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# Vitamin

| Vitamin | |
|---|---|
| *Drug class* | |

A bottle of B-complex vitamin pills

| | |
|---|---|
| **Pronunciation** | UK: /ˈvɪtəmɪn, ˈvaɪ-/<br>US: /ˈvaɪtəmɪn/[1] |
| In Wikidata | |

A **vitamin** is an organic molecule (or related set of molecules) which is an essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism. Essential nutrients cannot be synthesized in the organism, either at all or not in sufficient quantities, and therefore must be obtained through the diet. Vitamin C can be synthesized by some species but not by others; it is not a vitamin in the first instance but is in the second. The term *vitamin* does not include the three other groups of essential nutrients: minerals, essential fatty acids, and essential amino acids.[2] Most vitamins are not single molecules, but groups of related molecules called vitamers. For example, vitamin E consists of four tocopherols and four tocotrienols. The thirteen vitamins required by human metabolism are: vitamin A (retinols and carotenoids), vitamin $B_1$ (thiamine), vitamin $B_2$ (riboflavin), vitamin $B_3$ (niacin), vitamin $B_5$ (pantothenic acid), vitamin $B_6$ (pyridoxine), vitamin $B_7$ (biotin), vitamin $B_9$ (folic acid or folate), vitamin $B_{12}$ (cobalamins), vitamin C (ascorbic acid), vitamin D (calciferols), vitamin E (tocopherols and tocotrienols), and vitamin K (quinones).

Vitamins have diverse biochemical functions. Some forms of vitamin A function as regulators of cell and tissue growth and differentiation. The B complex vitamins function as enzyme cofactors (coenzymes) or the precursors for them. Vitamin D has a hormone-like function as a regulator of mineral metabolism for bones and other organs. Vitamins C and E function as antioxidants.[3] Both deficient and excess intake of a vitamin can potentially cause clinically significant illness; although excess intake of water-soluble vitamins is less likely to do so.

Before 1935, the only source of vitamins was from food. If intake of vitamins was lacking, the result was vitamin deficiency and consequent deficiency diseases. Then, commercially produced tablets of yeast-extract vitamin B complex and semi-synthetic vitamin C became available. This was followed in the 1950s by the mass production and marketing of vitamin supplements, including multivitamins, to prevent vitamin deficiencies in the general population. Governments mandated addition of vitamins to staple foods such as flour or milk, referred to as food fortification, to prevent deficiencies.[4] Recommendations for folic acid supplementation during pregnancy reduced risk of infant neural tube defects.[5] Although reducing incidence of vitamin deficiencies clearly has benefits, supplementation is thought to be of little value for healthy people who are consuming a vitamin-adequate diet.[6]

The term *vitamin* is derived from the word *vitamine*, coined in 1912 by biochemist Casimir Funk, who isolated a complex of micronutrients essential to life, all of which he presumed to be amines. When this presumption was later determined not to be true, the "e" was dropped from the name.[7] All vitamins were discovered (identified) between 1913 and 1948.

