

VITAMINS

Vitamins are essential nutrients required for normal chemical processes to occur in the body. They serve as essential components in enzymes and coenzymes. Enzymes are molecules involved in speeding up chemical reactions necessary for human bodily function such as energy production or the assembling of tissue components. Coenzymes are molecules that assist enzymes in chemical reactions.

Enzymes and coenzymes work to either join molecules together or split them apart by making or breaking the chemical bonds that link molecules together. Most enzymes are composed of a protein along with an essential mineral and possibly a vitamin. If an enzyme is lacking the essential mineral or vitamin, it cannot function properly.

There are thirteen vitamins divided into two primary classes. Those that dissolve in fat (fat-soluble) are the vitamins A, D, E, and K. Those that dissolve in water (water-soluble) are vitamin C, the B vitamins, biotin, and folic acid.

Fat-soluble vitamins can be stored in fat cells. For this reason your body is able to keep a supply of these vitamins available for use on demand. The downside is that toxic levels can be built up in the body leading to potentially severe side effects. Water-soluble vitamins, on the other hand, are stored in only small amounts in the body. Normally any quantity of these vitamins that your body does not use is excreted in the urine. However, while it is harder to build up toxic amounts of water-soluble vitamins, it is also easier to develop deficiencies of them.

THE RDA AND DRI

Included in the description of each vitamin is the Recommended Dietary Allowance (RDA). The RDAs for vitamins and minerals have been prepared by the Food and Nutrition Board of the National Research Council since 1941. These guidelines were originally developed to reduce the rates of severe nutritional deficiency diseases such as scurvy (deficiency of vitamin C), pellagra (deficiency of niacin), and beriberi (deficiency of vitamin B1 or thiamine). Another critical point is that the RDAs were designed to serve as the basis for evaluating the adequacy of diets of groups of people, not individuals, because individuals simply vary too widely in their nutritional requirements.

As a result, Dietary Reference Intakes or DRIs have been created. The DRIs reflect a shift in emphasis from preventing deficiency to decreasing the risk of chronic disease through nutrition and proper nutritional supplementation, such as ascertain cancers, cardiovascular disease, osteoporosis, and other diseases that are diet-related.

The DRIs are intended to apply to the healthy general population. They do not apply to individuals who are deficient in a particular nutrient and need to restore proper levels, nor do they apply to individuals with diseases associated with increased nutritional requirements or individuals whose genetic inheritance gives them a higher need for certain vitamin or mineral cofactors for the proper function and activity of various enzymes.

Dietary Reference Intakes (DRIs) is the umbrella term that includes the following values:

- 1. Estimated Average Requirement (EAR):** A nutrient intake value that is estimated to meet the requirement of half the healthy individuals in a group. It is used to assess the nutritional adequacy of intakes in population groups. In addition, EARs are used to calculate RDAs.
- 2. Recommended Dietary Allowance (RDA):** This value is a goal for individuals, and is based upon the EAR. It is the daily dietary intake level that is sufficient to meet the

nutrient requirement of 97-to-98% of all healthy individuals in a group. If an EAR cannot be set, no RDA value can be proposed.

3. **Adequate Intake (AI):** Used when a RDA cannot be determined, this is a recommended daily intake level based on an observed or experimentally determined approximation of nutrient intake for a group (or groups) of healthy people.
4. **Tolerable Upper Intake Level (UL):** The highest level of daily nutrient intake that is likely to pose no risks of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases.

FAT-SOLUBLE VITAMINS

Vitamin A

Vitamin A was the first fat-soluble vitamin to be recognized. The initial discovery of vitamin A in 1913 was made almost simultaneously by two groups of research workers, McCollum and Davis at the University of Wisconsin, and Osborne and Mendel at Yale University. They found that young animals fed a diet deficient in natural fats became very unhealthy, as evidenced by their inability to grow and poor immune function. These researchers also noted that the animals' eyes would become severely inflamed and infected on the restricted diet and that this could be quickly relieved by the addition to the diet of either butterfat or cod liver oil. Today, we know that these foods are excellent sources of vitamin A. Once known as the "anti-infective vitamin," vitamin A has recently regained recognition as a major determinant of immune status.

The best understood role of vitamin A however, is how it effects on the visual system. The human retina has four kinds of vitamin A-containing compounds that function in the visual process. Night blindness or poor dark adaptation is an early consequence of vitamin A deficiency.

Vitamin A is also necessary for proper growth and development, and is particularly important in maintaining the health and structure of the skin. Many skin disorders, including acne and psoriasis, are often responsive to vitamin A. Other body functions aided by vitamin A include: reproduction; adrenal and thyroid hormone manufacture and activity; maintaining structure and function of nerve cells; immunity; and cell growth.

