

Introduction

Vitamins do not share a common chemistry, but they do share certain characteristics. They are all organic nutrients that are necessary in small amounts for normal body functioning and good health. Your diet or any supplements you take provide most vitamins. The body can manufacture only three vitamins (D, K, and the B vitamin biotin) from nondietary sources. Unlike carbohydrates, fats, and proteins, vitamins are not sources of energy. Instead, vitamins are chemical partners for the enzymes involved in the body's metabolism, cell production, tissue repair, and other vital processes.

Vitamins are either fat soluble or water soluble. The fat-soluble vitamins, which include A, D, E, and K, are absorbed by the body using processes that closely parallel the absorption of fat. They are stored in the liver and used up by the body very slowly. The water-soluble vitamins include vitamin C and the B complex vitamins. The body uses these vitamins very quickly. Excess amounts are eliminated in urine.

Guidelines for Adequate Intake of Vitamins

The Recommended Dietary Allowance (RDA) for vitamins, set by the Food and Nutrition Board of the National Academy of Sciences-National Research Council, has been used for years as a guide for determining the amount of vitamins needed to prevent deficiency diseases. The RDA refers to an estimate of the average requirements of dietary components such as calories, vitamins, minerals, and proteins that are required to prevent deficiency. Different values apply to different groups based on gender and age.

The RDA is gradually being replaced by a new standard called the Dietary Reference Intake (DRI). The DRI represents a shift in nutritional emphasis -- from preventing deficiencies to lowering risks of chronic diseases, such as cardiovascular disease. The DRI values comprise four categories:

- The recommended dietary allowance (RDA). This is the current rating on most vitamins.
- The estimated average requirement (EAR). This is the amount that will meet the nutritional requirements of 50% of the population.
- Adequate intake (AI). This is an amount that will be used if there is insufficient data to calculate the RDA.
- Tolerable upper intake level (UL). This is the maximum dose likely to be safe in 98% of the population.

Food and supplement labels now typically list the Daily Value (DV). This is the percentage of the amount of a nutrient that experts believe a person needs in their daily diet. On food labels it is usually based on one serving size for a person who takes in 2,000 calories a day.

Regulating Quality

Regulation of dietary supplements by the U.S. Food and Drug Administration (FDA) is a complex issue.

Labels on vitamins and other dietary supplements now include nutrient information and list all ingredients, including identifying parts of plants from which ingredients may be taken. Unlike the labels for drugs, however, labels for vitamins and supplements may not claim to prevent or treat any specific disease. Labels for vitamins and supplements include one of the following:

- *Health claim* -- description of how the substance may reduce the risk of a health-related condition
- *Nutrient claim* -- description of the amount of the nutrient in the product or

HIGHLIGHTS

Overview

A diet naturally high in vitamins and minerals can be the best defense against many diseases. Fresh fruits and vegetables and whole grains are the primary sources of vitamins, carotenoids, and phytochemicals, as well as of fiber and important minerals.

Vitamin Intake

The American Academy of Pediatrics recommended in November 2008 that the minimum intake of vitamin D for children and adolescents be changed from 200 IU/day to 400 IU / day.

New Standard

The Recommended Dietary Allowance (RDA) for vitamins is gradually being replaced by a new standard called the Dietary Reference Intake (DRI). The DRI represents a shift in nutritional emphasis -- from preventing deficiencies to lowering risks of chronic diseases, such as cardiovascular disease.

People Who Should Take Vitamin Supplements

Among people who should take vitamin supplements are:

- Pregnant and breastfeeding women who especially need B6, B12, and folic acid
- People who have had gastric bypass surgery -- vitamin deficiency is a recognized complication of gastric bypass surgery
- Some older adults -- deficiencies of vitamins and important minerals have been observed in almost a third of elderly people

Cancer

- Growing evidence suggests that vitamins and micronutrients, especially from foods, may play important roles in the prevention or treatment of certain cancers:
- On the other hand, high amounts of folic acid (a B vitamin) may be associated with colorectal and prostate cancers, and beta-carotene supplements are associated with increased lung cancer risk in smokers and people exposed to asbestos.

- *Structure or function claim* -- description of how the product may affect organs or systems of the body, without claiming to prevent or treat specific disease

The quality of dietary supplements depends on the manufacturer and is not regulated by FDA. The U.S. government does not require that supplements be standardized, meaning that the amounts or quality of nutrients may vary depending on the batch. So, more expensive supplements are not necessarily better than the less expensive ones. Government regulations are in the process of catching up to the boom in the supplement industry. In the meantime, some companies voluntarily adhere to rigorous quality controls, while others do not.

The U.S. Pharmacopeia (USP), an independent organization that sets quality standards for drugs, has also implemented standards for vitamins. Consumers may look for the USP label on products of companies that adhere to these standards. USP verification means the following:

- What is in the bottle matches what is listed on the label.
- There are no harmful levels of contaminants.
- The supplement will be absorbed properly into the body.
- It has been produced according to good manufacturing standards.

Before selling any supplement introduced after 1994, manufacturers must submit information as to why the product is considered safe for people. The FDA may refuse to allow it on the market if it finds the evidence insufficient. The FDA does not require manufacturers to provide any scientific evidence that dietary supplements are safe and effective before a product is sold (unlike drugs, which must be proven both safe and effective through clinical trials). If a supplement causes side effects in people once it is for sale, the government may place restrictions on the supplement or withdraw it from the market. The FDA may also withdraw products from the market if their labels are misleading or false.

People Who Should Take Vitamin Supplements

About 30% of Americans take at least one vitamin or mineral supplement daily. However, studies evaluating the population as a whole found that there was no difference in mortality rate between those who took vitamin supplements and those who didn't. Most people who have a healthy diet do not need vitamins, but there are some exceptions.

Pregnant and Breastfeeding Women. Women who are pregnant or who are breastfeeding generally need additional vitamins. Folic acid and vitamins B6 and B12 are particularly important. Women who are vegetarians must be sure to avoid vitamin B12 deficiencies, which can harm their offspring. Folic acid reduces the risk for neural tube defects and possibly facial abnormalities, such as cleft palate. Studies also show that low folate levels during pregnancy are associated with low birth weight, a risk factor for the development of cardiovascular disease in adulthood. A woman's best approach is to take extra folic acid plus multivitamin supplements (which have additional benefits), starting them before becoming pregnant.

Pregnant women with healthy diets may have low folate levels and need to take supplements. Requirements are as follows:

- The recommended dietary allowance (RDA) for folic acid prior to conception is 400 mcg, and during and during pregnancy it is 600 mcg.
- During breastfeeding 500 mcg is recommended.

Some women have low vitamin A reserves in their liver. It is important to note, however, that too much vitamin A significantly increases the risk for birth defects. Daily amounts of 10,000 IU (international units) of vitamin A in supplements and food can pose

a danger. Experts recommend that pregnant women take in no more than 2,500 IU/day and avoid eating liver.

Infants and Children. Infants who are breast-fed by healthy mothers receive enough vitamins except, in some cases, vitamins K and D. Human milk has low levels of vitamin K, and the newborn's immature intestinal tract may not produce enough of the baby's own supply. Most babies are given an injection of this vitamin at birth. Infants being breast-fed by malnourished women or those who lack sufficient exposure to sunlight may be deficient in vitamin D. In these cases, supplements of 200 - 300 IU are recommended.

Formulas are required to contain sufficient vitamins and minerals. Beyond infancy, most American children receive all the vitamins they need from their diet, unless they are living in severely deprived circumstances.

Smokers. Smoking interferes with absorption of several vitamins, importantly vitamins C and D. Smoking can interfere with the metabolism of vitamin D, resulting in poor muscle function.

