AMINO ACIDS

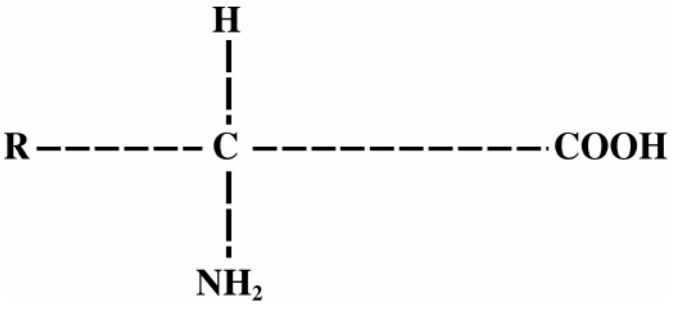
Of the six nutrients – carbohydrates, fats, proteins, vitamins, minerals and water – that are present in the food we eat, proteins have received far more attention from both the scientific community and the food industry. Proteins are an indispensable constituent of all living cells.

However, since it is the amino acids that make up a protein molecule and the quality of a protein is determined in the first place by its amino acid composition, more emphasis should be placed on these basic building blocks. Recent research has demonstrated that these amino acids have a vital role in the physiological functions at the cellular level.
With the ongoing research, the status of amino acids will be raised to the levels of vitamins and minerals, Dietary supplementation of individual amino acids will be a norm to provide an adequate and balanced nutrient intake to ensure proper nutrition and good health.

The importance of amino acids goes far beyond protein synthesis; amino acids serve as precursors for many compounds including neurotransmitters, mucopolysaccharides and enzyme cofactors. The following paragraphs will outline some of the properties of these amazing molecules, the amino acids.

Chemistry of Amino Acids

Amino acids are composed of carbon, hydrogen, oxygen, nitrogen and sometimes sulphur and are essential for life. To a chemist they look like this:



Where R can represent various chemical groups, the R will be different in each amino acid and will determine its nature and activity. Amino acids may function alone or in short sequences called peptides or in long chains called proteins. Amino acids can be either a D or L form; while they are composed of the same subunits, they are not identical; rather they are mirror images of each other. Imagine your right and left hands; they both have a palm, four fingers and a thumb but you cannot wear a right-handed glove on your left hand. Similarly, only the L form of amino acids can link together to form chains (proteins). Natural amino acids are in the L form. Commercially available natural amino acids are isolated from proteins that contain only L-amino Acids. D- or DL- (a mixture of D and L) amino acids can be produced synthetically or through modification of L-amino acids.

Classification of Amino Acids	
Essential	**Non Essential**
L-Tryptophan	L-Cysteine/L-Cystine**
L-Isoleucine	L-Tyrosine
L-Lysine	L-Alanine
L-Threonine	L-Glutamic Acid
L-Leucine	L-Proline/L-Hydroxyproline
L-Methionine	L-Glutamine
L-Phenylalanine	L-Aspartic Acid
L-Valine	L-Glycine
L-Arginine*	L-Serine
L-Histidine*	L-Asparginine
** L-arginine and L-histidine are semi-essential, necessary for mormal growth and development but not required for the maintaince of nitrogen balance.*	
*** Crysteine is essential for pre-term babies.*	

Sources of amino acids

With the proper starting materials (obtained from the diet), the body is able to synthesize many amino acids that are known as **non-essential amino acids**. Others, that the body cannot synthesize and, like vitamins, must be provided in the daily diet, are known as **essential amino acids**.

Amino acids are the building blocks of protein and consequently, they are also the digestive breakdown products of protein. Many dietary proteins have generous amounts of some amino acids while lacking others. Careful dietary planning requires the balancing of various proteins in order to provide adequate amounts of all the essential amino acids. The most deficient essential amino acid in a dietary protein is called the **limiting amino acid**. Remember that the body requires adequate amounts of all twenty amino acids in order to make proteins. The terms essential and non-essential refer only to the body's ability to manufacture them.

