

# 100 Questions about Vitamin C



The Linus Pauling Institute receives many questions about vitamin C and its role in human health. If you do not see an answer to your question here, see the [Additional Resources](#) section for more information.

## Table of Contents

[Recommendations for Vitamin C](#)

[Different Forms of Vitamin C](#)

[Intravenous Vitamin C](#)

[Additional Considerations of Vitamin C Supplementation](#)

[Biological Roles of Vitamin C](#)

[Illnesses, Diseases, and Conditions](#)

[Cancer](#)

[Immune System/COVID-19](#)

[Research and Clinical Studies](#)

[Additional Information](#)





## Recommendations for Vitamin C

### 1. What is the definition of vitamin status?

In general, vitamin status is an indicator of the amount of vitamin that is present in the body – how it is measured is different from vitamin to vitamin. For vitamin C, we use plasma or blood as a general indicator of vitamin C status, but tissue levels may be important for specific diseases. Unfortunately, measuring tissue levels of vitamin C are technically challenging.

### 2. What is the recommendation for blood levels of vitamin C?

It is hard to put specific values on blood levels because everyone will max out at a different level, depending on various factors in their body. Some guidelines suggest a blood concentration of 60 micromoles/L is sufficient to maximize antioxidant protection from vitamin C.



### **3. How can I test my body for vitamin C levels?**

The only reliable way to test vitamin C levels is through research laboratories that specialize in this test. Blood tests that are ordered by a doctor (clinical labs) can be difficult to interpret – sometimes the blood levels come back low, and might need to be repeated several times to get an accurate picture of vitamin C status. However, the only alternative is to use urine testing strips for vitamin C, as vitamin C will be present in the urine if you are consuming more than your body can utilize.

### **4. To maintain a high blood level, should vitamin C supplements be taken twice a day?**

Yes. You could even argue that more often is better, but taking frequent vitamin C supplements may be impractical. [Evidence shows](#) that doses of 200 mg or less are completely absorbed. Doses of 500 mg are about 75% absorbed. To maximize absorption, most experts recommend splitting doses of vitamin C throughout the day. It is important to note that health benefits from splitting doses have not been adequately researched, and the health benefits are theoretical.

### **5. Do athletes (i.e., people who do a lot of moderate and intense physical activity each week) have an increased need for vitamin C?**

Physical activity does create an oxidative stress burden, so extra vitamin C is certainly one way to combat that stress. However, it does not appear that large amounts of vitamin C are needed to compensate – indeed, it is likely possible to get enough through the diet without the need for supplements.

### **6. Do older adults need extra vitamin C on a daily basis?**

Unfortunately, we really don't know the answer. The information we have is limited to young and healthy adults. There is [some evidence](#) that vitamin C blood levels in older adults are lower than younger adults, either because they have a harder time absorbing vitamin C or they may metabolize vitamin C faster.



**7. Because vitamin C is water soluble, is the body capable of removing excess vitamin C without causing harm when taken at high doses?**

Even with intravenous infusions of 100-gram doses, the body simply filters out the extra vitamin C. This is one of the reasons that vitamin C infusions are performed over hours, because the body is so efficient at getting rid of the excess from the bloodstream.

However, that does not mean intravenous vitamin C is entirely harmless. There are precautions that should be taken before receiving intravenous vitamin C. See question #39 (Could intravenous vitamin C cause problems for some patients?).

**8. Are sustained/time-release forms of vitamin C supplements better?**

Sustained release vitamin C may be less absorbed [than other forms](#). Although the data are limited, the sustained-release formulation does not seem to be particularly useful in boosting absorption. It would probably be more effective (and cheaper) to take multiple doses throughout the day than use a sustained-release formula.

**9. Is dietary vitamin C enough for individuals with healthy immune systems?**

The Linus Pauling Institute recommends a daily multivitamin supplement. The amount of vitamin C contained in multivitamin supplements, combined with the recommended daily intake of 5-7 servings of fruit and vegetables, is a sufficient amount for individuals with healthy immune systems if vitamin C-rich foods are included (like kiwifruit, citrus fruit, and bell peppers).

**10. How much vitamin C is safe to take daily for an adult?**

The tolerable upper intake level of vitamin C is 2,000 mg/day due to reported gastrointestinal side effects when consuming above this amount. The amount of vitamin C that causes these effects may vary from person to person. These side effects are generally not serious and usually resolve by reducing vitamin C intake.



**11. Has there been any demonstrated difference between someone taking 2 grams, 5 grams, or 20 grams vitamin C per day?**

Not really, although this is an area of research that needs further development. The evidence that does exist on this topic is poor. While a [few papers suggest](#) that high doses of vitamin C (2 grams or more per day) reduce the duration of the common cold, we caution that these trials are nearly 40 years old and not well conducted.

**12. How much vitamin C would be best to take each day?**

That is debated in the vitamin C community. While the Linus Pauling Institute backs the science-based recommendation of 400 mg of vitamin C (from all sources) each day, others suggest that more vitamin C is needed. Unfortunately, the scientific literature on this topic is limited.

**13. Why do your recommendations differ from Dr. Pauling's vitamin C intake recommendations?**

Dr. Pauling's recommendations were based on the limited human studies performed at the time, extrapolation from animal data, and some conjecture on the nature of vitamin C. He recommended that people look to optimize their vitamin C status. However, he admitted that "optimum" is difficult to define and speculated that it could be different from person to person.

Our recommendations are based on collective evidence from human studies on vitamin C. There are no documented health benefits associated with large doses of vitamin C supplements, especially in excess of the tolerable upper intake level. However, we do not advise people to stop any vitamin C supplementation regimen that they believe is helpful.

