THE ANTIOXIDANT VITAMIN - VITAMIN C

MARCH 1, 1995

By Gary Null Ph.D.

In the 65 years since its discovery, vitamin C has come to be known as a "wonderworker." It's easy to see why: In addition to its role in collagen formation and other life-sustaining functions, vitamin C serves as a key immune system nutrient and a potent free-radical fighter. This double-duty nutrient has been shown to prevent many illnesses, from everyday ailments such as the common cold to devastating diseases such as cancer.

In the scientific world, the water-soluble vitamin C is known as ascorbic acid(meaning "without scurvy," the disease caused by a vitamin C deficiency). We depend on ascorbic acid for many aspects of our biochemical functioning; yet human beings are among only a handful of animal species that cannot produce their own supply of vitamin C. Like these other animals, including primates and guinea pigs, we have no choice but to obtain this nutrient in our diet. Considering the many benefits vitamin C may provide,that mandate is deceptively simple.

How Does Vitamin C Function in the Body?

Much like the immune system itself, which operates at a cellular level,the hardworking vitamin C reaches every cell of the body. The concentration of vitamin C in both blood serum and tissues is quite high.1In fact, this nutrient plays a major role in the manufacture and defense of our connective tissue, the elaborate matrix that holds the body together. It serves as a primary ingredient of collagen, a glue-like substance that binds cells together to form tissues.

Vitamin C helps some of our most important body systems. First and foremost, it helps the immune system to fight off foreign invaders and tumor cells. Vitamin C also supports the cardiovascular system by facilitating fat metabolism and protecting tissues from free radical damage, and it assists the nervous system by converting certain amino acids into neurotransmitters.

The skin, teeth and bones also benefit from vitamin C's collagen-forming and invader-resisting properties; this vitamin contributes to the maintenance of healthy bones, the prevention of periodontal disease and the healing of wounds. It even serves asa natural aspirin, of sorts, by combating inflammation and pain, according to FormulaFor Life. It accomplishes this task by inhibiting the secretion of the prostaglandins that contribute to such symptoms.2

What Biochemical Processes Require Vitamin C?

Collagen metabolism. Most of us know collagen as the much-promoted ingredient in our facial moisturizers and hand lotions. But the use of collagen in beauty and skin products only hints at the importance of this protein. The very structure of the body - the skin, bones, teeth, blood vessels, cartilage, tendons and ligaments - depends on collagen. And the integrity of collagen, in in turn, depends on vitamin C.

In a report on ascorbic acid in Vitamin Intake and Health, S.K. Gaby and V.N. Singh explain that collagen protein requires vitamin C for "hydroxylation," a process that allows the molecule to achieve the best configuration and prevents collagen from becoming weak and susceptible to damage. Beyond that, they say, recent evidence indicates that vitamin C increases the level of procollagen messenger RNA. "Collagen subunits are formed within fibroblasts asprocollagen, which is excreted into extra cellular spaces. Vitamin C is required to export the procollagen molecules out of the cell. The final... structure of the collagen is formed after pieces of the procollagen are enzymatically cleaved," state Gaby and Singh.3

Antioxidant functions. As a water-soluble antioxidant, vitamin C is in a unique position to "scavenge" aqueous peroxyl radicals before these destructive substances have a chance to damage the lipids. It works along with vitamin E, a fat-soluble antioxidant, and the enzyme glutathione peroxidase to stop free radical chain reactions.

Immune system functions. Vitamin C can enhance the body's resistance to an assortment of diseases, including infectious disorders and many types of cancer. It strengthens and protects the immune system by stimulating the activity of antibodies and immune system cells such as phagocytes and neutrophils.4

Other processes. Vitamin C contributes to a variety of other biochemical functions. These include the biosynthesis of the amino acid carnitine and the catecholamines that regulate

the nervous system. It also helps the body to absorb iron and to break down histamine, the inflammatory component of many allergic reactions.5

What Specific Locations in the Body does Vitamin C Affect?

Although vitamin C is found in every cell, it is especially useful in key parts of the body. These include the blood, the skin, the nervous system, the teeth and bones and glands such as the thymus, adrenals and thyroid.

What Foods are Good Sources of Vitamin C?

Large concentrations of vitamin C can be found in fruits such as oranges,grapefruits, tangerines, lemons, limes, papaya, strawberries and cantaloupe. Vitamin C and bioflavonoids – the water soluble substances that help to protect your capillaries – are found in the white linings of these and other plants. Many vegetables also pack in vitamin C including tomatoes, broccoli, green and red bell peppers, raw lettuce and other leafy greens.

How Is It Absorbed in the Body?

Species that make their own vitamin C synthesize it in the liver from glucose. Unfortunately, humans must get their ascorbic acid from dietary sources. Vitamin C is absorbed by an active transport system located in the gut and then reabsorbed through the kidneys, explain Gaby and Singh. Since the absorption mechanisms in the gut and kidneys can reach a saturation point, it is better to take multiple doses of vitamin C throughout the day than one large dose.6

How Much Vitamin C is Needed to Prevent a Deficiency?

The classic deficiency state related to vitamin C is scurvy, a condition characterized by gum disease, pain in the muscles and joints, skin lesions, fatigue and bleeding. An adult needs 10 milligrams of vitamin C per day to prevent scurvy. This is the absolute minimum, however, and some studies have shown that a daily dose of 100 mg or more may be needed to maintain or maximize the body pool of vitamin C.7

Who is Likely to Require a Higher Quantity of Vitamin C?

Depending on genetics and life-style factors, some people may require more vitamin C than the average healthy adult to prevent the disruption of important biochemical reactions. The elderly, alcohol consumers, diabetics and smokers, for example,tend to be low in vitamin C. In their report, Gaby and Singh offer the following evidence of this relationship.8

The elderly. Elderly people are known to be lacking in vitamin C,primarily because their diet is poor. In a 1978 study, elderly people had only half the level of ascorbic acid in their blood plasma as did younger subjects. How much vitamin C do they need to make up for this deficit? According to two studies, men and women over age65 need daily doses of 150 mg and 75 to 80 mg, respectively, to maintain a plasma level of1.0 mg/dl.

Alcohol consumers. Many chronic drinkers lack an adequate level of vitamin C because they tend to eat poorly, according to Gaby and Singh. Research also shows that a large intake of alcohol can depress the concentration of ascorbic acid in plasma and increase urinary excretion of vitamin C. Therefore, one study suggests that doses of vitamin C - at 500 to 1,000 mg per day can aid in the treatment of alcoholism.

Diabetics. The tissues and organs of diabetics may be deprived of vitamin C, requiring them to consume more of the nutrient than does the average person. Vitamin C must compete with glucose to reach the tissues and organs through a common cellular transport system. An insufficient supply of insulin also can inhibit the transport of vitamin C to cells that require insulin for their glucose uptake.

Workers exposed to toxins. Studies also show that the blood levels of vitamin C may be low in workers who are exposed to occupational pollutants such as lead and coal tar.

Smokers. At this point, it is a well accepted fact in the scientific arena that cigarette smoke has a negative impact on the metabolism of vitamin C. According to the Journal of Clinical Nutrition, people who smoke have a much lower level of ascorbic acid in the blood than do nonsmokers. While the Food and Nutrition Board recommends that smokers consume 100 mg of vitamin C a day, they may need 200 mg or more to maintain the same concentration of serum ascorbate as a nonsmoker who gets 60 mg of vitamin C per day.9

How Does Vitamin C Aid the Immune System Defenses?

Vitamin C assists the immune system in two of its primary functions to rid the body of foreign invaders and to monitor the systems for any sign of tumor cells. It accomplishes these vital tasks by stimulating the production of white blood cells,primarily neutrophils, which attack foreign antigens such as bacteria and viruses. It also boosts the body's production of both antibodies and interferon, the protein that helps protect us from viral invaders and cancer cells.10

As a constituent of collagen, vitamin C may contribute to our immune defenses in an even more fundamental way: our skin and the epithelial lining of the body's orifices,both of which contain collagen, serve as our first line of defense against foreigninvaders.11 They prevent these invaders from entering the body in the first place, where the immune system would have togo to war against them.

Beyond that, vitamin C acts against the toxic, mutagenic and carcinogenic effects of environmental pollutants by stimulating liver detoxifying enzymes. It also stimulates the production of PGE1, a prostaglandin which assists lymphocytes, the defender cells in our immune system.12

As the following studies demonstrate, vitamin C can enhance the immune function in a number of ways:

Healthy adults. In a 1981 study, healthy adults received 1 gram of vitamin C intravenously. One hour later, the neutrophil motility and leukocyte transformation in the subjects' blood had increased significantly. Other studies support the finding that vitamin C enhances the leukocyte function. It has also been shown to decrease bacteriological activity.13

Chronically ill adults. Recent studies show that vitamin C has a positive effect on patients suffering from a variety of chronic disorders. In one large study, 260patients with viral hepatitis A took 300 mg of vitamin C a day for several weeks. The researchers, who studied immune indicators, such as serum immunoglobulin and neutrophil phagocytosis, concluded that vitamin C "exerts a remarkable immuno-modulatingaction."14

Likewise, a study of 14 patients with chronic brucellosis found that vitamin C "might partially restore peripheral, monocyte function and help themonocyte-macrophage system to mount an effective immune response against [the infection]."15 In 60 patients with perennial allergic rhinitis, an ascorbic acid solution lessened symptoms in roughly three-

fourths of the patients.16 And asthmatic patients who were treated with vitamin C before their airway was constricted via exercise had much less difficulty breathing.17

Test tube. The immune system process called phagocytosis, in which certain cells "eat" invading bacteria, is stimulated by vitamin C. In addition, the nutrient may reduce the suppressor activity of the mononuclear leukocytes, which weakens the overall effectiveness of the immune system.18

Animal studies. In one study of guinea pigs (which, like humans, cannot manufacture their own vitamin C), the antibody to a particular antigen responded faster when the animals received vitamin C. Meanwhile, a study of chickens analyzed their ability to withstand E. coli challenge infection by taking 330 mg of vitamin C. Only 19% of the supplemented animals got the infection, while 76% of the unsupplemented control subjects were infected.19

As an Antioxidant, How Does Vitamin C Help to Protect the Body?