Amino acids in proteins

Protein digestion begins in the stomach where digestive enzymes cut the protein into fragments that are further cleaved into individual amino acids by enzymes found in the small intestine. L-amino acids are absorbed by active transport processes from the small intestine into mucosal cells from which they diffuse passively into the bloodstream8. Some of these amino acids are used by the body to make new proteins. Each of the body's cells contains genetic information in the form of DNA (deoxyribonucleic acid) including the recipe for each of the more than 100,000 different proteins that the body manufactures. Protein synthesis occurs within the cytoplasm of cells.

Proteins have a wide variety of functions. There are structural proteins such as collagen, found in connective tissue and bone, and contractile proteins such as actin and myosin found in skeletal muscle.

Other specialized proteins known as enzymes are biological catalysts and include the digestive enzymes trypsin and chymotrypinogen, the electrolyte-balancing enzymes, Na+ +K+ATPAse and the nucleic acid

synthesizing enzyme, DNA polymerase. Enzymes require specific temperatures and pH ranges in order to work. They also often require other molecules known as cofactors (21).

Hormones are molecules that carry messages from one region of the body to another. Insulin, ACTH and parathyroid hormone are all proteins while others such as the steroid hormones are not proteins (8). The ability of the body to ward off many infectious agents is based, to a large extent, on the presence of a special class of proteins known as antibodies. These substances recognize foreign materials in the body. They bind to them, rendering them inactive until the other defence mechanisms can respond and remove these potentially harmful complexes. Thrombin and fibrinogen are necessary for the clotting of blood, another defence mechanism (21).

Dietary protein is also important in maintaining the nitrogen balance that is a result of the body's continual intake and excretion of nitrogenous compounds. The human body cannot utilize the nitrogen that is found in the air and must obtain it in a combined form such as the amino acids in proteins. The body then uses this nitrogen to synthesize other nitrogenous compounds such as DNA, non-essential amino acids, neurotransmitters and mucopolysaccharides. The net dietary intake of nitrogen-containing compounds must be adequate to meet these anabolic (synthesizing) demands (8).

Amino acids in peptides

Short chains of amino acids are known as peptides and, like proteins, they have varied functions. Glutathione is a peptide that has recently attracted considerable attention due to its antioxidant and detoxicant properties. It is composed of only three amino acids: glutamic acid, cysteine and glycine. Glutathione forms conjugates with toxic compounds including heavy metals that reduce their reactivity and aid the body's natural excretory mechanisms. As well, glutathione, along with the enzyme glutathione peroxidase, helps to deactivate dangerous free-radical molecules. A synergism exists between glutathione and the other antioxidants, vitamin E and selenium. Glutathione is an integral part of the blood sugar controlling compound glucose tolerance factor (GTF) (40).

Carnitine is another simple peptide and an essential metabolite, being the key substance in carrying fatty acid into the mitochondria ('power-house') of cells for oxidation and energy production. It thus controls the rate of fat utilization to power muscle contractions, especially for sustained work, and is particularly important to the heart. It may also help in the combustion of lysine and valine for up to 10% of the energy supply. It is found in almost all animal tissues and is concentrated in muscles. It is, in fact, a trimethylated carboxyl-alcohol, made readily from methionine (which donates the three methyl groups) & lysine in the presence of niacin, pyridoxine, vitamin C, iron and perhaps manganese (4, 22).

Carnitine is abundant in red meat, less so in dairy products and fish and scanty in vegetables. Of the building blocks for carnitine, lysine is low in corn, wheat and rice and methionine is low in beans. Vegetarians should mix their plant protein intake properly to ensure a balanced supply of the needed amino acids. Carnitine has been reported to lower blood cholesterol and triglyceride and raise HDL1. (31). In patients with ischemic heart disease, carnitine reduces symptoms, ECG changes and exercise tolerance. It apparently stimulates pancreatic and stomach secretions. Carnitine deficiency may arise in face of increased demands, lack of raw material, defective manufacture or excessive loss. Severe shortage causes extreme weakness, muscle cramps, heart enlargement and failure and brain degeneration (4). L-carnitine, the natural form, is inhibited by the D-form, causing muscle weakness that is reversible when the D-form is stopped.