**14. When is the best time to take vitamin C, morning or night – with or without food?**

It does not seem to matter – do whatever works best for you.



**15. Is it important to take the same amount of vitamin C every day?**

In general, this is not important. Your body will not distinguish daily doses. The only exception to this is if you have been taking large doses (2 grams or higher) of vitamin C and suddenly stop. See question #49 (If one consistently takes high doses of vitamin C, are there any consequences of suddenly stopping?) for more information.

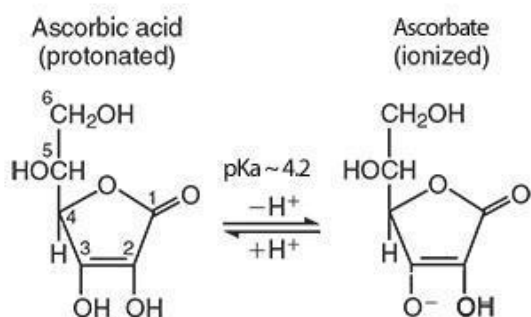




## Different Forms of Vitamin C

### 16. What is the difference between ascorbic acid and ascorbate?

The difference has to do with molecule ionization at different pH values. Ascorbic acid is the form of the molecule found at acidic pH, while ascorbate is the ionized form found at near-neutral pH and above (like in your blood).



On supplement labels, you may find vitamin C listed as ascorbic acid or mineral ascorbate salts (like sodium, magnesium, or calcium ascorbate). Essentially, this is just telling you what pH the molecule will be at when it is dissolved in water. Be careful with mineral ascorbates – because of their pH they are less stable in water. However, once in your stomach they will be stabilized by stomach acid.



**17. Could you please address the different formulations of vitamin C?**

There is little difference between different vitamin C formulations. Ester C or other “buffered” forms of vitamin C might help people who have heartburn when taking ascorbic acid. Liposomal vitamin C might increase bioavailability slightly (as discussed in the webinar). For more information, see our Micronutrient Information Center article on [supplemental forms of vitamin C](#).

**18. Is there any difference between natural and synthetic vitamin C?**

No. Natural and supplemental vitamin C are chemically the same and our bodies do not distinguish any difference between the sources.

Companies that sell “natural vitamin C” are usually making the claim that vitamin C is more than just ascorbic acid. However, we know that ascorbic acid is vitamin C because it alone (without any additional factors) can prevent and cure scurvy. Claims to the contrary are not supported by science.

**19. Are there any differences in the body when consuming synthetic vitamin C vs natural sources?**

No. [Studies](#) comparing the two in people have shown no differences. Dr. Anitra Carr has performed some of these studies and mentioned them briefly in our 2021 webinar on vitamin C and health (see Additional Resources, below).

It is important to note that “synthetic” vitamin C isn’t assembled from nothing – it is created by a mixture of microbial and chemical processes from naturally derived glucose.

**20. How is natural vitamin C listed on supplement labels?**

Natural vitamin C would need to come from a fruit or vegetable source, and would have to be labeled as such (for example, an extract of acerola). If you see “ascorbic acid” or any form of mineral ascorbates on the label, it is likely a synthetic source.



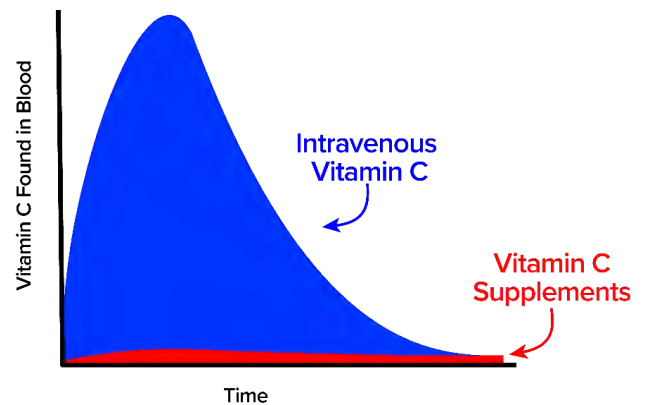


## 21. Is a vitamin C complex more effective than vitamin C as ascorbic acid?

The “vitamin C complex” is a marketing strategy to get people to take naturally sourced vitamin C over synthetic sources. There is no evidence that vitamin C taken in a natural form is superior to other forms.

## 22. If you cannot afford intravenous vitamin C, what is the next most effective, absorbable form?

In terms of blood vitamin C levels, no vitamin C supplement that you can take will compare to intravenous vitamin C. The differences between the two routes of administration are large. At present, it appears that the differences between liposomal and other supplemental forms [are marginal](#). On the figure provided here, blood vitamin C levels after taking liposomal vitamin C supplements would look indistinguishable from other vitamin C supplements.



## 23. Since the federal regulations are loose, how should consumers choose the correct brand of vitamin C?

The FDA has restricted manufacturers from making claims for treating illnesses without evidence. While they do not have to prove that supplements contain the exact amount of the ingredients listed on the label, some manufacturers do this voluntarily.

To help choose a quality supplement, pick one with a “NSF” or “USP” verification logo. These companies test the potency and purity of dietary supplements. Also,

Consumerlab.com (a paid service) has information on this

topic. You can also reach out to manufacturers for “Certificate of Analysis” (COA) to help verify your supplement does not contain any ingredients that you may not want to consume.



**24. Does it matter that most vitamin C comes from GMO corn?**

That depends on how you feel about GMO products. Vitamin C derived from corn sugar has none of the original source material left in it. In the end, the sugar has been converted to vitamin C, while other molecules that come from corn plants have been removed.