## Contents

# List

| Vitamin generic descriptor name | Vitamer chemical name(s) (list not complete) | Solubility | US Recommended dietary allowances (male/female, age 19–70)[8] | Deficiency disease | Overdose syndrome/symptoms | Food sources |
|---|---|---|---|---|---|---|
| **Vitamin A** | Retinol, Retinal, and four Carotenoids including Beta-carotene | Fat | 900 µg/700 µg | Night blindness, hyperkeratosis, and keratomalacia[9] | Hypervitaminosis A | Liver, orange, ripe yellow fruits, leafy vegetables, carrots, pumpkin, squash, spinach, fish, soy milk, milk |
| **Vitamin $B_1$** | Thiamine | Water | 1.2 mg/1.1 mg | Beriberi, Wernicke-Korsakoff syndrome | Drowsiness and muscle relaxation[10] | Pork, oatmeal, brown rice, vegetables, potatoes, liver, eggs |
| **Vitamin $B_2$** | Riboflavin | Water | 1.3 mg/1.1 mg | Ariboflavinosis, glossitis, angular stomatitis | | Dairy products, bananas, popcorn, green beans, asparagus |
| **Vitamin $B_3$** | Niacin, Niacinamide, Nicotinamide riboside | Water | 16 mg/14 mg | Pellagra | Liver damage (doses > 2g/day)[11] and other problems | Meat, fish, eggs, many vegetables, mushrooms, tree nuts |
| **Vitamin $B_5$** | Pantothenic acid | Water | 5 mg/5 mg | Paresthesia | Diarrhea; possibly nausea and heartburn.[12] | Meat, broccoli, avocados |
| **Vitamin $B_6$** | Pyridoxine, Pyridoxamine, Pyridoxal | Water | 1.3–1.7 mg/1.2–1.5 mg | Anemia,[13] Peripheral neuropathy | Impairment of proprioception, nerve damage (doses > 100 mg/day) | Meat, vegetables, tree nuts, bananas |
| **Vitamin $B_7$** | Biotin | Water | AI: 30 µg/30 µg | Dermatitis, enteritis | | Raw egg yolk, liver, peanuts, leafy green vegetables |
| **Vitamin $B_9$** | Folates, Folic acid | Water | 400 µg/400 µg | Megaloblastic anemia and deficiency during pregnancy is associated with birth defects, such as neural tube defects | May mask symptoms of vitamin $B_{12}$ deficiency; other effects. | Leafy vegetables, pasta, bread, cereal, liver |
| **Vitamin $B_{12}$** | Cyanocobalamin, Hydroxocobalamin, Methylcobalamin, Adenosylcobalamin | Water | 2.4 µg/2.4 µg | Pernicious anemia[14] | None proven | Meat, poultry, fish, eggs, milk |
| **Vitamin C** | Ascorbic acid | Water | 90 mg/75 mg | Scurvy | None known | Many fruits and vegetables, liver |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Vitamin D** | Cholecalciferol (D3), Ergocalciferol (D2) | Fat | 15 µg/15 µg | Rickets and osteomalacia | Hypervitaminosis D | Lichen, eggs, liver, certain fish species such as sardines, certain mushroom species such as shiitake |
| **Vitamin E** | Tocopherols, Tocotrienols | Fat | 15 mg/15 mg | Deficiency is very rare; mild hemolytic anemia in newborn infants[15] | Possible increased incidence of congestive heart failure.[16][17] | Many fruits and vegetables, nuts and seeds, and seed oils |
| **Vitamin K** | Phylloquinone, Menaquinones | Fat | AI: 110 µg/120 µg | Bleeding diathesis | Decreased anticoagulation effect of warfarin.[18] | Leafy green vegetables such as spinach; egg yolks; liver |

# Sources

For the most part, vitamins are obtained from the diet, but some are acquired by other means: for example, microorganisms in the gut flora produce vitamin K and biotin; and one form of vitamin D is synthesized in skin cells when they are exposed to a certain wavelength of ultraviolet light present in sunlight. Humans can produce some vitamins from precursors they consume: for example, vitamin A is synthesized from beta carotene; and niacin is synthesized from the amino acid tryptophan.[19] The Food Fortification Initiative lists countries which have mandatory fortification programs for vitamins folic acid, niacin, vitamin A and vitamins B1, B2 and B12.[4]

# Classification by solubility

Vitamins are classified as either water-soluble or fat-soluble. In humans there are 13 vitamins: 4 fat-soluble (A, D, E, and K) and 9 water-soluble (8 B vitamins and vitamin C). Water-soluble vitamins dissolve easily in water and, in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption.[20] Because they are not as readily stored, more consistent intake is important.[21] Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Vitamins A and D can accumulate in the body, which can result in dangerous hypervitaminosis. Fat-soluble vitamin deficiency due to malabsorption is of particular significance in cystic fibrosis.[22]

# Biochemical functions

Each vitamin is typically used in multiple reactions, and therefore most have multiple functions.[23]

## On fetal growth and childhood development

Vitamins are essential for the normal growth and development of a multicellular organism. Using the genetic blueprint inherited from its parents, a fetus begins to develop from the nutrients it absorbs. It requires certain vitamins and minerals to be present at certain times.[5] These nutrients facilitate the chemical reactions that produce among other things, skin, bone, and muscle. If there is serious deficiency in one or more of these nutrients, a child may develop a deficiency disease. Even minor deficiencies may cause permanent damage.[24]