Vitamin C protects the DNA of the cells from the damage caused by free radicals and mutagens. As Gaby and Singh report, it prevents harmful genetic alterations within cells and protects lymphocytes from mutations to the chromosomes. Vitamin C may be especially important in this day and age of widespread environmental pollution because it combats the effects of many such toxins, including ozone, carbon monoxide, hydrocarbons,pesticides and heavy metals.

It appears that vitamin C fights off these pollutants by stimulating enzymes in the liver that detoxify the body. In several studies, vitamin C reduced chromosome abnormalities in workers exposed to pollutants such as coal tar, styrene, methylmethacrylate and halogenated ethers. Another way in which vitamin C protects us is by preventing the development of nitrosamines, the cancer-causing chemicals that stem from the nitrates contained in many foods.20

Vitamin C prevents free radical damage in the lungs and may even help to protect the central nervous system from such damage.21In a study of guinea pigs, an ascorbic acid pretreatment effectively diminished the acute lung damage caused by the introduction of superoxide anion free oxygen radicals to thetrachea.22 Ascorbic acid also was tested as an antioxidant to inflammatory reaction in mice. High doses given after but not before the injury successfully suppressed edema.23

As an antioxidant, vitamin C's primary role is to neutralize free radicals. Since ascorbic acid is water soluble, it can work both inside and outside the cells to combat free radical damage. As explained earlier, free radicals will seek out an electron to regain their stability. Vitamin C is an excellent source of electrons; therefore, it "can donate electrons to free radicals such as hydroxyl and superoxide radicals and quench their reactivity," states Adrianne Bendich in "Antioxidant Micronutrients and Immune Responses".24

The versatile vitamin C also works along with glutathione peroxidase (a major free radical-fighting enzyme) to revitalize vitamin E, a fat-soluble antioxidant. In addition to its work as a direct scavenger of free radicals in fluids, then, vitamin C also contributes to the antioxidant activity in the lipids.

How Much Vitamin C Is Needed for Antioxidant Activity?

Free radical pathology may occur when the body's antioxidant mechanisms cannot keep pace with the rate at which free radicals and other oxidants are being formed.To supply the body with enough antioxidant power, R.F. Cathcart, a clinical practitioner who has treated thousands of patients with vitamin C, believes each person should take the vitamin up to his or her "bowel tolerance" level. Simply put, this is the level just below the daily dosage that would cause you to have diarrhea.

As Dr. Jeffrey Bland reports in The Nutritional Effects of Free Radical Pathology, Cathcart believes that the more severe the toxicity from oxygen radicals,the more vitamin C one can tolerate. Therefore, your bowel tolerance level may be 10,000mg per day or more which should be taken in divided doses.25

Does Vitamin C Contribute to Cardiovascular Health?

As an antioxidant and a constituent of collagen, vitamin C may play a number of roles in maintaining cardiovascular fitness. Here's how it affects some important aspects of cardiovascular functioning:

Atherosclerosis status. The fatty plaques that form in blood vessels,called atherosclerosis, are a major contributor to heart disease, Vitamin C may prevent this plaque formation by inhibiting the oxidative modification of low density lipoproteins(LDLs), according to a study conducted at the University of Texas Southwestern Medical Center. LDLs, commonly known as the "bad" form of cholesterol, may "contribute to the atherosclerotic process by its

cytotoxic effects, uptake by the scavenger receptor and influence on monocyte and macrophage motility," say theresearchers.26

Beyond that, vitamin C may play a mitigating role in another aspect of atherosclerosis - the buildup and adhesion of platelets on vessel walls. As Gaby and Singh report, an injury to the vessel wall prompts the production of a prostaglandin called thromboxane. This prostaglandin causes platelets to aggregate and clot. On the other hand,a prostaglandin called prostacyclin helps protect us against the effects of this process.

In human studies, vitamin C in doses ranging from 1 to 2 grams per day has been shown to hinder platelet aggregation and adhesion, reduce the level of an oxidation by-product in platelets, and increase fibrinolytic activity, which may help to clear arteries. Animal studies have found that vitamin C can prevent or reverse the plaque formation caused by a high-cholesterol diet, reduce platelet aggregation by stimulating the production of prostacyclin, and interfere in the platelet release mechanism, thereby reducing platelet activity.27

Serum lipid levels. By now, most of us know that too much cholesterol can lead to heart disease. However, studies on the relationship of vitamin C to blood cholesterol levels report mixed results. According to Gaby and Singh, a few human studies have noted a positive connection between the blood levels of vitamin C and high density lipoproteins (HDLs). Unlike the LDLs, which can lead to plaque, HDLs help to reduce the risk of heart disease by "scavenging" cholesterol. Conversely, a number of studies on the vitamin C/cholesterol connection concluded that the vitamin did not have a positive effect on serum lipids. Gaby and Singh point out that most of these studies were conducted with small groups of people for a short period of time.28

In one notable study, however, researchers monitored the cholesterol levels of people who took 1,500 mg of vitamin C a day. They found that the cholesterol levels were reduced significantly because vitamin C encouraged the conversion of cholesterol into bile acids, which are then eliminated from the body in the feces, according to Formulafor Life.29 Similarly,several animal studies indicate that vitamin C contributes to this conversion by stimulating an enzyme that regulates the process. In addition, vitamin C may increase the beneficial HDL cholesterol.30

Ischemic heart disease. When the blood supply to an organ is cut off, it deprives the cells and tissues of oxygen and results in a harmful condition called ischemia. Like other

antioxidants, vitamin C can protect the area of the heart that is deprived of oxygen from further damage by free radicals.31

Do Any Disease States Respond to the Use of Vitamin C?

Cataract development As we age, the large concentration of ascorbic acid in the optic lens beings to decline. At the same time, the risk of developing a cataract increases, in part from oxidative damage to the lens protein. As an antioxidant,vitamin C can defend the lens by hindering the destructive process of lipidphotoperoxidation, which clouds the vision.32In one national study of nutrition and disease, a reduced risk of age-related macular degeneration was related to the frequency of consumption of fruits and vegetables rich in vitamins A and C.33

Animal studies also show that vitamin C serves an important role in protecting the lens. In guinea pigs subjected to heat-induced protein damage, for example, large amounts of dietary ascorbic acid reduced the loss of water-soluble proteins in the lens,thereby protecting the eyes from this type of damage.34In another study, rats were exposed to selenite-induced cataracts, which result from oxidative stress to the lens. The preventive effects of an ascorbate treatment were significant, supporting the researchers' view that vitamin C serves as an "anticataractogenic substance."35

Hemolytic and Sickle Cell Anemia. Vitamin C can do much to enhance the body's absorption of iron, especially the "nonheme" variety found in plants and drinking water ("heme" iron comes from meat). Ordinarily, our absorption of iron is quite poor, putting us at risk of iron-deficiency anemia. But a handful of studies have found that 25 to 100 milligrams of ascorbic acid when taken with a meal, can double or even triple nonheme iron absorption.36

Periodontal disease. Not surprisingly, the mouth is susceptible to many invading bacteria, which can plant themselves in dental plaque and lead to periodontal disease. By improving the body's defense mechanisms, then, vitamin C can help to ward off bacterial infection and maintain periodontal health. Vitamin C may accomplish this task in several ways, including the stimulation of leukocyte and neutrophil chemotaxis and bactericidal activity.37,38

Remember, too, that vitamin C is a major constituent of collagen, which not only preserves the integrity of tissues but also supports the body's resistance to invading microbes. In one

study of people with damaged connective tissue in the gums, vitamin C supplements of 70 mg per day increased intracellular linkages and collagen bundles. In another study, gum bleeding caused by a vitamin C deficiency was reduced by supplements of the nutrient, with greater results at 600 mg per day than at 60 mg.39

Bone disorders. By now, you probably get the point that vitamin C's role in collagen formation is an important one. But if you're still not convinced, consider this addition to the picture: Strong bones depend on strong collagen. As we age, however,both the density of our bones and our level of vitamin C begin to decrease. While a number of factors contribute to osteoporosis (the loss of bone), studies show that a person's vitamin C status also is related to the maintenance of healthy bones. In fact, vitamin C may directly impact the growth of bone cells, above and beyond its call of duty in forming collagen.

