
Center for Veterinary Medicine

cc:
Miles McEvoy
Deputy Administrator, National Organic Program
United States Department of Agriculture
Room 2646-S, STOP 0268
1400 Independence Avenue, SW
Washington, DC 20250-0268

Nancy Cook
Pet Food Institute
2025 M Street, Suite 800
Washington, DC 20036

Attachment D - NRC Discussion on Protein and Amino Acids

Protein and Amino Acids

BASIC CONCEPTS

Introduction

Dogs have been used as a model for the study of human nutrition for nearly two centuries. Magendie (1816) was the first to demonstrate that protein was essential for life by showing that olive oil or sugar alone would not support life, but if protein was added, the dogs were in better condition for a much longer period of time. These early experiments and many others were confounded by the lack of knowledge and appreciation of the need for essential micronutrients. Nevertheless, it was clearly understood that protein was essential in the diet. The Magendie Commission was appointed in 1815 to evaluate the nutritive value of gelatin. In 1841, it reported (cited by McCollum, 1957) that dogs could not be maintained when fed gelatin alone. This led to the testing of other purified proteins with the result that no purified protein, when fed alone without other food ingredients, could maintain a dog in good health. Despite the lack of knowledge of the essentiality of micronutrients, over a period of a few decades there came a realization that the quality (amino acid composition) of protein in dog diets was important (Chittenden, 1904). In 1905, Kaufmann reported that dogs maintained nitrogen equilibrium when fed a gelatin-based diet supplemented with tyrosine, cystine, and tryptophan. Later work with rats showed that a similar diet was not nutritionally adequate (Jackson et al., 1928). The concentrations of other essential amino acids were too low to meet the requirement of animals for maintenance. Nevertheless, nutritional research with dogs helped establish that certain amino acids present in protein were essential in the diet. Although Abderhalden and coworkers were able to formulate satisfactory diets for dogs using protein hydrolysates during the early part of the twentieth century, they were never successful in formulating a satisfactory diet using amino acids as the sole nitrogen source (Abderhalden et al., 1912). This feat had to wait until Rose isolated and characterized threonine, the last essential amino acid to be discovered that is required by all animals (McCoy et al., 1935). In 1939, Rose and Rice reported a slight positive nitrogen balance in dogs fed amino acid diets containing the same 10 essential amino acids that are required for the growing rat. They also reported that the removal of arginine had no effect on nitrogen equilibrium, whereas later work (Burns et al., 1981) showed that arginine was an essential amino acid for the adult dog. Since Rose and Rice did not publish the composition of the diet they used, the difference between the two studies remains unexplained.

Cats were not used as early or as routinely in nutrition experiments on the essentiality of protein and amino acids as were dogs. One early experiment using cats that had general application was published by Bidder and Schmidt in 1852 in which they showed, using controlled experimental conditions, that after cats ingested all the meat they could eat during a 7-day period, all of the dietary nitrogen (except 0.7 percent, which was within experimental error) was found in feces and urine and none was released as nitrogen gas. Nevertheless, it was not until the middle of the twentieth century that Da Silva and coworkers (1950a,b) and Allison and coworkers (1956) designed satisfactory purified diets that cats would eat readily, and cats could then be used effectively in nutrition research. Not until 1979 were the same 10 amino acids shown to be essential for cats as for dogs and other animal species (Rogers and Morris, 1979).

Structure and Function

With the exception of proline, all amino acids present in most proteins are α-amino acids and have α-amino and α-carboxyl groups, both of which are involved in the peptide bonds that are essential for protein structure. Each amino acid has a side chain on the α-carbon that ranges in size from a hydrogen atom to an indole ring. The various side chains contribute to the secondary and tertiary structure of protein, and several are often conjugated to various other groups such as phosphate and amino sugars. Also of nutritional importance are the acidic and basic side chains in proteins that can accept or donate protons, depending on the pH of the medium in which the protein is present. Acid-precipitated proteins (e.g., casein) have protons added to the carboxyl group side chains. These protons, together with those on the basic side chains, are released during digestion, absorption, and utilization and contribute to metabolic acidosis. Amino acids are important in providing building blocks for many important biologically active compounds plus countless peptides and proteins. The sensory perception of purified proteins per se is that they are quite bland, whereas peptides and free amino acids have various tastes for humans that range from bitter (e.g., phenylalanine, tryptophan, arginine, leucine), to sour (e.g., glutamic and aspartic acids), sweet (e.g., glycine, threonine), umami (monosodium glutamate), or combinations thereof. The D-amino acids often have a different taste; for example, D-tryptophan is many times sweeter than sucrose. Whether dogs and cats perceive (taste) amino acids in the same way as humans is not known; however selection of amino acids such as leucine by the cat and different neuroresponses by cats and dogs indicate some differences in taste perceptions of different amino acids.

Essentiality of Amino Acids

Dietary protein is required for two reasons. First, protein provides amino acids that dogs and cats cannot synthesize (essential amino acids) but are required for synthesis of the many proteins in the body. Second, protein provides dispensable amino acids (amino acids that can be synthesized if appropriate nitrogen and carbon sources are provided) that animals need for maintenance, growth, gestation, and lactation. Dispensable amino acids provide nitrogen and carbon for the synthesis of any needed dispensable amino acid and carbon for gluconeogenesis and/or energy. Dispensable amino acids also provide nitrogen and/or structural components necessary to make other compounds that are essential for life, such as purines, pyrimidines, heme, various hormones, neurotransmitters, and/or neuromodulators (e.g., thyroxine, catecholamines, γ-aminobutyric acid, taurine). For either dogs or cats that consume primarily animal tissue, amino acids also provide carbon chains for gluconeogenesis to supply glucose to tissues that require it (e.g., red blood cells, nervous tissue) to maintain normal tissue metabolism. As for most other animals, the following 10 amino acids have been shown to be essential for both dogs and cats: arginine (Arg), histidine (His), isoleucine (Ile), leucine (Leu), lysine (Lys), methionine (Met), phenylalanine (Phe), threonine (Thr), tryptophan (Trp), and valine (Val). In omnivores and certain herbivores (e.g., rats, chicks), removal of a single essential amino acid results in a decrease in food intake that is known to be a primary neuroresponse caused by the lack of the limiting essential amino acid (Gietzen, 1993). In cats, the limited work available (e.g., Hardy et al., 1977; Rogers and Morris, 1979) shows that food intake does not decrease as quickly as in rats after initial consumption of a diet devoid of an essential amino acid. Although food intake does decrease with time, the depression is not as severe as in omnivores and herbivores. The depression of food intake appears to be a secondary effect, and the result of a lack of need of energy for growth, since the kittens stop growing and slowly lose weight. Cats may be a good model for strict carnivores since it could be argued teleologically that strict carnivores that eat only animal tissue would never experience an essential amino acid deficiency. Therefore, carnivores do not need to respond in such a sensitive way to a protein or an essential amino acid deficiency as omnivores and herbivores. There is less evidence for dogs. It appears, however, that dogs may respond more like other omnivores (Milner, 1979a,b).

Omnivores and herbivores avoid diets deficient in a single essential amino acid. Rats are able to select between diets that contains less than $0.1 g{\cdot}kg^{-1}$ difference in an essential amino acid (Hrupka et al., 1997). Hrupka et al. (1999) also showed that the learned taste aversion that mediates this choice against a low dietary concentration of a particular essential amino acid occurs before food intake is decreased. That is, the establishment of a learned taste aversion is more sensitive to a deficiency than simply a reduction of food intake. Little work has been done on whether learned aversions occur after feeding various essential amino acid-deficient diets to dogs and cats. Dogs are known to select for an adequate quantity of protein (three to four times their requirement; Romsos and Ferguson, 1983; Torres et al., 2003), whereas cats do not (Cook et al., 1985).

Digestibility and Bioavailability of Protein and Amino Acids

Digestion of dietary protein by animals involves enzymatic cleavage of the protein to amino acids and small peptide residues that are capable of being absorbed by the mucosal cells of the small intestine. Protein digestibility—or more specifically, total digestive tract digestibility—is generally defined in nutritional science as the percentage of ingested protein that is not excreted in the feces as measured by input and output of nitrogen. Bioavailability is generally defined as the degree to which an ingested nutrient in a particular source is absorbed in a form that can be utilized in the animal's metabolism (Lewis and Bayley, 1995). Much detailed work has been done on the bioavailability of amino acids from common proteins in food-animal nutrition (Lewis and Bayley, 1995; Sibbald, 1987) using ileal digestibilities as a measure of bioavailability. Similar studies have been done with dogs (see Johnson et al., 1998; Bednar et al., 2000; Clapper et al., 2001); however, almost nothing is available for cats (Hendriks and Emmens, 1998; Larsen et al., 2001, 2002), perhaps because of the perceived difficulty in keeping ileally cannulated cats (Mawby et al., 1999).

The first approach in determining bioavailability is to measure "apparent digestibility" of protein in a diet. This provides an overall evaluation of nitrogen absorbed but does not provide a measure of the "quality" or efficiency of utilization of nitrogen or of the individual essential amino acids. Historically, in human and animal nutrition, protein quality tests such as protein efficiency ratio (PER), biological value (BV), and net protein utilization (NPU), as determined in rat assays, have been used as one measure of overall amino acid bioavailability. Net protein utilization provides a measure of the efficiency of utilization of a protein. Differences in efficiencies of utilization of the same protein in various species may result from different digestibilities and/or nitrogen and amino acid requirements. Carnivores in general, including cats, have lower apparent digestibilities of poorly digestible proteins (Kendall et al., 1982; Ahlstrom and Skrede, 1998) and higher requirements for some amino acids such as arginine (Anderson et al., 1979a; Costello et al., 1980). Further refinement of the bioavailability values for individual amino acids results from determination of the ileal digestibility of individual essential amino acids. Although these values provide a better indication of bioavailability than total gastrointestinal (GI) tract digestibility, dietary protein could be 100 percent digested and absorbed, but protein and amino acids would still enter the colon because of gastrointestinal secretions (sloughed mucosa and digestive enzymes). Thus, "true" ileal digestibilities have been measured using a number of techniques to estimate endogenous protein excreted from the ileum (Moughan et al., 1998). Since only some of this endogenous protein is essential for protein utilization, even true digestibilities of nitrogen and essential amino acids may not reflect true bioavailabilities. It should be noted that some dietary proteins contain inhibitors of trypsin or other enzymes that can greatly increase the loss of secreted enzymes. Generally, some in vivo measure, such as weight gain and/or nitrogen retention, is considered the ultimate or "gold standard" for determining nitrogen and amino acid bioavailabilities (Lewis and Bayley, 1995).

The apparent total tract digestibility of protein is similar in rats, cats, and dogs for highly digestible proteins. Proteins with lower digestibilities have higher apparent digestibilities in dogs than in cats (Kendall et al., 1982). For proteins with digestibilities greater than 90 percent (e.g., fresh mince and purified diets), there is no difference in digestibility between dogs and cats. For dry or canned dog or cat foods, dogs have a protein digestibility about 5-8 percent higher than do cats (Kendall et al., 1982). This difference in digestibility of protein in processed foods appears to be the result of the shorter length of the small intestine, relative to body size, in cats compared to dogs. Animal proteins generally have a higher digestibility than do plant proteins (Meyer et al., 1981, 1989; Kendall and Holme, 1982; Neirinck et al., 1991), and prolonged heat processing decreases animal protein digestibility by dogs and cats (Meyer et al., 1981; Backus et al., 1998; Johnson et al., 1998). Heat processing increases the digestibility of some proteins because antitryptic activity is destroyed by heat (Morgan et al., 1951). The digestibility of protein varies with size, breed, and age of dogs. Pointers had a higher apparent total tract digestibility of protein than huskies (85 vs. 81 percent), and young miniature poodles or schnauzers had a higher digestibility (about 4 percent higher) than did older ones (Hannah et al., 1995). Insoluble fiber is not reported to affect protein digestibility, whereas soluble fiber often decreases the total tract protein digestibility in both dogs (Muir et al., 1996; Silvio et al., 2000) and cats (Sunvold et al., 1995; Harper, 1996).

