Organic Molecule – Lysine

Lysine is one of the twenty amino acids that make up natural proteins. Eleven of these amino acids can be made by the human body from other amino acids, while the remaining nine cannot be synthesized by the body they must be derived nutritionally from protein intake – these are the "essential amino acids". Lysine is one of nine essential amino acids and therefore an important molecule as proteins are made up of a melange of most of the amino acids. Formed in plants, algae, and fungi by two distinct biosynthetic pathways (*see* **Figures 1** and **2**) it helps maintain growth, lean body mass, tissue repair and the body's store of nitrogen.

Lysine is a polar molecule that has a net positive charge at physiological pH values making it one of the three basic (with respect to charge) amino acids. It therefore mostly prefers to substitute for the other positively charged amino acid arginine, though in some circumstances it will also tolerate a change to other polar amino acids. Lysine frequently plays an important role in structure. It can be considered to be somewhat amphipathic as the part of the side chain nearest to the backbone is long, carbon containing and hydrophobic, whereas the end of the side chain is positively charged.

Due to this lysine is located where part of the side-chain is buried, and only the charged portion is on the outside of the protein. However, this is by no means always the case, as lysine is often positioned on the outside of proteins. Lysine is also frequently involved in salt-bridges, where they pair with a negatively charged amino acids (such as aspartate, shown below) to create stabilizing hydrogen bonds, that can be important for protein stability. Furthermore lysine contains a positively charged amino on its side-chain that is sometimes involved in forming hydrogen bonds with negatively charged non-protein atoms.

This polar amino acid is commonly found on the surfaces of proteins and enzymes, and sometimes appears in the active or binding site. Lysine is an amino acid released in the hydrolysis of many common proteins but present in small amounts or lacking in certain plant proteins; for example gliadin from wheat or zein from corn (maize).

Good sources of lysine are foods rich in protein including meat (specifically red meat, pork, and poultry), dairy products such as cheese (particularly parmesan), certain fish (such as cod and sardines), nuts, eggs, soybeans (particularly tofu, isolated soy protein, and defatted soybean flour), lentils and spinach. Lysine is incorporated into proteins at the rate of 7 percent on a molar basis compared to the other amino acids.

Like all amino acids, lysine functions as a building platform for proteins, and thus key in the production of disease fighting antibodies, numerous enzymes, and hormones. It insures the adequate absorption of calcium; helps form collagen that makes up bone cartilage and connective tissues. A deficiency may result in tiredness, nausea, inability to concentrate, dizziness, emotional agitation, bloodshot eyes, retarded growth, decreased immunity, hair loss, anaemia, reproductive problems pneumonia, and acidosis (a pH imbalance in the body). It has also been reported that too little lysine in a diet can result in kidney stones.

Several inborn errors of lysine metabolism are known. Most are marked by mental retardation with occasional diverse symptoms such as absence of secondary sex characteristics, un-descended testes, abnormal facial structure, obesity, enlarged liver and spleen, and eye muscle imbalance.

With lysine being beneficial in building muscle protein, lysine is useful for patients recovering from injuries and recovery following surgical procedures. For instance certain forms of lysine and/or lysine bound to anti-inflammatory medications help alleviate pain following an episiotomy (a procedure performed during labour that involves cutting the vaginal area to enlarge the vaginal opening and facilitate delivery). It is believed that lysine may be beneficial in maintaining healthy blood vessels; relieve migraine headaches and painful periods as well as slowing down the process of osteoporosis. As you can see, lysine is a much-needed additive to our everyday lives.

Most people, including vegans (vegetarians who also avoid dairy and eggs), consume adequate amounts of lysine. Incidentally, vegans whose macrobiotic diets contain large amounts of grains (from corn or maize) and only minimal amounts of beans as a sole source of dietary protein could suffer from a lysine deficiency disease called "pellagra".

Athletes involved in frequent vigorous exercise have increased need for essential amino acids, although most diets meet these increased needs. The essential amino acid requirements of burn patients may exceed the amount of lysine in the diet.

Lysine is involved in the browning reaction, or carmelization, in foods such as pastries, doughnuts, cookies and cereals. In this process, lysine and sugar become linked together in a way that makes lysine difficult for the body to absorb. As a result, a diet high in cereals and baked goods, especially those that contain a lot of simple sugars, can result in low lysine intake.