Taking high doses of antioxidant vitamins, especially beta carotene, may actually be harmful in smokers. Instead of taking supplements, most smokers should be sure their diets are rich in fresh fruits, vegetables, and whole grains. Of course, smoking cessation is the most important intervention of all.

Alcoholics. Alcoholics often suffer from multiple vitamin deficiencies. The most dangerous deficiencies are in vitamins B1 (thiamin), folic acid, B6 (pyridoxine), B2 (riboflavin), and vitamin C. Low levels of vitamin B6 are associated with increased risk of colorectal cancer in men who drink large amounts of alcohol.

People Who Have Had Gastric Bypass Surgery. Vitamin deficiency is a recognized complication of gastric bypass surgery. Women, African-Americans of both sexes, and adults who have had laparoscopic Roux-en-Y bypass surgery are at highest risk. The deficiency is treated with water-soluble vitamin supplements.

Strict Vegetarians. Strict vegetarians need supplements of vitamin B12, unless they get enough of it from fortified cereals and other grain products.

Dieters and Vegetarians. People on weight-reduction diets with less than 1,000 calories a day should probably take a multivitamin and should also check regularly with a physician.

Vegetarians may need riboflavin, vitamin B12, and vitamin D supplements. Vegans, who do not eat dairy or eggs as well as meat, may be at further risk for vitamin A deficiencies if they do not also have plenty of dark colored fruits and vegetables. Those who eat eggs and dairy products need only watch their iron levels.

Deficiencies in vegetarian children may be particularly harmful. (One study, for example, reported that adolescents who had been on macrobiotic diets before age 6 and were deficient in vitamin B12 scored lower on psychological tests.) Pregnant and breastfeeding women who are vegetarians must be sure to have sufficient vitamins. Of special note, maternal deficiencies in vitamin B12 may cause delayed growth and neurologic problems in their newborns.

Older Adults. Deficiencies of vitamins and important minerals have been observed in almost a third of elderly people. Often their dietary habits slip and they fail to eat balanced meals regularly. In addition, older adults are more likely to be taking medications for a variety of conditions. Multiple drug regimens may prevent absorption of some vitamins.

Vitamin A and Provitamin A Carotenoids (E.g., Beta Carotene)	
Benefits	Essential for growth, bone development, night vision, reproduction, and healthy skin.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	<p>Vitamin A RDA and Upper Limit (when toxicity is risk) are the following:</p> <p>For children: 1,000 IU ages one to three (upper limit is 2,000 IU); 1,333 IU ages 4 - 8 (upper limit is 3,000 IU); and 2,000 IU for 9 - 13 (upper limit is 5,665 IU).</p> <p>For nonpregnant women: 2,333 IU ages 14 through adulthood. (Upper limit is 9,335 IU for ages 14 - 18 and 10,000 IU for women over 19.)</p> <p>For pregnant women: 2,500 IU for pregnant women under 18; 2,565 IU for pregnant women over 19. (Upper limit is 9,335 IU for ages 14 - 18 and 10,000 IU for women over 19. It should be noted that some experts recommend 8,000 IU as the upper limit during pregnancy.)</p> <p>Warning: Use of the topical acne medication tretinoin, a vitamin A derivative, during pregnancy can cause birth defects.</p> <p>For nursing women: 4,000 IU for nursing mothers under 18; 4,335 IU for nursing mothers over 19. (Upper limit is 9,335 IU for ages 14 - 18 and 10,000 IU for women over 19.)</p> <p>For men: 3,000 IU ages 14 - 18; 3,000 IU for ages 19 and above. (Upper limit is 10,000 IU.)</p> <p>Note: In determining the daily vitamin A allowance, experts also take note of provitamins, such as beta carotene, that convert to vitamin A. Some experts recommend 3 - 6 mg of beta-carotene.</p> <p>Vitamin A is also now being measured with a new unit called the Retinol Activity Equivalent (RAE). One RAE is equal to 1 mcg retinol, 12 mcg beta-carotene, 24 mcg alpha-carotene, and 24 mcg beta-cryptoxanthin. Retinol is the most active form of vitamin A.</p>
Foods containing the vitamin	Animal products, such as liver, dairy products, eggs, and fish liver oil. Provitamin A carotenoids are also found in dark red, green, and yellow vegetables and fruits. Requires some dietary fat to be absorbed.
Effects of deficiencies	Skin disorders, severe diarrhea, and eye damage. In less developed countries severe deficiencies cause blindness in 250,000 children each year. Diets low in vitamin A may also increase the risk of developing cancer. Low dietary intake of vitamin A has been associated with impaired lung function in children.
People at risk for deficiencies	<p>Preschool children and any child with inadequate intake of protein, calories, and zinc. Iron deficiency may also impair metabolism of vitamin A.</p> <p>People with asthma.</p> <p>People with serious disorders in the intestine, liver or pancreas, such as cystic fibrosis, steatorrhea, biliary obstruction, inflammatory bowel disease, cirrhosis, and others.</p> <p>People who have undergone Roux-en-Y gastric bypass surgery.</p> <p>Vegans (vegetarians who do not eat eggs and dairy). Such individuals should be sure to have plenty of deep-colored fruits and vegetables.</p> <p>People who abuse alcohol. It should be noted, however, that people with alcoholism may be at risk for vitamin A deficiency, but a combination of high-dose vitamin A and alcohol may cause toxic effects in the liver.</p> <p>Healthy adults usually have a year's store of vitamin A in the liver, so temporary nutritional deficiencies or problems with fat absorption are unlikely to cause serious vitamin A deficiency problems.</p>
Toxicities	<p>Very toxic when taken in high-dose supplements for long periods of time.</p> <p>Symptoms of overdose include dizziness, nausea, vomiting, headache, skin damage, mental disturbances, and, in women, infrequent periods.</p> <p>Can affect almost every part of the body, including eyes, bones, blood, skin, central nervous system, liver, and genital and urinary tracts. Severe toxicity can cause blindness and may even be life threatening. In children, chronic overdose can cause fluid on the brain and as well as the same complications seen in adults. High consumption of vitamin A may also increase the risk of gastric cancer, osteoporosis, and fractures in both men and women.</p> <p>Pregnant women who take amounts not much higher than RDA levels increase the risk for birth defects in their children. Liver damage can occur in children who take RDA-approved adult levels over prolonged periods of time or in adults who take as little as five times the RDA-approved amount for 7 - 10 years.</p>

B Vitamins, part 1		
	B Vitamins: General Information	Vitamin B1 (thiamin)
Benefits	The B vitamins have a wide and varied range of functions in the human body. Most B vitamins are involved in the process of converting blood sugar into energy.	Essential for converting blood sugar into energy and is involved in metabolic activities in nerves, heart, and muscles and in the production of red blood cells.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)		RDA is 0.5 mg/day for children aged 1-3 years, 0.6 mg/day for children aged 4-8, 0.9 mg/day for children aged 9-13, 1.2 for teen boys and men (ages 14 and up), 1 mg/day for girls aged 14-18 years, and 1.1 mg for women aged 18 and older. The RDA for pregnant and nursing women is 1.4 mg/day.
Foods containing the vitamin		Best source is pork and good sources are dried fortified cereals, oatmeal, corn, nuts, cauliflower, and sunflower seeds. Supplements for people with normal diets and health are unnecessary.
Effects of deficiencies	Deficiencies are uncommon in the U.S., but when they occur, they usually involve several B vitamins, since many of them come from the same food groups.	Severe vitamin B1 deficiency is known as beriberi. It can cause visual disturbances, paralysis, staggering, loss of sensation in the legs and feet, psychosis, and congestive heart failure.
People at risk for deficiencies	Alcohol interferes with these vitamins, and some of the physical and mental problems that alcoholics experience may be attributed to a deficiency of B vitamins. Elderly people are also at risk for deficiencies because of inadequate diets and potential interference with B-vitamin absorption by medications. Deficiencies can occur in severely malnourished people or in those receiving long-term dialysis or intravenous feeding. Vegetarians may be at risk.	See general vitamin B description.
Toxicities	Because the B vitamins are water-soluble and eliminated in the urine, toxic reactions from oral administration of most of them are extremely rare. (Exceptions are niacin and B6.) It should be noted that substances known as B15 (pangamic acid) and B17 (laetrile) are neither vitamins nor nutrients; both chemicals are highly dangerous and have no proven nutritional or health value.	No toxic effects have been reported from thiamin.