Digestibilities of the protein in various ingredients of typical dog food by ileally cannulated dogs have shown that the apparent ileal digestibility of crude protein (CP) is about 1-20 percentage units lower than apparent total tract digestibility. Presumably, bacteria degrade and utilize protein in the colon, with the release and absorption of ammonia and other low-molecular-weight nitrogen-containing compounds (Mühlum et al., 1989; Muir et al. 1996; Murray et al., 1997, 1998; Hendriks and Sritharan, 2002). Ileal crude protein digestibilities ranged from 63 to 96 percent whereas total tract protein digestibilities ranged from 71 to 98 percent. When diets contained a high content of low-digestible carbohydrate, ileal apparent protein digestibility was even more impaired than total tract digestibility (Muhlum et al., 1989). Ileal digestibilities of individual amino acids from normal ingredients in dog foods have been shown to vary tremendously (Johnson et al., 1998). True ileal digestibilities for some amino acids such as arginine varied from 77 to 87 percent, whereas others such as cystine, threonine, and lysine varied from 29 to 66 percent, 52 to 78 percent, and 62 to 84 percent, respectively. The lowest amino acid digestibilities were reported for rendered lamb meal, presumably because of extended heating during the rendering and drying process. For all of the essential amino acids, digestibilities of low-ash meat and bone meal were lower (5-18 percentage units) than those of high-ash meat and bone meal. The same was not true for poultry by-product meals for which no difference was found between high- and low-ash meals. Of particular interest is the very low cystine digestibility (29 percent) found in low-ash lamb meal and the finding that, in general, meat and bone meals had higher digestibilities of all of the essential amino acids than did poultry by-product meals. These results indicate the importance of quality control in processing ingredients (i.e., the need to control the rendering and drying processes to preserve a high digestibility of amino acids, especially cystine, threonine, and lysine). Surprisingly, the digestibility of methionine was not as low in this study, varying only from 83 to 93 percent (Johnson et al., 1998). Fiber content of the diet had little effect on ileal digestibility of crude protein except for soluble dietary fibers such as pectin (Meyer et al., 1989; Muir et al., 1996; Silvio et al, 2000). Addition of 50 g pectin-kg^{-1} diet caused a decrease of about 7 percent in ileal, but only 2 percent in total tract crude protein digestibility (Muir et al., 1996). Good-quality soybean meal (properly heat treated) as an ingredient in dog food has equal or higher ileal and total tract digestibilities than good-quality meat meals (Bednar et al., 2000; Clapper et al., 2001), and the content of various carbohydrates including oligosaccharides in soybean meal had no significant effect on ileal digestibility of soybean protein (Meyer et al., 1989; Zuo et al., 1996). Johnson et al. (1998) compared digestibilities of dog food determined with cecectomized roosters to that with ileally cannulated dogs and found correlation coefficients of 0.89, 0.94, 0.87, and 0.90 for lysine, cystine, threonine, and methionine, respectively. Thus, apparent digestibilities determined by cecectomized roosters may be reasonable approximations for the bioavailabilities of amino acids for dogs.

Larsen et al. (2001, 2002) reported validation of a growth assay to determine bioavailabilities of lysine and methionine in proteins for growing kittens. They showed that weight gain was 25 percent lower when kittens were given a casein diet (moistened, 50 g glucose·kg^{-1} casein, heated at 121°C for 2 hours) than when they were given a diet of non–heat-processed casein. Lysine in the casein before heat treatment had a bioavailability of 96 percent, whereas heat processing with glucose decreased its bioavailability to 56 percent. Since total tract protein digestibilities for the same food are lower in cats than in dogs (Kendall et al., 1982), it is doubtful that the rat or other omnivorous species will be satisfactory as a model for cats (Hendriks and Emmens, 1998).

Assessing Protein and Amino Acid Status

Long-term protein status can be assessed by the maintenance of serum albumin and lean body mass. Examination of concentrations of amino acids in plasma provides a basis for determining which amino acids may be limiting (Zicker and Rogers, 1990) in a particular diet. Acute protein deficiency with adequate intake of energy (e.g., very low protein or protein-free diet) causes a decrease in all amino acids in plasma. In long-term protein deficiency (protein-energy malnutrition), the concentrations of both serum albumin and the essential amino acids (except histidine and phenylalanine) plus tyrosine and cyst(e)ine are much lower than normal, and the dispensable amino acids (especially proline, alanine, serine, and glycine) are higher than normal (Holt et al., 1963). Since changes in concentrations of glycine and valine are most extreme after feeding a very low protein diet, the extent of distortion of the normal glycine:valine ratio has been used as an index of the severity of protein malnutrition. The only known cause of this unique pattern is protein-energy malnutrition. Food deprivation will not produce this pattern but will sustain a more normal amino acid pattern in plasma. If only the glycine:valine ratio is used for a nutritional diagnosis of dogs or cats with kidney disease, a false diagnosis of protein malnutrition may occur. In kidney disease, glycine increases in plasma because the kidney normally converts glycine to serine. However, dogs and cats are often anorexic during renal disease; so, some protein deficiency is not unusual.

Longenecker and Hause (1959) showed that even if dogs were not deficient in protein, the limiting dietary amino acid (and sometimes the second and third limiting) could be determined from the pattern of plasma amino acids. The essential amino acid that decreases the most (or increases the least), as a percentage, after feeding a complete meal containing the protein in question is the one that is most limiting; the one that decreases the next most is second limiting and so forth. This technique requires overnight food deprivation and the ingestion of a large meal. It is important to note that amino acids tend to return to normal if the animal is food deprived. Alternatively, plasma samples from dogs or cats fed a diet ad libitum for several days and taken in the absorptive phase provide the same information. For example, Hardy et al. (1977) reported that plasma valine decreased markedly when valine was limiting in the diet, from more than 300 nmol·mL^{-1} to 66 nmol·mL^{-1} at the requirement and to 33 nmol·mL^{-1} when valine was left completely out of the diet. Reference data generated in this way are useful to determine whether the need for each essential amino acid has been met. Rogers, Morris, and coworkers have determined the dose-response curve of each essential amino acid during amino acid requirement studies. These data—the concentration of each essential amino acid in plasma after feeding normal diets (adequate intake [AI], i.e, at least 1.5 times the minimum requirement [MR]); the concentration after feeding diets devoid of each essential amino acid (AA); the concentration after feeding diets containing each amino acid just at the MR; and for some amino acids, when present at a great excess (upper limit of tolerance or safe upper limit [SUL]) (Table 6-1)—can be used to determine the essential amino acid adequacy of diets for cats at various life stages. Unfortunately, similar complete plasma amino acid data are not available for dogs. Normal plasma amino acid concentrations are available (Strombeck and Rogers, 1978; Delaney et al., 2003), and some information is available for arginine, leucine, lysine, phenylalanine, and tyrosine for dogs (Tables 6-2A and B).

REQUIREMENTS, ALLOWANCES, AND TOLERANCES OF PROTEIN AND AMINO ACIDS

Role of Metabolic Adaptation in Protein and Amino Acid Nutrition

Relevant to both crude protein and essential amino acid requirements in various species is the nature and extent of metabolic adaptation in nitrogen and amino acid metabolism. For example, rats can down-regulate nitrogen catabolic enzymes to such an extent that they maintain nitrogen balance when fed a diet containing 4-5 percent of metabolizable energy (ME) as protein (National Research Council

TABLE 6-1 Plasma Amino Acid Concentrations (nmol·mL^{-1}) of Kittens

Amino Acid	-AA[a]	MR[b]	AI[c]	SUL[d]
Arginine	28	75	100	400
Histidine	9	55	100	>200
Isoleucine	8	30	75	>3,000
Leucine	25	75	125	>1,600
Lysine	45	60	110	>600
Methionine	11	30 (70)[e]	45	400
Phenylalanine	11	25 (75)[f]	65	>900
Tyrosine	10	35	50	310
Threonine	60	80	150	>1,400
Tryptophan	9	25	50	130
Valine	33	66	130	>6,000
Glutamate	50-100	—	50-100	200

[a]Amino acid concentration from kittens fed, in turn, diets lacking each amino acid.
[b]Amino acid concentration from kittens fed, in turn, diets containing each amino acid at the minimum requirement.
[c]Amino acid concentration from kittens fed, in turn, diets containing each amino acid at 150% or more of the requirement (i.e., adequate intake).
[d]Amino acid concentration from kittens fed, in turn, diets containing each amino acid at great excess, at or below the SUL.
[e]70, without any cystine in the diet.
[f]75, without any tyrosine in the diet.
SOURCE: Summarized from Zicker and Rogers (1990) and Taylor et al. (1996, 1998).

1995). Rats can also down-regulate the lysine catabolic pathway such that the lysine requirement for maintenance is only 12 percent that for growth, whereas the lack of specific down-regulation of isoleucine degradative enzymes results in an isoleucine requirement for maintenance 50 percent that for growth. The same detailed information is not available

TABLE 6-2A Plasma Amino Acid Concentrations (nmol·mL^{-1}) of Puppies

Amino Acid	-AA[a]	MR[b]	AI[c]	SUL[d]
Arginine	25	72	135	—
Leucine	18	100	150	—
Lysine	30	85	190	—
Phenylalanine	30[e]	85[e]	60[f]	—
Tyrosine	4[e,g]	12[g]	50[f]	—

[a]Amino acid concentration from puppies fed, in turn, diets lacking each amino acid.
[b]Amino acid concentration from puppies fed, in turn, diets containing each amino acid at the minimum requirement.
[c]Amino acid concentration from puppies fed, in turn, diets containing each amino acid at 150% or more of the requirement (i.e., adequate intake).
[d]Amino acid concentration from puppies fed, in turn, diets containing each amino acid at great excess, at or below the SUL.
[e]Concentration of phenylalanine when tyrosine is not present in the diet.
[f]Concentration of phenylalanine and tyrosine when both are present in the diet.
[g]Concentration of tyrosine when it is not present in the diet.
SOURCE: Summarized from the work of Strombeck and Rogers (1978); Czarnecki and Baker (1984); Milner et al. (1984); Czarnecki et al. (1985); Hirakawa et al. (1986); Delaney et al. (2001).

TABLE 6-2B Plasma Amino Acids Concentrations (nmol·mL^{-1}) from Normal, Small-, and Large-Breed Adult Dogs (n = 131) Fed a Variety of Commercial Diets Known to Be Adequate for Maintenance

Amino Acid	Mean	SEM
Alanine	388	9.6
Arginine	102	2.6
Asparagine	40	1.1
Aspartate	7	0.2
Citrulline	41	1.9
Cysteine	46	1.3
Glutamate	23	1.2
Glutamine	495	9.4
Glycine	268	8.4
Histidine	71	1.6
Hydroxyproline	67	4.1
Isoleucine	51	1.3
Leucine	120	3.2
Lysine	132	5.0
Methionine	57	1.6
Ornithine	35	1.5
Phenylalanine	45	0.9
Proline	246	8.2
Serine	107	2.6
Taurine	77	2.1
Whole blood	266	5.1
Threonine	178	5.0
Tryptophan	60	1.7
Tyrosine	39	1.1
Valine	157	4.1

NOTE: SEM = standard error of the mean.
SOURCE: Delaney et al. (2003).

for dogs or cats; however, it is known that neither is as efficient in down-regulating nitrogen catabolic enzymes as rats (Rogers et al., 1977; Morris et al., 2002). Herbivores and omnivores in general show up- and down-regulation of nitrogen catabolic enzymes and of enzymes involved in the first irreversible step in the catabolism of essential amino acids. For the disposal and conservation of nitrogen, these adaptations particularly involve the up- and down-regulation of all of the urea cycle enzymes (Schimke, 1962), as well as alanine aminotransferase and aspartic aminotransferase (Kaplan and Pitot, 1970). Changes in the flux through the urea cycle occur without a change in the amount of enzymes as a result of the following:

1. **Increasing or decreasing the concentration of substrate.** Increasing or decreasing the concentration of alanine, aspartic acid, ammonia, and glutamic acid will affect the flow of nitrogen from these and other amino acids into urea since most of the catabolic enzymes are working with substrate concentrations considerably below their Michaelis constant (K_m) values.

