

# Threonine

## Table of Contents

summary

Chemical Structure

- Stereochemistry

Biochemical Role

- Metabolism and Absorption

- Pathways and Functions

Dietary Sources

- Animal Sources

- Plant Sources

- Recommended Daily Intake

Health Benefits

- Digestive Health

- Neurological Function

- Immune System Support

- Muscle and Bone Strength

- Liver Health

- Additional Benefits

Deficiency

- Threonine Deficiency and Its Implications

- Groups at Risk

Supplementation

- Potential Benefits

- Safety and Side Effects

Research and Studies

- Overview of Threonine in Human Nutrition

- Threonine's Role in Tuberculosis Treatment

- Amino Acid Requirements and Threonine

Check <https://storm.genie.stanford.edu/article/1153090> for more details

The generated report can make mistakes.  
Please consider checking important information.  
The generated content does not represent the developer's viewpoint.

## summary

Threonine is an essential amino acid, denoted by the chemical formula  $C_4H_9NO_3$ , that plays a vital role in human metabolism and protein synthesis. As one of the building blocks of proteins, threonine is crucial for maintaining healthy connective tissues, skin integrity, and various biochemical processes in the body.[\[1\]\[2\]](#) It is particularly notable for its involvement in synthesizing important proteins such as collagen and elastin, as well as aiding in fat metabolism and supporting immune function.[\[3\]\[4\]](#)

Threonine exists in several stereoisomeric forms, including L-threonine and D-threonine, with the naturally occurring form, (2S,3R)-threonine, being biologically active and widely found in proteins.[\[5\]\[6\]](#) The chirality of threonine is significant, as it can influence the amino acid's biochemical interactions and overall physiological functions.[\[6\]](#) Deficiency in threonine can lead to a range of health issues, including muscle weakness, impaired immune response, and liver dysfunction, which highlights its importance in a balanced diet.[\[7\]\[8\]](#)

Dietary sources of threonine are primarily found in animal proteins, including meat, dairy, and eggs, although plant-based sources such as legumes and whole grains can also provide this amino acid for those adhering to vegetarian or vegan diets.[\[9\]\[10\]](#) Despite its availability in various foods, certain populations, such as older adults and individuals with chronic illnesses, may be at risk of threonine deficiency, necessitating careful dietary considerations to ensure adequate intake.[\[11\]\[12\]](#)

Research continues to explore threonine's broader implications in health, including its potential benefits for digestive health, neurological function, and overall metabolic regulation.[\[13\]\[14\]](#) Furthermore, threonine supplementation is being investigated for its therapeutic potential in various medical conditions, including muscle disorders and immune-related diseases, making it a subject of significant interest in nutrition and health sciences.[\[4\]\[15\]](#)

## Chemical Structure

Threonine is an amino acid with the chemical formula  $C_4H_9NO_3$ , which includes an amino group ( $-NH_2$ ), a carboxyl group ( $-COOH$ ), and a hydroxyl group ( $-OH$ ) as part of its structure[\[1\]\[16\]](#). Its molar mass is approximately 119.12 g·mol<sup>-1</sup>[\[17\]](#). Threonine exists in several stereoisomeric forms, including L-threonine and D-threonine, due to the presence of two chiral centers at the second and third carbon atoms of its linear structure[\[6\]\[18\]](#).

## Stereochemistry

Threonine has four possible stereoisomers due to its two chiral centers: L-threonine, D-threonine, L-allothreonine, and D-allothreonine. The naturally occurring form is (2S,3R)-threonine, which is biologically active and commonly found in proteins[\[5\]\[6\]\[19\]](#). The stereoisomers can be categorized into two pairs of enantiomers: L-threonine is the mirror image of D-threonine, while L-allothreonine is the mirror image of D-allothreonine[\[18\]](#).

The chirality of threonine is significant as it affects the amino acid's biological function and properties. Each stereoisomer can exhibit different interactions in biochemical processes, underscoring the importance of stereochemistry in molecular biology[\[6\]](#).