**25. When should I consider taking mineral ascorbate?**

Ascorbic acid may cause heartburn due to its acidity. Switching to a mineral ascorbate (such as sodium, potassium, calcium, or magnesium ascorbate) may reduce this side effect. People who are sensitive to sodium should avoid sodium ascorbate.

**26. How stable is ascorbic acid once added to liquid?**

The stability depends on the pH of the liquid. Any form of vitamin C is less stable in liquid than it would be in a dry powder. However vitamin C is more stable in acidic liquids than neutral ones. Ascorbic acid added to water is acidic, but sodium ascorbate (or other mineral ascorbates) will be near neutral pH when added to water.

Temperature can also be a factor. The stability of vitamin C increases in cold liquid.

**27. Is sublingual (under the tongue) vitamin C advantageous for higher absorption of oral vitamin C into the bloodstream vs swallowing?**

It is unclear if significant amounts of vitamin C can be absorbed through sublingual administration. If anyone tells you that this is superior to swallowing vitamin C, this is not a claim based on science.

**28. What is the most bioavailable form of vitamin C?**

For supplements, it is possible that liposomal vitamin C is better [absorbed](#), but this form of vitamin C has not been studied carefully. For food, it is unknown. However, in general terms, differences in bioavailability between sources of vitamin C to the next are considered negligible.



**29. How can we best make liposomal vitamin C on our own?**

While there are YouTube videos suggesting you can make your own liposomal vitamin C, it is unclear if that is really what is being produced. There has been no careful scientific analysis of “homemade” liposomal vitamin C.

**30. Is liposomal vitamin C mainly absorbed by the lymphatic system?**

There are many unfounded claims about liposomal vitamin C. Clinical trials are the only way to find out for sure, but many supplement manufacturers do not seek this evidence.

**31. What is the physiologic distribution of liposomal C vs. regular oral sodium ascorbate?**

Nobody knows. Liposomal vitamin C is poorly studied. All we really know is that it can deliver vitamin C in the bloodstream – nobody knows how well it delivers vitamin C to tissues. In all likelihood, it is the same as other vitamin C formulations.





## Intravenous Vitamin C

### 32. How is intravenous vitamin C different from oral?

Oral vitamin C (no matter what formulation you choose) will increase your blood vitamin C to the micromolar range. This is enough to maintain the amount in tissues and the bloodstream and body fluids for antioxidant defense.

Intravenous vitamin C increases your blood vitamin C concentrations to the millimolar level – which is at least 100 times higher (although can be up to 1,000 times higher) than oral vitamin C. At this level, vitamin C can take on some “pro-oxidant” properties, leading to the creation of hydrogen peroxide. It is this pro-oxidant effect that leads to the different effects with intravenous vitamin C. No amount of oral vitamin C can reproduce these effects.

### 33. What is the typical intravenous vitamin C dose?

The intravenous dose of vitamin C widely varies depending on who is administering it and the intent of its use. Intravenous vitamin C for disease treatment is higher than the treatment for replenishing vitamin C levels. Ultimately, it is up to the healthcare provider.



**34. Can I do intravenous vitamin C at home?**

Intravenous vitamin C should only be performed by a qualified medical practitioner who performs the required blood chemistry screens before administration, can monitor and respond to any adverse reactions and uses sterile, medical-grade vitamin C solutions.

**35. Is intravenous vitamin C effective in “boosting” the immune system?**

No. Although vitamin C is an essential component of the immune system, the scientific evidence does not show long-lasting benefits of using intravenous vitamin C to “boost” the immune system.

**36. Is intravenous vitamin C good for health maintenance and prevention?**

We don't know. Intravenous vitamin C has mostly been studied as a treatment for disease. Nobody has published any studies to look at intravenous vitamin C for general wellness.

**37. What are some additional considerations for taking intravenous vitamin C?**

Patients need to be pre-screened for a history of oxalate kidney stones and for [glucose-6-phosphate dehydrogenase deficiency](#) (also known as G6PD) to avoid complications. More studies need to be conducted to explore additional safety considerations.

**38. Can intravenously administered vitamin C be naturally sourced or is it strictly synthetic?**

We are unaware of any form of vitamin C for intravenous administration that comes from natural sources. However, anyone who claims there are significant differences between natural and synthetic vitamin C is not basing such claims on scientific evidence.



### **39. Could intravenous vitamin C cause problems for some patients?**

Intravenous vitamin C is generally considered safe, but specific cautions should be heeded by practitioners looking to administer this safely. See question #37 (What are some additional considerations for taking intravenous vitamin C?).

### **40. Why is Fenton chemistry apparently not an issue in intravenous vitamin C therapy?**

Fenton chemistry involves the donation of electrons from iron atoms to oxygen or hydrogen peroxide. When electrons are donated to hydrogen peroxide, it can form very harmful hydroxyl radicals. In the presence of vitamin C, this process can be accelerated. It is unclear if this is happening with intravenous vitamin C. One possibility is that iron is not available for this reaction – iron is often sequestered in the body to limit this type of reaction from happening.

### **41. If intravenous vitamin C is forming hydrogen peroxide, how does it decrease inflammation?**

Large amounts of intravenous vitamin C can be a pro-oxidant, but lower doses given for inflammatory conditions probably elicit antioxidant – rather than a pro-oxidant – effects.

### **42. Why not just inject hydrogen peroxide intravenously instead of vitamin C?**

There are several factors in the bloodstream that would quickly and effectively remove the hydrogen peroxide. Vitamin C, however, only creates hydrogen peroxide outside the bloodstream, and only when it is at high concentrations. It is thought that vitamin C acts this way in the “interstitial space” – a space that exists between blood vessels and tissues. Once hydrogen peroxide is generated, it can quickly flood into neighboring cells.