2. **Changes in the concentration of ornithine in the liver.** As the postabsorptive state approaches and ammonia coming from the amino acids decreases or after feeding a

low-protein diet, ornithine concentration in the liver decreases (as a result of the activity of ornithine δ-aminotransferase) and with very little acceptor available for carbamoyl phosphate, urea synthesis markedly decreases. After ingestion and absorption of arginine (usually in dietary protein) and the action of liver arginase, the liver is provided with sufficient ornithine to maximize urea synthesis for any particular activity of the urea cycle enzymes. If ornithine is limiting in the liver and a nitrogen source free of or low in arginine is given to an animal (Wergedal and Harper, 1964), hyperammonemia occurs. Cats (Morris and Rogers, 1978a,b) are more sensitive to arginine deficiency than dogs (Burns et al., 1981; Czarnecki and Baker, 1984), which, in turn, are more sensitive than rats (Milner et al., 1975; Rogers, 1994).

3. **Allosteric regulation of carbamoyl phosphate synthase.** The first step in the synthesis of urea occurs via activation by *N*-acetylglutamate (NAG). Synthesis of NAG is allosterically regulated by arginine. Thus, although the K_a of NAG synthesis for arginine is five times higher in cats than in rats, the concentration of arginine in liver, as well as the precursors of NAG (glutamate and acetyl coenzyme A), influence hepatic NAG concentrations (Stewart et al., 1981). Both arginine and glutamate increase rapidly in liver after the intake of a high-protein meal, enhancing the ability of the liver to dispose of excess nitrogen. As substrates for urea synthesis decrease, NAG diffuses out of the mitochondria and is cleaved by an acetylase.

4. **Up- and down-regulation of the nitrogen catabolic enzymes.** The final level of control to enable the animal to maintain amino acid homeostasis is the up- and down-regulation of the nitrogen catabolic enzymes. This regulation can occur by changing the rate of degradation of the enzymes or, more generally, by changing the rate of synthesis of the enzymes through increasing the rate of synthesis of mRNA. Up- and down-regulation of the nitrogen catabolic enzymes does not appear to occur to any great extent in the cat (Rogers et al., 1977; Tews et al., 1984) and occurs to a lesser extent in the dog (Morris et al., 2002) than in the rat. The three levels of control mentioned above are all rapid, occurring in seconds, whereas the changes in the amounts of the enzymes take 1-5 days. It appears that the extent to which animals can up- and down-regulate the amounts of the nitrogen catabolic enzymes is what really dictates the ability, on the one hand, to efficiently utilize high-protein diets, and, on the other, to be able to maintain nitrogen balance when fed a low-protein diet. Thus, it has been suggested that the high-protein requirement of adult cats at maintenance is the result of the inability to effectively down-regulate the hepatic nitrogen catabolic enzymes (Rogers et al., 1977). This interpretation has been challenged by Russell et al. (2002) using respiration calorimetry to measure protein oxidation in adult cats; they showed that cats fully oxidized all of the protein after adaptation to a normal (350 $g \cdot kg^{-1}$) and a high (520 $g \cdot kg^{-1}$) crude protein diet. These authors suggest that it is still unknown how the cats adapted to these two levels of protein, whereas Rogers and Morris (2002) contend that the first three levels of control described above, together with an increase in liver size (thereby increasing the total hepatic nitrogen catabolic enzymes), are sufficient to provide for complete oxidation of the relatively high quantities of dietary protein tested. Russell et al. (2002) did not address the inability of the cat to adapt to low-protein diets. Regardless of the interpretation of the results of these two groups, studies of the requirement for maintenance of adult cats show the lack of ability of cats to maintain nitrogen balance at the same minimal dietary concentration as dogs and the inability of dogs (at least long term) to maintain nitrogen balance at the same low concentration as that of rats.

The limited information available on the effect of dietary protein on amino acid metabolism (Primal et al., 1986; Humbert et al., 2002) and the adaptation of enzymes involved in the first step of the degradation of the essential amino acids (as well as important dispensable amino acids such as tyrosine and cystine) indicate some up- and down-regulation of these enzymes in the cat, but not to the same extent as in rats. For enzymes involved in the metabolism of tryptophan (Leklem et al., 1969), histidine (Rogers et al., 1977), methionine (Fau et al., 1987a; Strieker, 1991), threonine (Hammer et al., 1996b), tyrosine (Bai et al., 1998), cysteine (Park et al., 1999), and taurine transport (Park et al., 1989), only about a 20-120 percent increase in activity occurs in cats switched from a low- to a high-protein diet, compared to a severalfold increase of these enzymes in rats. For example, threonine catabolic enzymes increase only about twofold when cats are switched from a low- to a high-protein diet (Hammer et al., 1996b), whereas under similar conditions, better than a tenfold increase occurs in rats (Freedland and Avery, 1964; Harper, 1968). Likewise, diet-induced daily rhythms as a result of eating a normal diet cause only a slight change (about 35 percent) in hepatic tyrosine aminotransferase activity of cats (Bai et al., 1998), whereas in rats a four- to five-fold change occurs (Wurtman and Axelrod, 1967). The consequence of less metabolic adaptation in dogs and cats is that even after adapting to a high-protein diet, plasma amino acid concentrations are higher after a meal (Tews et al., 1984; Torres and Rogers, 2002), whereas in rats after adaptation, plasma amino acids are similar whether they are adapted to a low- or a high-protein diet (Anderson et al., 1968).

Nitrogen (Crude Protein) Minimum Requirements, Recommended Allowances, and Adequate Intakes

Variables Used in Assessing Protein and Amino Acid Requirements

Nitrogen Balance

Nitrogen balance has, for many decades, been the preferred dependent variable for determining nitrogen and amino acid requirements for all life stages. Often, there is no difference in the breakpoints for weight gain or nitrogen retention to determine individual amino acid requirements for growth of many species. Nevertheless, there are situations (and certain requirements) in which for dogs and cats, the breakpoint for nitrogen balance results in a higher requirement than that for weight gain. However, in determination of the nitrogen requirement of cats, a clear plateau does not always occur (Hammer et al., 1996a), but, after the breakpoint, there is still a significant positive slope. Although maximal nitrogen retention has been the standard variable used, when determining the nitrogen requirement, it has been shown that apparent nitrogen balance for maintenance may be sustained while lean body mass is decreasing, apparently because of the low sensitivity and consistent errors in a positive direction for nitrogen retention that do not exist for the usual determinations of lean body mass (Hannah and Laflamme, 1996). In some experiments, only weight gain has been used; in others, both weight gain and nitrogen balance or just nitrogen balance (e.g., for maintenance). In still others, some other metabolic or physiological variable was used. In reviewing the literature on nitrogen and amino acid requirements, the variable that resulted in the highest MR was used.

Growth

The crude protein requirements for growing puppies and kittens have been determined primarily by using weight gain and nitrogen balance as the dependent variable. Mixed-food proteins have been used in practical diets, and purified proteins or free amino acids have been used in purified diets. Many experiments were done before the individual essential amino acid requirements were known for either of these species. There do not appear to be any detrimental effects (except a slightly lower growth rate) of feeding diets at or slightly below the nitrogen requirement, provided all of the essential amino acid requirements are met for all functions known besides growth of muscle tissue and other structural body proteins (e.g., sufficient arginine for optimal urea cycle function, sufficient histidine to prevent cataracts). Under these conditions, if energy intake is restricted along with protein, there may be an increase in longevity in some breeds of dogs due to a delay in onset of chronic diseases (e.g., arthritis and insulin resistance) (Kealy et al., 2002).

Maintenance, Gestation, and Lactation

Satisfactory maintenance can be achieved using a wide variety of dietary crude protein concentrations for adult cats on purified diets and diets using common feed ingredients. Cats, as compared to dogs, rats, and many herbivores or omnivores, do not show effective adaptation to low-protein diets and, thus, excrete considerably more nitrogen when fed a protein-free diet (Hendricks et al., 1997) or when food deprived (Biourge et al., 1994). A comparison of obligatory nitrogen excretion in various species is shown in Table 6-3. It is apparent that the obligatory nitrogen loss in cats is similar whether adult cats were fed a protein-free diet or were food deprived, the loss being nearly twice that of dogs, while the loss in dogs is more than three times that of humans. These data support the fact that cats have a higher nitrogen requirement than these other species. The efficiency of utilization (e.g., NPU; Jansen et al., 1975) of protein for maintenance and growth is also lower in cats than in these other species. This appears to be the result of lack of ability to conserve both nitrogen and essential amino acids even though, on a relative basis, the nitrogen requirement is higher than that for the essential amino acids.

The protein requirements for reproduction of dogs or cats have not been studied extensively and, therefore, have not been well defined. General observations in both species indicate that the crude protein requirement and amino acid requirements for gestation do not exceed those found for maximal nitrogen retention of weanling puppies or kittens, whereas the requirement for maximal lactation is known to exceed that for maximal weight gain of weanling puppies and kittens.

Application of Variables to Assess Requirements

The most common variables found in reviewing the literature for crude protein and amino acid requirements of dogs and cats at various life stages were weight gain for growing animals and nitrogen balance for adult animals. In this section, the variables that result in the maximum requirement are used. Most often, a metabolic variable, such as minimizing urinary orotic acid for the arginine requirement or maximizing blood hemoglobin for the histidine requirement, gave the highest value. Often data on response to variable dietary concentrations were not available, especially for maintenance, gestation, and lactation. Therefore, for each amino acid, an adequate intake (AI) was estimated for the life stage from the quantity of each amino acid in the digestible protein of commercial, dry diets that were known to support normal maintenance, growth, and reproduction. Successful growth and reproduction of dogs and cats fed

TABLE 6-3 Endogenous Urinary Nitrogen Excretion of Animals Fed a Protein-Free Diet

Animal	$mg\ N \cdot kg^{-0.75} \cdot d^{-1}$
Human	62
Marmoset	110
Rat	128
Pig	163
Dog	210
Cat	360

SOURCE: Taken from Hendriks et al. (1997).

such diets over a period of several years are common. When requirement data were not available, these estimated AIs were also used as the recommended allowances.

Growth

Dogs

Estimates of the nitrogen requirement of growing puppies go back many decades. Summaries in the National Research Council (NRC) Nutrient Requirements series for dogs for crude protein, as a percentage of energy, in 1953, 1962, 1972-1974, and 1985 were, respectively, 200, 220, 220, and ~95-115 g·kg^{-1} diet. There is general consistency in the recommended crude protein requirement across the decades except the 1985, which is the sum of the amino acids suggested (including the dispensable amino acids). It becomes apparent from the review by the 1985 NRC committee and from reviewing the literature over the past 20 years that there is a marked decrease in the requirements for both nitrogen and essential amino acids between about 10 and 14 weeks of age for growing puppies; thus, different requirements for weanling puppies before and after 14 weeks of age are suggested. Also, in some instances, weight gain, rather than nitrogen balance, has been used as the variable to determine the requirement. For dogs, generally more dietary crude protein is required for maximal nitrogen retention than for maximal weight gain. For newly weaned small-breed or large-breed puppies, when near maximal weight gains were obtained, the MR appears to be a 180-g CP·kg^{-1} diet containing 4.0 kcal ME·g^{-1} (Milner, 1981; Burns et al., 1982; Nap et al., 1993; Schaeffer et al., 1989; Delaney et al., 2001). These studies used either highly digestible protein or free amino acid diets, and all of the known essential amino acid requirements were met for maximal nitrogen retention. When practical diets from cereals and various animal by-products are used, the crude protein needed for maximal nitrogen retention (AI) appears to be about 250 g·kg^{-1} diet (Ontko et al., 1957; Case and Czarnecki-Maulden, 1990). For puppies over 14 weeks of age, the respective crude protein requirements (MR) for purified highly digestible diets and practical diets (AI) are, respectively, 140 and 200 g·kg^{-1}diet containing 4.0 kcal ME·g^{-1} (Gessert and Phillips, 1956; Burns et al., 1982; Delaney et al., 2001).