## On adult health maintenance

Once growth and development are completed, vitamins remain essential nutrients for the healthy maintenance of the cells, tissues, and organs that make up a multicellular organism; they also enable a multicellular life form to efficiently use chemical energy provided by food it eats, and to help process the proteins, carbohydrates, and fats required for cellular respiration.[3]

# Effects of cooking

The USDA has conducted extensive studies on the percentage losses of various nutrients from different food types and cooking methods.[25] Some vitamins may become more "bio-available" – that is, usable by the body – when foods are cooked.[26] The table below shows whether various vitamins are susceptible to loss from heat—such as heat from boiling, steaming, frying, etc. The effect of cutting vegetables can be seen from exposure to air and light. Water-soluble vitamins such as B and C dissolve into the water when a vegetable is boiled, and are then lost when the water is discarded.[27]

| Vitamin | Soluble in Water | Stable to Air Exposure | Stable to Light Exposure | Stable to Heat Exposure |
|---|---|---|---|---|
| Vitamin A | no | partially | partially | relatively stable |
| Vitamin C | very unstable | yes | yes | yes |
| Vitamin D | no | no | no | no |
| Vitamin E | no | yes | yes | no |
| Vitamin K | no | no | yes | no |
| Thiamine ($B_1$) | highly | no | ? | > 100 °C |
| Riboflavin ($B_2$) | slightly | no | in solution | no |
| Niacin ($B_3$) | yes | no | no | no |
| Pantothenic Acid ($B_5$) | quite stable | ? | no | yes |
| Vitamin $B_6$ | yes | ? | yes | ? |
| Biotin ($B_7$) | somewhat | ? | ? | no |
| Folic Acid ($B_9$) | yes | ? | when dry | at high temp |
| Cobalamin ($B_{12}$) | yes | ? | yes | no |

# Deficient intake

The body's stores for different vitamins vary widely; vitamins A, D, and $B_{12}$ are stored in significant amounts, mainly in the liver,[15] and an adult's diet may be deficient in vitamins A and D for many months and $B_{12}$ in some cases for years, before developing a deficiency condition. However, vitamin $B_3$ (niacin and niacinamide) is not stored in significant amounts, so stores may last only a couple of weeks.[9][15] For vitamin C, the first symptoms of scurvy in experimental studies of complete vitamin C deprivation in humans have varied widely, from a month to more than six months, depending on previous dietary history that determined body stores.[28]

Deficiencies of vitamins are classified as either primary or secondary. A primary deficiency occurs when an organism does not get enough of the vitamin in its food. A secondary deficiency may be due to an underlying disorder that prevents or limits the absorption or use of the vitamin, due to a "lifestyle factor", such as smoking, excessive alcohol consumption, or the use of medications that interfere with the absorption or use of the vitamin.[15] People who eat a varied diet are unlikely to develop a severe primary vitamin deficiency. In contrast, restrictive diets have the potential to cause prolonged vitamin deficits, which may result in often painful and potentially deadly diseases.

Well-known human vitamin deficiencies involve thiamine (beriberi), niacin (pellagra),[29] vitamin C (scurvy), and vitamin D (rickets).[30] In much of the developed world, such deficiencies are rare; this is due to (1) an adequate supply of food and (2) the addition of vitamins and minerals to common foods (fortification).[15] In addition to these classical vitamin deficiency diseases, some evidence has also suggested links between vitamin deficiency and a number of different disorders.[31][32]

# Excess intake

Some vitamins have documented acute or chronic toxicity at larger intakes. The European Union and the governments of several countries have established Tolerable upper intake levels (ULs) for those vitamins which have documented toxicity (see table).[8][33][34] The likelihood of consuming too much of any vitamin from food is remote, but excessive intake (vitamin poisoning) from dietary supplements does occur.