## Additional Considerations of Vitamin C Supplementation

### 43. Why does my stomach hurt after I take vitamin C supplements?

There are a couple of reasons this could be happening. The most likely scenario is that the acid from the supplement is causing problems with your stomach. In this case, you can switch to a different form of vitamin C such as potassium ascorbate – these “buffered” forms are not acidic.

Other ingredients in your vitamin C supplement could also cause stomach problems. In this case, it may be useful to switch formulations to take a supplement with different added material.

### 44. Is a vitamin C flush a good idea?

A “vitamin C flush” refers to taking large amounts of supplemental vitamin C in order to induce diarrhea. This is known as exceeding “bowel tolerance.” While some people suggest taking vitamin C to intentionally induce this effect, there is no evidence that this is beneficial.



#### **45. Can you overdose on vitamin C?**

Since vitamin C is quickly eliminated in urine and has very low toxicity, there is no such thing as a vitamin C overdose. Even large amounts of intravenous vitamin C do not show signs of toxicity in most individuals.

However, that doesn't mean there aren't any side effects of taking vitamin C supplements. See question #46 (Are there any side effects of taking too much vitamin C from supplements?).

#### **46. Are there any side effects of taking too much vitamin C from supplements?**

Some individuals experience gastrointestinal side effects (heartburn, nausea, gas, bloating, diarrhea) when taking high amounts of vitamin C. The tolerable upper intake level for vitamin C is 2,000 mg/day for adults.

#### **47. Do vitamin C supplements cause hardening of the arteries?**

There is no good evidence that vitamin C results in hardening of the arteries. Reports of such an association have been overblown. On the other hand, vitamin C consumption (primarily from food) has been associated with a reduced risk of arterial thickening, suggesting that vitamin C is not promoting stiffness in the arteries.

#### **48. If one consistently takes high doses of vitamin C, are there any consequences of suddenly stopping?**

If you are taking large doses of vitamin C (in excess of 1 or 2 grams per day) for long periods of time and abruptly stop, it could result in a feeling of fatigue or symptoms that resemble a cold.

If you have been taking high doses of vitamin C for a long period of time (more than a month), it is better to taper down your dose slowly than stop altogether.





**49. Do vitamin C supplements significantly increase the risk of calcium oxalate kidney stones forming?**

We have discussed this topic in the [vitamin C webpage](#) on the Micronutrient Information Center. In short, it might be a good idea for people who are prone to kidney stones to avoid taking large supplemental doses of vitamin C (of 1,000 mg or higher per day).

**50. Does vitamin C supplementation have any effect on pregnancy?**

Taking vitamin C supplements during pregnancy may reduce the risk of placental abruption. However, vitamin C does not seem to reduce the risk of other pregnancy complications.

The reports of vitamin C supplements causing preterm delivery have been overstated. There are no significant contraindications for vitamin C supplementation during pregnancy – nor is there any reason to take large doses.

For more information on the role of vitamin C during pregnancy, visit our [webpage](#).

**51. Can high doses of vitamin C supplements interfere with standard lab tests?**

High doses of vitamin C may interfere with certain types of blood glucose tests, urine analyses, and fecal occult blood tests. Always disclose the supplements that you are currently taking to your healthcare professional – they will be able to find out if the amount of vitamin C you are taking will interfere with your test..

**52. If I use a continuous glucose monitor (CGM), do I need to worry about vitamin C supplements interfering with the readings?**

Taking supplemental vitamin C [may incorrectly raise your CGM readings](#). It is important to contact your CGM manufacturer for more information.



### **53. Does vitamin C found in food interfere with statin usage?**

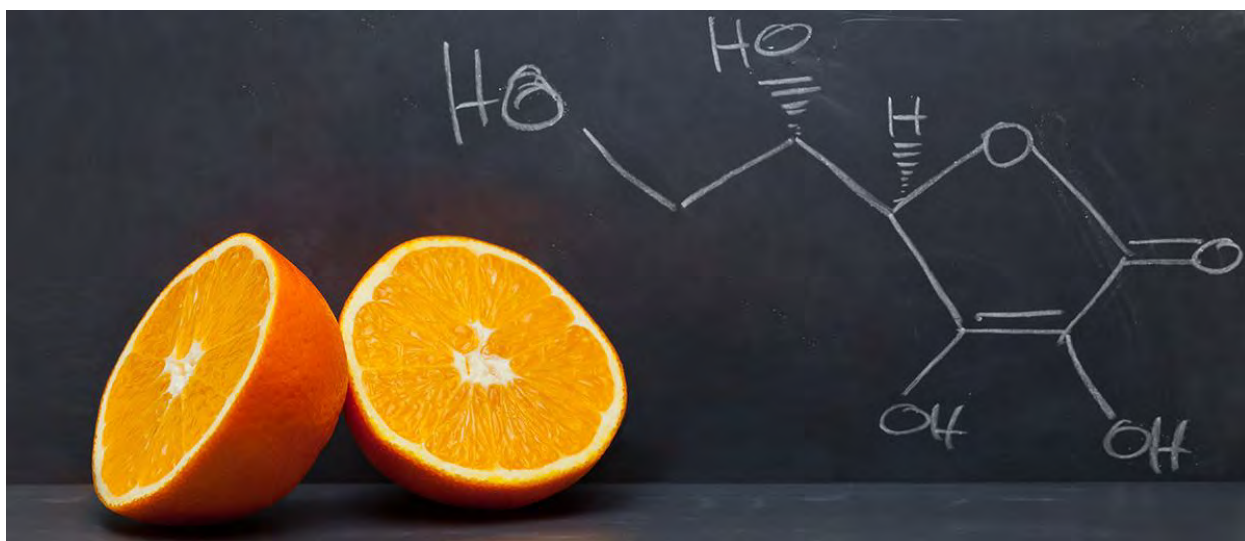
The interaction between vitamin C and statins have been overstated. One study indicated that a combination of antioxidant supplements might counteract [some effects of statins](#), but no study has investigated the effect of vitamin C supplements alone in statin users. In any case, most vitamin C-rich foods should not be an issue for statin users.