Vitamin A was originally measured in international units. In 1967, however, an FAO/WHO Expert Committee recommended that vitamin A activity be referred to in terms of retinol (vitamin A) equivalents rather than in I.U., with 1 mcg of retinol being equivalent to 1 retinol equivalent (R.E.). The amount of beta-carotene required for 1 R.E. is 6 mcg, while the amount required for other provitamin A carotenoids is 12 mcg. In 1980, The Food and Nutrition Board of the NRC/NAS adopted this recommendation. The Recommended Dietary Allowance (RDA) for vitamin A is now stated in mcg and R.E. For the adult male, the RDA is set at 1000 R.E. (750 as retinol and 250 as beta-carotene or 5000 I.U.) while the RDA for women is lower at 800 R.E. (4000 I.U.). Children need 400 to 1000 R.E. (2000 to 5000 I.U.), with the dosage increasing from infancy to 14 years.

The most concentrated sources of preformed vitamin A are liver, kidney, butter, whole milk, and fortified skim milk. Vitamin A can also be formed from beta-carotenes and other carotenes. The leading sources of provitamin A carotenes are dark green leafy vegetables, such as collards and spinach, and yellow-orange vegetables, such as carrots, sweet potatoes, yams, and squash. Toxicity to vitamin A has been reported in people who supplement with excessive doses (over 10,000 RE for many months) or eat 6-to-24 pounds

per week of liver. In contrast, beta-carotene exerts no toxicity.

Vitamin A Content of Selected Foods, in International Units (I.U.) per 3 1/2 oz.(100 g) Serving

Liver, beef	43,900	Sweet potatoes	8,800
Liver, calf	22,500	Parsley	8,500
Chili peppers	21,600	Spinach	8,100
Dandelion root	14,000	Mustard greens	7,000
Chicken liver	12,100	Mangoes	4,800
Carrots	11,000	Hubbard squash	4,300
Apricots, dried	10,900	Cantaloupe	3,400
Collard greens	9,300	Apricots	2,700
Kale	8,900	Broccoli	2,500

Vitamin D

Since vitamin D can be produced in our bodies by the action of sunlight on the skin, many experts consider it to be more of a hormone than a vitamin. In the skin, sunlight changes the precursor to vitamin D, 7-dehydrocholesterol, into vitamin D3 (cholecalciferol). It is then transported to the liver and converted by an enzyme into 25-hydroxycholecalciferol (25-OHD3), which is five times more potent than cholecalciferol (D3). The 25-hydroxycholecalciferol is then converted by an enzyme in the kidneys to 1,25-dihydroxycholecalciferol (1,25-(OH)₂D3), which is ten times more potent than cholecalciferol and the most potent form of vitamin D3.

Disorders of the liver or kidneys result in impaired conversion of cholecalciferol to more potent vitamin D compounds. In many patients with osteoporosis, levels of 25-OHD3 are high, while the level of 1,25-(OH)₂D3 is quite low. This signifies an impairment of the conversion of 25-OHD3 to 1,25-(OH)₂D3 in osteoporosis. Many theories have been proposed to account for this decreased conversion including relationships to estrogen and magnesium deficiency. Recently, the trace mineral boron has been theorized to play a role in this conversion, too.

Vitamin D deficiency results in rickets in children and osteomalacia in adults. Rickets and osteomalacia are characterized by an inability to calcify the bone matrix. This results in softening of the skull bones, bowing of legs, spinal curvature, and increased joint size. Once common, these diseases are now extremely rare.

Vitamin D is best known for its ability to stimulate the absorption of calcium. As such, it is added to milk and other foods. More natural sources of vitamin D are cod liver oil; cold water fish, such as mackerel, salmon, and herring; butter, and egg yolks. Vegetables are low in vitamin D, but the best plant sources are dark green leafy vegetables. Vitamin D has the greatest potential to cause toxicity in comparison to other fat soluble vitamins.

The RDA for adults younger than 25 years, children, adolescents, pregnant women: is 400 IU. Adults older than 25 years require 200 IU. RDA level production of vitamin D can occur when approximately 30% of a person's skin surface is exposed to sunlight at moderate latitudes. However, vitamin D is often deficient in people living in northern latitudes.

- 1 USP unit = 1 IU = 0.025mcg vit D2 or vitamin D3.

Vitamin D Content of Selected Foods, in International Units (I.U.) per 3 1/2 oz. (100g) serving

Unfortified foods	Fortified foods
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Cod Liver oil (1 tbl)	1200	Milk (1 cup)	100
Mackerel	820-1100	Rice or Soy Drinks (1 cup)	20-60
Herring	320-840	Cereals (1 cup)	36-48
Tuna	1052	Cheese	12-20
Mushrooms, shitake (1 cup)	70	Butter (1 Tbl)	8-35
Pork	45		
Halibut	44		
Egg yolk	25		
Lamb	20		
Beef	9-42		

Vitamin E

Vitamin E is required by most animal species, including humans. It was discovered in 1922 when rats fed a purified diet without vitamin E became unable to reproduce. Wheat germ oil added to their diet restored fertility. Later, vitamin E was isolated and was originally called the "antisterility" vitamin or tocopherol. The term tocopherol comes from the Greek words *tokos* which means "offspring," and *phero* which means "to bear." Hence, tocopherol literally means to bear children, a reference to the rats' renewed ability to reproduce. Alpha-tocopherol is the chemical name for the most active form of vitamin E, at least in rats. In humans, new research suggests that the gamma and delta fractions, and the tocotrienols may be much more important for cardiovascular health.

