Definition: vitamin from *The Penguin Dictionary of Psychology*

Any of a large number of extremely complex organic substances essential, in small quantities, for normal metabolism, growth and development. Vitamins are distinct from other essential substances like proteins, carbohydrates, fats, minerals and salts. Moreover, they supply no energy of their own and do not add significantly to bodily substance. Their primary roles are as regulators of metabolic processes and aids in the transformation of other substances into energy.

Summary Article: vitamin from *The Columbia Encyclopedia*

Group of organic substances that are required in the diet of humans and animals for normal growth, maintenance of life, and normal reproduction. Vitamins act as catalysts; very often either the vitamins themselves are coenzymes, or they form integral parts of coenzymes. A substance that functions as a vitamin for one species does not necessarily function as a vitamin for another species. The vitamins differ in structure, and there is no chemical grouping common to them all.

They were first called accessory factors because in 1906 it was found by English biochemist Sir F. G. Hopkins that most foods contain—besides carbohydrates, proteins, fats, minerals, and water—other substances necessary for health. The word *vitamin* was derived from the term *vitamine*, used by Polish-American biochemist Casimir Funk to describe an amine (organic base) that was essential to life (it was later found to be thiamine). In 1912 Hopkins and Funk formulated the vitamin hypothesis of deficiency disease; that is, that certain diseases are caused by a dietary lack of specific vitamins.

The chemical structures of the vitamins are all known, and all of them have been synthesized; the vitamins in foods are identical to the synthetic ones. A well-balanced diet usually satisfies the minimum vitamin requirements of human beings. The Recommended Dietary Allowance (RDA) of each vitamin is the standard guideline put forward by the Food and Nutrition Board, National Academy of Sciences—National Research Council. It is based on the nutritional needs of an average, healthy person. Different amounts may be recommended for children, older people, lactating mothers, or people dealing with an ongoing disease process. The U.S. RDA was the federal government’s interpretation of the National Research Council’s RDA. Since mid-1994, the U.S. RDA has been replaced on food labels by a Percent Daily Value (the percentage of the U.S. RDA that the labeled food offers). Listings for vitamins A and C are required; others are optional.

The amount of each vitamin that should be consumed for optimal health and the wisdom of taking vitamin supplements, especially in “megadoses,” is a controversial question. The Dietary Supplement Health and Education Act of 1994 defined vitamins as dietary supplements (rather than drugs) and shifted the burden of proof of safety from the manufacturers to the Food and Drug Administration. Although vitamins were previously seen only as preventives against the various deficiency diseases, more and more studies have examined additional health benefits of vitamins. Health claims that are unsubstantiated by scientific study, however, are regarded by many health and nutrition experts as fraudulent or dangerous, and many physicians now question the need for healthy persons to take multivitamin supplements, because many foods, such as milk and bread, are fortified with vitamins.
Vitamins were originally classified according to their solubility in water or fats, and as more and more were discovered they were also classified alphabetically. The fat-soluble vitamins are A, D, E, and K; the B complex and C vitamins are water soluble. A group of substances that decrease blood capillary fragility, called the vitamin P group, are no longer considered to be vitamins.

**Vitamin A**

Vitamin A (retinol), a fat-soluble lipid, is either derived directly from animal foods such as liver, egg yolks, cream, or butter or is derived from beta-carotene, a pigment that occurs in leafy green vegetables and in yellow fruits and vegetables. Vitamin A is essential to skeletal growth, normal reproductive function, and the health of the skin and mucous membranes. One form, retinal, is a component of visual purple, a photoreceptor pigment in the retina of the eye (see vision). In addition, beta-carotene, like other carotenoids, is now recognized as an important antioxidant.

A deficiency of vitamin A can cause retarded skeletal growth, night blindness, various abnormalities of the skin and linings of the genitourinary system and gastrointestinal tract, and, in children, susceptibility to serious infection. The eye disorders that result from a deficiency of vitamin A can lead to permanent blindness. Severe deficiency can cause death. As with the other fat-soluble vitamins, conditions that lead to an inability to absorb fats, such as obstruction of bile flow or excessive use of mineral oil, can produce a deficiency state. Overconsumption of vitamin A can cause irritability, painful joints, growth retardation, liver and spleen enlargement, hair loss, and birth defects. The National Research Council recommended daily dietary allowance for adults is 1,000 micrograms (retinol equivalents) for men and 800 micrograms for women.