B Vitamins, part 2			
B Vitamins	Vitamin B2 (riboflavin)	Vitamin B3 (niacin) also known as nicotinic acid	Vitamin B5 (Pantothenic Acid)
Benefits	Important in the production of energy.	Helps break down blood sugar for energy. Acts as a <i>vasodilator</i> , widening blood vessels and increasing blood flow. May be prescribed for improving cholesterol levels.	Important for metabolism of fats, carbohydrates, and proteins, as well as production of steroid hormones and other important chemicals.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	DRI is 1.7 mg.	RDA is 6 mg/day for children aged 1-3 years, 8 mg/day for children aged 4-8, 12 mg/day for children aged 9-13, 16 mg/day for teen boys and men (ages 14 and up), 14 mg/day for girls aged and women aged 14 and older. The RDA for pregnant women is 18 mg/day and for nursing women 17 mg/day.	AI is 2 mg/day for children aged 1-3 years, 2 mg/day for children aged 4-8, 4 mg/day for children aged 9-13, and 5 mg/day for teens and adults (ages 14 and up). The AI for pregnant women is 6 mg/day and for nursing women 7 mg/day.
Foods containing the vitamin	Liver, dried fortified cereals, dairy products, fish. Some dark green vegetables. Supplements for people with normal diets and health are unnecessary.	Mackerel, swordfish, chicken, veal, dried fortified cereals, pork, salmon, and beef liver. Supplements are unnecessary in people with normal health and diets.	Whole grains, beans, milk, eggs, and liver. Supplements are unnecessary in people with normal health and diets.
Effects of deficiencies	Deficiencies affect the skin and mucous membranes and can cause cracks on the lips or corners of the mouth, eczema of the face and genitals, a burning sensation on the tongue, eye irritation. May contribute to anemia when iron levels are low and contribute to elevated levels of homocysteine, a heart risk factor.	Deficiency causes pellagra; symptoms can include eczema, intestinal and stomach distress, depression, headache, thinning of the hair, and excess saliva production.	Deficiency is unlikely except in company with other B vitamin deficiencies. Symptoms include abdominal distress, burning sensation in the heels, and sleep problems.
People at risk for deficiencies	See general vitamin B description.	Alcoholics and any malnourished persons.	Alcoholics and any malnourished persons.
Toxicities	Until recently, no toxic effects had been reported even from large doses of riboflavin. However, one study indicated that high consumption of vitamin B2 might increase the risk of stomach cancer. More research is needed. (In the same study, vitamins B1, B3, and B6 were protective.)	Even mildly high doses of niacin can cause hot flushing of the face and shoulders, headache, itchiness, and stomach problems. Some report heart disturbances and temporarily lowered blood pressure. Large doses may produce ulcers, gout, diabetes, and liver damage, which are usually reversed when high doses are discontinued.	Although no toxicity has been reported in humans, high dosages have caused liver damage in rats.

B Vitamins, part 3		
B Vitamins	Vitamin B6 (pyridoxine)	Vitamin B12 (cobalamin)
Benefits	Has an effect on over 60 proteins in the body, importantly, those that play a role in the nervous system, in red and white blood cell production, and in heart disease.	Essential for the production of blood cells, manufacturing genetic material, and healthy functioning of the nervous system.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	RDA is 0.5 mg/day for children aged 1-3 years, 0.6 mg/day for children aged 4-8, 1 mg/day for children aged 9-13, 1.3 for teen boys and men ages 14-50, and 1.7 mg/day for men aged 50 and up; 1.2 mg/day for girls aged 14-18 years, 1.3 mg for women aged 18-50, and 1.5 mg/day for women aged 50 and up. The RDA for pregnant women is 1.9 mg/day and for nursing women 2 mg/day.	RDA is 0.9 mcg/day for children aged 1-3 years, 1.2 mcg/day for children aged 4-8, 1.8 mcg/day for children aged 9-13, and 2.4 for teens and adults ages 14 and up. The RDA for pregnant women is 2.6 mcg/day and for nursing women 2.8 mcg/day.
Foods containing the vitamin	Meats, oily fish, poultry, whole grains, dried fortified cereals, soybeans, avocados, baked potatoes with skins, watermelon, plantains, bananas, peanuts, and brewer's yeast.	The only natural dietary sources are animal products, including meats, dairy products, eggs, and fish (clams and oily fish are very high in B12). Like other B vitamins, however, B12 is added to commercial dried cereals.
Effects of deficiencies	Increased levels of homocysteine, associated with heart disease and possibly Alzheimer's disease. Skin problems and nervous system disorders, including impaired memory and concentration. Increased risk for kidney stones. In unborn children, some evidence shows that lack of vitamin B6, in addition to vitamin B12 and folic acid, may be responsible for defects such as cleft lip and palate and spina bifida. Supplementation with these vitamins is advised during pregnancy. Note: People who have been taking more than 50 mg for some time and stop suddenly are at risk for a so-called rebound deficiency. When people stop, they should taper off slowly.	Deficiencies elevate homocysteine, a possible risk factor for heart disease and Alzheimer's disease. Increased risk of bone fractures. Abnormal gaits in the elderly. May cause severe depression, memory loss, instability, disorientation, and decreased reflexes, and possibly hearing loss. Children who are deficient may experience growth failure. Deficiencies in pregnant and breast-feeding women may cause neurologic harm in their offspring. A genetic defect that causes vitamin B12 deficiencies is responsible for pernicious anemia, a serious disorder that causes rapid heart rate, shortness of breath, dizziness, weakness, and fatigue. It must be treated with injections of vitamin B12 or very high oral doses to prevent neurologic damage.
People at risk for deficiencies	Alcoholics and any malnourished person. In rare cases, infants are born unable to metabolize pyridoxine; in such cases, seizures or convulsions can occur and vitamin B6 must be administered.	Alcoholics and any malnourished persons. Evidence suggests deficiencies may be caused by <i>Helicobacter pylori</i> (<i>H. pylori</i>) bacteria (a cause of ulcers). Nearly 30% of patients with inflammatory bowel disease have vitamin B6 deficiency, as well as low levels of iron and vitamin D. People who take the antibiotic isoniazid, high blood pressure medication hydralazine, and the drug penicillamine are at risk for vitamin B6 deficiency. The elderly and people with Crohn's disease and those who have undergone ileal and ileocolonic resection may have trouble absorbing natural vitamin B12 and require supplements. Studies have found that patients with diabetes treated with metformin, but not rosiglitazone, are at risk for low levels of vitamin B12. Vitamin B12 deficiency is also common in patients with polyneuropathy. In up to one-third of patients, vitamin B12 deficiency is the sole or major contributing cause of their neuropathy. Treatment with vitamin B12 has a high success rate in improving the symptoms. Vegetarians are at higher risk for deficiencies.
Toxicities	Very high doses can cause nerve damage with symptoms of instability and numbness in the feet and hands, which may be permanent in some cases. Of specific concern are possible adverse effects on nerve development in the offspring of pregnant women who take large doses, such as for morning sickness.	There is no evidence of toxicity with this vitamin.