### **54. Can taking a vitamin C supplement interfere with the function of certain drugs (such as warfarin or aspirin)?**

High doses of vitamin C may interact with the action of certain drugs, but most of these interactions are [not considered severe](#). For example, it is recommended that people taking warfarin should limit their daily intake of vitamin C to less than 1,000 mg and should be monitored by their clinician because high doses may contribute to warfarin resistance over time.

Additionally, aspirin may interfere with the absorption of vitamin C. Therefore, people taking aspirin may wish to consider taking additional amounts of vitamin C.





## Biological Roles of Vitamin C

### 55. What is the mechanism of action of vitamin C?

This is a difficult question to answer in a biological system, as vitamin C likely has multiple modes of action. In general chemical terms, vitamin C is an electron donor. It can give electrons to iron or copper molecules found in proteins to fuel their enzyme reactions, it can give electrons to oxidized molecules to return them to a functional state, and it can donate electrons to free radicals to make them unreactive.

### 56. What is the role of vitamin C in cellular metabolism?

The roles of vitamin C in the cell are poorly understood, and a modern take on vitamin C in cellular metabolism is needed. Although [previous work](#) indicates that vitamin C is needed for a variety of enzymes in the body, it is unclear if vitamin C is specifically required or if other molecules can substitute for vitamin C in these reactions. Carnitine synthesis reactions appear to be one of those enzymatic reactions that can accept multiple antioxidants – vitamin C might be the most efficient, but others can take its place if vitamin C is lacking.



### 57. How is vitamin C involved in maintenance of connective tissue and bones?

Ascorbic acid is involved with the normal function of two enzymes involved in collagen production. These enzymes put a single oxygen onto either a proline or a lysine group found in a developing collagen chain, which prepares that chain for what is called a “cross-linking” reaction. These cross-links strengthen collagen and prevent it from falling apart when bending.

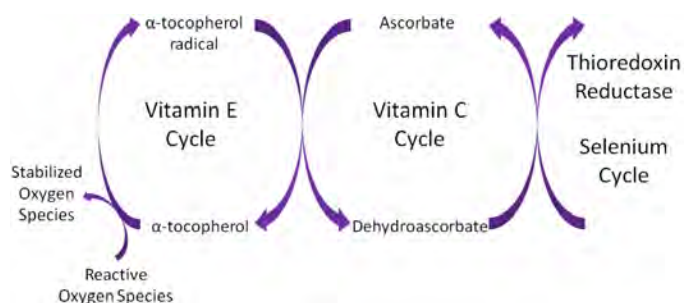
Collagen is an important part of cartilage and bone. If you don't get enough vitamin C, the structure of connective tissue and bone begins to weaken. However, this only happens after a long period of extreme vitamin C deficiency (known as scurvy).

### 58. How do blood vitamin C levels change as we age?

There is [some evidence](#) that vitamin C levels in the body decrease with age. We do not know if this is due to a decline in vitamin C absorption, an increase in vitamin C utilization, or an increase in vitamin C excretion. Older adults may want to consider additional sources of vitamin C, either through food or supplements.

### 59. How do vitamin C and E work together?

Vitamin E works as an antioxidant to protect against cell membrane damage, subsequently turning vitamin E into a free radical. Vitamin C can reduce the vitamin E free radical back into the active form of vitamin E.



During infection and increased oxidative damage, additional radicals are created and vitamin C and E work hand in hand to protect our bodies.



**60. Do vitamin C and vitamin D work together?**

Vitamin D is not an antioxidant, nor does it have any known chemical interactions with vitamin C. Vitamin D acts on the immune system in different ways than vitamin C, but the effects are thought to be complementary.

**61. Does vitamin C block absorption of B vitamins?**

No. Vitamin C can facilitate the degradation of vitamin B<sub>12</sub> when found in a liquid supplement, likely due to the production of oxidants in the presence of metal ions. However, in an acidic environment (like in your stomach), this does not happen. Vitamin C does not impede the absorption of other B vitamins.

**62. Is it a good idea to mix iron and vitamin C supplements?**

Vitamin C supplements can increase the absorption of nonheme iron (i.e., iron from supplements or plant sources). This can be especially beneficial for those with iron-deficiency anemia.

**63. What supplements should not be given concurrently with vitamin C?**

There are no known dietary supplements that interfere with vitamin C absorption, nor has vitamin C been shown to interfere with the absorption of any other supplement.

**64. Does caffeine alter vitamin C levels in the body? Does it inhibit absorption?**

As far as we know, there is no interaction between the two. There have been reports of interactions without any scientific basis for these claims.





## Illnesses, Diseases, and Conditions

### 65. How can vitamin C help in the treatment of autoimmune diseases?

Unfortunately, this has not been well studied. Vitamin C can help protect cells and aid in the body's defense against the free radicals formed in the inflammation process – a process often associated with autoimmune disorders. We do not know if vitamin C can diminish an autoimmune response.