Vitamin E functions primarily as an antioxidant in protecting against damage to cell membranes. Without vitamin E, the cells of the body would be quite susceptible to damage. Nerve cells would be particularly vulnerable. Severe vitamin E deficiency is quite rare, but there are a number of conditions where low levels of vitamin E have been reported, including acne, anemia, some cancers, gallstones, Lou Gehrig's disease, muscular dystrophy, Parkinson's disease, and Alzheimer's disease.

Vitamin E and high vitamin E diets have been shown to exert a protective effect in many common health conditions, including heart disease, cancer, strokes, fibrocystic breast disease, and viral infections. Typically, vitamin E is used at a dose of 400-to-600 I.U. per day. It is extremely well tolerated, even at these high doses. However, if you decide to take a vitamin E supplement, choose one containing mixed tocopherols rather than simply alpha tocopherol. Also, the D- form is the active form and the L- form is not used in the body.

Although the RDA for vitamin E is set at 10 mg (roughly 15 I.U.), the amount of vitamin E required is largely dependent upon the amount of polyunsaturated fats in the diet. The more polyunsaturated fats consumed, the greater the risk that they will be damaged. Since vitamin E prevents this damage, as the intake of polyunsaturated fatty acids increases, so does the need for vitamin E. Fortunately, in nature where high levels of polyunsaturated fatty acids are found, they are accompanied by higher levels of vitamin E. The best sources of vitamin E are wheat germ oil and polyunsaturated vegetable oils, seeds, and nuts. Good sources are asparagus, avocados, green leafy vegetables, tomatoes and whole grains.

Vitamin E Content of Selected Foods, in International Units (I.U.) per 3 ½ oz (100g) serving

Food	Amount	Vitamin E (I.U.)
Wheat germ oil	¼ cup	63.6
Sunflower seeds	¼ cup	26.8

Safflower oil	¼ cup	19.5
Sunflower oil	¼ cup	18.3
Almonds	¼ cup	12.7
Wheat germ	¼ cup	6.0
Whole wheat flour	½ cup	3.6
Spinach	½ cup	2.2-3.3
Peaches, canned	½ peach	2.1-2.4
Dried prunes	10 prunes	1.61-1.85
Tomato	1 medium	1.5
Cabbage	1 cup, raw	1.5
Asparagus	5 spears	1.1-1.6
Avocados	½ avocado	.95-2.0
Broccoli	1 cup	.8-3.4
Whole wheat cereal	1 cup	.4-.6
Beef	3 ½ ounces	.33-1.0
Turkey	3 ½ ounces	0.09
Milk, whole	1 cup	0.02

Vitamin K

One vitamin that is often neglected is vitamin K. Natural vitamin K from plants is termed vitamin K1, or phyloquinone. Vitamin K2, or menaquinone, is derived from bacteria in the gut, and vitamin K3 or menadione is a synthetic derivative.

The three vitamin Ks function similarly in helping with blood clotting, but for other important functions, vitamin K1 appears to be substantially superior. For example, vitamin K1 plays an important role in bone health as it is responsible for converting the bone protein osteocalcin from its inactive to its active form. Osteocalcin is the major non-collagen protein found in our bones. As displayed below, vitamin K is necessary for allowing the osteocalcin molecule to join with calcium and hold it place within the bone.

A deficiency of vitamin K1 leads to impaired mineralization of the bone due to inadequate active osteocalcin levels. Very low blood levels of vitamin K1 have been found in patients with fractures due to osteoporosis. The severity of the fracture strongly correlated with the level of circulating vitamin K: the lower the level of vitamin K, the greater the severity of the fracture. Vitamin K1 is found in green leafy vegetables and may be one of the protective factors of a vegetarian diet against osteoporosis.

Rich sources of vitamin K are dark green leafy vegetables, green tea, spinach, broccoli, lettuce, and cabbage. Good sources are asparagus, oats, whole wheat, and fresh green peas. The RDA for vitamin K is 1 mcg per 2.2 pounds body weight.

Vitamin K Content of Selected Foods, in Micrograms per 3 ½ oz. (100 g) Serving

Kale	729	Watercress	57
Green tea	712	Asparagus	57
Turnip greens	650	Oats	20
Spinach	415	Green peas	19
Broccoli	200	Whole wheat	17
Lettuce	129	Green beans	14
Cabbage	125		

WATER SOLUBLE VITAMINS

Thiamin (Vitamin B1)

Thiamin, or vitamin B1, was the first B vitamin discovered. Thiamin functions as part of the enzyme thiamin pyrophosphate of TPP, which is essential for energy production, carbohydrate metabolism, and nerve cell function. A deficiency of thiamin usually results initially in fatigue, depression, pins and needles sensations or numbness in the legs, and constipation. Severe thiamin deficiency results in a deficiency syndrome known as "beriberi." Symptoms include mental confusion, muscle wasting (dry beriberi), fluid retention (wet beriberi), high blood pressure, difficulty walking, and heart disturbances.

