

Lysine

Table of Contents

summary

Chemical Structure

Biological Role

- Protein Synthesis

- Neurotransmitter Synthesis

- Immune Function and Metabolism

- Dietary Sources and Requirements

Dietary Sources

- Animal-Based Sources

- Plant-Based Sources

- Recommended Intake and Supplementation

Health Benefits

Deficiency and Health Implications

- Causes of Deficiency

- Health Implications

- Supplementation

Research and Studies

- Health Benefits

- Cardiovascular Effects

- Osteoporosis Research

- Clinical Trials and Dosage

Biosynthesis of Lysine

- Diaminopimelate (DAP) Pathway

- Alpha-Aminoadipate (AAA) Pathway

Check <https://storm.genie.stanford.edu/article/1150414> for more details

Stanford University Open Virtual Assistant Lab

The generated report can make mistakes.

Please consider checking important information.

The generated content does not represent the developer's viewpoint.

summary

Lysine is an essential diamino acid, known scientifically as L-lysine or (2S)-2,6-diaminohexanoic acid, with the chemical formula $C_6H_{14}N_2O_2$.[\[1\]\[2\]](#) This amino acid plays a vital role in protein synthesis, making it crucial for growth, repair, and maintenance of tissues within the human body. Unlike non-essential amino acids, lysine cannot be synthesized endogenously, necessitating its intake through dietary sources.[\[3\]\[4\]](#) Due to its significance in various physiological processes, lysine is notable for its impact on health, particularly in the formation of collagen, neurotransmitter synthesis, and immune function enhancement.[\[3\]\[5\]\[6\]](#)

The biological importance of lysine extends to its involvement in the synthesis of critical neurotransmitters such as serotonin and dopamine, which are essential for mood regulation and cognitive function.[\[3\]\[5\]](#) Moreover, lysine has been linked to numerous health benefits, including improved calcium absorption, potential roles in managing osteoporosis, and cardiovascular health, showcasing its broad relevance in both physical and mental well-being.[\[7\]\[4\]](#) Its dietary sources range from animal products like meat and dairy to plant-based options such as legumes and wheat germ, emphasizing the need for a balanced diet to meet daily lysine requirements.[\[8\]\[9\]](#)

Lysine deficiency can lead to significant health issues, such as protein-energy malnutrition, immune dysfunction, and various metabolic disturbances, particularly in individuals adhering to restrictive diets or those with high physical demands.[\[10\]\[11\]](#) The hereditary condition known as hyperlysinemia, which results from metabolic dysfunctions leading to elevated lysine levels, poses additional health risks, including neurological disabilities.[\[12\]\[13\]](#) Consequently, while most individuals typically meet their lysine needs through diet, supplementation may be beneficial in specific cases, although it is advised to avoid excessive intake due to potential adverse effects.[\[11-\]\[14\]](#)

Research continues to explore lysine's potential therapeutic applications, particularly in the realms of anxiety reduction and herpes simplex virus management, where supplementation has demonstrated promise.[\[15\]\[7\]](#) As scientific inquiry into this essential amino acid evolves, its multifaceted roles in health and disease underscore the importance of maintaining adequate lysine levels for optimal well-being.

Chemical Structure

Lysine is a diamino acid with the chemical formula $C_6H_{14}N_2O_2$, specifically identified as L-lysine or (2S)-2,6-diaminohexanoic acid[\[1\]\[2\]](#). Its structure consists of a central carbon atom (the α -carbon) to which an amino group (NH_2), a carboxyl group ($COOH$), a hydrogen atom, and a unique organic side chain (the ϵ -amino group) are attached[\[16\]\[17\]](#). The ϵ -amino group is what distinguishes lysine from other amino acids and is responsible for its basic properties[\[12\]](#).

As an essential amino acid, lysine plays a crucial role in protein synthesis and is necessary for various metabolic processes. The presence of the additional amino

group makes lysine positively charged at physiological pH, influencing its interactions within proteins and contributing to its hydrophilic character[\[17\]\[18\]](#). The unique side chain also allows lysine to participate in hydrogen bonding and ionic interactions, which are vital for protein folding and stability[\[19\]\[12\]](#).

