2024

STUDENT JOURNAL

UNC Nutrition Research Institute

VIRTUAL INTERNSHIP PROGRAM

UNC | NUTRITION RESEARCH INSTITUTE

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What is VIP?

Our Virtual Internship Program is offered to high school students (those entering 9th grade through recent graduates entering their freshman year of college in the fall of 2024). This four-week program provides opportunities to learn from NRI principal investigators, participate in group mentoring sessions, and complete an independent nutrition research paper and presentation.

To successfully complete the program, students must attend all scheduled lectures and mentoring sessions. This year, the program featured six sessions across four weeks, lasting at least one hour each. Leading these sessions were:

> **Deborah Tate, PhD,** *NRI Interim Director, Professor of Nutrition and Health Behavior*
> **Jenna Baker,** *VIP Coordinator*
> **Ryan Dayvault,** *Associate Director of Operations and Planning*
> **Sandra Mooney, PhD,** *Associate Professor of Nutrition*
> **Natalia Krupenko, PhD,** *Associate Professor of Nutrition*
> **Evan Paules, PhD,** *Postdoctoral Research Associate, Hursting Lab*
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> **Tyisha Harper,** *Project Coordinator, Goode Lab*
> **Ximena Bustamante-Marin, PhD,** *Assistant Professor of Nutrition*
> **Melody Burke, Assistant Director,** *Office of Undergraduate Admissions*

In the fourth week, students presented their papers to their peers and NRI scientists and staff. You're invited to read their papers in this journal.

Disclaimer

This journal is a student-created publication and the content within may not be entirely accurate. The articles and opinions expressed here do not reflect the official research, views, or positions of the UNC Nutrition Research Institute (NRI). Readers are encouraged to consult verified sources for accurate information.

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About the NRI

The UNC Nutrition Research Institute is an internationally recognized center that conducts innovative basic and translational science studying how individual differences in requirements and responses to diet affect our individual nutritional needs. We believe that our advances in nutrition science are leading to successes in preventing or mitigating the negative effects of chronic diseases and aging and in improving human development, even prior to conception.

MISSION

To understand how nutrition affects individual health through our leadership in precision nutrition research, establishing how differences in our genes, bacteria, metabolism, and environment shape our individual disease risk.

VISION

To use scientific discovery to ensure optimal health through individualized nutrition.

GUIDING SCIENTIFIC PREMISE

Each of us is metabolically unique. The UNC NRI is dedicated to answering the question of how these differences affect an individual's health, and, in so doing, update the current but outdated paradigm of a singular dietary guideline with specific nutritional recommendations and actions by which an individual can improve his or her health and quality of life.

Learn more at: UNCNRI.org

Grade 12 Papers

Neha Panda

Fiber

Neha Panda
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Grade 12

Dating back to Ancient Greece, bran cereals were used to reduce or prevent constipation well before they were identified as a fiber-rich food. The effect of bran on patients with colitis and constipation was examined in depth by J.H. Kellogg in the 1930s, but it took until 1974 for Hugh Trowell to develop the first acceptable definition of dietary fiber (Megazyme). In the mid- to late 1980s, scientists discovered and defined soluble and insoluble dietary fiber. Since then, fiber has proven to be an invaluable, multifunctional asset to the human digestive system.

Dietary fiber is essentially the components of plant matter that the human body cannot digest. It has three purposes: improving motility of stool, regulating blood glucose after meals, and keeping the bacteria in the digestive system healthy. Water-soluble fiber, also known as prebiotic fiber, slows the rate of digestion and mitigates diarrhea; it can also be fermented in the cecum and ascending colon to maintain gut microbiome health (Zhang, Feng, et al.). Fiber-rich foods are often filling but low-calorie and delay the absorption of sugars from the intestines. Water-insoluble fiber absorbs water as food passes through the intestines and bulks up stool to support GI tract motility. In this way, it balances out soluble fiber and prevents constipation.

Age (Years)	Adequate Intake (g/day)	
1–3	19	
4–8	25	
9–13	Male: 31	Female: 26
14–50	Male: 38	Female: 25
>50	Male: 30	Female: 21
Pregnant or lactating women	28–29	

Fig. 1. Physicians agree upon a standard level of dietary

If an individual adds too much fiber to their diet too suddenly, they may experience abdominal pain and gas buildup in their intestines. However, adults should ultimately aim to consume 25 to 30 grams of total dietary fiber a day as per their age and gender recommendations (Fig.1), or approximately 14 grams for every 1000 calories consumed in a day. Without enough fiber in their diet, a person may experience gas, cramping, diarrhea, dehydration, weight changes, bloating, and intestinal blockage in the short term and chronic cardiovascular or GI conditions in the long term (Vasquez). In the 1940s, British physicians Burkitt and Trowell found that by studying native African communities with fiber rich diets that their consistently high fiber intake fended off conditions like diabetes, arteriosclerosis, and ischemic heart disease in comparison to modernized countries ("The History"). Doctors advise sourcing fiber from natural foods rather than supplements such as Metamucil because these supplements can be harsh on the stomach and encourage constipation rather than aiding in intestinal movement.

Humans do not possess the digestive enzymes to thoroughly catabolize fiber. The body does not digest, absorb, or store fiber in any way or produce it on its own. A small amount is metabolized in the stomach and intestine; the rest passes through the GI tract, absorbs water, and becomes part of the stool, adding the bulk and improving motion through the intestines. The body does not store fiber in any way or produce on its own, so it is important to replenish its stores daily. Fiber is found naturally in plants and plant-based foods like celery, whole grains, nuts, apples, berries, beans, and legumes (Deakin University). Sometimes, cereals and breads are labeled as high fiber, offering consumers a straightforward swap that will increase and integrate fiber into their existing lifestyle.

Content of Fiber, total dietary in g in 100 grams of foods	List by ECstep.com	
Food item	*g / 100 g*	*kcal / 100 g*
Corn bran, crude	79.0	224
Fungi, Cloud ears, dried	70.1	284
Wheat bran, crude	42.8	216
Carob flour	39.8	222
Seeds, chia seeds, dried	34.4	486
Parsley, freeze-dried	32.7	271
Lentils, raw	30.5	353
Peppers, hot chile, sun-dried	28.7	324
Seeds, flaxseed	27.3	534
Peppers, pasilla, dried	26.8	345
Chives, freeze-dried	26.2	311
Peas, split, mature seeds, raw	25.5	341
Beans, french, mature seeds, raw	25.2	343
Beans, yellow, mature seeds, raw	25.1	345
Broadbeans (fava beans), mature seeds, raw	25.0	341

As fiber was identified relatively recently, scientists and physicians continue to explore its importance in different communities and contexts. In the cross-sectional study "Fibre-Related Dietary Patterns: Socioeconomic Barriers to Adequate Fibre Intake in Polish Adolescents," researchers examined the fiber consumption of 1176 adolescents aged 13–18 years from both urban and rural areas of Poland. The researchers sought to establish a connection between subjects' household socioeconomic status and the consumption frequency of nine sources of dietary fiber. Though low socioeconomic status and limited parental education are often associated with difficulty balancing a healthy diet, a poor economic situation was associated with "higher-frequency consumption of high-fibre or bran cereal and beans... since these high-fibre foods are relatively cheap" (Krusinska, et al.). These findings are critical because they provide a starting point to identify weaknesses in the diets of underserved communities, but they also identify strengths. This study demonstrated that it is possible to deliver proper nutrition to people despite their struggling finances or education levels, contradicting the widely accepted notion that low socioeconomic status automatically destines a community to improper nutrition. For example, beans are a relatively inexpensive, accessible, and nutrient-dense way for people of various socioeconomic levels to get enough fiber in their diet. In spite of many unwavering obstacles, the study identifies hope for people of low socioeconomic status to provide themselves and their families with a nutritionally appropriate diet.

The study above used a small, non-random sample that cannot be generalized. If I were to redo or continue this line of research, I would conduct larger, randomly selected experiments from a variety of cultures to cross-reference the needs of different demographics and continue to identify common, accessible, high-nutrient foods to fuel low-income populations. I hope research around dietary fiber and the overall field of nutrition will be used worldwide to empower those from any background to identify their nutritional needs and take control of their own health.

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VIP NRI

VIRTUAL INTERNSHIP PROGRAM
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Grade 11 Papers

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Vitamin B-12

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Vitamin B12, also known as cobalamin, is a water soluble vitamin that is one of the eight B vitamins and is responsible for the proper functioning of several bodily processes (7). The history of vitamin B12 begins in the late 19th century when Thomas Addison discovered a fatal condition that was characterized by severe anemia, known as pernicious anemia because of its severe progression (9). Unknown to Addison and the medical community at the time, pernicious anemia is caused by a deficiency in intrinsic factor, which inhibits the body's ability to absorb vitamin B12. In 1920 George Whipple discovered that feeding liver (rich in vitamin B12) to anemic dogs improved their condition and reduced the symptoms of anemia. Building off of George Whipple, George Minot and William Murphy further proved that liver consumption improved symptoms of anemia (specifically pernicious anemia in humans) in 1926 and their research led to them earning a Nobel Peace Prize of Medicine and Physiology in 1934. In the 1940s Edwin Cohn isolated vitamin B12 from liver extracts, initially observing it as a red crystalline substance. Building off of the isolation of the vitamin, Dorothy Hodgkins used x-ray crystallography to discover the structure and chemical makeup of the vitamin (9). The discovery and further research of Vitamin B12 has led to discoveries of interesting and quirky features of the vitamin (4). One of the main features that makes the vitamin interesting and different is that it is the largest and most complex vitamin and is the only vitamin that is not readily available in plants. Another quirk of vitamin B12 is that unlike most water-soluble vitamins, vitamin B12 can be stored in the liver for several years which can help prevent immediate deficiency even if dietary intake of the vitamin is low for a period of time (4).

In the nervous system vitamin B12 has a major role in mental/ cognitive health, proper neuron function, and synthesis of neurotransmitters.

Vitamin B12 serves a massive part in proper bodily function across a span of organ systems in the human body. The first major role that the vitamin plays is in the cardiovascular system, where the vitamin assists in the proper formation and growth of red blood cells (erythrocytes), by ensuring that the erythrocytes are large and oval shaped as opposed to small and round. This ensures that the red blood cells can properly transport oxygen and that the cells can move from bone marrow into the bloodstream (1). In the nervous system vitamin B12 has a major role in mental/cognitive health, proper neuron function, and synthesis of neurotransmitters. For neuron development, vitamin B12 is essential for the synthesis of myelin which ensures the proper transmission of nerve impulses along the axon via the myelin sheath. Deficiency in the vitamin can lead to improper myelin sheath function which can lead to neurological issues like numbness in part of the body, memory loss, and problems with balance (6). Alongside this, vitamin B12 has been shown in studies to be associated with better memory and cognitive function, and deficiency is linked to an increased risk of neurodegenerative diseases like Alzheimer's disease. Cognitive function being affected by vitamin B12 is also contributed to by the vitamins role in the synthesis of neurotransmitters such as serotonin and dopamine, which can drastically affect mood and general mental health (4). Deficiency in vitamin B12 can cause severe health problems, especially in the body systems mentioned prior. One of the major illnesses caused by deficiency of the vitamin is Megaloblastic Anemia which is where the bone marrow produces unusually large and immature red blood cells that are not effective at transporting nutrients and molecules. This causes symptoms like fatigue, weakness, pale or jaundiced skin, and shortness of breath (1). Aside from anemia, deficiency in vitamin B12 also causes many issues with the nervous system such as peripheral neuropathy which causes symptoms like numbness and tingling, balance issues, cognitive changes like memory loss and confusion, and general psychiatric symptoms like mood changes and depression (4).

Vitamin B12 cannot be produced within the human body, and since the molecule is the largest and most complex of all the vitamins, the process of breaking down, processing, and storing the vitamin is complex and involves multiple steps. The first step occurs when the human body ingests a food that contains the vitamin- animal products like fish, dairy, and eggs- and digestive enzymes in the mouth and stomach release the vitamin from the food (4). Then when the vitamin is released, it binds to a protein called haptocorrin- also known as r-protein- which moves the vitamin through the stomach. Once the vitamin reaches the small intestine, enzymes released by the pancreas break down the haptocorrin and vitamin molecule and release vitamin B12 where it is absorbed in the ileum via receptor mediated endocytosis and specific receptors on the intestinal walls with the help of intrinsic factor (4). Once the vitamin is absorbed by the ileum, it is released from the intrinsic factors and binds to transcobalamin II which allows for the vitamin to move into the bloodstream and be distributed to different tissues across the body. Once the cells receive the vitamin via cell receptors, they are processed inside the cell and converted into the active forms of the vitamin called methylcobalamin and adenosylcobalamin, and used for cellular functions. The vitamin can also be stored in the liver where it is transformed into adenosylcobalamin and methylcobalamin and lasts for several years which helps prevent dietary deficiencies of the vitamin.

Vitamin B12 is special, as it is only naturally found in animal products and not in plant products, and it cannot be produced by the human body. Animal products are the main and only natural source of vitamin B12 in our diets with foods like beef liver, fish, poultry, milk, milk products like cheese and yogurt, and eggs being the most common sources (5). Aside from animal sources, the vitamin can also be consumed through fortified foods like cereals, plant-based milks, and nutritional yeast as well as supplements such as tablets, capsules, liquids, and even injections (7). There are some special cases where vitamin B12 can be consumed from different sources, but they are not reliable sources of the vitamin. One of these special cases is with fermented foods, because of the bacterial fermentation that occurs trace amounts of vitamin B12 can be produced. Another special case is in seaweed and algae that can contain the vitamin, but it is not a reliable source due to how well the human body can digest it (3).

The study I chose to research was a collaborative study from Spain about the effects of prenatal vitamin B intake from different women, and the cognitive function of their children at the age of four (8). The researchers found that deficiency of vitamin B12 in pregnant mothers during the first trimester negatively impacted the child's cognitive ability at the age of four, and deficiency in the third trimester had a weak to no effect on cognitive ability in the children at the age of four (8). This research is important because it highlights the importance of proper prenatal nutrition and diet and the consequences of not having proper prenatal nutrition, and can help guide medical professions, dietitians, and expecting mothers on what pregnant women should try to eat during pregnancy. This study interested me because of the nutritional aspects of child development and how to ensure that all children can avoid cognitive impairments. If I was a scientist working on this study, I would follow up the study with another study similar to this one but look at how this cognitive impairment affects the children as they further develop into adults to see the lasting implications of the deficiency during fetal development.

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Vitamin C

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The vitamin commonly referred to as vitamin C, or L-ascorbic acid was discovered in. In 1928 by Albert Szent-Györgyi when he isolated a substance from adrenal glands that he called 'hexuronic acid'. Another scientist named Charles Glen King concluded that the vitamin C that he isolated in his lab was the same as this 'hexuronic acid'. We can see the use of vitamin C in history especially among the sailors and pirates of the ancient world. Oftentimes these sailors would not have access to fresh food, and therefore fruits and vegetables for months on end, leading to a disease called scurvy of which symptoms include fatigue and malaise or in extreme cases bone degeneration and gum disease. Sailors discovered however, that they could prevent this by consuming a citrus fruit, such as a lemon or an orange, whose vitamin C content prevents the disease. Even though these sailors were unaware that vitamin C was the reason that they were scurvy free, they still obviously knew the benefits of the oranges were enough to hold off the disease.

Vitamin C plays an essential role in many bodily functions, especially in the immune system and "is one of the safest and most effective nutrients" (Zelman). It assists with immunocompromised areas, eye and skin health, prenatal functions, and even cardiovascular health. In some studies, it has been used as a benchmark for health in the body. The recommended dietary allowances (RDAs) for vitamin C in adults is 90mg for males and 75 for females, with the allowance going up if the subject is pregnant or lactating. Pregnant women should ingest more vitamin C to assist with their immune functions which may have been compromised by their pregnancy or their breastfeeding. The NIH recommends that people who smoke consume around 35mg more vitamin C than the average person. Not consuming enough vitamin C can lead to the development of scurvy (just like the pirates!). Fortunately for us vitamin C has low toxicity and is not believed to cause serious adverse effects at high intakes.

Vitamin C is absorbed through the energy requiring processes of simple diffusion and active transport. Sodium dependent vitamin C transporters allow the vitamin to reach the site of absorption in the distal small intestine. Doses up to 100mg of the vitamin are usually completely absorbed and used as an enzyme complement, a co-substrate or as an antioxidant in metabolic processes. Despite its general abundance in the body, it cannot be stored for later use by the immune system or other systems which may find vitamin C necessary for its functions.

Unfortunately, the body cannot create vitamin C, making it a necessary consumptionary item. Vitamin C can be found in tissues across the body but are particularly prominent in bodily centers focused on fighting pathogens. Some of these areas are the pituitary gland, the adrenal gland, the brain, leukocytes, and the eyes. Vitamin C is found naturally in fruits and vegetables such as oranges, tomatoes, and potatoes. Vitamin C is sometimes added in fruit juices or drinks, particularly ones that advertise it as a bonus of their drink. Vitamin C is available to be taken as a supplement, usually in

the form of a pill or a chewable tablet and is a commonplace ingredient in most all everyday multivitamin forms. Some examples of everyday multis with vitamin C are Flintstones kid's gummies, and the everyday drink packet known as Emergen-C.