### 66. What is the role of vitamin C in osteoarthritis and other degenerative disorders/diseases?

Vitamin C will help reduce the consequences of out-of-control inflammation. You can think of it as a shield for neighboring tissues that may reduce the intensity of symptoms. However, vitamin C is unlikely to directly treat these diseases.



### **67. Should we combine vitamin C and zinc for the treatment of respiratory infections?**

Vitamin C and zinc are important components of the immune system. The Linus Pauling Institute's recommended intake levels (at least 400 mg/day of vitamin C; 11 mg/day of zinc for men or 8 mg/day of zinc for women) are sufficient to maintain the immune system.

Additional amounts of these micronutrients may be helpful in the treatment of respiratory infections. Up to 1,000 mg/day of vitamin C and 20 mg/day of zinc are generally tolerable. These doses can be increased if no side effects are observed. It is generally advised to stay below 2,000 mg of vitamin C and 40 mg of zinc per day, but some studies have exceeded these amounts for short periods of time during an infection.

### **68. Since vitamin C is stored in the adrenal glands and released during stress, do vitamin C needs increase during chronic stress?**

There are indications that the body would need more vitamin C during stress, although the amount is unknown. Although the Linus Pauling Institute recommends getting at least 400 mg of vitamin C per day, taking larger amounts, especially if kept under 2,000 mg/day, is likely not going to cause any harm in the short term.

### **69. Can vitamin C help with diabetes management?**

[Research shows](#) that individuals with low vitamin C intake are at higher risk for developing type 2 diabetes. In addition, there are [some reports](#) that suggest vitamin C may help control blood glucose and hypertension related to diabetes. However, more evidence is needed before the standard recommendation is changed. It is important to follow the recommendations set by your doctor.



**70. What is the recommended dose of vitamin C for individuals with diabetes?**

People with diabetes are typically under a great amount of oxidative stress. This means they usually have lower levels of antioxidants in their bodies and/or use them up more quickly than people without this disease.

While the source of vitamin C is not important, it is thought that people with diabetes should strive to consume at least 400 mg of vitamin C per day. However, these recommendations are very non-specific as more research is needed.

**71. Does vitamin C have an effect on insulin resistance?**

This is unclear. Oxidative stress is one potential source of insulin resistance, so at least strive to get the recommended amounts of vitamin C every day.

**72. How much vitamin C should be taken for vascular health?**

It is recommended that you eat or take enough vitamin C to maximize the amount of vitamin C in your blood. This is what we call “saturation.” Unfortunately, it is hard to know when you have reached this state without blood testing, which is not widely available. The Linus Pauling Institute’s recommendation of at least 400 mg of vitamin C per day (from food and supplement sources combined) should maximize antioxidant protection in most young and healthy adults. It is unknown if older adults or individuals with preexisting conditions need more vitamin C for optimum health.

**73. Is there any information on vitamin C and cardiovascular disease, especially coronary artery disease and high blood pressure?**

Yes, but it is hard to summarize here. We would suggest that you look at the Micronutrient Information Center’s pages on [vitamin C](#) and [cardiovascular disease](#) for more information.





#### **74. Can vitamin C help dissolve atherosclerotic plaque?**

Although Dr. Linus Pauling suggested that vitamin C can help dissolve atherosclerotic plaques, it is unclear if this is possible. Additional research is needed to test this hypothesis.

#### **75. Does vitamin C help with erectile dysfunction (ED)?**

It may, but this has not been studied. Vitamin C is an important part of vascular health, which is also important in ED. See question #72 (How much vitamin C should be taken for vascular health?) for more information.

#### **76. Should people with a history of kidney stones take vitamin C supplements?**

In individuals with a history of calcium oxalate kidney stones, it is possible that vitamin C supplements may exacerbate the problem. It is recommended not to exceed 500 mg of supplemental vitamin C per day for those with a history of oxalate kidney stones.

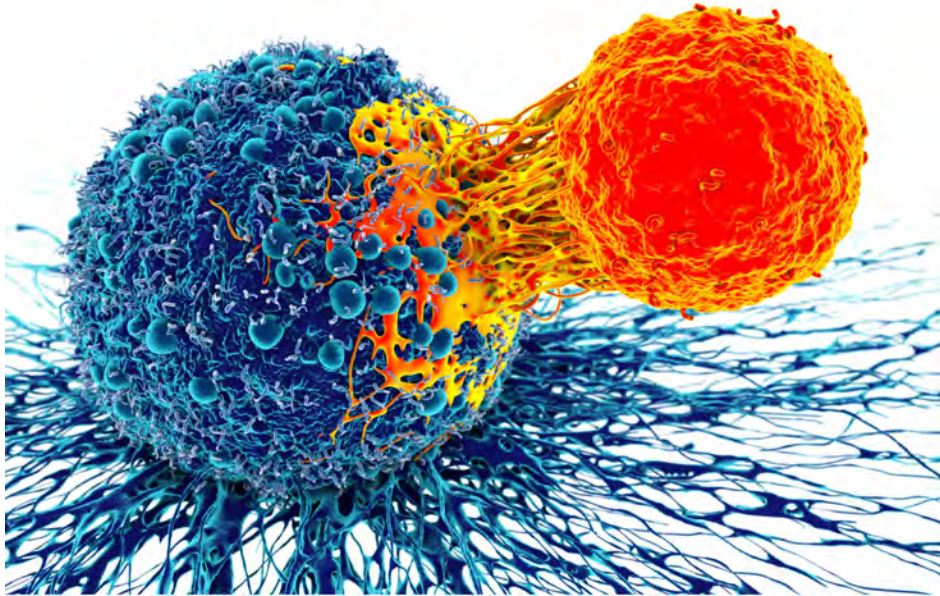
For more information on vitamin C and kidney stone risk, see the [Micronutrient Information Center webpage](#).