In 2016, overdose exposure to all formulations of vitamins and multi-vitamin/mineral formulations was reported by 63,931 individuals to the American Association of Poison Control Centers with 72% of these exposures in children under the age of five.[35]

# Government guidelines

In setting human nutrient guidelines, government organizations do not necessarily agree on amounts needed to avoid deficiency or maximum amounts to avoid the risk of toxicity.[33][8][34] For example, for vitamin C, recommended intakes range from 40 mg/day in India[36] to 155 mg/day for the European Union.[37] The table below shows U.S. Estimated Average Requirements (EARs) and Recommended Dietary Allowances (RDAs) for vitamins, PRIs for the European Union (same concept as RDAs), followed by what three government organizations deem to be the safe upper intake. RDAs are set higher than EARs to cover people with higher than average needs. Adequate Intakes (AIs) are set when there is not sufficient information to establish EARs and RDAs. Governments are slow to revise information of this nature. For the U.S. values, with the exception of calcium and vitamin D, all of the data date to 1997-2004.[38]

| Nutrient | U.S. EAR[8] | Highest U.S. RDA or AI[8] | Highest EU PRI or AI[37] | Upper limit | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | U.S.[8] | EU [33] | Japan[34] | |
| Vitamin A | 625 | 900 | 1300 | 3000 | 3000 | 2700 | µg |
| Vitamin C | 75 | 90 | 155 | 2000 | ND | ND | mg |
| Vitamin D | 10 | 15 | 15 | 100 | 100 | 100 | µg |
| Vitamin K | NE | 120 | 70 | ND | ND | ND | µg |
| α-tocopherol (Vit E) | 12 | 15 | 13 | 1000 | 300 | 650-900 | mg |
| Thiamin (Vit $B_1$) | 1.0 | 1.2 | 0.1 mg/MJ | ND | ND | ND | mg |
| Riboflavin (Vit $B_2$) | 1.1 | 1.3 | 2.0 | ND | ND | ND | mg |
| Niacin (Vit $B_3$) | 12 | 16 | 1.6 mg/MJ | 35 | 10 | 60-85 | mg |
| Pantothenic acid (Vit $B_5$) | NE | 5 | 7 | ND | ND | ND | mg |
| Vitamin $B_6$ | 1.1 | 1.3 | 1.8 | 100 | 25 | 40-60 | mg |
| Biotin (Vit $B_7$) | NE | 30 | 45 | ND | ND | ND | µg |
| Folate (Vit $B_9$) | 320 | 400 | 600 | 1000 | 1000 | 900-1000 | µg |
| Cyanocobalamin (Vit $B_{12}$) | 2.0 | 2.4 | 5.0 | ND | ND | ND | µg |

**EAR** US Estimated Average Requirements.

**RDA** US Recommended Dietary Allowances; higher for adults than for children, and may be even higher for women who are pregnant or lactating.

**AI** US and EFSA Adequate Intake; AIs established when there is not sufficient information to set EARs and RDAs.

**PRI** Population Reference Intake is European Union equivalent of RDA; higher for adults than for children, and may be even higher for women who are pregnant or lactating. For Thiamin and Niacin the PRIs are expressed as amounts per MJ of calories consumed. MJ = megajoule = 239 food calories.

**Upper Limit** Tolerable upper intake levels.

**ND** ULs have not been determined.

**NE** EARs have not been established.

# Supplements

In those who are otherwise healthy, there is little evidence that supplements have any benefits with respect to cancer or heart disease.[6][39] Vitamin A and E supplements not only provide no health benefits for generally healthy individuals, but they may increase mortality, though the two large studies that support this conclusion included smokers for whom it was already known that beta-carotene supplements can be harmful.[39][40]

Calcium combined with vitamin D (as calciferol) supplement tablets with fillers.