Amino acids in intermediary metabolism

A great many biochemical reactions require amino acids in their free forms rather than in the chains known as peptides or proteins. They play important roles in many metabolic processes that convert foods into utilizable materials and provide energy for the growth and maintenance of the body. They are precursors to neurotransmitters, the chemicals that carry messages from one nerve to another or to a target tissue. Amino acids may stimulate or inhibit a large number of reactions and may combine with other molecules to form coenzymes. The following paragraphs will discuss some of these unique actions.

L-arginine

L-arginine is very important in the growth and development of children due to its stimulation of growth hormone secretion. This action continues throughout life but is more important in children by virtue of their rapid growth rates. Secreted by the anterior pituitary, growth hormone (also known as somatotropin or STH) stimulates the addition of muscle to the body of adults as well as children. It increases the transport of amino acids into cells thus making them available for the synthesis of muscle protein. This hormone also enhances the burning of fatty tissues and the deposition of muscle (8).

Arginine inhibits tumour development and growth. It has been shown to significantly reduce the number of Ascites tumour cells in experimental animals and to increase the lifespan of these animals (26). Proper production of collagen with high tensile strength necessary in wound healing is stimulated by this amino acid (39). L-arginine affects the production of normal sperm levels in adult males (38).

L-arginine plays an essential role in the urea cycle and thus the detoxification of the ammonia produced in protein metabolism and normalization of muscle metabolism of nitrogen. It is in the urea cycle that L-arginine is converted to L-ornithine that eventually cycles back to L-arginine (21). There have been some reports that excessive amounts of L-arginine may precipitate certain schizophrenias and that use of high levels of L-arginine without a concomitant increase in L-lysine may encourage the replication of the herpes virus (27).

Branched chain amino acids (BCAA)

There are three essential amino acids in this group: L-leucine, L-isoleucine and L-valine. They share a common feature distinctive amongst the amino acids - a non-terminal (hence branched) methyl group to the main carbon chain. Together, they make up 40% of the essential amino acid requirement in man and 35% of the striated muscle bulk. They all play important roles in body reactions to stress, in that:

1. They are broken down by preference when under demand, hence 'sparing' other amino acids (4, 42).
2. They encourage protein building to combat the extra losses (anti-catabolic); and
3. Unlike most other amino acids, they can directly burn for energy in striated muscles, as an additional fuel to glucose.

Thus in conditions like surgery, trauma and severe burns and infections, etc., more BCAA are required than other amino acids and leucine more so than the other two. The BCAA also serve as neurotransmitters (e.g. leucine encephalins). Vitamins B 1, B2, B6 and copper and magnesium are closely linked to different stages of BCAA metabolism.

BCAA's are abundant in fish, meat, poultry, bean, soy protein, various nuts and seeds, eggs and dairy products. When given as individual amino acids, isoleucine is the best absorbed of the three members. For

rapid replacement, however, BCAA's by intravenous infusion are helpful in severe injuries, sepsis or post-operative states (2).

L-cysteine

L-cysteine is an important sulphur-containing amino acid that can be synthesized in the body from L-methionine and L-serine (21). It is a powerful antioxidant that binds to dangerous and reactive free molecules rendering them harmless.