Vitamin C is a highly studied and touted supplement whose beneficial effects are still being found to this day. One study at the Linus Pauling Institute at Oregon State University focused on vitamin C's effect on cancer and heart disease prevention. The study in particular uses the role of vitamin C in dealing with the toxins that result from fat metabolism and was published in a professional journal called the Proceedings of the National Academy of Sciences. In the study, scientists measured the reaction of vitamin C with oxidized lipids, and even though previous experiments suggested that vitamin C can cause potential genotoxins to form, the study at OSU shows that they react once again to form harmless conjugates. The study also demonstrates that by having more vitamin C, the amount of risk of inflammation or other problems caused by these toxins are greatly reduced. The role of vitamin C in decreasing the negative effects of the lipids are still being studied and have shown that without regulation, they can lead to increased risk of atherosclerotic lesions.

This finding is extremely important because it shows that vitamin C, along with its help in autoimmune responses, allows the body to prevent certain types of heart diseases and cancers. This finding is extremely important because there are thousands of sufferers of cancer across the globe and all research that can potentially reduce the risk or prevent cancers is vital. This study was particularly interesting to me because

of my personal connection to this story. In 2003 my grandmother endured a yearlong battle with breast cancer which she survived. To this day when one of us falls ill or bruises ourselves, she will tell us to get some vitamin C in. Although she had to avoid vitamin C during her chemotherapy, when she was cleared to take it, she credits it with helping her weakened immune system to fight off any diseases that she contracted after. Even if vitamin C has affected the patients in a different way than my grandmother, it being beneficial is vital to the helping hand of the vitamin itself. If I were a scientist, I would have personally measured the effect of vitamin C on cancer patients after chemo, to see if it helps their immune health in fighting off disease.

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Flouride

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Fluoride, or also known as the ionic compound of the element fluorine, is a mineral in various food sources. The research for fluoride was first started in 1901 when a dental school scholar named Frederick McKay observed that multiple citizens in Colorado had brown stains on their teeth. Dr. McKay, alongside his colleague Dr. Black, investigated for years why the citizens' teeth were stained and was intrigued by the theory that the water supply had something to do with the stained teeth of the citizens. Dr. McKay analyzed the water pipeline and although there was nothing physically wrong with it, he still advised town leaders to shut the pipe down and use a different water source.

Dr. Fredrick McCay
nytimes.com

The town leaders did so and because of that, the next generation of children didn't have brown stains on their teeth. This confirmation of McKay's theory drove him to discover what was wrong with the water. After analyzing many water samples, he noticed an unusually high level of fluoride in the town's pipe water (National Institute of Dental and Craniofacial Research). Upon further research in later years, it was revealed that the citizens in Colorado had a condition named 'fluorosis' and saw that fluorosis was caused by an excessive consumption of a mineral named fluoride.

It remains unclear if fluoride is needed in the body because it is considered to be more beneficial than essential. Fluoride is a mineral that is crucial in many systems. It is important in the skeletal system, specifically in the process of bone formation. Fluoride can help to increase osteoblast, the cells responsible for building bones, activity, and bone density. Fluoride has been thought to be helpful for patients diagnosed with osteoporosis because of its beneficial properties towards osteoblast production and bone density. It is to say that despite producing dense bones, the fracture risk is not reduced. More benefits of fluoride are strengthening the teeth, rebuilding the enamel layer, and reducing the risk of cavities. Fluoride contains properties that will help by strengthening the resistance to acid. Likewise, there are effects if a person doesn't get enough fluoride. A fluoride deficiency affects weakened bones, cavities, and possibly osteoporosis. To prevent low intakes of fluoride, the American Dental Association strongly supports fluoridation of community drinking water supplies (American Dental Association).

Fluoride in excessive amounts can result in a variety of health complications and toxicity. Fluoride toxicity can be caused by ingesting high-fluoride items like water or supplements, inhalation from industrial settings, and skin absorption from fluoride insecticides (Ly and Shin). There are two categories of toxicity relating to fluoride: acute and chronic. Acute toxicity exhibits symptoms such as bone pain, nausea, vomiting, and diarrhea; in more severe cases it can cause coma, renal and cardiac dysfunction, and death. Most acute toxicity cases in children are caused by ingestion of fluoride-containing toothpaste or mouthwashes. It is quite rare to see an adult suffer from acute toxicity. Chronic toxicity, medically known as fluorosis, is a more severe version of acute toxicity and is caused by high fluoride concentrations in drinking water or fluoride supplements. High fluoride concentrations can be found in different bodies of water such as in the Mediterranean Sea, India, Northern Thailand, and China. Constant chronic toxicity can develop into dental fluorosis: the appearance of faint white lines or streaks on the teeth in which the teeth look mottled (Mouth Healthy). In more severe cases, it can lead to skeletal fluorosis in which bone is fragile but radiologically dense. This can lead to fractures, calcifications of joints and ligaments, and reduced joint

Age	Fluoride concentration in community drinking water		
	<0.3 ppm¶	0.3 to 0.6 ppm	>0.6 ppm
0 to 6 months	None	None	None
6 months to 3 years	0.25 mg/day	None	None
3 to 6 years	0.5 mg/day	0.25 mg/day	None
6 to 16 years	1 mg/day	0.5 mg/day	None

* Sodium fluoride (2.2 mg sodium fluoride contains 1 mg fluoride ion).

¶ ppm: parts per million; 1 ppm = 1 mg/L.

UpToDate: Recommendations for using fluoride to prevent and control dental caries in the United States- CDC

mobility. It can also cause extensive calcification of ligaments and cartilage and bony outgrowths of osteophytes (bony lumps that form on the spine) and exostoses (existing bone tumor that grows on bone tissue). To prevent ingesting too much Fluoride, there are recommendations for adequate fluoride intake as per the age group: 0.7 mg/ per day for toddlers, 3 mg per day for adult females, and 4 mg per day for adult males.

Dietary Fluoride is quickly absorbed through the lining of the stomach and small intestine. From there fluoride is transported through the body specifically in the areas of teeth and bones, with 99% of fluoride being stored in the bones and teeth and the amount steadily increasing during life. The body breaks down fluoride and 50% of fluoride is stored in the teeth and bones, where it waits to be used in different processes such as bone formation and rebuilding the enamel layer (NIH Office of Dietary Supplements). All the fluoride that is not stored in the bones or teeth is later excreted in urine.

Fluoride can be produced naturally in the form of Calcium Fluoride, which is found mainly in bones and teeth. However, fluoride can be attained through other means as well. Fluoride is naturally found in the Earth's crust (Children's Dentistry). Fluoride is normally found in all natural waters, both seawater and natural water (Children's Dentistry). Another odd water that fluoride is found in is tap water. Fluoride can also be found in toothpaste, other dental products that contain fluoride, and foods and beverages that are made with fluoridated water. Some food sources in our everyday life that contain fluoride are broth, seafood, and spinach. Fluoride is not added to any food products; however, it can be found in different supplements such as tablets, toothpaste, and lozenges. Fluoride can also be administered in different forms such as dental sealant and fluoride.

Despite fluoride being such an essential part of the human body, little is known about it outside of being used for dental and skeletal purposes. So much more could be discovered about fluoride's effects on other parts of the body such as the central and peripheral nervous system or the digestive system. Researchers have already started looking into this plethora of theories.

A study was conducted in 2023 by a group of scientists researching fluoride and its possible cause-and-effect relationship to Attention Deficit Hyperactivity Disorder (ADHD). There have always been theories of outside factors influencing ADHD due to ADHD's common occurrence today. The reason fluoride has been specified is that fluoride is also quite common in many food sources today. This is why I found this research article interesting, that the thought of ADHD being caused by an outside force that can be easily influenced. In this study, fluoride is the outside factor being tested. The

study had multiple methodologies: one consisted of a survey asking about the subject's consumption of fluoridated drinking water, and another consisted of collecting different urine samples and measuring them for fluoride content. Analyzing the data has shown that there is a positive link between ADHD and fluoride exposure since the fluoride levels for those with ADHD were higher than those without ADHD by 0.5 mg/L (Fiore). However, due to the heterogeneity of the methodologies used, strong evidence is insufficient to support the conclusion that ADHD and fluoride are linked (Fiore).

This discovery is significant because it gives answers to not only what fluoride can do to the body, but also shows that disorders such as ADHD can be caused by outside factors or influences, fluoride being one of them. If I were a scientist studying this topic, I would make sure the methodology is the same for every experiment to get robust evidence. I would also consider environmental factors, pre-existing health conditions, and co-morbidities so that there can be definite evidence fluoride and ADHD have a connection. Having concrete evidence that there is a link between the two opens possibilities that ADHD might not just be caused genetically, but also by the influence of outside factors.

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Vitamin K

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The significance of vitamin K on the human body has been on the rise since 1928 when Carl Peter Henrik Dam was able to deduce the nutrient's existence through a scientific investigation involving chickens and their ability to coagulate, or clot blood (Gröber et al.). An apparent deficiency has become observable from the unnecessary bleeding due to a lack of vitamin K, especially in newborns with about 1 in 60 to 1 in 250 having vitamin K deficiency bleeding (VKDB) (CDC). In the current medicine market, the vitamin has been categorized into three different forms, however, the only variant currently available as a supplement, K1, is scientifically known as phylloquinone (natural) and phytonadione (synthetic) (Mount Sinai). With the use of K1 as injections and oral medicine, VKDB has fortunately become less of a threat than when first discovered in 1928, reducing 98% of late-onset VKDB after birth (Cheng et al.).

Vitamin K, or Koagulationsvitamin in its German title, is best considered for its helping hand in supporting proper and imperative clotting of blood (Mount Sinai). Nevertheless, vitamin K is also a strong variable in our body's immune system strength and cognitive functions like thinking and memorizing (WebMD). Furthermore, vitamins are responsible for a large portion of our skeletal durability (WebMD). To fulfill the requirements of this nutrient's potential benefits, there is a varying intake that should be consumed. These differences are measured by the distinction in age, sex, and body mass yet should still be ingested daily.

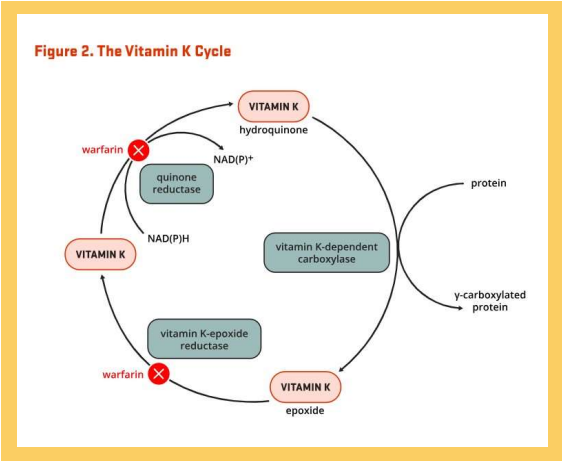
The following intake recommendations are meant to reflect a normal and consistent intake while all other circumstances are negligible. Although this may greatly change according to the National Institutes of Health "newborns who don't receive an injection of vitamin K at birth, people with conditions (such as cystic fibrosis, celiac disease, ulcerative colitis, and short bowel syndrome) that decrease the amount of vitamin K their body absorbs, [and] people who have had bariatric (weight loss) surgery" can all be patients who need larger vitamin K intakes (NIH).

Life Stage	Recommended Amount
Birth to 6 months	2.0 mcg
7–12 months	2.5 mcg
1–3 years	30 mcg
4–8 years	55 mcg
9–13 years	60 mcg
14–18 years	75 mcg
Adult men 19 years and older	120 mcg
Adult women 19 years and older	90 mcg
Pregnant or breastfeeding teens	75 mcg
Pregnant or breastfeeding women	90 mcg

Source: National Institutes of Health. "Vitamin K." Office of Dietary Supplements, ods.od.nih.gov/factsheets/VitaminK-Consumer/.

As mentioned before, there is an adverse effect when vitamin K is not consumed consistently, creating a deficiency in the nutrient, and eventually leading to severe symptoms. Vitamin K levels in the body can be affected not only by inconsistent intakes but also by antibiotics and digestive disorders (usually concerning the liver) (healthdirect). More specifically, VKDB is considered a hemorrhagic (blood loss from a vessel) disease targeting newborns (CHOP). The treatment for this can fluctuate based on the doctor's diagnosis, usually resulting in blood transfusions, supplement feeding, and vitamin K shots (CHOP). For this reason, the figure above is a strongly advised reference for impregnated women and parents of the newborn(s). Furthermore, since vitamin K is heavily important in the bones, low levels of vitamin K can create easily made bruises, and even osteoporosis (healthdirect). Osteoporosis is known as a bone disease that creates brittle bones due to low mineral density and mass (NIH). On the other hand, as the saying goes "too much of anything is bad for you" and this is also the case with vitamin K. Vitamin K toxicity is an infrequent problem, but if it were to occur then there can be "signs of jaundice, hyperbilirubinemia, hemolytic anemia, and kernicterus in infants" according to the National Institutes of Health (NIH).

To initialize, process, and store vitamin K for substantial and necessary dietary benefits, there is a cycle referred to as the vitamin K cycle that our body uses to appreciate and depreciate levels of vitamin K and preserve the nutrient. The body has a limited capability of storing vitamin K so it resorts to the use of



Source: Linus Pauling Institute. "Vitamin K." Oregon State University, lpi.oregonstate.edu/mic/vitamins/vitamin-K.

rapidly depleted and relies on daily intakes (MIC Linus Pauling Institute). The digestive system will oxidize and reduce vitamin K in the forms of epoxide (the oxidized version) and hydroquinone (the reduced version) (MIC Linus Pauling Institute). As shown by Figure 2, with the help of enzymes like vitamin K epoxide-reductase this cycle can continue, except if there is warfarin (an anticoagulant drug) in the body's system which will block this recycling and acts as an inhibitor (MIC Linus Pauling Institute). The repetitive and frequent deterioration and formulation of vitamin K allow the body to sustain significant health conditions while not creating an overload of nutrients.

To ensure the body maintains adequate levels of this essential vitamin, it is important to include a variety of vitamin K sources in the diet. While our body can create a synthetic version of vitamin K (menaquinone) in the liver and intestines through bacteria, we usually ingest most of our vitamin K from green plants (phylloquinone) and dairy (menaquinone) as previously stated (URMC). Referencing to the WebMD, vitamin K is also available as a supplement, commonly through its K1 variant, and in its less bioavailable form, K2 (WebMD). As a supplement, it can be used for those who require larger intakes and/or process the vitamin abnormally.

Interestingly, in 2012, Nancy Presse and fellow researchers investigated the relationship between vitamin K levels and cognitive function in older adults (pg.2777). The study included 320 healthy participants aged 67-84 with normal and healthy cognitive function (Presse et al., pg.2777). Controlling for age, sex, and education, researchers measured vitamin K levels and assessed cognitive function through memory, executive function, and processing speed tests (Presse et al., pgs. 2778-2779). They found higher serum phylloquinone (Vitamin K1) levels were linked to better verbal episodic memory, suggesting the potential for vitamin K-based treatments to prevent memory loss or dementia (Presse et al., pgs.2780-2781). Personally, this is significant as I have elderly relatives experiencing memory loss, and so it highlights the nutrient's practicality throughout different biological processes. Future research could explore other vitamin K variants like K2 to broaden our understanding of its impact on cognitive function.

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Folate

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Folate is a naturally occurring nutrient that is also referred to as vitamin B9. It was first discovered in 1931 by Dr. Lucy Wills while studying a way to prevent anemia in pregnant women. Dr Wills discovered that Brewer's Yeast was able to reverse the anemia because of the folate it contained (Mandal). Since then, folate has proven to be an important nutrient that affects many aspects of our health, including cell division as well as DNA repair and replication. It is also critical during the development of an unborn child. Folate can be found in many foods, particularly dark leafy greens, but can be consumed through supplements or enriched foods with folic acid by those lacking folate in their diet.

Folate plays a role in many necessary functions of the body. It is especially important in the diets of women who are pregnant, or those who are planning to become pregnant in the future. One of the main functions of folate in pregnant women is assisting in preventing Neural Tube Defects (NTD) for the offspring (Arnarson). As the fetus is growing, the "folate demand in the body increases with pregnancy secondary to support rapidly growing maternal and fetal tissue". NTD can manifest themselves and appear as conditions such as spina bifida, anencephaly, and hydrocephalus. These can be detrimental to the health of the fetus and may even be fatal. The consumption of folate is also necessary for the neurodevelopment of the unborn child. In a study performed to assess the neurodevelopment of two-year-old children in relation to the amount of folate in their mothers' systems at different stages of gestation, data proved that the amount of folate present in the mother in late gestation positively correlated with neurodevelopment. In fact, "for each 10 nmol increase in serum folate concentration, there was a 3.1-unit increase in the language developmental quotient of children". These children were assessed on fine language, adaptive, motor, and social behavior (Virdi and Jadavji). This finding highlights the importance of consistently consuming folate while pregnant to aid the neurodevelopment of the fetus. In addition to the positive effect of folate during pregnancy, folate has also been proven to have many other uses. It is extremely important for RNA synthesis as well as DNA replication and repair. Additionally, folate aids with cell division and protein synthesis (Andrews). Folate has also proven to be an integral part of methylation reactions as well as amino acid homeostasis (Virdi and Jadavji). It also helps lower the risk of cardiovascular disease and assists in the prevention of certain cancers, particularly colorectal cancer (Sauer et al.).

