LINUS PAULING INSTITUTE

DIGITAL DIGEST

SPRING 2025

LOOKING FORWARD TO DIET AND OPTIMUM HEALTH 2025 SEE INSIDE ►

IV VITAMIN C AND PANCREATIC CANCER

Exploring the Efficacy of Intravenous Vitamin C in Terminal Cancer Patients

Evidence suggests that vitamin C may have utility in the treatment of certain types of cancer. Ongoing research in patients with cancer is focused on intravenously administered vitamin C as a complement to conventional cancer therapies.

Researchers and physicians at the University of Iowa recently published the results of a new trial using intravenous (IV) vitamin C in patients with terminal pancreatic cancer. Adding IV vitamin C therapy to standard chemotherapy extended the survival time and quality of life for many patients involved in the trial, setting the stage for more expansive studies using this approach.

IV Vitamin C and Cancer: A Brief History

Examining the potential of vitamin C for cancer treatment was spearheaded by Dr. Linus Pauling and his collaborator, Dr. Ewan Cameron, in the early 1970s. In 1976, Pauling and Cameron published a groundbreaking study suggesting that high-dose vitamin C could extend the lives of terminal cancer patients.

This work combined IV vitamin C with oral supplementation, achieving results that sparked both excitement and controversy. Many oncologists dismissed these trials at the time; however, the last three decades have seen a renewed interest in vitamin C as a cancer therapy.

The reason for this resurgence stems from cell, animal, and human clinical research led by Dr. Mark Levine at the National Institutes of Health in the late 90s. Levine's team found that IV administration achieved high blood concentrations of vitamin C. This changes the way vitamin C acts in the body (see page 5 for more information). Ultimately, these studies revealed the properties of vitamin C that make it useful as a cancer therapy.

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Linus Pauling Institute

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OSU Distinguished Professor,
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FROM THE DIRECTOR

I hope this new year brings you good health! As always, we at the Linus Pauling Institute remain committed to advancing research and public education on nutrition and other drivers of optimal health.

On February 28, we held our annual **Linus Pauling Day event** to celebrate Dr. Pauling's birthday and share our latest research with the community. We had record attendance this year, and our faculty and students enjoyed connecting with those who joined us for our open house and social.

The open house was an opportunity to introduce **Dr. Maria Purice**, the latest principal investigator to join our faculty. Purice's research focuses on the intricate interactions between glial cells and neurons during aging and in neurodegenerative diseases. Her work aims to uncover pathways that enhance brain health and healthspan. We look forward to sharing more about her exciting research soon.

Planning is also underway for our Diet and Optimal Health conference happening September 9th and 10th here in Corvallis. **Precision Nutrition and Healthspan** is the focus, and we are bringing together leading experts in nutrition, cognition, immunity, the gut microbiome, and data science.

The conference is open to everyone, and it's a great resource for professionals seeking to advance their understanding and spark new collaborations in health research.

Please visit **our conference website** for a list of speakers and registration information.

I hope you enjoy our first *Digital Digest* of 2025. Our cover story features groundbreaking research from the University of Iowa on the potential applications of **intravenous vitamin C** in clinical settings, as a complement to conventional therapies in patients with end-stage pancreatic cancer.

On page 3, be sure to check out the summary of **our latest webinar**, *Aging Well and Optimum Health: Micronutrients for Bone, Brain, and Immune Health*. The recording for this webinar is **now on our YouTube page.**

On page 6, you can learn about **gut health and gut microbiota**, and how you can improve its function with dietary choices. The information is based on new content in our Micronutrient Information Center.

Lastly, please note that Oregon State University's annual day of giving, **Dam Proud Day, is April 30**! We are highlighting three funds to support our research, public outreach, and student scientists. Find out more about these initiatives **on our Dam Proud Day page**, and join us online April 30!

As we embark on another year of discovery and education, thank you for your ongoing support!

Emily

AGING WELL WITH MICRONUTRIENTS:
Supporting Bone, Brain, and Immune Health

Aging introduces challenges to our health, particularly losses in bone strength, cognitive sharpness, and immune resilience. While aging is inevitable, our nutrition choices can help us mitigate these changes.