B Vitamins, part 4			
B Vitamins	Biotin (a B vitamin)	Choline (a B vitamin)	Folate, or Folic Acid, its synthetic form (a B vitamin)
Benefits	Involved in the production of amino acid proteins and fatty acids.	Essential for fetal brain development and for learning and memory.	Important for many metabolic processes in the body. It is used in the manufacturing of neurotransmitters (chemical messengers in the brain), in protecting the heart, and for synthesizing genetic materials (DNA) in the cells. It may improve blood flow.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	AI (daily) is 8 mcg in children 1-3 years of age, 12 mcg in children 4-8, 20 mcg for children 9-13, 25 mcg for children aged 14-18, and 30 mcg for anyone over 18, including pregnant women. The AI for nursing women is 35 mcg/day.	AI (daily) is 200 mg in children 1-3 years of age, 250 mg in children 4-8, 375 mg for children 9-13, 550 mg for boys and men aged 14 years and up, 400 mg for girls aged 14-18 years, and 425 for women older than 18. The AI for pregnant women is 450 mg/day, and 550 mg/day for breastfeeding women.	Supplements may be <i>folate</i> (natural) or <i>folic acid</i> (synthetic). Folic acid is nearly twice as potent as folate. RDA is 400 mcg <i>folate</i> for ages 14 and up, 600 mcg during pregnancy and 500 mcg while nursing. The DRI for children aged 1-3 is 150 mcg/day, 200 mcg for children aged 4-8 years, and 300 mcg for children aged 9-13. Women who are planning to be pregnant should certainly take 400 mcg of folic acid before conception, during pregnancy, and while nursing.
Foods containing the vitamin	Dietary sources are eggs, milk, liver, mushrooms, bananas, tomatoes, whole grains, nuts, and brewer's yeast. Also produced by bacteria in the intestines.	Peanuts, eggs, cauliflower, and meats, especially liver.	Avocado, bananas, orange juice, cold cereal, asparagus, green leafy vegetables, dried beans and peas, and yeast. Folic acid supplements are now added to commercial breads and cereals.
Effects of deficiencies	Deficiencies are almost unheard of.	Low levels during pregnancy increase risk of birth defects in newborns.	As with vitamins B6 and B12, deficiencies of folate elevate levels of homocysteine, an amino acid in the body that may increase the risk for heart disease, and possibly Alzheimer's disease. Folic acid supplements lower homocysteine levels, but with little or no impact on risk of atherosclerotic disease in the heart or in the peripheral arteries and veins. This suggests that homocysteine may be a marker of cardiovascular disease, rather than a cause. This being said, some evidence suggest that folic acid supplementation in patients with low folic acids levels substantially reduced the risk of a first stroke. Low levels during pregnancy increase risk of birth defects in newborns, and folic acid supplementation plays a key role in preventing birth defects. Folic acid deficiencies can also cause depression, megaloblastic anemia, and impairments in concentration, memory, and hearing.
People at risk for deficiencies			Alcoholics, malnourished persons, people with conditions that disturb the small intestine, people taking certain drugs, particularly methotrexate. Other risk factors for deficiency: high-dose aspirin, smoking, treatment for seizures, taking oral contraceptives.
Toxicities		Excessive doses can cause intestinal problems, and there is also some concern that high doses can be carcinogenic.	Possible connection between high consumption of folate/folic acid and colorectal cancer now under exploration. Some link between high doses and central nervous system disorders, zinc deficiency, and seizures in epileptics. This risk appears to be low, but results indicate that megadoses should be avoided. High amounts in the elderly may mask symptoms of vitamin B12 deficiencies.

Vitamin C (Ascorbic Acid)

Benefits	Vitamin C is a water-soluble vitamin. Acts as an antioxidant (reduces harm from damaging chemical processes in the body). Essential for the production of collagen, the basic protein in bones, cartilage, tendons, and ligaments. Other possible benefits include protection against bronchoconstriction during exercise in people with asthma. May help boost the immune system.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	RDA (daily) is 75 mg (women and boys aged 14-18 years) and 90 mg (men 19 and up). (Smokers need an additional 35 mg.) Pregnant women require 85 mg (80 mg if 18 or younger). Nursing mothers need 120 mg (115 mg if 18 or younger). Children 1-3 years of age need 15 mg, and those aged 4-8 require 25 mg.
Foods containing the vitamin	Citrus fruits and juices, papayas, hot chili peppers, bell peppers, broccoli, potatoes, dark leafy greens, kale, red cabbage, cauliflower, cantaloupe, sweet potatoes, and Brussels sprouts. Orange juice is the most important source of vitamin C in the U.S., with frozen juice being the best source of the vitamin.
Effects of deficiencies	Scurvy is the primary deficiency disease. Affects most body tissues, particularly bones, teeth, and blood vessels. Early symptoms include tiredness, weakness, irritability, weight loss, and vague muscle aches. Later symptoms are bleeding gums, wounds that won't heal, rough skin, and wasting away of the muscles. Deficiencies may contribute to periodontal disease and gallstones. Low dietary intake of vitamin C has been associated with impaired lung function in children. Low intake may also increase lead levels in the blood.
People at risk for deficiencies	Deficiency has been uncommon in the U.S., usually occurring in the elderly, alcoholics, cancer patients, and some people on severely limited diets low in fresh fruits and vegetables. Surprisingly, however, studies now suggest that as many as 16% of middle-aged Americans, with the highest risk in smokers and middle aged men, are deficient in vitamin C. High doses of aspirin taken over a long period of time can interfere with vitamin C.
Toxicities	Tolerable upper limit is 2000 mg/day. High doses may cause headaches and diarrhea. Long-term high doses may increase risk for kidney stones. Ascorbic acid increases iron absorption so people with blood disorders, such as hemochromatosis, thalassemia, or sideroblastic anemia, should avoid high doses. Large doses may also thin blood and interfere with anticoagulant medications, blood tests used in diabetes, and stool tests. Rebound scurvy can occur after abrupt withdrawal from long-term large doses. This may affect infants or pregnant women who withdraw suddenly from high doses.

Vitamin D

Benefits	Vitamin D is actually a single term for several hormones that are stored mainly in the liver and also in fat and muscle tissue. It is essential for the absorption of calcium into the bone and for normal bone growth.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	AI (daily) is 200 IU (5 mcg) for children and most adults to age 50, 400 IU (10 mcg) for people between ages 50 and 70, and 600 IU (15 mcg) over age 70. Note that many experts currently recommend a dose of 800 - 1000 IU daily for adults. People who are housebound, do not have sufficient exposure to sunlight, or are dark-skinned, as well as breast-fed infants, should take vitamin D supplements. The maximum tolerated dose after the age of 12 months is 2,000 IU/day (50 mcg/day). Note that the American Academy of Pediatrics recommended in November 2008 that the minimum intake for children and adolescents be changed to 400 IU / day.
How the Body Obtains the vitamin	There are two forms of vitamin D. Vitamin D3 is made in the body from a chemical reaction to the ultraviolet radiation in sunlight. Vitamin D2 is found in a few food sources, including vitamin D fortified milk, fatty fish, egg yolk, and liver.
Effects of deficiencies	Softening of the bones caused by low levels of calcium and phosphorous (called rickets in children and osteomalacia in adults). Also increases the risk for bone-related knee problems, and hip fractures in postmenopausal women. Associated with a higher risk for prostate cancer and breast cancer risk. Evidence suggests that vitamin D deficiency may be responsible for poor muscle strength after bone fracture. The deficiency is associated with high blood pressure and diabetes, but it is unknown whether supplementation with vitamin D impacts these diseases. Studies now suggest vitamin D plays a role in age-related macular degeneration (AMD), and that drinking milk with added vitamin D can help protect against AMD.
People at risk for deficiencies	Older people, particularly if they live in the North, who are underexposed to sunlight. Obesity may also increase risk. There is some concern, in fact, that vitamin D deficiency may be a growing problem in the US among younger adults as sunscreen use becomes widespread. Individuals at highest risk for vitamin D deficiency are those who assiduously avoid the midday sun, wear protective clothing, regularly use sunscreen, and have dark skin. Exposure to sunlight for about 15 - 20 minutes at mid-morning or mid-afternoon three times a week is recommended for most people who live in temperate climates.
Toxicities	Vitamin D is very toxic in high doses. In infants, daily amounts higher than 1,000 IU can cause mental and growth retardation, kidney failure, and death. In children and adults, daily amounts over 50,000 IU can cause weakness, anorexia, vomiting, diarrhea, and mental changes. Prolonged use of megadoses can cause calcification of soft tissue and life-threatening kidney failure. Low-calcium diets and withdrawal from the vitamin can usually reverse the side effects except for kidney failure.