Low lysine levels have been found in patients with Parkinson's, hypothyroidism, kidney disease, asthma and depression. The exact significance of these levels is unclear, yet lysine therapy can normalize the level and has been associated with improvement of some patients with these conditions.

In order for the body to secure lysine levels needed, taking lysine supplements or increasing diet with those foods with higher levels of lysine is encouraged. Lysine supplementation increases the absorption of calcium from the digestive tract and prevents loss of calcium in the urine. In so doing, some researchers speculate that L-lysine may help prevent bone loss associated with osteoporosis. Test tube studies suggest that L-lysine in combination with L-arginine increases the activity of bone-building cells and enhances production of collagen. In addition it is believed to slow the damage to the eye caused by diabetes.

A diet that is high in lysine and low in arginine a useful tool in managing HSV infections. In a recent study, participants consumed large amounts of lysine (about 1 gram three times each day) while restricting food sources of arginine. A significant number of participants (74%) noticed an improvement in their HSV infections and a decrease in the number of outbreaks. Lysine supplements may even prevent HSV outbreaks in chronic sufferers.

In animals, high amounts of lysine have been linked to increased risk of gallstones and elevated cholesterol. At supplemental amounts, no consistent problems have been reported in humans, though abdominal cramps and transient diarrhoea have occasionally been reported at very high intakes.

L-lysine is an amino acid with a pharmacological use much more specific than that of most other amino acids. So far, supplementation of l-lysine is one of the best options available for the treatment of herpes simplex virus infections, especially oral forms.

In the 1950's, scientists discovered that foods containing certain amino acids could encourage or discourage the growth of the herpes virus. When added to herpes DNA, the amino acid L-arginine was used to replicate itself and form a virus. Early studies using laboratory cultures demonstrated that L-arginine was necessary for herpes growth. It soon became clear that another amino acid, L-lysine blocked the bioavailability of arginine by tilting the balance between lysine and arginine heavily in favour of lysine. Thus this ameliorates herpes outbreaks because the herpes virus depends on the presence of arginine for its replication. By 1981, Dr. Griffith had demonstrated that lysine concentrations similar to those found in human blood could suppress herpes growth in lab cultures.

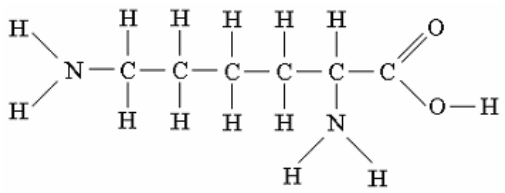
The herpes virus, an ancient and unwelcome human companion, comes in more than one form. Herpes simplex 1 is almost always the culprit in cold sores or fever blisters that erupt around the mouth; herpes simplex 2 is generally responsible for genital herpes. But, in fact, both forms of the virus can cause eruptions on the genitals and around the mouth.

Herpes outbreaks, wherever they occur, are usually painful and unsightly, as well as contagious. Supposedly lysine has been observed to inhibit the growth of Herpes simplex 1. Herpes simplex lives in the nerves in the Trigeminal nerve ganglion. When one is under stress and the immune system is therefore somewhat disabled, the Herpes virus migrates down the nerve axons to the lips, creates a sore, and waits to get kissed over to another "host". It would make sense therefore to use the lysine both "topically", as an ointment on the sore, and "systemically" internally to affect the whole system. Anywhere from 60 to 90% of us carry herpes simplex 1, probably as a result of childhood infection, and genital herpes is one of the most common sexually transmitted diseases these days. (Perhaps 20 million people have genital herpes, and one million become infected each year.) Once you have the virus, you have it. It may lie dormant, but it does not go away.

Lysine in combination with arginine is used by bodybuilders for the combination's alleged effect of stimulating the release of growth hormone. L-lysine may help prevent glycosylation, the combining of a sugar and protein molecule accelerated by elevated levels of sugar in the blood, which causes some signs of aging. Linus Pauling has provided evidence that it may also help in the prevention of arteriosclerosis, a hardening of the walls of arteries caused by deposits of lipoproteins (fats). Lysine may be capable of loosening and preventing such deposits, therefore keeping artery walls flexible. Thus, there is less susceptibility for hypertension (high blood pressure), which is a major factor in coronary heart disease and strokes.