## Biochemical Role

Threonine is an essential amino acid that plays a crucial role in various biochemical processes within the human body. It is significant for the synthesis of proteins, collagen, and elastin, which are vital for maintaining healthy connective tissues and skin integrity[\[2\]\[3\]](#). Additionally, threonine contributes to fat metabolism by aiding lipotropic function, which helps regulate the breakdown of fats in the liver, thus preventing fat accumulation and reducing the risk of liver failure[\[11\]\[8\]\[4\]](#).

## Metabolism and Absorption

Threonine is involved in metabolic pathways that are essential for nutrient absorption. It aids in the production of a protective gel layer in the digestive tract, which supports the function of digestive enzymes. This layer enhances the breakdown of nutrients from ingested food, promoting overall gut health and efficient nutrient absorption[\[11\]\[7\]](#). Furthermore, threonine assists in maintaining the balance of proteins within the body, ensuring that amino acids are available for various physiological functions[\[20\]](#).

## Pathways and Functions

In humans, threonine primarily follows the dehydratase pathway for its metabolism. However, during periods of fasting or high protein intake, alternative metabolic pathways may also become significant, indicating the flexibility of threonine's role in energy and protein metabolism[\[3\]\[4\]\[21\]](#). Beyond its involvement in metabolism, threonine also supports immune function and gut health, highlighting its multifaceted role in maintaining overall health[\[4\]\[20\]](#).

## Dietary Sources

Threonine is an essential amino acid that must be obtained from dietary sources, as the human body cannot synthesize it. It is crucial for protein synthesis and plays various roles in metabolic pathways. The best sources of threonine are found in both animal and plant-based foods.

## Animal Sources

Animal proteins are among the richest sources of threonine. Foods such as meat, poultry, fish, eggs, and dairy products are particularly high in this amino acid. For instance, threonine is abundant in products like cheese, especially Swiss cheese, and is also present in significant amounts in meats such as beef, chicken, and fish[\[22\]\[3\]](#). Dairy products like milk and yogurt also contribute to threonine intake, providing a valuable source for those who include these foods in their diet[\[9\]\[10\]](#).

## Plant Sources

While plant sources typically contain lower concentrations of threonine compared to animal sources, they are still important, especially for individuals following vegetarian or vegan diets. Legumes such as lentils, soybeans, and peas are notable for their threonine content[\[9\]\[13\]](#). Whole grains, including whole wheat bread, oatmeal, and brown rice, also provide threonine, making them beneficial for a balanced diet[\[10\]\[13-1\]](#). Additionally, nuts and seeds contribute to threonine intake, with foods like sesame seeds, walnuts, and peanuts being good examples[\[23\]](#).

## Recommended Daily Intake

Although there is no officially established recommended daily intake (RDI) for threonine, it is classified as an essential amino acid. Adequate intake levels can vary based on factors such as age and health status. Generally, adults are advised to consume approximately 40-60 mg of threonine per kilogram of body weight per day, with varying needs for infants and children based on their developmental stages[\[13\]](#). Incorporating a diverse array of protein sources can help ensure adequate threonine intake along with other essential nutrients.

## Health Benefits

Threonine is an essential amino acid that plays a critical role in various bodily functions and health benefits. Its intake is vital for maintaining overall well-being, as it is involved in protein synthesis, immune function, and metabolic regulation.

### Digestive Health

Threonine is essential for supporting digestive health. It promotes the protective effects of the gut mucus barrier, thereby enhancing gut function. Furthermore, it influences the secretion of immunoglobulin A (IgA), which is important for gut immunity, and can modulate inflammatory cytokine expression[\[10\]\[3\]](#).

### Neurological Function

Research indicates that threonine may be beneficial for neurological health. It is involved in the synthesis of neurotransmitters, which are crucial for proper nervous system function. Abnormalities in threonine metabolism have been linked to neurodegenerative diseases, suggesting that adequate threonine levels could play a protective role against such conditions[\[24\]\[14\]](#).

## Immune System Support

Threonine contributes significantly to immune health by aiding in the production of antibodies and other immune cells. This amino acid supports the immune system's ability to protect against illness and infection, making it a crucial nutrient for maintaining immune function[\[13\]\[10\]](#).