Since folate is so critical to the body and particularly to fetus development, it is important that we consume enough of it. It can be found in foods such as beef liver, vegetables such as dark leafy greens (particularly spinach), fruits, juices, nuts, beans and peas. For those that do not consume enough folate rich foods, supplements are a popular option and in 1998 the FDA mandated that food companies add folic acid to cornmeal, pasta, bread, flour, rice, and other grain products. Since so many Americans eat these foods regularly, these fortified foods have helped decrease the number of babies being born with neural tube defects ("Folate").

While folate and folic acid are commonly used as interchangeable names, folate occurs naturally while folic acid is the commercially synthesized form of folate used in vitamin supplements and added to foods. Since folic acid is not very costly to produce and is a necessity for our body in its active form, it is often made synthetically as a supplement (Chan et. al). Both folate and folic acid are processed and converted into 5-methylhydrofolate (5-MTHF) which is the active form of the naturally occurring vitamin B9. However, folate is converted in the digestive system prior to entering the bloodstream, but folic acid becomes 5-MTHF in the liver. The processing of folic acid compared to folate is a much slower process and one might still have an unmetabolized dose in their system when the next dosage is taken. This can lead to a buildup of unmetabolized folic acid in the body. While studies are still working towards solidifying a cause-and-effect relationship, the buildup of unmetabolized folic acid in the body is correlated with health risks such as cancer. It is therefore more ideal to receive one's intake of folate through whole foods rather than as a supplement when possible (Arnarson).

Exposing oneself to too much or too little folate or folic acid can be dangerous to one's health. For instance, because of the role that folate plays in cell division and protein synthesis, too little of the nutrient within the body may lead to megaloblastic anemia. Red blood cells require high rates of division and if they are not properly dividing the result may be incomplete large blood cells or megaloblasts. Similarly, folate plays a large part in Methylation reactions and "methylation of DNA is valuable in preventing cancer" (Andrews). There are also many risks in terms of mothers receiving too little or too much folate while pregnant. Deficiencies have been shown to decrease brain size, thickness of brain regions, and play a significant role in neuropsychological disorders (Virdi and Jadavji). Additionally, low levels of folate in humans have been linked to depression ("Folate"). Conversely, taking too much folic acid during a pregnancy can slow neurodevelopment as well as increase insulin resistance. One of the dangers of folate in general is that it can mask deficiencies in Vitamin B12. This vitamin is responsible for making red blood cells and it works to keep the heart, brain, and nervous system functioning correctly. Since the body uses vitamins B9 and B12 very similarly, a deficiency in either can cause similar symptoms and the deficiency in vitamin B12 can go unnoticed. An untreated B12 deficiency can result in irreversible nerve damage among other harmful effects. In addition, studies show that a healthy dose of folate can keep cells in the body healthy; however, exposing cells to too much supplemental folic acid can cause the cells to become cancerous. The exposure also increases the risk of cancer returning for former cancer patients (Ajmera and Petre).

One of the dangers of folate in general is that it can mask deficiencies in Vitamin B12. This vitamin is responsible for making red blood cells and it works to keep the heart, brain, and nervous system functioning correctly.

Since consuming the correct amount of folate and folic acid is so important, the National Institute of Health currently recommends that those over 19 limit their intake of the nutrient and its supplement to 1000 micrograms per day. This decreases to 400 mcg for those 14 and older, and even lower for younger children (Ajmera and Petre). Because of the importance of folate in the diet of pregnant women in preventing NTD, it is recommended that those affected by NTD in the past take 4000-5000 mcg of folic acid. This recommendation is to be followed for 3 months prior to conception for those planning to be pregnant and continue all the way through the first trimester (Chan et al.). Pregnant women receiving the adequate amount of folate too late, however, can also pose a risk to the health of the child. Studies have shown that women with inadequate amounts of the nutrient in their diet or women who start taking the supplement too late in their pregnancy are more at risk to have children with emotional issues including being anxious, reactive, or depressed (Virdi and Jadavji). There are many regulations for folate intake to ensure it is consumed at a healthy level.

There are many functions of the body that rely on folate and folic acid in its active form, 5-MTHF. The consumption of this nutrient, whether it be through naturally rich foods or supplemented with synthetically made folic acid, is extremely important to healthy living. Pregnant women who want to ensure the safety of their fetus and prevent NTD and cognitive issues should especially focus on consuming this nutrient.

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Zinc

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Zinc, being the trace element with the second highest abundance, is a crucial micronutrient for the human body. In fact, "more than 300 enzymes and 1000 transcription factors depend on zinc for their activities," with one in ten proteins in the human body being a zinc protein (Stiles, Ferrao, Mehta). Zinc holds a plethora of beneficial functions ranging from cell growth, protecting immune function, skin health, protein synthesis, and more. In this specific research paper, we will focus more on zinc's impact on inflammation and the digestive system.

What initially interested me in nutrition and zinc was my background interning in a gastroenterology clinic. Working there, I met patients everyday struggling with types of inflammatory bowel disorders such as Crohn's and ulcerative colitis. Keeping my eyes and ears open, one common thread I noticed in hanging posters and overheard conversations was the mention of nutrients. I quickly learned the importance that nutrition plays in regulating inflammatory symptoms. One conversation that particularly struck me was one I had with a patient in which they said that they had to take supplements to combat nutritional deficiencies they faced, as the medication they took stripped the nutrients from their body. Striking my interest, as I investigated which nutrients played the biggest role in inflammation, I came upon the micronutrient and trace element zinc.

What is it and why is it important?

But what exactly is Zinc? Zinc is an essential mineral required for every stage of life from pregnancy and infancy to adulthood for aspects of cellular metabolism, immune function, wound healing, and cell signaling and division (NIH). Zinc reinforces healthy growth and development, playing a major role in even the sense of taste and smell. Without zinc, hundreds of cellular processes like homeostasis, metabolism and protein production would not be possible. This is why it's important to have a healthy amount of zinc in our bodies, to support life. Zinc, an essential nutrient, is one which your body cannot produce naturally, which is why it's important to absorb it through diet and supplementation.

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months*	2 mg	2 mg		
7–12 months	3 mg	3 mg		
1–3 years	3 mg	3 mg		
4–8 years	5 mg	5 mg		
9–13 years	8 mg	8 mg		
14–18 years	11 mg	9 mg	12 mg	13 mg
19+ years	11 mg	8 mg	11 mg	12 mg

Table shows the recommended daily zinc absorption.

Zinc can be consumed through a variety of different plant and animal sources such as fish, oysters and broccoli. According to the NIH, oysters are the food with the highest concentration of zinc, but in America, beef is the leading contributor of zinc absorption. Eggs, dairy products, beans and whole grains contribute to Zinc levels as well. However, non-animal sources of zinc such as beans and whole grains contribute significantly less than their counterparts due to the presence of phytate, inhibiting zinc through intestinal absorption. Another way zinc can be absorbed besides food is supplementation. Due to zinc's undisputable beneficial nature, zinc is incorporated into lozenges, denture adhesive creams, and multivitamins.

Zinc is found throughout our body but stored in highest concentration in our skeletal muscle and bone. Our body uses the zinc we receive and processes it through absorption in the small intestines. Current research shows that in humans the duodenum and jejunum absorb the highest concentrations. Zinc is carried in the body and processed by a protein called serum albumin which links to zinc maintaining homeostasis.

There is still a limit to the amount of zinc one should absorb as too much zinc can lead to neurological diseases, nausea, diarrhea and copper deficiency.

Zinc Deficiency

However, America suffers more from under absorption rather than over absorption. "Nearly two billion people in the developing world are deficient in zinc. In children it causes an increase in infection and diarrhea, contributing to the death of approximately 800,000 children worldwide per year" (Mustapha, Usman). Zinc deficiency prevails globally and is something that needs to be addressed due to its negative consequences. This deficiency impacts all groups and people with IBD are most

susceptible. There are a multitude of reasons why those with inflammatory bowel disorder are deficient ranging from "poor diet intake, decreased absorption, and increased urinary excretion" (NIH). These different factors lead to 1 out of 2 IBD patients having zinc deficiencies (LD, Smith, MS, RD).

Research study and Discussions

Addressing the rising problem, we are facing zinc deficiency is especially vital in conversation with inflammatory bowel disorder. If zinc plays a significant role in limiting inflammation of the intestines, it gives good cause to find solutions to address zinc deficiency in people with Crohn's and colitis. A study that answered the question of the extent to which zinc regulates inflammation is Dr. Christer Hogstrand's paper published in Nature. Hogstrand's study used mice in an experimental design to link zinc and a sensory protein to the management of "leaky gut" and inflammatory bowel disorder. Dr. Hogstrand, with his highly trained team, used mice and human stem cells to replicate "mini guts' and showcase the effect of zinc on inflammation. Dr. Hogstrands team used two groups of mice to showcase the effect of zinc on inflammation: the experimental group of mice received foods high in zinc like broccoli, while the control group did not receive foods high in zinc. They investigated the role of zinc in stimulating a sensor called Aryl Hydrocarbon (AHR). Once ARH was activated by the food rich in zinc, inflammation of the bowels of the mice was deterred. In comparison, the control group, mice without zinc, still experienced inflammation of the bowels, proving the positive effects that zinc has on health. Dr. Hogstrands team explained that our gut, serving as a selectively permeable barrier for our digestive system, is made from thousands of thin cells. These thin cells are held together by "tight junctions," maintaining the integrity of the cells. When these "tight junctions" become looser, a "leaky gut" is formed. Hogstrand goes on to explain that certain nutrients such as zinc play a vital role by communicating and linking with the AHR receptors, tightening the junctions and preventing IBD. Inflammatory bowel disease, a disorder that is characterized by cramping and bleeding, then goes on to damage the intestines and digestive tract, leading to a "leaky gut." Zinc is crucial in keeping these tight junctions in the cell compact. Hogstrand's research solidifies the significance of zinc in our food and goes to show that to limit inflammation for IBD patients, there should be an emphasis on incorporating zinc heavy foods like broccoli and oysters into diet.

Now that it has been proven by Hogstrands team that zinc plays a vital role in limiting inflammation, we know that the next steps are to figure out how we can address and combat the severe deficiency of zinc IBD patients face. I would like to conduct research like this in the future to help people like the ones I see at the clinic everyday alleviate their pain. While Hogstrands team focuses more on the scientific aspect of zinc, I would like to focus more on the social implications and how we can apply the findings to daily diet. I hope if we were able to do this, we could lighten the burden those with inflammatory bowel disorder face little by little, making it easier for them.

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β-Cryptoxanthin

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Cryptoxanthin, a carotenoid found in plants, gives color to fruits and vegetables. There are two major forms of cryptoxanthin: alpha (α) and beta (β). The term commonly refers to β-cryptoxanthin, the biologically active form with molecular formula C40H56O. As a provitamin A carotenoid, β-cryptoxanthin when taken via food can be converted by body into vitamin A. β-cryptoxanthin was first isolated and identified by the British chemist Richard Willstätter in the early 20th century, who made significant contributions in the understanding of plant pigments, including chlorophyll and carotenoids, and was awarded the Nobel Prize in Chemistry in 1915. β-cryptoxanthin is more stable in its esterified form than a free form and is hydrolyzed in the digestive system to release the active free form for absorption and use by the body (Burri 2016).

β-cryptoxanthin, consumed through foods, is particularly high in pumpkins and squash, tangerines and oranges, papayas, peaches, (Table 1 for detailed list). Its concentrations in fruits and vegetables depend on the cultivar, maturity, growing conditions, season, and storage method (Namitha 2010, Boon 2010). For example, citrus fruits have peak β-cryptoxanthin during the ripening season. The bioaccessibility of β-cryptoxanthin (i.e., the amount the body can absorb), can be influenced by how food is processed and cooked (Namitha 2010, Boon 2010). Gentle and brief cooking methods increase bioaccessibility by breaking down cell walls and proteins that bind to β-cryptoxanthin, whereas intense or lengthy processing like refining, drying, or long boiling can decrease their bioaccessibility (Namitha 2010, Boon 2010).

Table 1: Common foods rich in β-cryptoxanthin

Food	β-cryptoxanthin (µg/100 g of food)
Butternut squash	3471
Persimmons	1447
Hubbard squash	1119
Hot chili peppers	1103
Tangerines (canned; raw)	775; 407
Papaya	589
Sweet red peppers	490
Rose hips	483
Sweet pickles	271
Carrots	199
Kumquats	191
Orange juice	169
Sweet corn	161
Oranges	116

Data: from USDA/ARS National Nutrient Database for Standard Reference, Release 27 (2014)
Source: Burri 2016

β-cryptoxanthin is extracted more easily from yellow and orange fruits compared to green leafy vegetables (Burri 2016). In the small intestine, the bile acids emulsify the fat-soluble carotenoids, including β-cryptoxanthin. Pancreatic lipases further break down the emulsified fats and release β-cryptoxanthin. β-cryptoxanthin, being fat-soluble, is incorporated into micelles, which helps to transport it across the intestinal lumen to the enterocytes via passive diffusion. Once inside enterocytes, β-cryptoxanthin is incorporated into chylomicrons, which transport β-cryptoxanthin through the lymphatic system into bloodstream and various tissues in the body. In enterocytes and liver, β-cryptoxanthin can be converted into retinol (vitamin A), which contributes to meeting the body's requirement for vitamin A (Grune 2010).

There is no specific recommendation for daily intake of beta-cryptoxanthin as it is part of the overall intake of carotenoids and vitamin A. The recommended daily level for vitamin A for adult males is 900 mcg of retinol activity equivalents (RAE) and for adult females is 700 mcg RAE (NIH). There is no specific concern for deficiency in beta-cryptoxanthin if vitamin A intake level is adequate. Insufficient vitamin A levels can cause vision problems, weakened immune function, skin issues, and reproductive and growth problems, while excessive intake can lead to nausea and vomiting, dizziness, headaches, dry skin, and liver damage (Hodge 2023).

Studies assessing carotenoids and β-Cryptoxanthin in human diet, blood (serum or plasma) or breast milk samples suggest variability by country. Higher consumption rates are found in Spain and Japan, given Tangerines as a significant source of their diet (Granado 1996, Xiang 2008), and lower rates in lower-income countries like Bangladesh (Turner 2013). A recent study in various geographic regions (Europe, North America, Asia and Australia) confirmed the previous findings, and suggest variability in β-Cryptoxanthin concentration due to differences in dietary intake (Olmedilla-Alonso 2020). In European samples, four fruits and two vegetables (orange and orange juice, tangerine, red pepper, carrot, tomato and spinach) contributed to >50% of intake of the three provitamin A carotenoids (Olmedilla-Alonso 2020).

β-cryptoxanthin acts as an antioxidant, and shields organs and tissues from oxidative and inflammatory stress and harm. Studies have shown that higher concentration of β-cryptoxanthin and other carotenoids is linked to reduced risks of diseases such as cancer, obesity, type 2 diabetes, non-alcoholic fatty liver disease, osteoporosis, hip fracture and degenerative diseases (Sugiura 2015, Burri 2016, Nishino 2022). Provitamin A carotenoids including β-Cryptoxanthin have also been shown to support vision, cognitive, immune function and skin health, neurocognitive development. Many cognitive studies looking at the influence of provitamin A carotenoids have focused on elderly populations, and little is known about the influence on neurocognitive functions during early childhood. One recent study I came across is a prospective cohort study of 419 mother-offspring pairs that looked at the relationship of maternal plasma concentrations of three provitamin A carotenoids with antioxidative properties–α-carotene, β-carotene, and β-cryptoxanthin–at the time of delivery with the cognitive development of their offspring at age 2 (measured using the Bayley Scales of Infant and Toddler Development, 3rd edition) and 4.5 years (measured using the Kaufman Brief Intelligence Test, 2nd edition) (Lai 2021). The study found that higher maternal concentrations of β-cryptoxanthin were positively associated with better cognitive, receptive language, fine and gross motor development in children at 2 years of age. Additionally, higher maternal β-carotene concentrations were linked to improved cognitive scores at the same age. However, no significant associations were observed between maternal carotenoid concentrations and neurocognitive functions in children at 4.5 years of age. These findings suggest that certain carotenoids, particularly β-cryptoxanthin with greater antioxidant activity and higher bioaccessibility and bioavailability, may play a beneficial role in early cognitive and motor development. Findings from this study provide novel evidence that prenatal exposure to specific carotenoids, especially β-cryptoxanthin, can positively impact early cognitive and motor development in children. This insight is crucial as it underscores the significance of adequate maternal nutrition for optimizing early child development outcomes. By highlighting the role of carotenoids in early neurodevelopment, the study informs public health strategies and nutritional guidelines aimed at improving maternal dietary intake during pregnancy, ultimately contributing to better health outcomes for children in the long term. Another interesting observation from this study is the differences in fruit intake rather than vegetable intake contributed significantly to the higher β-cryptoxanthin levels. This has an important practical implication, given it emphasizes the importance of consuming orange- and yellow-colored, and tropical fruits with greater abundance of β-cryptoxanthin.

Lai 2021 study is among very few that

was able to follow participants to assess the influence of maternal nutrition on early cognitive development. More such studies are needed in different populations with different dietary patterns to confirm such findings. Further, this study only followed the children up to the age of 4.5 years and found significant relationship of provitamin A carotenoids only at 2 years of age. If I were to do this study, I would like to make the follow-up time longer. Given the fact that different brain regions have different developmental trajectories (Fox 2010), the influences of provitamin A carotenoids on cognitive functions may depend on the maturation stage of the brain and the timing of assessment. Thus, if the interest is in understanding the longer-term influence of maternal provitamin-A carotenoids on various areas of cognitive development, a study following infants throughout the childhood and adolescence periods can provide a better insight.