Cats

Several estimates have been made of the nitrogen requirement of growing kittens. The earliest estimates, determined without considering the essential amino acid requirements, were about 250-350 g of dietary crude protein per kilogram of diet (Dickinson and Scott, 1956; Miller and Allison, 1958; Greaves, 1965; Jansen et al., 1975). More recent estimates, based on dose-response curves in which protein or amino acid diets were used that contained all of the essential amino acids at least 50 percent above the requirements as listed by the NRC (1986), reported crude protein requirements in the range of 160-240 g·kg^{-1} diet containing 4 kcal ME·g^{-1} (Anderson et al., 1980a; Smalley et al., 1985; Rogers et al., 1987). In a series of papers, Taylor and coworkers (1996, 1997, 1998; Rogers et al., 1998) examined the pattern of amino acids required for maximal weight gain and nitrogen retention by growing kittens, varying both the concentration of crude protein in the diet and the ratio of essential amino acid nitrogen to total amino acid nitrogen (E:T). At or below the essential dietary amino acid requirements, the addition of crude protein (as dispensable amino acids) caused a decrease in weight gain and nitrogen retention that was corrected by additional arginine supplementation. If methionine and arginine were restricted to not more than about twice their requirements, optimal weight gains and nitrogen retention were observed, with all of the nitrogen coming from essential amino acids plus cystine and tyrosine. Kittens, therefore, can grow maximally (see Figure 6-1) with a much broader E:T ratio (Rogers et al., 1998; Taylor et al., 1998) than rats (Stucki and Harper, 1962) or chicks (Stucki and Harper, 1961). This work, using free amino acid diets and diets containing purified proteins (Smalley et al., 1985; Schaffer et al., 1989), indicates the minimum crude protein requirement (MR) for growth (with essential amino acids at about 150 percent of the 1986 NRC requirements) is about 180 g CP·kg^{-1} diet containing 4.0 kcal ME·g^{-1}. The E:T ratio may vary widely at intermediate crude protein concentrations; however, the ratio has to be higher for similar weight gains at both low and high dietary crude protein concentrations (Figure 6-1). The E:T ratio must be high for low dietary crude protein concentrations in

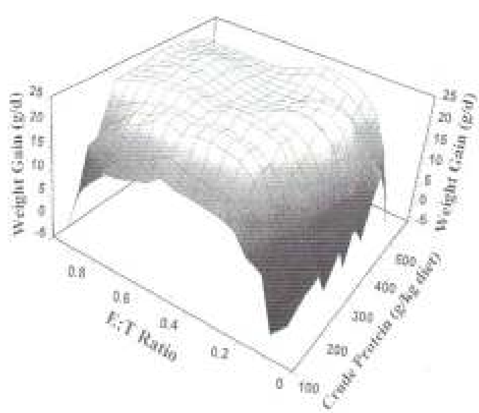


FIGURE 6-1 Effect of dietary crude protein and ratio of essential amino acid nitrogen to total amino acid nitrogen (E:T) on weight gain of kittens. SOURCE: Taken with permission from Rogers et al., 1998.

order to provide all of the necessary essential amino acids (Taylor et al., 1997) and high at very high dietary crude protein concentrations to prevent toxicity of some dispensable amino acids such as glutamate. Glutamate is considerably more toxic when other dispensable amino acids are also high in the diet, presumably because metabolic equilibrium results in higher plasma and tissue glutamate concentrations (Taylor et al., 1998). Thus, for both low and high dietary protein concentrations, body weight gains are higher with high-quality than with low-quality proteins. Protein quality is less important at intermediate protein concentrations in the diet. In evaluating commercial, dry expanded diets that have sustained normal growth for growing kittens, none contained less than 280 g CP·kg^{-1} diet containing 4.0 kcal ME·g^{-1}.

Maintenance

Dogs

Early estimates of the MR for crude protein for adult dogs at maintenance, using nitrogen balance as the criterion, varied from about 35 to 90 g·kg^{-1} diet containing 4.0 kcal ME·g^{-1} for good-quality proteins. These values came from experiments using food proteins without knowledge of the amino acid requirements for either growth or maintenance (Melnick and Cowgill, 1937; Kade et al., 1948; Arnold and Schad, 1954; Wannemacher and McCoy, 1966). Recently, Sanderson et al. (2001) published a study in which beagles maintained body weight (BW) and sustained normal blood chemistries and health (except for one dog that developed dilated cardiomyopathy, which was corrected by taurine supplementation) for 42-48 months with a diet calculated to be 82 g·kg^{-1} diet containing 4.0 kcal ME·g^{-1} as a highly digestible, high-quality protein. Except for the question about meeting the taurine need of the dogs, these results together with earlier work suggest 80 g of crude protein per kilogram of diet containing 4.0 kcal ME·g^{-1} as the MR. Other studies (Wannemacher and McCoy, 1966; Ward, 1976), published and unpublished, support an AI of about 100 g·kg^{-1} diet containing 4 kcal ME·g^{-1} as being adequate, thus suggesting 100 g CP·kg^{-1} diet as the RA. Older dogs appear to require somewhat more crude protein to maintain labile protein (so-called protein reserves), perhaps as much as 50 percent more (Wannemacher and McCoy, 1966). The optimal concentrations for other variables and outcomes (e.g., optimal immune response, wound healing, health in old age) have to be evaluated before more specific recommendations can be made.

Cats

Early estimates of the minimum crude protein requirement (or allowance) (MR) of adult cats for maintenance, using nitrogen balance as the criterion, varied from about 10 to 30 percent of ME. These values came from experiments using food proteins without knowledge of the amino acid requirements for either growth or maintenance (Allison et al., 1956; Miller and Allison, 1958; Greaves and Scott, 1960) or sometimes without considering the digestibility of the dietary proteins. The difficulty in making a purified diet readily acceptable to adult cats, (often very choosy about the texture and taste of their food), has made determining the crude protein and amino acid requirements problematical. Indeed, in one of the most thorough, long-term studies reported, using nitrogen balance as the criterion in which the diet contained the essential amino acids at a dietary concentration at least equivalent to the essential amino acid requirements of the growing kitten, the crude protein requirement was suggested to be 125 g·kg^{-1} diet (100 g·kg^{-1} diet containing 4.0 kcal ME·g^{-1}) (Burger et al., 1984; Burger and Smith, 1987). However, the authors removed some cats from the study because they would not accept the diet, and the cats as a whole lost a small amount of weight. Nitrogen balance is known to underestimate the nitrogen requirement because of incomplete collection of feces and spilled food. In most experiments with most species, there is a plateau at a small positive nitrogen balance. In the work of Burger et al. (1984), when the regression line crossed at 0 nitrogen balance, 7 of 18 cats fed 164 g CP·kg^{-1} diet were in negative nitrogen balance. With all but one cat in positive nitrogen balance, the protein intake was calculated to be about 160 g·kg^{-1} diet containing 4 kcal ME·g^{-1}. This value is taken as the crude protein MR of adult cats for maintenance. It should be pointed out that other outcome variables such as optimizing immune response, labile tissue protein, or environmental stress were not considered in this MR. If a safety allowance is made for such needs, a recommended allowance (RA) of 200 g CP·kg^{-1} diet containing 4 kcal ME·g^{-1} is suggested. In evaluating commercial, dry, expanded diets that have sustained maintenance for months to years, none were found with less than 265 g CP·kg^{-1} diet containing 4.0 kcal ME·g^{-1}.

Gestation and Lactation

Dogs

The protein and amino acid requirements of dogs during reproduction have not been well defined. In general, it has been assumed that, if the dietary crude protein requirement is met for growing puppies, the diet would meet the crude protein requirement of bitches during gestation and lactation. No reports could be found in which the crude protein requirement for gestation or lactation had been determined using dose-response relationships in bitches fed purified diets. From experimental work using natural ingredients (Visek et al., 1976) and evaluating commercial, dry dog foods that have routinely supported normal gestation and lactation, the AI for crude protein for gestation and lactation for the bitch has been shown to be 180-210 g·kg^{-1} diet containing 4 kcal ME·g^{-1}. Meyer et al. (1985) did a factorial calculation based on experimental work on milk yield and milk composition of bitches and recommended 210 g CP·kg^{-1} diet containing 4 kcal ME·g^{-1}, provided the protein quality was good and the diet contained carbohydrates. Based on their experimental work, they also calculated values of 10 g protein·kg BW$^{-0.75}$ for small bitches suckling two puppies, 20 g·kg BW$^{-0.75}$ for medium-sized bitches suckling six puppies, and 25 g·kg BW$^{-0.75}$ for large bitches suckling eight puppies. Romsos et al. (1981) evaluated reproduction with and without dietary carbohydrate using diets containing about 260g·kg^{-1} crude protein (180-210 g digestible crude protein·kg^{-1} at 4 kcal ME· g^{-1}) and showed that this concentration was ample protein for both gestation and lactation if the diet contained carbohydrate, whereas, if the diet contained no carbohydrate, 260 g CP·kg^{-1} diet was insufficient for the latter part of gestation but was sufficient for lactation. Kienzle et al. (1985) showed that, when carbohydrate-free diets were fed to pregnant and lactating bitches, a protein content of 400 g·kg^{-1} diet was sufficient for successful reproduction, but a protein content of only 200 g·kg^{-1} diet led to severe impairment of reproduction including hypoglycemia in the bitches, high losses of puppies, low liver glycogen in the puppies, increased milk fat, decreased milk lactose and water content, and decreased milk yield. From the above results, the AI/RA for highly digestible crude protein for gestation and lactation is set at 200 g·kg^{-1} diet containing 4.0 kcal ME·g^{-1}, provided there is carbohydrate in the diet.

Cats

The protein and amino acid requirements of queens during reproduction have not been well defined. It has been assumed that the dietary crude protein requirement for the growing kitten would meet the crude protein requirement of the queen during gestation and lactation. Factorial calculations by Kienzle (1998) of the protein requirements of queens during peak lactation indicated that 210-290 g·kg^{-1} diet containing 4 kcal ME·g^{-1} was required. Piechota et al. (1995), using purified diets based on soybean protein-casein (supplemented with essential amino acids to bring each one to at least 150 percent of the 1986 NRC requirements for growth), reported the MR to be not greater than 170 g·kg^{-1} diet containing 4 kcal ME·g^{-1} for gestation and about 240 g·kg^{-1} for lactation using kitten weight gain and queen weight loss during lactation as key variables. Thus, the MRs for crude protein for cats during gestation and lactation, respectively, are taken as 170 and 240 g·kg^{-1} diet containing 4.0 kcal ME·g^{-1}. This requirement for lactation is consistent with the lowest level of digestible crude protein found in a number of dry, expanded, commercial diets that have regularly sustained gestation and lactation. From an evaluation of plasma amino acid results, the highest nutritional requirement appeared to be during peak lactation (third to fourth week), before the kitten's intake of the queen's diet was significant. When plasma amino acids were used as the criterion, several essential amino acids appeared to be near limiting, even with commercial diets containing 260 g·kg^{-1} crude protein (4 kcal ME·g^{-1}). Methionine appeared to be the limiting amino acid most often, with the crude protein and amino acid requirements being higher for maximal lactation than for maximal growth of kittens.

Amino Acid Minimum Requirements, Recommended Allowances, Adequate Intakes, and Safe Upper Limits

Satisfactory maintenance and maximal growth and reproduction of dogs and cats can be achieved on a wide variety of concentrations of amino acids in purified diets using either free amino acids, amino acids in purified proteins, or proteins from common feed ingredient incorporated into dry expanded or canned diets; that is, no upper limit is known. The 10 amino acids shown to be essential for growing rats have been shown to be essential for growing dogs and cats. No studies have been reported in which the essential amino acids for other life stages have been deleted from the diet of either dogs or cats, except for the abstract of Rose and Rice (1939), which showed that all of the same amino acids that are essential for adult rats are essential for adult dogs. Later, Burns et al. (1981) reported that arginine was essential in the diet to prevent hyperammonemia and orotic aciduria in the adult dog. Similar to other adult species, it is assumed all of the other amino acids essential for adult rats and humans are essential for adult dogs and cats.