Although severe thiamin deficiency is relatively uncommon, except in alcoholics, many Americans do not consume the RDA of 1.5 mg, and subclinical thiamine deficiency is very common. In addition, diuretics, such as furosemide (Lasix®), are known to induce thiamin deficiency, and digoxin (Lanoxin®) interferes with thiamin in the heart muscle. Individuals on these drugs require thiamin supplementation (200-to-240 mg daily).

Rich plant sources of thiamin are sunflower seeds, peanuts, and soybeans. Good sources are whole wheat and nuts. It should be noted that thiamin is extremely sensitive to alcohol and sulfites. In the presence of either, thiamin is destroyed or made useless. Thiamin is also destroyed by antithiamine factor in uncooked freshwater fish and shell fish, and in tea. There is no known toxicity due to thiamin.

Thiamin Content of Selected Foods, in Milligrams per 3 ½-oz. (100 g) Serving

Yeast, brewer's	15.61	Lima beans, dry	.48
Yeast, torula	14.01	Hazelnuts	.46
Wheat germ	2.01	Wild rice	.45
Sunflower seeds	1.96	Cashews	.43
Rice polishings	1.84	Rye, whole grain	.43
Pine nuts	1.28	Mung beans	.38
Peanuts, with skins	1.14	Cornmeal, whole-ground	.38
Soybeans, dry	1.10	Lentils	.37
Peanuts, without skins	.98	Green peas	.35
Brazil nuts	.96	Macadamia nuts	.34
Pecans	.86	Brown rice	.34
Soybean flour	.85	Walnuts	.33
Beans, pinto & red	.84	Garbanzo beans	.31
Split peas	.74	Garlic, cloves	.25
Millet	.73	Almonds	.24
Wheat bran	.72	Lima beans, fresh	.24
Pistachio nuts	.67	Pumpkin & squash seeds	.24
Navy beans	.65	Chestnuts, fresh	.23
Buckwheat	.60	Soybean sprouts	.23
Oatmeal	.60	Peppers, red chili	.22
Whole-wheat flour	.55	Sesame seeds, hulled	.18
Whole-wheat grain	.55		

Riboflavin (Vitamin B2)

Riboflavin, or vitamin B2, was first recognized as a yellow-green pigment in milk in 1879. Ingesting an excess of riboflavin results in an increased urine content of riboflavin, which can give urine a yellow-green fluorescent glow. Riboflavin functions in two important enzymes involved in energy production, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD).

Riboflavin deficiency results in decreased energy production, particularly in cells that replicate frequently such as the skin and mucus membranes. Early riboflavin deficiency is characterized by cracking of the lips and corners of the mouth; an inflamed tongue; visual disturbances, such as sensitivity to light and loss of visual acuity; cataract formation; burning and itching of the eyes, lips, mouth and tongue; and other signs of disorders of mucous membranes.

The RDA for riboflavin is 1.7 mg for males and 1.3 mg for females. Rich sources of riboflavin are yeast and organ meats, such as liver, kidney, and heart. Good plant sources are almonds, mushrooms, whole grains, soybeans, and green leafy vegetables. Riboflavin is destroyed by light, but is not destroyed by cooking.

Riboflavin Content of Selected Foods, in Milligrams per 3 ½ oz. (100 g) Serving

Yeast, torula	5.06	Wheat bran	.35	Sunflower seeds	.23
Yeast, brewer's	4.28	Collards	.31	Navy beans	.23
Liver, calf	2.72	Soybeans, dry	.31	Beet & mustard greens	.22
Almonds	.92	Split peas	.29	Lentils	.22
Wheat germ	.68	Kale	.26	Prunes	.22
Wild rice	.63	Parsley	.26	Rye, whole grain	.22
Mushrooms	.46	Rice bran	.25	Beans, pinto & red	.21
Millet	.38	Broccoli	.23	Black-eyed peas	.21
Soy flour	.35	Pine nuts	.23		

Niacin (Vitamin B3)

Since niacin, or vitamin B3, can be made in the body by the conversion of tryptophan, many nutritionists do not consider niacin an essential nutrient as long as tryptophan intake is adequate. Niacin functions in the body as a component in the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP), which are involved in well over 50 different chemical reactions in the body. These niacin containing coenzymes play an important role in energy production; fat, cholesterol, and carbohydrate metabolism; and in the manufacture of many body compounds, including sex and adrenal hormones.