The Institute's most recent webinar, *Aging Well and Optimum Health: Micronutrients for Bone, Brain, and Immune Health*, examined how micronutrients can support these vital systems during the aging process. Dr. Emily Ho was joined in this webinar by Dr. Dusti Linnell from Oregon State University's Extension Family and Community Health Program to combine cutting-edge science with tips to help us thrive in our later years.

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From Science to the Plate

Ho emphasized that the positive cumulative impact of consistent, nutrient-dense eating patterns becomes increasingly apparent as we age. By addressing nutritional gaps early, individuals can reduce their risk of chronic diseases, maintain mobility, and support cognitive and immune resilience.

Linnell demonstrated how to incorporate micronutrient-rich foods into everyday meals. In the webinar, she shared some creative ideas from the **Food Hero website**, like adding spinach to an omelet to increase the amount of vitamin C and calcium or adding nuts to meals for extra vitamin E, zinc, magnesium, and omega-3 fatty acids.

Linnell also addressed challenges like food access and dietary restrictions, suggesting substitutions like fortified plant-based milk as a calcium source for those who avoid dairy, or canned salmon for a budget-friendly source of calcium, vitamin D, and omega-3 fatty acids.

Empowering Healthy Aging

This webinar is part of the **Top 10 Project**, a collaborative initiative between the Linus Pauling Institute and Oregon State University Extension Service. The goal is to translate scientific findings into actionable strategies that empower individuals to age with strength and resilience.

In addition to the brochure, *Top 10 Micronutrients for Aging Well*, the Top 10 Project has three new handouts highlighting nutrition **for bone, brain, and immune health**. Each handout connects individual micronutrients to their function in the body and identifies a "Top 10 Foods" list where those nutrients can be obtained.

For more information, visit our **Top 10 Project webpage**.

Continued from Cover

Further animal and cell culture studies conducted by the Levine group showed that the oxidants produced by vitamin C were beneficial because they appeared to target cancer cells while leaving surrounding healthy tissue unharmed.

Follow up work in human clinical trials showed that the administration of IV vitamin C could slow the growth of certain tumors. The doses employed were typically 50 grams or higher, resulting in high plasma concentrations of vitamin C unattainable by oral supplementation.

A research team at the University of Iowa continued to explore the clinical potential of high-dose IV vitamin C in patients with different types of cancer. Over the years they have demonstrated how it can enhance the effectiveness of both chemotherapy and radiation therapy.

The Case for Pancreatic Cancer Treatment

The most common form of pancreatic cancer is known as pancreatic ductal adenocarcinoma. It is among the deadliest of cancers. The five-year survival rate for this type of cancer is just 12 percent overall, and the rate plummets to 3 percent for patients with advanced forms of this disease.

For patients with end-stage pancreatic cancer, the standard chemotherapy regimen is a combination of the drugs gemcitabine and *nab*-paclitaxel. This typically extends survival by about eight months. However, these treatments are not without challenges.

Neutropenia, a dangerous condition marked by very low white blood cell counts, is a serious side effect of chemotherapy. When a patient has neutropenia, it dramatically increases their risk of severe infection because the immune system cannot react properly.

When neutropenia occurs, physicians often stop all cancer therapies to allow the patient's immune system to recover. Unfortunately, this usually means the efficacy of the cancer treatment is reduced.

Thus, oncologists are interested in any therapy that can be added to standard treatments to improve survival without compromising quality of life. In recent years, this has led several physicians and researchers to revisit the potential of integrating IV vitamin C into standard treatment protocols.

Doubling Survival in Advanced Pancreatic Cancer: The Latest Breakthrough

A randomized clinical trial in patients with end-stage pancreatic cancer was led by the University of Iowa group in collaboration with colleagues at the Medical College of Wisconsin. The results were published in ***Redox Biology***.

In this study, 34 participants were randomized into two groups. While all of the enrolled patients were administered gemcitabine and *nab*-paclitaxel, half of the participants were also given 75 grams of IV vitamin C weekly.