Physical Properties:

Molecular Weight: 146.19
Molecular Formula: $C_6H_{14}N_2O_2$
Structural Formula: $H_2N(CH_2)_4CH(NH_2)COOH$
Displayed Formula:



Skeletal Formula:

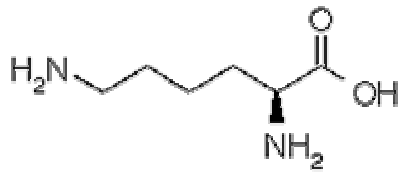


Figure 1: Lysine biosynthesis (early stages)

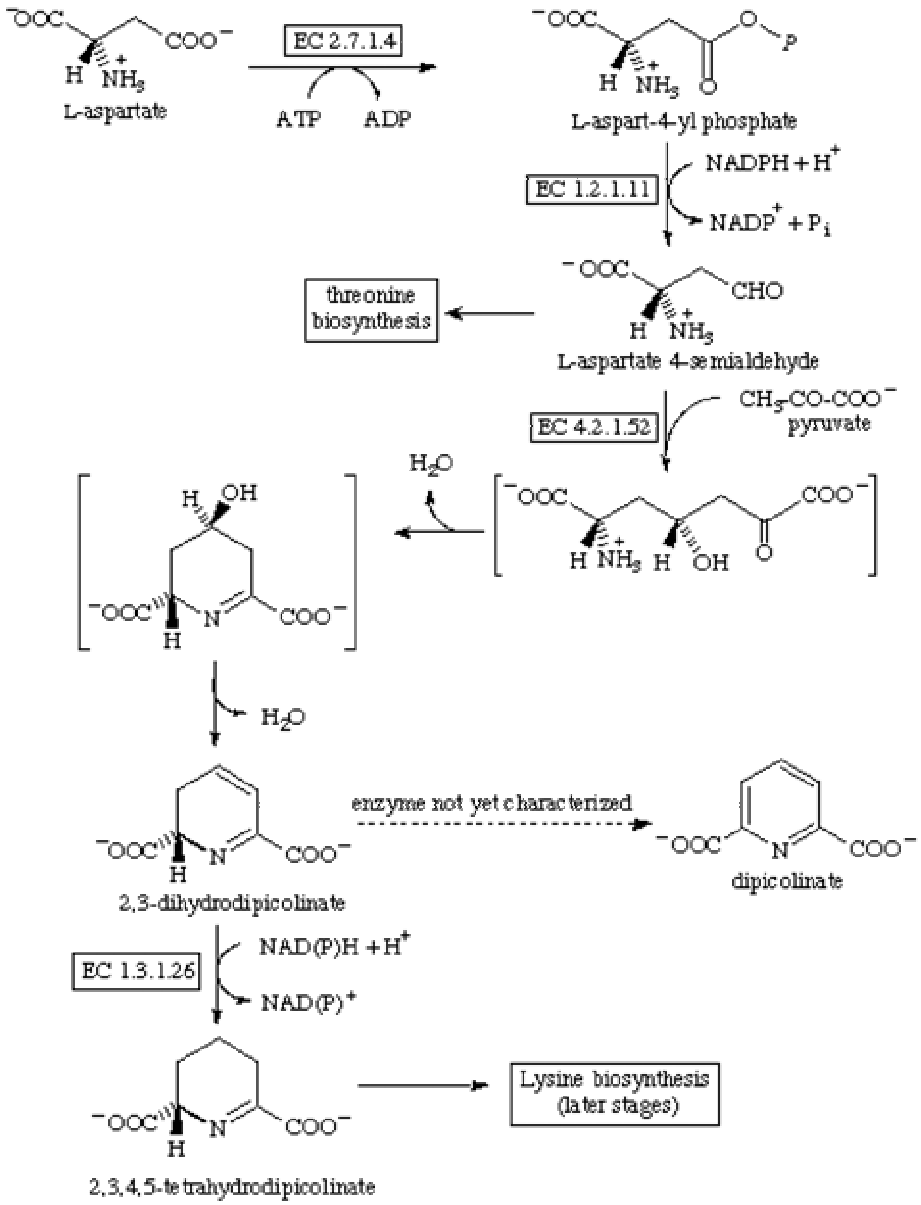


Figure 2: Lysine biosynthesis (later stages)