Niacin was discovered during the search for the cause of pellagra. Pellagra was a common disease in Spain and Italy in the 18th century. In Italian, pellagra means "skin that is rough." It is characterized by the "3-Ds" of pellagra: dermatitis, dementia, and diarrhea. The skin develops a cracked, scaly dermatitis; the brain does not function properly, leading to confusion and dementia; and diarrhea results from the impaired manufacture of the mucous lining of the gastrointestinal tract. Pellagra is now known to be due to a severe deficiency of niacin and tryptophan. Although the RDA for niacin is based on caloric intake, an intake of at least 18 mg per day is recommended by most authorities. However, additional niacin has been shown to exert a favorable effect on many health conditions. Supplemental niacin is available as either nicotinic acid or niacinamide. Each form has different applications. In the nicotinic acid form, niacin is an effective agent for lowering blood cholesterol levels, while in the niacinamide form, niacin is useful in treating arthritis. In the field of orthomolecular psychiatry, large doses of niacin in the form of nicotinic acid or niacinamide are often utilized in the treatment of schizophrenia. Doses in excess of 50 mg of niacin as nicotinic acid typically produce a transient flushing of the skin. Also, high doses, 2-to-6 grams per day, of either nicotinic acid or niacinamide should be monitored by a physician as they may result in liver disorders, peptic ulcers, and glucose intolerance.

Rich food sources of niacin as nicotinic acid include liver and other organ meats, eggs, fish, and peanuts. All of these foods are also rich sources of tryptophan. Good sources of

niacin include legumes and whole grains (except corn).

Niacin Content of Selected Foods, in Milligrams per 3 1/2 oz. (100g) Serving

Yeast, torula	44.4	Swordfish	10.2	Whole-wheat, grain	4.4
Yeast, brewer's	37.9	Wild, rice	6.2	Whole-wheat flour	4.3
Rice bran	29.8	Sesame seeds	5.4	Wheat germ	4.2
Rice polishings	28.2	Sunflower seed	5.4	Barley	3.7
Liver, beef	21.4	Brown rice	4.7	Almonds	3.5
Wheat bran	21.0	Pine nuts	4.5	Split peas	3.0
Peanuts, with skin	17.2	Buckwheat	4.4	Egg, whole	2.6
Peanuts, without skin	15.8	Peppers, red chili	4.4		

Pantothenic Acid (Vitamin B5)

Pantothenic acid, or vitamin B5 (please note there is not a vitamin B4), is a component of coenzyme A (CoA), which plays a critical role in the utilization of fats and carbohydrates in energy production, as well as in the manufacture of adrenal hormones and red blood cells. Pantothenic acid is particularly important for optimal adrenal function and has long been considered the "anti-stress" vitamin because of its central role in adrenal function and cellular metabolism.

A deficiency of pantothenic acid is believed to be quite rare in humans as pantothenic acid is found in a large number of foods. In fact, its name is derived from the Greek word *pantos* which means "everywhere." However, additional pantothenic acid is often used to support adrenal function, and pantethine, the most active stable form of pantothenic acid, is used to lower blood cholesterol and triglyceride levels.

Pantothenic acid is found in highest concentrations in liver and other organ meats, milk, fish, and poultry. Good plant sources of pantothenic acid include whole grains, legumes, sweet potatoes, broccoli, cauliflower, oranges, and strawberries. There is no official RDA for pantothenic acid, but a daily intake of 4-to-7 mg is believed to be adequate.

Pantothenic Acid Content of Selected Foods, in Milligrams per 3 1/2 oz. (100 g) Serving

Yeast, brewer's	12.0	Hazelnuts	1.1
Yeast, torula	11.0	Brown rice	1.1
Liver, calf	8.0	Whole-wheat flour	1.1
Peanuts	2.8	Peppers, red chili	1.1
Mushrooms	2.2	Avocados	1.1
Soybean flour	2.0	Black-eyed peas, dry	1.0
Split peas	2.0	Wild rice	1.0
Pecans	1.7	Cauliflower	1.0
Soybeans	1.7	Kale	1.0
Oatmeal, dry	1.5	Hazelnuts	1.1
Buckwheat flour	1.4	Brown rice	1.1
Sunflower seeds	1.4	Whole-wheat flour	1.1
Lentils	1.4	Peppers, red chili	1.1
Rye flour, whole	1.3	Avocados	1.1
Cashews	1.3	Black-eyed peas, dry	1.0
Garbanzo beans	1.2	Wild rice	1.0
Wheat germ	1.2	Cauliflower	1.0
Broccoli	1.2	Kale	1.0

Pyridoxine (Vitamin B6)

Pyridoxine, or vitamin B6, is an extremely important B vitamin involved in the formation of body proteins and structural compounds, chemical transmitters in the nervous system, red

blood cells, and prostaglandins. Vitamin B6 is also critical in maintaining hormonal balance and proper immune function.