Arginine

Some synthesis of arginine occurs in many mammals and at a sufficient rate to provide all of the arginine needs for a variety of species including humans, ruminants, and adult rats and swine (Rogers, 1994). Metabolically, arginine is glucogenic and has functions other than its role in the synthesis of innumerable proteins. Arginine is an intermediate in the urea cycle, and when absorbed with a meal, it acts both anaplerotically to stimulate urea synthesis and as an allosteric activator of acetylglutamate, which in turn, is an essential allosteric activator of carbamoyl-phosphate synthase, the first enzyme in the detoxification of ammonia and the synthesis of urea. In addition, arginine has been shown to elicit the release of several hormones and metabolic mediators including insulin, glucagon, and gastrin, and it is a precursor of biogenic amines, which are important in cell replication. Arginine is also the precursor of nitric oxide, the neurotransmitter involved in many systems, from its effect on blood pressure via relaxation of blood vessels to its role in macrophages in killing foreign cells (e.g., bacteria and viruses). There have been many studies using arginine as a therapeutic agent, apart from its role in normal nutrition and health. The committee's recommendations are based on the need of dogs and cats to minimize urinary orotic acid.

Attachment E -- NRC Tables for Nutrient Requirements of Dogs and Cats

Table 15-3 Nutrient Requirements for Growth in Puppies after Weaning

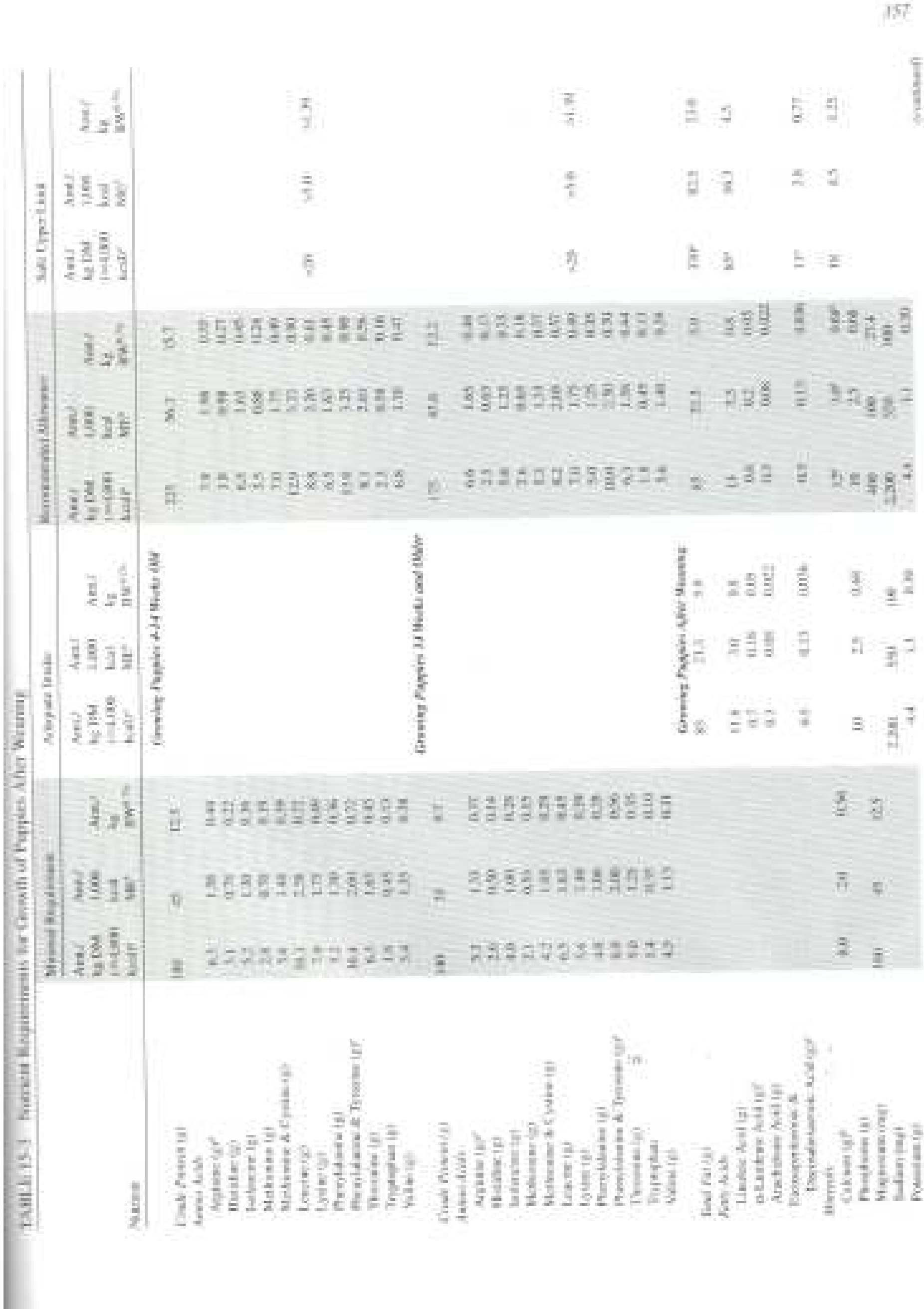


TABLE 15-3 (continued)

Nutrient	Minimal Requirement: Amt./kg DM (≡4,000 kcal)[a]	Minimal Requirement: Amt./1,000 kcal ME[b]	Minimal Requirement: Amt./kg $BW^{0.75c}$	Adequate Intake: Amt./kg DM (≡4,000 kcal)[a]	Adequate Intake: Amt./1,000 kcal ME[b]	Adequate Intake: Amt./kg $BW^{0.75c}$	Recommended Allowance: Amt./kg DM (≡4,000 kcal)[a]	Recommended Allowance: Amt./1,000 kcal ME[b]	Recommended Allowance: Amt./kg $BW^{0.75c}$	Safe Upper Limit: Amt./kg DM (≡4,000 kcal)[a]	Safe Upper Limit: Amt./1,000 kcal ME[b]	Safe Upper Limit: Amt./kg $BW^{0.75c}$
Chloride (mg)				2,900	720	200	2,900	720	200			
Iron (mg)[i]	72	18	5.0				88	22	6.1			
Copper (mg)[i]				11	2.7	0.76	11	2.7	0.76			
Zinc (mg)	40	10	2.7				100	25	6.84			
Manganese (mg)				5.6	1.4	0.38	5.6	1.4	0.38			
Selenium (μg)	210	52.5	13.7				350	87.5	25.1			
Iodine(μg)				880	220	61.0	880	220	61.0			
Vitamins												
Vitamin A (RE)[j]				1,212	303	84	1,515	379	105	15,000[j]	3,750[j]	1,044[j]
Cholecalciferol (μg)[k]				11.0	2.75	0.76	13.8	3.4	0.96	80 ≡	20	5.6
Vitamin E (α-tocopherol) (mg)[l]				24	6.0	1.7	30	7.5	2.1			
Vitamin K												
(Menadione) (mg)[m]				1.3	0.33	0.090	1.64	0.41	0.11			
Thiamin (mg)				1.08	0.27	0.075	1.38	0.34	0.096			
Riboflavin (mg)				4.2	1.05	0.27	5.25	1.32	0.37			
Pyridoxine (mg)				1.2	0.3	0.084	1.5	0.375	0.10			
Niacin (mg)				13.6	3.4	0.94	17.0	4.25	1.18			
Pantothenic Acid (mg)				12	3.0	0.84	15.0	3.75	1.04			
Cobalamin (μg)				28	7	1.95	35	8.75	2.4			
Folic Acid (μg)				216	54	15.0	270	68	18.8			
Biotin[n]												
Choline (mg)				1,360	340	95	1,700	425	118			

[a]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term ≡ signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.

[b]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement for the puppy in kcal (calculated from Table 15-2) and divide by 1,000.

[c]The values for Amt/$BW^{0.75}$ apply only to 5.5-kg puppies of expected mature body weight of 35 kg. To calculate the amount of a nutrient for puppies of different current or expected mature body weights, calculate the energy requirement from Table 15-2 and multiply this by the nutrient Amt/1,000 kcal and divide by 1,000.

[d]For 4 to 14 week-old puppies, 0.01 g arginine should be added for every g of crude protein above 180 g and 225 g, for the MR and RA, respectively, of arginine. For puppies over 14 weeks of age, 0.01 g arginine should be added for every g of crude protein above 140 g and 175 g for the MR and RA of arginine, respectively.

[e]The quantity of tyrosine required to maximize black hair color may be about 1.5-2.0 times this quantity.

[f]The requirement for α-linolenic acid varies depending upon linoleic acid content of the diet. The ratio of linoleic acid to α-linolenic acid should be between 2.6 and 16. Note that 0.8 g/kg DM value shown is the minimum RA of α-linolenic acid at 13 g linoleic acid per kg DM, resulting in a ratio of linoleic acid to α-linolenic acid of approximately 16.

[g]Eicosapentaenoic acid should not exceed 60% of the total amount.

[h]The RA for the calcium requirements of weaned puppies (of expected mature body weight >25 kg) for up to 14 weeks of life should not be less than 0.54 g calcium/kg body weight.

[i]Some oxide forms of iron and copper should not be used because of low bioavailability.

[j]For vitamin A, requirements are expressed as RE (retinol equivalents). One RE is equal to 1 μg of all-*trans* retinol, and one IU of vitamin A is equal to 0.3 RE. Safe upper limit values are expressed as μg retinol.

[k]1 μg cholecalciferol = 40 IU vitamin D_3.

[l]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).

[m]Dogs have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets are fed. Adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.

[n]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Table 15-5 Nutritional Requirements of Adult Dogs for Maintenance

TABLE 15-4 Daily Metabolizable Energy Requirements for Adult Dogs at Maintenance

Type	Kcal × kg $BW^{0.75}$
Average for laboratory kennel dogs or active pet dogs[a]	130
Above average requirements:	
Young adult laboratory dogs or young adult active pet dogs	140
Adult laboratory Great Danes or active pet Great Danes	200
Adult laboratory terriers or active pet terriers	180
Below average requirements:	
Inactive pet dogs[b]	95
Older laboratory dogs or older active pet dogs or laboratory Newfoundlands	105

[a]Dogs kept in a domestic environment with strong stimulus and ample opportunity to exercise, such as dogs in multiple dog households in the country or in a house with a large yard.
[b]Dogs kept in a domestic environment with little stimulus and opportunity to exercise. Requirements of older or overweight dogs may still be overestimated.