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Vitamin A

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Vitamin A is an essential nutrient crucial for various bodily functions, including vision, immune response, and cellular communication. Its importance extends beyond basic nutrition, impacting health outcomes, disease prevention, and therapeutic applications.

Vitamin A encompasses a group of compounds, including retinol, retinal, and retinoic acid, known collectively as retinoids. Additionally, certain carotenoids like beta-carotene serve as provitamin A, which the body can convert into active forms. Vitamin A's bioavailability and efficacy are influenced by factors such as dietary sources, metabolism, and genetic variations.

Vitamin A's functions are mediated through its conversion to active metabolites. Preformed vitamin A (retinol and its esters) and provitamin A carotenoids (beta-carotene) undergo metabolic transformations to become bioactive. Retinol is oxidized to retinal, essential for vision, and further to retinoic acid (RA), a potent regulator of gene expression through its interaction with nuclear receptors. RA acts as a transcription factor ligand, influencing genes involved in cell morphogenesis, differentiation, and proliferation (Dawson).

One of the most well-known functions of vitamin A is its role in vision. Retinal, a derivative of retinol, is a critical component of rhodopsin, a protein in the retina that absorbs light and initiates the visual cycle. A deficiency in vitamin A can lead to night blindness and, in severe cases, complete blindness. This aspect of vitamin A is extensively covered in literature but remains crucial for understanding its importance (Dawson).

Vitamin A and its derivatives, particularly retinoic acid (RA), are known to regulate cell growth, differentiation, and apoptosis, processes that are often dysregulated in cancer.

Vitamin A's role in immune function is multifaceted. It maintains the integrity of epithelial tissues, which serve as barriers against pathogens. Retinoic acid influences the differentiation and function of T-cells, essential for adaptive immunity. Huang et al. (2018) emphasized its anti-inflammatory properties and therapeutic potential in autoimmune diseases.
Moreover, adequate Vitamin A levels are associated with reduced severity and mortality of infectious diseases, including measles and respiratory infections (Huang et al.).

Vitamin A is vital for fetal development and maternal health. Ma et al. (2021) explored the relationship between vitamin A, oxidative stress, and pregnancy outcomes in patients with gestational diabetes mellitus (GDM). Their findings indicate that sufficient vitamin A levels can mitigate oxidative stress, thereby improving pregnancy outcomes and reducing complications in GDM (Ma et al.).

Vitamin A deficiency remains a significant public health issue in many developing countries. In Malawi, Williams et al. (2021) observed a decline in deficiency rates but highlighted the problem of elevated vitamin A levels due to over-supplementation. Similarly, Ghosh et al. (2021) reported persistent deficiencies among children under five in India, underscoring the need for ongoing and balanced supplementation programs (Williams et al.; Ghosh et al.).

The role of vitamin A in retinal health extends beyond vision. Retinoids are crucial for maintaining photoreceptor function and preventing retinal diseases. Sajovic et al. (2022) reviewed its therapeutic potential in treating conditions such as retinitis pigmentosa and age-related macular degeneration. Their research supports the use of retinoids in preserving retinal health and preventing degenerative diseases (Sajovic et al.).

Research by Ma et al. (2021) delves into the impact of vitamin A on oxidative stress and pregnancy outcomes in patients with gestational diabetes mellitus (GDM). The study revealed that adequate vitamin A levels are essential for mitigating oxidative stress, a common complication in GDM, thereby

improving pregnancy outcomes. This shows the critical role of vitamin A in prenatal health and its potential in managing high-risk pregnancies (Ma et al.).

The potential role of vitamin A in cancer prevention has also garnered significant attention. Vitamin A and its derivatives, particularly retinoic acid (RA), are known to regulate cell growth, differentiation, and apoptosis, processes that are often dysregulated in cancer (Takahashi et al.). RA acts on nuclear receptors to modulate gene expression, influencing cell cycle control and promoting the differentiation of malignant cells. This ability to induce cellular differentiation has led to the use of RA in treating acute promyelocytic leukemia (APL), where it induces remission by differentiating leukemic cells into mature granulocytes (Takahashi et al.).

Vitamin A's role in wound healing extends beyond its immune-modulating properties. Polcz and Barbul (2019) highlight that vitamin A enhances collagen synthesis, a crucial component of the extracellular matrix necessary for wound closure. Additionally, retinoic acid influences the proliferation and migration of keratinocytes, accelerating epithelialization. These properties make vitamin A a valuable nutrient in clinical settings for managing wounds, burns, and other skin injuries (Polcz & Barbul).

Emerging research has revealed a connection between vitamin A signaling and metabolic health. Blaner (2019) examines how vitamin A influences lipid metabolism and insulin sensitivity, highlighting its potential in combating obesity and related metabolic disorders. Retinoic acid regulates genes involved in adipogenesis and lipid oxidation, processes that are critical in metabolic homeostasis. This regulation suggests that adequate Vitamin A intake could play a role in preventing and managing obesity and diabetes (Blaner).

The role of Vitamin A in epigenetic regulation is a burgeoning field of study. Epigenetics involves heritable changes in gene expression without alterations in the DNA sequence, such as DNA methylation and histone modifications. Bar-El Dadon and Reifen (2015) review how retinoic acid influences epigenetic mechanisms, affecting gene transcription and phenotypic outcomes. For instance, RA has been shown to modulate the expression of genes involved in stem cell differentiation and immune function, making it a potent agent in both developmental biology and therapeutic interventions (Bar-El Dadon & Reifen).

Considering the COVID-19 pandemic, the relevance of Vitamin A in enhancing immune resistance and recovery has come to the forefront. Stephensen and Lietz (2021) review how adequate vitamin A levels can improve outcomes for patients with respiratory infections, including SARS-CoV-2. Vitamin A supports mucosal integrity and immune responses, crucial for defending against respiratory pathogens. This shows the importance of maintaining sufficient vitamin A levels in the diet, particularly during global health crises (Stephensen & Lietz).

Overall, vitamin A's diverse roles in human health truly shows its importance as a nutrient. From prenatal health and immune function to retinal health and wound healing, the benefits of vitamin A are extensive. Recent research continues to uncover new insights into its potential in disease prevention and therapeutic applications, affirming the need for balanced dietary intake and targeted supplementation programs.

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Vitamin B3

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Niacin (Vitamin B3), a vital component of the B-complex vitamins, is a critical player in our body's energy production, cognitive function, and cellular metabolic processes. It converts food (carbohydrates) into fuel (glucose), which our body uses to produce energy. These B vitamins, often referred to as B-complex vitamins, also assist in the body's utilization of fats and protein. They are essential for a healthy liver, skin, hair, and eyes and to properly ensure the nervous system functions. Understanding the significance of niacin, more specifically, in our overall health, is crucial.

Niacin, also known as vitamin B3, is widely distributed in the body's tissues and organs. It is particularly abundant in the liver, where it is synthesized from the amino acid tryptophan. Niacin is also found in muscles, the heart, kidneys, and brain. Most niacin is absorbed in the small intestine, but some can also be absorbed in the stomach. Once absorbed from dietary sources or supplements, all tissues in the body transform niacin into its active form, NAD (nicotinamide adenine dinucleotide). NAD can be converted into another form, NADP (nicotinamide adenine dinucleotide phosphate), in all tissues except skeletal muscle. NAD is essential for the function of over 400 enzymes, making it the body's most widely used vitamin-derived coenzyme. However, while both coenzymes derive from niacin, their attribution to the human body differs. NAD helps break down nutrients like carbohydrates, fats, and proteins to produce energy (ATP), which our cells use to function. It also helps with essential cell activities like repairing DNA, controlling which genes are active, and helping cells communicate with each other. On the other hand, NADP helps build important molecules like cholesterol and fatty acids.

Niacin can be obtained after being synthesized in the body by the amino acid tryptophan or various dietary sources, making it accessible to everyone. Excellent food sources of niacin include fish, beef, chicken, and turkey. Many legumes, nuts, seeds, and soy products also provide some niacin. When NAD and NADP are consumed in foods, they are converted to nicotinamide in the gut and absorbed. Ingested niacin is absorbed primarily in the small intestine, but some is absorbed in the stomach. Additionally, Niacin is found in multivitamins, B-complex supplements, and standalone niacin supplements. The most common forms in supplements are nicotinic acid and nicotinamide. Some niacin-only supplements can contain 500 mg or more per serving, far exceeding the recommended daily allowance.

High doses of nicotinic acid can cause skin flushing, so some supplements are designed as prolonged, sustained, extended, or timed release to reduce this side effect. Nicotinamide does not cause flushing due to its slightly different chemical structure. Niacin is also available as inositol hexanicotinate, and it is labeled flush-free since it does not cause flushing. However, the body absorbs about 30% less niacin from inositol hexanicotinate than nicotinic acid or nicotinamide, which are fully absorbed.

Additionally, nicotinamide riboside and nicotinamide mononucleotide (NMN) are available as supplements but are not labeled as sources of niacin. In November 2022, the FDA ruled that NMN cannot market as a dietary supplement because it is being investigated as a new drug.

What makes niacin so crucial to our bodies are its various functions, one being to help keep DNA intact. As a precursor to NAD, niacin is needed for

DNA synthesis and the enzyme poly (ADP-ribose) polymerase-1 activity, vital for adequate DNA repair, mainly when DNA strand breaks occur due to cellular damage and oxidative stress. Furthermore, vitamins enhance blood circulation, which can cause vasodilation (widening of blood vessels), enhancing oxygen and nutrients delivery to tissues. In addition, niacin contributes to synthesizing various sex and stress-related hormones in the adrenal glands and other tissues, influencing stress levels. Due to its anti-inflammatory properties, Niacin can affect hormone production. Reduced inflammation can help alleviate stress and improve stress-related conditions. Therefore, niacin can be crucial in managing and mitigating stress-related diseases.

Niacin supplements are most known for their ability to manage high cholesterol. The body regulates the levels of cholesterol in the blood. This includes balancing the levels of low-density lipoprotein, often referred to as "bad" cholesterol, and high-density lipoprotein, known as "good" cholesterol. Proper regulation helps prevent the buildup of cholesterol in the arteries, reducing the risk of cardiovascular disease. High–dose niacin (1,500–2,000 mg/day) was one of the first cholesterol-lowering drugs. However, studies found that niacin, unlike newer cholesterol-lowering drugs, did not lower the risk of heart attack or stroke. Researchers had not understood why. Recent studies suggest that "A metabolite of niacin (vitamin B3) is associated with elevated risk of heart attack and stroke, due to inflammation in arteries. The findings suggest new measures that may prevent or treat cardiovascular disease and raise concerns about the health effects of too much niacin" (National Institutes of Health). In summary, while niacin remains a valuable supplement for managing cholesterol, recent findings display the need for cautious use and further research to understand its impact on cardiovascular health fully. A study by Dr. Stanley Hazen at the Cleveland Clinic, funded by the NIH, explored why niacin might promote cardiovascular disease (CVD). Published in Nature Medicine on February 19, 2024, the research examined blood plasma from over 1,100 individuals and identified two molecules, 2PY and 4PY, produced when the body metabolizes excess niacin. These molecules were linked to a higher risk of major cardiac events like heart attacks and strokes. High-dose niacin, once a common cholesterol-lowering drug, did not reduce heart attack or stroke risk, puzzling researchers. The study found that elevated levels of 2PY and 4PY were associated with increased cardiovascular disease risk and variants in the ACMSD gene, affecting protein VCAM-1 levels. VCAM-1 is involved in inflammatory responses that lead to plaque formation in arteries. This process involves the buildup of various substances in the arterial walls, leading to narrow and less flexible arteries. It increases the risk of heart attack, stroke, and other severe conditions. Injecting mice with 4PY increased VCAM-1 and white blood cell adhesion to blood vessel walls, suggesting that excess niacin triggers inflammatory pathways promoting arterial plaque. This research offers insight into niacin's paradoxical effects and emphasizes the need for further study on niacin's health impacts. Ensuring an optimal dosage of niacin is a responsibility we all share. According to the National Institute of Health, the daily intake for women above the age of 19 is 14mg NE, and for men above the age of 19, it is 16mg NE. Pregnant women are recommended to intake more as it is seen to prevent birth defects and potential miscarriages after a study in mice. However, it is crucial to note that excessive niacin intake can be highly harmful, potentially leading to cardiac diseases, as mentioned previously. By being mindful of our niacin intake, we can take a proactive step towards maintaining our health.

Table 1: Recommended Dietary Allowances (RDAs) for Niacin [2]

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months*	2 mg	2 mg		
7–12 months*	4 mg NE	4 mg NE		
1–3 years	6 mg NE	6 mg NE		
4–8 years	8 mg NE	8 mg NE		
9–13 years	12 mg NE	12 mg NE		
14–18 years	16 mg NE	14 mg NE	18 mg NE	17 mg NE
19+ years	16 mg NE	14 mg NE	18 mg NE	17 mg NE

While too much niacin can be harmful, too little can lead to a disease called pellagra. A trio of symptoms characterizes this disease: dermatitis, dementia, and diarrhea, and it can be fatal. Niacin deficiency can also arise from genetic disorders, malabsorption issues, and interactions with certain medications. Niacin deficiency has also been found to lead to neurological symptoms that cause neurodegenerative decline. However, the direct link between niacin and AD pathogenesis, the processes leading to the development of Alzheimer's disease, has not been proven (Table 1). While

niacin deficiency is rare in industrialized countries due to adequate dietary intake, some groups are still at risk. So, it is essential to intake the correct amount according to America's health guidelines.

Niacin (Vitamin B3) is vital for energy production, cognitive function, and cellular metabolism. It is obtained from dietary sources and supplements and supports skin, nerve, and digestive health. Excessive intake can increase cardiovascular disease risk due to metabolites that promote inflammation and arterial plaque. Recent studies emphasize the need for cautious use of high-dose niacin supplements. Maintaining the recommended daily intake is crucial to avoid deficiency and ensure overall well-being.

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Selenium

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Selenium is a vital mineral found in almost all soils. It was discovered in 1817 by Jöns Jacob Berzelius a Swedish chemist and named after Selene, the Greek goddess of the moon (National Library of Medicine). When it was first discovered it was believed that this element was poison, but in truth it is the opposite of that. Selenium is a powerful antioxidant that combats a multitude of conditions and supports our long-term health.

Selenium is a trace mineral, and it is recommended to consume 55 micrograms a day for adults (National Institutes of Health). Selenium intake varies on the soil content of different regions, but it is found in seafood, lean meat and poultry, whole grains, Brazil nuts, eggs, and low-fat dairy. It can also be supplemented and can be found in many forms such as selenomethionine and sodium selenate. People with HIV, undergoing kidney dialysis, and people who live in selenium-deficient areas are at risk for selenium deficiency ("Selenium – The Nutrition Source"). The thyroid gland has the greatest selenium concentration (Cleveland Clinic). Selenium deficiency can lead to thyroid dysfunction, impaired immune function, and reproduction problems (Shreenath et al.). Both selenium deficiency and excess can lead to health issues, so it is best to consume this mineral in moderation.

The antioxidant fights free radicals which are damaging parts of the body.

Free radicals can harm cell membranes and DNA which is suspected to contribute to cancer, heart disease, and Alzheimer's (Mount Sinai). Selenium was beneficial against gastrointestinal cancer and lower rates of lung cancer in selenium-deficient populations (Dolaro et al.). It is an essential part of regulating thyroid hormone metabolism (Alehagen et al.).

Selenium is metabolized through a series of biochemical processes to incorporate it into selenoproteins (Minich). Once selenium is digested, it is absorbed in the small intestine and carried through the bloodstream to the liver. The body synthesizes selenium into selenoproteins by synthesizing it into selenocysteine. Excess selenium is usually excreted through urine and feces to prevent toxicity. It can be stored in tissues which can lead to toxicity, this is usually caused by excess supplementation. The efficiency of this breakdown depends on the body's ability to regulate these processes.

A recent study published in 2024 showed the impact selenium has on our health. Published in BMC Medicine, a peer-reviewed journal based in the United Kingdom, a team of researchers supplemented an elderly Swedish population, aged 70-88 that was selenium deficient with selenium and coenzyme Q10 (used to synthesize the selenium). It followed the participants for 4 years and the active group took 200 micrograms of the supplements. This study worked hard to eliminate all biases by implementing placebo, double-blind, randomized procedures. Thyroid stimulating hormones and ft4 were found to increase 10-year cardiovascular mortality. By supplementing with selenium, researchers hoped to find that the mineral would control the thyroid and reduce cardiovascular mortality.

The results about the importance of selenium were profound. The participants who took the supplement had lower levels of thyroid-stimulating hormones and increased fT3 and rT3. The quality of life improved in the active group. They believe it can be explained by an increased level of deiodinases. Deiodinases are selenium-containing enzymes used to synthesize the active form of T3. Low T3 levels are correlated with hypothyroidism (ScienceDirect). They concluded that some elderly populations may be suffering from impaired thyroid function due to selenium deficiencies.

This study is interesting to me because it exhibits how drastically important selenium is to our lives. If I were a scientist, I would try to replicate this experiment in other selenium deficient regions to see if the same results can be produced.

The thyroid gland has the greatest selenium concentration.

Even though we consume tiny amounts of Selenium, it is a powerhouse antioxidant that has mighty power in the thyroid gland and immune system. It protects us from our cells being damaged and demonstrates the immense importance of trace minerals for human wellbeing.