Deficiency of vitamin B6 is characterized by depression, convulsions (especially in children), glucose intolerance, and impaired nerve function. Although extreme deficiency of vitamin B6 is believed to be quite rare, numerous clinical studies have demonstrated the importance of vitamin B6 in a number of health conditions that typically respond to B6 supplementation, including asthma, premenstrual syndrome (PMS), carpal tunnel syndrome, depression, morning sickness, and kidney stones. It is of interest to note that the increased rate of these disorders since the 1950s parallels the increased levels of vitamin B6 antagonists found in the food supply and used as drugs during the same period. These antagonists to vitamin B6 include the hydrazine dyes, such as FD&C yellow #5; certain drugs, such as isoniazid, hydralazine, dopamine, and penicillamine; oral contraceptives; alcohol; and excessive protein intake. The intake of yellow dye #5, also called tartrazine, is especially problematic as it is often consumed in greater quantities, with a per capita intake of 15 grams per day, than the RDA for vitamin B6, which is 2.0 mg for males and 1.6 mg for females.

Good plant sources of vitamin B6 include whole grains, legumes, bananas, seeds and nuts, potatoes, Brussels sprouts, and cauliflower. Also, vitamin B6 levels inside the cells of the body appear to be intricately linked to the magnesium content of the diet as well, see Magnesium below.

Pyridoxine Content of Selected Foods, in Milligrams per 3 ½ oz. (100g) Serving

Yeast, torula	3.00	Navy beans, dry	.56	Spinach	.28
Yeast, brewer's	2.50	Brown rice	.55	Turnip greens	.26
Sunflower seeds	1.25	Hazelnuts	.54	Peppers, sweet	.26
Wheat germ, toasted	1.15	Garbanzo beans, dry	.54	Potatoes	.25
Soybeans, dry	.63	Pinto beans, dry	.53	Prunes	.24
Walnuts	.73	Bananas	.51	Raisins	.24
Soy bean flour	.63	Avocados	.42	Brussels sprouts	.23
Lentils, dry	.60	Whole-wheat flour	.34	Barley	.22
Lima beans, dry	.58	Chestnuts, fresh	.33	Sweet potatoes	.22
Buckwheat flour	.58	Kale	.30	Cauliflower	.21
Black-eyed peas, dry	.56	Rye flour	.30		

Folic acid

Folic acid, also known as folate, folacin, and pteroylmonoglutamate, functions together with vitamin B12 in many body processes and is critical to cellular division because it is necessary in DNA synthesis. Without folic acid, cells do not divide properly. In the case of folic acid deficiency, all cells of the body are affected, but it is the rapidly dividing cells, such as red blood cells and cells of the gastrointestinal and genital tracts that are affected the most. Folic acid deficiency is characterized by poor growth, diarrhea, anemia, gingivitis, and an abnormal pap smear in women. Folic acid is critical to the development of the nervous system of the fetus and deficiency of folic acid during pregnancy has been linked to several birth defects including neural tube defects like spina bifida.

Folic acid, vitamin B12, and betaine also function to reduce body concentrations of homocysteine, an intermediate in the conversion of the amino acid methionine to cysteine. Higher than average homocysteine has been implicated in a variety of conditions, including atherosclerosis and osteoporosis. Homocysteine is thought to promote atherosclerosis by directly damaging the artery, as well as reducing the integrity of the vessel wall. In osteoporosis, elevated homocysteine levels lead to a defective bone matrix by interfering with the proper formation of collagen, the main protein in bone.

Despite its wide occurrence in food, folic acid deficiency is the most common vitamin deficiency in the world. The reason reflects food choices: animal foods, with the exception of liver, are poor sources of folic acid, while plant foods are rich sources but are not as frequently consumed. In addition, alcohol and many prescription drugs, such as estrogens, sulfasalazine, and barbiturates, impair folic acid metabolism; and folic acid is extremely sensitive and easily destroyed by light or heat. The RDA for folic acid is 200 mcg for males and 180 mcg for females.

Folic acid received its name from the Latin word *folium* which means "foliage" because it is found in high concentrations in green leafy vegetables, such as spinach, kale, beet greens, and Swiss chard. Other good sources of folic acid include whole grains, legumes, asparagus, broccoli, and cabbage.

Folic Acid Content of Selected Foods, in Micrograms per 3 ½ oz. (100 g) Serving

Yeast, brewer's	2,022	Lentils	105	Whole-wheat flour	38
Black-eyed peas	440	Walnuts	77	Oatmeal	33
Rice germ	430	Spinach, fresh	75	Cabbage	32
Soy flour	425	Kale	70	Dried figs	32
Wheat germ	305	Filbert nuts	65	Avocado	30
Liver, beef	295	Various greens	60	Green beans	28
Soy beans	225	Peanuts, roasted	56	Corn	28
Wheat bran	195	Peanut butter	56	Coconut, fresh	28
Kidney beans	180	Broccoli	53	Pecans	27
Mung beans	145	Barley	50	Mushrooms	25
Lima beans	130	Split peas	50	Dates	25
Navy beans	125	Whole-wheat cereal	49	Blackberries	14
Garbanzo beans	125	Brussels sprouts	49	Orange	5
Asparagus	110	Almonds	45		