TABLE 15-5 Nutrient Requirements of Adult Dogs for Maintenance

	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
Nutrient	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$
Crude Protein (g)	80	20	2.62				100	25	3.28			
Amino Acids												
Arginine (g)[f]	2.8	0.70	0.092				3.5	0.88	0.11			
Histidine (g)	1.5	0.37	0.048				1.9	0.48	0.062			
Isoleucine (g)	3.0	0.75	0.098				3.8	0.95	0.12			
Methionine (g)	2.6	0.65	0.085				3.3	0.83	0.11			
Methionine & Cystine (g)	5.2	1.30	0.17				6.5	1.63	0.21			
Leucine (g)	5.4	1.35	0.18				6.8	1.70	0.22			
Lysine (g)	2.8	0.70	0.092				3.5	0.88	0.11			
Phenylalanine	3.6	0.90	0.12				4.5	1.13	0.15			
Phenylalanine & Tyrosine (g)[f]	5.9	1.48	0.19				7.4	1.85	0.24			
Threonine (g)	3.4	0.85	0.11				4.3	1.08	0.14			
Tryptophan (g)	1.1	0.28	0.036				1.4	0.35	0.046			
Valine (g)	3.9	0.98	0.13				4.9	1.23	0.16			
Total Fat (g)				40	10	1.3	55	13.8	1.8	330[e]	82.5	10.8
Fatty Acids												
Linoleic Acid (g)				9.5	2.4	0.3	11	2.8	0.36	65[e]	16.3	2.1
α-Linolenic Acid (g)[f]				0.36	0.09	0.012	0.44	0.11	0.014			
Arachidonic Acid (g)												
Eicosapentaenoic + Docosahexaenoic Acid (g)[f]				0.44	0.11	0.03	0.44	0.11	0.03	11[e]	2.8	0.37
Minerals												
Calcium (g)	2.0	0.50	0.059				4.0	1.0	0.13			
Phosphorus (g)				3.0	0.75	0.10	3.0	0.75	0.10			
Magnesium (mg)	180	45	5.91				600	150	19.7			

(continued)

TABLE 15-5 (continued)

Nutrient	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$	Amt./ kg DM (=4,000 kcal)[a]	Amt./ 1,000 kcal ME[b]	Amt./ kg $BW^{0.75}$
Sodium (mg)	300	75	9.85				800	200	26.2	>15 g		
Potassium (g)				4.0	1.0	0.14	4.0	1.0	0.14			
Chloride (mg)				1,200	300	40	1,200	300	40	23.5 g		
Iron (mg)[g]				30	7.5	1.0	30	7.5	1.0			
Copper (mg)[g]				6	1.5	0.2	6	1.5	0.2			
Zinc (mg)				60	15	2.0	60	15	2.0			
Manganese (mg)				4.8	1.2	0.16	4.8	1.2	0.16			
Selenium (μg)				350	87.5	11.8	350	87.5	11.8			
Iodine (μg)	700	175	23.6				880	220	29.6	≥ 4 mg		
Vitamins												
Vitamin A (RE)[h]				1,212	303	40	1,515	379	50	64,000[h]	16,000[h]	2,099[h]
Cholecalciferol (μg)[i]				11.0	2.75	0.36	13.8	3.4	0.45	80	20	2.6
Vitamin E (α-tocopherol) (mg)[j]				24	6.0	0.8	30	7.5	1.0			
Vitamin K (Menadione) (mg)[k]				1.3	0.33	0.043	1.63	0.41	0.054			
Thiamin (mg)				1.8	0.45	0.059	2.25	0.56	0.074			
Riboflavin (mg)	4.2	1.05	0.138				5.25	1.3	0.171			
Pyridoxine (mg)				1.2	0.30	0.04	1.5	0.375	0.049			
Niacin (mg)				13.6	3.4	0.45	17.0	4.25	0.57			
Pantothenic Acid (mg)				12	3.0	0.39	15	3.75	0.49			
Cobalamin (μg)				28	7	0.92	35	8.75	1.15			
Folic Acid (μg)				216	54	7.1	270	67.5	8.9			
Biotin[l]												
Choline (mg)				1,360	340	45	1,700	425	56			

[a]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term = signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.

[b]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement for laboratory kennel dogs in kcal (calculated from Table 15-4) and divide by 1,000. For dogs with an unusually low energy intake (below the suggested requirement), the nutrient concentrations (Amt/1,000 kcal) may not be adequate. These animals should be fed the nutrient amounts shown in the column Amt/kg $BW^{0.75}$.

[c]0.01 g arginine should be added for every g of crude protein above 80 g and 100 g for the MR and RA, respectively.

[d]The quantity of tyrosine required to maximize black hair color may be about 1.5-2.0 times this quantity.

[e]The requirement for α-linolenic acid varies depending upon linoleic acid content of the diet. The ratio of linoleic acid to α-linolenic acid should be between 2.6 and 26. Note that 0.44 g/kg DM value shown is the minimum RA of α-linolenic acid at 11 g linoleic acid per kg DM, resulting in a ratio of linoleic acid to α-linolenic acid of approximately 25.

[f]50-60% of the total amount should be eicosapentaenoic acid, and 40-50% should be docosahexaenoic acid.

[g]Some oxides of iron and copper should not be used because of low bioavailability.

[h]Vitamin A requirements expressed as RE (retinol equivalents). One RE is equal to 1 μg of all-*trans* retinol, and one IU of vitamin A is equal to 0.3 RE. Safe upper limit values expressed as μg retinol.

[i]1 μg cholecalciferol = 40 IU vitamin D_3.

[j]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).

[k]Dogs have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets are fed. Adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.

[l]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Table 15-8 Nutrients Requirements of Bitches for Late Gestation and Peak Lactation

TABLE 15-8 Nutrient Requirements of Bitches for Late Gestation and Peak Lactation[a]

Nutrient	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
	Amt./kg DM (=4,000 kcal)[b]	Amt./1,000 kcal ME[c]	Amt./kg $BW^{0.75}$[d]	Amt./kg DM (=4,000 kcal)[b]	Amt./1,000 kcal ME[c]	Amt./kg $BW^{0.75}$[d]	Amt./kg DM (=4,000 kcal)[b]	Amt./1,000 kcal ME[c]	Amt./kg $BW^{0.75}$[d]	Amt./kg DM (=4,000 kcal)[b]	Amt./1,000 kcal ME[c]	Amt./kg $BW^{0.75}$
Crude Protein				200	50	24.6	200	50	24.6			
Amino Acids												
Arginine (g)[e]				10.0	2.50	1.23	10.0	2.50	1.23			
Histidine (g)				4.4	1.10	0.54	4.4	1.10	0.54			
Isoleucine (g)				7.1	1.78	0.87	7.1	1.78	0.87			
Methionine (g)				3.1	0.78	0.38	3.1	0.78	0.38			
Methionine & Cystine (g)				6.2	1.55	0.76	6.2	1.55	0.76			
Leucine (g)				20.0	5.00	2.46	20.0	5.00	2.46			
Lysine (g)				9.0	2.25	1.11	9.0	2.25	1.11			
Phenylalanine (g)				8.3	2.08	1.02	8.3	2.08	1.02			
Phenylalanine & Tyrosine (g)[f]				12.3	3.08	1.51	12.3	3.08	1.51			
Threonine (g)				10.4	2.60	1.28	10.4	2.60	1.28			
Tryptophan (g)				1.2	0.30	0.15	1.2	0.30	0.15			
Valine (g)				13.0	3.25	1.60	13.0	3.25	1.60			
Total Fat (g)				85	21.3	10.5	85	21.3	10.5	330[h]	82.5	40.6
Fatty Acids												
Linoleic Acid (g)				11	2.8	1.4	13	3.3	1.6	65[h]	16.3	8.0
α-Linolenic Acid (g)[g]				0.7	0.18	0.09	0.8	0.2	0.10			
Arachidonic Acid (g)												
Eicosapentaenoic + Docosahexaenoic Acid (g)[h]				0.5	0.13	0.06	0.5	0.13	0.06	11[h]	2.8	1.4
Minerals												
Calcium (g)				8.0	1.9	0.82	8.0	1.9	0.82			
Phosphorus (g)				5.0	1.2	0.58	5.0	1.2	0.58			
Magnesium (mg)				600	150	69	600	150	69			
Sodium (mg)				2,000	500	238	2,000	500	238			
Potassium (g)				3.6	0.9	0.430	3.6	0.9	0.43			
Chloride (mg)				3,000	750	358	3,000	750	358			
Iron (mg)[i]				70	17	8.67	70	17	8.67			
Copper (mg)[j]				12.4	3.1	1.52	12.4	3.1	1.52			
Zinc (mg)				96	24	11.7	96	24	11.7			
Manganese (mg)				7.2	1.8	.87	7.2	1.8	.87			
Selenium (μg)				350	87.5	43	350	87.5	43			

Iodine (µg)		880	220	108	880	220	108			
Vitamins										
Vitamin A (RE)[j]		1,212	303	149	1,515	379	186	15,000[j]	3,750[j]	1,846[j]
Cholecalciferol (µg)[k]		11.0	2.75	1.35	13.8	3.4	1.70	80	20	9.8
Vitamin E (α-tocopherol) (mg)[l]		24	6.0	3.0	30	7.5	3.7			
Vitamin K (Menadione)(mg)[m]		1.3	0.33	0.16	1.6	0.41	0.20			
Thiamin (mg)		1.8	0.45	0.22	2.25	0.56	0.28			
Riboflavin (mg)		4.2	1.05	0.52	5.3	1.3	0.64			
Pyridoxine (mg)		1.2	0.30	0.15	1.5	0.375	0.185			
Niacin (mg)		13.6	3.4	1.67	17	4.25	2.09			
Pantothenic Acid (mg)		12	3.0	1.48	15	3.75	1.84			
Cobalamin (µg)		28	7	3.45	35	8.75	4.3			
Folic Acid (µg)		216	54	26.6	270	67.5	33.2			
Biotin[n]										
Choline (mg)		1,360	340	167	1,700	425	209			

[a]Few data could be found for the dietary concentrations for the minimal requirement for gestation for the bitch. The values for lactation relative to kg DM and 1,000 kcal ME may be taken as satisfactory for gestation.

[b]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term = signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.

[c]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement in kcal (calculated from Tables 15-6 and 15-7) and divide by 1,000.

[d]The values for Amt/BW$^{0.75}$ apply only to a 22-kg bitch in peak lactation with 8 puppies and consuming 5,000 kcal/day. To calculate the amount for bitches of different body weights or litter sizes, calculate the energy requirement from Table 15-7 and multiply this value by the nutrient Amt/1,000 kcal and divide by 1,000. To calculate the amount of a nutrient for gestating dogs, calculate the energy requirement from Table 15-6, and multiply this value by the nutrient Amt/1,000 kcal and divide by 1,000.

[e]0.01 g arginine should be added for every g of crude protein above 200.

[f]The quantity of tyrosine required to maximize black hair color may be about 1.5-2.0 times this quantity.

[g]The requirement for α-linolenic acid varies depending upon linoleic acid content of the diet. The ratio of linoleic acid to α-linolenic acid should be between 2.6 and 16. Note that 0.8 g/kg DM value shown is the minimum RA of α-linolenic acid at 13 g linoleic acid per kg DM, resulting in a ratio of linoleic acid to α-linolenic acid of approximately 16.

[h]50-60% of the total amount should be eicosapentaenoic, acid and 40-50% should be docosahexaenoic acid.

[i]Some oxides of iron and copper should not be used because of low bioavailability.

[j]Vitamin A requirements expressed as RE (retinol equivalents). One RE is equal to 1 µg of all-*trans* retinol, and one IU of vitamin A is equal to 0.3 RE. Safe upper limit values expressed as µg retinol.

[k]1 µg cholecalciferol = 40 IU vitamin D_3.

[l]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).

[m]Dogs have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets are fed. Adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.

[n]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Table 15-10 Nutrient Requirements for Growth of Kittens after Weaning

364

TABLE 15-9 Daily Metabolizable Energy Requirements for Growth of Kittens After Weaning

ME (kcal) = maintenance amount × 6.7 × $[e^{(-0.189p)} - 0.66]$
ME (kcal) = 100 × $BW_a^{0.67}$ × 6.7 × $[e^{(-0.189p)} - 0.66]$
Where:

$p = BW_a/BW_m$
BW_a = actual body weight at time of evaluation (kg)
BW_m = expected mature body weight (kg)
e = base of natural log = 2.718

Example: Kitten, 1 kg BW_a, 4 kg BW_m
ME (kcal) = 100 × $1^{0.67}$ × 6.732 × $[e^{(-0.189 \times 1/4)} - 0.66]$ = 198 kcal