The European Union and other countries of Europe have regulations that define limits of vitamin (and mineral) dosages for their safe use as dietary supplements. Most vitamins that are sold as dietary supplements are not supposed to exceed a maximum daily dosage referred to as the tolerable upper intake level (UL). Vitamin products above these regulatory limits are not considered supplements and should be registered as prescription or non-prescription (over-the-counter drugs) due to their potential side effects. The European Union, United States, Japan and some other countries each set ULs.[33][8][34]

Dietary supplements often contain vitamins, but may also include other ingredients, such as minerals, herbs, and botanicals. Scientific evidence supports the benefits of dietary supplements for persons with certain health conditions.[41] In some cases, vitamin supplements may have unwanted effects, especially if taken before surgery, with other dietary supplements or medicines, or if the person taking them has certain health conditions.[41] They may also contain levels of vitamins many times higher, and in different forms, than one may ingest through food

### Governmental regulation

Most countries place dietary supplements in a special category under the general umbrella of *foods*, not drugs. As a result, the manufacturer, and not the government, has the responsibility of ensuring that its dietary supplement products are safe before they are marketed. Regulation of supplements varies widely by country. In the United States, a dietary supplement is defined under the Dietary Supplement Health and Education Act of 1994.[42] There is no FDA approval process for dietary supplements, and no requirement that manufacturers prove the safety or efficacy of supplements introduced before 1994.[29][30] The Food and Drug Administration must rely on its Adverse Event Reporting System to monitor adverse events that occur with supplements.[43] In 2007, the US Code of Federal Regulations (CFR) Title 21, part III took effect, regulating Good Manufacturing Practices (GMPs) in the manufacturing, packaging, labeling, or holding operations for dietary supplements. Even though product registration is not required, these regulations mandate production and quality control standards (including testing for identity, purity and adulterations) for dietary supplements.[44] In the European Union, the Food Supplements Directive requires that only those supplements that have been proven safe can be sold without a prescription.[45] For most vitamins, pharmacopoeial standards have been established. In the United States, the United States Pharmacopeia (USP) sets standards for the most commonly used vitamins and preparations thereof. Likewise, monographs of the European Pharmacopoeia (Ph.Eur.) regulate aspects of identity and purity of vitamins on the European market.

## Naming

The reason that the set of vitamins skips directly from E to K is that the vitamins corresponding to letters F–J were either reclassified over time, discarded as false leads, or renamed because of their relationship to vitamin B, which became a complex of vitamins.

The German-speaking scientists who isolated and described vitamin K (in addition to naming it as such) did so because the vitamin is intimately involved in the coagulation of blood following wounding (from the German word *Koagulation*). At the time, most (but not all) of the letters from F through to J were already designated, so the use of the letter K was considered quite reasonable.[46][49] The table *nomenclature of reclassified vitamins* lists chemicals that had previously been classified as vitamins, as well as the earlier names of vitamins that later became part of the B-complex.

There are other missing B vitamins which were reclassified or determined not to be vitamins. For example, $B_9$ is folic acid and five of the folates are in the range $B_{11}$ through $B_{16}$, forms of other vitamins already discovered, not required as a nutrient by the entire population (like $B_{10}$, PABA for internal use[50]), biologically inactive, toxic, or with unclassifiable effects in humans, or not generally recognised as vitamins by science,[51] such as the highest-numbered, which some naturopath practitioners call $B_{21}$ and $B_{22}$. There are also nine lettered B complex vitamins (e.g. $B_m$). There are other D vitamins now recognised as other substances,[50] which some sources of the same type number up to $D_7$. The controversial cancer treatment laetrile was at one point lettered as vitamin $B_{17}$. There appears to be no consensus on any vitamins Q, R, T, V, W, X, Y or Z, nor are there substances officially designated as Vitamins N or I, although the latter may have been another form of one of the other vitamins or a known and named nutrient of another type.

Nomenclature of reclassified vitamins

| Previous name | Chemical name | Reason for name change[46] |
|---|---|---|
| Vitamin $B_4$ | Adenine | DNA metabolite; synthesized in body |
| Vitamin $B_8$ | Adenylic acid | DNA metabolite; synthesized in body |
| Vitamin $B_T$ | Carnitine | Synthesized in body |
| Vitamin F | Essential fatty acids | Needed in large quantities (does not fit the definition of a vitamin). |
| Vitamin G | Riboflavin | Reclassified as Vitamin $B_2$ |
| Vitamin H | Biotin | Reclassified as Vitamin $B_7$ |
| Vitamin J | Catechol, Flavin | Catechol nonessential; flavin reclassified as Vitamin $B_2$ |
| Vitamin $L_1$[47] | Anthranilic acid | Non essential |
| Vitamin $L_2$[47] | Adenylthiomethylpentose | RNA metabolite; synthesized in body |
| Vitamin M | Folic acid | Reclassified as Vitamin $B_9$ |
| Vitamin P | Flavonoids | No longer classified as a vitamin |
| Vitamin PP | Niacin | Reclassified as Vitamin $B_3$ |
| Vitamin S | Salicylic acid | Proposed inclusion[48] of salicylate as an essential micronutrient |
| Vitamin U | S-Methylmethionine | Protein metabolite; synthesized in body |