In combination with vitamins C and B 1, L-cysteine protects cells from the toxic effects of radiation and aldehyde compounds which are found in smog, in tobacco smoke and in the metabolic by-products of ingested rancid (oxidized) fats (20, 28, 43). It is the sulphur-containing amino acid found in the peptide glutathione (mentioned earlier) and is necessary for the production of coenzyme A (a coenzyme that is essential in a broad range of biochemical reactions, especially those involving the transfer of acyl groups and fatty acid metabolism (21). This amino acid is also instrumental in stimulating the immune system, most notably the macrophage phagocytic activity that rids the body of foreign toxins, bacteria and viruses. L-cysteine is also active in detoxifying ingested poisons in the gastro-intestinal tract and clearing mucus obstructions in bronchial tissues in diseases such as bronchitis, tuberculosis and emphysema (23).
L-cysteine and L-methionine have been shown to exert a protective effect against the damaging sequalae of copper toxicity and of radiation effects on skin and mucous membranes. L-cysteine is concentrated in the hair and wool of humans and other animals.

The growth and health of these tissues are dependent on adequate amounts of this amino acid. L-cysteine should not be confused with L-cystine, a related but non-identical compound. L-cystine does not possess the very important antioxidant property that is central to many of the actions of L-cysteine, but the strong disulphide bond in cystine helps to maintain the shape of protein molecules.

L-cysteine may prevent hypoglycaemic responses by blocking insulin activity and should, therefore, be used with caution by diabetics (27).

The glutamate amino acids

The three members of this group, L-glutamic acid (GA), L-glutamine (GAM), and gamma-amino butyric acid (GABA), form an all important trio widely distributed in body proteins and enzymes but highly concentrated in brain tissue where they play key roles in energy supply and brain functions.

GA is a non-essential amino acid and a precursor of the other two, though in fact, all three are interconvertible. GAM, a neutral salt, is the only one of the trio which can readily pass from the blood to the brain, where it can be converted into GA and act as an important energy source, a role it shares only with glucose. The trioare vital N2 donors in the formation of other non-essential amino acids, mucopolysaccharides, DNA, Glutathione, niacin (vitamin B3) and folic acid. Also, they are involved in the metabolism of pyrroles (hence uric acid) and arginine and in the detoxification of brain ammonia. In addition, GA is a stimulatory and GABA an inhibitory neurotransmitter and GBA are reported to lower blood pressure in hypertensives (13). GAM and GA reduce alcohol craving in alcoholics (33, 37, 41) and protect cells from the deleterious effects of alcohol; they have also been reported to improve memory and IQ in elderly people (6). GA is the most abundant amino acid in food being rich in all animal proteins and dairy products; however, little GAM or GABA can be found ready-made in dietary proteins apart from brain tissue. In man, doses of GA at 1g/kg/day or over may cause brain damage or seizures. Monosodium glutamate (MSG, the Na salt of GA0 is commonly used to enhance flavours in Chinese food. When taken in excess (e.g.2-3g or more), it may cause the 'Chinese restaurant syndrome with headache, dizziness, flushing and weakness.

L-histidine

L-Histidine is an amino acid widely distributed in proteins and enzymes. It is a metabolic intermediate in the production of Histamine, a compound involved in smooth muscle contraction and vasodilation; neurotransmission (stimulation of adenylate cyclase activity); and the stimulation of gastric secretion (29).

Oral administration of L-Histidine has been useful in the diagnosis of ulcers of the digestive tract and gastric secretory disorders. In addition, L-Histidine is quite beneficial in the management of rheumatoid arthritis; these patients have blood levels of L-Histidine averaging one quarter those of normal individuals (10, 11, 18).

L-lysine

L-lysine is an essential amino acid that often limits the quality of vegetarian diets due, in part, to its low availability in wheat, rice, oat, millet and sesame protein. It is especially important for the optimal growth and development of children.

L-lysine is widely distributed in body proteins and enzymes and is involved in the synthesis of collagen (a vital component of tendons and connective tissue), pipecolic acid (a neurotransmitter) and carnitine, a compound required for the utilization of fatty acids in energy production. For this reason, L-lysine plays an important role in growth and repair mechanisms throughout life.