Other Vitamins		
	Vitamin E (Tocopherol or Tocotrienol)	Vitamin K
Benefits	A fat-soluble antioxidant vitamin that helps prevent cell membrane damage and may inhibit oxidation of LDL cholesterol (a process that increases its harmful effects on arteries). Researchers once thought that vitamin E might protect against cardiovascular disease. This theory has been debunked. However, vitamin E supplementation may reduce the risk of deep vein thrombosis (DVT) in women at risk for, or with a history of, DVT.	The most important function of vitamin K is its role in blood clotting and prevention of bleeding. As a result, the vitamin may be able to help treat hepatoma, leukemia, and hepatocellular carcinoma, a form of liver cancer. The vitamin also contributes to maintaining healthy bones and healing fractures. Vitamin K is widely used in Japan to treat osteoporosis, and studies suggest it may be effective in treating rheumatoid arthritis.
Recommended daily allowance (RDA) or dietary reference intake (DRI) (mcg = micrograms, mg = milligrams, IU = international units)	RDA is 15 mg (22 IU) for all adults, including pregnant women. Nursing mothers need 19 mg (28 IU). (Supplements should be taken along with some oil or fat to be absorbed.) Vitamin E is composed of 8 compounds (four tocopherols and four tocotrienols). Vitamin E is most often available as supplements of dl alpha tocopherol (a synthetic form). Other vitamin E compounds may prove to be more active than the standard synthetic supplement. They include natural vitamin E, called d-alpha- or RRR-alpha-tocopherol succinate (VES). Other vitamin E compounds of interest are tocotrienol and beta and gamma tocopherol. Supplements that contain a combination of some of these forms may be most beneficial.	AI is 120 mcg/day in men over age 19 and 90 mcg/day in women over 19, including pregnant and nursing women. The AI for pregnant and nursing girls 18 and younger is 75 mcg/day. The AI for children aged 1-3 years is 30 mcg/day, for children 4-8 55 mcg/day, for children 9-13 60 mcg/day, and for teens 14-18 75 mcg/day.
Foods containing the vitamin	Vegetable oils (particularly wheat germ oil), sweet potatoes, turnip greens, mangos, avocados, nuts, sunflower seeds, and soybeans. Tocotrienol (a possibly beneficial form) is found in natural tropical oils. Palm oil sold in the US is refined and does not contain tocotrienol.	Best dietary sources are canola oil, cruciferous vegetables, and soybean oil. Good sources are beef liver, bran, and olive oil. Also produced by bacteria in the intestines.
Effects of deficiencies	Deficiencies have not been established.	Easy bruising, bleeding. May increase the risk of hip fractures in women.
People at risk for deficiencies	Low-birth weight infants. People who eat a low-fat diet. People with medical problems that impair fat absorption, such as Crohn's disease, cystic fibrosis, steatorrhea, liver diseases (such as cirrhosis). People with abetalipoproteinemia, a rare genetic disorder that impairs fat metabolism.	Deficiency may occur in patients who have problems absorbing fats, such as those with cirrhosis, people who are on long-term antibiotic therapy, or who are taking other medications, including cholestyramine, Dilantin, and phenobarbital. Some evidence suggests that more young people may be deficient than previously believed.
Toxicities	Upper level recommended is 1,000 IU of alpha tocopherol. Large doses may cause bleeding problems, particularly in people taking anti-clotting medications. Some research now indicates that vitamin E, like other antioxidants, may have pro-oxidant and damaging effects. Although vitamin E is one of the best studied vitamins, research has yielded conflicting results, and definitive conclusions about the benefits and toxicity of vitamin E have not yet been determined. In one major study, there was no significant difference in cancer rates between people who took 400 IU of vitamin E daily and those who did not, although those who took the supplement had a higher risk of heart failure. Additional studies also link high levels of vitamin E with a slightly increased risk of heart failure and death.	Allergic-type responses, including rash and itching, to high doses have been reported. Those who are taking Coumadin, an anticoagulant, should not take vitamin K without consulting a physician. Vitamin K deficiency can cause anorexia, lethargy, growth retardation, bone loss, soft tissue calcification, and death.

Elderly people, particularly if they are not exposed to sunlight, may be deficient in vitamin D. They also may have low levels of important B vitamins. (Older adults showing signs of dementia should be checked for B12 deficiencies as well as other disorders causing mental disturbances.) One study reported that the immune systems of elderly people may benefit from higher levels of vitamin E than the dietary recommended dosage. It should be noted, however, that metabolism slows down as a person ages, and in elderly people it takes the liver longer to eliminate drugs and vitamins from the body. The effect of some vitamin supplements, therefore, may be intensified. Dosage levels of vitamin A, for instance, which might be harmless in a younger adult, could be toxic in an elderly patient.

People Who Avoid Sunlight. People who avoid sunlight or are housebound, and whose diet is low in foods that contain vitamin D should take supplements. People with darker skin are at higher risk for deficiencies than those with whiter skin. (Note: vitamin D is toxic in high doses, and no one should exceed the recommended dietary intake of vitamin D except under the direction of a physician.)

Carotenoids

Carotenoids are a group of more than 700 fat soluble nutrients that produce the colors in foods such as carrots, pumpkins, sweet potatoes, tomatoes, and other deep green, yellow, orange, and red fruits and vegetables. Many are proving to be very important for health. Beta carotene is the most widely studied carotenoid, but others are proving to be of great interest. As with some, but not all, carotenoids, beta carotene is known as a provitamin A because it converts to the vitamin in the body.

Carotenoids are categorized as either *xanthophylls* or *carotenes* according to their chemical composition.

Carotenes

Carotenes are hydrocarbons and most are found in yellow, orange, and red vegetables. They include beta and alpha carotene and lycopene.

- Beta Carotene and other Provitamin A Carotenoids. Beta carotene, alpha-carotene, and beta-cryptoxanthin are carotenes that are converted into vitamin A or retinol (the active form of vitamin A) in the body. They are found in many yellow fruits and vegetables. Beta carotene is the most widely studied carotenoid. Evidence now strongly suggests that when taken as a separate supplement it can have harmful effects, at least in smokers.
- Lycopene. Lycopene is responsible for the red color in fruits and vegetables, including tomatoes, red grapes, watermelon, and pink grapefruit. It is also found in papayas and apricots. It does not convert to vitamin A, but may have important cancer fighting properties and other health benefits.

The beneficial actions of most carotenes such as those in tomatoes, corn, and carrots, appear to be enhanced by cooking them, especially in oil (preferably olive, canola, or another monounsaturated oil). (Note: Cooking can also destroy certain nutrients, such as vitamin C, in these vegetables.)

Xanthophylls

Xanthophylls contain oxygen and most are found in green vegetables, such as broccoli, cabbage, and kale. They are also in yellow fruits and vegetables. Xanthophylls include lutein and zeaxanthin, which are both stored in the retina of the eye. Neither converts to vitamin A. Both are powerful antioxidants and may be very important for healthy eyes. Unlike carotenes, cooking may reduce the antioxidant activity of some xanthophylls in foods, although probably not to any significant degree.