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Total Sugar

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Introduction

Humans have known about sugar for a long period of time: it was discovered around 350 AD (The History and Origin). Sugar has been the subject of research studies since then. Sugar, chemically known as sucrose, is commonly found in daily diets consisting of a vast range of foods including fruits, milk, vegetables, and other processed foods. The nutrition facts label lists two types of sugars: added sugars and total sugars. Added sugars, which do not include natural sugars, are the "sugars that are added during the processing of foods, foods packaged as sweeteners such as table sugar, sugars from syrups and honey, and sugars from concentrated fruit or vegetable juices." (Center for Food). On the other hand, total sugars include both natural sugars and any added sugars. Given the various different forms and ubiquitous presence of sugar, it is of utmost importance that consumers choose healthy sources of sugar to avoid being exposed to many chronic diseases following inappropriate sugar intake.

The Metabolism of Sugars in the Human Body

Sugars are metabolized in the human body through a complex system as they are broken down into different forms of sugar called glucose, which serves as a primary source of energy in the human body. Generally, sugars are either stored as fat or converted into glucose to be used as energy after undergoing metabolic processing in human bodies. In the human body, 15–25% of "ingested glucose is metabolized in the gut and liver" (Tappy). The liver is a unique organ that both stores and produces sugar. When people are not actively consuming sugar like overnight or between meals, the liver produces sugar or glucose through a process called glycogenolysis or gluconeogenesis, which are processes involving turning glycogen into glucose and de novo synthesis of glucose respectively (Adeva-Andany, María M, et al.). Specifically during the digestion process of natural sugar found in carbohydrates, "the digestive system breaks down the digestible ones into sugar, which enters the blood" (Carbohydrates and Blood). Analogous to the process by which carbohydrates are metabolized, during the digestion of protein, the protein molecule gets broken down into "amino acids to build and repair tissues or convert into glucose in the liver" through gluconeogenesis (Brixius). The metabolization of sugars in carbohydrates and proteins illustrates a complex system used to produce glucose, the body's main energy source.

Adverse Effects of Excessive and Insufficient Sugar Intake

Every nutrient has adverse effects when individuals consume an excessive amount of insufficient amount of a particular nutrient. According to the National Library of Medicine, "Clinical trials and epidemiologic studies have shown that individuals who consume greater amounts of added sugar, especially sugar-sweetened beverages, tend to gain more weight and have a higher risk of obesity, type 2 diabetes mellitus, dyslipidemia, hypertension, and cardiovascular disease" (Witek,

Wydra, Filip). Likewise, sugar yields several harmful physical consequences when days of consuming sugar in excessive amounts accumulate over a long period. Not only can sugar cause detrimental effects on the physical body, but it can additionally impact people's mental health and cognitive abilities. Specifically for children with Attention-deficit/hyperactivity disorder (ADHD), "amount of sugar products consumed, ratio of sugar products to nutritional foods, and ratio of carbohydrates to protein were all significantly associated with the amount of destructive-aggressive and restless behaviors observed during free play" (Prinz, Robert, et al). Thus, if children suffering from ADHD consume excessive amounts of sugar, they could be at a disadvantage, reflecting even more hyperactive behaviors.

On the other hand, there are also adverse physical and mental impacts when one receives an insufficient amount of sugar. Although a sufficient amount of sugar can be absorbed by the body from daily diet, skipping a meal causes hypoglycemia, which is "a condition in which your blood sugar level is lower than the standard range" (Hypoglycemia). Its physical symptoms include shakiness, headache, and an irregular or fast heartbeat. Moreover, its mental symptoms include fatigue, anxiety, difficulty concentrating, and dizziness. Thus, maintaining healthy eating habits with foods that are nutrient-dense is significant in maintaining a healthy body without mental and physical illnesses.

Research Study: "Dietary correlates of hyperactive behavior in children"

In the 1980s, a study was conducted investigating the correlation between sugar and hyperactive behavior in children. This study lasted seven days, recording the behaviors of 28 hyperactive 4–7-year-olds. The reports indicated that "amount of sugar products consumed, the ratio of sugar products to nutritional foods, ... were all significantly associated with the amounts of destructive-aggressive and restless behaviors observed" (Prinz et al.). Moreover, the study's additional result showed that food items discouraged by the Feingold Diet were irrelevant to aggressive and restless behaviors disproving the effectiveness of the Feingold Diet. This study enables individuals concerned with children's behavior to understand how sugar affects them and choose healthier diets with less sugar for children with ADHD symptoms. As this study concentrated specifically on young children, further studies exploring the effects of sugar on hyperactive adults could be conducted in the future.

Guidelines for Regulating Sugar Intake to Avoid Health Risks

To minimize the risks of consuming an inappropriate amount of sugar, daily recommended amounts of sugar are listed in the American Dietary Guidelines. Appropriate amounts of sugar can be obtained through a daily diet without added sugar, as glucose can be obtained by breaking down molecules of natural sugars. According to the Dietary Guidelines for Americans, "limiting calories from added sugars to less than 10 percent of total calories per day" is recommended (Center for Food). Currently, the majority of adults "exceed recommended limits for added sugars" ("Dietary Guidelines" 103). One feasible solution that can transform people's diet to keep blood sugar level in a healthy range is employing a low-glycemic index (low-GI) diet, which aims to "choose foods that are less likely to raise blood sugar levels" with an established glycemic index that

ranks the effect a food has on blood sugar levels, a low numerical value representing a minimal effect on blood sugar levels (Low-glycemic index). These specific numerical figures aid people in managing their meals and maintaining a healthy weight and blood sugar levels.

Conclusion

In conclusion, sugar, a ubiquitous component of people's diets, is metabolized in the human body through a complex system. Although it provides the human body with energy, if consumed in inadequate or excessive amounts, it can lead to physical and mental adverse effects, including many chronic diseases. Thus, reducing the amount of added sugar in the diet is crucial to overall wellness, which may be achievable with a low-glycemic index (low-GI) diet. Nowadays, acknowledging the prevalence of obesity and diabetes, some sugars in processed foods are being replaced by new sugar substitute: aspartame, sodium saccharin, and sucralose. Understanding the specific effects of total sugars on our body is equally important as being conscious of newly emerging dietary patterns with sugar substitutes. Those innovations with the purpose of reducing sugar in dietary practices are likely to considerably influence the food and nutrition fields in our society.

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Caffeine

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Caffeine, also known as trimethylxanthine and mateine, is a naturally occurring chemical stimulant and alkaloid found in many plants and nuts. It is a pure white, odorless powder (NIH) and was first discovered in 1819 by Friedlib Ferdinand Runge, a German analytical chemist, who isolated and clarified this substance. Runge received a box of rare Arabian mocha beans from the esteemed German writer Goethe and was requested to perform an analysis. It was a result of this analysis that led to the isolation of the world's first caffeine sample (University of Bristol). Caffeine, though not discovered until the 1800s, has long been used as a medicinal and recreational drug by the consumption of plants containing caffeine.

Though some might associate caffeine with solely coffee and other caffeinated beverages such as energy or soft drinks, caffeine is essential because it is found in many medicinal substances in both over the counter and prescription medicines. Due to caffeine being a central nervous system (brain and spinal cord) stimulant, it can help alleviate symptoms associated with migraines, post-dural puncture headaches, and apnea (Mayo Clinic) by increasing activity in the brain. Caffeine has a plethora of other functions in the body, including stimulating the nervous system and increasing the circulation of neurotransmitters such as adrenaline and cortisol. Caffeine affects the nervous system, but also plays a major role in other body systems such as the respiratory system by improving aerobic performance (National Library of Medicine). This is one reason why caffeine can benefit the body if consumed in moderation.

As far as the nutritional need for caffeine, there is no need for it to be in one's diet and specialists recommend no more than 400 mg per day. Since caffeine does have many adverse effects such as anxiety and headaches, it is not required for the human body to sustain itself and thrive. However, if a person drinks caffeinated beverages but doesn't receive enough caffeine, they may experience withdrawal symptoms such as fatigue and drowsiness. This is often referred to as caffeine tolerance where the body requires more caffeine in order to affect the body. On the contrary, if a person has too much caffeine in their system, they can experience trouble breathing, changes in alertness, and even hallucinations. This is why caffeine can be detrimental if the body doesn't process it quickly and efficiently (Mount Sinai).

The human body processes caffeine by the small intestine after it passes through the oral cavity and it begins to peak after thirty minutes. Caffeine can also be quickly absorbed into the bloodstream, stomach, and through the oral mucosa after ingestion. The time it takes the body to absorb caffeine varies based on how it is consumed. For example, chewing caffeine-containing gum is more rapidly absorbed in the body than drinking caffeinated beverages such as coffee. Other factors such as smoking and pregnancy can change the time it takes caffeine to break down as well–smoking speeds it up while pregnancy slows it down. While the human body does absorb caffeine, it doesn't store it. After caffeine is absorbed through the bloodstream, it is then transported to the body's cell membranes and brain. It then makes its way to the liver and leaves the body in the form of urine.

The human body processes caffeine by the small intestine after it passes through the oral cavity and it begins to peak after thirty minutes.

The nutrient caffeine doesn't naturally produce in the body. However, there are lots of studies and theories that suggest the body is producing a substance similar to caffeine (PubMed). As the world knows it, caffeine is found in coffee beans and contains more caffeine than any other beverage. Apart from coffee beans, caffeine is also found in tea leaves, cacao beans, and kola nuts. Caffeine is also added to many foods and drinks such as chocolate, energy drinks, green tea, sodas, and supplements (Healthline). With supplements, however, it is imperative to monitor how many pills one is consuming as these pills are highly concentrated in caffeine which

can lead to death if overdose occurs. Caffeine is not only used in foods and drinks, but also in weed management. According to a 1984 study by Harvard Medical School, "caffeine in plants may be helpful in pest management and acts as a natural pesticide." It is used as a defense mechanism in many plant bushes by acting as a natural pesticide that is discharged into the soil.

In the article that I chose, it examined the health effects of coffee consumption and found some surprising results. The study, published in the New England School of Medicine, found that coffee has striking effects on physical activity levels, causing people to move more and taking roughly 1000 extra steps every day. However, there were some downsides to a daily cup of coffee. The research indicated that people lost 36 minutes of sleep on days they drank coffee, which shows that more coffee consumption results in sleep deprivation. On the other hand, coffee can lower the risk of chronic diseases and perhaps extend someone's lifespan. These findings suggest that the health effects are quite complex. I think these findings are significant because coffee is one of the most consumed caffeinated beverages and people should be aware of the findings of this study. Coffee isn't considered an unhealthy beverage but there are definitely some health effects that can be detrimental to someone's health if it isn't consumed in moderation. This study is interesting to me because I myself drink a lot of coffee and was curious about the effects this beverage can have on our body, especially adolescents. I wondered how caffeine can affect someone's sleep and whether or not there should be a daily dose limit. I would use the findings in this study to conduct a study on how caffeine can affect the organs since it can reduce the risk of heart diseases. I would like to study how it affects our heart, muscles, arteries, and other organs.

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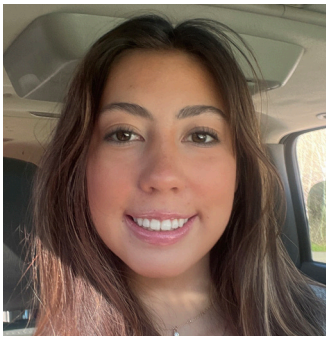

Pantothenic Acid

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Pantothenic acid, a B vitamin and essential nutrient, is crucial for human health. Also referred to as vitamin B5, it is a water-soluble vitamin. The main function of this nutrient is to turn the food you eat into energy through coenzyme A (COA) synthesis. Pantothenic acid was discovered in 1931 by American biochemist Roger J. Williams, "He derived its name from the Greek word "pantos," meaning "everywhere," as small quantities of pantothenic acid are found in nearly every food...In the mid-1960s, pantothenic acid was identified as a component of an acyl carrier protein (ACP) in the fatty acid synthesis complex." (2). The nutrient is found in both plant and animal foods in varying quantities.

B vitamins are essential for the conversion of food, such as carbohydrates, into the glucose your body uses for energy. These vitamins are necessary for helping the liver function properly and maintaining healthy hair, skin, and eyes. Pantothenic acid in particular is important for the manufacture of red blood cells, as well as synthesizing hormones such as stress and sex-related hormones. Vitamin B5 helps maintain a healthy digestive tract and utilize other vitamins as well. Overall, this B vitamin is essential for our bodies' well-being. According to the U.S. Food and Drug Administration (FDA), the daily value for pantothenic acid is 5 mg for people aged 14 years old and higher. This number can fluctuate if a person is pregnant or diagnosed with certain health conditions. It is generally hard to be deficient in this nutrient due to its presence in nearly every food, but deficiency can be seen through severe malnutrition. It can be hard to find the exact effects of solely pantothenic acid deficiency, "When someone has a pantothenic acid deficiency, it is usually accompanied by deficiencies in other nutrients, making it difficult to identify the effects that are specific to pantothenic acid deficiency" (1). There are also no reports of toxicity of Vitamin B5 in humans at high dosage intakes; the only likely symptoms are diarrhea and discomfort.

Pantothenic acid in particular is important for the manufacture of red blood cells, as well as synthesizing hormones such as stress and sex-related hormones.

In short, pantothenic acid is absorbed in the intestine and delivered directly into the bloodstream by active transport. As a water-soluble vitamin, our body doesn't store it. According to Terrence Sanvictores and Shaylika Chauhan, "To be absorbed into the body, these substances must undergo hydrolysis by intestinal enzymes...Pantetheine, the resulting product, can then be metabolized into pantothenic acid with the help of another intestinal hydrolase called pantetheinase...When proteins and peptides, such as those derived from ACP, are hydrolyzed, there is an almost complete release of pantothenic acid or pantetheine" (2). Free pantothenic acid is absorbed in intestinal cells through a sodium-dependent active transport system. Our bodies excrete pantothenic acid through urine, and that amount is based on dietary intake.

Pantothenic acid is found in nearly every plant and animal food we consume. The richest dietary sources can include beef, chicken, organ meats, whole grains, and vegetables, although it is present in all foods in varying amounts. Pantothenic Acid can also be added to food, this is the only time you will see this nutrient on a food label, "FDA does not require food labels to list pantothenic acid content unless pantothenic acid has been added to the food" (1). Our bodies also produce this B vitamin from the intestinal flora, but the total amount absorbed is unknown. Another way you can increase your Vitamin B5 intake even more is through supplements, "It is available in a variety of forms including tablets, softgels, and capsules" (3). Clearly, pantothenic acid is readily available in our day-to-day lives.

In a study, researchers looked at the cerebral deficiency of vitamin B5 as a potential and reversible cause of neurodegeneration and dementia

specifically within Alzheimer's disease (AD). This disease is the most common cause of age-related brain degeneration. Studies have found that vitamin B5 levels between AD patients and controls are significant. The results showed that AD patients were severely deficient in Vitamin B5 in their brain and damaged in areas like the hippocampus, entorhinal cortex, and middle temporal gyrus. The research states that this deficiency is important because, "Vitamin B5 is the obligate precursor of CoA/acetyl-CoA (acetyl-coenzyme A), which plays myriad key roles in the metabolism of all organs, including the brain" (5). Interestingly, treatment with oral doses of Vitamin B5 may prevent or reverse symptoms of neurodegeneration and dementia in the early stages of Alzheimers disease. To expand to this experiment, I would increase the sample size and include individuals in the early stages of Alzheimer's to determine if we can slow or prevent the disease all together.

Pantothenic Acid is clearly a much-needed B vitamin for our overall health. It serves many, known and unknown, that we can use to our advantage. I thoroughly enjoyed researching this nutrient to learn more about what it is and how it benefits our bodies.

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Grade 10 Papers

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Vitamin B-6

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As someone who is always on the move, either working out, playing sports, or traveling, I consume a lot of protein to help build my muscles. But this protein is unable to be broken down without the aid of vitamin B6. Because of this, foods enriched with vitamin B6 have become a significant portion of my diet. So, the more protein I eat, the more vitamin B6 I must ingest to break down the protein ("Vitamin B6"). This has caused vitamin B6 to become a substantial part of my life, and will become yours too, once you understand the significance of this nutrient. To introduce vitamin B6, I will present the history of the vitamin, the importance, how it is digested and used, and where you can find it. Lastly, I will discuss and examine a research article relating to how vitamin B6 alleviates stress.

Introduction and History of Vitamin B6

The vitamin B complex contains eight synthetically discrete compounds. One of these being the vitamin B6. Vitamin B6 is an essential nutrient needed for biochemical reactions relating to amino acid biosynthesis and degradation and metabolism. The nutrient consists of three pyridine derivatives: pyridoxine, pyridoxal, and pyridoxamine. Although, vitamin B6 is more commonly referred to as pyridoxine as opposed to its other pyridine derivatives (Hellman). Vitamin B6 was first discovered by the Hungarian physician Paul György in 1934 when he was attempting to search for a substance that could cure a skin disease known as dermatitis acrodynia in rats. After György's discovery, numerous other scientists contributed to the breakthrough regarding the vitamin's structure and function. Some of these scientists include Samuel Lepkovsky, who detached vitamin B6 from rice bran, Harris and Folkers, who discovered the structure of pyridoxine, and Snell, who presented the pyridoxal and pyridoxamine versions of the vitamin ("Vitamin B6 (Pyridoxine").