Treatment continued until the disease progressed, the patient withdrew or died, or an increase in toxicity was noted.

As is typical with this type of study, the investigators performed an interim analysis to monitor progress and evaluate safety. These analyses evaluate the effectiveness of a new therapy or examine any undesirable outcomes to determine if the study should be terminated early because it is doing more harm than good.

However, the interim analysis of the Iowa study revealed something quite remarkable: that IV vitamin C in conjunction with chemotherapy increased survival times for patients with advanced pancreatic cancer; patients receiving the IV vitamin C and chemotherapy combination lived a median of 16 months compared to approximately 8 months for those patients receiving chemotherapy alone.

> **"When we started the trial, we thought it would be a success if we got to 12 months survival, but we *doubled overall survival* to 16 months."**
>
> **Dr. Joseph Cullen, University of Iowa**

Stopping the trial early emphasized the strength of the clinical data and the potential benefits for cancer patients. Once the trial was terminated, the IV vitamin C could be offered to other patients with pancreatic cancer, in addition to their normal cancer treatment regimen.

Reduced Side Effects, Increased Quality of Life

In addition to extended survival, the patients receiving IV vitamin C experienced fewer chemotherapy-related side effects, including neutropenia.

"Not only does it increase overall survival, but the patients seem to feel better with the treatment," explained Dr. Joseph Cullen, lead investigator at the University of Iowa. "They have fewer side effects and appear to be able to tolerate more treatment, and we've seen that in other trials, too."

The progression of the disease and the effects of chemotherapy treatment led to reports of fatigue, nausea, constipation, and other issues throughout the study, as would be expected for patients with advanced cancer.

While patients in both groups reported a decline in quality of life over time, those in the IV vitamin C group experienced this decline later than those receiving only chemotherapy, suggesting that IV vitamin C delayed the onset of these health declines.

Looking Ahead

As a phase 2 clinical trial, this study focused on establishing efficacy. The investigators' decision to halt the trial early reflected their confidence in the potential of IV vitamin C therapy to improve clinical outcomes.

This study is not the only evidence of the benefits of including IV vitamin C in cancer therapy. Notably, another clinical trial from the Iowa group – also published in 2024 – demonstrated similar results in patients with glioblastoma, a deadly form of brain cancer. A third phase 2 trial in patients with non-small cell lung cancer is currently underway, with results expected this year.

While many of the trial results incorporating IV vitamin C therapy are encouraging, it is essential to emphasize that IV vitamin C alone is not a cure for cancer. In all of these studies conducted at the University of Iowa, IV vitamin C was added to support existing chemotherapy and limit its side effects.

That said, the resurgence of interest in IV vitamin C therapy pays tribute to the pioneering work of Pauling and Cameron. By demonstrating the efficacy and safety of this approach, Cullen and his colleagues are paving the way for more extensive trials and further research into the role of IV vitamin C in cancer care.

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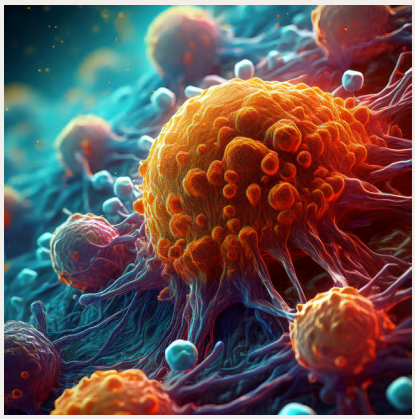


How Does Vitamin C Kill Cancer Cells?

Very high blood concentrations of vitamin C, such as those achieved during IV vitamin C therapy, can generate a small amount of damaging molecules known as reactive oxygen species. This is not typically harmful, as our blood and cells contain several detoxifying enzymes that can remove the threat that these oxidants possess.

By contrast, many cancer cells lack adequate defenses to reactive oxygen species and are thus susceptible to any exposure to these molecules. Several standard cancer therapies also create reactive oxygen species that result in cancer cell death and slow tumor growth. IV vitamin C is likely going to be most effective when combined with standard cancer treatments such as chemotherapy or radiation.