Phytochemicals

The word phytochemicals means plant chemicals. Hundreds of phytochemicals are currently being studied. Many are believed to have a major positive impact on human health. Some contribute to the bright and vivid colors found in fruits and vegetables.

The results of studies on specific phytochemicals are not necessarily applicable to the vegetables or fruits that harbor small concentrations of these chemicals. Nevertheless, it is obvious that vegetables and fruits are healthful, which is probably due to some balance of phytochemicals, carotenoids, vitamins, fibers, and minerals rather than any single substance.

The benefits of individual phytochemical supplements are largely unproven. Furthermore, they are not regulated. High concentrations of some phytochemical may behave like drugs and be toxic, possibly even contributing to cancer cell growth.

Polyphenols and Flavonoids

Polyphenols are important phytochemicals, and flavonoids (or catechins) are members of the polyphenol family that may have significant health benefits. Laboratory studies have shown that specific flavonoids suppress tumor growth, interfere with sexual hormones, prevent blood clots, and have anti-inflammatory properties. In general, flavonoids are found in celery, cranberries, onions, kale, dark chocolate, broccoli, apples, cherries, berries, tea, red wine or purple grape juice, parsley, soybeans, tomatoes, eggplant, and thyme. Most common berries contain flavonoids and are particularly rich in potent antioxidants.

Among the important flavonoids are resveratrol, quercetin, and catechin. Evidence suggests that resveratrol (found in red wine, grapes, olive oil) may be extremely potent. In laboratory studies, it increases cell survival and has been shown to increase the life span of worms and fruit flies. Catechins are the primary flavonoids in tea and may be responsible for its possible beneficial effects. Flavonoids in dark chocolate may also be health protective.

Isoflavones (Phytoestrogens)

Isoflavones, commonly known as phytoestrogens, have actions that are similar to the female hormone estrogen. A high consumption of soy, which is primarily composed of isoflavones, may reduce symptoms resulting from estrogen depletion during menopause. No evidence to date indicates that phytoestrogen supplements provide any benefit for hot flashes or other menopausal symptoms.

Lignan is another phytoestrogen and is found in the fiber layers of whole-grains, berries, some seeds, some vegetables, and a few fruits. In laboratory studies, it seems to have anti-cancer properties.

Isothiocyanates

Isothiocyanates and related substances, indoles, are also known as mustard oils and are responsible for the sharp taste in cruciferous (also called brassica) vegetables. Such vegetables include broccoli, cabbage, Brussels sprouts, cauliflower, collards, kale, kohlrabi, mustard greens, rutabaga, turnips, and bok choy. Isothiocyanates stimulate enzymes that convert estrogen to a more benign form and may block steroid hormones that promote breast and prostate cancers. (Cruciferous vegetables are also high in fiber, vitamin C, and selenium.)

Monoterpenes

Monoterpenes have two important phytochemicals, perillyl alcohol and limonene. They block proteins that stimulate cell growth and reproduction and are being tested for actions against cancer. Limonene is found in the peels of citrus fruits.

Organosulfur Compounds

Organosulfurs are part of the allium family of phytochemicals. Compounds such as allicin may have benefits on the immune system, assist the liver in rendering carcinogens harmless, and reduce production of cholesterol in the liver. These compounds are found in garlic, leeks, onions, chives, scallions, and shallots.

Capsaicin

Capsaicin seems to reduce levels of substance P, a compound that contributes to inflammation and the delivery of pain impulses from the central nervous system. Research suggests that it may inhibit cancer-generating substances. It is found in hot red peppers.

Sterols

Sterols, which include sitosterol, stigmasterol, campesterol, and squalene, are found in vegetable oils. Sitosterol is the most studied and appears to have cholesterol-lowering effects.

Beta-sitosterols may help improve urine flow and urinary symptoms in men with enlarged prostate glands (benign prostatic hyperplasia, or BPH). Beta-sitosterols come from South African star grass, *Hypoxis rooperi*, or species of *Pinus* and *Picea*.

Healthy Foods

Evidence increasingly suggests that a varied diet, not individual food chemicals, is essential for basic health and a longer life. Such diets are rich in fresh fruits and vegetables and whole grains, and low in saturated fats.

Dietary Health Benefits

The benefits of any dietary factors are very difficult to prove, and, to date, there is little evidence that most dietary supplements protect against major diseases in otherwise healthy people with normal eating habits. However, a diet naturally high in vitamins and minerals can be the best defense against many diseases. Fresh fruits and vegetables and whole grains are the primary sources of vitamins, carotenoids, and minerals, as well as of fiber and important minerals.

Antioxidants: Pros and Cons

Description of Free Radicals (Oxidants). Currently, the most important benefit claimed for vitamins A, C, E, and many of the carotenoids and phytochemicals is their role as antioxidants, which are scavengers of particles known as free radicals (also sometimes called oxidants). These chemically active particles are by-products of many of the body's normal chemical processes. Their numbers are increased by environmental assaults, such as smoking, chemicals, toxins, and stress. In higher levels, oxidants can be very harmful in the following way:

- They can damage cell membranes and interact with genetic material, possibly contributing to the development of a number of disorders including cancer, heart disease, cataracts, and even the aging process itself.

- Free radicals can also enhance the dangerous properties of low-density lipoprotein (LDL) cholesterol, a major player in the development of atherosclerosis.

Description of Antioxidants and Warnings on High-Dose Supplements. Antioxidant vitamins (A, C, and E), carotenoids, and many phytochemicals can neutralize free radicals. Unfortunately, although it is clear that vitamins are required to prevent deficiency diseases, high doses of vitamin C, vitamin E, and beta carotene supplements may also have pro-oxidant effects, which can be harmful in patients with cancer. In these people, high doses of antioxidant vitamins may actually protect cancer cells just as they do healthy cells.

The strongest evidence on negative effects to date comes from studies reporting an increase in lung cancer and overall mortality rates among smokers who took beta carotene supplements.

Some evidence also indicates that high doses of vitamin C may speed up atherosclerosis, or hardening of the arteries.

Some researchers speculate that certain immune factors generate oxidants to fight bacteria. The antioxidant vitamin E may block that action. Further study is necessary.

Protection against Heart Disease

Vitamins and Heart Protection.

- **Antioxidant Vitamins A, C, and E.** A low dietary intake of vitamins A, C, E, and beta carotene has been linked to heart disease. All of these nutrients have antioxidant effects and other properties that should benefit the heart. However, there is now clear evidence that supplements of these vitamins, singly or in combination, do *not* protect against heart disease or cancer.
- **Folate and B12 Vitamins.** Deficiencies in the B vitamins folate (known also as folic acid) and B12 have been associated with elevated blood levels of homocysteine, an amino acid that has been associated with a higher risk for heart disease, stroke, and heart failure. However, there is now clear evidence that supplements of these vitamins do *not* reduce the risk of heart disease.
- **Niacin.** Niacin (vitamin B3) is used for improving unhealthy cholesterol levels, though very high doses are required. Although vitamin B3 is available over the counter, it can have significant side effects. A physician should prescribe niacin in order to ensure its safety and effectiveness. [For more information, see *In-Depth Report #23, Cholesterol.*]

Carotenoids and Heart Protection. Studies have reported that a diet high in fruits and vegetables containing beta carotene, lycopene, and other carotenoids may reduce the risk of heart attack. Diets low in lycopene (particularly from tomatoes) were associated with a significantly higher risk of heart disease and stroke.

Phytochemicals and Heart Protection. Several phytochemicals are associated with heart protection.