Osteoporosis occurs most often in older women, in part because estrogen appears to help protect against bone loss. In several studies of postmenopausal women and a mixed population, vitamin C intake was correlated with bone mineral content or bone density. "Ascorbic acid intake at moderate doses is important and safe for bone maintenance,and therefore a factor in mitigating or delaying osteoporosis," say Gaby and Singh.40

What about the joints that connect our bones? Vitamin C may help here, too. When mice with arthritis and inflammation in their paws received vitamin C for 20 days, the treatment reduced arthritic swelling, increased their pain tolerance and decreased polymorphonuclear leukocyte infiltration. The researchers concluded: "Vitamin C may provide podiatrists with a supplemental or alternative treatment for patients with rheumatoid arthritis."41Another study found that the rapid depletion of vitamin C at the site of an inflammation -such as a rheumatoid joint - may facilitate proteolytic damage.42

Diabetes. Diabetics tend to have low levels of vitamin C not only in the plasma but also in the white blood cells, which constitute our immune defenses. One study,conducted at the University of Massachusetts, measured the ascorbic acid content of mononuclear leukocytes in adults with insulin-dependent diabetes mellitus. This content level, which serves as a gauge of the vitamin C status of tissues, was reduced by 33% in the diabetic patients, even though their intake of dietary vitamin C was adequate. According to the researchers, this impaired storage capacity "supports the theory that intercellular scurvy contributes to the chronic degenerative complications of the disease."43

Can Vitamin C help to Prevent or Treat Cancer?

Over the years, many studies have found that vitamin C is an effective anti-cancer agent. It works in the following ways to help the body combat cancer cells:

Studies suggest that vitamin C's antioxidant mechanisms may help to prevent cancer in several ways. It combats the per oxidation of lipids, for example, which has been linked to the aging process and degeneration. One study of elderly people found that 400mg of vitamin C per day (for a one-year period) reduced serum lipid peroxide levels. Vitamin C can also work inside the cells to protect DNA from the damage caused by free radicals. In several studies, report Gaby and Singh, vitamin C reduced the level of potentially destructive genetic alterations or chromosome aberrations.44

Many of the pollutants that now pervade our environment can cause toxic,carcinogenic or mutagenic effects. Vitamin C may be able to arrest these harmful effects,in part by stimulating detoxifying enzymes in the liver. In another study, vitamin C was shown to block the formation of fecal mutagens.45

Vitamin C can help to optimize the immune system, which does the all important job of surveying the body for the presence of cancer cells. According to Richard A. Passwater,Ph.D., it also enhances an intracellular material called ground substance that holds tissues together. When this substance is strong, cancer cells have a harder time infiltrating cells.46

Finally, vitamin C can reduce the development of nitrosamines from nitrates,chemicals that are commonly used in processed foods. Once formed, nitrosamine can become a carcinogen. But in several human studies, in which the subjects consumed a nitrosamine precursor, the urinary levels of nitrosamines were significantly reduced by vitamin C.47 Three animal studies also support the preventive effects of ascorbic acid on nitrate-induced cancer. In all three cases, the formation of tumors was inhibited, suppressed or reduced in frequency in the animals treated with vitamin C.48-50

As far back as the late 1940s, researchers began to note a connection between the incidence of cancer and a dietary deficiency of vitamin C or low blood levels in the body. Studies conducted in the past decade have confirmed that link. According to two studies from the early 1980s, 2 to 5 grams of vitamin C per day can correct these low serum levels and, in some patients, improve the immune system defenses.51

At this point, it seems clear that there is a strong relationship between a person's vitamin C intake and cancer risk. In 1991, the American Journal of Clinical Nutrition conducted a comprehensive analysis of some 46 studies on vitamin C's protective effects against various types of cancer. Of these, 33 studies reported a significant link between vitamin C intake and the incidence of cancer. In fact, a high intake of vitamin C offered twice the protection of a low intake. Many of these studies defined a high intake as a daily dosage of 160 mg or more per day; a low intake generally was less than 70 mg.52

According to author Gladys Block, the greatest effects were noted with cancer of the esophagus, larynx, oral cavity and pancreas, followed by cancer of the stomach,rectum, breast and cervix. While vitamin C's impact on lung cancer was less consistent,several studies did find significant protective effects. "The strength and consistency of the results reported here for several sites suggests that there may be a real and important effect of ascorbic acid in cancer prevention," states Block.

Here, we summarize Block's findings regarding specific types of cancer, including non-hormone-dependent cancers (of the oral cavity, larynx, esophagus, lung, pancreas,stomach, colon and rectum) and hormone-dependent cancers (of the breast, ovaries,endometrium and prostate). In all cases, the studies either developed an index that measured participants' vitamin C intake or reported on the effects of a vitamin C-rich food, primarily fruit, in the diet.53

Oral cavity, larynx and esophagus. All 8 studies reporting on a vitamin C index found that people with a low intake had a significantly greater risk of developing these cancers. Meanwhile, six of the 12 studies of food intake rather than a nutrient index found a significant risk for low fruit intake. Of the remaining six, two found suggestive results, two found low intakes in high-risk populations and one found noeffect.54

Lung. The lung cancer studies generated mixed reports on vitamin C. Of 11 such studies, five found a significant protective effect, four found protective but not significant effects and two found no effect. Interestingly, four studies reported that vitamin C had stronger effects than carotenoids. "Whereas a large body of evidence suggests an important effect for carotenoids in lung cancer prevention," says Block, "the recent data suggest that there may also be an independent protective effect of vitamin C intake."55

Pancreas. In the one study that developed a vitamin C index, a high intake decreased the risk of pancreatic cancer by half. Five studies also found that fruit (and vegetables in some cases) offered significant protective effects against this cancer,which is the fifth leading cause of cancer death in this country.56

Stomach. All seven studies on vitamin C intake and the risk of stomach cancer concluded that the nutrient's protective effects were significant. Of eight studies that analyzed fruit intake, all but one found that people with stomach cancer had a lower consumption of fruit.57

Colon and rectum. Of six studies on rectal cancer, four found that vitamin C offered significant protection and two found suggestive results. The results with colon cancer were less consistent. Four studies noted significant protection, two found suggestive effects and two studies that developed a nutrient index found no effect. One of these, however, reported that vitamin C-rich foods had a significant effect.58

Breast, ovary, endometrium and prostate. According to Block, recent evidence indicates that vitamin C may play an important role in protecting against breast cancer. But with endometrial, ovarian and prostate cancer, studies have not found the vitamin's effects to be significant.59

In 1976, Dr. Linus Pauling brought vitamin C into the limelight by reporting on the results of his cancer research. In the study he conducted with Ewan Cameron, 100terminally ill cancer patients received 10 grams of vitamin C a day. As Dr. Passwater reports in The Antioxidants, these patients lived more than four times longer than the 1,000 control subjects who did not receive vitamin C. Only three of these1,000 patients survived for more than a year, while 16 of the 100 patients taking vitamin C lived a year or longer.60

More recently, E. Cameron reported similar results from a study he conducted in Alexandria, Scotland, between 1978 and 1982. In this case he created a database to record various details about every cancer patient who attended 3 hospitals in Scotland during the four-year period.

The study included 1,826 "incurable" (in a total population of 2,804).Of the "incurable" patients, 294 had received supplemental ascorbate at some point during their illness. The remaining 1,532 patients, who did not take vitamin C,served as the controls. In analyzing

the data, the researchers found that "the ascorbate-supplemented patients had a median overall survival time (343 days) almost double that of the controls (180 days)."61

Still, other studies have found that large daily doses of vitamin C had no effect on advanced cancer or the survival rate of women with breast cancer. "Current evidence suggests that the major benefit of ascorbic acid with regard to cancer may be in reducing the risk of developing cancer, rather than in therapy," state Gaby and Singh.62

Does Vitamin C Function Synergistically With Other Nutrients?

As an antioxidant, vitamin C can rejuvenate vitamin E, making it an indirect contributor to the fight against free radical damage in the lipids. It's not surprising, then, that these two nutrients can be effective partners in reducing the destructive process of lipid peroxidation. In human and animal studies, this reduction took place in subjects with diabetes, cerebral arteriosclerosis or a heart disorder.63-65 Together, vitamins C and E can help to prevent the blood from clotting, a condition that contributes to the risk ofstroke.66 This combination may offer protection against cataracts as well.67

The synergistic combination of vitamins C and E may be further enhanced by the addition of vitamin A. In one study of 30 elderly long-stay patients, for example, this trio was effective in improving certain aspects of cell-mediated immunity, such as the number of T cells, T4 subsets and the ratio of T4 to T8 cells.68In another study, a complex of vitamins A, E and C significantly enhanced the "characteristics of enzymatic and non-enzymatic antioxidant protection of the liver" in mice.69 Finally, a classic antioxidant combination - vitamins C and E, beta carotene and selenium - helped to alleviate pancreatitis, or an inflammation of the pancreas, in a study of 28 patients.

Is There Any Evidence that Vitamin C has Harmful Side Effects?

Over the years, vitamin C has been blamed for a number of harmful side effects, generating much controversy about the safety of the nutrient. But most of these claims are undeserved. "Apparently, vitamin C has a low order of toxicity, or intoxications would be common. Although large intakes may cause adverse effects in some individuals, some of the widely reported and often cited adverse effects have little apparent basis," states John Hathcock in "Safety of Vitamin and Mineral Supplements."