Importance of Vitamin B6 in the Body

As aforementioned, vitamin B6 is involved with many of the biochemical reactions that occur in the body. The metabolically active form of vitamin B6 is known as pyridoxal 5'-phosphate (PLP) which functions as a coenzyme which aids enzymes in reactions. In summation, PLP aids for "decarboxylation, transamination, racemization, elimination, replacement, and beta-group interconversion." The most known function of vitamin B6 is its use for metabolism in the liver. The metabolism of amino acids is a cofactor in the biosynthesis of five significant neurotransmitters: dopamine, serotonin, norepinephrine, epinephrine, and gamma-aminobutyric acid (GABA). These neurotransmitters are used regularly are for cognitive operations ("Vitamin B6 (Pyridoxine)"). Vitamin B6 also helps to make antibodies and hemoglobin, control glucose, and break down proteins ("Vitamin B6"). The amount of recommended nutrient intake for vitamin B6 (based on the Recommended Dietary Allowances [RDA]) is dependent on a person's age and gender. For infants, both male and female, younger than 12 months, the recommended intake is 0.1 to 0.3 mg per day and for children, both male and female. Ages 1 through 13, the recommended intake is 0.5 to 1.0 mg per day. For women older than 14, intake should be between 1.2 to 1.5 mg per day and for men older than 14, intake should be between 1.3 to 1.7 mg per day. According to the U.S. food and dietary supplement labeling, the daily value of vitamin B6 is 1.7 mg as of May 2016 ("Vitamin B6 (Pyridoxine)"). Though a deficiency of vitamin B6 is uncommon, it can still result if other B complex vitamin concentrations decrease. If someone does not obtain enough of vitamin B6 they will experience symptoms such as "microcytic anemia, electroencephalographic abnormalities, dermatitis with cheilosis (scaling on the lips and cracks at the corners of the mouth) and glossitis (swollen

tongue), depression and confusion, and weakened immune function." ("Vitamin B6 - Health Professional"). A deficiency can happen if someone has a kidney or liver disease, or alcohol dependence ("Vitamin B6"). On the other hand, if someone receives too much of vitamin B6 they will "experience symptoms of peripheral neuropathy, dermatoses, photosensitivity, dizziness, and nausea ... [and possibly] ataxia and dysesthesias" if a dose of 250 mg per day or above is consumed (Hemminger).

Vitamin B6 is useful when accelerating the effect of magnesium to control emotions and feel a sense of tranquility.

Storage and Breakdown of Vitamin B6

Like all the vitamin B complex nutrients, vitamin B6 is also water-soluble. Because of this, the vitamin dissolves in water and most of it cannot be stored in the body. This denotes those water-soluble vitamins, including vitamin B6, must be taken frequently to maintain function. Vitamin B6 is absorbed by the body in the jejunum which occurs when the phosphorylated forms of the vitamin are dephosphorylated, and the vitamin is then absorbed through passive diffusion ("Vitamin B6").

Production and Location of Vitamin B6

The human body stores around eighty to ninety percent of vitamin B6 in the muscles. In adults, this would be around 170 mg that has a half-life of 25 to 33 days ("Assessment of Vitamin B6"). Since the body cannot produce vitamin B6 by itself, we must consume the nutrient (Streit). Each of the three pyridine derivatives (pyridoxine, pyridoxal, and pyridoxamine) and their phosphates are all present in numerous foods, and in their glycosylated form are found in plants ("Assessment of Vitamin B6"). Most of these foods are natural sources of vitamin B6 include tuna, salmon, banana, legumes, and chickpeas. Vitamin B6 can also be added to breads and cereals artificially ("Vitamin B6"). If someone is unable to receive the vitamin, it can also be used as a food supplement, in which the compound of pyridoxine hydrochloride is most used ("Assessment of Vitamin B6").

Latest Research on the Importance Vitamin B6

A research study about the effects of magnesium and vitamin B6 consumption on mental health and quality of life in stressed healthy adults was conducted in December of 2021. To study this, the researchers conducted a randomized control study with participants who had low amounts of magnesium and high amounts of stress. The results indicated that these participants had a stronger stress reduction when magnesium and vitamin B6 were consumed rather than just magnesium (Noah). This finding is significant because it demonstrates that vitamin B6 is useful when accelerating the effect of magnesium to control emotions and feel a sense of tranquility. It also demonstrates that low amounts of vitamin B6 can cause depression (Noah). Personally, I chose this study because it deals with an emotion that many people endure today: stress. Stress is common in teenagers and adults, especially in the workforce or at educational places. If people can understand how to dwindle stress, they will be able to accomplish more tasks and stay fit and healthy. I was also interested in this study since it is not well known for vitamin B6 to be used in these scenarios. On the other hand, the vitamin is usually used for metabolism or biosynthesis. If I were a scientist and partook in this experiment, I would advance the notion and perform more experiments to understand if only vitamin B6 helps with depression and stress or if any vitamin in the B complex, such as vitamin B12, expedites the process to lower stress.

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Vitamin E

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Often referred to as the 'beauty vitamin' for its ability to enhance skin health, boost immunity, and protect cells from damage, this nutrient may also support brain health by slowing cognitive decline. Quietly present in your kitchen pantry, this powerhouse nutrient is none other than vitamin E. Vitamin E is a group of fat-soluble antioxidants called tocopherols that naturally occurs in the form of Alpha-tocopherol for humans (NIH, "Vitamin E: Fact Sheet for Health Professionals").

In 1922, Herbert Evans and Katherine Bishop, medical researchers at UC Berkeley, discovered vitamin E when observing that lab rats fed a diet with milk and lard could not reproduce, despite the presence of vitamins A, B, C, and D. After they had added lettuce leaves and wheat germ, foods high in vitamin E, the female rats were able to carry pregnancies to term. Concurrently, at the University of Rochester NY, Matill conducted experiments highlighting the role of natural foods in reproduction and pregnancy. The collective research revealed a missing factor for fertility which researchers called the "anti-sterility vitamin." Vitamin E was recognized for its antioxidant properties and has become an essential part of nutrition and health since (DSM, "Happy 100th Birthday Vitamin E!").

There are crucial functions of vitamin E in the body. Firstly, it acts as an antioxidant and protects cells from damage caused by free radicals. Free radicals are unstable molecules that can harm cells, tissues, and organs by damaging cell membranes. They are also thought to be connected to certain age-related conditions. Vitamin E boosts immune function by shielding against oxidative stress and pathogens. Vitamin E aids in the formation of red blood cells and widens blood vessels to prevent clotting. Additionally, it helps the body use vitamin K and facilitates cellular communication. Additional research is needed to determine whether vitamin E can effectively prevent cancers, heart diseases, and improve ocular health (MedlinePlus, "Vitamin E").

Beyond its well-established qualities, vitamin E continues to interest researchers for the potential roles it may play in holistic well-being. Recent studies, such as the one discussed in the Journal of the American Medical Association Neurology, delves into vitamin E's effects on cognitive health and neurological disorders. For instance, a study published in JAMA Neurology explores the impact of vitamin E supplementation on cognitive decline in the elderly population. This study aimed to explore the relationship between antioxidant nutrient intake of vitamin E, vitamin C, and carotene and cognitive decline associated with aging over a 3.2-year period. Participants completed a food frequency questionnaire to assess their dietary intake of these antioxidants, and their cognitive function evaluated using four standardized tests measuring memory, mental state, and processing speed. Understanding the role of antioxidant nutrients in cognitive health is important because identifying factors that could slow cognitive decline and neurodegenerative diseases such as Alzheimer's could improve the quality of life for the elderly. The study found that participants who took the highest amounts of vitamin E exhibited a 36% slower decline in cognitive scores compared to those who took the least amounts. This association was also prevalent after adjusting for factors such as age, sex, education level,

smoking status, alcohol consumption, and total calorie intake. This study was interesting since there was little evidence of a similar effect with vitamin C and carotene intake. If I were to conduct a similar study, I would like to research the impacts of different forms of vitamin E (Morris et al. 1125).

Vitamin E cannot be produced by the body and can be found naturally in some foods or can be added as a dietary supplement. Natural forms are labeled as "d-alpha-tocopherol," while synthetic forms are labeled as "dl-alpha-tocopherol. (NIH, "Vitamin E: Fact Sheet for Health Professionals"). The best natural sources of vitamin E include vegetable oils (such as wheat germ, sunflower, and corn oils), nuts (such as almonds and peanuts), seeds (such as sunflower seeds), and leafy green vegetables (such as broccoli and spinach). Additional examples of fortified foods include certain breakfast cereals, fruit juices, and jelly spreads (MedlinePlus, "Vitamin E"). Vitamin E is stored in fatty tissues and the liver before it is released into the bloodstream for use (Crichton-Stuart).

The specific amounts of vitamin E needed vary from person to person. There is a recommended dietary allowance (RDA) for children, adolescents, and adults. This amount meets the nutritional needs of nearly 97-98% of healthy people. There is an adequate intake (AI) level for infants. This is the level that is established when not enough information for an RDA is available. The AI for infants that are 0 to 6 months old is 4 milligrams per day (mg/day) and for 7-12 months is 5 mg/day. The RDA of children of 1 to 3 years of age is 6 mg/day. The RDA of children of 4 to 8 years of age is 7 mg/day. The RDA of children of 9 to 13 years of age is 11 mg/day. The RDA of ages 14 and older is 15 mg/day. This amount can change for pregnant or breastfeeding women (MedlinePlus, "Vitamin E").

Vitamin E boosts immune function by shielding against oxidative stress and pathogens. Vitamin E aids in the formation of red blood cells and widens blood vessels to prevent clotting.

While consuming vitamin E through foods is not risky, high doses of vitamin E supplements may lead to hemorrhagic stroke or increase the risk of birth defects, though more research is needed. Vitamin E deficiency may lead to hemolytic anemia in premature babies' muscle damage, neuropathy, and changes in skin collagen (MedlinePlus, "Vitamin E") (MayoClinic, "Vitamin E") (Linus Pauling Institute, Vitamin E and Skin Health).

Vitamin E is a vital nutrient with a wide range of functions in the body from acting as an antioxidant to supporting skin health by preventing inflammation after UV exposure and reducing erythema (Linus Pauling Institute, Vitamin E and Skin Health). Understanding its dietary sources, daily requirements, and potential adverse effects is essential for maintaining proper intake and improving health. Research continues to uncover new benefits and applications of vitamin E, ensuring that it is a topic of interest and promising further discoveries.

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VIP NRI

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Vitamin D

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Vitamin D, more formally known as calciferol, is a fat-soluble vitamin that was discovered in the early 1920s by multiple researchers, including Dr. E.V. McCollum and Sir Edward Mellanby (Jones). Despite being discovered only a century ago, early descriptions of vitamin D deficiency diseases, such as rickets in adolescents and osteomalacia in adults, date back to the 1600s. Even with the little knowledge on vitamin D at the time, it was understood that these conditions were related to one's diet and environmental factors, particularly a lack of sunlight, sparking debates about whether the issue was environmental or nutritional (George).

Vitamin D is crucial for building and maintaining healthy bones and teeth. This is due to the fact that vitamin D aids in calcium absorption in the small intestine, as "without enough vitamin D, the body can only absorb 10% to 15% of dietary calcium, but 30% to 40% absorption is the rule when vitamin reserves are normal" (Harvard Health). Additionally, vitamin D strengthens the immune system by "stimulating the production of pattern recognition receptors (PRRs), antimicrobial peptides, and cytokines in the cells" (Ghaseminejad-Raeini et al.). Vitamin D also influences cell growth, differentiation, and apoptosis, which are vital in preventing cancer (National Institutes of Health).

The recommended daily intake of vitamin D varies depending on a person's age and gender (see figure 1). While these daily intakes are only recommended, negative impacts can be observed if a person is consuming too much or too little vitamin D (National Institutes of Health). Deficiency can lead to diseases such as rickets in children and osteoporosis in adults. Due to the many functions that vitamin D serves within the body, "many conflicting studies are now showing an association between vitamin D deficiency and cancer, cardiovascular disease, diabetes, autoimmune diseases, and depression" (Sizar). Conversely, excessive vitamin D intake can cause hypercalcemia, a toxic buildup of calcium in the blood. Hypercalcemia may lead to symptoms such as nausea, vomiting, excessive urination, kidney stones, pain, and loss of appetite.

Age	Male	Female	Pregnancy	Lactation
0-12 months*	10 mcg (400 IU)	10 mcg (400 IU)		
1–13 years	15 mcg (600 IU)	15 mcg (600 IU)		
14–18 years	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)
19–50 years	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)	15 mcg (600 IU)
51–70 years	15 mcg (600 IU)	15 mcg (600 IU)		
>70 years	20 mcg (800 IU)	20 mcg (800 IU)		

Fig. 1. This chart outlines the suggested daily vitamin D intake for individuals across different ages and genders (National Institutes of Health).

To fully appreciate the complexities of vitamin D and its role in human health, it is essential to recognize that vitamin D exists in two major forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). While both vitamin D2 and vitamin D3 play similar roles within the body, they differ in molecular structure and sources. Vitamin D2 can be obtained from plants and fortified foods such as milk and breakfast cereals, whereas vitamin D3 can be obtained from animal sources or synthesized in the skin after exposure to ultraviolet B radiation. Foods naturally high in vitamin D include fatty fish, fish liver, egg yolks, and mushrooms, although many people rely on supplements to meet their needs (Rebelos et al.).

When the skin is exposed to UVB radiation, 7-dehydrocholesterol, a cholesterol derivative in the skin, is converted into previtamin D3. If obtained orally, vitamin D is absorbed by the small intestine and distributed into the bloodstream to be transported to the liver. In the liver, vitamin D is hydroxylated into 25-hydroxyvitamin D. It is then transported to the kidneys, where it undergoes a second hydroxylation to form the biologically active form of vitamin D, 1,25-dihydroxyvitamin D (Rebelos et al.). Excess vitamin D is stored in body fat and muscle tissues. This stored vitamin D can be mobilized when needed, helping to maintain adequate serum levels when dietary intake is insufficient.

Understanding how vitamin D is synthesized in the body highlights the necessity of maintaining adequate levels of this nutrient, particularly during pregnancy. The demand for vitamin D

increases significantly during this period, as it is not only needed to maintain maternal bone health but also to support the skeletal development of the growing fetus. Research on vitamin D and its effects on pregnancy has been studied long before the discovery of vitamin D. It began in the 1600s, when many children were being born with rickets, and doctors did not know what was causing this condition. Since then, there has been continued research on vitamin D and how deficiency can affect both mothers and fetuses during pregnancy. A systematic review was done in 2022 on the effects of vitamin D on fertility, pregnancy, and newborns. This research did not conduct a new experiment but rather looked at pre-existing research articles and created an overall review of the findings from the different research articles. The researchers found that "to date, during pregnancy, different studies have shown the association between hypovitaminosis D and the onset of preeclampsia, cesarean section indication, preterm delivery, low birth weight, low weight for gestational age, and gestational diabetes" (Mansur et al.). These findings highlight the multifaceted importance of vitamin D during pregnancy, extending beyond bone health to also include various critical aspects of maternal and fetal well-being. Furthermore, the potential benefits of neonatal and childhood health other than bone formation, including immune function and neurodevelopment, emphasize the long-term importance of maintaining adequate vitamin D levels beginning from conception (Mansur et al.). These findings are important because vitamin D has such a vast impact on the body, and they show the huge impact that vitamin D deficiency can have on an expecting mother's pregnancy and a newborn.

If I were a scientist, I do not think I would have done anything differently when creating this systematic review. The researchers chose very specific research articles and used reliable sources to get the information. I think to add to the review, I would have conducted an experiment by learning the levels of vitamin D in women trying to get pregnant and expecting mothers. I understand that ethically there could be some concerns over the experiment, but if it were approved, I would then separate them into a group of women that are consuming enough vitamin D and a group that is not consuming enough vitamin D. I would then record the differences in the pregnancies and symptoms to see if there are other side effects of hypovitaminosis D in pregnancy and fertility.

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Magnesium

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Magnesium is a vital nutrient, classified as a mineral and commonly known or referred to as an electrolyte. It doesn't naturally occur as magnesium (element) alone, but rather as isotopes or a compound such as magnesium sulfate (epsom salts), magnesium oxide (magnesia), or magnesium carbonate (magnesite). The mineral and its importance were first discovered in the compound magnesia by Sir Humphry Davy in 1808, and our understanding of what all it can do continues to grow today. Magnesium is not only something we consume, but it is also used in manufacturing in the form of magnesium alloys (mixed with other metals) which are present in many everyday items. Examples of this can be seen in its contribution to aerospace engineering, factory machines, and photography where the metal was burned to create a bright flash.

The Mg2+ ion is what humans rely on to carry out various functions such as the making of DNA, RNA, protein, and bone. The mineral helps muscle and nerve function, as well as metabolism regulation and aids as a catalyst in enzyme reactions. Magnesium helps to regulate blood pressure and blood sugar, showing importance in treatment and prevention for diabetes patients. It also aids in the transport of other minerals in the body. Plants use magnesium too, and require the mineral to supply their chlorophyll, an essential part in photosynthesis.