NEW RESOURCES ON GUT HEALTH FROM THE LINUS PAULING INSTITUTE

The Micronutrient Information Center's Health & Disease section now includes two articles on gut health. Here, we present an overview of the gut microbiota. For more information on this topic, check out these new resources online: *Gut Health In Brief* and *Gut Health In Depth*.

The gut microbiome refers to both the trillions of microorganisms that live in the gastrointestinal tract and the environment in which they live – mostly in our colon, also known as the large intestine. We provide a habitat for them; in return they provide us with helpful compounds and functions.

The organisms that live in our colon are known collectively as **the gut microbiota**. This includes bacteria, viruses, and yeast, but it can also refer to other microbes. However, the majority of gut microbiota research has focused on bacteria that inhabit our colon.

Functions of Gut Bacteria

The bacteria living in our gut can affect us in many ways. Their two main functions are to produce beneficial compounds from the food we eat and to provide some additional protection against disease-causing microorganisms.

Production of beneficial compounds

Gut bacteria consume some of the undigested food material that reaches the colon. The enzymes within the bacteria cells can digest some of this material further. In the process, they can produce a variety of metabolites and other small molecules.

One example is the fermentation of dietary fibers, which is described in more detail on the next page. Other examples include the transformation of bile acids, amino acids, and plant polyphenols into beneficial compounds.

These compounds can exert their influence directly inside the colon and in other parts of the body since they can be absorbed into the bloodstream and travel through the lymphatic system.

Protection against pathogens

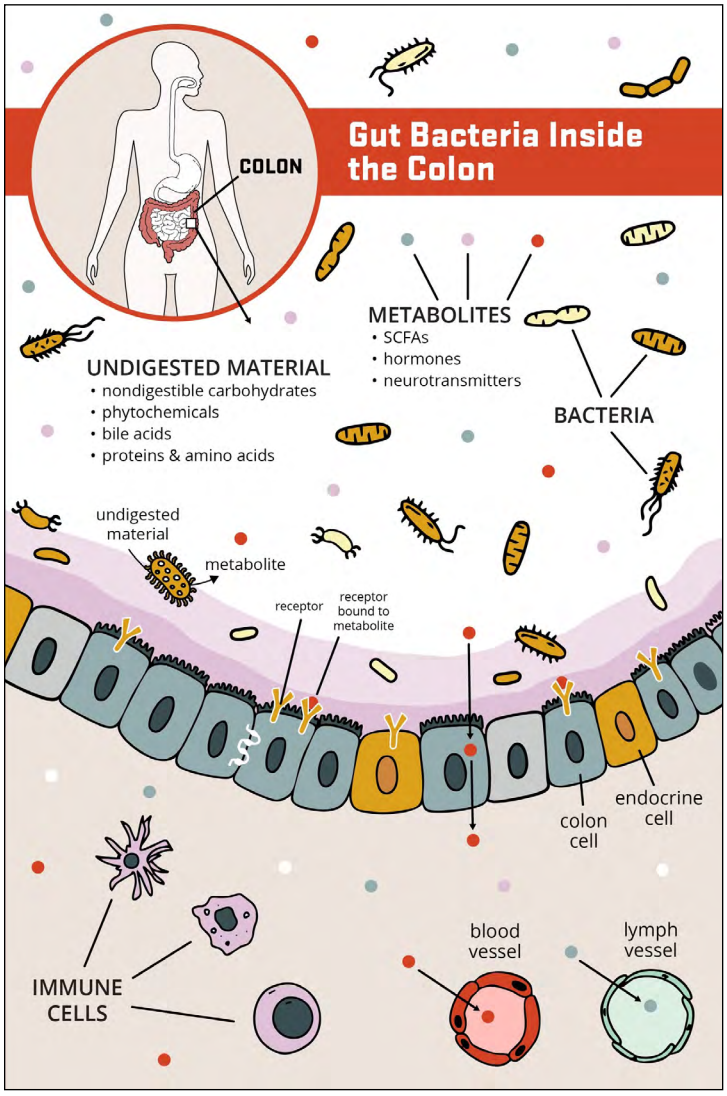
Pathogens such as bacteria and viruses, are disease-causing microorganisms. Beneficial bacteria in the gut employ several strategies to keep the numbers of these pathogens in check.