- **Flavonoids.** Certain flavonoids, found in both black and green tea, dark chocolate, onions, red wine or red grape juice, and apples, appear to be heart protective. Flavonoids may protect against damage done by cholesterol and help prevent blood clots. A number of studies have now reported heart protection from the flavonoid catechin, which is found in both black and green tea. The flavonoid resveratrol, which is found in grape skin, appears to contribute to the heart protective effects in red wine. Ethanol, the alcohol found in wine, beer, and spirits is

likely to be the most beneficial ingredient -- as long as the "dose" is only low or moderate.

- **Organosulfurs.** Organosulfurs found in onions and garlic have been under investigation for possible beneficial effects on cholesterol levels.
- **Isoflavones.** Soy protein is the most studied source of isoflavones (known as phytoestrogens, or plant estrogens). Not all studies are consistent, but some have shown an improvement in at least one of the cholesterol components in people who consumed at least 25 grams of soy protein. A meta-analysis of all soy protein studies performed from 1990 - 2006 found that soy protein significantly decreased total cholesterol and LDL cholesterol, but had no effect on HDL or triglycerides. The effect was particularly evident in people with hypercholesterolemia. Soy may also reduce other heart risk factors, at least in certain populations. For example, in one study, soy was beneficial for controlling blood sugar and lowering LDL in postmenopausal women with type 2 diabetes. In a study of overweight men and postmenopausal women, soy protein reduced blood pressure and arterial stiffness. The best sources are soy products (tofu, soy milk) or whole soy protein. Powdered soy protein that contains at least 60 mg of isoflavones may provide similar benefits.
- **Sterols.** The plant sterols, including sitosterol, are also proving to be potent cholesterol fighters by blocking the absorption of cholesterol in the intestine. Sitostanol, a derivative of sitosterol, is being used in new margarine products to lower cholesterol levels. Sterols and stanols are now found in breads, cereals, yogurt, and fruit juices.

Protection against Stroke

A healthy diet rich in fruits and vegetables and low in salt and saturated fats may significantly lower the risk for a first stroke, perhaps by helping to protect against high blood pressure -- a major risk factor for stroke.

Vitamins and Stroke Protection. The effects of antioxidant vitamins and carotenoids (vitamins C or E, or beta carotene) on stroke have been studied extensively. Most studies have found that these vitamins do not help protect against stroke.

Recent studies have indicated that while B vitamin supplements help lower homocysteine levels, they have no effect on heart disease outcomes. A large randomized controlled trial is underway to evaluate the benefit of vitamins on reducing stroke risk.

Protection against Cancer

Many fresh fruits and vegetables contain chemicals that may fight many cancers, including lung, breast, colon, and prostate cancers. Examples of important cancer fighting foods include the following:

- Cruciferous vegetables (such as cabbage, Brussels sprouts, and broccoli)
- Tomatoes (which contain lycopene)
- Carrots (which contain alpha carotene)

Any protective effects of vitamins or specific phytochemical against cancer, however, appear to depend on the cooperative effort among them. Individual supplements of any vitamin or food chemical have not as yet shown any benefits.

Additionally, certain supplements may actually encourage tumor growth, particularly when taken in large amounts. Two recent studies found a connection between folate supplements and colorectal cancer. A large National Cancer Institute/AARP study found an increased risk of advanced and fatal prostate cancer in men who took more than 7 multivitamins a week, but no association between multivitamin use and localized prostate cancer.

High consumption of cruciferous vegetables (at least once per week) was associated with lower risk of kidney cancer, and low consump-

tion (less than once per month) of cruciferous vegetables was associated with higher risk of kidney cancer in a multinational European study. Cruciferous vegetables also appear to offer protection against head and neck cancer resulting from chemical toxins found in cigarettes and alcohol, for example.

Vitamins and Cancer Protection. Because many cancers are thought to be initiated by the effects of oxygen-free radicals on DNA, the antioxidants A, C, and E and beta carotene have been intensively studied. Beta-carotene supplementation increased lung cancer risk in smokers and persons exposed to asbestos.

In 2006, a study for the National Institutes of Health reviewed randomized trials evaluating the effectiveness and safety of multivitamin and mineral supplements in preventing cancer and chronic disease. The studies had mixed results, and some supplements reduced cancer rates in certain populations. However, the reviewers concluded that current evidence is not sufficient to determine that multivitamin and mineral supplements prevent cancer and chronic disease.

Carotenoids and Cancer Protection. A number of studies have reported that fruits and vegetables rich in carotenoids are associated with protection against many cancers. Lycopene, found in tomatoes, may have particular value in protection against prostate, colon, lung, and bladder cancer. Individual supplements, however, do not offer any advantage. In fact, evidence now strongly suggests that beta carotene supplements increase the risk for lung cancer in smokers and people exposed to asbestos.

Phytochemicals and Cancer Protection. The following phytochemicals appear to have cancer-protecting properties.

- **Isothiocyanates.** Isothiocyanates and sulforaphane, found in cruciferous vegetables, may block the effects of carcinogens and suppress tumor growth.
- **Isoflavones.** Isoflavones, found in soy beans and flax seed, behave like estrogen in some ways and not in others. Researchers are very interested, then, in their effects on hormone-related cancers, including breast and prostate cancers. Much research has focused on soy. In general, a number of Asian studies have reported an association between a higher intake of soy and a lower incidence of reproductive and breast cancers. The effects of phytoestrogens in all women, however, are far from settled. Some evidence suggests the genistein in soy may have properties that are protective against lung cancer. Nonfermented soy products (tofu, soy milk) also may protect against stomach cancer, while fermented soy products (miso, soy paste) appears to increase the risk.
- **Organosulfurs.** The organosulfur compounds found in the onion and garlic family may have very potent properties in suppressing or blocking carcinogenic substances. Studies indicate that people who regularly consume fresh or cooked garlic have about half the risk of developing stomach cancer and two thirds the risk of colorectal cancer as people who eat little or no garlic. One possible explanation for garlic's anti-cancer effect in the stomach is its antibacterial action against *H. pylori*, which can promote stomach cancer. Taking garlic supplements, however, did not offer these benefits.

It should be noted that studies on the health benefits of vitamins and minerals have some important limitations. Some are held to rigorous standards, while others are not. In most cases, the results of existing research are complex, as they can easily be complicated by factors such as diet, exercise, the presence of healthy or unhealthy lifestyle behaviors, environmental and genetic factors, and more.