Biological Role

Lysine is one of the nine essential amino acids required by the human body and plays several critical roles in maintaining health and supporting physiological functions. As an essential amino acid, lysine must be obtained through dietary sources, as the human body cannot synthesize it independently[\[3\]\[4\]](#).

Protein Synthesis

The primary role of lysine in the body is to participate in protein synthesis, which is vital for the growth, repair, and maintenance of tissues. Proteins, composed of long chains of amino acids, perform numerous functions, including serving as enzymes, hormones, and antibodies. Lysine contributes significantly to the formation of collagen, a key protein in connective tissues, skin, and bones. This is particularly important for individuals with conditions such as osteoarthritis, where adequate lysine intake is essential for regenerating damaged cartilage[\[20\]\[3\]\[5\]](#).

Neurotransmitter Synthesis

In addition to its structural roles, lysine is involved in the synthesis of neurotransmitters, which are crucial for proper brain function. Neurotransmitters like serotonin and dopamine depend on lysine for their production, thereby influencing mood and cognitive function. The amino acid's involvement in neurotransmitter synthesis highlights its importance not only for physical health but also for mental well-being[\[3\]\[5\]](#).

Immune Function and Metabolism

Lysine also plays a role in enhancing the immune response and is involved in various metabolic processes. It participates in the production of antibodies and aids in nutrient transport and metabolism, including one-carbon unit metabolism, which is vital for DNA synthesis and cellular redox signaling[\[6\]](#). Moreover, lysine has been shown to exert anti-oxidative responses, further underscoring its importance in overall health maintenance[\[6\]](#).

Dietary Sources and Requirements

Lysine can be sourced from both animal and plant-based foods, with animal products such as meat, eggs, and dairy being particularly rich in this amino acid. For those following vegetarian or vegan diets, it is crucial to combine various incomplete protein sources, such as legumes, grains, and nuts, to ensure adequate lysine intake[\[5\]\[4\]](#). The recommended dietary allowance for lysine varies based on age, sex, and

physiological status, but ensuring sufficient lysine intake is fundamental for optimal health and well-being[\[3\]](#).

Dietary Sources

Lysine is an essential amino acid that plays a critical role in various biological processes. It is primarily obtained through dietary sources, which can be categorized into animal and plant-based foods.

Animal-Based Sources

The richest dietary sources of lysine are animal products, particularly:

Meat: Red meat, poultry, and pork are excellent sources of lysine.[\[8\]](#)

Dairy Products: Cheese, especially Parmesan, and other dairy items like cottage cheese contribute significantly to lysine intake.[\[8\]](#)

Eggs: Eggs are a high-quality source of lysine and are commonly included in diets.[\[8\]](#)

Fish: Certain types of fish, such as cod and sardines, are also notable sources of this essential amino acid.[\[8\]](#)

These animal-based foods provide lysine in a bioavailable form, making them effective for meeting daily nutritional requirements.

Plant-Based Sources

For those following vegetarian or vegan diets, several plant-based sources can help fulfill lysine needs, although they typically contain lower amounts than animal products.

Legumes: Beans, lentils, and soybeans are good sources of lysine, making them vital components of plant-based diets.[\[8\]](#)

Wheat Germ: This part of the wheat kernel contains a significant amount of lysine compared to other cereal grains.[\[9\]](#)

Nuts and Seeds: While not as rich in lysine, various nuts can contribute to overall intake.[\[9\]](#)

Spirulina: This blue-green algae is often consumed in powdered or tablet form and is a good source of lysine for vegetarians and vegans.[\[9\]](#)

Additionally, pseudocereals such as quinoa and amaranth, while not produced in large quantities, also provide lysine, albeit at lower levels compared to legumes and soy products.[\[8\]](#)

Recommended Intake and Supplementation

Most individuals, including those on vegetarian diets, typically meet their daily lysine requirements through regular dietary consumption and do not require supplementation. However, lysine supplements are available and are generally safe when taken at recommended doses, with typical daily intake not exceeding 3 grams to avoid

potential digestive issues.[\[9\]](#) High doses may lead to side effects such as diarrhea, nausea, and stomach cramps if taken in excess.[\[9\]](#)

Health Benefits

Lysine, an essential amino acid, is associated with various health benefits that contribute to both physical and mental well-being.