This amino acid has been shown to be efficacious in the management of herpes simplex, especially with concomitant administration of ascorbic acid. L-lysine interferes with the body's metabolism of L-arginine, a compound vital for replication of the virus. This results in a decrease in both the frequency and severity of outbreaks of herpes (15, 27).

L-methionine

L-methionine, an essential amino acid, is, like L-cysteine, a sulphur-containing compound and a powerful antioxidant that protects cells from the ravages of dangerous free radical molecules (20).

Vitamin B6 helps to maintain this free radical scavenging capacity (21).

L-methionine also functions in the initiation of endogenous protein synthesis and in the biochemical transfer of methyl groups, a process that is important in the production of many compounds including choline, creatine, and adrenaline (21). It is also needed in the production of lecithin and is the limiting amino acid in many foods including soya beans, peanuts, cottonseeds and potatoes. A deficiency of L-methionine may result in anaemia, retarded protein synthesis and fatty infiltration of the liver. Like L-cysteine, L-methionine has been shown to counteract many of the symptoms of copper toxicity (17).

L-ornithine

L-ornithine, a metabolically important amino acid, is neither incorporated into protein, nor has any role in endogenous protein synthesis (21). L-ornithine is about twice as effective as L-arginine in stimulating the secretion of growth hormone (27). Growth hormone increases the body's metabolism of adipose (fat) tissue. It also enhances the transport of amino acids into intra-cellular spaces where they become available for increased synthesis of protein (8). Like L-arginine, L-ornithine plays an important role in wound healing as a result of its effect on growth hormone release and stimulation of the immune system. These two amino acids are interconverted in the urea cycle where they effect the detoxification of

ammonia (21). L-ornithine is valuable in the production of polyamines that stabilize membrane structure and DNA integrity as well as promote cell growth (21).

L-phenylalanine

L-phenylalanine is an essential amino acid widely distributed in the proteins of the human body and is, as well, a vital component in the production of the powerful adrenal catecholamines. Catecholamines are neurotransmitter substances with a wide scope of activities and include the compounds epinephrine (adrenaline), dopamine and neoepinephrine (nor adrenaline) (29). Vitamins B6 and C are necessary for the conversion of L-phenylalanine into these neurotransmitters (8) (30). Systemic functions affected by the catecholamines include heart rate, cardiac output, blood pressure, oxygen consumption, blood glucose levels, lipid energy metabolism and central nervous system action (29).

L-Phenylalanine, by virtue of its role in dopamine and nor epinephrine production, is useful in the management of some forms of depression (3). (Patients who are taking MAO inhibitors–a class of prescriptive antidepressants should not use it).

In addition, this amino acid, as a result of its activity on norephinephrine metabolism, may suppress the appetite. Because L-phenylalanine increases norephenephrine stores rather than diminishes them, as do prescriptive and over the counter appetite suppressants, it has been suggested that there is no diminution in effectiveness with neither time nor wild cycling of appetite levels (22).

L-Phenylalanine also stimulates brain production of the hormone cholecystokinin, that appears to act as a signal indicating a sense of 'fullness' and has been shown to cause experimental animals to stop eating sooner (12, 24). L-phenylalanine may increase blood pressure and should, therefore, be used with caution by hypertensives. It should also be restricted in case of certain tumours, notably melanoma that needs L-phenylalanine to produce its pigment, melanin.

D-phenylalanine

As mentioned previously, D-amino acids are not incorporated into proteins. D-phenylalanine is the mirror image of L-phenylalanine being composed of the same chemical units in a slightly different conformation (in the same way, your right hand is a mirror image of your left and both are composed of a palm, four fingers and a thumb). Also, D-phenylalanine cannot be transformed into nor adrenaline, dopamine and the other neurotransmitters.

D-phenylalanine may be effective in the management of certain types of severe pain due to its ability to inhibit the enzymes that normally break down enkephalins, the body's natural morphinelike painkillers. The resulting heightened levels of these substances results in an increased ability to withstand pain (27).