Three of the most serious side effects that have been attributed to vitamin C are conditioned scurvy, kidney stones and the destruction of vitamin B12. But in analyzing the studies that reported on the relationship between vitamin C and these health problems,Hathcock has found that there is no real clinical evidence to support the idea that vitamin C is responsible for any of these conditions.

One common complaint regarding vitamin C is that it can cause gastrointestinal distress, including cramps, diarrhea and nausea. These symptoms, which are caused by the acidity rather than the ascorbate itself, seem to disappear when a buffered form of vitamin C is taken. In some cases, the chewable form of vitamin C also has led to erosion of dental enamel. In facilitating the absorption of iron, vitamin C can decrease the intake of copper and lead to a "negative copper balance," says Hathcock.

References

1. Eberhard Kronhausen and Phyllis Kronhausen with Harry B. Demopoulos, M.D., Formula for Life, William Morrow and Co., New York, 1989, p. 95.

2. Ibid, p. 102.

3. S.K. Gaby and V.N. Singh, "Vitamin C," – Vitamin Intake and Health: A Scientific Review, S.K. Gaby, A. Bendich, V. Singh and L. Machlin (eds.)Marcel Dekker, N.Y. 1991 p. 103-1043.

4. Kronhausen. p. 96.

5. Gaby, p. 103-104.

6. Ibid, p. 105.

7. Ibid, p. 104-105.

8. Gaby, p. 105-108. sg

9. Gordon Schectman, James C. Byrd and Raymond Hoffmann, "Ascorbic Acid Requirements for Smokers: Analysis of a Population Survey," American Journal of Clinical Nutrition, 1991; 53:1;1466-70.

10. Kronhausen, p. 96.

11. Gaby, p.120.

12. Kronhausen, p. 102.

13 Gaby, p. 120-121.

14 V.S. Vasil'ev, V.l. Komar and N.l. Kisel, "Humoral and Cellular Indices of Nonspecific Resistance In Viral Hepatitis A and Ascorbic Acid", Ter-Arkh; 1989 61(11); p.44-6.

15. P. Boura at al., "Monocyle Locomotion In Anergic Chronic Brucellosis Patients: The In Vivo Effect of Ascorbic Acid," Immunopharmacol; 1989;11(1): p. 119-29.

16. L. Podoshin, R. Gertner and M. Fradis, "Treatment of Perennial Allergic Rhinos with Ascorbic Acid Solution," Ear-Nose-Throat J.; January 1991; 70(1); p.54-5.

17. M. Miric and M.A. Haxhiu, "Effect of Vitamin C on Exercise-induced Bronchoconstriction," Plucne-Bolesti; January-June 1991, 43(1-2); p. 94-7.

18. Gaby, p. 120.

19. W.B. Gross, D. Jones and J. Cherry, "Effect of Ascorbic Acid on the Disease Caused by Escherichia Coli Challenge Infection,"" Avian-Dis.; July-September, 1988;32(3); p. 407-9.

20. Gaby, p. 108-109.

21. Kronhausen, p. 104.

22. G. Becher and K. Winsel, "Vitamin C Lessens Superoxide Anion(02)-lnduced Bronchial Constriction," Z-Erkr-Atmungsorgane; 1989; 173 (10): p. 100-4.

23. C.R. Spillert et al., "Inhibitory Effect of High Dose Ascorbic Acid on Inflammatory Edema," Agents-Actions; June 1989; 27(3-4); p. 401-2.

24 . Adrianne Bendich , "Antioxidant Micronutrients and Immune Responses," Micronutrients and Immune Functions, A. Bendich and R.K. Chandra (eds.) New York Academy of Sciences,New York, 1990, p. 175.

25. Jeffrey Bland, Ph.D., The Nutritional Effects of Free Radical Pathology: 1966/A Year in Nutritional Medicine, Keats Publishing Inc., New Canaan, CT; 1986; p. 16.

26. Ishwaral Jialal, Gloria Lena Vega and Scott M. Grundy, "Physiologic Levels of Ascorbate inhibit the Oxidative Modification of Low Density Lipoprotein," Atherosclerosis; 82, 1990 p. 185.

27. Gaby, p. 125.

28. Ibid, p. 123-124.

29. Kronhausen, p. 96.

30. Gaby, p. 123.

31. Kronhausen, p. 103.

32. Gaby, p. 130-131.

33. J. Goldber et al., "Factors Associated with Age-Related Macular Degeneration," Am. J Epidemiol.; October 1988; 128(4); p. 700-10.

34 C.S. Tsao, L.F. Xu and M. Young, "Effect of Dietary Ascorbic Acid on Heat-Induced Eye Lens Protein Damage in Guinea Pigs," Opthalmic, Res.; 1990;22(2); p. 106-10.

35. P.S. Devamanoharan et al., "Prevention of Selenite Cataract by Vitamin C,"Exp. Eye Res.; May 1990; 52(5); p. 563-8.

36. Gaby, p. 131.

37. Ibid, p. 134-135.

38. A. B. Rubinoff et al., "Vitamin C and Oral Health," J. Can. Den. Assoc.;September 1990; 55(9); p. 705-7.

39. Gaby, p. 135.

40. Ibid, p. 134.

41. R.H. Davis et al. "Vitamin C Influence on Localized Adjuvant Arthritis J. Am. Podiatr.Med. Assoc.; August 1990; 80(8); p. 414-8.

42. B. Halliwell et al.; "Biologically Significant Scavenging of the Myeloperoxidase-Derived Oxidant hypochlorous Acid by Ascorbic Acid," FEBS. lett.;March 9, 1987; 213 (1); p. 15-7.

43. J.J. Cunningham et al., "Reduced Mononuclear Leukocyte Ascorbic Acid Content in Adults with Insulin-Dependent Diabetes Consuming Adequate Dietary Vitamin C;" Metabolism;February 1991; 40(2); p. 146-9.

44. Gaby, p. 108.

45. Ibid, p. 108 & 110.

46. Richard A. Passwater, The Antioxidants, Keats Publishing, Inc., New Canaan,CT, 1985, p. 13-15,

47. Gaby, p. 109.

48. F.K. Dzhioev, "Prevention Using Ascorbic Acid, Hexamethylenetetramine and Sodium Metabisulfite of the Blastomogenic Effect Caused by the Combined Administration into the Stomach of Mice of Sodium Nitrate with Methylurea or with Aminopyrene," Vopr.Onkol.; 1988; 34(11); p. 1369-73.

49. S. Dittrich et al., "Effects of Nitrate and Ascorbic Acid on Careinogenesis In the Operated Rat Stomach," Arch. Geschwulstforsch; 1988; 58(4); p. 235-42.

50. N.L. Viasenko et al., "Effect of Different Doses of Ascorbic Acid on the Induction of Tumors with N-nitroso Compound precursors in Mice," Vopr. Onkol.; 1988;34(7); p. 839-43.

51. Gaby, p. 109.

52. Gladys Block, "Vitamin C and Cancer Prevention: The Epidemiologic Evidence," American Journal of Clinical Nutrition; 1991; 53:270S-82S.

53. Ibid, p. 270S.

54 Ibid, p. 271S-272S.

55. Ibid p. 272S-273S.

56. Ibid p. 273S.

57. Ibid, 273S-274S.

58. Ibid., 275S-276S.

59. Ibid, 276S-278S.

60. Passwater, p. 14.

61. E. Cameron and A. Campbell, "Innovation vs. Quality Control: An'Unpublishable' Clinical Trial of Supplemental Ascorbate in Incurable Cancer,"Med. Hypotheses; Nov. 1991; 36(3); p. 185-9.

62. Gaby, p. 117.

63. K.G. Karagezian and D.M. Gevorkian, "Phospholipid-Glycerides, Cross-Resistance of Erythrocytes, Malonic Dialdehyde Level and Alpha-Tocopherol Levels in the Plasma and Erythrocytes of Rats with Alloxan Diabetes Before and After Combined Antioxidant Therapy," Vopr. Med. Khim; September-October 1989; 35(5); p. 27~30.

64. V.N. Bobyrev, I. Sh. Vese'lskil and L.E. Bobyreva, "Antioxidants in the Prevention and Treatment of Cerebral Arteriosclerosis," Zh. Nevrapatol.Psikltatr.; 1989; 89(9); p. 60-3.

65. E. Barta et al., "Protective Effects of Alpha-Tocopherol and L-Ascorbic Acid Against the Ischemic Reperfusion Injury in Patients During Open-Heart Surgery,"Bratisl. Lek. Listy.; March-April 1991; 92(3-4); p. 174-83.

66. Kronhausen, p. 103.

67. J.M. Robertson et al., "A Possible Role for Vitamins C and E In Cataract Prevention," Am. J. Clin. Nutr.; January 1991; 53 (1 Suppl.); p. 346S-351S.

68. N.D. Penn et al., "The Effect of Dietary Supplementation with Vitamins A, C and E on Cell-Mediated Immune Function In Elderly Long-Stay Patients: A Randomized Controlled Trial," Age-Aging, May 1991; 20(3); p. 169-74.

69. V.A. Kuvshinnikov et al., "Use of the Antioxidant Complex of Vitamins A, E and C In Murine Leukemia," Gematol. Transvuziol.; August 1989; 34(8): p. 23-8.