One of the primary ways they do this is by competing with pathogens for space and nutrients. Additionally, beneficial bacteria can produce antimicrobial substances or alter the gut environment to be less inviting to pathogens.

A Healthy Gut Microbiota

There is not one ideal composition of a healthy gut microbiota, as this varies due to people's diets, lifestyles, and cultures. However, features of a healthy microbiota include diversity and a dominance of certain beneficial bacterial species that thrive in a low-oxygen environment.

A diverse microbiota contains many different bacterial species and is resilient to external challenges, such as infections, medications (especially antibiotics), and changes in the diet. Diversity of bacteria species also provides a diversity of bacteria functions. This allows for some bacteria to compensate for the loss of a particular strain when it does occur.



Food Choices Matter

Dietary choices directly impact the abundance of different bacterial species and the compounds they produce. This in turn influences the health of the colon and the entire body.

An important dietary component that feeds the gut microbiota is dietary fiber, a diverse group of complex carbohydrates that cannot be digested by human enzymes in the small intestine.

Fermentation of dietary fiber results in the production of beneficial short-chain fatty acids (SCFAs). These compounds directly nourish colonic epithelial cells, also called the gut barrier, and create a favorable environment for beneficial bacteria.

Indirectly, SCFAs interact with cellular receptors in the colon and throughout the body, engaging a number of signaling pathways (see sidebar) that can influence inflammation, appetite, and insulin secretion, to name a few.

There is a great deal of variability from person to person; what is produced depends not only on the food you consume but also which bacteria are present. This is one of several complications that make it difficult to predict how an individual will respond to specific foods.

What Can I Do?

When you eat, it's not just about fueling and nourishing your body, it's also about feeding your gut microbiota. Even though we each have a unique mixture of bacteria (and other microorganisms), the same guiding principles that benefit your overall health can also benefit the health of your gut.

- Eat a diversity of fruit, vegetables, whole grains, beans, nuts, and seeds (see right) – they all contain fiber.
- Try to consume the recommended amount of fiber each day (women: 28 grams; men: 35 grams), but if you need to increase your fiber intake, do it gradually – abrupt changes can cause discomfort and your body may need time to adapt.
- Limit highly processed foods and added sugar, as they promote the growth of less beneficial species of bacteria.
- Consume fermented foods, like kimchi, sauerkraut, yogurt, or kefir. Fermented foods can be a great source of probiotics with live bacteria, but take note that not all fermented foods contain live bacteria. Look for products with live cultures (for example, vinegar-based or pasteurized pickles do not have live cultures).

To establish and maintain changes to the gut microbiota, regular consumption of a diverse, healthy diet is necessary; for example, adding fiber occasionally is not going to have the same impact. If you encounter issues making these changes, consult with a physician or dietitian for some suggestions and strategies.