It has been suggested that chronically obese individuals may have an actual addiction to food. This may be related to the release of enkephalins in response to eating. By preventing their breakdown and therefore maintaining high levels, it has been suggested that D-Phenylalanine may reduce the craving for food in these individuals (27).

Taurine

Taurine is a naturally occurring amino acid that, like L-ornithine, is not incorporated into proteins. Structurally, taurine is distinct from the other amino acids and is available in only one form. The D and L naming system do not apply to taurine. Although mammals capable of synthesizing some taurine from

L-cysteine, the majority is obtained from the diet. Molluscs such as oysters, clams, mussels and squid are the most abundant source of this amino acid. A vast amount of research has been carried out in Japan concerning the nutritional value of these rich sources of taurine (46). Taurine is the second most prevalent amino acid in human milk; however, it is not found in significant amounts in cow's milk. The milk of lactating cows contains roughly 30 times as much taurine as commercially available cow's milk. Taurine is abundant in brain tissue, especially in infants and is concentrated in areas concerning smell, taste and memory. Infants need taurine for proper brain development, but they may not have the capacity to synthesize enough of the amino acid. Supplementation of taurine may be necessary in low birth weight infants and/or infants not receiving mother's milk (19).

Taurine is important in the functional control of all electrically excitable tissues, especially the brain and the heart. Low taurine levels have been observed in brain tissues of subjects with certain types of epilepsy. This compound has anti-convulsant activity and studies in experimental animals indicate that it may be valuable in the control of certain types of epilepsy. The subject of two recent international symposia, Taurine has been proposed as a neuromodulator or neurotransmitter in the central nervous system (CNS) (7).

Taurine is the most prevalent amino acid in cardiac tissues, representing greater than 50% of the free amino acid pool in the human heart. Taurine levels are reduced by myocardial infarction and increased by congestive heart failure. This compound has an inotropic effect on the heart (it makes the heart beat harder) probably due to its effect on calcium movement. Ongoing studies are attempting to define the role of taurine in the development of stroke and hypertension (45, 46). In rats, taurine lowers the blood pressure probably by antagonizing rennin, a renal hormone that raises blood pressure (48).

L-tryptophan

L-tryptophan is an essential amino acid vital in protein structure and function as well as in the production of the neurotransmitter serotonin (29). It is one of only a few biochemicals capable of passing the blood-brain-barrier, reflecting its vital role in brain chemistry. This amino acid is often limited in the diet, being present in quantitatively small amounts in dietary protein and rapidly destroyed even by low cooking temperatures.

L-tryptophan is the body's precursor for serotonin, an inhibitory neurotransmitter that functions in sleep physiology and sensory perception (29). Consumption of dietary L-tryptophan, (along with vitamins B6 and C that are necessary for serotonin production) especially just prior to bedtime is very effective in reducing sleep onset latency without producing the adverse effects of changing sleep stages (8, 30). Consequently, individuals with sleep disorders (insomnia) find that it takes less time to fall asleep and more restful time is spent sleeping with the use of L-tryptophan (5).

L-tryptophan has also been reported to have a calming effect on nervous individuals and a stimulating effect on those experiencing depression. In other words, it appears to be a mood stabilizer (5).

L-tyrosine

L-tyrosine is readily manufactured in the body from the essential amino acid L-phenylalanine, thereby indicating that the total dietary requirement for L-phenylalanine reflects the requirement for both of these amino acids. L-tyrosine is broadly distributed in the proteins and enzymes in the body and has a functional role in neurotransmission (conduction of nerve impulses), mood levels and free radical neutralization.

L-tyrosine is similar to L-phenylalanine in its biochemical participation in the production of the neurotransmitters, the catecholamines. Catecholamines have profound hormonal activities in the brain as

well as many other tissues including the heart, arteries, bronchioles and uterus. It has been suggested that this stimulation of neurotransmitter synthesis in the brain may result in increased mental clarity and alertness as well as improved memory (44). The catecholamine, norephenephrine, derived from L-tyrosine, plays an important role in mental anxiety and depression.