In the 65 years since its discovery, vitamin C has come to be known as a "wonderworker." It's easy to see why: In addition to its role in collagen formation and other life-sustaining functions, vitamin C serves as a key immune system nutrient and a potent free-radical fighter. This double-duty nutrient has been shown to prevent many illnesses, from everyday ailments such as the common cold to devastating diseases such as cancer.

In the scientific world, the water-soluble vitamin C is known as ascorbic acid(meaning "without scurvy," the disease caused by a vitamin C deficiency). We depend on ascorbic acid for many aspects of our biochemical functioning; yet human beings are among only a handful of animal species that cannot produce their own supply of vitamin C. Like these other animals, including primates and guinea pigs, we have no choice but to obtain this nutrient in our diet. Considering the many benefits vitamin C may provide,that mandate is deceptively simple.

How Does Vitamin C Function in the Body?

Much like the immune system itself, which operates at a cellular level,the hardworking vitamin C reaches every cell of the body. The concentration of vitamin C in both blood serum and tissues is quite high.1In fact, this nutrient plays a major role in the manufacture and defense of our connective tissue, the elaborate matrix that holds the body together. It serves as a primary ingredient of collagen, a glue-like substance that binds cells together to form tissues.

Vitamin C helps some of our most important body systems. First and foremost, it helps the immune system to fight off foreign invaders and tumor cells. Vitamin C also supports the cardiovascular system by facilitating fat metabolism and protecting tissues from free radical damage, and it assists the nervous system by converting certain amino acids into neurotransmitters.

The skin, teeth and bones also benefit from vitamin C's collagen-forming and invader-resisting properties; this vitamin contributes to the maintenance of healthy bones, the prevention of periodontal disease and the healing of wounds. It even serves asa natural aspirin, of sorts, by combating inflammation and pain, according to FormulaFor Life. It accomplishes this task by inhibiting the secretion of the prostaglandins that contribute to such symptoms.2

What Biochemical Processes Require Vitamin C?

Collagen metabolism. Most of us know collagen as the much-promoted ingredient in our facial moisturizers and hand lotions. But the use of collagen in beauty and skin products only hints at the importance of this protein. The very structure of the body - the skin, bones, teeth, blood vessels, cartilage, tendons and ligaments - depends on collagen. And the integrity of collagen, in in turn, depends on vitamin C.

In a report on ascorbic acid in Vitamin Intake and Health, S.K. Gaby and V.N. Singh explain that collagen protein requires vitamin C for "hydroxylation," a process that allows the molecule to achieve the best configuration and prevents collagen from becoming weak and

susceptible to damage. Beyond that, they say, recent evidence indicates that vitamin C increases the level of procollagen messenger RNA. "Collagen subunits are formed within fibroblasts asprocollagen, which is excreted into extra cellular spaces. Vitamin C is required to export the procollagen molecules out of the cell. The final... structure of the collagen is formed after pieces of the procollagen are enzymatically cleaved," state Gaby and Singh.3

Antioxidant functions. As a water-soluble antioxidant, vitamin C is in a unique position to "scavenge" aqueous peroxyl radicals before these destructive substances have a chance to damage the lipids. It works along with vitamin E, a fat-soluble antioxidant, and the enzyme glutathione peroxidase to stop free radical chain reactions.

Immune system functions. Vitamin C can enhance the body's resistance to an assortment of diseases, including infectious disorders and many types of cancer. It strengthens and protects the immune system by stimulating the activity of antibodies and immune system cells such as phagocytes and neutrophils.4

Other processes. Vitamin C contributes to a variety of other biochemical functions. These include the biosynthesis of the amino acid carnitine and the catecholamines that regulate the nervous system. It also helps the body to absorb iron and to break down histamine, the inflammatory component of many allergic reactions.5

What Specific Locations in the Body does Vitamin C Affect?

Although vitamin C is found in every cell, it is especially useful in key parts of the body. These include the blood, the skin, the nervous system, the teeth and bones and glands such as the thymus, adrenals and thyroid.

What Foods are Good Sources of Vitamin C?

Large concentrations of vitamin C can be found in fruits such as oranges,grapefruits, tangerines, lemons, limes, papaya, strawberries and cantaloupe. Vitamin C and bioflavonoids - the water soluble substances that help to protect your capillaries - are found in the white linings of these and other plants. Many vegetables also pack in vitamin C including tomatoes, broccoli, green and red bell peppers, raw lettuce and other leafy greens.

How Is It Absorbed in the Body?

Species that make their own vitamin C synthesize it in the liver from glucose. Unfortunately, humans must get their ascorbic acid from dietary sources. Vitamin C is absorbed by an active transport system located in the gut and then reabsorbed through the kidneys, explain Gaby and Singh. Since the absorption mechanisms in the gut and kidneys

can reach a saturation point, it is better to take multiple doses of vitamin C throughout the day than one large dose.6

How Much Vitamin C is Needed to Prevent a Deficiency?

The classic deficiency state related to vitamin C is scurvy, a condition characterized by gum disease, pain in the muscles and joints, skin lesions, fatigue and bleeding. An adult needs 10 milligrams of vitamin C per day to prevent scurvy. This is the absolute minimum, however, and some studies have shown that a daily dose of 100 mg or more may be needed to maintain or maximize the body pool of vitamin C.7

Who is Likely to Require a Higher Quantity of Vitamin C?

Depending on genetics and life-style factors, some people may require more vitamin C than the average healthy adult to prevent the disruption of important biochemical reactions. The elderly, alcohol consumers, diabetics and smokers, for example,tend to be low in vitamin C. In their report, Gaby and Singh offer the following evidence of this relationship.8

The elderly. Elderly people are known to be lacking in vitamin C,primarily because their diet is poor. In a 1978 study, elderly people had only half the level of ascorbic acid in their blood plasma as did younger subjects. How much vitamin C do they need to make up for this deficit? According to two studies, men and women over age65 need daily doses of 150 mg and 75 to 80 mg, respectively, to maintain a plasma level of1.0 mg/dl.

Alcohol consumers. Many chronic drinkers lack an adequate level of vitamin C because they tend to eat poorly, according to Gaby and Singh. Research also shows that a large intake of alcohol can depress the concentration of ascorbic acid in plasma and increase urinary excretion of vitamin C. Therefore, one study suggests that doses of vitamin C - at 500 to 1,000 mg per day can aid in the treatment of alcoholism.

Diabetics. The tissues and organs of diabetics may be deprived of vitamin C, requiring them to consume more of the nutrient than does the average person. Vitamin C must compete with glucose to reach the tissues and organs through a common cellular transport system. An insufficient supply of insulin also can inhibit the transport of vitamin C to cells that require insulin for their glucose uptake.

Workers exposed to toxins. Studies also show that the blood levels of vitamin C may be low in workers who are exposed to occupational pollutants such as lead and coal tar.

Smokers. At this point, it is a well accepted fact in the scientific arena that cigarette smoke has a negative impact on the metabolism of vitamin C. According to the Journal of Clinical Nutrition, people who smoke have a much lower level of ascorbic acid in the blood than do

nonsmokers. While the Food and Nutrition Board recommends that smokers consume 100 mg of vitamin C a day, they may need 200 mg or more to maintain the same concentration of serum ascorbate as a nonsmoker who gets 60 mg of vitamin C per day.9

How Does Vitamin C Aid the Immune System Defenses?

Vitamin C assists the immune system in two of its primary functions to rid the body of foreign invaders and to monitor the systems for any sign of tumor cells. It accomplishes these vital tasks by stimulating the production of white blood cells,primarily neutrophils, which attack foreign antigens such as bacteria and viruses. It also boosts the body's production of both antibodies and interferon, the protein that helps protect us from viral invaders and cancer cells.10

As a constituent of collagen, vitamin C may contribute to our immune defenses in an even more fundamental way: our skin and the epithelial lining of the body's orifices,both of which contain collagen, serve as our first line of defense against foreigninvaders.11 They prevent these invaders from entering the body in the first place, where the immune system would have togo to war against them.

Beyond that, vitamin C acts against the toxic, mutagenic and carcinogenic effects of environmental pollutants by stimulating liver detoxifying enzymes. It also stimulates the production of PGE1, a prostaglandin which assists lymphocytes, the defender cells in our immune system.12

As the following studies demonstrate, vitamin C can enhance the immune function in a number of ways:

Healthy adults. In a 1981 study, healthy adults received 1 gram of vitamin C intravenously. One hour later, the neutrophil motility and leukocyte transformation in the subjects' blood had increased significantly. Other studies support the finding that vitamin C enhances the leukocyte function. It has also been shown to decrease bacteriological activity.13

Chronically ill adults. Recent studies show that vitamin C has a positive effect on patients suffering from a variety of chronic disorders. In one large study, 260patients with viral hepatitis A took 300 mg of vitamin C a day for several weeks. The researchers, who studied immune indicators, such as serum immunoglobulin and neutrophil phagocytosis, concluded that vitamin C "exerts a remarkable immuno-modulatingaction."14

Likewise, a study of 14 patients with chronic brucellosis found that vitamin C "might partially restore peripheral, monocyte function and help themonocyte-macrophage system to mount an effective immune response against [the infection]."15 In 60 patients with perennial allergic rhinitis, an ascorbic acid solution lessened symptoms in roughly three-

fourths of the patients.16 And asthmatic patients who were treated with vitamin C before their airway was constricted via exercise had much less difficulty breathing.17

Test tube. The immune system process called phagocytosis, in which certain cells "eat" invading bacteria, is stimulated by vitamin C. In addition, the nutrient may reduce the suppressor activity of the mononuclear leukocytes, which weakens the overall effectiveness of the immune system.18

Animal studies. In one study of guinea pigs (which, like humans, cannot manufacture their own vitamin C), the antibody to a particular antigen responded faster when the animals received vitamin C. Meanwhile, a study of chickens analyzed their ability to withstand E. coli challenge infection by taking 330 mg of vitamin C. Only 19% of the supplemented animals got the infection, while 76% of the unsupplemented control subjects were infected.19

As an Antioxidant, How Does Vitamin C Help to Protect the Body?