**Vitamin B Complex**

Commonly grouped as the vitamin B complex are eight water-soluble vitamins.

**Thiamine**

Thiamine (vitamin B₁ or antiberiberi factor) is a necessary ingredient for the biosynthesis of the coenzyme thiamine pyrophosphate; in this latter form it plays an important role in carbohydrate metabolism. Good sources are yeast, whole grains, lean pork, nuts, legumes, and thiamine-enriched cereal products. This vitamin is a factor in the maintenance of appetite, normal intestinal function, and in the health of the cardiovascular and nervous systems. A deficiency of the vitamin may lead to beriberi; the disease was first shown to result from a dietary deficiency by Dutch physician Christiaan Eijkman. The recommended dietary allowance for adults is 1.2 to 1.4 mg for men and 1.0 to 1.1 mg for women. Riboflavin is widely distributed in plant and animal tissues; milk, organ meats, and enriched cereal products are good sources.

**Riboflavin**

Riboflavin (vitamin B₂ or lactoflavin) is used to synthesize two coenzymes that are associated with several of the respiratory enzymes of plants and animals (including humans) and is therefore important in biochemical oxidations and reductions. Deficiency leads to fissures in the corners of the mouth, inflammation of the tongue showing a reddish purple coloration, skin disease, and often severe irritation of the eyes. The recommended dietary allowance for adults is 1.4 to 1.7 mg for men and 1.2 to 1.3 mg for women. Riboflavin is widely distributed in plant and animal tissues; milk, organ meats, and enriched cereal products are good sources.

**Niacin**

The B vitamins niacin (nicotinic acid) and niacinamide (nicotinamide) are commonly known as preventives of pellagra, which in 1912 was shown by American medical researcher Joseph Goldberger to result from
a dietary deficiency. Niacin was first synthesized in 1867. The amino acid tryptophan is the precursor of niacin. Niacin and niacinamide function in the biochemistry of humans and other organisms as components of the two coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP); these operate in many enzyme-catalyzed oxidation and reduction reactions. The deficiency state in humans causes skin disease, diarrhea, dementia, and ultimately death. The deficiency state in dogs analogous to pellagra in humans is called blacktongue disease. Lean meats, peanuts and other legumes, and whole-grain or enriched bread and cereal products are among the best sources of niacin. The recommended daily dietary allowance for adults is 16 to 19 mg niacin equivalents (60 mg of dietary tryptophan to 1 mg of niacin) for men and 13 to 14 mg for women.

**Vitamin B₆ Group**

Pyridoxine, pyridoxal, and pyridoxamine make up the vitamin B₆ group. They all combine with phosphorus in the body to form the coenzyme pyridoxal phosphate, which is necessary in the metabolism of amino acids, glucose, and fatty acids. The best sources of B₆ vitamins are liver and other organ meats, corn, whole-grain cereal, and seeds. Deficiency can result in central nervous system disturbances (e.g., convulsions in infants) due to the role of B₆ in serotonin and gamma-aminobutyric acid synthesis. More generally the effects of deficiency include inadequate growth or weight loss and anemia due to the role of B₆ in the manufacture of hemoglobin. The recommended dietary allowance for adults is 2.0 to 2.2 mg for men and 2 mg for women. Additional doses are required in pregnancy and by those taking oral contraceptives or the tuberculosis drug isoniazid. Severe nerve damage has been reported from megadoses.

**Pantothenic Acid**

Pantothenic acid, another B vitamin, is present in perhaps all animal and plant tissues, as well as in many microorganisms. Good sources of it include liver, kidney, eggs, and dairy products. It is a component of the important substance coenzyme A, which is involved in the metabolism of many biochemical substances including fatty acids, steroids, phospholipids, heme, amino acids, and carbohydrates. The adrenal gland is an important site of pantothenic acid activity. There is no known naturally occurring deficiency state and no known toxicity to pantothenic acid. The estimated safe and adequate daily intake for adults is 4 to 7 mg.

**Biotin**

Biotin is a B vitamin that functions as a coenzyme in the metabolism of carbohydrates, fats, and amino acids. Although it is vitally necessary to the body, only exceedingly small quantities are needed, and since biotin is synthesized by intestinal bacteria, naturally occurring biotin deficiency disease is virtually unknown. The disease state can be produced artificially by including large quantities of raw egg white in the diet; the whites contain avidin, a biotin antagonist. Especially good sources of this widely distributed vitamin include egg yolk, kidney, liver, tomatoes, and yeast. There is no known toxicity to biotin. The estimated safe and adequate daily intake for adults is 100 to 200 micrograms.