The recommended amount of magnesium daily can be attained through whole foods or in some fortified foods such as dark leafy greens, nuts and seeds, legumes, whole grain, fish, or some cereals (fortified). It is best to gain your nutrients from whole foods as it is not processed and more nutrient dense. The recommended amount of magnesium according to age and gender is the following:
Many supplements are available for magnesium in the form of different magnesium complexes. The different supplements have a variety of specific benefits and complications, and some are more easily absorbed such as magnesium citrate or magnesium glycinate. What complex one should use is often left up to personal preference or underlying and relevant health conditions.
The short-term effects of someone not meeting their daily recommended amount are not as obvious due to the body's ability to make up for the lack of magnesium, unless it becomes a long-term problem resulting in magnesium deficiency. The kidneys can control the amount of magnesium being released in the urine to keep a balance of the mineral in the body, aiding in short term loss of magnesium. Extreme magnesium deficiency can cause loss of some nerves, muscle, and heart function, while symptoms could also look like fatigue or nausea. Other medical conditions or medications can increase the risk for magnesium deficiency by causing imbalances of magnesium in the body. A high intake of magnesium, more commonly from supplemental usage, can lead to heart related problems or have effects similar to a laxative (such as diarrhea), and magnesium toxicity is possible. However most excess magnesium can be filtered by the kidneys (if healthy) and excreted through the urine. It is not uncommon for supplements to exceed the daily recommended values for supplemental magnesium and is only recommended in certain cases by medical professionals.

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months	30 mg*	30 mg*		
7–12 months	75 mg*	75 mg*		
1–3 years	80 mg	80 mg		
4–8 years	130 mg	130 mg		
9–13 years	240 mg	240 mg		
14–18 years	410 mg	360 mg	400 mg	360 mg
19–30 years	400 mg	310 mg	350 mg	310 mg
31–50 years	420 mg	320 mg	360 mg	320 mg
51+ years	420 mg	320 mg		

* Adequate Intake (AI)

Chart source: (Abbasi, Behnood et al. vol. 17,12)

Magnesium is absorbed during digestion through the intestines and is stored in bone minerals, while excess magnesium is processed by the kidneys and excreted through urination or leaves the body through feces. The amount of magnesium the intestines absorb compared to what is disposed

of by the body depends on the current balance of magnesium in the body, ensuring an equilibrium is maintained. The function of magnesium is also responsible for the intestinal absorption of calcium. Magnesium is found mostly in bone and soft tissue (bone mineral where it is stored), and it cannot be produced on its own in the body, only from whole, fortified foods, and supplements.

An article published in 2012 by Abbasi B, Kimiagar M, Sadeghniiat K, Shirazi MM, Hedayati M, Rashidkhani B, called "The effect of magnesium supplementation on primary insomnia in elderly: A double-blind placebo-controlled clinical trial", focused on the correlation between magnesium and sleep in a group of elderly with insomnia. Using a placebo group and a group that was given a magnesium supplement of 500mg daily, significant differences were observed from before and after the study. "As compared to the placebo group, in the experimental group, dietary magnesium supplementation brought about statistically significant increases in sleep time (P = 0.002), sleep efficiency (P = 0.03), concentration of serum renin (P < 0.001), and melatonin (P = 0.007), and also resulted in significant decrease of ISI score (P = 0.006), sleep onset latency (P = 0.02) and serum cortisol concentration (P = 0.008). Supplementation also resulted in marginally between-group significant reduction in early morning awakening (P = 0.08) and serum magnesium concentration (P = 0.06)." (Vol. 17,12) The research found benefits that were proven by the significant differences between the placebo group and the group given a magnesium supplementation. Many of the differences referred to quality of sleep

and other factors that pertain to sleep for people with insomnia.

These findings prove and reiterate the importance of the nutrient magnesium, and do so by focusing on sleep, a foundation of human health. I found this study interesting as many people in my life are currently facing and observing issues relating to sleep and are not eating the most nutrient dense diet either. I became curious to see what nutrients would most benefit their health struggles, and if supplementation was a sufficient option as allergies, food preferences, and food access are all obstacles to the whole food options. In the future I would love to research and experiment with how your body recharges and uses the nutrients in your body while you are in the different stages of sleep. Relating to magnesium, I would love to study its prevalence in our soils and how over the years that prevalence has been depleted along with changing soil quality.

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Phosphorus

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The body needs a variety of minerals and nutrients to maintain optimal health, one of the many is Phosphorus. Discovered in 1669 by German alchemist Hennig Brandt, phosphorus derives its name from the Greek word 'phosphorus,' meaning bringer of light. Brandt first believed that he had found the so-called 'Philosopher's Stone,' which was sought by all alchemists at that time. They believed that it could turn common metals into gold and silver, so Brandt kept it a secret. Later, he sold his process to Robert Boyle, who introduced it to the rest of the world. Phosphorus soon became widely known (Royal Society of Chemistry).

Phosphorus is an extremely important mineral for the human body, playing various roles in maintaining health and supporting many biological functions. As the second most abundant mineral in the body, phosphorus makes up about 1% of a person's body weight and is present in every single cell. The primary function is to form and strengthen bones and teeth, working with calcium to provide structural support. However, phosphorus's importance extends beyond bone health. It is essential for the body's metabolism. Assisting in converting carbohydrates and fats into energy and synthesizing of proteins necessary for the growth, maintenance, and repair of tissues and cells. It is also crucial in the production of adenosine triphosphate (ATP), the body's main energy source that stores and transports energy within cells (MedlinePlus).

In addition to these roles, phosphorus plays an important role in the formation of DNA and RNA, the molecules that carry genetic information and guide cellular functions. By regulating genes, activating enzymes, and forming cell membranes, Phosphorus has an important role in the human body. It works with B vitamins and helps in kidney function, muscle contractions, maintaining a normal heartbeat, and nerve signaling. Its presence in every cell demonstrates its importance in a variety of bodily processes, making phosphorus essential for health (MedlinePlus).

The body requires a certain amount of phosphorus every day to support the essential functions. The Recommended Dietary Allowance (RDA) for phosphorus varies based on age and gender, but adults need 700 mg per day and children and teens need 1250 mg per day (National Institutes of Health). The body stores Phosphorus primarily in the bones and teeth, 85%, where it helps maintain structure and strength. Around 15% is in the cell membrane, and 0.1% is in extracellular fluid (Mount Sinai). It is naturally abundant in a wide variety of foods. Although, for individuals who may have difficulty obtaining enough phosphorus naturally, it is available as multivitamins and dietary supplements. Insufficient phosphorus intake can lead to problems such as hypophosphatemia, a condition involving muscle weakness, bone pain, and potentially severe issues. On the other hand, excessive phosphorus intake can cause hyperphosphatemia, leading to effects such as kidney damage and increased risk of cardiovascular diseases. To avoid these issues, people should make sure they are consuming the correct amount of phosphorus consistently and balancing their diets (National Institutes of Health).

Age	Male	Female
Birth to 6 months	100 mg	100 mg
7-12 months	275 mg	275 mg
1-3 years	460 mg	460 mg
4-8 years	500 mg	500 mg
9-13 years	1,250 mg	1,250 mg
14-18 years	1,250 mg	1,250 mg
19+ years	700 mg	700 mg

(*Recommended Dietary Allowances (RDAs) for Phosphorus*, National Institutes of Health)

So how does the human body process and use phosphorus to meet all the body's needs? The body processes

Food	Milligrams (mg) per serving	Percent DV (daily value)
Yogurt, plain, low fat, 6-ounce container	245	20
Milk, 2% milkfat, 1 cup	226	18
Salmon, Atlantic, farmed, cooked, 3 ounces	214	17
Scallops, breaded and fried, 3 ounces	201	16
Cheese, mozzarella, part skim, 1.5 ounces	197	16
Chicken, breast meat, roasted, 3 ounces	182	15
Lentils, boiled, ½ cup	178	14
Beef patty, ground, 90% lean meat, broiled, 3 ounces	172	14
Cashew nuts, dry roasted, 1 ounce	139	11

(*Phosphorus Content of Selected Foods*, National Institutes of Health)

phosphorus through a specific order involving digestion, absorption, transportation, and regulation. After you consume foods that contain phosphorus such as dairy, meats, and seeds, the nutrient is absorbed in the form of phosphates and phosphate in the small intestine. Most phosphorus is absorbed passively, but some undergoes active transport. This is because phosphorus from specific foods like seeds exist in the form of phytic acid, but human intestines lack phytase enzymes that are needed to release phosphorus from this specific form. After it is absorbed, phosphorus enters the bloodstream and is transported to a variety of tissues, playing crucial roles in bone and teeth formation, energy production, and cellular function. The kidneys, intestines, and bones work together to regulate phosphorus homeostasis, balancing the absorption, excretion, and deposition in the bone to maintain stable levels (National Institutes of Health). This is important so that there is not an abnormally high or low level of phosphorus content in the body.

Recently, the agricultural sector and scientists have been facing challenges involving phosphorus management. Farmers are facing a critical phosphorus shortage due to the overuse of fertilizers. Normally, phosphorus (essential for plant growth) is added to soil to increase the crop yield. Most of this phosphorus comes from sources of phosphate rock in the US, China, and Morocco. However, due to rapid use, scientists believe that these sources may be exhausted in the next 50-100 years. This threatens future food security and phosphorus availability. Researchers are studying sustainable farming practices to address this concern and rely less on phosphorus fertilizers. Recent research has been focusing on this challenge and environmental sustainability. One study, titled 'Farmers are facing a phosphorus crisis. The solution starts with soil' by National Geographic, explores how historical phosphorus deposits in soil can be used to support crop growth without excessively relying on phosphorus fertilizers. This study by Sheida Sattari and colleagues examines the use of naturally present phosphorus in soil to reduce the use of fertilizers. The researchers studied soil samples and investigated how crops could utilize these accumulated phosphorus reserves (National Geographic).

They found that in fields with buildup of natural phosphorus, or 'legacy phosphorus', supported its crops and thrived with little to no additional phosphorus fertilizer. This suggests that legacy phosphorus can help sustain crop growth. This study demonstrates that soils contain enough naturally present phosphorus to support the crops to stop the need for overuse of phosphorus fertilizers. They have concluded that applying excess phosphorus fertilizers for crop growth is often unnecessary and environmentally damaging. This study offers a sustainable pathway for agricultural practices that balance crop productivity and environmental stewardship. If I were a scientist, I would explore the role plant-root interactions play in using legacy phosphorus. This could help to further understand the role of this interaction and how we could modify it to use more of the legacy phosphorus (National Geographic).

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Zeaxanthin

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The name "zeaxanthin" is derived from Zea mays, which simply refers to yellow maize corn. The Greek word "xanthos" means "yellow", which is fitting since zeaxanthin is a yellow pigment. In 1945, George Wald analyzed macular pigment and discovered that zeaxanthin and meso-zeaxanthin (its oxygen form) were one of the nutrients responsible for the yellow color (Nowak, 2022). In addition to plant coloration, this nutrient from the xanthophyll family of carotenoids has many applications throughout the body. For instance, zeaxanthin has some important roles in vision, liver health, and cardiovascular health, as well as in neurodevelopment, neural morphology, and neurodegenerative diseases.

Starting with vision, zeaxanthin is one of the two carotenoids that is present in the macula and lens of the eye. Both tissues play a key role in vision. In addition, zeaxanthin functions as a powerful antioxidant and exercises an important function of reducing typical oxidative damage which the eyes are susceptible to. Furthermore, zeaxanthin protects your eye's tissues by blocking damage from sunlight and free radicals that can cause oxidation. It also helps recycle glutathione, another important antioxidant. Zeaxanthin can also help with heart health by reducing oxidative stress, which can help support arterial health. Moreover, this nutrient can promote healthy cholesterol levels, which in turn can support healthy circulation and overall heart health.

In addition to cardiovascular health and vision, zeaxanthin can also help with liver health. According to clevelandclinic.org, zeaxanthin might be able to help prevent and treat metabolic dysfunction-associated steatotic liver disease (MASLD). Moreover, this powerful nutrient may also be able to help mitigate the symptoms of steatotic liver disease (SLD) by reducing inflammation and oxidative stress ("What Is Zeaxanthin? Benefits and Side Effects", 2024). Zeaxanthin can also impact skin health by protecting it against blue light damage. Additionally, zeaxanthin intake may help improve skin hydration, elasticity, and inflammation.

Zeaxanthin has many important roles in brain health. Firstly, it can help with neurodevelopment. For instance, this nutrient has been shown to improve overall focus and decision-making skills ("3 Ways Dietary Zeaxanthin Supports Brain Function", 2023). According to a study, zeaxanthin has been proven to also enhance neural processing speed and efficiency (Renzi et al., 2014). Moreover, it can help improve cognitive sharpness, especially in memory. According to EyePromise, studies show that some brains lacking in zeaxanthin have detrimental memory issues. Furthermore, people with Alzheimer's who have higher zeaxanthin levels have lower mortality rates from the disease (Alexis, 2021). Some other studies also link higher levels of dietary zeaxanthin to greater word recall and visual learning. Therefore, zeaxanthin can have a positive impact on neurodevelopment.

Secondly, this nutrient can enhance neural morphology. Oxidation in the brain leads to neural inflammation, neurotoxicity, and reduced cerebral perfusion (Lindbergh et al., 2019). To combat these negative effects, researchers have studied antioxidants like zeaxanthin. Moreover, zeaxanthin and lutein are the dominant carotenoids in the central nervous system (CNS) where they account for 66-77 percent

of total carotenoid concentration in neural tissue. In addition, zeaxanthin can benefit neural functioning in dorsolateral prefrontal cortex and anterior cingulate, areas that are vulnerable to age-related decline (Lindbergh et al., 2019). Thus, zeaxanthin can impact neural morphology by strengthening specific areas of the brain and reducing oxidative stress prevalent in the brain.

Lastly, this important nutrient may help protect the brain from neurodegenerative conditions like Alzheimer's disease (Ahern, 2024). Research has shown the various protective activities of Zeaxanthin in neurological disorders by employing experimental models that involve anti-inflammatory, antioxidant, and anti-apoptotic mechanisms (Bouyahya, 2021). Another study reported lower Alzheimer's mortality in individuals, with higher levels of zeaxanthin and greater caregiver-reported improvements in memory, sight, and mood of patients (Min, 2013). Another neurodegenerative disease is age-related macular degeneration (AMD). This condition is a late-onset neurodegenerative retinal disease which shares some properties with Alzheimer's disease (Kaarniranta, 2011). Zeaxanthin can have a beneficial effect in delaying the progression of AMD and cataracts (Mrowicka, 2022).

Zeaxanthin can have a beneficial effect in delaying the progression of age-related macular degeneration (AMD) and cataracts.

In conclusion, zeaxanthin is a nutrient with a vast variety of functions. It can help with vision, cardiovascular health, liver health, neural morphology, neurodevelopment, and neurodegenerative diseases. This nutrient is found in dark leafy greens (like kale and spinach), egg yolks, oranges, red grapes, corn, mangos, honeydew melon, orange peppers, and goji berries. There are supplements for zeaxanthin, but they can lower blood sugar and cause yellowing of the skin. It is advised to take two milligrams of zeaxanthin daily (Bedinghaus, 2024). All in all, zeaxanthin is a magnificent nutrient which everyone can take to improve their overall body health.

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Protein

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Proteins, also called polypeptides (long chains of amino acids), are the building blocks of life and are essential for basic human body functions. Discovered in the 19th century by Dutch chemist Gerardus Johannes Mulder, proteins have a wide range of uses, from rebuilding muscles to aiding in biochemical reactions. Intriguingly, protein was used by ancient Egyptians in the form of egg whites as an adhesive (Heritage.com, 2018, para.1). This research paper delves deeply into the impact of this nutrient, exploring its functions, daily requirements, and how the body processes it.

Importance of Protein

Proteins are vital to the body, serving as the building blocks for muscles, organs, skin, hair, and nails. These tissues reply on proteins for growth, maintenance, and repair, ensuring that the body is performing at maximum capacity while upholding structural integrity. Proteins also aid in enzymatic activity. Enzymes, which are composed of proteins, catalyze almost every biochemical reaction inside of the body (ncbi.gov, 2023, para.2).

Additionally, proteins are needed in transport and storage. Hemoglobin, a protein found in red blood cells, binds to oxygen in the bloodstream and transports it throughout tissues in the body. This allows each cell to receive enough oxygen to produce energy and cycle through the metabolic processes (Brittanica, 2024). Ferritin is another protein that stores iron in the liver, spleen, and bone marrow, ensuring that iron levels remain at homeostasis (Storey, 2008). Protein also plays a role in the immune system, defending against pathogens in the form of antibodies. These antibodies neutralize pathogens such as bacteria and viruses to protect the body from diseases.

Daily Intake of Protein

The daily intake of protein varies based on several factors such as age, weight, height, and activity levels. Overall the daily intake recommended is typically your body weight in pounds multiplied by 0.4x. For adults, this is 46 grams per day for women and 56 grams per day for men. Protein should also constitute 10 to 35 percent of your daily calories (Wempmen, 2022).

How the Body Utilizes Protein

When proteins are ingested through sources such as dairy, eggs, lentils, and meat, they are broken down in the body by stomach acid, hydrochloric acid, and other pancreatic enzymes (myplate.gov). This process breaks the large polypeptide chain into smaller peptides and even amino acids which can be absorbed in the bloodstream. These free amino acids are translated into proteins in the ribosomes, structures within the cell where protein production occurs. DNA is first transcribed into mRNA, and translated into tRNA, which brings the correct amino acids to the ribosome so they can be linked together (Miller, 2020). This is vital as each combination of RNA codes for different amino acids, which can be deciphered through a codon chart. Proteins are not stored in the body as the body maintains a balance between the synthesis and degradation of proteins. The body does keep a circulating pool of amino acids in the bloodstream that are readily available to be linked to form peptides and proteins. Damaged proteins are often broken down so the

amino acids can be reused. Proteins also undergo a process known as autophagy, wherein damaged proteins are cleared out, freeing up amino acids to make functional proteins. The urea cycle also allows for the excretion of excess proteins as they're converted to ammonia and processed to leave the body through urine (Brodsky, 2014).