Vitamin C protects the DNA of the cells from the damage caused by free radicals and mutagens. As Gaby and Singh report, it prevents harmful genetic alterations within cells and protects lymphocytes from mutations to the chromosomes. Vitamin C may be especially important in this day and age of widespread environmental pollution because it combats the effects of many such toxins, including ozone, carbon monoxide, hydrocarbons,pesticides and heavy metals.

It appears that vitamin C fights off these pollutants by stimulating enzymes in the liver that detoxify the body. In several studies, vitamin C reduced chromosome abnormalities in workers exposed to pollutants such as coal tar, styrene, methylmethacrylate and halogenated ethers. Another way in which vitamin C protects us is by preventing the development of nitrosamines, the cancer-causing chemicals that stem from the nitrates contained in many foods.20

Vitamin C prevents free radical damage in the lungs and may even help to protect the central nervous system from such damage.21In a study of guinea pigs, an ascorbic acid pretreatment effectively diminished the acute lung damage caused by the introduction of superoxide anion free oxygen radicals to thetrachea.22 Ascorbic acid also was tested as an antioxidant to inflammatory reaction in mice. High doses given after but not before the injury successfully suppressed edema.23

As an antioxidant, vitamin C's primary role is to neutralize free radicals. Since ascorbic acid is water soluble, it can work both inside and outside the cells to combat free radical damage. As explained earlier, free radicals will seek out an electron to regain their stability.

Vitamin C is an excellent source of electrons; therefore, it "can donate electrons to free radicals such as hydroxyl and superoxide radicals and quench their reactivity," states Adrianne Bendich in "Antioxidant Micronutrients and Immune Responses".24

The versatile vitamin C also works along with glutathione peroxidase (a major free radical-fighting enzyme) to revitalize vitamin E, a fat-soluble antioxidant. In addition to its work as a direct scavenger of free radicals in fluids, then, vitamin C also contributes to the antioxidant activity in the lipids.

How Much Vitamin C Is Needed for Antioxidant Activity?

Free radical pathology may occur when the body's antioxidant mechanisms cannot keep pace with the rate at which free radicals and other oxidants are being formed.To supply the body with enough antioxidant power, R.F. Cathcart, a clinical practitioner who has treated thousands of patients with vitamin C, believes each person should take the vitamin up to his or her "bowel tolerance" level. Simply put, this is the level just below the daily dosage that would cause you to have diarrhea.

As Dr. Jeffrey Bland reports in The Nutritional Effects of Free Radical Pathology, Cathcart believes that the more severe the toxicity from oxygen radicals,the more vitamin C one can tolerate. Therefore, your bowel tolerance level may be 10,000mg per day or more which should be taken in divided doses.25

Does Vitamin C Contribute to Cardiovascular Health?

As an antioxidant and a constituent of collagen, vitamin C may play a number of roles in maintaining cardiovascular fitness. Here's how it affects some important aspects of cardiovascular functioning:

Atherosclerosis status. The fatty plaques that form in blood vessels,called atherosclerosis, are a major contributor to heart disease, Vitamin C may prevent this plaque formation by inhibiting the oxidative modification of low density lipoproteins(LDLs), according to a study conducted at the University of Texas Southwestern Medical Center. LDLs, commonly known as the "bad" form of cholesterol, may "contribute to the atherosclerotic process by its cytotoxic effects, uptake by the scavenger receptor and influence on monocyte and macrophage motility," say theresearchers.26

Beyond that, vitamin C may play a mitigating role in another aspect of atherosclerosis - the buildup and adhesion of platelets on vessel walls. As Gaby and Singh report, an injury to the vessel wall prompts the production of a prostaglandin called thromboxane. This prostaglandin causes platelets to aggregate and clot. On the other hand,a prostaglandin called prostacyclin helps protect us against the effects of this process.

In human studies, vitamin C in doses ranging from 1 to 2 grams per day has been shown to hinder platelet aggregation and adhesion, reduce the level of an oxidation by-product in platelets, and increase fibrinolytic activity, which may help to clear arteries. Animal studies have found that vitamin C can prevent or reverse the plaque formation caused by a high-cholesterol diet, reduce platelet aggregation by stimulating the production of prostacyclin, and interfere in the platelet release mechanism, thereby reducing platelet activity.27

Serum lipid levels. By now, most of us know that too much cholesterol can lead to heart disease. However, studies on the relationship of vitamin C to blood cholesterol levels report mixed results. According to Gaby and Singh, a few human studies have noted a positive connection between the blood levels of vitamin C and high density lipoproteins (HDLs). Unlike the LDLs, which can lead to plaque, HDLs help to reduce the risk of heart disease by "scavenging" cholesterol. Conversely, a number of studies on the vitamin C/cholesterol connection concluded that the vitamin did not have a positive effect on serum lipids. Gaby and Singh point out that most of these studies were conducted with small groups of people for a short period of time.28

In one notable study, however, researchers monitored the cholesterol levels of people who took 1,500 mg of vitamin C a day. They found that the cholesterol levels were reduced significantly because vitamin C encouraged the conversion of cholesterol into bile acids, which are then eliminated from the body in the feces, according to Formulafor Life.29

Similarly,several animal studies indicate that vitamin C contributes to this conversion by stimulating an enzyme that regulates the process. In addition, vitamin C may increase the beneficial HDL cholesterol.30

Ischemic heart disease. When the blood supply to an organ is cut off, it deprives the cells and tissues of oxygen and results in a harmful condition called ischemia. Like other antioxidants, vitamin C can protect the area of the heart that is deprived of oxygen from further damage by free radicals.31

Do Any Disease States Respond to the Use of Vitamin C?

Cataract development As we age, the large concentration of ascorbic acid in the optic lens beings to decline. At the same time, the risk of developing a cataract increases, in part from oxidative damage to the lens protein. As an antioxidant,vitamin C can defend the lens by hindering the destructive process of lipidphotoperoxidation, which clouds the vision.32In one national study of nutrition and disease, a reduced risk of age-related macular degeneration was related to the frequency of consumption of fruits and vegetables rich in vitamins A and C.33

Animal studies also show that vitamin C serves an important role in protecting the lens. In guinea pigs subjected to heat-induced protein damage, for example, large amounts of dietary ascorbic acid reduced the loss of water-soluble proteins in the lens,thereby protecting the eyes from this type of damage.34In another study, rats were exposed to selenite-induced cataracts, which result from oxidative stress to the lens. The preventive effects of an ascorbate treatment were significant, supporting the researchers' view that vitamin C serves as an "anticataractogenic substance."35

Hemolytic and Sickle Cell Anemia. Vitamin C can do much to enhance the body's absorption of iron, especially the "nonheme" variety found in plants and drinking water ("heme" iron comes from meat). Ordinarily, our absorption of iron is quite poor, putting us at risk of iron-deficiency anemia. But a handful of studies have found that 25 to 100 milligrams of ascorbic acid when taken with a meal, can double or even triple nonheme iron absorption.36

Periodontal disease. Not surprisingly, the mouth is susceptible to many invading bacteria, which can plant themselves in dental plaque and lead to periodontal disease. By improving the body's defense mechanisms, then, vitamin C can help to ward off bacterial infection and maintain periodontal health. Vitamin C may accomplish this task in several ways, including the stimulation of leukocyte and neutrophil chemotaxis and bactericidal activity.37,38

Remember, too, that vitamin C is a major constituent of collagen, which not only preserves the integrity of tissues but also supports the body's resistance to invading microbes. In one study of people with damaged connective tissue in the gums, vitamin C supplements of 70 mg per day increased intracellular linkages and collagen bundles. In another study, gum bleeding caused by a vitamin C deficiency was reduced by supplements of the nutrient, with greater results at 600 mg per day than at 60 mg.39

Bone disorders. By now, you probably get the point that vitamin C's role in collagen formation is an important one. But if you're still not convinced, consider this addition to the picture: Strong bones depend on strong collagen. As we age, however,both the density of our bones and our level of vitamin C begin to decrease. While a number of factors contribute to osteoporosis (the loss of bone), studies show that a person's vitamin C status also is related to the maintenance of healthy bones. In fact, vitamin C may directly impact the growth of bone cells, above and beyond its call of duty in forming collagen.