Some Examples of Healthy Foods			
Foods	Phytochemicals and Carotenoids	Vitamins and other valuable food components	Benefits
Apples	Flavonoids		May have activity against certain cancers (lung). Also may help maintain healthy cholesterol. May protect against asthma.
Beans	Flavonoids	Folate, iron, potassium, and zinc	Some experts believe beans are the perfect food.
Berries, all kinds of dark colored	Ellegic Acid	Vitamin C, minerals	The anthocyanins in berries such as bilberries, blueberries, cranberries, elderberries, and others, have numerous healthful properties including anti-cancer and antioxidant effects. Bilberry (<i>Vaccinium myrtillis</i>) is widely used to prevent macular degeneration. Blueberries may protect the aging brain. (In one study blueberries were most effective.)
Broccoli (also kale, Brussels sprouts, cauliflower)	Flavonoids, isothiocyanates, lutein, beta and alpha carotene. Note: Young sprouts of broccoli and cauliflower contain much higher levels of isothiocyanates than their mature forms.	Vitamin C, folate, fiber, and selenium	Anticancer properties. Protective against heart disease and stroke.
Carrots and other bright yellow vegetables	Lutein, beta carotene and other provitamin A carotenoids	Vitamin A (converted from carotenoids), vitamin C	Protects eyes, lungs. (Cooking carrots may increase the potency of food nutrients.)
Chocolate, dark. Note: Milk chocolate does not have benefits.	Flavonoids		Heart protective (may improve lipids and help prevent blood clotting. May have protective properties against lung cancer (not other cancers).
Eggs	Lutein	Many B vitamins, vitamin A, vitamin D	Although egg yolks are high in cholesterol, it has little negative effect on people with normal levels. (People with diabetes or those with high cholesterol should restrict eggs, however.)
Fish, oily (mackerel, salmon, sardines)		Vitamin B3, B12. Essential fatty acids, selenium	Heart and brain protective.
Garlic	Allium (organosulfurs)		Possibly protective against certain cancers, heart diseases, and infection. Heating garlic can reduce benefits. Allowing crushed fresh garlic to stand 10 minutes before heating, however, may preserve beneficial chemicals while cooking.
Ginger	Zingiberaceae		Cancer fighting properties.
Grains (whole)	Lignans (phytoestrogens)	Vitamin B, Selenium (important antioxidant mineral), fiber, folate	May help reduce the ability of cancer cells to invade health tissue.
Grapes, including purple grape juice, and red wine	Flavonoids, (resveratrol, quercetin and catechin)		Fight heart disease and cancer. May help lower the risk for asthma.
Nuts		Vitamin E, vitamin B1, essential fatty acids, folate	Protects the heart and may help prevent stroke.
Onions	Flavonoids, allium (organosulfurs)		May have activity against certain cancers (lung).
Oranges	Monoterpenes	Vitamin C, folate, potassium.	Many health benefits. Increases HDL levels.
Potatoes (Sweet)		Vitamin C, vitamin E, vitamin A	Many health benefits.
Soy. The best products are tofu, soy milk, or whole soy protein.	Isoflavones (phytoestrogens), flavonoids, phytosterol, phytate, saponins.		May have some effects similar to estrogen, including maintaining bone calcium. May also help protect against prostate cancer and possibly other cancers. More studies are needed. Effects on breast cancer are uncertain. (Note: Soy may have different effects in men than in women.)

Some Examples of Healthy Foods (continued)			
Foods	Phytochemicals and Carotenoids	Vitamins and other valuable food components	Benefits
Spinach and other dark green leafy vegetables	Zeaxanthin, Beta carotene	Vitamin C, folate, vitamin A (converted from carotenoids)	Protects lungs and brain.
Tea (Both black and green tea are beneficial. Best results associated with green tea.)	Flavonoids (primarily catechins)		Cancer fighting properties, particularly in green tea, which may be especially beneficial for smokers. Both black and green tea may protect against heart disease and stroke, although studies are mixed. Tea drinking also may help with weight control and help prevent osteoporosis.
Tomatoes	Lycopene, Flavonoids	Vitamin C, biotin, minerals	Studies link to reductions in prostate and other cancers. Infection fighters.

Note on Organic versus Inorganic Products. There is some evidence that organic produce has higher levels of antioxidants and that some agricultural chemicals may destroy flavonoids. Nevertheless, organic produce is expensive, and fruits and vegetables, no matter how they are grown, are still filled with healthful nutrients.

Evidence of Protection against Other Diseases with Vitamins, Carotenoids, and Phytochemicals		
Disease or Condition	Vitamins	Carotenoids, Phytochemicals, and Healthy Foods
Alzheimer's Disease	<p><i>Vitamin E.</i> Some reports, including a large 2002 population study, have suggested that vitamin E intake, from food or supplements, may protect against mental decline. (One study suggested that the vitamin protected only those who carried the apoE4 gene. No strong evidence to date has found any protection from antioxidant supplements.) Most studies performed since 2002 challenge this finding, while others agree with it.</p> <p><i>B Vitamins.</i> Folate and Vitamin B12. Some studies suggest that deficiencies of vitamins B6, B12, and folate (folic acid) may be a risk factor for Alzheimer' diseases. Deficiencies in these vitamins can increase homocysteine levels, which some research associates with a higher risk for Alzheimer's disease. Foods containing folate include avocados, bananas, oranges, asparagus, green leafy vegetables, and dried beans. While some studies have described a benefit with administration of fully, vitamin B12, or vitamin B6, there is no good evidence from randomized controlled trials that these supplements prevent Alzheimer's disease.</p>	
Infectious Disease	<p>Studies are mixed whether vitamin supplements protect against upper respiratory infections. The weight of evidence suggests there is little or no benefit. Two studies in 2002 on multivitamins reported opposite results, with one finding fewer infections and one finding no difference. It is possible that vitamin C or multivitamin supplements may be helpful in specific people, such those who are vitamin deficient or have medical problems that impair their immune systems.</p>	
Eye Disorder	<p><i>Cataracts and Macular Degeneration.</i> Oxygen-free radicals play a role in cataract formation and age related macular degeneration, the most common cause of irreversible blindness in the elderly.</p> <p>Low levels of vitamin C in the lens of the eye have been particularly strong predictors of cataracts. People with cataracts are frequently deficient in vitamin A, the carotenes, lutein, and zeaxanthin. Studies on protection against cataracts using antioxidant supplements have been mixed, including two identically conducted studies that reported opposite results. Vitamin C currently has the strongest evidence for protection, but even with this antioxidant studies are not consistent.</p> <p>A combination of zinc and antioxidants, including vitamin C and E, may slow the progression of macular degeneration. (Vitamin E alone does not appear to be protective.)</p>	<p>Several studies report that the consumption of antioxidant-rich foods is associated with a decreased risk for cataracts. Carotenoids, especially lutein, lycopene, and zeaxanthin, are especially eye-protective and may help prevent cataracts and macular degeneration. The National Eye Institute in 2007 suggested that people with intermediate- or advanced macular degeneration in one eye may want to take a vitamin formula shown to reduce the risk of macular degeneration in the other eye by 25%. The formula contains vitamin C, vitamin E, beta-carotene, and zinc. They also suggest that a diet high in lutein and zeaxanthin may help reduce the risk of advanced age-related macular degeneration.</p> <p>Several studies report that the consumption of antioxidant-rich foods is associated with a decreased risk for cataracts. Carotenoids, especially lutein lycopene, and zeaxanthin are especially eye-protective and may help prevent cataracts and macular degeneration.</p>

Evidence of Protection against Other Diseases with Vitamins, Carotenoids, and Phytochemicals (continued)		
Disease or Condition	Vitamins	Carotenoids, Phytochemicals, and Healthy Foods
Osteoporosis	<p><i>Vitamin D.</i> A combination of calcium and vitamin D can reduce the risk of osteoporosis. (For strong bones, people need enough of both calcium and vitamin D.) The National Osteoporosis Foundation (NOF) recommends:</p> <ul style="list-style-type: none"> • Adults under age 50 should have 1,000 mg of calcium and 400 - 800 IU of vitamin D daily. • Adults age 50 and older should have 1,200 mg of calcium and 800 - 1,000 IU of vitamin D daily. 	
Menstrual Disorders	<p><i>Vitamin B6.</i> Limited clinical evidence suggests that vitamin B6 may be beneficial in reducing premenstrual symptoms, including depression. Typically, women take 100 mg per day, although one study suggested that a lower dose (50 mg) may have the same effect.</p>	

Resources

- <http://fnic.nal.usda.gov> -- The Food and Nutrition Information Center
- <http://dietary-supplements.info.nih.gov> -- Office of Dietary Supplements, National Institutes of Health
- www.ars.usda.gov/ba/bhnrc/ndl -- Nutrient Data Laboratory
- www.fda.gov -- Food and Drug Administration
- www.eatright.org -- The American Dietetic Association
- www.acsh.org -- American Council on Science and Health
- www.aicr.org -- American Institute for Cancer Research
- www.nutritiondata.com -- Information on vitamins and nutrients in foods
- www.consumerlab.com -- Independent testing of nutritional supplements' contents and quality
- www.usp.org -- US Pharmacopeia
- www.herbs.org -- Herb Research Foundation

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