#### **77. How much vitamin C should people with hemochromatosis take?**

Hemochromatosis (also known as iron overload) is a hereditary disorder that results in iron accumulation in the liver. There is a concern that this iron could react with oxygen to form deleterious compounds, a process known as the Fenton reaction. Vitamin C has been implicated in fueling this reaction.

Studies have shown that people with hemochromatosis should not completely avoid vitamin C. In general, individuals with hemochromatosis should follow general recommendations of taking a multivitamin (without iron and approximately 90 mg of vitamin C) along with 5-7 servings of fruit and vegetables per day (i.e. obtain most of your vitamin C from food). There is no reason for people with hemochromatosis to take additional vitamin C supplements.





## Cancer

### 78. Since Dr. Pauling's book, has vitamin C and cancer been researched?

Absolutely. In the last 20 years, [some remarkable discoveries](#) have been made using vitamin C in the treatment of cancer. Some research groups have been investigating the mechanisms by which intravenous vitamin C kills cancer cells, hoping to find ways to make cancer cells more susceptible to this treatment.

For additional information on intravenous vitamin C and cancer, see our webinars on vitamin C and health from 2021 and 2022 (links are found in the Additional Resources section, below).

### 79. How does intravenous vitamin C work with chemotherapy?

Intravenous vitamin C can work as an adjuvant with some types of chemotherapy. However, vitamin C can also interfere with certain types of chemotherapy. It is important to consult with your oncologist before considering intravenous vitamin C as a treatment option.



**80. What are the current guidelines regarding intravenous ascorbic acid and adjunctive cancer management?**

It is clear that not every cancer is affected by intravenous vitamin C, but we do not yet know why. This makes it difficult to make clear guidelines on the topic. In regards to oral vitamin C, it is important to talk to your oncologist. Specific drugs can react with vitamin C, such as chemotherapies that show diminished effects for people taking large amounts of vitamin C supplements. On the other hand, some research has shown that side effects of chemotherapies can be diminished by oral vitamin C.

**81. Are there specific cancer types or locations that are uniquely resistant or susceptible to intravenous vitamin C?**

Although there is some evidence that vitamin C may be useful in the treatment of certain types of cancer, other types of cancer are resistant to intravenous ascorbic acid. It is unclear why this is the case. There is an inadequate amount of research to determine which cancers are resistant or susceptible to intravenous vitamin C. More research is needed before vitamin C can be recommended as a complementary treatment.

**82. Can urinary ascorbate levels rise high enough with oral dosing to have a beneficial effect on bladder cancer?**

Unfortunately, there is no evidence to support the use of vitamin C supplements in bladder cancer.

**83. Is it possible to measure iron in tumors to predict the effects of intravenous vitamin C?**

In theory, the “labile iron pool” is the amount of iron available in a cell to react with other molecules, such as oxygen and vitamin C. [Some researchers](#) working on intravenous vitamin C are already trying to make an association between labile iron and the effectiveness of vitamin C treatment.





## Immune System/COVID-19

### 84. How much vitamin C is needed during a viral infection?

It is likely that additional vitamin C supplementation would be beneficial. Research studies show that blood vitamin C levels could go down during an infection. You can consider taking an additional vitamin C supplement, but a specific vitamin C dose cannot be recommended.

### 85. Is vitamin C a treatment for COVID, a form of prevention, or both?

While it is prudent to get the recommended amounts of vitamin C to help support the immune system prior to an infection, there is no evidence that vitamin C supplements can stop you from getting COVID. Although vitamin C supplements may help with COVID symptoms, there is more convincing clinical evidence in the use of intravenous vitamin C in the treatment of the disease. More details are available in our Spring 2022 [Research Newsletter](#) (available May 2022).



**86. The studies done on the effects of vitamin C on COVID are mainly around the administration of intravenous vitamin C. Would you say that oral vitamin C is ineffective in COVID?**

Not ineffective, but possibly limited in effectiveness. Intravenous vitamin C is used in order to quickly restore vitamin C levels. While oral vitamin C is helpful, the absorption is limited. In cases of severe inflammation, blood vitamin C may be lost faster than it can be replaced with an oral supplement. However, it may be helpful in long-term recovery from COVID.

**87. Is there support for intravenous vitamin C in the treatment of COVID?**

The current evidence from [four randomized controlled trials](#) suggests that intravenous vitamin C may have utility as a COVID therapy – patients receiving this treatment showed improved oxygenation parameters, reduced inflammatory markers, and faster resolution of symptoms.

It should be noted that these published trials are small, and there are some inconsistencies among the studies, making the effect of intravenous vitamin C hard to define. The vitamin C dose in these studies range from 4g/day to 24g/day.

**88. Why isn't vitamin C more recognized as a therapy in COVID?**

Although there are many claims about vitamin C in COVID, only a few scientific studies are available. At the moment, there is no support for the use of vitamin C alone. The current trials suggest that intravenous vitamin C might be a useful complementary therapy. For an up-to-date list of trials on this topic, see [Dr. Anitra Carr's website](#) at the University of Otago.

**89. What is the recommended dose of vitamin C for wound healing?**

Studies on the effect of vitamin C supplementation on wound healing have reported somewhat [mixed results](#). While vitamin C is an important part of wound healing, the relationship is complex. More research is needed.



**90. Has anyone looked at changes in the gut microbiome before and while getting vitamin C and how it might contribute to immune functioning?**

Based on the chemical properties of ascorbic acid, an effect is plausible. [Only a few recent trials](#) have looked at how vitamin C might change the microbiome, but there is no information on its connection to immunity. This is certainly an excellent topic for future studies on the effects of vitamin C.