Osteoporosis occurs most often in older women, in part because estrogen appears to help protect against bone loss. In several studies of postmenopausal women and a mixed

population, vitamin C intake was correlated with bone mineral content or bone density. "Ascorbic acid intake at moderate doses is important and safe for bone maintenance,and therefore a factor in mitigating or delaying osteoporosis," say Gaby and Singh.40

What about the joints that connect our bones? Vitamin C may help here, too. When mice with arthritis and inflammation in their paws received vitamin C for 20 days, the treatment reduced arthritic swelling, increased their pain tolerance and decreased polymorphonuclear leukocyte infiltration. The researchers concluded: "Vitamin C may provide podiatrists with a supplemental or alternative treatment for patients with rheumatoid arthritis."41Another study found that the rapid depletion of vitamin C at the site of an inflammation -such as a rheumatoid joint - may facilitate proteolytic damage.42

Diabetes. Diabetics tend to have low levels of vitamin C not only in the plasma but also in the white blood cells, which constitute our immune defenses. One study,conducted at the University of Massachusetts, measured the ascorbic acid content of mononuclear leukocytes in adults with insulin-dependent diabetes mellitus. This content level, which serves as a gauge of the vitamin C status of tissues, was reduced by 33% in the diabetic patients, even though their intake of dietary vitamin C was adequate. According to the researchers, this impaired storage capacity "supports the theory that intercellular scurvy contributes to the chronic degenerative complications of the disease."43

Can Vitamin C help to Prevent or Treat Cancer?

Over the years, many studies have found that vitamin C is an effective anti-cancer agent. It works in the following ways to help the body combat cancer cells:

Studies suggest that vitamin C's antioxidant mechanisms may help to prevent cancer in several ways. It combats the per oxidation of lipids, for example, which has been linked to the aging process and degeneration. One study of elderly people found that 400mg of vitamin C per day (for a one-year period) reduced serum lipid peroxide levels. Vitamin C can also work inside the cells to protect DNA from the damage caused by free radicals. In several studies, report Gaby and Singh, vitamin C reduced the level of potentially destructive genetic alterations or chromosome aberrations.44

Many of the pollutants that now pervade our environment can cause toxic,carcinogenic or mutagenic effects. Vitamin C may be able to arrest these harmful effects,in part by stimulating detoxifying enzymes in the liver. In another study, vitamin C was shown to block the formation of fecal mutagens.45

Vitamin C can help to optimize the immune system, which does the all important job of surveying the body for the presence of cancer cells. According to Richard A.

Passwater,Ph.D., it also enhances an intracellular material called ground substance that holds tissues together. When this substance is strong, cancer cells have a harder time infiltrating cells.46

Finally, vitamin C can reduce the development of nitrosamines from nitrates,chemicals that are commonly used in processed foods. Once formed, nitrosamine can become a carcinogen. But in several human studies, in which the subjects consumed a nitrosamine precursor, the urinary levels of nitrosamines were significantly reduced by vitamin C.47

Three animal studies also support the preventive effects of ascorbic acid on nitrate-induced cancer. In all three cases, the formation of tumors was inhibited, suppressed or reduced in frequency in the animals treated with vitamin C.48-50

As far back as the late 1940s, researchers began to note a connection between the incidence of cancer and a dietary deficiency of vitamin C or low blood levels in the body. Studies conducted in the past decade have confirmed that link. According to two studies from the early 1980s, 2 to 5 grams of vitamin C per day can correct these low serum levels and, in some patients, improve the immune system defenses.51

At this point, it seems clear that there is a strong relationship between a person's vitamin C intake and cancer risk. In 1991, the American Journal of Clinical Nutrition conducted a comprehensive analysis of some 46 studies on vitamin C's protective effects against various types of cancer. Of these, 33 studies reported a significant link between vitamin C intake and the incidence of cancer. In fact, a high intake of vitamin C offered twice the protection of a low intake. Many of these studies defined a high intake as a daily dosage of 160 mg or more per day; a low intake generally was less than 70 mg.52

According to author Gladys Block, the greatest effects were noted with cancer of the esophagus, larynx, oral cavity and pancreas, followed by cancer of the stomach,rectum, breast and cervix. While vitamin C's impact on lung cancer was less consistent,several studies did find significant protective effects. "The strength and consistency of the results reported here for several sites suggests that there may be a real and important effect of ascorbic acid in cancer prevention," states Block.

Here, we summarize Block's findings regarding specific types of cancer, including non-hormone-dependent cancers (of the oral cavity, larynx, esophagus, lung, pancreas,stomach, colon and rectum) and hormone-dependent cancers (of the breast, ovaries,endometrium and prostate). In all cases, the studies either developed an index that measured participants' vitamin C intake or reported on the effects of a vitamin C-rich food, primarily fruit, in the diet.53

Oral cavity, larynx and esophagus. All 8 studies reporting on a vitamin C index found that people with a low intake had a significantly greater risk of developing these cancers. Meanwhile, six of the 12 studies of food intake rather than a nutrient index found a significant risk for low fruit intake. Of the remaining six, two found suggestive results, two found low intakes in high-risk populations and one found noeffect.54

Lung. The lung cancer studies generated mixed reports on vitamin C. Of 11 such studies, five found a significant protective effect, four found protective but not significant effects and two found no effect. Interestingly, four studies reported that vitamin C had stronger effects than carotenoids. "Whereas a large body of evidence suggests an important effect for carotenoids in lung cancer prevention," says Block, "the recent data suggest that there may also be an independent protective effect of vitamin C intake."55

Pancreas. In the one study that developed a vitamin C index, a high intake decreased the risk of pancreatic cancer by half. Five studies also found that fruit (and vegetables in some cases) offered significant protective effects against this cancer,which is the fifth leading cause of cancer death in this country.56

Stomach. All seven studies on vitamin C intake and the risk of stomach cancer concluded that the nutrient's protective effects were significant. Of eight studies that analyzed fruit intake, all but one found that people with stomach cancer had a lower consumption of fruit.57

Colon and rectum. Of six studies on rectal cancer, four found that vitamin C offered significant protection and two found suggestive results. The results with colon cancer were less consistent. Four studies noted significant protection, two found suggestive effects and two studies that developed a nutrient index found no effect. One of these, however, reported that vitamin C-rich foods had a significant effect.58

Breast, ovary, endometrium and prostate. According to Block, recent evidence indicates that vitamin C may play an important role in protecting against breast cancer. But with endometrial, ovarian and prostate cancer, studies have not found the vitamin's effects to be significant.59

In 1976, Dr. Linus Pauling brought vitamin C into the limelight by reporting on the results of his cancer research. In the study he conducted with Ewan Cameron, 100terminally ill cancer patients received 10 grams of vitamin C a day. As Dr. Passwater reports in The Antioxidants, these patients lived more than four times longer than the 1,000 control subjects who did not receive vitamin C. Only three of these1,000 patients survived for more than a year, while 16 of the 100 patients taking vitamin C lived a year or longer.60

More recently, E. Cameron reported similar results from a study he conducted in Alexandria, Scotland, between 1978 and 1982. In this case he created a database to record various details about every cancer patient who attended 3 hospitals in Scotland during the four-year period.

The study included 1,826 "incurable" (in a total population of 2,804).Of the "incurable" patients, 294 had received supplemental ascorbate at some point during their illness. The remaining 1,532 patients, who did not take vitamin C,served as the controls. In analyzing the data, the researchers found that "the ascorbate-supplemented patients had a median overall survival time (343 days) almost double that of the controls (180 days)."61

Still, other studies have found that large daily doses of vitamin C had no effect on advanced cancer or the survival rate of women with breast cancer. "Current evidence suggests that the major benefit of ascorbic acid with regard to cancer may be in reducing the risk of developing cancer, rather than in therapy," state Gaby and Singh.62

Does Vitamin C Function Synergistically With Other Nutrients?

As an antioxidant, vitamin C can rejuvenate vitamin E, making it an indirect contributor to the fight against free radical damage in the lipids. It's not surprising, then, that these two nutrients can be effective partners in reducing the destructive process of lipid peroxidation. In human and animal studies, this reduction took place in subjects with diabetes, cerebral arteriosclerosis or a heart disorder.63-65 Together, vitamins C and E can help to prevent the blood from clotting, a condition that contributes to the risk ofstroke.66 This combination may offer protection against cataracts as well.67

The synergistic combination of vitamins C and E may be further enhanced by the addition of vitamin A. In one study of 30 elderly long-stay patients, for example, this trio was effective in improving certain aspects of cell-mediated immunity, such as the number of T cells, T4 subsets and the ratio of T4 to T8 cells.68In another study, a complex of vitamins A, E and C significantly enhanced the "characteristics of enzymatic and non-enzymatic antioxidant protection of the liver" in mice.69 Finally, a classic antioxidant combination - vitamins C and E, beta carotene and selenium - helped to alleviate pancreatitis, or an inflammation of the pancreas, in a study of 28 patients.

Is There Any Evidence that Vitamin C has Harmful Side Effects?

Over the years, vitamin C has been blamed for a number of harmful side effects, generating much controversy about the safety of the nutrient. But most of these claims are undeserved. "Apparently, vitamin C has a low order of toxicity, or intoxications would be common. Although large intakes may cause adverse effects in some individuals, some of

the widely reported and often cited adverse effects have little apparent basis," states John Hathcock in "Safety of Vitamin and Mineral Supplements."