Protein also plays a role in the immune system, defending against pathogens in the form of antibodies. These antibodies neutralize pathogens such as bacteria and viruses to protect the body from diseases.

Where is Protein Found?

There are 20 different amino acids that the body utilizes. While the body can make most of them on its own, there are 9 essential amino acids that the body cannot produce. These must be obtained from the foods people eat. This protein can come from both plant and animal sources, although the amino acids found in animal sources are already in the right balance while most fruits and vegetables contain low amounts of protein and are not balanced correctly (Hermann, 2021). Protein supplements come in the form of powders, gummies, bars, and shakes. They can be found in most grocery stores and sometimes even convenience stores. These supplements can be made from a variety of products ranging from beef to whey and soy and can often contain up to 50 grams of protein per serving. They are popular among underweight individuals and those who visit the gym regularly. While these are good options for people seeking to increase their protein intake, it is vital to take them properly, consult doctors, and not abuse them. The recommended amount of protein from supplements is between 25 to 50 grams per day (Patel, 2023).

Accurate prediction of protein-nucleic acid complexes using RoseTTAFoldNA

This researcher used RoseTTAFoldNA to predict protein-nucleic acid complexes using data methods. This research was intended to advance machine learning models, specifically predicting the structures. The RoseTTAFoldNA uses protein and nucleic data to make their predictions. They found that this model can accurately predict the structures even for the complexes without homologous structures. These findings are important because they address the issue regarding nucleic acid flexibility. This research advances the field of biology by providing a more accurate method of prediction for complexes. This includes gene regulation, replication, and repair (Baek, 2024).

This research is interesting to me because it combines current technological advances with biology. This research stands as a crosspoint between two of my interests and also involves interdisciplinary fields. The research was carried out using computational docking calculations which involve finding the best match between a ligand and a receptor. If I were a scientist, I would have used different types of protein-nucleic complexes to test out the computational program. This could have further proved the technology's ability to be used for different systems in the body and also show how AI could be imported for the use of biology.

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Potassium

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Critical to human health, potassium is a mineral and electrolyte that carries small electric charges which stimulate multiple cell and nerve functions. Also known as kalium and its symbol on the periodic table is K and its atomic number is 19. Potassium's main function is to maintain the fluid balance inside the cells and is also integral to muscle contraction, regulation of blood pressure, heart and kidney function, and preservation of bone density. Potassium was the first metal to be isolated by electrolysis and was discovered by Sir Humphry Davy in 1807. Electrolysis, which uses electricity to separate water into hydrogen and oxygen, was the method used to isolate potassium from molten caustic potash, from which its name originates.

Potassium helps maintain fluidity inside the cells, while sodium acts as its counterpart, maintaining fluidity outside the cells. Sodium and potassium are kept at disequilibrium, meaning there is a higher concentration of potassium inside the cells. The sodium-potassium pump maintains these levels by moving the sodium out of the cells and bringing the potassium in. Our bodies need more potassium than sodium, and the body produces neither of these nutrients, so they must be obtained from our diet. Potassium is also affected by magnesium levels. When magnesium levels are low, potassium levels are often low as well. This is because low magnesium impairs the retention of potassium inside the cell.

The recommended daily intake of potassium depends on many factors, such as age, gender, and activity level. Various organizations worldwide recommend that healthy adults consume 3,500 mg daily, but the United States recommends consuming 4,700 mg (Ramen,2024). Some individuals may benefit from consuming more than the recommended amount. For example, athletes who lose a significant amount of potassium through exercise.

Potassium is found in many whole foods, particularly fruits and vegetables. Some of the best resources for potassium include tomato produces, raw spinach, avocado, cooked beet greens, and cooked soybeans. Potassium supplements are not a good source of this mineral and studies have found some potassium supplements can damage the lining in the gut (Ramen, 2024).

Potassium's main function is to maintain the fluid balance inside the cells and is also integral to muscle contraction, regulation of blood pressure, heart and kidney function, and preservation of bone density.

The kidneys flush out excess amounts of potassium through urine to help maintain normal levels, but it can also be lost through sweat and stool. The human body needs 400-800 mg of potassium daily to account for normal losses. Hypokalemia, or potassium deficiency, can be caused by conditions such as vomiting and diarrhea due to excessive fluid loss. It is most common in hospitalized patients due to medication. Symptoms of hypokalemia include fatigue, muscle weakness and cramps, constipation, and irregular heartbeat. Potassium deficiency is not normally caused by low food intake because it is present in many foods. However, when low food intake is combined with heavy sweating, laxative abuse, and vomiting, hypokalemia becomes a risk. On the other end, hyperkalemia is an excess amount of potassium. This can be caused by advanced kidney disease, certain medications, and consuming a high potassium diet that consists of more than 4,700 mg per day. Symptoms of hyperkalemia include weakness, fatigue, nausea, vomiting, shortness of breath, chest pain, and irregular heartbeat (Harverd, 2023).

A 2016 study, "Potassium and Obesity/ Metabolic Syndrome: A Systematic Review and Meta-Analysis of the Epidemiological Evidence" discusses the link between potassium and metabolic syndrome. Dietary potassium is inversely correlated with blood pressure, meaning when potassium is

low, blood pressure is high and vice versa. The results of the study showed that high potassium intake cannot lower the risk of obesity, but the ratio of sodium to potassium in the body is associated with obesity. Overall, the study concluded that potassium is associated with metabolic syndrome and highly recommends consuming a sufficient amount of fruits and vegetables.

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Grade 9 Papers

Sisira Chalasani
Navya Linga
Mollie Pate

Fatty Acids

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Grade 9

The name of my chosen nutrient is Omega-3 fatty acids. Omega-3 fatty acids are more commonly known as healthy fats or polyunsaturated fats. The three types of omega-3s include Eicosatetraenoic acid (EPA), Docosahexaenoic acid (DHA), and Alpha-linolenic acid (ALA) (3). Omega-3 Fatty Acids were first introduced in the 8th century by the Romans with a sauce made from rotting fish guts and salt called garum (7).It had become popular because of its ability to flavor many foods and drinks but was later believed to have medicinal benefits such as curing headaches or being used as a laxative (7).

The body needs omega-3 fatty acids because they keep your heart, lungs, blood vessels, cells, and immune system functioning properly as well as providing calories to give your body energy (6). Omega-3 fatty acids also have many helpful benefits like preventing cardiovascular disease, asthma, Alzheimer's disease, and dementia (6). Omega-3s can help lessen the effect of ADHD, depression, and autoimmune diseases. The National Institute of Health suggests that a healthy diet should contain 1-1.6 grams of omega-3s per day (4). Ingesting too much omega-3 can result in an increased risk of bleeding and high blood sugar (1). On the other hand, too little of omega-3 can cause your brain to function improperly and itchy rashes on your skin (2).

After you consume omega-3 fatty acids the liver will oxidize and metabolize ALA, DHA, and EPA. Then they will stay stored in the body's cell membranes to help support every cell (4). Although these fatty acids are necessary for all cells, the cells that are the most concentrated can be found in the eyes and brain (4). Any excess fat will be stored in the liver.

The body does not produce omega-3 fatty acids on its own which is why it's important for people to have a diet that contains enough omega-3 for your body to properly function. Omega-3 has to be consumed through food or a supplement. The main food in which a high amount of omega-3 is found is fish. Specifically, salmon, mackerel, tuna, sardines, and other cold-water fatty fish (6). This is where DHA and EPA are found. Some other vegetarian options would be nuts, avocado, plant oils, and seeds which is where ALA can be found (6). Omega-3 fatty acids can also be ingested in the form of a supplement which is usually fish oil or sometimes algae depending on one's preference. There are many types and amounts of these fish oil supplements.

The UT Health newsletter from October 5, 2022 written by Will Sansom focuses on how omega-3s improve brain structure and cognition at midlife. The University of Texas Health Science Center at San Antonio, other investigators, and Claudia Satizabal, PhD who was the lead author of this study conducted an experiment to prove this by using volunteers who were all around 46 years old. These scientists then studied red blood cell omega-3 fatty acid concentration in relation to Alzheimer's disease and brain aging (5). The scientists also did an experiment similar to this but with volunteers whose red blood cell omega-3 concentration was very low. Both of these studies proved that the more omega-3 you consume, the more

Omega-3 fatty acids also have many helpful benefits like preventing cardiovascular disease, asthma, Alzheimer's disease, and dementia.

benefits for your brain health (5). This finding is important so that people in their middle ages can have a lesser chance of brain aging, Alzheimer's, dementia, or strokes just by a simple change in their diet. I found this study particularly interesting because it included patients already struggling with less omega-3 showing that, that alone increased their chances of an unhealthy brain as they grow older (5). This study also shows just how easy it can be to prevent certain brain diseases and more.

Overall omega-3 fatty acids are important because they are a great source of energy and nutrition which you can get by making an easy addition to your diet. They are beneficial for brain health, immune system, cardiovascular health, and even eye health. Being consistent in ingesting omega-3s can also make a very positive impact on your health in the future. All of these reasons are exactly why you should make an effort to include some sort of omega-3 in your everyday diet.

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Sodium

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Sodium (also written as Na) is a nutrient that is essential for the body in small doses, and was discovered by Sir Humphry Davy in 1807. Sodium is typically used in other forms such as sodium bicarbonate, sodium citrate, or sodium chloride due to sodium being a toxic metal in its natural form. Sodium is often used interchangeably with the word salt, but the two are not the same. Salt is a compound composed of both sodium and chloride, giving it its chemical name (sodium chloride). When people claim that too much salt is dangerous, it is the sodium in it that is harmful (9).

Many people think of sodium as a nutrient that is detrimental for our health, but this is only true when it is taken in large amounts. The recommended daily sodium intake for adults (according to the Dietary Guidelines for Americans) is less than 2,300 mg a day (2). This amount is equivalent to a teaspoon. When consumed in moderation, sodium is helpful for our bodies and helps maintain plasma volume, acid-base balance, and normal cell function (11).

The body processes sodium by absorbing it into the gastrointestinal tract and by bringing water along with it. In the body, sodium is found in plasma, blood, and other bodily fluids (8). It is rare for people to have sodium deficiency (also known as hyponatremia) if they are healthy, but the main cause of it is having too much fluid in the body. Hyponatremia can cause people to have headaches, seizures, nausea, low blood pressure, and more. To help hyponatremia, one can take salt tablets. These can help increase someone's sodium levels and can help prevent the side effects of low sodium. These salt tablets do not have any side effects when taken as recommended, but if they are taken at too high of a dosage, they can cause hypernatremia (6).

High sodium (also known as hypernatremia), a much more commonly known case, is also detrimental for our health. It can cause high blood pressure and puts people at risk for heart disease and stroke, which together account for the deaths of over 835,000 Americans each year (3).

Sodium is found in many different foods, but foods that are highest in sodium are processed food. These include foods such as pizza, processed cheese, pretzels, pickles, and more. To decrease sodium intake, one can eat fresh food that hasn't been minimally processed. It is also possible to replace salt as seasoning and use herbs and other spices that do not contain sodium.

In a study done by the American Heart Association, 213 individuals (aged

50-75) participated in an experiment comparing high sodium diets to low sodium diets and how they affect systolic blood pressure. It is important to note that some of these adults

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had diabetes or already had high blood pressure before the trials were conducted. People were randomly put into a high sodium diet with an added 2,200 mg of sodium to their usual diet or a low sodium diet consisting of having 500 mg of sodium every day for a week. The participants' blood pressure was taken over a 24-hour period on the last day of their diet (7). The low sodium diet consisted of foods such as greek yogurt, fruits, oatmeal, and more minimally processed food. The high sodium diet involved eating two chicken bouillon packets a day that had 1,100 mg of sodium in each.

The results of the study showed that the individuals who were on the low sodium diet's blood pressure reduced by around 7-8 mm Hg compared to those who were participating in the high sodium diet. Their blood pressure decreased by around 6-7 mm Hg compared to their usual diet as well. Meanwhile, the adults who were on the high-sodium diet's blood pressure did not differ compared to their blood pressure during their normal diet. However, the people participating in the low sodium diet's blood pressure did go up after returning to their regular diets.

In conclusion, sodium is a nutrient that is essential to our body in small doses as it can help regulate our bodily fluids and keep our cells healthy. Though sodium is helpful for our bodies at these amounts, it can be unhealthy for us to consume too much or (though it is rare) too little of the nutrient. Maintaining a balanced diet and incorporating more whole foods into our meals can help avoid the harmful effects of high and low sodium. This being said, despite its negative reputation, sodium can be helpful for our bodies.

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Calcium

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Eat Healthy, Have Good Nutrition, Consume the Rainbow, Eat a Balanced Diet; we hear these words and phrases all around us, but what do they truly mean? Everybody has their own way of eating healthy, not everyone is going to be the same in their eating habits, but we all hear these same sayings on how to become "healthy". In all the food we eat, there are many different nutrients, and these nutrients affect our bodies in many different ways. There are Macronutrients, which consist of Carbohydrates, Lipids, and Proteins. There are also Micronutrients, which consist of Vitamins and Minerals. And lastly, water is said to be the most important nutrient to all humankind.

But, have you ever actually sat down and taken a look at what's on your plate at every meal? Are you eating food that will fuel your body? Are you consuming nutrients important for human health? In today's society, it's easy to get caught up in the whirl of fast food, pre-packaged snacks, soda, and sweets, but we need to take time and truly "think before we eat".

This paper will inform people about the importance of a specific nutrient, Calcium. Most of the time when people hear the word calcium, they immediately think of milk and having strong bones. However, there is a whole lot more to know about calcium. Calcium is a nutrient that is vital for human health in many different ways and affects many parts of our bodies. Calcium makes sure our bones and teeth are strong and have structure and also supports the systems of our blood, muscles, and tissues. Ninety-nine percent of calcium in our body is located in our bones and teeth, while the other 1% is found in blood, muscles, and tissues. Further, calcium helps in the movement of our muscles, supports the transmission of nerves from the brain to the rest of the body, is essential for the release of hormones, is necessary for clotting blood, and helps the body maintain a regular heartbeat.

Life Stage	Recommended Amount
Birth to 6 months	200 mg
Infants 7–12 months	260 mg
Children 1–3 years	700 mg
Children 4–8 years	1,000 mg
Children 9–13 years	1,300 mg
Teens 14–18 years	1,300 mg
Adults 19–50 years	1,000 mg
Adult men 51–70 years	1,000 mg
Adult women 51–70 years	1,200 mg
Adults 71 years and older	1,200 mg
Pregnant and breastfeeding teens	1,300 mg
Pregnant and breastfeeding adults	1,000 mg

The table provided is from the National Institutes of Health (NIH) to show the recommended amount of calcium intake needed daily

The human body doesn't produce calcium on its own, so we have to consume the right foods and beverages that will provide our bodies with the calcium we need. The most common foods with calcium include:

- Seeds (Poppy, Chia, etc.)
- Cheese (Cheddar, Mozzarella, etc.)
- Fish (Sardines, Salmon, etc.)
- Beans (Pinto, Chick Pea, etc.)
- Yogurt and Milk
- Nuts (Almonds, Pistachios, etc.)
- Vegetables (Kale, Spinach, Broccoli, etc.)

All these foods help us consume the right amount of calcium each day. The amount of calcium we are supposed to consume depends on age, gender, and what conditions might be going on in your life.

There are cases that occur where the wrong amount of calcium is consumed into the body. These conditions can cause hypocalcemia and hypercalcemia, which are characterized by too little calcium in the blood compared to too much calcium in the blood. Hypocalcemia is the overall name for a deficiency of calcium in the body. Common side effects of this include; muscle spasms, tingling, twitching, and numbness. There are many other conditions that fall into the category of calcium deficiency, including osteoporosis. Osteoporosis is a very

common disorder that many Americans have, but don't know they have. Osteoporosis is a condition where low calcium intake can cause decreasing bone density, leading to early bone loss and putting individuals at an increased risk of breaks and fractures to their bones.

When people aren't able to consume enough calcium from their diet, there are other ways to receive the calcium needed through the intake of calcium supplements. These supplements help to increase calcium levels in the blood, reduce the risk for osteoporosis, and decrease the chance of rickets in children. Although calcium supplements are an option for low levels of calcium in the blood, it's more heavily advised to eat a diet to support your body and its needs.

A research article titled, Calcium Intake in Bone Health: A Focus on Calcium-Rich Mineral Waters, is an article focusing on the importance of correct calcium intake. This article talks about how calcium is essential for skeletal mineralization, metabolism, and many other human body functions. Although calcium can be found in numerous amounts of food and drinks, in studies done and research conducted, calcium-rich mineral water has been seen as beneficial to many. A study was conducted and results came back showing that calcium-rich mineral water had a positive effect on bone health, bone strength, and bone structure. The article and results found from this study show that there are many alternate solutions to calcium deficiency, but the main importance and goal is to eat the right foods and supply your body with the right nutrients to maintain a healthy way of living.

This brings me back to the point that we need to truly "think before we eat". Calcium is one of many nutrients that has a major impact on the body and health. With the increased knowledge on understanding what is beneficial and harmful to our bodies, changes can be made to the diet we consume and to our lifestyle that will make a difference in our overall health.

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