Deficiency and Health Implications

Lysine deficiency can have significant adverse effects on health, primarily affecting protein synthesis and other critical bodily functions. It is most commonly observed in non-Western societies and can manifest as protein-energy malnutrition, leading to systemic health issues[\[12\]\[10\]](#). Symptoms of lysine deficiency include fatigue, poor concentration, irritability, slowed growth, red eyes, nausea, anemia, reproductive issues, and high blood pressure[\[15\]\[11\]](#).

Causes of Deficiency

Individuals who are at a higher risk of lysine deficiency include those following restrictive diets, such as vegans, and athletes with high training volumes, who may not consume adequate amounts of lysine-rich foods[\[11\]\[13\]](#). Foods rich in lysine include red meats, poultry, dairy products, fish, eggs, soybeans, lentils, and other legumes[\[15\]\[10\]](#).

Health Implications

In addition to the immediate symptoms, lysine deficiency can lead to long-term health issues, including immune dysfunction and growth retardation, highlighting the necessity for a balanced diet rich in lysine sources[\[10\]\[11\]](#). Moreover, a hereditary condition known as hyperlysinemia arises from mutations in enzymes responsible for lysine metabolism, leading to elevated lysine levels in the blood, which can result in neurological disabilities in severe cases[\[12\]\[13\]](#).

Supplementation

For those unable to meet their lysine needs through diet alone, supplementation may be beneficial. L-lysine is the most commonly used form in supplements and has been shown to aid in reducing the recurrence of herpes simplex virus infections, improve calcium absorption, and potentially enhance wound healing[\[11\]\[14\]\[21\]](#). However, it is important to note that lysine supplementation is generally safe for most individuals, but it is not recommended for those with hyperlysinemia[\[11\]\[13\]](#).

Research and Studies

Health Benefits

Lysine has been extensively studied for its potential health benefits, particularly in relation to calcium absorption and bone health. Research indicates that lysine increases intestinal absorption of calcium and reduces its renal excretion, which may play a significant role in the management of osteoporosis and in promoting bone density.[\[4\]\[7\]](#). Furthermore, lysine is involved in the cross-linking process of collagen in bones, potentially enhancing bone strength and structure.[\[7\]](#) A study highlighted that lysine deficiency can lead to increased anxiety, and supplementation may help lower stress and anxiety levels in deficient individuals.[\[15\]](#)

Cardiovascular Effects

Emerging evidence suggests that lysine may exert positive cardiovascular effects by blocking a lysine-binding domain on lipoprotein(a), which could be beneficial for blood pressure regulation and may lower the incidence of stroke.[\[7\]](#) In animal studies, female Sprague-Dawley rats on a lysine-supplemented diet exhibited significantly lower cholesterol levels, indicating that lysine may improve lipid profiles and the biological value of protein consumed.[\[7\]](#)

Osteoporosis Research

Specific investigations into lysine's role in osteoporosis have shown that it not only aids in calcium absorption but also helps in bone growth and collagen production.[\[15\]](#) A single-blind, placebo-controlled pilot study on patients with schizophrenia indicated a significant reduction in symptoms with lysine supplementation, suggesting potential psychiatric benefits as well.[\[7\]](#)

Clinical Trials and Dosage

Clinical trials have utilized various dosages of lysine, ranging from 312 mg to 4 g daily for different conditions, including the prevention and treatment of herpes simplex infections and the management of anxiety and hypertension.[\[15\]](#) A pilot study using 6 g/day of lysine for schizophrenia showed notable improvement, warranting further investigation into lysine's broader therapeutic applications.[\[7\]](#)

Biosynthesis of Lysine

Lysine biosynthesis occurs through two primary metabolic pathways: the diaminopimelate (DAP) pathway and the alpha-aminoadipate (AAA) pathway. The DAP pathway is predominantly found in eubacteria, some archaea, and plants, while the AAA pathway is present in fungi, yeast, and certain protists[\[22\]\[23\]](#).