Three of the most serious side effects that have been attributed to vitamin C are conditioned scurvy, kidney stones and the destruction of vitamin B12. But in analyzing the studies that reported on the relationship between vitamin C and these health problems,Hathcock has found that there is no real clinical evidence to support the idea that vitamin C is responsible for any of these conditions.

One common complaint regarding vitamin C is that it can cause gastrointestinal distress, including cramps, diarrhea and nausea. These symptoms, which are caused by the acidity rather than the ascorbate itself, seem to disappear when a buffered form of vitamin C is taken. In some cases, the chewable form of vitamin C also has led to erosion of dental enamel. In facilitating the absorption of iron, vitamin C can decrease the intake of copper and lead to a "negative copper balance," says Hathcock.

References

1. Eberhard Kronhausen and Phyllis Kronhausen with Harry B. Demopoulos, M.D., Formula for Life, William Morrow and Co., New York, 1989, p. 95.

2. Ibid, p. 102.

3. S.K. Gaby and V.N. Singh, "Vitamin C," – Vitamin Intake and Health: A Scientific Review, S.K. Gaby, A. Bendich, V. Singh and L. Machlin (eds.)Marcel Dekker, N.Y. 1991 p. 103-1043.

4. Kronhausen. p. 96.

5. Gaby, p. 103-104.

6. Ibid, p. 105.

7. Ibid, p. 104-105.

8. Gaby, p. 105-108. sg

9. Gordon Schectman, James C. Byrd and Raymond Hoffmann, "Ascorbic Acid Requirements for Smokers: Analysis of a Population Survey," American Journal of Clinical Nutrition, 1991; 53:1;1466-70.

10. Kronhausen, p. 96.

11. Gaby, p.120.

12. Kronhausen, p. 102.

13 Gaby, p. 120-121.

14 V.S. Vasil'ev, V.l. Komar and N.l. Kisel, "Humoral and Cellular Indices of Nonspecific Resistance In Viral Hepatitis A and Ascorbic Acid", Ter-Arkh; 1989 61(11); p.44-6.

15. P. Boura at al., "Monocyle Locomotion In Anergic Chronic Brucellosis Patients: The In Vivo Effect of Ascorbic Acid," Immunopharmacol; 1989;11(1): p. 119-29.
16. L. Podoshin, R. Gertner and M. Fradis, "Treatment of Perennial Allergic Rhinos with Ascorbic Acid Solution," Ear-Nose-Throat J.; January 1991; 70(1); p.54-5.
17. M. Miric and M.A. Haxhiu, "Effect of Vitamin C on Exercise-induced Bronchoconstriction," Plucne-Bolesti; January-June 1991, 43(1-2); p. 94-7.
18. Gaby, p. 120.
19. W.B. Gross, D. Jones and J. Cherry, "Effect of Ascorbic Acid on the Disease Caused by Escherichia Coli Challenge Infection,"" Avian-Dis.; July-September, 1988;32(3); p. 407-9.
20. Gaby, p. 108-109.
21. Kronhausen, p. 104.
22. G. Becher and K. Winsel, "Vitamin C Lessens Superoxide Anion(02)-Induced Bronchial Constriction," Z-Erkr-Atmungsorgane; 1989; 173 (10): p. 100-4.
23. C.R. Spillert et al., "Inhibitory Effect of High Dose Ascorbic Acid on Inflammatory Edema," Agents-Actions; June 1989; 27(3-4); p. 401-2.
24 . Adrianne Bendich , "Antioxidant Micronutrients and Immune Responses," Micronutrients and Immune Functions, A. Bendich and R.K. Chandra (eds.) New York Academy of Sciences,New York, 1990, p. 175.
25. Jeffrey Bland, Ph.D., The Nutritional Effects of Free Radical Pathology: 1966/A Year in Nutritional Medicine, Keats Publishing Inc., New Canaan, CT; 1986; p. 16.
26. Ishwaral Jialal, Gloria Lena Vega and Scott M. Grundy, "Physiologic Levels of Ascorbate inhibit the Oxidative Modification of Low Density Lipoprotein," Atherosclerosis; 82, 1990 p. 185.
27. Gaby, p. 125.
28. Ibid, p. 123-124.
29. Kronhausen, p. 96.
30. Gaby, p. 123.
31. Kronhausen, p. 103.
32. Gaby, p. 130-131.
33. J. Goldber et al., "Factors Associated with Age-Related Macular Degeneration," Am. J Epidemiol.; October 1988; 128(4); p. 700-10.
34 C.S. Tsao, L.F. Xu and M. Young, "Effect of Dietary Ascorbic Acid on Heat-Induced Eye Lens Protein Damage in Guinea Pigs," Opthalmic, Res.; 1990;22(2); p. 106-10.
35. P.S. Devamanoharan et al., "Prevention of Selenite Cataract by Vitamin C,"Exp. Eye Res.;

May 1990; 52(5); p. 563-8.
36. Gaby, p. 131.
37. Ibid, p. 134-135.
38. A. B. Rubinoff et al., "Vitamin C and Oral Health," J. Can. Den. Assoc.;September 1990; 55(9); p. 705-7.
39. Gaby, p. 135.
40. Ibid, p. 134.
41. R.H. Davis et al. "Vitamin C Influence on Localized Adjuvant Arthritis J. Am. Podiatr.Med. Assoc.; August 1990; 80(8); p. 414-8.
42. B. Halliwell et al.; "Biologically Significant Scavenging of the Myeloperoxidase-Derived Oxidant hypochlorous Acid by Ascorbic Acid," FEBS. lett.;March 9, 1987; 213 (1); p. 15-7.
43. J.J. Cunningham et al., "Reduced Mononuclear Leukocyte Ascorbic Acid Content in Adults with Insulin-Dependent Diabetes Consuming Adequate Dietary Vitamin C;" Metabolism;February 1991; 40(2); p. 146-9.
44. Gaby, p. 108.
45. Ibid, p. 108 & 110.
46. Richard A. Passwater, The Antioxidants, Keats Publishing, Inc., New Canaan,CT, 1985, p. 13-15,
47. Gaby, p. 109.
48. F.K. Dzhioev, "Prevention Using Ascorbic Acid, Hexamethylenetetramine and Sodium Metabisulfite of the Blastomogenic Effect Caused by the Combined Administration into the Stomach of Mice of Sodium Nitrate with Methylurea or with Aminopyrene," Vopr.Onkol.; 1988; 34(11); p. 1369-73.
49. S. Dittrich et al., "Effects of Nitrate and Ascorbic Acid on Careinogenesis In the Operated Rat Stomach," Arch. Geschwulstforsch; 1988; 58(4); p. 235-42.
50. N.L. Viasenko et al., "Effect of Different Doses of Ascorbic Acid on the Induction of Tumors with N-nitroso Compound precursors in Mice," Vopr. Onkol.; 1988;34(7); p. 839-43.
51. Gaby, p. 109.
52. Gladys Block, "Vitamin C and Cancer Prevention: The Epidemiologic Evidence," American Journal of Clinical Nutrition; 1991; 53:270S-82S.
53. Ibid, p. 270S.
54 Ibid, p. 271S-272S.
55. Ibid p. 272S-273S.

56. Ibid p. 273S.
57. Ibid, 273S-274S.
58. Ibid., 275S-276S.
59. Ibid, 276S-278S.
60. Passwater, p. 14.
61. E. Cameron and A. Campbell, "Innovation vs. Quality Control: An'Unpublishable' Clinical Trial of Supplemental Ascorbate in Incurable Cancer,"Med. Hypotheses; Nov. 1991; 36(3); p. 185-9.
62. Gaby, p. 117.
63. K.G. Karagezian and D.M. Gevorkian, "Phospholipid-Glycerides, Cross-Resistance of Erythrocytes, Malonic Dialdehyde Level and Alpha-Tocopherol Levels in the Plasma and Erythrocytes of Rats with Alloxan Diabetes Before and After Combined Antioxidant Therapy," Vopr. Med. Khim; September-October 1989; 35(5); p. 27~30.
64. V.N. Bobyrev, I. Sh. Vese'lskil and L.E. Bobyreva, "Antioxidants in the Prevention and Treatment of Cerebral Arteriosclerosis," Zh. Nevrapatol.Psikltatr.; 1989; 89(9); p. 60-3.
65. E. Barta et al., "Protective Effects of Alpha-Tocopherol and L-Ascorbic Acid Against the Ischemic Reperfusion Injury in Patients During Open-Heart Surgery,"Bratisl. Lek. Listy.; March-April 1991; 92(3-4); p. 174-83.
66. Kronhausen, p. 103.
67. J.M. Robertson et al., "A Possible Role for Vitamins C and E In Cataract Prevention," Am. J. Clin. Nutr.; January 1991; 53 (1 Suppl.); p. 346S-351S.
68. N.D. Penn et al., "The Effect of Dietary Supplementation with Vitamins A, C and E on Cell-Mediated Immune Function In Elderly Long-Stay Patients: A Randomized Controlled Trial," Age-Aging, May 1991; 20(3); p. 169-74.
69. V.A. Kuvshinnikov et al., "Use of the Antioxidant Complex of Vitamins A, E and C In Murine Leukemia," Gematol. Transvuziol.; August 1989; 34(8): p. 23-8.