Vitamin B12 (Cobalamin)

Vitamin B12, or cobalamin, was isolated from a liver extract in 1948 and identified as the nutritional factor in liver that prevented pernicious anemia. The crystallized compound of vitamin B12 is bright due to its high content of the mineral cobalt. Vitamin B12 works with folic acid in many body processes including the synthesis of DNA. Since vitamin B12 works to reactivate folic acid, a deficiency of B12 will result in a folic acid deficiency if folic acid levels are only marginal. More specifically, vitamin B12 deficiency will result in impaired nerve function, which can cause numbness, pins and needles sensations, or a burning feeling in the feet, as well as impaired mental function, which in the elderly, can mimic Alzheimer's disease. In addition to depression or mental confusion, vitamin B12 deficiency can present as anemia; a smooth, beefy red tongue; and diarrhea. Vitamin B12 deficiency is thought to be quite common in the elderly.

Vitamin B12 is necessary in only very small quantities. The RDA is 2.0 mcg. Vitamin B12 is found in significant quantities only in animal foods. The richest sources are liver and kidney, followed by fish, eggs, meat, and cheese. Strict vegetarians (vegans) are often told that fermented foods like tempeh are excellent sources of vitamin B12, and depending upon the medium on which it is grown, nutritional Brewer's yeast may also provide B12. However, in addition to tremendous variation of B12 content in fermented foods and Brewer's yeast, there is some evidence that the form of B12 in these foods is not exactly the form that meets our body requirements. Although the vitamin B12 content of certain cooked sea vegetables is in the same range as beef, it is not known if this form is utilized in the same manner either. Therefore, at this time it appears that it is an extremely good idea for vegetarians to supplement their diets with vitamin B12.

Vitamin B12 Content of Selected Foods, in Micrograms per 3 ½ oz. (100 g) Serving

Liver, lamb	104.0	Salmon	4.0	Blue cheese	1.4
Clams	98.0	Tuna	3.0	Haddock	1.3
Liver, beef	80.0	Lamb	2.1	Flounder	1.2
Kidneys, lamb	63.0	Eggs	2.0	Scallops	1.2
Liver, calf	60.0	Whey, dried	2.0	Cheddar cheese	1.0
Kidneys, beef	31.0	Beef, lean	1.8	Cottage cheese	1.0
Liver, chicken	25.0	Edam cheese	1.8	Mozzarella cheese	1.0
Oysters	18.0	Swiss cheese	1.8	Halibut	1.0
Sardines	17.0	Brie cheese	1.6	Perch, filets	1.0
Trout	5.0	Gruyere cheese	1.6	Swordfish	1.0

Biotin

Biotin is a B vitamin that functions in the manufacture and utilization of fats and amino acids. Without biotin, metabolism is severely impaired. However, since biotin is manufactured in the intestines by gut bacteria, it is not discussed very much. For adults, a vegetarian diet has been shown to alter the intestinal bacterial flora in such a manner as to enhance the synthesis and promote the absorption of biotin. There is no official RDA for biotin, but a daily intake of 30-to-100 mcg is believed to be adequate.

A biotin deficiency in adults is characterized by dry, scaly skin; nausea; anorexia; and seborrhea. In infants under six months of age, the symptoms are seborrheic dermatitis (cradle cap) and alopecia (hair loss). In fact, the underlying factor for cradle cap in infants appears to be a biotin deficiency. Cradle cap is a common condition that may be associated with excessive oiliness (seborrhea) and scales. Since a large portion of the human biotin supply is provided by intestinal bacteria, it has been postulated that the absence of normal intestinal flora in the newborn may be responsible for cradle cap. A number of studies have demonstrated successful treatment of cradle cap with biotin when given as a supplement of 2-10 mg per day or as liver or egg yolk to the nursing mother and/or the infant.

The best sources of biotin are cheese, organ meats, and soybeans. Good sources are eggs, peanuts, oatmeal, cauliflower, and mushrooms. Note: raw egg whites contain avidin, a protein which binds biotin and prevents its absorption. Avidin is destroyed with cooking.

Biotin Content of Selected Foods, in Milligrams per 3 ½ oz. (100 g) Serving

Yeast, brewer's	200	Peanuts, roasted	34
Liver, beef	96	Barley	31
Soy flour	70	Pecans	27
Soybeans	61	Oatmeal	24
Rice bran	60	Black-eyed peas	21
Rice germ	58	Split peas	18
Rice polishings	57	Almonds	18
Peanut butter	39	Cauliflower	17
Walnuts	37	Mushrooms	16

Choline

Choline is often referred to as an "unofficial member" of the B vitamin family. Although choline can be manufactured in the body from either the amino acid methionine or serine, it has recently been designated an essential nutrient. Choline works very closely with other B vitamins, performing a vital function in the proper metabolism of fats. Without choline, fats

become trapped in the liver where they block metabolism. Specifically, it is required for the export of fat from the liver. Technically this is referred to as a lipotropic effect. Choline is also required to make the important neurotransmitter acetylcholine and main components of our cell membranes such as phosphatidylcholine (lecithin) and sphingomyelin. Good dietary sources of choline include egg yolks, organ meats, legumes, and lecithin.