TABLE 15-10 Nutrient Requirements for Growth of Kittens After Weaning

Nutrient	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$
Crude Protein	180	45	9.40				225	56.3	11.8			
Amino Acids												
Arginine (g)[d]	7.7	1.93	0.40				9.6	2.4	0.50	35	8.75	1.83
Histidine (g)	2.6	0.65	0.14				3.3	0.83	0.17	>22	>5.5	>1.15
Isoleucine (g)	4.3	1.08	0.23				5.4	1.4	0.29	>87	>21.7	>4.54
Methionine (g)	3.5	0.88	0.18				4.4	1.1	0.23	13	3.25	0.68
Methionine & Cystine (g)	7.0	1.75	0.37				8.8	2.2	0.46			
Leucine (g)	10.2	2.55	0.53				12.8	3.2	0.67	>87	>21.7	>4.54
Lysine (g)	6.8	1.70	0.35				8.5	2.1	0.44	>58	>14.5	>3.03
Phenylalanine (g)	4.0	1.00	0.21				5.0	1.3	0.27	>29	>7.25	>1.51
Phenylalanine & Tyrosine (g)[e]	15.3	3.83	0.80				19.1	4.8	1.00	68	17	3.55
Threonine (g)	5.2	1.30	0.27				6.5	1.6	0.33	>51	>12.7	>2.66
Tryptophan (g)	1.3	0.33	0.069				1.6	0.40	0.084	17	4.25	0.89
Valine (g)	5.1	1.28	0.27				6.4	1.6	0.33	>87	>21.7	>4.54
Glutamic Acid (g)										75	18.8	3.92
Taurine (g)[f]	0.32	0.080	0.017				0.40	0.10	0.021	>8.9	>2.22	>0.46
Total Fat (g)				90	22.5	4.7	90	22.5	4.7	>330[e]	>82.5	>17.2
Fatty Acids												
Linoleic Acid (g)				5.5	1.4	0.29	5.5	1.4	0.29	55[g]	13.8	2.9
α-Linolenic Acid (g)				0.2	0.05	0.010	0.2	0.05	0.010			
Arachidonic Acid (g)				0.2	0.05	0.010	0.2	0.05	0.001			
Eicosapentaenoic & Docosahexaenoic (g)[h]				0.1	0.025	0.005	0.1	0.025	0.005			
Minerals												
Calcium (g)	5.2	1.3	0.274				8.0	2.0	0.410			
Phosphorus (g)	4.8	1.2	0.251				7.2	1.8	0.372			

Magnesium (mg)	160	40	8.3				400	100	20			
Sodium (mg)	1,240	310	65				1,400	350	74	>10 g		
Potassium (g)	2.68	0.67	0.14				4.0	1.0	0.209			
Chloride (mg)	760	190	42				900	225	46.5			
Iron (mg)[h]	70	17	3.2				80	20	4.2			
Copper (mg)[h]	4.5	1.1	0.23				8.4	2.1	0.44			
Zinc (mg)	50	12.5	2.6				75	18.5	3.9			
Manganese (mg)				4.8	1.2	0.25	4.8	1.2	0.25			
Selenium (μg)	120	30	6.23				300	75	15.8			
Iodine (μg)				1,800	450	93	1,800	450	93			
Vitamins												
Vitamin A (μg retinol)[i]				800	200	42	1,000	250	52	80,000[i]	20,000[i]	4,180[i]
Cholecalciferol (μg)[j]	2.78	0.70	0.14				5.6	1.4	0.29	750	188	39
Vitamin E (α-tocopherol) (mg)[k]				30	7.5	1.6	38	9.4	2.0			
Vitamin K (Menadione) (mg)[l]				1.0	0.25	0.05	1.0	0.25	0.05			
Thiamin (mg)	4.4	1.1	0.23				5.5	1.4	0.29			
Riboflavin (mg)				3.2	0.80	0.17	4.0	1.0	0.21			
Pyridoxine (mg)	2.0	0.5	0.10				2.50	0.625	0.13			
Niacin (mg)				32	8.0	1.7	40	10.0	2.1			
Pantothenic Acid (mg)	4.6	1.15	0.24				5.70	1.43	0.30			
Cobalamin (μg)				18	4.5	0.9	22.5	5.6	1.18			
Folic Acid (μg)	600	150	31				750	188	39			
Biotin (μg)[m]				60	15	3.1	75	18.75	3.9			
Choline (mg)	2,040	510	107				2,550	637	133			

[a]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term = signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.

[b]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement in kcal for kittens (calculated from Table 15-9) and divide by 1,000.

[c]The values for Amt/$BW^{0.67}$ apply only to 800 g kittens with an expected mature body weight of 4 kg. To calculate the amounts for kittens of different actual or expected mature body weights, calculate the energy requirement from Table 15-9 and multiply this by the nutrient Amt/1,000 kcal and divide by 1,000.

[d]0.02 g arginine should be added for every g of crude protein above 180 g and 225 g for the MR and RA, respectively.

[e]To maximize black hair color, an equal quantity or greater of tyrosine to that of phenylalanine is required.

[f]The recommended allowance of taurine for highly digestible purified diets is 0.4 g/kg diet, whereas the allowances for dry expanded and canned diets are 1.0 g and 1.7 g/kg DM, respectively.

[g]It is advised that eicosapentaenoic acid not exceed 60% of the total eicosapentaenoic + docosahexaenoic amount.

[h]Some forms of iron and copper should not be used because of low bioavailability.

[i]One IU of vitamin A is equal to 0.3 μg of all-*trans* retinol or 1 μg retinol = 3.333 IU of vitamin A. Safe upper limit values expressed as μg retinol.

[j]1 μg cholecalciferol = 40 IU vitamin D_3.

[k]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).

[l]Cats have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets (except fish-based diets) are fed. Under most conditions, adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.

[m]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Table 15-12 Nutrient Requirements of Adult Cats for Maintenance

TABLE 15-11 Daily Metabolizable Energy Requirements for Adult Cats at Maintenance[a]

Type	Metabolizable Energy Requirement
Domestic cats, lean[b]	100 kcal × kg $BW^{0.67}$
Domestic cats, overweight[c]	130 kcal × kg $BW^{0.4}$
Exotic cats	55-260 kcal × kg $BW^{0.75}$

[a]Requirements of individual cats may be over- or underestimated by more than 50%.
[b]Body condition scores (Table 3-7) ≤ 5 on a 9-point scale.
[c]Body condition scores (Table 3-7) > 5 on a 9-point scale.

TABLE 15-12 Nutrient Requirements of Adult Cats for Maintenance

	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
Nutrient	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$	Amt./kg DM (=4,000 kcal)[a]	Amt./1,000 kcal ME[b]	Amt./kg $BW^{0.67c}$
Crude Protein	160	40	3.97				200	50	4.96			
Amino Acids												
Arginine (g)[f]				7.7	1.93	0.19	7.7	1.93	0.19			
Histidine (g)				2.6	0.65	0.064	2.6	0.65	0.064			
Isoleucine (g)				4.3	1.08	0.11	4.3	1.08	0.11			
Methionine (g)[f]	1.35	0.34	0.033				1.7	0.43	0.042			
Methionine & Cystine (g)	2.7	0.68	0.067				3.4	0.85	0.084			
Leucine (g)				10.2	2.55	0.25	10.2	2.55	0.25			
Lysine (g)	2.7	0.68	0.067				3.4	0.85	0.084			
Phenylalanine (g)				4.0	1.00	0.099	4.0	1.00	0.099			
Phenylalanine & Tyrosine (g)[f]				15.3	3.83	0.38	15.3	3.83	0.38			
Threonine (g)				5.2	1.30	0.13	5.2	1.30	0.13			
Tryptophan (g)				1.3	0.33	0.032	1.3	0.33	0.032			
Valine (g)				5.1	1.28	0.13	5.1	1.28	0.13			
Taurine (g)[g]	0.32	0.080	0.0079				0.40	0.10	0.0099			
Total Fat (g)				90	22.5	2.2	90	22.5	2.2	330[i]	82.5	8.2
Fatty Acids												
Linoleic Acid (g)				5.5	1.4	0.14	5.5	1.4	0.14	55[j]	13.8	1.4
α-Linolenic Acid (g)												
Arachidonic Acid (g)				0.02	0.005	0.0005	0.06	0.015	0.0015	2[k]	0.5	0.049
Eicosapentaenoic & Docosahexaenoic Acid (g)[h]				0.1	0.025	0.0025	0.1	0.025	0.0025			
Minerals												
Calcium (g)	1.6	0.40	0.040				2.9	0.72	0.071			
Phosphorus (g)	1.4	0.35	0.035				2.6	0.64	0.063			
Magnesium (mg)	200	50	4.9				400	100	9.5			
Sodium (mg)	650	160	16.0				680	170	16.7	>15 g		
Potassium (g)				5.2	1.3	0.13	5.2	1.3	0.13			
Chloride (mg)				960	240	23.7	960	240	23.7			

Iron (mg)[i]				80	20	1.98	80	20	1.98			
Copper (mg)[i]				5.0	1.2	0.119	5.0	1.2	0.119			
Zinc (mg)				74	18.5	1.9	74	18.5	1.9	>600		
Manganese (mg)				4.8	1.2	0.119	4.8	1.2	0.119			
Selenium (μg)				300	75	6.95	300	75	6.95			
Iodine (μg)	1,300	320	31.6				1,400	350	35			
Vitamins												
Vitamin A (μg retinol)[j]				800	200	19.8	1,000	250	24.7	100,000[j]	25,000[j]	2,469[j]
Cholecalciferol (μg)[k]				5.6	1.4	0.14	7	1.75	0.17	750	188	19
Vitamin E (α-tocopherol) (mg)[l]				30	7.5	0.74	38	10	0.94			
Vitamin K (Menadione) (mg)[m]				1.0	0.25	0.025	1.0	0.25	0.025			
Thiamin (mg)				4.4	1.1	0.11	5.6	1.4	0.14			
Riboflavin (mg)				3.2	0.80	0.079	4.0	1.0	0.099			
Pyridoxine (mg)	2.0	0.5	0.05				2.50	0.625	0.06			
Niacin (mg)				32	8.0	0.79	40	10.0	0.99			
Pantothenic Acid (mg)	4.6	1.15	0.11				5.75	1.44	0.14			
Cobalamin (μg)				18	4.5	0.44	22.5	5.6	0.56			
Folic Acid (μg)	600	150	15				750	188	19			
Biotin (μg)[n]				60	15	1.5	75	18.75	1.9			
Choline (mg)	2,040	510	50				2,550	637	63			

[a]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term = signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.

[b]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement for lean cats in kcal ME (calculated from Table 15-11) and divide by 1,000. For cats with an unusually low energy intake (below the suggested requirement), the nutrient concentrations (Amt/1,000 kcal) may not be adequate. These animals should be fed the nutrient amounts shown in the column Amt/kg $BW^{0.67}$.

[c]The values in Amt/$BW^{0.67}$ have been calculated for a lean cat with an energy intake of 100 kcal × $BW^{0.67}$. To calculate the amounts for adult cats that are not lean, calculate the energy requirements from Table 15-11 and multiply this value by the nutrient Amt/1,000 kcal and divide by 1,000.

[d]0.02 g arginine should be added for every g of crude protein above 200 g for the RA of arginine.

[e]Methionine presumed to be one-half the sum of the requirement for methionine + cystine combined.

[f]To maximize black hair color, an equal quantity or greater of tyrosine to that of phenylalanine is required.

[g]The recommended allowance of taurine for highly digestible purified diets is 0.4 g/kg diet, whereas the allowances for dry expanded and canned diets are 1.0 and 1.7 g/kg diet, respectively.

[h]Includes docosahexaenoic acid only; no information is available on eicosapentaenoic acid. It is advised that eicosapentaenoic acid is included but not exceed 20% of the total eicosapentaenoic + docosahexaenoic amount.

[i]Some oxides of iron and copper should not be used because of low bioavailability.

[j]One IU of vitamin A is equal to 0.3 μg of all-*trans* retinol or 1 μg retinol =3.333 IU of vitamin A. Safe upper limit values expressed as μg retinol.

[k]1 μg cholecalciferol = 40 IU vitamin D_3.

[l]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).

[m]Cats have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets (except fish-based diets) are fed. Under most conditions, adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.