Once discovered, vitamins were actively promoted in articles and advertisements in *McCall's*, *Good Housekeeping*, and other media outlets.[29] Marketers enthusiastically promoted cod-liver oil, a source of Vitamin D, as "bottled sunshine", and bananas as a “natural vitality food". They promoted foods such as yeast cakes, a source of B vitamins, on the basis of scientifically-determined nutritional value, rather than taste or appearance.[52] World War II researchers focused on the need to ensure adequate nutrition, especially in processed foods.[29] Robert W. Yoder is credited with first using the term *vitamania*, in 1942, to describe the appeal of relying on nutritional supplements rather than on obtaining vitamins from a varied diet of foods. The continuing preoccupation with a healthy lifestyle has led to an obsessive consumption of additives the beneficial effects of which are questionable.[30]

# Anti-vitamins

Anti-vitamins are chemical compounds that inhibit the absorption or actions of vitamins. For example, avidin is a protein in raw egg whites that inhibits the absorption of biotin; it is deactivated by cooking.[53] Pyrithiamine, a synthetic compound, has a molecular structure similar to thiamine, vitamin $B_1$, and inhibits the enzymes that use thiamine.[54]

# History

The value of eating certain foods to maintain health was recognized long before vitamins were identified. The ancient Egyptians knew that feeding liver to a person may help with night blindness, an illness now known to be caused by a vitamin A deficiency.[56] The advancement of ocean voyages during the Renaissance resulted in prolonged periods without access to fresh fruits and vegetables, and made illnesses from vitamin deficiency common among ships' crews.[57]

In 1747, the Scottish surgeon James Lind discovered that citrus foods helped prevent scurvy, a particularly deadly disease in which collagen is not properly formed, causing poor wound healing, bleeding of the gums, severe pain, and death.[56] In 1753, Lind published his *Treatise on the Scurvy*, which recommended using lemons and limes to avoid scurvy, which was adopted by the British Royal Navy. This led to the nickname *limey* for British sailors. Lind's discovery, however, was not widely accepted by individuals in the Royal Navy's Arctic expeditions in the 19th century, where it was widely believed that scurvy could be prevented by practicing good hygiene, regular exercise, and maintaining the morale of the crew while on board, rather than by a diet of fresh food.[56] As a result, Arctic expeditions continued to be plagued by scurvy and other deficiency diseases. In the early 20th century, when Robert Falcon Scott made his two expeditions to the Antarctic, the prevailing medical theory at the time was that scurvy was caused by "tainted" canned food.[56]

During the late 18th and early 19th centuries, the use of deprivation studies allowed scientists to isolate and identify a number of vitamins. Lipid from fish oil was used to cure rickets in rats, and the fat-soluble nutrient was called "antirachitic A". Thus, the first "vitamin" bioactivity ever isolated, which cured rickets, was initially called "vitamin A"; however, the bioactivity of this compound is now called vitamin D.[58] In 1881, Russian medical doctor Nikolai I. Lunin studied the effects of scurvy at the University of Tartu .[59] He fed mice an artificial mixture of all the separate constituents of milk known at that time, namely the proteins, fats, carbohydrates, and salts. The mice that received only the individual constituents died, while the mice fed by milk itself developed normally. He made a conclusion that "a natural food such as milk must therefore contain, besides these known principal ingredients, small quantities of unknown substances essential to life."[59] However, his conclusions were rejected by his advisor, Gustav von Bunge, even after other students reproduced his results.[60] A similar result by Cornelius Pekelharing appeared in a Dutch medical journal in 1905, but it was not widely reported.[60]