## Muscle and Bone Strength

This amino acid is involved in muscle tissue formation, collagen, and elastin production, which are critical for muscle and connective tissue strength. Threonine supplementation may improve muscle contractions and overall muscle performance, contributing to better exercise recovery and enhanced physical performance[\[2\]\[13\]-\[14\]\[25\]](#).

## Liver Health

Threonine plays a role in liver health by assisting in the removal of waste products from the liver. It acts as a lipotropic agent, helping to control fat buildup in the liver and maintaining mitochondrial function[\[13\]\[3\]](#). A deficiency in threonine may lead to altered energy processing and increased liver fat, potentially impacting metabolic health[\[13\]\[25\]](#).

## Additional Benefits

Threonine may also help improve exercise performance, wound healing, and alleviate symptoms of anxiety and mild depression[\[4\]\[14\]](#). Higher serum levels of threonine have been associated with better healing outcomes in diabetic patients, further highlighting its importance in recovery processes[\[12\]\[25\]](#).

## Deficiency

Threonine deficiency is relatively rare among individuals consuming a balanced diet, as this amino acid is abundant in animal products. However, populations such as vegans and vegetarians may be at risk of inadequate threonine intake due to the lower concentrations of this amino acid in plant-based foods[\[7\]\[26\]](#).

## Threonine Deficiency and Its Implications

The deficiency of threonine can lead to various health issues.

Muscle weakness and fatigue

Increased susceptibility to infections due to a compromised immune system

Slower wound healing processes

Development of fatty liver conditions[\[7\]\[8\]](#).

Early recognition of these symptoms is crucial to prevent further complications associated with threonine deficiency[\[27\]](#).

## Groups at Risk

Certain demographics are more likely to experience threonine deficiency.

**Vegans and Vegetarians:** Plant-based diets may not provide adequate levels of threonine, increasing the risk for those who do not consume animal products.

**Older Adults:** Age-related changes in metabolism and dietary intake may contribute to lower threonine levels.

**Individuals with Chronic Illnesses:** Certain medical conditions can affect the body's ability to utilize threonine effectively, leading to deficiency[\[11\]](#)[\[12\]](#).

Addressing dietary gaps and ensuring sufficient intake of threonine is particularly important for these at-risk groups to maintain optimal health and metabolic function.

## Supplementation

Threonine supplementation can provide various health benefits and support numerous bodily functions. As an essential amino acid, threonine is crucial for protein synthesis, collagen production, immune system function, and gut health[\[4\]](#)[\[28\]](#). It may also assist in muscle contractions and enhance athletic performance by contributing to muscle rebuilding processes[\[15\]](#)[\[29\]](#).

## Potential Benefits

Research suggests that threonine supplementation may help improve muscle spasticity in certain neurological conditions, including amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS) [\[4\]](#)[\[9\]](#). It may also promote better sleep and reduce symptoms of anxiety and mild depression[\[15\]](#). Additionally, threonine is important for digestive health, supporting the gut lining and overall immune function, which may further enhance nutrient absorption and metabolic health[\[2\]](#)[\[8\]](#).

## Safety and Side Effects

Threonine supplements are generally considered safe for most individuals when taken within recommended dosages, which may range from a few hundred milligrams to several grams per day depending on individual needs and purposes[\[3\]](#). However, excessive intake can lead to adverse effects, and those with underlying health conditions or those taking certain medications should consult with healthcare professionals before starting supplementation[\[4\]](#)[\[3\]](#). For instance, individuals taking memantine (Namenda), a medication for Alzheimer's, should avoid threonine due to potential interactions[\[4\]](#).

Notably, while threonine supplementation may be beneficial, dietary sources such as meat, fish, dairy, and legumes can also provide adequate threonine without the associated risks of high-dose supplements[\[28\]](#). Symptoms of threonine deficiency



can include digestive issues, muscle weakness, and impaired immune function, underscoring the importance of adequate threonine intake[3].