## Research and Clinical Studies

### 91. In research studies, what is used to determine vitamin C concentration?

It depends on the laboratory. We have used several methods for measuring vitamin C in clinical samples and food. We prefer a technique called high-pressure liquid chromatography with electrochemical detection. In the right hands, this technique is very accurate and reliable. Other methods include spectroscopic methods and mass spectrometry, but some of these methodologies make use of additional chemicals that react with vitamin C to be able to measure it.

### 92. Why did the recent [Cleveland Clinic Study](#) not show an effect of vitamin C supplements in the treatment of COVID? Why are there so many conflicting views?

The [Cleveland Clinic study](#) has undergone scrutiny from the scientific community for its poor study design, early termination, and statistical analysis of the data collected. A [re-analysis of the data](#) suggests that 8 grams of vitamin C per day did benefit COVID patients, but follow-up studies are needed to confirm this relationship.

In general, many vitamin C trials are not designed properly to test the effects of vitamin C, especially in the immune system. Poor study designs create inconsistent results.



**93. What dose of intravenous vitamin C did Dr. Fowler use in his CITRIS-ALI study?**

[Dr. Fowler's CITRIS-ALI study](#) was designed to investigate the effects of intravenous vitamin C on organ failure and biomarkers of inflammation in patients admitted to the ICU with sepsis and severe acute respiratory failure. In the protocol, 50 mg/kg body weight of sodium ascorbate in dextrose 5% in water was used every 6 hours for 96 hours. For an 80 kg individual, this would equate to 4,000 mg of vitamin C every 6 hours.

**94. In the [CITRIS-ALI study](#) and other related sepsis trials, why are intravenous vitamin C treatments stopped after 96 hours?**

The primary goal of using intravenous vitamin C in sepsis is to restore blood vitamin C concentrations – replacing vitamin C that has been lost to oxidative stress and inflammation. After 96 hours of intravenous vitamin C treatment, vitamin C deficiency was corrected and treatment was stopped.

**95. Have any of these intravenous vitamin C studies in critically ill patients investigated outcomes other than survival?**

Usually studies run by hospitals look at mortality as a primary endpoint, followed by other quantifiable markers (tumor size, blood biomarkers, etc.). Qualitative markers (such as quality of life) are rarely included and are typically not a primary or secondary endpoint, making them harder to find in the literature.

**96. Is there any evidence that the "Pauling Therapy" of ascorbate and lysine works?**

There is no evidence from human clinical trials. The [Pauling Therapy](#) was built around a framework that vitamin C and lysine could prevent the deposition of lipoprotein(a) in atherosclerotic plaques. Unfortunately, the only evidence supporting this theory comes from animal studies that often do not represent the human condition.





**97. Is there any research on potential gene therapies to restore the body's ability to synthesize vitamin C?**

No. The gene for [vitamin C biosynthesis](#) was lost and significantly damaged during the course of primate evolution, and there would be no way to restore that gene without significant gene editing (borrowing from other species). Primates have evolved to adapt to this loss of vitamin C synthesis capacity; therefore, it is likely that a restoration of vitamin C synthesis function would result in dysregulation of other genes in the body.

Also, vitamin C synthesis is not without its costs. During the production of vitamin C, hydrogen peroxide is generated. It is thought that a loss of vitamin C synthesis might provide an evolutionary advantage in the form of lowered oxidative stress.

**98. Is there any research combining mushrooms with vitamin C?**

[Dr. Fukumi Morishige and Dr. Linus Pauling](#) published papers on reishi mushrooms and vitamin C in cancer treatments. Mushrooms and vitamin C have also been suggested as supplements for the immune system. These are currently hypothetical treatments with inadequate evidence to support recommendations for use.

**99. Will hospitals offer intravenous C therapy or will a patient have to request it?**

Intravenous vitamin C is currently not part of any standard treatment protocol nor is it common practice outside of clinical research studies. You may request it from your doctor, but it may not be available nor approved by insurance companies.

Many naturopathic physicians and some other physicians administer intravenous vitamin C therapy. Websites that may help you find a physician willing to administer intravenous vitamin C can be found in the Additional Resources section of this document, below.



**100. How do you know a person is qualified to give you intravenous vitamin C?**

Any intravenous vitamin therapy should only be delivered from a person with an advanced medical degree. Practitioners should screen your medical history and run standard blood tests. There are specific blood tests performed when considering intravenous vitamin C to ensure that it is administered safely.



## Additional Information

For more in-depth information on vitamin C:

[The Linus Pauling Institute's Micronutrient Information Center](#)

Find out more about the different types of vitamin C supplements:

[Supplemental Forms of Vitamin C](#)

Information on vitamin C in skin health:

[Vitamin C and Skin Health](#)

Articles on vitamin C from the Linus Pauling Institute's blog:

[Analyzing Ascorbic Acid: More Questions About Vitamin C](#)

[Questions About Vitamin C](#)

[Vitamin C and Colds: a New Beginning](#)

Choosing supplements wisely:

[Which Supplements Should I Get?](#)

[What's in that Supplement Bottle?](#)

Information from the Office of Dietary Supplements:

[Vitamin C Health Professional Fact Sheet](#)

Linus Pauling Day 2021 webinar on vitamin C and health:

[Vitamin C and Health: New Frontiers - YouTube](#)

For those seeking intravenous vitamin C from naturopaths and practitioners of integrative medicine :

[Naturopathic.org](#)

[ACAM.org](#)

**Any further questions? Email us at [lpi@oregonstate.edu](mailto:lpi@oregonstate.edu)**



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