The discovery dates of the vitamins and their sources

| Year of discovery | Vitamin | Food source |
|---|---|---|
| 1913 | Vitamin A (Retinol) | Cod liver oil |
| 1910 | Vitamin $B_1$ (Thiamine) | Rice bran |
| 1920 | Vitamin C (Ascorbic acid) | Citrus, most fresh foods |
| 1920 | Vitamin D (Calciferol) | Cod liver oil |
| 1920 | Vitamin $B_2$ (Riboflavin) | Meat, dairy products, eggs |
| 1922 | Vitamin E (Tocopherol) | Wheat germ oil, unrefined vegetable oils |
| 1929 | Vitamin $K_1$ (Phylloquinone) | Leaf vegetables |
| 1931 | Vitamin $B_5$ (Pantothenic acid) | Meat, whole grains, in many foods |
| 1931 | Vitamin $B_7$ (Biotin) | Meat, dairy products, Eggs |
| 1934 | Vitamin $B_6$ (Pyridoxine) | Meat, dairy products |
| 1936 | Vitamin $B_3$ (Niacin) | Meat, grains |
| 1941 | Vitamin $B_9$ (Folic acid) | Leaf vegetables |
| 1948[55] | Vitamin $B_{12}$ (Cobalamins) | Meat, organs (Liver), Eggs |

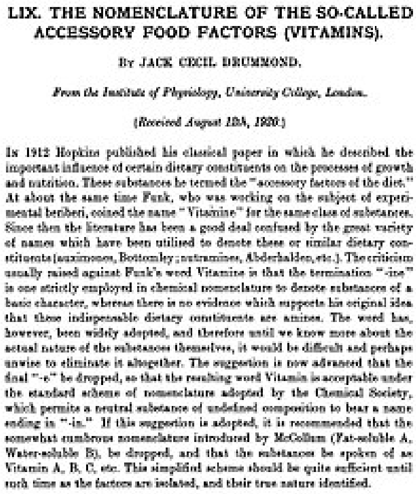
In East Asia, where polished white rice was the common staple food of the middle class, beriberi resulting from lack of vitamin $B_1$ was endemic. In 1884, Takaki Kanehiro, a British-trained medical doctor of the Imperial Japanese Navy, observed that beriberi was endemic among low-ranking crew who often ate nothing but rice, but not among officers who consumed a Western-style diet. With the support of the Japanese navy, he experimented using crews of two battleships; one crew was fed only white rice, while the other was fed a diet of meat, fish, barley, rice, and beans. The group that ate only white rice documented 161 crew members with beriberi and 25 deaths, while the latter group had only 14 cases of beriberi and no deaths. This convinced Takaki and the Japanese Navy that diet was the cause of beriberi, but they mistakenly believed that sufficient amounts of protein prevented it.[61] That diseases could result from some dietary deficiencies was further investigated by Christiaan Eijkman, who in 1897 discovered that feeding unpolished rice instead of the polished variety to chickens helped to prevent beriberi in the chickens.[29] The following year, Frederick Hopkins postulated that some foods contained "accessory factors" — in addition to proteins, carbohydrates, fats *etc.* — that are necessary for the functions of the human body.[56] Hopkins and Eijkman were awarded the Nobel Prize for Physiology or Medicine in 1929 for their discoveries.[62]

In 1910, the first vitamin complex was isolated by Japanese scientist Umetaro Suzuki, who succeeded in extracting a water-soluble complex of micronutrients from rice bran and named it aberic acid (later *Orizanin*). He published this discovery in a Japanese scientific journal.[63] When the article was translated into German, the translation failed to state that it was a newly discovered nutrient, a claim made in the original Japanese article, and hence his discovery failed to gain publicity. In 1912 Polish-born biochemist Casimir Funk, working in London, isolated the same complex of micronutrients and proposed the complex be named "vitamine". It was later to be known as vitamin $B_3$ (niacin), though he described it as "anti-beri-beri-factor" (which would today be called thiamine or vitamin $B_1$). Funk proposed the hypothesis that other diseases, such as rickets, pellagra, coeliac disease, and scurvy could also be cured by vitamins. Max Nierenstein a friend and reader of Biochemistry at Bristol University reportedly suggested the "vitamine" name (from "vital amine").[64][65] The name soon became synonymous with Hopkins' "accessory factors", and, by the time it was shown that not all vitamins are amines, the word was already ubiquitous. In 1920, Jack Cecil Drummond proposed that the final "e" be dropped to deemphasize the "amine" reference, after researchers began to suspect that not all "vitamines" (in particular, vitamin A) have an amine component.[61]