GLP-1 Hormone

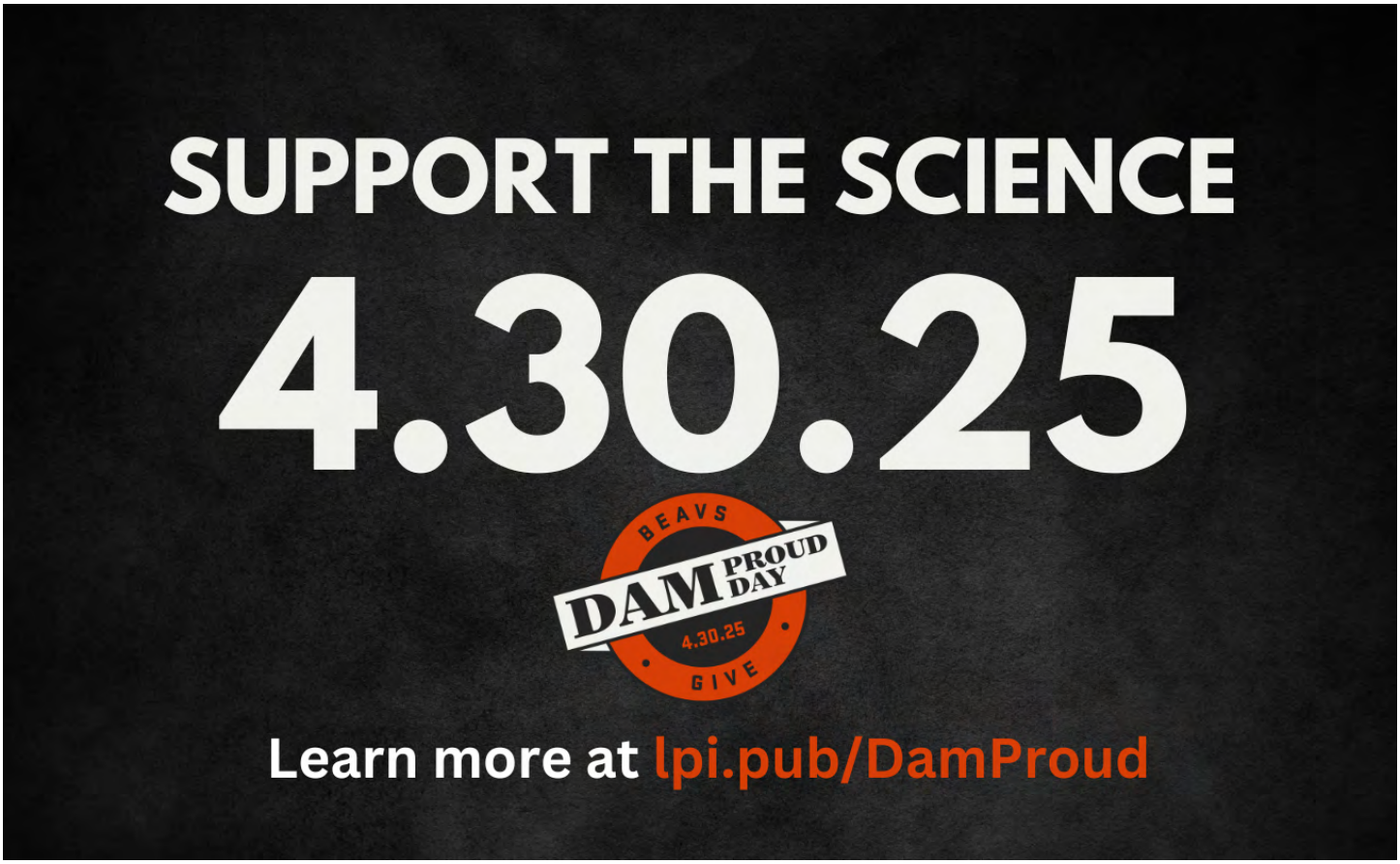
The intestines can produce about 30 different types of peptide hormones, each with different functions. One of these gut hormones, glucagon-like peptide-1 or GLP-1, is produced by the colon after exposure to SCFAs. Thus, eating more fermentable fiber stimulates GLP-1 production, and GLP-1 helps regulate insulin secretion and appetite.

A class of drugs known as **GLP-1 Receptor Agonists** mimic the effect of the hormone. These drugs include semaglutide (sold under the brand names Ozempic or Wegovy) and tirzepatide (sold under the brand names Mounjaro or Zepbound).

These drugs can stimulate the GLP-1 receptor, but their effects last in the body for much longer than the naturally produced GLP-1 hormone, making them effective for the control of blood glucose levels and appetite. They are currently FDA approved for weight management or the treatment of type 2 diabetes.

Common sources of dietary fiber*	Fiber content
1 banana	3 grams
1 cup of broccoli	4 grams
1 cup cooked oats	4 grams
¼ cup almonds (small handful)	4 grams
1 medium apple	5 grams
½ medium avocado	7 grams
½ cup cooked lentils	8 grams
1 oz chia seeds (2 Tbsp.)	10 grams

*All of the foods listed are rich sources of fermentable fiber



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