**Folic Acid**

Folic acid (pteroylglutamic acid, folacin, or vitamin B₉) occurs abundantly in green leafy vegetables, fruits (e.g., apples and oranges), dried beans, avocados, sunflower seeds, and wheat germ. Derivatives of this vitamin are directly involved in the synthesis of nucleic acids; for this reason cells in the body that are subject to rapid synthesis and destruction are especially sensitive to folic acid deprivation. For example, the retarded synthesis of blood cells in folic acid deficiency results in several forms of anemia.
while failure to replace rapidly destroyed cells in the intestinal wall results in a disease called sprue. Inadequate amounts of folic acid in the diet of pregnant women have been strongly associated with neural tube defects (i.e., spina bifida and anencephaly) in newborns; fortification of flours, cornmeal, rice, and pasta (in a manner similar to the fortification of milk with vitamin D) has been required in the United States since 1998. Adequate folic acid also reduces the risk of premature birth. A U.S. study published in 1998 involving 80,000 women showed significant reduction of heart disease among those whose diets included adequate amounts of folate and vitamin $B_6$. Several chemical antagonists to the action of folic acid have been developed in the hope that they might inhibit the growth of rapidly dividing cancer cells; one such compound, methotrexate, is used to treat leukemia in children. The recommended daily dietary allowance for adults is 400 micrograms. Para-aminobenzoic acid (PABA), which is incorporated into the folic acid molecule, is sometimes listed separately as a B vitamin, although there is no evidence that it is essential to the diet of humans.

**Vitamin $B_{12}$**

The molecular structure of vitamin $B_{12}$ (cobalamin), the most complex of all known vitamins, was announced in 1955 by several scientists, including British biochemists A. R. Todd and Dorothy Hodgkin. In 1973 the vitamin was reported to have been synthesized by organic chemists. Vitamin $B_{12}$ and closely related cobalamins are necessary for folic acid to fulfill its role; both are involved in the synthesis of proteins. American physicians G. R. Minot and W. P. Murphy in 1926 fed large amounts of liver to patients with pernicious anemia and cured them; the curative substance in this case was probably vitamin $B_{12}$. However, pernicious anemia in humans is caused not by a vitamin $B_{12}$ deficiency in the diet but rather the absence of a substance called the intrinsic factor, ordinarily secreted by the stomach and responsible for facilitating the absorption of $B_{12}$ from the intestine. When a person's body cannot produce the intrinsic factor, the standard treatment today is to inject vitamin $B_{12}$ directly into the bloodstream. Minot and Murphy's therapy worked because the liver they fed their patients contained such large quantities of $B_{12}$ that sufficient amounts of the vitamin were absorbed without the assistance of the intrinsic factor. Inadequate absorption of $B_{12}$ causes pernicious anemia, nervous system degeneration, and amenorrhea. The only site of cobalamin synthesis in nature appears to be in microorganisms; neither animals nor higher plants are capable of making these vitamin $B_{12}$ derivatives. Nevertheless, such animal tissues as the liver, kidney, and heart of ruminants contain relatively large quantities of vitamin $B_{12}$; the vitamin stored in these organs was originally produced by the bacteria in the ruminant gut. Bivalves (clams or oysters), which siphon microorganisms from the sea, are also good sources. Plants, on the other hand, are poor sources of vitamin $B_{12}$. The recommended daily dietary allowance for adults is 3 micrograms.

**Vitamin C**

Vitamin C, or ascorbic acid, a water-soluble vitamin, was first isolated (from adrenal cortex, oranges, cabbage, and lemon juice) in the laboratories of American biochemists Albert Szent-Gyorgyi and Charles King in the years 1928–33. Szent-Gyorgyi found the Hungarian red pepper to be an exceptionally rich source; citrus fruits and tomatoes are also excellent sources. Other good sources include berries, fresh green and yellow vegetables, and white potatoes and sweet potatoes. The vitamin is readily oxidized and therefore is easily destroyed in cooking and during storage. All animals except humans, other primates, guinea pigs, and one bat and bird species are able to synthesize ascorbic acid. Ascorbic acid is necessary for the synthesis of the body's cementing substances: bone matrix, collagen, dentin, and cartilage. It is an antioxidant and is necessary to several metabolic...
processes. Deficiency of vitamin C results in scurvy, the symptoms of which are largely related to inadequate collagen synthesis and defective formation of intercellular materials. Ascorbic acid is metabolized slowly in humans, and symptoms of scurvy are usually not seen for three or four months in the absence of any dietary vitamin C. The use of megadoses of ascorbic acid to prevent common colds, stress, mental illness, cancer, and heart disease is a continuing subject of research. The recommended daily allowance for adults is 60 mg.