Diaminopimelate (DAP) Pathway

The DAP pathway initiates with a condensation reaction between L-aspartate semi-aldehyde and pyruvate, catalyzed by dihydrodipicolinate synthase (DHDPS). This reaction produces (4S)-4-hydroxy-2,3,4,5-tetrahydro-(2S)-dipicolinic acid, which is subsequently reduced to 2,3,4,5-tetrahydrodipicolinate (THDP) by dihydrodipicolinate reductase (DHDPR) using NAD(P)H as a reducing agent. The pathway further diverges into several variants that utilize different enzymes, such as the acetylase, aminotransferase, dehydrogenase, and succinylase pathways[24][25][12].

The DAP pathway is crucial not only for lysine biosynthesis but also for the synthesis of other amino acids including threonine, methionine, and isoleucine[26].

Alpha-Aminoadipate (AAA) Pathway

The AAA pathway begins with the condensation of ~~α~~ketoglutarate and acetyl-CoA, leading to the formation of ~~α~~aminoadipate as an intermediate. This pathway is characterized by its presence in yeast and certain fungi, and it has been shown to involve multiple enzymes, including homocitrate synthase (HCS) and homoaconitase (HAc) during its early stages[12][27][28]. The pathway then proceeds through a series of enzymatic reactions involving lysine-specific enzymes like LysX, LysY, LysZ, and others, ultimately converting ~~α~~aminoadipate into lysine[29].

Both pathways reflect the evolutionary diversity of organisms and their adaptations to synthesize this essential amino acid, which plays a significant role in protein synthesis and overall metabolic functions[30][24]. As lysine is an essential amino acid for higher organisms, it must be obtained through dietary sources, making the understanding of its biosynthesis particularly important in nutrition and metabolic studies[30].

References

- [1]: [Lysine Hydrochloride | C6H15CIN2O2 | CID 69568 - PubChem](#)
- [2]: [Lysine \(Compound\) - Exposome-Explorer](#)
- [3]: [Essential Amino Acids: Chart, Abbreviations and Structure](#)
- [4]: [Lysine - Amino Acids - The Biology Project](#)
- [5]: [Lysine - Wikipedia](#)
- [6]: [Amino Acid Physical Properties | Thermo Fisher Scientific - US](#)
- [7]: [Lysine Supply Is a Critical Factor in Achieving Sustainable Global ...](#)
- [8]: [Plant-Based Lysine: Do You Need Meat To Get Enough Lysine?](#)
- [9]: [Top 11 High-Lysine Foods: Dietary Tips - Season Health](#)
- [10]: [L-lysine dietary supplementation for childhood and adolescent growth](#)
- [11]: [Amino Acid: Benefits & Food Sources - Cleveland Clinic](#)
- [12]: [Dietary requirements of synthesizable amino acids by animals](#)
- [13]: [Lysine Information | Mount Sinai - New York](#)
- [14]: [Lysine health benefits: Evidence and food sources](#)
- [15]: [Lysine Metabolism: Pathways, Regulation, and Biological Significance](#)

- [16]: [Lysine: What Is It, Benefits, Sources, Side Effects | Ro](#)
- [17]: [Top Foods High In Lysine: Benefits, Risks, And More | Nourish](#)
- [18]: [Hyperlysinemia - Genetics - MedlinePlus](#)
- [19]: [L-lysine dietary supplementation for childhood and adolescent growth](#)
- [20]: [Low-quality protein modulates inflammatory markers and the ...](#)
- [21]: [Lysine Uses, Benefits & Dosage - Drugs.com](#)
- [22]: [A schematic representation of the AAA and DAP lysine biosynthesis...](#)
- [23]: [The evolutionary history of lysine biosynthesis pathways within ...](#)
- [24]: [The coordinated action of the enzymes in the L-lysine biosynthetic ...](#)
- [25]: [Methanococci Use the Diaminopimelate Aminotransferase \(DapL ...](#)
- [26]: [MetaCyc L-lysine biosynthesis I](#)
- [27]: [Biosynthesis of diaminopimelate, the precursor of lysine ... - PubMed](#)
- [28]: [Molecular Evolution of the Lysine Biosynthetic Pathways](#)
- [29]: [Lysine Biosynthesis of Thermococcus kodakarensis with the ...](#)
- [30]: [What Is Lysine? Other Names: Hydrochlorure de L-Lysine, Lisina, Lys](#)
- [undefined]: [Lysine: Benefits and How to Get It - Verywell Health](#)