[n]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Table 15-14 Nutrient Requirements of Queens in Late Gestation and Peak Lactation

TABLE 15-13 Daily Metabolizable Energy Requirements for Lactating Queens

Kittens	Energy Requirement
<3	ME kcal = maintenance + 18 × BW × L
	ME kcal = 100 × $BW^{0.67}$ + 18 × BW × L
3-4	ME kcal = maintenance + 60 × BW × L
	ME kcal = 100 × $BW^{0.67}$ + 60 × BW × L
>4	ME kcal = maintenance + 70 × BW × L
	ME kcal = 100 × $BW^{0.67}$ + 70 × BW × L

L = factor for stage of lactation from week 1 to week 7: 0.9, 0.9, 1.2, 1.2, 1.1, 1.0, 0.8

Example: Queen, 3.5 kg BW at mating, 4 kittens, peak lactation (week 3)
ME kcal = 100 × $3.5^{0.67}$ + (60 × 3.5 × 1.2) = 231 + 252 = 483 kcal

TABLE 15-14 Nutrient Requirements of Queens in Late Gestation and Peak Lactation[a]

Nutrient	Minimal Requirement			Adequate Intake			Recommended Allowance			Safe Upper Limit		
	Amt./ kg DM (=4,000 kcal)[b]	Amt./ 1,000 kcal ME[c]	Amt./ kg $BW^{0.67}$[d]	Amt./ kg DM (=4,000 kcal)[b]	Amt./ 1,000 kcal ME[c]	Amt./ kg $BW^{0.67}$[d]	Amt./ kg DM (=4,000 kcal)[b]	Amt./ 1,000 kcal ME[c]	Amt./ kg $BW^{0.67}$[d]	Amt./ kg DM (=4,000 kcal)[b]	Amt./ 1,000 kcal ME[c]	Amt./ kg $BW^{0.67}$[d]
Gestating Adult Cats												
Crude Protein	170	43	5.90				213	53	7.40			
Amino Acids												
Arginine (g)[e]				15	3.75	0.52	15	3.75	0.52			
Histidine (g)				4.3	1.08	0.15	4.3	1.08	0.15			
Isoleucine (g)				7.7	1.93	0.27	7.7	1.93	0.27			
Methionine (g)				5.0	1.25	0.170	5.0	1.25	0.170			
Methionine & Cystine (g)				9.0	2.25	0.31	9.0	2.25	0.31			
Leucine (g)				18	4.50	0.63	18	4.50	0.63			
Lysine (g)				11	2.75	0.38	11	2.75	0.38			
Phenylalanine (g)												
Phenylalanine & Tyrosine (g)[f]	15.3	3.83	0.53				19.1	4.78	0.66			
Threonine (g)				8.9	2.23	0.31	8.9	2.23	0.31			
Tryptophan (g)				1.9	0.48	0.066	1.9	0.48	0.066			
Valine (g)				10	2.50	0.35	10	2.50	0.35			
Taurine (g)[g]	0.42	0.105	0.015				0.53	0.13	0.018			
Lactating Adult Cats												
Crude Protein	240	60	12.9				300	75	16.10			
Amino Acids												
Arginine (g)[e]				15	3.8	0.81	15	3.8	0.81			
Histidine (g)				7.1	1.8	0.39	7.1	1.8	0.39			
Isoleucine (g)				12	3.0	0.64	12	3.0	0.64			
Methionine (g)				6.0	1.5	0.32	6.0	1.5	0.32			
Methionine & Cystine (g)				10	2.6	0.56	10.4	2.6	0.56			
Leucine (g)				20	5.0	1.07	20	5.0	1.07			
Lysine (g)				14	3.5	0.75	14	3.5	0.75			
Phenylalanine (g)												
Phenylalanine & Tyrosine (g)[f]	15.3	3.83	0.52	0.82			19.1	4.8	1.03			
Threonine (g)				10.8	2.7	0.58	10.8	2.7	0.58			
[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			

Taurine (g)[g]	0.42	0.105	0.015									
Total Fat (g)				90	22.5	4.8	90	22.5	4.8	330[k]	82.5	17.6
Fatty Acids												
Linoleic Acid (g)				5.5	1.4	0.3	5.5	1.4	0.3	55[l]	13.8	2.93
α-Linolenic Acid (g)				0.2	0.050	0.011	0.2	0.05	0.011			
Arachidonic Acid (g)				0.2	0.050	0.011	0.2	0.050	0.011			
Eicosapentaenoic & Docosahexaenoic Acid (g)[h]				0.1	0.0250	0.0067	0.1	0.025	0.0044			
Minerals												
Calcium (g)				10.8	2.7	0.565	10.8	2.7	0.565			
Phosphorus (g)	4.9	1.22	.261				7.6	1.9	0.411			
Magnesium (mg)	416	104	22				500	125	32			
Sodium (mg)				2,680	670	142	2,680	670	142			
Potassium (g)				5.2	1.3	.277	5.2	1.3	0.277			
Chloride (mg)				4,000	1,000	213	4,000	1,000	213			
Iron (mg)[i]				80	20	4.3	80	20	4.3			
Copper (mg)[i]				8.8	2.2	0.47	8.8	2.2	0.47			
Zinc (mg)	42	10.5	2.2				60	15	3.2			
Manganese (mg)				7.2	1.8	0.38	7.2	1.8	0.38			
Selenium (µg)				300	75	16	300	75	16			
Iodine (µg)				1,800	450	96	1,800	450	96			
Vitamins												
Vitamin A (µg retinol)[j]				1,600	400	85	2,000	500	107	100,000[j]	25,000[j]	5,333[j]
Cholecalciferol (µg)[k]				5.6	1.4	0.30	7.0	1.75	0.37	750	188	40
Vitamin E (α-tocopherol) (mg)[l]				30	7.5	1.6	31	7.8	1.67			
Vitamin K (Menadione) (mg)[m]				1.0	0.25	0.18	1.0	0.25	0.18			
Thiamin (mg)				5.0	1.25	0.27	6.3	1.56	0.32			
Riboflavin (mg)				3.2	0.80	0.17	4.0	1.0	0.21			
Pyridoxine (mg)	2.0	0.5	0.10				2.50	0.625	0.11			
Niacin (mg)				32	8.0	1.71	40	10.0	2.10			
Pantothenic Acid (mg)	4.6	1.15	0.25				5.75	0.19	0.31			
Cobalamin (µg)				18	4.5	0.80	22.5	5.6	1.0			
Folic Acid (µg)	600	150	27				750	187	33			
Biotin (µg)[n]				60	15	2.7	75	18.75	3.3			
Choline (mg)	2,040	510	91				2,550	637	113			

[a]With the exception of amino acids, few data could be found for the dietary concentrations for the minimal requirement for gestation for the queen. For other nutrients, the values for lactation relative to kg DM and 1,000 kcal ME may be taken as satisfactory for gestation and lactation in the queen.
[b]The values for Amt/kg DM have been calculated assuming a dietary energy density of 4,000 kcal ME/kg. (The term = signifies equivalence.) If the energy density of the diet is not 4,000 kcal ME/kg, then to calculate the Amt/kg DM for each nutrient, multiply the value for the nutrient in the column labeled Amt/kg DM by the energy density of the pet food (in kcal ME/kg) and divide by 4,000.
[c]To calculate the amount to feed of each nutrient, multiply the value for Amt/1,000 kcal ME for each nutrient by the energy requirement in kcal ME (calculated from Table 15-13 for a lactating cat, or by multiplying kg $BW^{0.67}$ by 140 for a cat during gestation) and divide by 1,000.
[d]The values for Amt/$BW^{0.67}$ only apply to a queen weighing 4 kg in peak lactation with 3-4 kittens consuming 540 kcal ME/day. If the queen does not fit these criteria, calculate the ME requirement from Table 15-13, multiply this value by nutrient Amt/1,000 kcal and divide by 1,000. To calculate the nutrient requirements for late gestation, compute the energy requirements from 140 × kg $BW^{0.67}$ and multiply by Amt/1,000 kcal and divide by 1,000.
[e]0.02 g arginine should be added for every g of crude protein above 170 g and 213 g for the MR and RA, respectively.
[f]To maximize black hair color, an equal quantity or greater of tyrosine to that of phenylalanine is required.
[g]The recommended allowance of taurine for highly digestible purified diets is 0.53 g/kg DM, whereas the allowances for dry expanded and canned diets are 1.0 and 1.7 g/kg dietary DM, respectively.
[h]It is advised that eicosapentaenoic acid not exceed 60% of the total eicosapentaenoic + docosahexaenoic amount.
[i]Some oxides of iron and copper should not be used because of low bioavailability.
[j]One IU of vitamin A is equal to 0.3 µg of all-*trans* retinol or 1 µg retinol = 3.333 IU of vitamin A. Safe upper limit values expressed as µg retinol.
[k]1 µg cholecalciferol = 40 IU vitamin D_3.
[l]Higher concentrations of vitamin E are recommended for high PUFA diets. One international unit of vitamin E = 1 mg all-*rac*-α-tocopheryl acetate (see Chapter 8).
[m]Cats have a metabolic requirement, but a dietary requirement has not been demonstrated when natural diets (except fish-based diets) are fed. Under most conditions, adequate vitamin K is probably synthesized by intestinal microbes. The vitamin K allowance is expressed in terms of the commercially used precursor menadione that requires alkylation to the active vitamin K.
[n]For normal diets not containing raw egg white, adequate biotin is probably provided by microbial synthesis in the intestine. Diets containing antibiotics may need supplementation.

Attachment F -- References and Research Information

American Association of Feed Control Officials (2011) Official Publication, Oxford, IN

Ajnomoto (2011) Encyclopedia of Amino Acids. http://www.ajinomoto.com/amino/eng/product.html

Baker, David H (2008) Animal Models in Nutrition Research, American Society for Nutrition Journal Vol. 138, pp 391-396.

Briston, Andrew W.; Whitehead, David C.; Cockburn, John E (1992) Nitrogenous constituents in the urine of cattle, sheep and goats. Journal of the Science of Food and Agriculture, Volume 59, Issue 3, pp 387-394.

Deshpande, S.S. (2002) Handbook of Food Toxicology, Mercel Decker, Inc., New York, NY

European Pet Food Industry Federation (2011) Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs, B-1050 Bruxelles. http://www.nutricao.vet.br/pdfs/FEDIAF_Nutritional_Guidelines_-_final_version_6-09-11.pdf

Holisticmed.net (2003) Amino acid Production. http://www.holisticmed.net/aspartame/aminoacid.pdf

FDA (2010) Pet Food Labels – General, Center for Veterinary Medicine, March

Journal of Chemical Education (2004) Commercial Production of MSG and Other Amino Acids, Cornell College, Mount Vernon, IA

Morris, James (2002) Idiosyncratic nutrient requirements of cats appear to be diet-induced evolutionary adaptations. Department of Molecular Biosciences, School of Veterinary Medicine, University of California, Davis. Nutrition Research Reviews, 15 Pages 153-168. http://journals.cambridge.org/download.php?file=%2FNRR%2FNRR15_01%2FS0954422402000070a.pdf&code=395e67a2405fe3e7ef0a6e06d5ccf9fa

Morris, James; and Rogers, Quinton (1978) Arginine: An Essential Amino Acid for the Cat, Journal of Nutrition, 108 Pages 1944-1953. http://jn.nutrition.org/content/108/12/1944.full.pdf

National Research Council (2006) Nutrient Requirements of Dogs and Cats, Animal Nutrition Series, NRC of the National Academes, Washington, D.C.

Paustian, Timothy (2000) Synthesis of Amino Acids. University of Wisconsin, Madison

Penn State (2011) The N Cycle, Crops and Soil Sciences, State College, PA
http://cropsoil.psu.edu/research/kaye-lab/lab-logo

Soeter, Peter; van de Poll, Marcell; van Geemer, Wim; van Gemert, Dejong, Cornelis (2004) Amino Acid Adequacy in Pathophysiological States, *The American Society for Nutritional Sciences* J. Nutr. 134:1575S-1582S, June 2004

UN FAO (1998) Organic matter decomposition and the soil food web
http://www.fao.org/docrep/009/a0100e/a0100e05.htm

UN World Health Organization (2007) Protein and Amino Acid Requirements in Human Health, Joint Report of WHO/FAO/UNU Expert Commission,
http://whqlibdoc.who.int/trs/WHO_TRS_935_eng.pdf

Virginia-Maryland Regional College of Veterinary Medicine (2010) Nutrition for the Adult Cat, http://www.vetmed.vt.edu/vth/sa/clin/cp_handouts/Nutrition_Adult_Cat.pdf

Virginia-Maryland Regional College of Veterinary Medicine (2010) Nutrition for the Adult Dog http://www.vetmed.vt.edu/vth/sa/clin/cp_handouts/Nutrition_Adult_Dog.pdf

Zoran, Debra L., DVM, PhD, DACVIM (2002) The carnivore connection to nutrition in cats. Journal of the American Veterinary Association, Vol. 221, No. 11, December, 1.
http://catinfo.org/docs/zorans_article.pdf