In 1930, Paul Karrer elucidated the correct structure for beta-carotene, the main precursor of vitamin A, and identified other carotenoids. Karrer and Norman Haworth confirmed Albert Szent-Györgyi's discovery of ascorbic acid and made significant contributions to the chemistry of flavins, which led to the identification of lactoflavin. For their investigations on carotenoids, flavins and vitamins A and $B_2$, they both received the Nobel Prize in Chemistry in 1937.[66]

In 1931, Albert Szent-Györgyi and a fellow researcher Joseph Svirbely suspected that "hexuronic acid" was actually vitamin C, and gave a sample to Charles Glen King, who proved its anti-scorbutic activity in his long-established guinea pig scorbutic assay. In 1937, Szent-Györgyi was awarded the Nobel Prize in Physiology or Medicine for his discovery. In 1943, Edward Adelbert Doisy and Henrik Dam were awarded the Nobel Prize in Physiology or Medicine for their discovery of vitamin K and its chemical structure. In 1967, George Wald was awarded the Nobel Prize (along with Ragnar Granit and Haldan Keffer Hartline) for his discovery that vitamin A could participate directly in a physiological process.[62]

In 1938, Richard Kuhn was awarded the Nobel Prize in Chemistry for his work on carotenoids and vitamins, specifically $B_2$ and $B_6$.[67]



LIX. THE NOMENCLATURE OF THE SO-CALLED ACCESSORY FOOD FACTORS (VITAMINS).

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*(Received August 12th, 1920.)*

In 1912 Hopkins published his classical paper in which he described the important influence of certain dietary constituents on the processes of growth and nutrition. These substances he termed the "accessory factors of the diet." At about the same time Funk, who was working on the subject of experimental beriberi, coined the name "Vitamine" for the same class of substances. Since then the literature has been a good deal confused by the great variety of names which have been utilised to denote these or similar dietary constituents (auximones, Bottomley; nutramines, Abderhalden, etc.). The criticism usually raised against Funk's word Vitamine is that the termination "-ine" is one strictly employed in chemical nomenclature to denote substances of a basic character, whereas there is no evidence which supports his original idea that these indispensable dietary constituents are amines. The word has, however, been widely adopted, and therefore until we know more about the actual nature of the substances themselves, it would be difficult and perhaps unwise to eliminate it altogether. The suggestion is now advanced that the final "-e" be dropped, so that the resulting word Vitamin is acceptable under the standard scheme of nomenclature adopted by the Chemical Society, which permits a neutral substance of undefined composition to bear a name ending in "-in." If this suggestion is adopted, it is recommended that the somewhat cumbrous nomenclature introduced by McCollum (Fat-soluble A, Water-soluble B), be dropped, and that the substances be spoken of as Vitamin A, B, C, etc. This simplified scheme should be quite sufficient until such time as the factors are isolated, and their true nature identified.

Jack Drummond's single paragraph paper in 1920 which provided structure and nomenclature used today for vitamins

# Etymology

The term *vitamin* was derived from "vitamine", a compound word coined in 1912 by the Polish biochemist Casimir Funk[68] when working at the Lister Institute of Preventive Medicine. The name is from *vital* and *amine*, meaning amine of life, because it was suggested in 1912 that the organic micronutrient food factors that prevent beriberi and perhaps other similar dietary-deficiency diseases might be chemical amines. This was true of thiamine, but after it was found that other such micronutrients were not amines the word was shortened to vitamin in English.

# See also

- Vitamin deficiency
- Hypervitaminosis
- Human nutrition

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- USDA RDA chart in PDF format
- Health Canada Dietary Reference Intakes Reference Chart for Vitamins
- NIH Office of Dietary Supplements: Fact Sheets

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