**Vitamin D**

Vitamin D is a name given to two fat-soluble compounds; calciferol (vitamin D$_2$) and cholecalciferol (vitamin D$_3$). They are now known to be hormones, but continue to be grouped with vitamins because of historical misclassification. Vitamin D$_3$ plays an essential role in the metabolism of calcium and phosphorus in the body and prevents rickets in children. A plentiful supply of 7-dehydrocholesterol, the precursor of vitamin D$_3$, exists in human skin and needs only to be activated by a moderate amount of ultraviolet light (less than a half hour of sunlight) to become fully potent. Rickets is usually caused by a lack of exposure to sunlight rather than a dietary deficiency, although dietary deficiencies can result from malabsorption in the small intestine caused by conditions such as sprue or colitis. Rickets can be prevented and its course halted by the intake of vitamin D$_2$ (found in irradiated yeast and used in some commercial preparations of the vitamin) or vitamin D$_3$ (found in fish liver oils and in fortified milk).

Symptoms of vitamin D deficiency in children include bowlegs, knock knees, and more severe (often crippling) deformations of the bones. In adults deficiency results in osteomalacia, characterized by a softening of the bones. Excessive vitamin D consumption can result in toxicity. Symptoms include nausea, loss of appetite, kidney damage, and deposits of insoluble calcium salts in certain tissues. The recommended daily dietary allowance for cholecalciferol is 15 to 20 micrograms (600 to 800 IU) depending upon age and the availability of sunlight. Fortified cow's milk supplies 400 IU per quart (422 IU per liter).

**Vitamin E**

Vitamin E occurs in at least eight molecular forms (tocopherols or tocotrienols); in humans the most biologically active form has generally been considered to be alpha-tocopherol, which is also the most common. All forms exist as light yellow, viscous oils. The best sources are vegetable oils. Other sources include green leafy vegetables, wheat germ, some nuts, and eggs. Vitamin E is necessary for the maintenance of cell membranes. It is essential to normal reproduction in some animals, but there is no evidence that it plays a role in human reproduction. It is a potent antioxidant; numerous studies have pointed to a protective effect against arterial plaque buildup and cancer. It is helpful in the relief of intermittent claudication (calf pain) and in preventing problems peculiar to premature infants. In large doses, it has an anticoagulant effect. The recommended daily dietary allowance for adults is 10 mg (tocopherol equivalents) for men and 8 mg for women, but nutritionists and physicians sometimes recommend higher doses for disease prevention.

**Vitamin K**

Vitamin K consists of substances that are essential for the clotting of blood. It was identified in 1934 by Danish biochemist Henrik Dam. Two types of K vitamins have been isolated: K$_1$, an oil purified from alfalfa concentrates, and K$_2$, synthesized by the normal intestinal bacteria. Both can be derived from the synthetic compound menadione (sometimes called vitamin K$_3$), a yellow crystalline solid that is as potent in its ability to promote blood clotting as the natural vitamins. The best sources are leafy green vegetables, such as cabbage and spinach, and intestinal bacteria (which produce most of the body's
supply of vitamin K). Vitamin K is required for the synthesis in the liver of several blood clotting factors, including prothrombin. Coumarin derivatives, used in medicine to prevent blood coagulation in certain cases, act by antagonizing the action of vitamin K. In the deficiency state an abnormal length of time is needed for the blood to clot, and there may be hemorrhaging in various tissues. Deficiency occurs in hemorrhagic disease of the newborn infant, in liver damage, and in cases where the vitamin is not absorbed properly by the intestine. It can also occur in coumarin therapy or when normal intestinal bacteria are destroyed by extended antibiotic therapy. Vitamin K does not treat hemophilia. Deficiency is rarely of dietary origin. The estimated safe and adequate intake for adults is 70 to 140 micrograms.

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