Vitamin C (Ascorbic Acid)

Vitamin C is perhaps the most publicized vitamin. The primary function of vitamin C is the manufacture of collagen, the main protein substance of the human body. Specifically, vitamin C is involved in the joining of a portion of molecule to the amino acids lysine and proline to form hydroxylysine and hydroxyproline. The result is a very stable collagen structure. Since collagen is such an important protein for the structures that hold our body together, including cartilage, connective tissue, ligaments, and tendons, vitamin C is vital for wound repair, healthy gums, and the prevention easy bruising. In addition to its role in collagen manufacture, vitamin C is also critical to immune function, the manufacture of certain nerve transmitting substances and hormones, and the absorption and utilization of other nutritional factors. Vitamin C is also a very important nutritional antioxidant.

Numerous experimental, clinical, and population studies have shown increased vitamin C intake to result in a number of beneficial effects, including reducing cancer rates; boosting immunity; protecting against pollution and cigarette smoke; enhancing wound repair; increasing life expectancy; and reducing the risk for cataracts. Many claims have also been made about the role of vitamin C in enhancing the immune system, especially regarding the prevention and treatment of the common cold. However, despite numerous positive clinical and experimental studies, for some reason this effect is still hotly debated. But from a biochemical viewpoint, there is considerable evidence that vitamin C plays a vital role in many immune mechanisms. Specifically, vitamin C has been shown to increase many different immune functions, including enhancing white blood cell function and activity; and increasing interferon levels, antibody responses, antibody levels, secretion of thymic hormones, and integrity of ground substance, the basic material that adheres cells together. Vitamin C also possesses many biochemical effects very similar to interferon, the body's natural antiviral and anticancer compound. The high concentration of vitamin C in white blood cells, particularly lymphocytes, is rapidly depleted during infection, and a relative vitamin C deficiency may ensue if vitamin C is not regularly replenished.

During times of chemical, emotional, psychological, or physiological stress, the urinary excretion of vitamin C is increased, signifying an increased need for vitamin C during these times. Examples of chemical stressors include cigarette smoke, pollutants, and allergens. Extra vitamin C in the form of supplementation or increased intake of vitamin C-rich foods is often recommended to keep the immune system working properly during times of stress. In certain instances, vitamin C supplementation is the only way to meet the concentrations needed for many health conditions. The RDA for vitamin C is 60 mg per day.

In the case of scurvy or severe vitamin C deficiency, the classic symptoms are bleeding gums, poor wound healing, and extensive bruising. In addition to these symptoms, susceptibility to infection, hysteria, and depression are also hallmark features of vitamin C deficiency. Only 10-20 mg per day is required to prevent scurvy and severe vitamin C deficiency, although this amount is too low to support optimal health.

While most people think of citrus fruits as the best source of vitamin C, vegetables also contain high levels, especially peppers, broccoli, potatoes, and Brussels sprouts. Vitamin C is destroyed by exposure to air. So eating fresh foods as quickly as possible is best. Although a salad from a salad bar is a healthier lunch choice, the vitamin C content of the fruits and

vegetables is only a fraction of what they would be if the salad was made fresh. For example, freshly sliced cucumbers, if left standing, will lose between 41% and 49% of their vitamin C content within the first 3 hours. A sliced cantaloupe, left uncovered in the refrigerator, will lose 35% of its vitamin C content in less than 24hours.

Vitamin C content of Selected Foods, in Milligrams per 3 ½ oz. (100 g) Serving

Acerola	1300	Strawberries	59	Okra	31
Peppers, red chili	369	Papayas	56	Tangerines	31
Guavas	242	Spinach	51	New Zealand spinach	30
Peppers, red sweet	190	Oranges & juice	50	Oysters	30
Kale leaves	186	Cabbage	47	Lima beans, young	28
Parsley	172	Lemon juice	46	Black-eyed peas	29
Collard leaves	152	Grapefruit & juice	38	Soybeans	29
Turnip greens	128	Elderberries	36	Green peas	27
Peppers, green sweet	128	Liver, calf	36	Radishes	26
Broccoli	113	Turnips	36	Raspberries	25
Brussels sprouts	102	Mangoes	35	Chinese cabbage	25
Mustard greens	97	Asparagus	33	Yellow summer squash	25
Watercress	79	Cantaloupe	33	Loganberries	24
Cauliflower	78	Swiss chard	32	Honeydew melons	23
Persimmons	66	Green onions	32	Tomatoes	23
Cabbage, red	61	Liver, beef	31	Liver, pork	23