## Research and Studies

### Overview of Threonine in Human Nutrition

Threonine, an essential amino acid, plays a crucial role in various physiological processes, including protein synthesis, immune function, and the maintenance of gut health. Its requirement in human nutrition is particularly significant, as deficiencies can lead to impaired growth and immune responses[30][16]. Research has indicated that threonine is vital for the synthesis of proteins involved in immune responses, thereby underscoring its importance in dietary formulations[31].

### Threonine's Role in Tuberculosis Treatment

Recent studies have investigated the relationship between threonine and tuberculosis (TB). It has been found that certain amino acids, including threonine, may influence the outcome of TB treatment by enhancing immune function and supporting the overall health of patients[32]. A study noted that specific nutritional interventions could provide benefits for TB patients, including enhanced recovery rates[33]. For instance, one research highlighted the significance of amino acids like threonine in conjunction with other nutrients to optimize treatment outcomes for those affected by TB[12].

### Amino Acid Requirements and Threonine

The dietary requirements for threonine have been studied extensively, with various guidelines suggesting intake levels that support overall health and metabolic functions. For adults, recommendations are based on the amino acid composition of common dietary sources and the body's physiological needs[23]. In comparison to other amino acids, threonine has shown to be essential not only for protein synthesis but also for the production of other critical biomolecules that facilitate metabolic processes in the body[2].

## References

- [1]: [Threonine - the NIST WebBook](#)
- [2]: [Threonine - Wikipedia](#)
- [3]: [L-Threonine | 98%\(HPLC\) | In Stock - Selleck Chemicals](#)
- [4]: [Threonine, an amino acid, has four stereoisomers. The ... - Pearson](#)
- [5]: [5.6: Diastereomers - Chemistry LibreTexts](#)
- [6]: [\[PDF\] Threonine: An Amino Acid Autonomous Molecular Assembly](#)
- [7]: [L-Threonine - American Chemical Society](#)

- [8]: [Threonine: The Amino Acid Needed for Collagen Production - Dr. Axe](#)
- [9]: [Threonine | Rupa Health](#)
- [10]: [Threonine Benefits: 5 Important Facts About this Amino Acid](#)
- [11]: [Threonine Benefits: 5 Important Facts About this Amino Acid](#)
- [12]: [What Is Threonine? Role, Benefits, And Side Effects](#)
- [13]: [Threonine Benefits: 5 Important Facts About this Amino Acid](#)
- [14]: [Threonine | C<sub>4</sub>H<sub>9</sub>NO<sub>3</sub> | CID 6288 - PubChem](#)
- [15]: [MetaCyc L-threonine Biosynthesis - BioCyc](#)
- [16]: [Amino Acid: Benefits & Food Sources - Cleveland Clinic](#)
- [17]: [Threonine: Definition, Structure, Benefits, Sources and Uses](#)
- [18]: [Threonine - Nutrivore](#)
- [19]: [What is L-Threonine used for? - Kemiex](#)
- [20]: [Threonine - Lab Results explained - HealthMatters.io](#)
- [21]: [Overview of Threonine Metabolism - Creative Proteomics](#)
- [22]: [Amino Acids - WebMD](#)
- [23]: [Threonine Health Benefits: The Essential Amino Acids Guide](#)
- [24]: [The Role of Amino Acids in Tuberculosis Infection: A Literature Review](#)
- [25]: [Threonine Benefits: 5 Important Facts About this Amino Acid](#)
- [26]: [Threonine Benefits: 5 Important Facts About this Amino Acid](#)
- [27]: [Threonine - Lab Results explained - HealthMatters.io](#)
- [28]: [4 Must-Have Benefits Of Threonine - Swolverine](#)
- [29]: [4 Must-Have Benefits Of Threonine - Swolverine](#)
- [30]: [The Mycobacterium tuberculosis serine/threonine kinases PknA and ...](#)
- [31]: [AMINO ACID SCORING PATTERNS](#)
- [32]: [Reasoning of generation of threonine indispensability in humans ...](#)
- [33]: [Potential Role of Vitamins A, B, C, D and E in TB Treatment ... - MDPI](#)