Indeed, L-tyrosine has been used medically, with excellent results, as a mood elevator and antidepressant (9, 14). (Patients taking MAO inhibitors–a class of prescriptive antidepressants should not use L-tyrosine.) L-tyrosine has also been shown to be highly effective in alleviating the discomforts of hay fever, grass and pollen allergies (25, 32).

Nutritional requirements for amino acids

The various biochemical processes just described depend on the availability of adequate amounts of amino acids in specific tissues. The first priority is to provide the body with adequate amounts of amino acids for protein synthesis. Essential amino acids must be available in the diet along with precursors for the synthesis of non-essential ones to provide all 20 amino acids for the body's anabolic demands. The nutritional value of many foods is limited by the absence of one or more essential amino acids. These foods should not be avoided but should, instead, be complimented with foods rich in the amino acids of concern.

Having provided, in the daily diet, sufficient high quality protein, some individuals may need to take supplements of individual amino acids. For maximum absorption, these should be taken on an empty stomach. Active transport processes in the upper regions of the small intestine absorb individual amino acids, but not whole proteins. The absorption of individual free amino acids (as opposed to amino acids from proteins) is not dependent on the efficiency of peptide bond cleavage beforehand by digestive enzymes (8).

Choosing amino acids

Amino acids are available in either the natural L-form or the synthetic DL-form (composed of D and L molecules). Only L-amino acids are absorbed from the digestive tract by the active transport processes and only the L-amino acids are incorporated into proteins. D-amino acids may even compete with L-amino acids, slowing the synthetic processes. Some D-amino acids, such as D-phenylalanine, possess unique properties and may provide benefit for some individuals.

Although they are available in both capsule and tablet form, there are advantages to taking amino acids in capsules. Tableting processes frequently involve high temperatures that may denature amino acids. All tablets contain some excipients that are designed to bind the tablet together and then to release the ingredients in the digestive tract. Capsules, although they are slightly more expensive to manufacture, have the advantage of requiring few excipients that might bind to the amino acids and inhibit their absorption. The disintegration of capsules is more rapid than that of tablets allowing more rapid absorption of the nutrients. Amino acids are available in either gelatin of non animal capsules.

Commercially, amino acids are available alone or in the form of salts. The salts contain significant amounts of inert material. The wise consumer will inspect a label to see how much amino acid they are buying. For example, L-cysteine is a pure amino acid while L-cysteine HCl is a salt, containing only 77% of natural L-cysteine. Pure amino acids are more expensive but are biologically more active.

Additionally the presence of these salt groups on amino acids may, in some cases, limit the absorption of the amino acid. The natural active transport processes may not carry the amino acids with the bulky groups present and may require additional digestion.

Some amino acids such as L-ornithine and L-lysine are unstable on their own and therefore only available in the salt forms. Their labels should still indicate how much of the pure amino acid you are buying.

Taking amino acids

Absorption of amino acids occurs in the upper regions of the small intestine. In order to limit the interaction of amino acids with other molecules that might inhibit their absorption, it is generally felt that they should be taken with water, on an empty stomach.

The action of amino acids varies greatly from individual to individual, and depends to a great extent on specific amino acid deficiencies. The effects of regular amino acid supplementation can vary from less than one hour as in the case of tryptophan when used as a sleep inducer, to periods of one month or more. It should also be emphasized that the activities of amino acids depend on a number of vitamins and minerals and therefore concomitant supplementation with a well-balanced vitamin and chelated mineral formula, such as ***SOURCE Optimum*** is essential for maximum benefit from the amino acid supplement. Finally, good dietary habits should be followed and help from a qualified dietician or nutritionist in planning a balanced diet is often good advice.

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